## Chapter 4

# Effects of Deregulation and Divestiture on Research

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## Findings

As a major source of information technology R&D—and as an organization that has recently undergone major legal, regulatory, and institutional changes-AT&T's Bell Laboratories merits special attention. In reviewing the potential effects of the AT&T divestiture and of recent regulatory decisions on Bell Labs, OTA made the following findings:

- Organizational changes within AT&T Technologies and within Bell Labs indicate that AT&T is already preparing to speed the development and marketing of new products. Other firms may also increase their development activities to meet competition from AT&T.
- The effects on the research side are less clear. AT&T has some incentives to continue funding applied and basic research at past levels, but these stand in tension with powerful new forces that could tempt AT&T to direct more resources away from research and into short-term research and development projects. There is little reason to think that AT&T's competitors will perform more basic research now than they have in the past.
- The areas where AT&T will be the most likely to focus its competitive efforts are also the areas where Bell Labs has been responsible for major scientific contributions computer science, solid-state physics, and photonics. Work in those areas, including basic research, is likely to continue into the foreseeable future.
- A significant portion of Bell Labs' research base has been moved to Bell Communications Research, Inc. (Bellcore), a unique new organization owned jointly by the divested Bell operating companies. Bellcore's role in basic research is still unclear.
- It is possible to monitor research activities over the next few years to determine whether the quality or direction of basic research change in a deregulated environment. Because of the long-term nature of the work, however, it may take some years for any changes to become evident.

The AT&T divestiture has been making headlines since January 1982, when AT&T and the Department of Justice announced the settlement of the Department long-standing antitrust suit. The divestiture marked the end of an era. Before divestiture, AT&T had been the nationwide provider of end-to-end telecommunications services. AT&T's system of Bell operating companies provided local service to 85 percent of the telephones in the United States; the Long Lines division carried the vast majority of long-distance calls; the Western Electric subsidiary manufactured most of the equipment used in the system and leased to end users. With assets of $150 billion and annual revenues of $69 billion, it was the biggest communications company in the world. On January 1, 1984, the size of the corporation was reduced to one-fourth as AT&T spun off the Bell operating companies and gave up local telephone service.

While divestiture is indeed a dramatic event, the concern and publicity associated with it have tended to obscure a related regulatory decision: the Federal Communications Commission's (FCC's) decision in the Second Computer Inquiry (Computer II) detariffed the sale of terminal equipment, deregulated enhanced telecommunication services, and permitted AT&T to sell these to end users through a subsidiary after Jan. 1, 1983.[1] These changes in AT&T's structure and markets have raised some important questions related to research and development in telecommunications. The question addressed here is how divestiture and deregulation will affect the functioning of AT&T's research arm, Bell Laboratories,

[1]"Enhanced communications" are services which require adding value to a transmission by altering the message in some way, as explained below.

viewed by some as the star of modern industrial and scientific research.

In 1982, before any of the changes associated with divestiture and compliance with Computer II, Bell Labs had a budget of $2 billion, facilities at 21 locations, and 25,000 employees-3,000 with doctorates and 5,000 with masters degrees. Bell Labs provided nearly all R&D leading to the manufacture of Western Electric's products, as well as systems engineering to support the Bell System generally. While the Labs' principal role is in developing products for sale or use by AT&T, about 10 percent of the budget has been dedicated to scientific research. The research has had fallout applications in a wide variety of fields, from telephony and computer science to astrophysics and health care. The research results and technical standards are widely published in scientific and technical journals. Bell Labs researchers have made many fundamental advances, inventing the transistor and other concepts at the base of the current generation of computer and telecommunication technology. Among Bell Labs' employees and alumni are seven Nobel laureates.

The Labs recently (1983) received its 20,000th patent; this amounts to one patent per day since Bell Labs was incorporated in 1925, and many other of its inventions have not been patented. Traditionally, about 99 percent of AT&T's R&D has been done internally. Very little technology has been bought from outside, although AT&T does enter into cross-

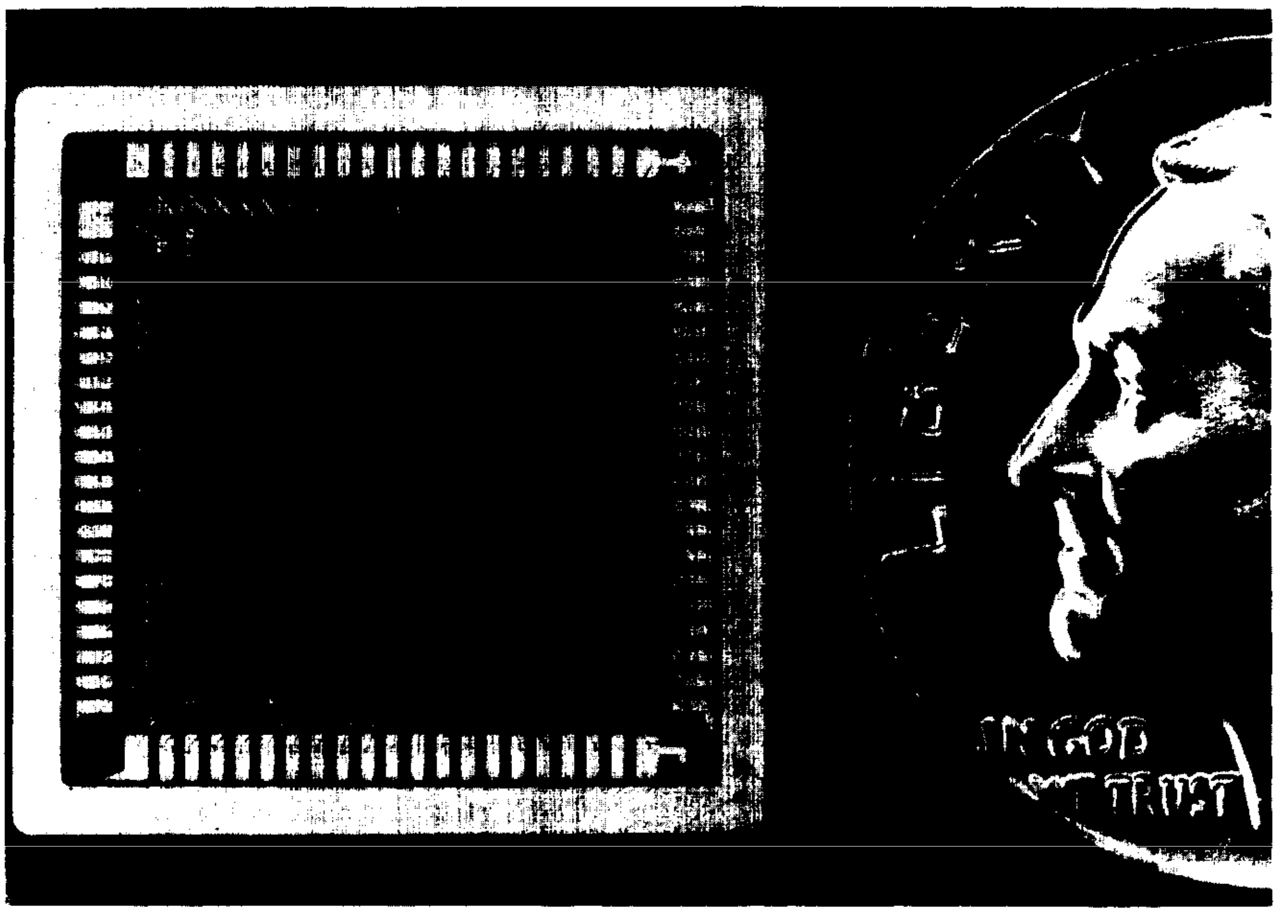


*Photo credit: AT&T Bell Laboratories*

Bell Labs developed the first 32 bit microprocessor: the dime-sized chip contains nearly 150,000 transistors and has processing power comparable to that of today's minicomputers.

licensing agreements. On the other hand, it had been AT&T's policy since the 1920s, and a legal requirement under the 1956 consent decree described below, to license its own patents to other firms at reasonable cost. There are currently over 400 such licensing agreements outstanding in the United States and 200 more with foreign firms. Arno Penzias, Bell Lab's Vice President, has been quoted as saying that "without Bell Labs there would be no Silicon Valley."[2]

Although that may be hyperbole, it is certainly true that Bell Labs holds the basic patents for the processes and products needed by many United States and foreign firms to get their start in microelectronics, computers, telecommunications, or other fields. The availability of licenses and technical information from Bell Labs greatly speeded development of the microelectronics industry.

Bell Labs' R&D efforts are clearly important to information technology generally. The Labs' budget makes up perhaps 15 percent of the R&D investment by information technology firms.[3] Further, if Bell Labs is producing over 370 patents per year, then it accounts for perhaps 5 percent of U.S. patents in information technology fields.[4] Anything that might reduce the scope or quality of research at Bell Labs alarms observers who see the Labs as a major contributor to the U.S. lead in information technology R&D.

The restructuring of AT&T creates pressures and incentives for Bell Labs that did not exist while AT&T was a regulated, end-to-end monopoly. Because of competitive pressures on AT&T in the deregulated markets, Bell Labs may choose to devote more of its resources to product development and to reduce the number of long-term research projects leading to fundamental scientific discoveries. Such an event could be deleterious to the long-run competitive position of AT&T, and more importantly, might negatively affect the level of U.S. R&D in information technology.

This chapter discusses the problems and opportunities that the new post-divestiture environment offers Bell Labs, and the possible effects that the changes in AT&T's corporate structure may have on research at the Labs, and throughout the telecommunication and computer industry. It focuses specifically on the future stability of AT&T's earnings, its incentives to engage in research, and the possible effects of deregulation on research elsewhere in the telecommunications and computer industry. Finally, it outlines some methods for monitoring the health of research at Bell Labs and possible options for Federal Government action.

