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Antitrust in High-Tech Industries

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Abstract

A large share of the recent growth in the United States economy has been in high-technology industries or service industries that use high-tech services. Information and communications technologies have developed very rapidly, generating productivity growth throughout the economy.[1] The firms developing many of these technologies—such as Oracle, Intel, and Microsoft—have achieved a dominant position in the marketplace and thus attracted the attention of competition authorities. But successful innovation, with or without patent protection, is often accompanied by a position of market power. Transitory or even not so transitory monopoly profits are the reward for successful innovation and may be required to promote a dynamic economy, as Joseph Schumpeter explained decades ago. As a result, successful innovators often find themselves in conflict with competition policy authorities.

In this paper, we analyze the impacts of recent United States Section 2 Sherman Act cases brought against three major information and communications technology sector firms in the last half of the 20th century: *IBM, AT&T, and Microsoft*. These cases provide a particularly interesting set of case studies because they all involve major players in the high-tech sector, but each case had a different legal outcome. One—IBM—was dropped after 13 years; another – AT&T—was settled after 8 years of litigation; and the third—Microsoft—resulted in a court decision that was a clear victory for the government. But what was the effect of each case's resolution on the relevant markets? Has the remedy that was imposed in the two latter cases actually worked to produce a more competitive industry structure? Could the remedy proposed by the government in *IBM* have improved the performance of the computer industry?

We will argue that, unlike earlier landmark antitrust cases against steel, oil, tobacco, or aluminum, a successful outcome in these Section 2 cases brought against high-technology firms would not simply be an expansion of output and lower prices of a relatively homogeneous commodity, but rather the development of new products to replace or to compete with the dominant firm's product or service. Is it conceivable that antitrust authorities can design remedies that obtain such results?

[1] For a recent summary of the research on the recent surge in productivity growth in the United States, see Jorgenson, Ho, and Stiroh (2005).

I. Introduction

In 1984, Frank Easterbrook offered a general warning to antitrust authorities in "The Limits of Antitrust." In this article, Easterbrook noted that the authorities should be careful in bringing suits against firms simply because those firms had pursued business practices that damage competitors and that they should be particularly wary when they cannot predict how such suits will eventually play out in rapidly changing markets. After all, markets are often better at restoring competition than are the antitrust authorities and the courts. As a result, policymakers should be reluctant to intervene in rapidly changing industries, such as high-tech industries. Easterbrook's warning was published just after the *IBM* case was dropped, as the AT&T decree was being implemented, and much before the Microsoft case was even filed.

Recent Antitrust Policy Evaluations

The antitrust establishment has had two major chances to address some of the concerns raised by Easterbrook. In 2002, Congress established an Antitrust Modernization Commission to review antitrust policy and provide recommendations for changes in antitrust statutes and policies.[2] This Commission reported its findings in April 2007, among which were the following:

> "There is no need to revise the antitrust laws to apply different rules to industries in which innovation, intellectual property, and technological change are central features.
>
> "In industries in which innovation, intellectual property, and technological change are central features, just as in other industries, antitrust enforcers should carefully consider market dynamics in assessing competitive effects and should ensure proper attention to economic and other characteristics of particular industries that may, depending on the facts at issue, have an important bearing on a valid antitrust analysis."[3]

Moreover, the Commission recommended that

> "Congress should not amend Section 2 of the Sherman Act. Standards currently employed by U.S. courts for determining whether single-firm conduct is unlawfully exclusionary are generally appropriate."[4]

Surprisingly, this rather bland recommendation came on the heels of the final resolution of the *Microsoft* case in September 2006.[5] Despite the controversy stirred by remedy in the Microsoft case, the Commission had little to say about such remedies in rapidly-changing, high-tech industries.

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2 Antitrust Modernization Commission Act, Public Law No. 107-273, 116 Stat. 1758, 2002.

3 Antitrust Modernization Commission, *Report and Recommendations* (2007), p. 9.

4 *Id.*, p.12.

5 *U.S. v. Microsoft Corporation, Modified Final Judgment*, Civil Action No. 98-1232 (CKK), September 7, 2006.

Professor Dennis Carlton was the only economist on the Commission and was serving as Deputy Assistant Attorney General for Antitrust at the Department of Justice during the latter days of the Commission's deliberations. In a 2007 Department of Justice working paper, Carlton addressed the issue of remedies for anticompetitive conduct uncovered in high-tech industries:

> "Remedies for anticompetitive exclusionary conduct can be hard to fashion, as the *Microsoft* case illustrates. The difficulty of devising effective remedies does not necessarily mean the government should refrain from prosecuting such matters, because a liability finding likely would trigger private actions in which monetary damages could be awarded."[6]

But this observation was deleted from the version of Carlton's paper that was published in the *Journal of Economic Perspectives*.[7] For some reason, Carlton confined his discussion of remedies in this final, published version to remedies in cases involving intellectual property, devoting just one paragraph to the design of "reasonable royalties" for patents.

