Co-evolution of Business, Government, Technology, and Economics: Lessons from U.S. Telecommunications

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This paper explores co-evolution of institutions, technologies and economics by considering the U.S. telecommunications industry. Industry and government strategies led to technology changes that lowered costs and triggered customer interest in advanced services. AT&T's primary strategic responses were special pricing, raising rivals' costs, and seeking government protections. These tactics actually created opportunities for rivals, who adopted new technologies faster than AT&T, and triggered changes in government policies to favor competitors. The development of broadband followed several paths that eventually converged. Competition in long distance networking led to technology advances and strategic choices that forced local exchange competition. The growth of what had been a separate industry, cable television, facilitated the development of competition for broadband access. The paper draws principles by which co-evolution occurs.

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I. Introduction

It has long been recognized that industry and government institutions undergo a co-evolution in response to changing technologies, economics, and cultures. An early view of the interaction between government and industry was that technology enables market power and that the resulting public outcries lead to government oversight. (Trebing 2001) Another view is that businesses seek government regulation to limit competition that technology might otherwise allow. (Peltzman 1976) Rolf Künneke (2009) explores the idea that government and business institutions adapt to technology to form coherence. Cherry and Bauer (2004) adopt a complexity framework to consider how industry and government co-evolve. Tim Wu (2003) developed his notion of net neutrality based on a concern that industry might tilt technology in its favor.

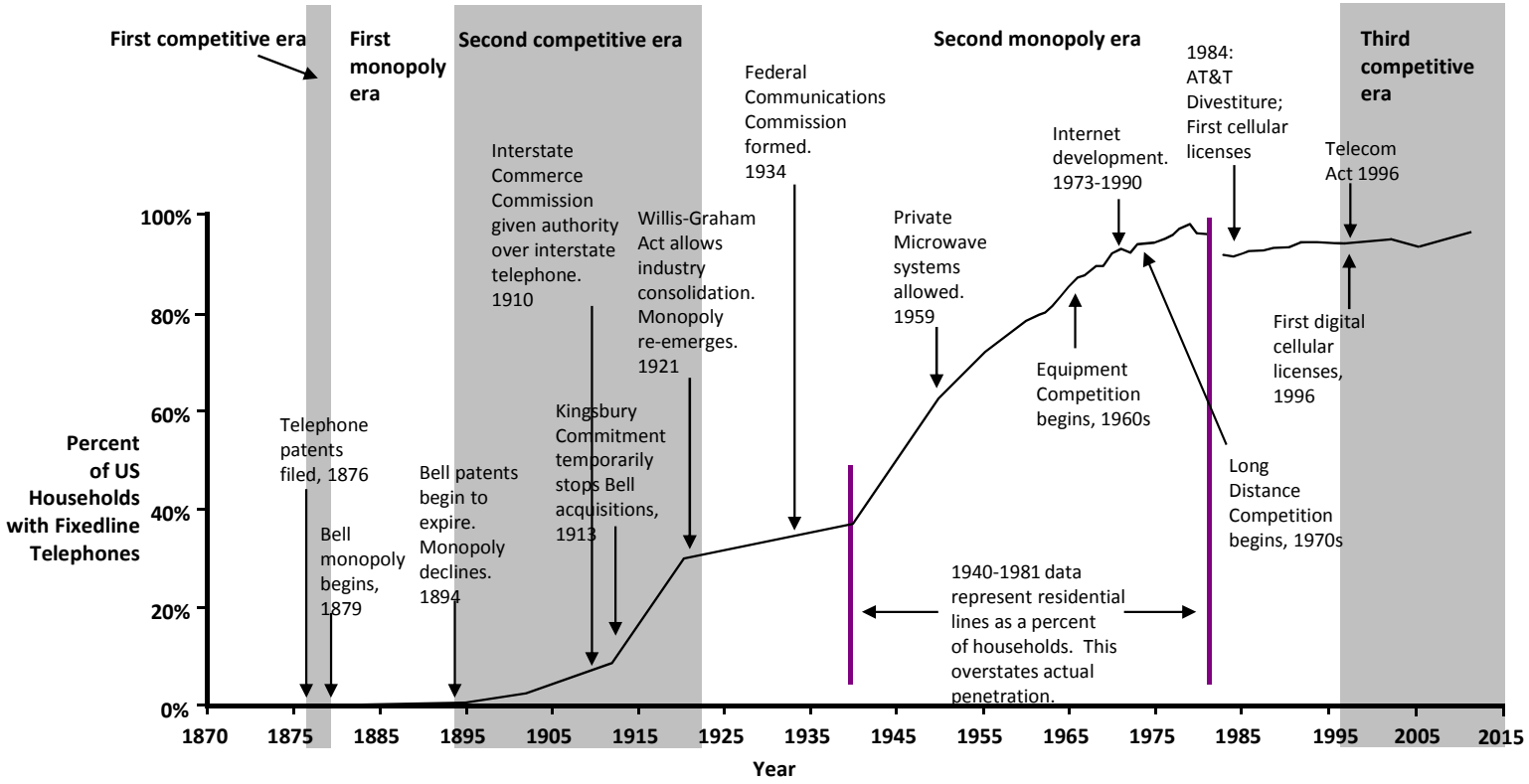
The history of telecommunications demonstrates that the advance of technology depends at least in part in government and business institutions and their economics before the next technology option emerges and is chosen: businesses and government invest in developing technologies, laws affect the economics of business, and consumer and citizen experiences affect societal demands and expectations. This raises the question: What are the principles by which business and government strategies, economic environments, and technology evolve together?