Before examining the effects on Bell Labs, it is necessary to briefly review the regulatory and legal decisions leading to deregulation and divestiture and to discuss the technological and market forces that drove them.

[2] "Bell Labs, Threatened Star of US Research," *Fortune*, July 5, 1982, p. 47.

[3] See page 316. Investment in information technology by industry in 1983 is estimated to be about $10.8 billion. Bell Labs' R&D budget of $2 billion is about 18 percent of the $10.8 billion invested in IT R&D by large IT companies in 1982. However, the $10.8 billion figure may be too low, as it does not include R&D expenditures of many small firms.

[4] This is an estimate based on approximately 5,180 Bell Labs patents as a fraction of 101,900 US patents in communications equipment and electronic components in 1963-1981. Data on U.S. patents from National Science Board, *Science Indicators, 1982*, U.S. Government Printing Office, 1983, p. 207.

# Antitrust Laws, Deregulation, and Divestiture

American Telephone and Telegraph is no stranger to antitrust litigation. In order to avoid a threatened Government suit under the Sherman Antitrust Act in 1913, AT&T entered into negotiations with the U.S. Attorney General that resulted in the Kingsbury commitment. In the commitment, AT&T agreed: 1) to end its policy of aggressive mergers with competing independent telephone companies; 2) to allow the remaining independents to interconnect with its long-distance system; and 3) to get out of the telegraph business by divesting itself of the Western Union telegraph company.[5] It removed AT&T from the telegraphy market and significantly constrained future purchases of competing telephone companies.

However, the actual effect of the Kingsbury commitment was to confirm AT&T as a regulated monopoly and to quell the competition between Bell operating companies and independents which had grown up in the 1895-1913 period. Under terms of the commitment, Bell companies and independents negotiated the borders of their service areas and exchanged telephones where necessary to give each other geographical monopolies. AT&T was acknowledged to control the entire long-distance network, and the independents used that network as noncompeting partners in end-to-end service.

The next major antitrust case against AT&T, in 1949, asked for an end to AT&T's ownership of Western Electric and an end to all restrictive agreements among AT&T, the Bell Operating Companies, and Western Electric. The suit essentially sought the separation of regulated monopoly services from equipment supply.

A negotiated settlement of the 1949 suit led to a consent decree in January 1956. The consent decree imposed two important restrictions on AT&T's future activities. First, AT&T was restrained from entering other lines of business, such as the sale of solid-state components or computers. It was restricted to providing regulated common carrier service, with Western Electric as its captive equipment manufacturer. AT&T was free to develop Bell Labs technology, such as the transistor, for use within its own system, but was forbidden to market these products to the public. Second, AT&T was required to license all patents controlled by the Bell System to any applicant at a "reasonable royalty" and to provide technical information along with patent licenses on payment of reasonable fees. This licensing provision ensured that other firms could use Bell technology outside of regulated telephone markets.[6]

Two major trends, each with a technological and a regulatory component, developed over the ensuing 25 years to make the line of business restriction of the 1956 consent decree increasingly unworkable. First was the development of technological alternatives in transmission and switching that greatly reduced the cost of providing long-distance service and made it economically attractive for competitors to challenge AT&T's dominance of the long-distance market. Second was the advance in computer microelectronics, which has been leading to a convergence and interdependence of communication and computation services. These technological changes, and the market activity that they generated, led to a number of regulatory decisions that eroded AT&T's monopoly position and gradually opened the telecommunication transmission and equipment markets to competition.

The first chink in the long-distance monopoly was FCC's 1959 *Above* 890 decision,[7] opening the microwave radio spectrum to private users. This led eventually to FCC's approval, in 1969 and again in 1971, of MCI's application for authorization to offer private line service via microwave. It was also in 1971 that the FCC made its *Specialized Common Carrier* decision,[8] in which it concluded that a general policy in favor of entry by new carriers into specialized communications would serve the public interest. Long-distance service from "other common carriers" became more widely available to the public in 1979 after a series of FCC and court decisions. By the end of 1984, other carriers had captured 15 to 20 per-

[5] Gerald W. Brock, *The Telecommunications Industry: The Dynamics of Market Structure* (Cambridge: Harvard University Press, 1981), p. 155.

[6] AT&T had been granting licenses and making available technical information on its inventions before 1956. AT&T had developed cross-licensing agreement with major manufacturers like General Electric over the previous two decades. The policy of licensing patents to smaller firms was in force in the 1940s.

[7] 27 FCC (1959).

[8] 29 FCC 2nd 8 70 (1971).

cent of the long-distance market, as measured by minutes of calls transmitted.[9] Other carriers can now claim relatively small numbers of subscribers, but they are principally the high volume users. AT&T estimates that other carriers serve about one-third of the highest volume residential callers (those spending over $25 per month) and one-half of high volume business callers (over $150 per month).*

In the terminal equipment market, the FCC's 1968 decision in the Carterphone case[10] was the first FCC action to allow consumer-owned terminal equipment to be attached to the Bell system network. This decision, together with an equipment registration program authorized by FCC in the 1970s, allowed manufacturers other than Western Electric to enter the U.S. market, giving rise to the "interconnect" market for telephones and other customer equipment.

Meanwhile, the computer industry was growing rapidly and without significant government regulation. In order to determine how best to deal with the policy questions that were already emerging from remote-access data processing, FCC initiated in 1966 its first *Inquiry into Regulatory and Policy Problems Presented by the Interdependence of Computer and Communication Services and Facilities* (Computer I Inquiry). The decision in Computer I, adopted in 1970, divided computer/communications services into two regulated services—pure communications and hybrid communications-and two nonregulated services—hybrid data processing and pure data processing. Under the terms of the 1956 Consent Decree, AT&T could provide pure and hybrid communications but could not provide any service or product that fell into the data processing categories.

Throughout the 1960s and 1970s, AT&T had been manufacturing and selling terminals for access to mainframe computers. These were primarily built by the Teletype Corporation, a subsidiary of Western Electric. Early terminals were clearly communication devices—they were only of use for sending information to a remote computer for processing. As microelectronics advanced, however, more intelligence and power could be placed in terminals. It became increasingly difficult to determine at what point a terminal ceased to be a "hybrid communications" device and became a "hybrid data processing" device.

AT&T's applications to the FCC for permission to market new terminal equipment were sometimes challenged as being in violation of Computer I rules and the consent decree. " Further, AT&T was at a competitive disadvantage because it had to go through a (sometimes lengthy) regulatory process before introducing each new product, whereas the unregulated terminal suppliers (computer manufacturers) could introduce new products whenever, at whatever price, they chose. It was clear that the combination of Computer I rules, the consent decree, and the evolution of technology were preventing AT&T from offering state-of-the-art terminal equipment to the public.

FCC initiated its second inquiry, Computer II, in 1976 and issued a decision in 1980. That decision deregulated the sale of terminal equipment, both voice and data, and allowed

*FAA estimate, private communication, February 1985.

[9] AT&T Communications briefing to OTA staff, August 17, 1984.

[10] See 13 FCC 2d, 420, 437 (1968). "Terminal equipment" or "customer premises equipment" terminates the telephone wire on the customer's premises. The most common example is the ordinary telephone. The terms are also used to refer to systems of telephones, like the six button "key sets" used by many small businesses, and to switching equipment, like the private branch exchanges (PBX) used to route calls inside large businesses. Modems (modulators-demodulators that convert analog signals to digital signals) interface between the telephone wire and a computer and are considered terminal equipment, as are computer terminals with built-in modems.

[11] For example, AT&T's request for a tariff to sell the Dataspeed 40/4 was denied by FCC's Common Carrier Bureau in December 1976. IBM and others objected that the terminal would be in direct competition with terminals built by computer manufacturers, and the Common Carrier Bureau agreed that the terminal's storage and processing capabilities (designed to allow an operator to correct mistakes before sending data to the computer) violated FCC rules. The full Commission overturned this decision 9 months later. In its decision the Commission noted that the Computer I rules were inadequate to deal with the changing technology and that Computer II Inquiry then beginning would establish a new policy. See FCC Transmittal No. 12449, 1977.

AT&T to offer this equipment for sale to the public through a subsidiary. Computer II also allowed AT&T to offer other enhanced telecommunication services through a subsidiary.[12] AT&T created that subsidiary, AT&T Information Services or ATTIS (originally called American Bell), in June 1982.

## Divestiture

Meanwhile, the Department of Justice brought an antitrust suit against AT&T in 1974, seeking many of the same goals as in 1949. The suit alleged that AT&T monopolized the manufacturing, long-distance, and local service markets; that it used its monopoly power in each market to strengthen its power in the other markets; and that it attempted to prevent competing equipment manufacturers and long-distance carriers from gaining access to the local networks. In January 1982, Department of Justice announced that it had reached agreement with AT&T on changes to the 1956 consent decree and in August 1982, Judge Harold H. Greene of the U.S. District Court for the District of Columbia approved the Modified Final Judgment. The Government's case was dismissed upon acceptance of the terms of the Modified Final Judgment by all parties.

Under the Modified Final Judgment, local Bell operating companies providing local exchange telephone services were divested by AT&T, and spun off into seven regional holding companies. AT&T retained ownership of a nationwide intercity network composed of its Long Lines division and the intercity facilities of the Bell operating companies, and continued to own Bell Laboratories and Western Electric. The Modified Final Judgment allowed AT&T to enter computer, computer-related, and information services markets in competition with unregulated firms (although there are still restrictions on AT&T's actions; e.g., AT&T may not provide information services over its own lines for 7 years).

The breakup, according to Judge Greene, reduces AT&T's ability to rely on its monopoly at the local exchange to exact competitive advantage in interexchange (long-distance), terminal equipment, and computer services markets. AT&T's long-distance market is still regulated, but FCC regulation was not viewed by the court as so extensive, nor were barriers to entry seen as so high, that AT&T will be able to use its currently large share in this market to provide a competitive advantage in unregulated segments of the industry.

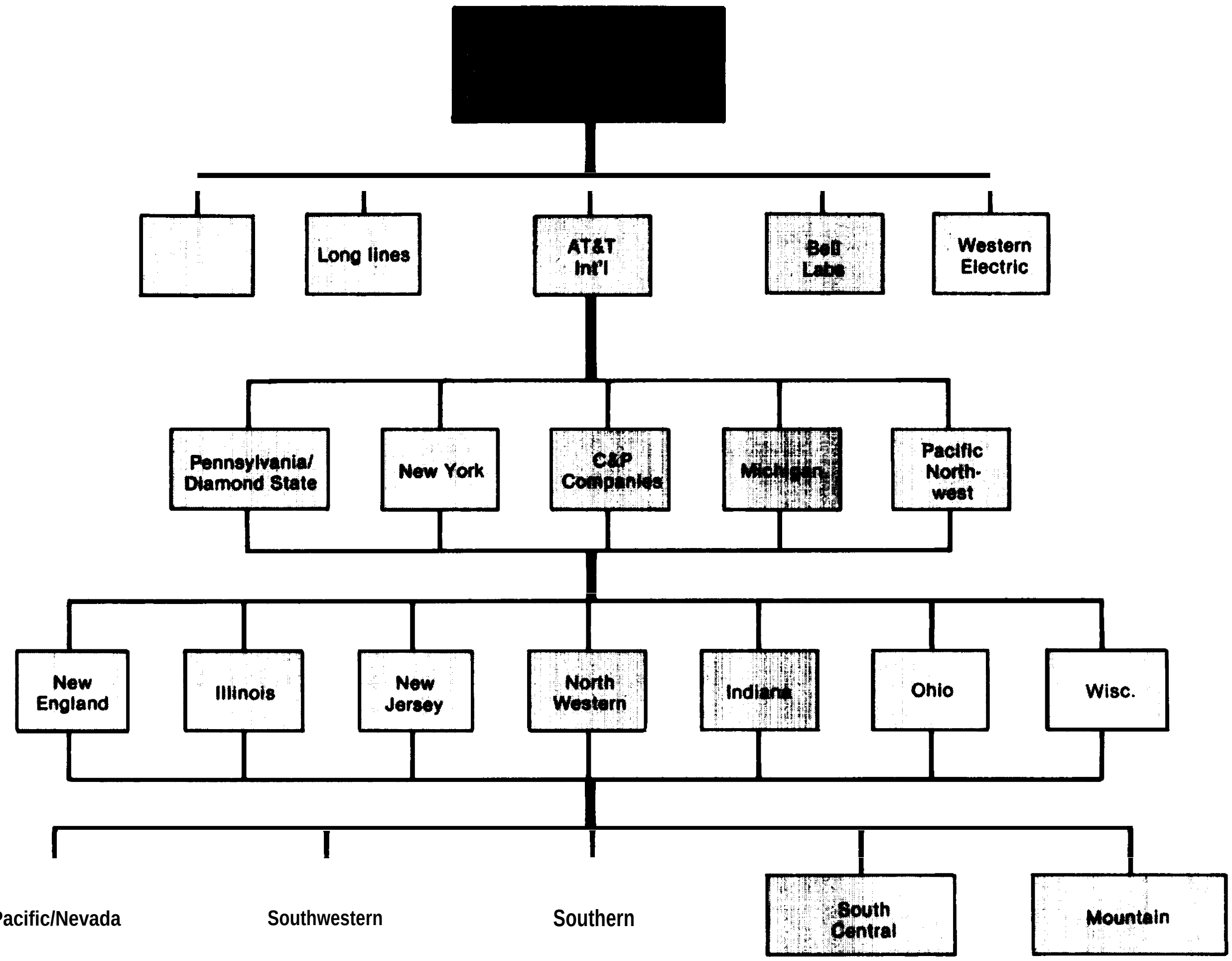
Figures 16 and 17 compare the predivestiture and post-divestiture organizational structure of AT&T and the Bell operating companies. Before divestiture the entire Bell system existed under a single corporate umbrella and the firm was organized to provide end-to-end telephone service. The Long Lines division provided interstate long-distance services; Western Electric manufactured equipment for use throughout the system; the 22 wholly owned Bell operating companies provided local and intrastate service; a small international division marketed AT&T equipment abroad. Bell Labs provided design and development for Western Electric as well as research and network system engineering for the rest of the system. The AT&T Information Systems subsidiary was created in 1982 in response to the Computer II decision.

As figure 17 shows, AT&T after divestiture is primarily comprised of AT&T Communications, AT&T Technologies, AT&T International, and the subsidiary, AT&T Information Systems. AT&T Communications provides long-distance service between local calling areas.[13] AT&T Technologies includes the functions of Western Electric and Bell Labs. It now provides research and development, man-

[12] In its *Second Computer Inquiry* decision, the FCC distinguished between basic and enhanced services. Basic services were defined to be the transmission of information, while enhanced services involved adding value to transmission by changing or acting on the message itself in some way. As an example, in voice traffic, a simple long-distance telephone call constitutes basic service. Enhanced service would be provided if the carrier stores and forwards calls or provides recorded messages for those who are calling. An enhanced data service might be one that provides protocol conversion so that non-compatible computers can communicate.

[13] LATA—Local Access and Transport Area-is the term now used to identify a local calling area.

**Figure 16.—Pre.Divestiture Bell System[a]**




[a]All entitles report to AT&T

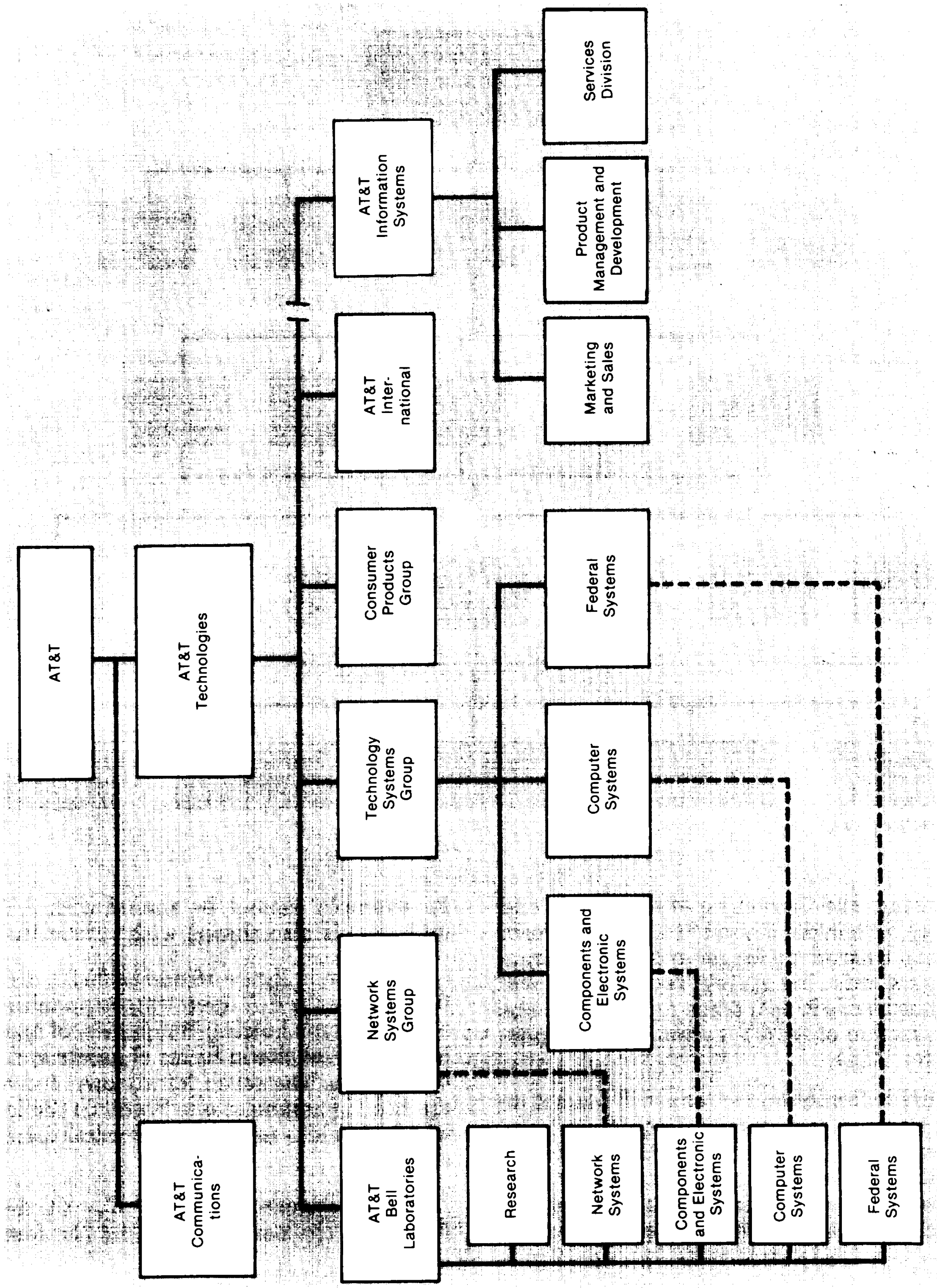
ufacturing, and marketing of equipment and services both in the United States and abroad. Western Electric no longer exists as an organizational unit, but AT&T Technologies will continue to use it as a trade name. Bell Labs is the section of AT&T Technologies responsible for R&D.

AT&T Information Systems will market information services, terminal equipment and computers to end users. Dealings between ATTIS and the other AT&T entities, under rules of Computer II, must be at arm's length. Information related to AT&T's customer base, for example, cannot be shared with ATTIS (unless it is also shared with competitors).

As shown in figure 18 and table 23, divestiture places the Bell operating companies into seven regional holding companies, of approximately equal size in terms of assets and customer base. The seven jointly own and operate Bell Communications Research (Bellcore), which provides technical and administrative services.