This paper explores this co-evolution by considering the evolution of the U.S. telecommunications industry. As Figure 1 shows, there have been five eras in telecommunications, marked by the rise and fall of competition. The figure also maps the expansion of traditional telephone service, which experienced its first rapid growth during the competitive era of 1894 through 1921, and then during the post World War II economic boom from 1945 through the 1960s. Broadband developed as an outgrowth of changes in customer demand, technologies developed for long distance and high speed computing, and government interest in advanced networking.

This paper maps the evolution to three themes, namely technology change, the development of competition, and the adoption of broadband. Technology changes lowered costs and triggered customer interest in advanced services. AT&T's primary strategic responses were special pricing for customers it might lose to rivals, raising rivals' costs, and seeking government protections. Rather than helping the company, these tactics created opportunities for rivals, led rivals to adopt new technologies faster than AT&T, and triggered changes in government policies to favor competitors.

The transition from monopoly to competition has roots in the 1950s when manufacturing costs declined for microwave transmission equipment and policymakers decided that customers could attach their own equipment to AT&T's network. Again AT&T's strategic pricing created opportunities for companies such as MCI. Primarily because of its monopoly and regulatory legacies, AT&T was slower to adopt new technologies than its rivals, which gave the rivals a competitive advantage.

Figure 1. US Telecommunications Competitive and Monopoly Eras: 1876-2012



Sources: 1895, 1902, 1912, 1920 -- Mueller, "Universal Service."; 1940, 1950, 1955 -- Majority Staff of the Subcommittee on Telecommunications, Consumer Protection, and Finance of the U.S. House Committee on Energy and Commerce, *Telecommunications in Transition: The Status of Competition in the Telecommunications Industry*, H.R. Doc. No. 86-058, 97th Congress, 1st Session, November 3, 1981; 1960-1981 -- FCC, *Common Carrier Statistics*; 1983-1996 -- FCC, *Trends in Telephone Service*; 1997-2010 – FCC, *Universal Service Monitoring Report*.

The development of broadband followed several paths that eventually converged. One path was the development of technologies that would lower the cost of providing long distance networking, including digital microwave and fiber optics. Another path was the advancement of digital computing technologies, which lowered the cost of computing and created an interest among large customers for high capacity lines that could transfer data, and the long distance technologies were adapted for this purpose. The growth of cable television facilitated the development of competition for broadband access, which sped the deployment of broadband relative countries without facilities-based competition.

The rest of this paper is organized as follows. The next section describes the interaction between technology, business strategy and regulation. Section III explores these changes in the context of the growth and decline of competition. Section IV integrates the development of broadband into the analysis. Section V draws principles regarding how: (1) technology change impacts entry and business models; (2) industry structure affects incentives for technology change; (3) incremental change is an inadequate response to disruptive business models; (4) new technologies create unanticipated business opportunities; (5) fundamental changes often lie beyond the vision of business and government; (6) new regulations create stakeholders, who both resist change and seek new regulatory advantages; and (7) governments cannot be depended upon to keep commitments, especially during times of change. Section VI is the conclusion.

II. Technology Change

The initial technologies of telecommunications led to a network architecture that incorporated telephone sets, local wireline access, manual and then automated switches for connecting callers, and intercity lines that provided long distance service. This architecture, illustrated in the value chain framework in Table 1, developed alongside an industry structure and a government regulatory framework consisting of local telephone companies with local franchises, interconnected through a single long distance network owned and operated largely by AT&T, end-to-end network control by the telephone companies, and utility-style rate regulation with common carrier service obligations. (Brock 1981)

Today telephone sets have been replaced by a wide range of customer devices, including simple cell phones, smartphones, iPads, television sets, and PCs and other computing devices, all under the control of the customer. Wireline access has been replaced by a mixture of wireless and wire technologies that connect customer devices to the network. Switches have been replaced by servers and data routers. And intercity lines have been replaced by a mixture of middle mile, regional, and backbone networks using fiber optics, microwave, coaxial cable, and satellites, mostly using Internet protocols. Additions to the value chain include web content, videos, e-commerce software, and software apps that find, manage and present information, sound, and video. More recently introduced has been cloud computing, which reduces the network to a customer-centric environment that is portable across devices and geographic space.