Judge Greene ruled shortly after the divestiture that the name "Bell" and the familiar

Figure 17.—Post-Divestiture Organization of AT&T




SOURCE: Adapted from AT&T, April 1984.

**Figure 18.-Bell Operating Companies[a]**

The seven regional Bell operating companies

1 Nynex
New England Telephone
New York Telephone

2 Bell Atlantic
C&P Telephone (4 companies)
Diamond State Telephone
New Jersey Bell
Bell of Pennsylvania

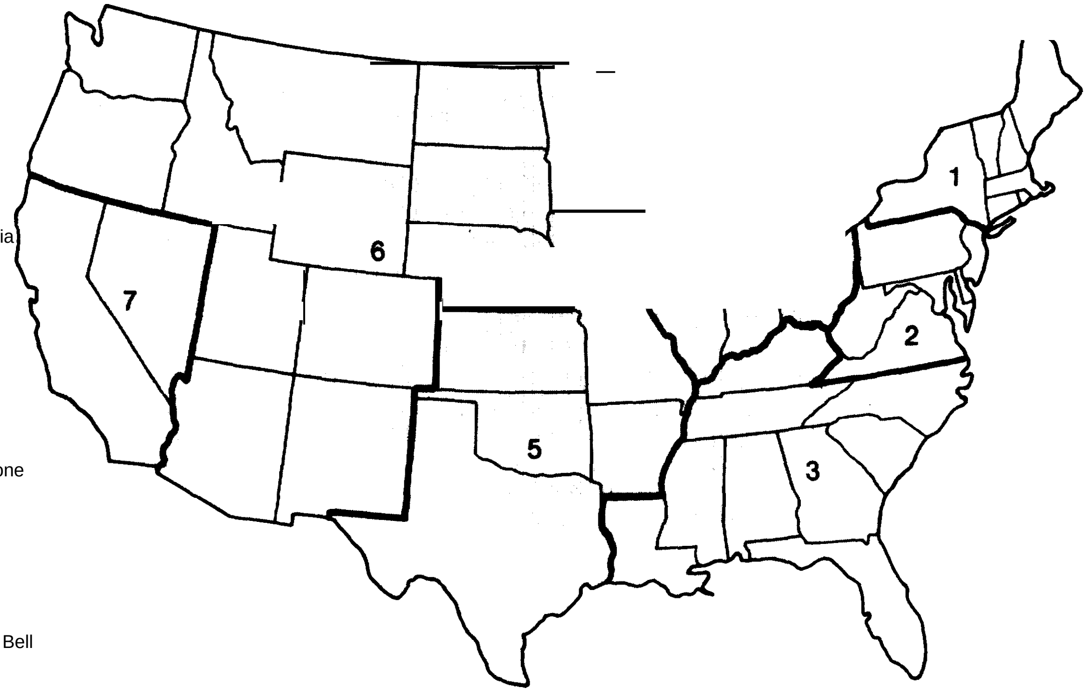
3 Bellsouth
Southern Bell
South Central Bell

4 Ameritech
Illinois Bell
Indiana Bell
Michigan Bell
Ohio Bell
Wisconsin Telephone

5 Southwestern Bell
Southwestern Bell

6 U.S. West
Mountain Bell
Northwestern Bell
Pacific Northwest Bell

7 Pacific Telesis
Paclflc Telephone
Nevada Bell




a The regional Bell operating companies are holding companies for Bell operating companies that offer service in the States indicated above Within most States local telephone service is also provided by Independent telephone companies

SOURCE: AT&T.

**Table 23.—Regional Bell Operating Companies**

| Regions | Total operating revenue (millions) | 1984 assets (billions) | Net income (millions) | Value of embedded plant (millions) | Access lines (thousands) |
|---|---|---|---|---|---|
| Ameritech . . . . . . . . . . . . . . . . . | 8,900 | 16,26 | 1,037.1 | 14,409 | 13,970 |
| Bell Atlantic. . . . . . . . . . . . . . . . | 8,732 | 16.26 | 1,054.5 | 14,596 | 14,011 |
| Bell South . . . . . . . . . . . . . . . . . | 10,512 | 20.81 | 1,393.1 | 19,081 | 13,367 |
| NYNEX . . . . . . . . . . . . . . . . . . . | 10,006 | 17.39 | 1,029.8 | 15,186 | 12,658 |
| Pacific Telesis. . . . . . . . . . . . . . | 7,895 | 16.19 | 977.1 | 14,493 | 10,717 |
| Southwestern Bell . . . . . . . . . . | 8,859 | 15.51 | 887.9 | 14,112 | 10,189 |
| U.S. West . . . . . . . . . . . . . . . . . | 7,596 | 15.05 | 910.9 | 13,767 | 10,381 |

SOURCE: Bell Communications Research, Inc., November 1984.

38-802 0 - 85 - 9

logo are the property of the Bell system–that is, the Bell operating companies. AT&T may not use the name or logo in the United States, although AT&T International may use it abroad. The one exception to this ruling was that the name of Bell Laboratories did not have to be changed, although it is now called AT&T Bell Laboratories.

## Management of Research at AT&T

Bell Labs was named and incorporated in 1925, but it grew out of an in-house research capability which AT&T had maintained since 1907. AT&T was a groundbreaker in bringing R&D out of the homes and private laboratories of individual inventors and into the industrial context. In many ways, research at AT&T was a model for the modern industrial lab as it developed in other industries.

Most of Bell Labs' resources have been devoted to design and development of products for sale or use in the Bell system. However, about 10 percent has traditionally been devoted to research. "Research" at Bell Labs encompasses those projects for which no specific, short-term benefit to the corporation is foreseen. Most of the research is applied or directed systematically toward the solution of particular problems, but some resources have been devoted to basic research, sometimes leading to major scientific advances.

Before divestiture, Bell Labs' work was supported by the other AT&T entities. In 1982, and typically in the predivestiture era, about half of the Labs' support (54 percent) came from Western Electric, to cover costs of specific design and development.[14] In addition, Western paid another 3 percent to support work on products being developed under Government contract. Another 11 percent came from Bell operating companies to pay for centralized development of computer information systems.

The remaining 32 percent of Bell Labs budget was paid by AT&T for research and systems engineering. The majority of the funds used for research and system engineering came to AT&T from the Bell operating companies under the "license contract." The contract was an arrangement under which the operating companies were assessed up to 2.5 percent of their annual revenues to pay for their use of AT&T technical and administrative services. About 30 percent of these funds, together with a contribution from the Long Lines division, were allocated to research.

Funding of research at Bell Labs was analogous to some of today's attempts at joint research funding, such as Microelectronics and Computer Technology Corporation (MCC) or Semiconductor Research Corporation (SRC).[15] The operating companies were, in a sense, separate user companies that contributed to the support of a central research facility for mutual benefit. The difference in this case was that the operating companies all existed under a single corporate umbrella, so that they had little control over how their contributions were spent and no option of withdrawing from the joint funding venture or establishing other arrangements.

A number of factors in the "climate" of Bell Labs have been cited as contributing to its achievements in fundamental research. Some have pointed out that Bell Labs scientists had access to state-of-the-art equipment, and were free to focus on their research without the responsibilities of teaching or serving on committees that would be required in a university setting. Because of job security and the stability of funding, there was no need for researchers to spend time pursuing grant support.

[14] Figures from Charles River Associates, *Impacts of the AT&T divestiture on Innovative Behavior,* unpublished paper prepared for OTA, 1983, p. 17.

[15] For a description of these joint research ventures, see ch. 6.

There has been a tradition of staff interactions across disciplinary boundaries. Bell Labs maintained an open publication policy-its researchers have published about 2,000 papers per year. With these advantages, Bell Labs was able to attract outstanding scientists and engineers to work in its research organization.[16]

### The Modified Final Judgment and Bell Laboratories

In his opinion on the Modified Final Judgment, Judge Greene commented on the proposal that Western Electric and the Bell Laboratories be divested from AT&T. He noted that the success of the Bell Laboratories in basic and applied research (and the beneficial impact of that research on the Nation's economic position) was due to its relationship with the operating companies and the Long Lines division. He argued that continued association of the Labs with the AT&T entities providing manufacturing and long-distance services would supply "the practical experience that would be useful in stimulating the research operations. "[17]

The possibility of negative effects on research at Bell Labs was considered in the negotiations leading to divestiture, but was not considered a matter of highest priority. Chessler,[18] in summarizing the position of Government negotiators, indicates that they accepted the possibility that divestiture might lead to a reduction in basic research activities:

> The competitive era in station equipment, interexchange communications, and information services under the [MFJ] will bring forth a great blossoming of progress in those areas of telephony. It was the thought of the framers . . . that the blossoming will be so great as to more than compensate for the loss of pure research at Bell Telephone Laboratories, and the reduced incentives for innovation at the Bell operating companies.

Judge Greene did not believe that incentives for innovation were being sacrificed or that divestiture per se would hurt the quality of service provided by the operating companies or the research performed by of Bell Laboratories. He noted-that the largest potential customers of Western Electric will be the divested operating companies, hence, Western Electric's association with Bell Laboratories should provide an incentive to improve equipment and technology.[19]

The Modified Final Judgment sets aside the 1956 Consent Decree and the requirement that AT&T grant nonexclusive licenses for its patents to any applicant. The elimination of this requirement makes it easier for Bell Labs to appropriate the potential benefit of new breakthroughs, and therefore might be considered an incentive to research. AT&T may now grant or deny licenses as it chooses, and may change whatever royalty it chooses. Before divestiture, when revenues from local exchange ratepayers were supporting Bell Labs' research, it made sense to require AT&T to share the fruits of its monopoly financing with others, according to Judge Greene. With the divestiture of the-operating companies and the termination of the license contract fee payments, this rationale for required licensing is eliminated. Judge Greene also believed that the advance of technology and the dispersion of knowledge related to telecommunications technology has reduced the dependence of established domestic firms and foreign competitors on information from Bell Laboratories.[20]

The Modified Final Judgment requires that AT&T grant licenses to the divested operating com-panics on all existing patents and all patents issued for a period of 5 years following approval of the Modified Final Judgment. AT&T is also required to provide the operating companies with nonpatentable technical information that has been funded by the license contracts. The operating companies will have the right to sublicense AT&T patents and technic-d information to those providing them with goods and services.

[16] OTA, notes on interview with workshop participants.
[17] *Opinion and Order,* Aug. 11, 1982, p. 62.
[18] Cited in "Bell Labs on the Brink, " *Science,* Sept. 23, 1983.
[19] Charles River Associates, "Impacts," p. 43.
[20] Ibid.

## Bell Labs After Divestiture

The most noticeable change resulting from Computer II and divestiture is a reduction in Bell Labs' size. About 4,000 employees became part of AT&T Information Services (ATTIS). FCC has interpreted the Computer II ruling that ATTIS and Bell Labs deal at arm's length to mean that ATTIS employees must be kept separated from former Bell Labs colleagues, even though they are sometimes located in the same buildings. Another 3,000 Bell Labs employees went to the newly created Bell Communications Research Inc. (Bellcore, formerly the Central Services Organization) of the Bell operating companies. This leaves Bell Labs with about 18,000 employees, returning it to approximately the size it was in 1978.

Organizational changes taking place elsewhere in AT&T Technologies will also affect Bell Labs. In 1983, AT&T Technologies was organized into "line of business" divisions defined by customer and product type. Within Bell Labs, development teams have been reorganized along the same line of business categories in order to facilitate cooperation with manufacturing.[21] Authority for managing design and development of products within Bell Labs was given to executives running each line of business division, as shown by the dotted lines in figure 17.

This is a major departure from previous AT&T policy wherein Bell Labs, Western Electric, and AT&T shared this authority; unlike practice at most firms, the old arrangement gave Bell Labs some control over a product even after it went into production. The new arrangement was chosen to make development more responsive to the needs of marketing and manufacturing, and is a preparation to enter competitive markets. Although the organizational structure is new, it marks the continuation of a trend which began when the market for large private branch exchanges (PBXs)[22] became competitive after 1968. Shortly thereafter, nearly all Bell Labs personnel working on PBXs were collected in one Colorado Lab facility near the Western Electric facility where PBXs were manufactured.

Figure 17 also shows that research at Bell Labs remains independent from the lines of business in AT&T Technologies. However, sources in Bell Labs note that research is undergoing review and changes as a result of deregulation and divestiture. The loss of research personnel to ATTIS and Bellcore caused some realignment of research projects. Some other areas of research-for example, regulatory economics and social psychology-have been judged unproductive or inappropriate and have been cut back. New research topics, such as robotics, are being undertaken.

A major change to Bell Labs' funding since divestiture is the termination of the license contract revenues from the local operating companies, funds that were specifically dedicated to research and system engineering. Under the current funding arrangements, research is supported by AT&T Headquarters with funds provided by the AT&T companies under a "composite allocator. " AT&T entities will be assessed for Bell Labs research (as well as administrative functions of AT&T Headquarters) according to their size, number of employees, and revenues. The allocation formula, under the Computer II rules, must be reviewed and approved by FCC to ensure that AT&T allocates a reasonable portion of research costs to the unregulated portion of its business and does not subsidize it from regulated long distance revenues.[23]

Another major change for Bell Labs will be an increase in the work done on military projects. AT&T Technologies is planning to increase the number of defense contracts, and the design and development work will be done in Bell Labs. Although defense contracts were once very important to Bell Labs, they had been reduced to a minor part of the R&D budget during the 1970s. In 1971, Bell Labs derived 30 percent of its income from defense-related

[21] Bro Uttal, "Cold New World," *Fortune*, June 27, 1983, P. 83.

[22] Private Branch Exchange is a generic term for the switch used on the customer premises for routing calls within a building or organization.

[23] See FCC 83-600, Dec. 22, 1983 and FCC 83-123, Mar. 31, 1983.

work; by 1976 the share was down to 2 percent and in 1983 about 3 percent.[24]

Growth of defense projects to an expected 10 percent of Bell Labs' budget should not be difficult. Based on its previous work, AT&T has strong ties with the Pentagon and a good reputation for designing and building the kinds of large complex systems that the Department of Defense wants. As Solomon J. Buchsbaum, executive vice president for consumer systems, points out, "The military side of government is a voracious eater of new technology, and we are good at [providing] that."[25]

[24]Marilyn A. Harris, "Bell Labs Looks to Military Research," *Electronics*, Feb. 9, 1984.

[25]"Bell Labs: The Threatened Star of U.S. Research," *Business Week*, July 5, 1982, p. 49.

# Factors Affecting Research

All the changes taking place in AT&T's mission, markets, and corporate structure cannot but affect the activities of AT&T Bell Labs. The purpose of the Labs has always been to provide research, systems engineering, and product design to support the corporate activities of AT&T. As those activities have evolved, the role of the Labs has also changed. Of particular concern to many observers is the way in which deregulation and divestiture might cause changes in the commitment *to research*, particularly basic research, within Bell Labs.

Several concerns have been voiced. Will AT&T, as a smaller corporation with a narrower revenue base, be able to support research as it has in the past? What incentives does AT&T have to allocate funds to research, and how strong are they compared to incentives to allocate more resources to development of competitive products? How will changes related to divestiture and deregulation affect research at other firms in the telecommunication and computer industries? Could a reduction in the level of research at Bell Labs have a negative effect on U.S. research generally, and if so, what can be done about it? The remainder of this chapter addresses these questions.

## Stability of Earnings

The future funding of research at Bell Labs will depend, at least in part, on AT&T's success in the market. The combination of divestiture and deregulation leave AT&T a smaller firm. While the predivestiture AT&T had a book value of $150 billion, the new AT&T has assets of only about $34 billion. However, the new AT&T is expected to have a much more favorable ratio of revenues to assets. Annual revenues are now expected to be on the order of $57 billion, compared with $69 billion for the predivestiture firm. This is largely because AT&T will continue to provide long-distance service, which has traditionally been very profitable and is estimated to provide two-thirds of the corporation's profit base.[26] Also, AT&T will continue to manufacture telecommunications equipment. Further, AT&T now has the opportunity to expand into potentially profitable computer-related markets.

While competitive computer markets are potentially profitable, they are also notable for their volatility over the past few years: new firms and new products have had meteoric successes and catastrophic failures. This kind of market may be dangerous for a firm which is unaccustomed to competition. AT&T has not been particularly successful in markets where it has been open to competition in the past. After 1976, when customers were permitted to purchase their own private branch exchange (PBX) switching equipment from other manufacturers, AT&T's market share fell sharply. Although AT&T is still the largest single manufacturer, it now has 24 percent of U.S. sales,

[26]Peter Hall, "AT&T and the Great Divide," *Financial World*, Jan. 10, 1984.

compared to 100 percent 8 years ago. Major competitors, specifically, Northern Telecom, Rolm, and Mitel have shares of 16,14, and 11 percent, respectively .27

This loss of market share is due at least partly to AT&T's higher prices and relative slowness in bringing new products to market. Both these tendencies could be major disadvantages in industries that are noted for rapid introduction of new products and rapid obsolescence of old ones. In part, slowness in bringing products to market was related to the regulatory process-a situation that has been eased since Computer II, but not eliminated.

AT&T has traditionally designed and manufactured its products to extremely high standards; they were expected to be highly reliable with a long useful life. Such a strategy made sense when AT&T was the owner of a huge nationwide network of transmission and terminal equipment that had to be depreciated over 20 to 40 years. The higher costs of conservative design *were* made up by a long production run. Western Electric maintained a price advantage over some other manufacturers by producing large numbers of standard products over many years.

Western Electric has often been at a cost disadvantage, however, in the case of newer electronic products, the very ones that are the target of the competitive market. Small digital PBXs for example, cost Western about 75 percent more to manufacture than those made by their lowest cost competitor, Mitel.[28]

AT&T has made a concerted effort to streamline its manufacturing and to reduce costs. AT&T Technologies is reducing its work force, and several former Western Electric factories have been closed down or cut back. Although AT&T did not sell integrated circuits and other electronic components to the public, it is the Nation's 12th largest manufacturer. AT&T Technologies is now expanding that manufacturing capability, including construction of a new plant in Florida to make lower cost chips for use in computers and switches.

AT&T Technologies will continue to be a major manufacturer of telecommunication transmission equipment, large central office switches, and terminal equipment. Potential customers include Bell operating companies, independent telephone companies, and telecommunications agencies abroad.[29]

In addition, AT&T is now free to sell products it developed but could not market to the public under the 1956 consent decree. It can now market computers based on the UNIX operating system, the 256 K-byte memory chip, and the 32-bit processor, all developed at Bell Labs. Its 3B computer series will offer a range of computers of varying size and capability.

For the first time, AT&T is acquiring some of its new products, marketing talent, and distribution channels through other firms. For example, AT&T acquired a 25 percent interest in Italy's Olivetti Co. at a cost of about $260 million.[30] Olivetti is Europe's largest word processor and computer manufacturer. The agreement is expected not only to supply AT&T with Olivetti office equipment for the U.S. market, but also to provide a European distribution system for AT&T products. AT&T has also entered a joint venture with a Netherlands electronics firm, Philips, to manufacture central office switching equipment for Europe. AT&T has also made agreements with a number of smaller US. office computer manufacturers for development of new office automation equipment.

At the same time, and equally importantly, AT&T is developing its own marketing capability. Before divestiture, Western Electric was strictly a manufacturer and dedicated very few resources to marketing. One observer notes that a competitor, Northern Telecom, spends about 9 percent of manufacturing sales on marketing while Western Electric spent

[27]Northern Business Information, Inc., as cited in "ITT's Big Gamble" Business *Week*, Oct. 22, 1984.