Table 1. Changes in Telecommunications Value Chain, 1950 through 2010

Time Period	Manufacturing	Networking	Applications and Content	Access	Devices
1950s	Microwave transmission technology (1950s)	Microwave transmission technology (1950s)			Hush-a-phone (1956)
1960s	Moore's Law (1960s to present)	Beginning of Internet (1960s) Telpak (1960s)	Beginning of Internet (1960s)	Denial of interconnection (1960s-1970s) Carterfone (1968)	Moore's Law (1960s to present)
1970s	Digital technologies (1970s – 1980s) Fiber optic technologies (1970s – 1990s)	Start of long distance competition (1970s) Fiber optic technologies (1970s – 1990s)			
1980s	Break-up of AT&T (1984)	Break-up of AT&T (1984)		Fiber optics deployed for access (1982 to present) Break-up of AT&T (1984) Cellular deployed (1980s to present)	Break-up of AT&T (1984)
1990s		Telecom Act 1996		Telecom Act 1996	
2000s			Development of smart phones (2000s)	Widespread use of WiFi (2000s)	Development of smart phones (2000s)

Table 1 illustrates this evolution in how telecommunications provides value. The 1950s was marked by a technology change in manufacturing that impacted the economics of long distance networking. In the 1960s, declines in the cost of manufacturing electronics impacted all stages of the value chain, except how customers connected to the network, which remained dominated by copper wire. (Brock 1981) The boundary between long distance network and local access began changing in the 1970s with the implementation of fiber optics in long distance, which found its way into local access in the 1980s. (Jamison and Sichter 2010) Customers became active players in the value chain, first with the development of the Internet, which enabled customers to be content providers, but more firmly with the introduction of residential broadband and smart phones. (Weinhaus et al. 1995)

Development of Microwave. The evolution of telecommunications networks occurred in several steps. An early step was the development of microwave technologies in the 1950s that made it economical for manufacturers to produce microwave equipment that customers could use for their own private networks. Prior to this time, only carriers such as AT&T were provided with radio spectrum for microwave transmission systems. (Bolter et al. 1984) The manufacturers of this equipment wanted the Federal Communications Commission (FCC), which was and is responsible for allocating radio spectrum for non-federal government uses, to allocate radio spectrum in the microwave bands for private use. AT&T saw the strategic importance of controlling radio spectrum and fought this development, but lost in 1959 when the FCC granted private microwave systems a dedicated portion of the radio spectrum above 890 MHz. The FCC's decision thus made it possible for large customers to develop their own networks. (Brock 1981)

AT&T responded to this FCC decision, known as the *Above 890 Decision*,[1] with a pricing plan called TelPak, which provided price discounts to customers who were large enough to build their own networks. AT&T intended that TelPak would encourage large customers to stay with AT&T, but instead it facilitated the development of rivals that purchased the TelPak service and resold it to multiple customers that were too small to individually qualify for the price discounts. The FCC's decision also facilitated the formation of MCI, initially known as Microwave Communications, Inc., by making it possible for MCI to purchase and use its own microwave equipment for serving large customers. MCI became the main rival to AT&T in the 1970s through the early 1990s and was instrumental in the 1984 breakup of AT&T. (Brock 1981)

Advances in Electronics in Networking. The development of economical microwave technologies was part of a broader advancement in electronics that also made it economical for customers to own other telecommunications equipment, including radio and terminal equipment. One such set of radio equipment, called Carterfone, manufactured by Carter Electronics Corp., allowed customers to economically develop private radio networks. Customers wanted to connect these networks to AT&T's network for completing calls, but AT&T refused the interconnection. Carter appealed to the FCC, which in 1968 ruled that AT&T could not refuse interconnection with any lawful

[1] Federal Communications Commission, *In the Matter of Allocation of Frequencies in Bands Above 890 Mc*, Memorandum Opinion and Order, 29 FCC 825 (1960), Docket 11886.

device that does not harm the telephone network.[2] This opened the way for MCI and others to interconnect their networks with the AT&T network.

Advances in Electronics in Terminal Equipment. The advancement of electronics also included the development of digital computing equipment. The performance of the old analogue transmission and switching technologies was hampered by signal degradation and limited computing power. An analogue signal would degrade as it passed through the network and information would be lost because the exact form of the original signal could not be recovered. The introduction of digital technologies meant that information could be completely restored as long as it remained clear whether the information bit was meant to be a zero or a one. (Bolter et al. 1984) Digitalization of transmission made data transmission economical, which increased the demand for computing. This rapid change in customer demand was difficult for AT&T to satisfy given the company's utility-style regulation and tradition of long-lived investments.

The introduction of digital electronics in telecommunications also increased computing power by lowering equipment manufacturing costs and increasing opportunities for software-based services because digitalization simplified programming. The availability of affordable software-based services in turn stimulated customers' interests in advanced communications services and made it economical for computer manufacturers to develop equipment, such as digital PBXs, that customers could own and use to develop private networks. Because of a regulatory restriction by the FCC, imposed under Computer Inquiry II, AT&T could not supply customers with this equipment, so the company's competitive response to PBXs and private networks was to expand a virtual PBX service called Centrex.[3] Offering Centrex required extensive investment in copper wires and digital switches, which drove up AT&T's overall costs for its local networks. These higher costs caused problems for the company's regulators because of the political difficulties associated with raising prices.