[28]Northern Business Information, as quoted in Bro Uttal, "Cold New World," *Fortune*, June *27, 1983,* p. *83.*

[29]Kathleen K. Wiegner, "Prometheus is Unbound and Seeking His Footing," *Forbes*, Mar, 12, 1984, p. 143.

[30]Ibid.

only 1.2 percent in 1982.[31] Now, AT&T Technologies will be responsible for marketing all products not handled by ATTIS, and a marketing division and all the support functions are being developed.

## Allocation of Research and Development Expenditures

As listed in table 24, AT&T and IBM have the largest R&D budgets among the U.S. firms shown. The R&D intensity, that is, R&D as a percent of revenues, is based on total sales, which before divestiture included revenues of the operating companies providing local telephone service. AT&T's R&D intensity is a fairly low 3.3 percent when based on total revenues. Nordhaus cites historical evidence, however, to indicate that as a percent of *manufacturing sales* AT&T spent approximately 9.8 percent of revenues on R&D in the 1970s, as compared with an average of about 2.8 percent for communication firms, and 1.9 percent for manufacturers generally.[32]

On average, Bell Labs has spent about 10 percent of its R&D budget on research. Among the other firms in table 24, both Northern Telecom and IBM also claim to spend about 10 percent on research. While Northern Telecom is a competitive firm, it operates under the corporate umbrella of Bell Canada, and shares the expenses of Bell-Northern Research with the regulated firm.

The general argument expressed by concerned observers is that AT&T may be forced, because of competitive pressures, to invest more of its R&D funds in developing salable

[31] Bro Uttal, "Cold New World," *Fortune*, June 27, 1983, p. 83.

[32] Charles River Associates, Op. Cit., P. 7.

**Table 24.–R&D Intensities of Selected Major Telecommunication Firms (1982)**

| Company | R&D Expenses (millions of dollars) (1) | Sales (millions of dollars) (2) | R&D intensity (percent) (1)/(2) |
|---|---|---|---|
| AT&T | $2,126[a] | $65,093 | 3.3 "/0 |
| COMSAT | 22.3 | '41O | 5.4 |
| GTE | 267.0 | 12,066 | 2.2 |
| Harris | 92.8 | 1,719 | 5.4 |
| ROLM | 24.4 | 381 | 6.4 |
| United Telecommunications | 11.2 | 2,249 | 0.5 |
| Western Union | 11.0 | 1,025 | 1.1 |
| Zenith Radio | 63.8 | 1,239 | 5.1 |
| ITT | 519.0 | 15,958 | 3.3 |
| Rockwell International | 222.0 | 7,395 | 3.0 |
| General Dynamics | 139.0 | 6,155 | 2.3 |
| IBM | 2,053.0 | 34,364 | 6.0 |
| Motorola | 278.0 | 3,786 | 7.3 |
| RCA | 195.4 | 8,237 | 2.4 |
| General Electric | 781.0 | 26,500 | 2.9 |
| L. M. Ericsson (1980) | 231.3 | 2,779.4 | 8.3 |
| Northern Telecom | 241.4[b] | 3,035.5b | 8.0 |
| Plessey (fiscal year 1982) | 241.8 | 1,723.9 | 14.0 |
| Siemens (fiscal year 1982) | 3,300(DM) | 34,600(DM) | 9.5 |
| Thomson-CSF (1980) | 3,600(FF) | 22,300(FF) | 16.1 |
| The CIT-Alcatel Group (1981) | 1,000(FF) | 1O,7OO(FF) | 9.3 |
| Hitachi (fiscal year 1981) | 609.0 | 15,996.1 | 3.8 |
| NEC (1981) | 227.8 | 4,820.2 | 4.7 |
| Fujitsu | 256.1 | 2,769.9 | 9.2 |

[a] Includes $1,515 million spent by Western Electric Co. and other subsidiaries, not reported in AT&T's 10K.
[b] Canadian dollars.

SOURCES: *Business Week*, June 20, 1983; L. M. Ericsson Telephone Co., *Annual Report*, 1980; Plessy, *Report and Accounts*, 1982; Siemens, *Annual Report 198142; Thomson-CSF in 1980: The Year in Review; CIT Alcatel Group Review;* Hitachi, *1981 Annual Report;* NEC Nippon Electric Co., Limited, Annual Report, 1981; and Fujitsu Limited, *Annual Report*, March 1981.

FROM: Charles River Associates, "Impact of the AT&T Divestiture on Innovative Behavior," unpublished report prepared for Office of Technology Assessment, December 1983.

products, and correspondingly less in funding research projects that may lead to future scientific breakthroughs. They note that the license contract fees described above, which provided a steady income source for Bell Labs, will no longer be available, and that research funding will depend on yearly corporate decisions. Any reductions, instability, or even uncertainty about funds could have negative effects on the productivity of research projects that by their nature require long-term attention and investment.

The arguments related to a possible change in AT&T's policy toward research are based on two major effects of the deregulation and divestiture-AT&T will be operating in competitive markets and it will be a smaller corporation.

Neither the theoretical nor the empirical relationships between market structure, firm size, and innovative activity are straightforward or well understood. It is not clear whether innovation is most likely to occur under conditions of competition or of monopoly. In addition, although many support the view that larger firms have more incentives to innovate, there are many examples, especially in the information industries, of small firms that grow large due to extremely successful innovations. Further, most existing theory deals with "innovative behavior" or R&D as a whole, rather than with the specific relationship of market


Photo credit: AT&T Bell Laboratories

A dust-free "clean room" for manufacturing integrated circuits.

structure or firm size with the basic research component of R&D.

One theoretical argument, as proposed by Schumpeter and others, is that innovative behavior is greater in monopolistic industries than in competitive ones because a firm with monopoly power: 1) can prevent imitation and therefore capture more profit from innovation, and 2) is better able to assemble the funds and bear the risks of R&D.[33] On the other hand, critics of this position theorize that firms in competitive industries are more likely to innovate because new products or processes will help them to reduce costs or increase market share. In this view, monopolistic firms would be slow innovators because they can continue to earn profits by continuing to produce the current products. In addition, because the monopolistic firm is under less pressure to operate efficiently, the results of innovative activity would be obtained at excessive cost.[34]

Real-world markets are characterized by varying degrees of concentration rather than extremes of pure competition or monopoly. Attempts to empirically measure the relationship between innovation and degree of industry concentration have had mixed results.[35] For example, Scherer[36] found some evidence that dominant firms in highly concentrated industries are more innovative. However, in a later study[37] he found that the relationship varied greatly depending on the industry, and that there were examples where higher levels of innovation were associated with more competitive industries. In some cases, dominant firms were only moderately productive innovators, but they were able to aggressively take advantage of innovations by other firms. IBM was given as an example of such a firm.[38]

The empirical evidence on the effects of firm size on innovation is less ambiguous than the evidence on market structure. R&D at small firms is sometimes more efficient than at large ones for R&D projects undertaken by both large and small firms.[39] However, some projects are simply beyond the reach of small firms and there may be economies of scale for other projects. It appears that R&D intensity increases with firm size until firms reach annual sales of $250 million to $400 million (1978 prices) and then level off.[40] After reviewing the empirical evidence on firm size and innovation, Scherer concludes that an industry with a moderate degree of concentration and a variety of firms of different sizes is most conducive to innovation.

> All things considered, the most favorable industrial environment for rapid technological progress would appear to be a firm size distribution that includes a preponderance of companies with sales below *$500* million, pressed on one side by a horde of small, technology-oriented enterprises bubbling over with bright new ideas and on the other by a few larger corporations with the capacity to undertake exceptionally ambitious developments.[41]

After divestiture, AT&T is still many times the threshold level of size that empirical studies have associated with maximum R&D. It will still be the dominant firm in a telecommunications industry that fits well Scherer's description of the environment most favorable for innovation. Thus, though the details of AT&T's R&D may change, there are no convincing theoretical arguments or empirical evidence related to market structure or firm size that would predict a lessening of its innovative activity.

[33] Summarized in Morton I. Kamien and Nancy Schwartz, *Market Structure and Innovation* (New York: Cambridge University Press, 1982), p. 47.
[34] Morris E. Morkre, "Innovation and Market Structure: A Survey," Working Paper No. 82, Bureau of Economics, Federal Trade Commission, 1982, p. vi.
[35] The literature is reviewed in Morkre, "Innovation, p. 11.
[36] F. M. Scherer, "Firm Sizes, Market Structure, Opportunity, and the Output of Patented Inventions,' *American Economic Review,* 55:11 19.
[37] F. M. Scherer, *Industrial Market Structure and Economic Performance* (New York: Rand McNally, 1980), p. 431-432.
[38] Ibid., p. 432.
[39] Morkre, p. vi.
[40] Charles River Associates, "Impacts," p. 88.
[41] Scherer, *Industrial Market Structure,* p. 422.

Scherer and others have concluded that the important determinant of innovation may not be market structure or firm size but rather the richness of innovative opportunities opened up by the underlying base of scientific knowledge. Advances in science related to semiconductors, computers, software, satellites, microwave transmission, fiber optics, and lasers provide a rich set of technological opportunities upon which to base innovations in telecommunications and information technology.[42]

### Basic Research

Economic literature on "innovation," however, does not deal adequately with the effect of firm size or market structure on contributions to the knowledge base that supports innovation. The expected effect of competition, as noted above, is investment in development of new products and services, which will reduce cost or improve market share in the short term. Investments in research, especially basic research, may not pay off until many years after the initial investment is made.