Fiber Optics. A fourth major step in the technological evolution was the development of fiber optics. Fiber optic technologies allow large amounts of data to be rapidly transmitted digitally over long distances using lightweight cables. (Bolter et al. 1984) Commercial applications began for AT&T and GTE in 1977, but emerging competition provided the biggest boost to fiber optics. In the early 1980s, the New York Port Authority developed an organization called Teleport that initially aggregated telecommunications traffic for New York City business districts. Teleport deployed fiber optics to gather traffic and quickly found that it could then economically provide additional telecommunications services because each fiber cable had significant economies of scale. Imitators, such as Metropolitan Fiber Systems, quickly arose and an industry segment known as Competitive Access Providers, or CAPS, was born. CAPs eventually began working with AT&T's long distance competitors, primarily MCI and Sprint, to bypass local telephone networks. (McDermott 2002, Tomlinson 2000)

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[2] *Carterfone*, 13 FCC 2d 240 (1968), *recon. denied*, 14 FCC 2d 571 (1968).

[3] *Second Computer Inquiry, Final Decision*, 77 FCC 2d 384 (1980), *modified on reconsideration*, 84 FCC 2d 50 (1980), *aff'd sub nom*. *Computer and Communications Industry Association v. FCC*, No. 80-1471 (D.C. Cir. November 12, 1982).

The other competition that drove implementation of fiber optics was competition in long distance. One of AT&T's early long distance competitors, Sprint, was developed by a railroad company that placed fiber optics on its rail right-of-ways. Sprint's extensive use of fiber optics became the company's marketing angle. Its "pin drop" commercial and its commercial blowing up microwave towers helped make technology leadership a viable market position. (Huber, Kellogg and Thorne 1992)

Packet Switching and the Internet. Running parallel with these technology developments was the development of packet switching and the Internet. The U.S. government funded universities to develop a telecommunications networking that would be robust and exploit packet switching. From this work emerged ARPANET (Advanced Research Projects Agency Network), a network of computers, and the protocols for the Internet (TCP/IP). Other packet networks emerged, but ARPANET played a central role among the network of packet networks until NSFNET, created by the National Science Foundation, became a key center of activity. The NSF backbone (largely fiber optics) was provided by private companies (largely MCI and IBM). In 1995 NSF privatized its traffic hubs (Network Access Points or NAPs) and decommissioned its own backbone so that all backbone services were privately owned, largely by companies such as MCI, Sprint, and PSI. (Leiner et al. 2016)

AT&T was slow to embrace the Internet. AT&T's strategy with respect to customers' data needs was incremental change in the form of Integrated Services Digital Network (ISDN). ISDN would maintain much of the traditional voice network architecture and slowly adapt it for data. ISDN was limited in its capabilities and the migration was too slow, which allowed the Internet technologies to become the dominant data technologies. (Bolter et al. 1984)

Wireless Access. The latest major technology advancement was that of wireless technologies. Wireless communications has its roots in the 1800s and commercial radio began in the early 1900s. But the primary advances that revolutionized telecommunications were the development of cellular radio – a technology that allows customers to move across a network of radio cells without losing their connections – and WiFi – which provides local broadband access. Cellular technology was first conceptualized in the early 1900s, but its inventor, AT&T, decided to not pursue commercializing the technology because it might cannibalize AT&T's expanding wireline service. In 1947 AT&T's Bell Labs developed a working cellular technology and continued to work on it until the 1970s, when the technology was ready for commercialization. By that time AT&T was interested in commercializing the service, but it needed radio spectrum from the FCC, which did not see the technology as being particularly useful. Because of its lack of vision, the FCC took several timid steps in licensing radio spectrum for the technology. Indeed, cellular service was first available commercially in Europe before it was in the U.S. (Rohlfs, Jackson and Kelly 1991, Brodsky 2008)

The first national licensing of cellular in the U.S. was in the early 1980s, but it wasn't until the mid 1990s that the FCC provided sufficient radio spectrum for digital cellular service in the U.S. and the service took off. Several factors were important for this change in approach for the FCC. Cellular telecommunications was growing rapidly in Europe and in Asia, leaving U.S. consumers far behind in terms of the telecommunications services and technologies that could be purchased. In 1993 Congress deregulated the cellular industry and authorized the FCC to use auctions to license radio spectrum.

Deregulation unleashed innovation and auctions allowed the companies with the greatest profit potential to obtain radio spectrum. (Brodsky 2008)

WiFi, which was developed in 1997 by the Institute of Electrical and Electronics Engineers, is an economical technology for multiple users to have wireless broadband access to the Internet. WiFi locations are known as hotspots and can be private, commercial, or public. (The Economist 2004)

In contrast to cellular technology, the deployment of which was delayed by FCC inaction, the FCC actually enabled WiFi by allowing part of the radio spectrum to remain unlicensed, meaning that any person could use that part of the radio spectrum as long as the person used equipment that met FCC specifications for power, radio frequency, and the like. This largely deregulated approach to the development of wireless services, which was advocated several years by FCC staff before it was adopted by the Commission, allowed engineers to experiment and develop products that customers found valuable. (The Economist 2004)

III. Development of Competition

As the section on technology change implies, the changes in technology and in market structure went hand in hand, with technology change enabling new services and providers, and the competition driving operators to develop and adopt new technologies.