One unique characteristic of Bell Labs is its reputation for doing basic research.[43] In general, only a few firms in the information industries have spent much on in-house basic research. In 1981, out of 110 firms doing R&D in information technology, only seven did any basic research at all, according to the National Science Foundation.[44] Speaking of Bell Labs one observer from Bell-Northern Research noted, "Most other organizations are looking at how to exploit technology, not at how to push it forward."[45]

When AT&T gets more experience as a competitive firm, will it continue to do basic research, or will it begin to behave as it appears other competitive firms do, and dedicate more resources to product-oriented research and development? Some observers, including Nordhaus, believe that AT&T will now "tilt much more toward a conventional equipment manufacturer, and it will therefore have a relatively greater incentive to invest in R&D that will enhance its equipment sales and profits" and relatively less incentive to invest in basic research.[46]

At the present time, AT&T's management has voiced a commitment to continuing fundamental research, recognizing that advances in science are necessary to advances in technology. In testimony before the Senate Commerce Committee, AT&T President Charles L. Brown called Bell Labs the "jewel" of the Bell system, and pointed out that "basic research has been the root of Bell Laboratories success and will continue to be the root of it. We do not intend to skimp on it . . . . This is something we have as a basic tenet."[47]

It is probably true that more than half a century of reliance on internally developed technology will not be quickly tossed aside. One Bell Labs spokesman said that the "corporate culture" of AT&T is completely oriented toward doing basic research in-house. The forces of habit and tradition may resist some pressures to shift too many resources to development.[48] Most of the technologies that will be commercially important to AT&T in the future–computer science, photonics, and solid-state physics—are the very areas where Bell Labs has made ongoing contributions to basic

[42] Charles River Associates, *Impacts,* p. 85.

[43] National Science Foundation, *Research and Development in Industry, 1981,* NSF 83-325 (Washington, DC: U.S. Government Printing Office, 1983), p. 3. The National Science Foundation defines basic research as "original investigations for the advancement of scientific knowledge not having specific commercial objectives, although such investigations may be in fields of present or potential interest to the firm.

[44] Information technologies in this case includes firms in the following categories: office, computing, and accounting machines (SIC 357); communications equipment (SIC 366); electronic components (SIC 367). See "Table B-33–Number of R&D Performing Companies Conducting Basic Research By Industry: 1981," p. 38 in National Science Foundation, *Research and Development in Industry, 1981,* NSF 83-325 (Washington, DC: U.S. Government Printing Office, 1983).

[45] John A. Roth, executive VP, Bell Northern Research, as cited in "Bell Labs the Threatened Star of US Research," *Business Week,* July 5, 1982.

[46] William Nordhaus, cited in "Bell Labs on the Brink," *Science,* Sept. 23, 1983, p. 1267.

[47] Testimony of Charles L. Brown Before the Senate Committee on commerce, Science and Transportation, March 1982.

[48] Interview, March 1984.

science. It is highly unlikely that AT&T will abandon research in these areas. Further, as was pointed out in the case studies in chapter 3, the boundaries between basic and applied research in these fields are sometimes very fuzzy. Bell Labs' researchers are likely to make some contributions to the advancement of science even in pursuit of commercial ends.

There are some tangible and intangible benefits of performing basic research that are as advantageous to AT&T now as they were before Computer II or divestiture. For example, Nelson[49] points out that research often yields discoveries and inventions in unexpected areas. The wider a firm's scope of activities, the higher the proportion of these unanticipated outcomes it will be able to use. Thus, diversified firms can realize higher rates of return from research, and engage in more of it than firms with narrow product lines. Prior to divestiture, AT&T was a vertically integrated firm which could make use of research results in a large number of areas. Although the size of the firm is now reduced, AT&T is now in a position to diversify in other areas, and will continue to benefit from research results.

An additional benefit to funding basic research is that a reputation for achievements in basic science gives the Labs a certain prestige, credibility, and glamour, even if its chief business is not basic research. Although these benefits are not quantifiable, they are useful in attracting qualified scientists and engineers.

Divestiture and Computer II changed the rules under which AT&T funds research, and there has been speculation that the new rules may bring about a reduction in the amount spent on research over the long term. As a rate-base regulated monopoly, AT&T was able to spread the costs of basic research over many ratepayers. The license contract fee was essentially a "tax" on telephone calls. The revenues generated provided a regular source of income that could be counted on year after year.[50] AT&T was free to use those funds much as a government might use tax revenues, allocating some portion of those revenues to support activities that were for the general good but provided no immediate commercial benefit. While some research eventually paid off in discoveries useful to AT&T, some never paid off at all. Many research results that were not of direct benefit to AT&T were made available to others through licenses of patents or through scientific and technical publication.

As a competitive firm, AT&T must now support its research through a different internal funding mechanism. An important aspect of the deregulation and divestiture rules is that AT&T will be watched closely by FCC to be sure that it allocates a reasonable portion of research costs to the nonregulated portion of its business. Before divestiture, most of the cost of research was paid for by the Bell operating companies and the Long Lines division. Under the new "composite allocator" developed by AT&T and approved by FCC, approximately 50 percent of research costs will be paid by AT&T Communications and 50 percent will be paid by AT&T Technologies and AT&T Information Systems.

## Role of Bell Communications Research, Inc.

Another unknown factor in the future of telecommunications research is the role of Bell Communication Research, Inc. (Bellcore), the technical services organization owned by the regional holding companies. The scope and quality of Bellcore's research effort is still unknown. One of Bellcore's jobs will be to test and evaluate products and equipment for the Bell operating companies. In order to do this properly, Bellcore will have to stay ahead of the manufacturers, anticipating the state-of-the-art and doing some basic research. According to Alan G. Chynoweth, Vice President for

[49] Richard R. Nelson, "The Simple Economics of Basic Scientific Research," *Journal of Political Economy 67, 3* (June): pp. 297-306.

[50] AT&T points out that the license contract payments were not completely guaranteed income. Occasionally a State regulatory commission would disallow a portion of a BOC'S license contract payment.

Applied Research, "Everything we do will be chosen because of its relevance to the long-term needs of the telephone companies. We're smaller than Bell Labs. We have to be more selective. But in those areas we select to be expert in, we'll dig very deeply. "[51] Among the areas where research will be done are mathematics and computer science, materials, solid-state science, fiber optics and photonics, and switches.

Nearly half of Bellcore's technical personnel came from Bell Labs. To the extent that former Bell Labs research personnel will still pursue the same sorts of problems at Bellcore, the value of their research contributions has not been lost to the Nation. It remains to be seen whether the creation of Bellcore will have a positive or negative impact on basic research in areas related to information technology. The research agendas of Bellcore and Bell Labs will naturally overlap in certain areas. It is possible that this duplication of effort will be inefficient and may reduce the quality of U.S. research in information technology overall. On the other hand, it maybe that the creation of this new center of initiative will have a stimulating effect on research.

The regional Bell operating companies are the owners of Bellcore and have control over how funds are spent. Under the current arrangement, they all contribute to certain "core" projects, but each is able to limit its investment in "noncore" projects it does not believe to be beneficial to its own business.[52]

Funding priorities for Bellcore will depend partially on actions of State regulatory commissions. Before divestiture, a few State commissions sometimes disallowed part of a Bell operating company's payment for support of Bell Labs on the grounds that research did not benefit the telephone ratepayers of that State. Support of research at Bellcore may face the same sort of problem.

The growing competition among its owners may also affect Bellcore's future. Although they provide regulated telephone service only within their assigned geographic areas, the regional operating companies are creating subsidiaries to enter other lines of business. Among the enterprises already under way are computer sales and repair, computer software sales, office equipment sales, cable television installation, and real estate development. In many cases the regionals are providing goods and services in nationwide markets, in direct competition with one or more of the others. Other ventures are being planned, subject to approval by Judge Greene's court, under terms of the divestiture.

The regional Bell operating companies have many common R&D goals because the majority of their business will continue to be the provision of regulated local and interstate telephone service. However, there are a growing number of areas where their interests diverge or where one company wishes to withhold information from some or all of the others. Bellcore is still developing an organizational structure to deal with this situation. It is possible that the growing competition between the owners could encourage them to jointly fund basic research at Bellcore but to turn to other labs for development of products needed for the competitive market. At this point it is impossible to say what Bellcore's long-term research agenda will be. Bellcore will be an interesting experiment in jointly funded R&D. It remains to be seen how much of Bellcore's resources the regional Bell operating companies will be willing or able to spend on basic research with possible long-term payoffs.

## Availability of Research Results

Even if Bell Labs continues to perform research at the current levels, it has fewer incentives to make the results available to others. It has maintained a fairly open policy, encouraging its scientists to publish results, present papers, and consult informally with other researchers. Some of the research results, as well as some of the patents, were of little direct value to AT&T because it was permitted only to provide regulated common carrier service. But some of them were of immense value to firms in related fields and even to AT&T's competitors.

Now, according to Bell Labs Vice President Arno Penzias, AT&T will "have the opportunity and motive to use our own technology. "

[51] Lee Dembart, "Dividing Bell Labs: Breakup to Put the Best to New Test, " *Los Angeles Times,* Sept. 6, 1983, pp. 1,3.
[52] Remarks of Irwin Dorros at seminar "Research at Bell" held Apr. 5, 1984, Massachusetts Institute of Technology, Program on Research in Communications Policy.

Photo credit AT&T Bell Laboratories

An experimental, interactive computer-based system is helping Bell Labs engineers design integrated circuits.

However, he emphasized that in the area of basic research, Bell Labs is still part of the scientific and technical community where communication and trading of information is vital. In order to benefit from the results of research elsewhere, it will have to continue to share its research results. In order to keep good scientists on the staff, it will have to allow them to publish.

Only a small number of basic research projects lead to results that have an obvious application. In some of those cases AT&T would probably get patent protection before publishing the results. In other cases, the published paper may report a discovery without giving details of how to duplicate it. This type of protection has been used by many labs, including Bell Labs in the past. Penzias noted that at IBM the number of papers published per dollar of research is about the same as Bell Labs, even though IBM is a competitive firm.[53]

A policy of complete openness of research results may be transferred to Bellcore. Its interest is to see that research results are disseminated widely so that manufacturers can use them to produce the best and lowest cost products for use by the Bell operating companies. Bellcore itself, under its current charter, will not be able to manufacture products or otherwise benefit from any discoveries or inventions resulting from its research. Therefore, it may establish a publication and licensing policy even more open than Bell Labs' has been in the past.