Early Competition and then Monopolization. As Figure 1 shows, the first era of competition was actually during the time of the invention of the telephone in the late 1800s, during which time Western Union and Alexander Graham Bell (the founder of AT&T) raced to deploy each of their newly developed telephone technologies. The industry monopolized when Western Union sold its patent claims to AT&T, but then competition re-emerged when the key patents began expiring around 1900. The competition of building networks was costly to the industry players and AT&T began purchasing rivals. The U.S. Department of Justice was concerned about re-monopolization, but the Willis Graham Act, passed in 1921, authorized industry consolidation. (Brock 1981)

Emerging Competition in Networking. A system of local telephone monopolies, interconnected by AT&T's long distance network, emerged after 1921 and maintained end-to-end control of telephone service until 1956 when the D.C. Circuit Court of Appeals, overruling the FCC in a decision called Hush-a-phone,[4] ruled that customers could attach items to the network that did not physically harm the network and that did not affect more than the conversation of the user. This opened the door for the Carterfone decision, which in turn opened the door for competition in telephone devices. AT&T tried to limit the competition by requiring customers who chose to purchase rival telephone devices to also purchase AT&T network protection devices, which were generally cost prohibitive. The FCC eventually developed standards for telephone equipment and ruled that the protection devices were unnecessary.

[4] *Hush-A-Phone v. United States*, 238 F.2d 266 (D.C. Cir. 1956).

Competition in equipment subsequently became the norm and by the late 1980s, AT&T and its former local exchange companies had largely exited the market for telephone equipment. (Brock 1981)

Competition in the long distance portion of the network began with the FCC's *Above 890 Decision*, but the most critical events were the introduction of MCI's Execunet and the FCC's decision requiring AT&T to allow MCI to interconnect with AT&T's network. MCI was initially authorized by the FCC to provide private line services, which were point-to-point circuits dedicated to particular customers. Traditionally such services were subscribed to on a monthly basis. MCI developed what it called shared private line, which allowed customers to subscribe to a private line service on shorter term bases. This development led to Execunet, which MCI described as shared private line, but which actually allowed customers to dial into the MCI network and communicate with any other telephone user, and pay on a per minute basis. AT&T fought back by disconnecting MCI, but the FCC overruled AT&T and ordered that MCI be allowed to connect to AT&T's network and use local telephone companies' local access lines to reach customers. AT&T's response was to develop interconnection charges (later called access charges) that were prohibitively expensive for MCI. The FCC then ordered AT&T to develop lower interconnection charges and tariff the interconnection service so that it was available to any would-be competitors. (Bolter et. al 1984, Coll 1988)

Subsidies to Hinder Competition. During the development of competition in the 1970s, AT&T lobbied Congress to adopt legislation that would make competition to its network illegal. To garner political support from rural telephone companies, AT&T developed a revenue sharing plan, called the Ozark Plan, which in effect gave large portions of AT&T's interstate long distance revenues to rural telephone companies. The lobbying effort failed – no legislation was passed -- but the financial transfers to the rural telephone companies remained because they were embedded in the FCC's regulatory rules on how long distance revenues would be used to support costs of local networks. (Mueller 1993) These rules, called separations and settlements, were formally the FCC's rules, but were effectively overseen by both the FCC and the state utility regulators. The state regulators benefited from the payments to rural telephone companies because the transfers enabled state regulators to keep prices for local telephone service lower than they would have been otherwise. (Weinhaus and Oettinger 1988) For the next 25 years the rural local telephone companies and the state regulators worked to protect these cash flows: As a general rule, whenever regulatory policy changes, such as introducing additional competition, threatened to impact the transfer system, the changes would be delayed until a means was developed to ensure that the changes were "revenue neutral", meaning that they had little or no immediate financial impact on the rural telephone companies. This preference for revenue neutral changes complicated and slowed the development of competition, even in regions where customers would clearly benefit from it. (Weinhaus et. al 1992)

Breakup of AT&T. AT&T's attempts to stop competition, primarily its attempts to subsidize its equipment manufacturing arm, Western Electric, with revenue from its monopoly telephone services, led the U.S. Department of Justice in 1974 to re-open an earlier antitrust suit against the company. This anti-trust case resulted in a 1982 agreement, called the Modification of Final Judgment (MFJ), between the Department of Justice and AT&T. Under that agreement the company would divest its ownership in the Bell Operating Companies (BOCs), which were AT&T's local telephone companies, and which

controlled approximately 80% of the local telephone lines in the country, including those in almost all major cities. For its part AT&T would keep what were considered the fast-growing and potentially competitive portions of the business, the manufacturing component and long distance service.[5]

AT&T made some strategic mistakes in the breakup. AT&T voluntarily gave up its claims for cellular telephone to the BOCs, thinking that the technology did not have great promise. The DOJ had not asked AT&T to do this. Also, AT&T and most industry observers thought that manufacturing and long distance were the most promising parts of the business, so AT&T elected to keep those parts of the business rather than the local lines. The belief turned out to be false as the control over bottlenecks, namely the facilities and radio spectrum that all networks needed to access customers, proved to be the most important competitive advantage. It was the unanticipated advantage that the BOCs held. (Jamison and Sichter 2010)

Implementing the breakup of AT&T occupied the companies and the industry regulators for many years. They developed a system of access charges that would be the basic mechanism for keeping local telephone companies revenue neutral through the development of long distance competition. But the large cash payments from long distance companies to local telephone companies became a source of industry tension. (Jamison 1995) The long distance carriers tried to bypass the charges by directly connecting with large customers. (Bolter 1984) The strategic importance of having another network directly connect with large customers was not lost on the BOCs and they began pressing to be permitted to vertically integrate into providing long distance, something they were prohibited from doing by the MFJ. The tension revealed two fundamental flaws in the MFJ, namely the idea that local telephone service and long distance service were distinct services from a customer perspective and a business perspective (they were actually a construct of the original telephone technology and of regulation) and that local telephone access lines were inherently monopolistic. Neither belief was correct. (Jamison and Sichter 2010)

Telecommunications Act of 1996. Under intense lobbying by all industry players, Congress passed the Telecommunications Act of 1996 (1996 Act),[6] which effectively opened all telecommunications markets to competition (but with special protections for rural telephone companies), allowed the BOCs to provide long distance service after meeting certain criteria for opening

[5] In 1982, the Antitrust Division of the U.S. Department of Justice and AT&T agreed to enter into a consent decree to settle the government's antitrust suit against AT&T. This decree would, among other things, caused AT&T to divest its ownership of the Bell Operating Companies, through which AT&T owned local access facilities. See *United States v. Western Electric Co.*, 552 F. Supp. 131 (D.D.C. 1982) (*Modification of Final Judgment* or *MFJ), aff'd sub nom. Maryland v. United States,* 460 U.S. 1001 (1983) (approving MFJ); *United States v. AT&T*, 569 F. Supp. 1057 (D.D.C. 1983) *(Plan of Reorganization), aff'd sub nom. California v. United States*, 464 U.S. 1013 (1983) (approving Plan of Reorganization).

[6] Telecommunications Act of 1996, Public Law No. 104-104, 110 Stat. 56 (codified as amended in scattered sections of 15, 18, and 47 U.S.C.) [hereinafter 1996 Act].

their markets to competition, and established regimes for interconnection of rival local telephone networks. The regulators tried to maintain revenue neutrality for rural telephone companies.

Unfortunately, the provisions of the 1996 Act also failed to recognize that local and long distance were not distinct services. As a result, the regulatory, interconnection, and intercompany payment schemes that it established were outdated before they were even written. This situation gave cellular service, which was largely unregulated, a competitive advantage over wireline service, which was constricted by the antiquated legacy regulations. It also left the industry regulators with the task of trying to sustain a pricing and subsidy system that was unsustainable in any economic sense. The inclusion of universal service objectives in the Act contributed to the problem because they do not necessarily align with competitive objectives. The industry and its regulators continue to struggle with these deficiencies in the 1996 Act. (Jamison and Sichter 2010)

Industry Restructuring. Despite the 1996 Act's shortcomings, it did provide an opportunity to reorganize the industry, which had been locked into a structure that made sense in the early 1900s, but made no economic or technological sense by the 1970s. Following the 1996 Act, one of the BOCs, Southwestern Bell, which served areas from Texas to Missouri and Kansas, purchased three of its fellow BOCs. These included Ameritech, which served region north and to the east of Southwestern Bell, Pacific Telesis, which served California and Nevada; and BellSouth, which served the southeastern part of the U.S. In 2005 Southwestern Bell purchased AT&T, which was struggling with the decline of long distance as a distinct business, and took on the AT&T name. The other BOC, Bell Atlantic, purchased GTE and took on the name Verizon. Verizon then purchased the long distance company WorldCom (which had earlier purchased MCI), which was suffering from accounting fraud and the decline of long distance. The last remaining long distance company of any size, Sprint, which had been purchased by a local telephone company, United Telecom, broke itself up in 2006.

IV. Development of Broadband

The development of broadband followed several paths, which eventually converged. One path was the development of technologies that would lower the cost of providing long distance networking, including digital microwave and fiber optics. Another path was the advancement of digital computing technologies, which lowered the cost of computing and created an interest among large customers for high capacity lines that could transfer data, and the long distance technologies were adapted for this purpose.