[53]Arno Penzias, remarks at a seminar "Research at Bell, " held Apr. 5, 1984, Massachusetts institute of Technology, Program on Research in Communication Policy.

# Policy Implications

The recent divestiture and the entry of AT&T into competitive markets poses new challenges for U.S. policy toward the telecommunication and information industries. The 1979-83 period in which the divestiture and Computer II decisions were announced and implemented was also a period of intensive congressional debate about telecommunications. Bills have been introduced to modify the Communications Act of 1934, to deregulate parts of the industry, or to force some version of AT&T divestiture.[64] Many of the policy issues raised in this legislative debate have now been addressed by FCC in Computer II and through settlement of the Department of Justice suit. Speculation over the effects of the new policies have added to the uncertainty and change in the information industry. Several years under the new rules will be necessary before all the effects can be assessed.

Similarly, the full effects of deregulation and divestiture on the quality and direction of research at Bell Labs will only become clear as this "shakedown" period goes on. Neither history nor economic theory seem to be of much help in foreseeing the future of research at Bell Labs. There appear to be only a few things that government can do about major changes in research at Bell Labs. Clearly, in the post-divestiture era, decisions about the funding and nature of research will be in the hands of AT&T management. This is not new. Decisions about research have always been management decisions, in AT&T as throughout U.S. industry.

"For example, S. 898, H.R. 5158, as introduced in the 97th Congress, are only two bills which proposed modifying the 1956 consent decree, creating a subsidiary of AT&T to enter new unregulated markets, and stimulating competition in terminal equipment.

It is possible that, in the new climate created by deregulation and divestiture, AT&T management will make decisions about research that will allow the quality or quantity of Bell Labs' research to decline. In that case, there may be a role for limited government action. Some regulatory or funding policies might be developed to stimulate or facilitate research. These policy changes, discussed later in this section, might be aimed at AT&T alone, but might also be applied more generically to raise the quality of research in industry, universities, and government.

However, it would be premature to introduce policy changes without evidence that the current institutional arrangements are inadequate, or that the U.S. research capability is in jeopardy. The first step of government action might be to monitor Bell Labs' research over the next several years to see whether the quality of research actually changes. The monitoring effort might be expanded to include the whole range of industry and university research in information technology. It would not be difficult to develop an analytical framework and a set of criteria for measuring the vigor or quality of research. A number of possible measures are suggested below. While none of them is decisive in isolation, together they might give a picture of the health of research at Bell Labs and at other research organizations.[65]

For example, it would be possible to monitor the funds that AT&T allocates to research over the next few years. Dollar amounts seem very objective and quantifiable, but alone are not a sufficient gauge of the quality or direction of research effort. For example, if all basic science were dropped and the research effort steered toward more applied projects, the total amount spent for "research" might remain the same. This criterion may be useful, but cannot be used in isolation.

Another measure would be the number of papers by Bell Labs scientists published in prestigious scientific and technical journals each year. A decline in the number of papers could be an indication that the amount of research is declining, perhaps, or that AT&T is significantly limiting publication in order to protect possible commercial advantage stemming from certain types of research.

In addition to monitoring the number of papers published, it might also be possible to examine the quality of the journals in which they appear. Although this measure is subjective, it should reflect the quality of Bell Labs work as viewed by other members of the scientific community. Researchers in all fields have a clear idea which of their journals is the "best." To the extent that Bell Labs work continues to be published in the same sorts of journals as now, it may be evidence that the quality of results remains unchanged. A shift to publication in less prestigious journals might indicate a decline in quality.

The vigor of research can also be measured by its usefulness to other researchers. Thus, a possible measure of the continuing value of Bell Labs research would be the number of times their work is cited in papers published by scientists in universities and other labs. In addition, the attitude of the scientific community toward Bell Labs could be monitored by its ability to attract and retain well-qualified research workers.

There is the possibility that, even with a reduction of basic research at Bell Labs, research in the information field generally will not suffer. Scientific research may simply move to other laboratories. Any decline in quality of fundamental research would certainly make it harder for Bell Labs to attract and keep a staff of qualified scientists. Top graduate students would choose to work at other firms or at universities. To the extent that researchers continue to work in the same scientific fields and are equally productive in their new surroundings, there may be no noticeable effect on U.S. basic research.

To get a complete picture of the effects of deregulation and divestiture on the state of information technology basic research in the United States as a whole, it would be necessary to monitor the research performed throughout industry and at university labs as well. Even then, it would be extremely difficult to attribute observed changes in the U.S. research environment to changes occurring at Bell Labs. As noted in chapter 2, the state of information technology research is in flux and changes will occur with or without Bell Labs.

"Some of the measures listed have actually been used informally by Bell Labs management to monitor the strength of research in the Labs.

It may be possible, however, to trace some causal factors and to, at least, draw reasonable inferences.

One difficulty with the proposed studies is the collection of relevant data over an extended period of time. While the data needed are not extensive, they include items that firms do not currently report to any Federal agency (except that the FCC will continue to be concerned with AT&T's research budget). Some special effort and cooperation on the part of industry and the Federal Government would be needed to collect and analyze the necessary information.

It is difficult to say who might be best suited to carry out the studies mentioned above. One possibility is the FCC, which is responsible for oversight of many aspects of AT&T's business. However, many of the firms and institutions engaging on information technology research are not regulated by the FCC and it may not be appropriate for the Commission to study them. Other possibilities might be the National Telecommunications and Information Administration (NTIA), which has an interest in the health of U.S. information R&D, or the National Science Foundation (NSF), which monitors the state of R&D and basic research in a number of fields. Yet another possibility might be an independent research group outside of government—perhaps one created by a university or industry association. Most of the technical and scientific journals needed for bibliometric studies are already in the database of the Library of Congress. These analyses might be performed by the Congressional Research Service, an independent research group, or one of the agencies mentioned above.

For some of the studies mentioned above data may only be available several years after the actual research has been done, and in many cases meaningful conclusions can be drawn only after data for 5 or 10 years have been analyzed. If there is a reduction in basic research at Bell Labs, the trend might have been under way for several years before the data indicate a change. By that time, it might be difficult to effect any correction in the trend.

If it is determined that changes in basic research at AT&T have had a major effect on the U.S. research capability, and that Government action is warranted, there is a question of what can be done. Basically, it appears that two general approaches might be considered. Regulatory policies might be changed to modify the rules under which AT&T operates, giving it greater incentives to perform basic research or requiring it to do so. More broadly, consideration could be given to implementing funding policies that might stimulate more basic research throughout industry and in university laboratories.

In the regulatory area, for example, it might be possible to allow some subsidy for basic research. At the present time, FCC is working under the terms of the divestiture and Computer II to make sure that AT&T does not use the revenues it earns in the regulated market to support research or development that leads to advantages in the nonregulated market. For this reason FCC must approve the "composite allocator" developed by AT&T to allocate research costs among the various AT&T entities. The economic theory is that a competitive firm should pay its own R&D costs without shifting them to regulated ratepayers.

On the other hand, when AT&T was permitted to use such a cross-funding arrangement, it used the funds to create a highly respected and productive research organization that presumably benefited the Nation as a whole. If experience over the next few years shows that it is impossible for AT&T to maintain Bell Labs' quality without additional funding, and if it is determined to be in the national interest that such an organization be maintained, then additional funds must be provided. They could come from a direct Federal subsidy or from some kind of cross-funding. The former is not likely to be politically acceptable; the later is increasingly complex as the long-distance telecommunication market becomes more competitive. By its own estimate, AT&T now provides only 69 percent of total long-distance capacity.[56] AT&T is rapidly losing the market power it once had

[56] AT&T, private communication, Apr. 30, 1984.

to control prices throughout the industry. If it were required to raise the price of long-distance calls to provide greater support for basic research, it would be placed at a competitive disadvantage with respect to other long-distance carriers that do not support research. Development of a mechanism by which all long distance carriers contribute to funding basic research would be difficult in the increasingly competitive long distance market.

An alternative regulatory approach might be *to* stimulate basic research by allowing more cooperation between ATTIS and Bell Labs. About 4,000 former Bell Labs employees were moved to ATTIS when it was created in 1982. Expertise in some research areas has been lost to Bell Labs through this transfer and through the subsequent transfer of 3,000 employees to Bell Communications Research. The FCC's interpretation of Computer II rules do not allow the exchange of market and network information between ATTIS and Bell Labs and they also prohibit the joint development of certain products, especially computer software.

In the future, easing this requirement to the extent of allowing ATTIS and Bell Labs to cooperate on certain types of research, might allow greater cross-fertilization among the two research organizations.

Policies to stimulate basic research generally might include such incentives as additional grant support from National Science Foundation (for example), direct support of basic research through direct Federal subsidies, or tax incentives for industries that engage in basic research. Such policies might be applied not only to Bell Labs, of course, but to Bellcore or to other university and industry research organizations. Over the next few years, while the health of research is being monitored, it might be possible to structure such programs to stimulate research and to develop "trigger" mechanisms for putting them into place if results indicate that the quality of research is declining.

In conclusion, it is still too early to tell whether the quality or direction of research at Bell Labs will be adversely affected by deregulation and divestiture, or whether any changes in its research would have major repercussions for U.S. research as a whole. There are several possible measures for monitoring the health of basic research at Bell Labs, but evidence of change may not be apparent for several years. While Bell Labs is a major contributor to the sciences related to information technology, it is not the only important player. To gain a true picture of the effects of deregulation and divestiture it would be worthwhile to expand such studies to monitor the state of basic research throughout industry and at university labs as well. It will be important to begin collecting information soon in order to fully document the transition from the pre- to post-deregulation environment.

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