Transmission Technologies. Coaxial cable, which was developed and used for both long distance telephony and video transmission, enabled the development of cable television in the United States. Cable television expanded rapidly because cable offered customers a greater choice of channels than over-the-air broadcasting (the FCC limited the number of television broadcast licenses), regulation was light, and financing was relatively easy given the liberalization of financial markets in the U.S. The cable industry provided the first broadband wireline into the home, although it was slow to exploit this first mover advantage because of its lack of technological expertise (the cable networks were essentially one-

way transmission lines). Moreover, the industry lacked a vision that went much beyond consolidation and the ownership of content. (Huber, Kellogg and Thorne 1992)

Impact of the Internet. As described above, the Internet was developing about the same time as the advancement in broadband-capable technologies and the development of the cable television industry. When NSF closed NSFNET, the commercial interests in the Internet took over and began exploiting its potential. The killer app appears to have been the World Wide Web, which was made accessible to non-technical consumers by the use of Internet browsers, such Netscape. However, companies such as America Online (AOL) and CompuServe also played key roles by making it easy for customers to have dialup Internet access and easy-to-use email. The declining cost of PCs increased their numbers in people's homes and at work, which in turn decreased consumers' incremental costs of using the Internet.

Applications. The growing customer use of the Internet, the increasing sophistication of web sites, the growing amount of content that was best used with broadband connections, the development of sophisticated search engines such as Google, and competition between telephone companies and cable television companies led customers to migrate from dialup to broadband, with fixed broadband initially being more dominant than mobile broadband.

V. Principles Shaping Co-Evolution of Institutions, Technology, and Economics

Table 2 highlights the interplay of changes in telecommunications. It groups events and actions into categories of shocks, policy/politics, demand conditions, strategic responses, and innovations. Only one event/action is considered a shock, namely the decline in technology costs. All other events/actions are endogenous, meaning that they arise within the system.

Figure 1 provides a chronological description of system dynamics, which emphasizes eras, the contexts of decision makers, and the pace of change. Table 1's views the industry in the framework of a value chain, which helps illustrate where changes emerge and how they might impact different industry players. It also illustrates how a value chain view can cause businesses to miss fundamental changes because it limits their vision. The view in Table 2 is that of cause and effect, recognizing that causes arise within the system and are often effects of earlier causes.

Principle 1. Technologies developed to accommodate a perceived need actually change the nature of the need by impacting entry and business models. Declining technology costs lowered costs of entry in networking and terminal equipment. Coupled with AT&T's monopoly culture of slow, incremental change, competition to satisfy unmet customer demand was inevitable as long as the government did not stand in the way and it was profitable for entrant companies to provide service.

Table 2. Summary of Shocks, Policy Changes, Demand Changes, Strategic Responses, and Innovations and their Consequences in Telecommunications

Category	Events or Actions	Consequences
Shocks	1. Decline in costs of technology, i.e., Moore's Law (1960s to present)	1. Lowered economic barriers to entry and to self supply
Policy/Politics	1. Hush-a-phone (1956) and Carterfone (1968) regulatory decisions	1. Allowed customers to provide own telephone equipment, which ended AT&T's end-to-end control of telecommunications
	2. Regulatory decisions opening of long distance to competition and requiring AT&T to interconnect with rivals (1970s)	2. Ended AT&T's terminal-to-terminal control of the network. Established that rivals could interconnect with AT&T.
	3. Break-up of AT&T (1984)	3. Antitrust court determined that regulation could not constrain AT&T's anticompetitive conduct, so forced divestiture of bottleneck facilities
	4. "Revenue neutral" became a policy criteria in regulatory decisions regarding access charges (fees paid by long distance companies to connect with local telephone companies) and changes in separations (process for allocating telephone company costs between federal and state jurisdictions) (1984-2011)	4. Established pricing for network interconnection. Established precedent for regulators to allow competition without disrupting local telephone companies' profits
	5. Telecom Act 1996 driven by conflict between local telephone companies and long distance companies (1996)	5. Established that all parts of the industry should be open to competition. Failed to address broadband.

Table 2. (cont.)

Demand Conditions	1. Cold War meant government wanted resilient telecommunications network for national defense (1960s) 2. Growth in computing meant customers wanted economical way to interconnect computers (1960s – 2010s) 3. Globalization (1950 to present)	1. AT&T wasn't interested, so government funded development of what became the Internet 2. Internet officially became commercial when National Science Foundation privatized its network access points (1995) 3. Growth in international traffic
Strategic Responses	1. TelPak: AT&T price discounts for large customers who were potential developers of private microwave systems (1960s) 2. AT&T and the Baby Bells seek to create legal barriers to entry (1960s – 1990s) 3. AT&T denies interconnection to rival equipment and rival networks (1960s – 1970s) 4. AT&T and Baby Bells attempt to make price of interconnection sufficiently high to foreclose competition (1970s – 1990s) 5. Telecom operators seek mergers in response to new industry economics and, maybe, to preempt competition (1990s to present)	1. Rivals to AT&T resold TelPak services to arbitrage price discounts. AT&T ceased offering TelPak. 2. Government agencies and legislative bodies slow to support the barriers and eventually side with the competitors 3. Government begins regulating interconnection 4. Government begins regulating price of interconnection 5. Government unable to adapt to new industry economics, so treats mergers with traditional tools. Nearly results in re-emergence of monopoly AT&T.

Table 2. (cont.)

	6. Telecom operators embrace wireless technology (1990s to present)	6. Allows operators to manage intermodal competition. Wireless service flourishes.
Innovations	1. Microwave technology for transmission (1950s)	1. Made it economical for MCI to develop long distance to compete with AT&T
	2. Digital technology (1970s – 1980s)	2. Decreased costs and increased functionality of telecommunications and computing equipment
	3. Fiber optic technology (1970s – 1990s)	3. Decreased costs of transporting large amounts of data and of transporting telecommunications long distances
	4. Cellular technology (1970s – 2000s)	4. Increased capacity of mobile telecommunications networks and improved functionality

Principle 2. Changes in industry structure, even those driven by technology change, alter incentives for technology change. AT&T's rivals had different cultures and business plans than AT&T and so saw opportunities to exploit technologies in new ways. Teleport arose in part because AT&T wasn't ready to deploy fiber optics for local access. Indeed, AT&T's incapacity at the time to deploy the technology led to its assistance to the City of New York in developing Teleport. Preoccupied with the antitrust lawsuit and internal issues, AT&T and its New York operating company, New York Telephone, simply failed to understand that the Teleport local access business model would be portable across almost all cities in the United States.

Principle 3. Incremental technology change is an inadequate response to new needs that are fundamentally different traditional services. The Internet was superior to ISDN as a technology for data. ISDN was designed to combine voice and data services on an incremental basis. From AT&T's perspective, ISDN was important because it would keep customers on the AT&T network while AT&T changed its network. However, ISDN was awkward for many customers and was in adequate for internetworking. ISDN is used today, but only for a few specialized purposes.

Principle 4. New technologies create unanticipated business opportunities. Cellular technologies were viewed by AT&T and the FCC as interesting, but not particularly important. Indeed AT&T initially was concerned that cellular technologies would compete with its wireline network and so declined to aggressively pursue the new technology. The apprehension turned out to be well founded, but the strategic response was mistaken because it missed an opportunity to develop a single system of both wireless and wireline technologies.

Principle 5. Vision is limited to the horizon, but fundamental changes often lie beyond it. AT&T's strategic responses to emerging competition – creating legal barriers, hindering interconnection, pursuing cross-subsidies and promoting price discrimination – may have worked if the emerging competition had not been a symptom of basic changes in telecommunications technologies, customer demand, and government philosophies. AT&T's tactics that made sense from the vantage point of history actually hastened change and made it more costly for AT&T to adapt to its new environment. Signals that fundamental change was coming include:

- **The players changed.** Signals for AT&T included companies like Motorola going before the FCC to secure radio spectrum for microwave transmission and the creation of Carterfone by a new company.
- **Customers wanted things that were not provided.** Signals for AT&T included customer interest in Carterfone, MCI's innovating pricing of private line, and the need to create Teleport.
- **The company found itself seeking government protection.** AT&T began its rearguard action with Hush-a-phone, Above 890, and Carterfone. AT&T and the BOCs continued seeking government protection from competition into the implementation of the 1996 Act.
- **Traditional actions began having unanticipated impacts.** Signals for AT&T included price discounts for large customers (Telpak) leading to business opportunities for rivals (resale by MCI) and the government proceeding to develop the Internet rather than waiting on AT&T to provide a solution to the government's networking needs.

Principle 6. New regulations created stakeholders, who then sought self-interested changes or resisted change. Strategic advantage gained through regulations sometimes became an albatross. The subsidy system that AT&T developed to build a coalition against competition in the 1970s became embedded in regulatory rules that have been slow to change because they benefit politically active stakeholders.

Principle 7. Governments may not keep their commitments. Government officials must stay in office to keep their promises, but they sometimes have to break promises to stay in office. AT&T thought it had a legally enforceable monopoly, but that was not specified in legislation and the government's interests changed over time. Similarly, the 1982 MFJ specified that BOCs could not provide long distance service until they could no longer leverage their local networks to harm long distance competition. This was impractical for any extended period of time, so the 1996 Act changed the rules.

VI. Conclusion

A business developing and executing its business strategy should view itself as playing a role in a dynamic, complex system of customers, rivals, government, suppliers, technologies, and the like, where the elements constantly interact and players come and go. Traditional models for business strategy, such as Porter (1980), treat these elements as exogenous to a company's strategic choices, but in practice there is little that is truly uninfluenced by a business's decisions, especially when the business is large and historically dominates its industry. Indeed, as AT&T learned, it is risky for a company if its business model is largely defined by government regulation: The government will sometimes hold fast to the status quo of business regulations even when changing conditions make the status quo largely unsustainable, and at other times quickly abandon traditions without allowances for the business to develop transitions.

Viewing a business as a player in a dynamic system highlights the importance of foreseeing fundamental change as resulting from strategic decisions. This paper presents this approach by examining government and industry using multiple approaches. It focuses primarily on technology and competition themes because they dominated telecommunications' evolution and so highlighted most of the connections. But a chronological perspective was also important because it illustrated the government and business relationships that made up AT&T's beliefs about its situation, beliefs that often proved incorrect. The action-consequences framework helped identify unanticipated outcomes, which were indicators that fundamental changes were occurring. An examination of the value chain highlighted how the changing nature of the value that customers obtain from the sector and how the industry was reorganizing to meet the new value proposition.

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