In June 2006, the Department of Justice (DOJ) and the Federal Trade Commission launched a set of hearings designed to explore issues in the enforcement of Section 2 of the Sherman Act against single-firm anticompetitive conduct. In June 2008, they released their Final Report, which focused substantial attention on the crafting of remedies. In its discussion of remedies, it began by asserting that

> "Without a proper remedy, winning a judgment of a section 2 violation is similar to winning a battle but losing the war. Designing and implementing effective remedies in unilateral conduct cases often is a daunting challenge."[8]

The Report continued,

> "Notwithstanding their importance, the study of remedies has been somewhat neglected. As one panelist quipped, 'Everybody likes to catch them, but nobody wants to clean them.' Because selecting and implementing a suitable remedy is such a crucial yet difficult task, panelists stressed that the antitrust enforcement agencies need to give careful consideration to potential remedies early in their investigations."[9]

When considering remedies for rapidly-changing, high-tech industries the DOJ Report noted that

> "The rapid changes and innovation typical of new-economy industries raise the question whether current antitrust enforcement mechanisms, which often involve lengthy investigation, followed by complex, time consuming trials, are suitable for implementing

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6 Carlton (2007a), p.13.
7 Carlton (2007b).
8 U.S. Department of Justice (2008), p. 143.
9 *Id.*

> effective remedies that adequately protect competition. Developing an equitable remedy in these markets has been likened to 'trying to shoe a galloping horse.'"[10]

But the problem in such cases is not simply that the judicial process moves too slowly. Rather, the major problem is that the relief that is drafted—even at the end of a lengthy trial—is based on industry conditions that are changing rapidly. Today's remedy may be reasonably matched to today's problems, but not to those of tomorrow. Indeed, the Justice Department Report concedes this point:

> "The same potential for dynamic change between complaint and judgment that complicates crafting a remedy in the first place raises further complexity after a remedy is in place. . . [W]hen technology is changing rapidly, a fixed remedy running years into the future may have damaging, unintended consequences."[11]

Unfortunately, we cannot know if these observations signal a potential change in the Justice Department's approach to enforcement of Section 2 of the Sherman Act because the current administration renounced the 2008 Report shortly after assuming office.[12]

Recent Academic Studies

There are very few general assessments of the effects of antitrust remedies, although a few cases, such as the landmark *Standard Oil* case, *United Shoe Machinery*, *Paramount*, *AT&T*, and *Microsoft* have received substantial attention from academic researchers.

Recently Crandall (2001) and Crandall and Elzinga (2004) examined the effectiveness of remedies in Sherman Act monopolization cases, relying on a number of case studies. Their conclusion was that there is little evidence that these remedies—in the form structural or injunctive relief—have worked. These analyses suffer from a potential selectivity bias that plagues all such case studies, and they do not focus particularly on cases involving high-technology industries.

Borrowing in part on Crandall (2001), Crandall and Winston (2003) concluded that there is no empirical evidence that U.S. antitrust policy has systematically contributed to improving consumer welfare. However, they do not provide specific new evidence on the effect of antitrust policy in high-technology industries.

Epstein (2007) provided a more recent critique of antitrust remedies, focusing on consent decrees negotiated to settle several cases: *Swift*, *AT&T*, and *Microsoft.* He concluded that many antitrust

[10] *Id.,* p. 158.
[11] *Id.*, p. 159.
[12] U.S. Department of Justice, Office of Public Affairs, "Justice Department Withdraws Report on Antitrust Monopoly Law," May 11, 2009.

decrees have been overly broad and have not been tailored simply to correct anticompetitive abuses of firms with putative market power. His critiques of the *AT&T* decree and the remedy imposed on Microsoft clearly bear on the issues central to this paper. He concluded that the *AT&T* decree and the remedy approved by Judge Jackson on Microsoft, which was subsequently overturned by an appellate court, were misguided attempts to fashion structural relief to create competition in markets with network effects in which successful innovators necessarily enjoy dominant positions. Attempts to use Sherman Act cases to establish competition in such markets necessarily are doomed to failure in Epstein's view.

The Three Major High-Tech Section 2 Cases

In the sections that follow, we analyze the outcome of the three most prominent monopolization cases brought against high-technology firms over the last half century. The *IBM* case was filed in January 1969 and litigated for thirteen years. In 1982, Assistant Attorney General William Baxter asked the trial court to dismiss the *IBM* case, citing the complete change in IBM's product offerings in the intervening 13 years. Richard Levine, his deputy, argued that releasing AT&T from its own 1956 decree's restrictions would provide the best relief for the *IBM* case because AT&T would be free to compete in computers and related equipment.[13] This proved to be a stunning example of the inability of antitrust authorities to anticipate changes in dynamic, high-tech markets. While dismissing the *IBM* case may have been the correct decision, it was not because it unleashed competition from AT&T in computer-related equipment. AT&T's equipment-manufacturing division, Western Electric (which became Lucent) never became a major player in computers or computer-related equipment, even though it attempted to do so through its acquisition of NCR in 1991.

The *AT&T* case was brought in 1974 and resolved by structural separation of AT&T's local operating companies from the parent's long-distance and manufacturing operations so as to allow entrants to compete in the long-distance and terminal-equipment markets. Long-distance markets became competitive after the 1984 divestiture, in large part because of equal-access requirements imposed on AT&T's divested local companies. But these markets responded slowly to entry, much more slowly than the Canadian long-distance markets after they were liberalized in 1993 without a similar vertical divestiture.[14] Eventually, however, the new or existing stand-alone long-distance carriers in both countries declined and were acquired by the once-dominant incumbent companies, SBC, Verizon, and Bell Canada. Was the AT&T divestiture necessary? Why did other countries' telecommunications markets evolve competitively without such divestiture? Was the break-up of AT&T based on a market failure or the failure of the FCC to allow entry and to mandate equal access for entrants? We will address these issues and extend the work of one of us (Crandall), published in the *University of Chicago Law Review* in 2005.

[13] See Temin and Galambos (1987), p. 282.
[14] See Crandall (2005), p. 11.

The *Microsoft* case is the most recent of our case studies, and therefore the results of the behavioral relief obtained by the government are more difficult to detect at this time. After being rebuffed by the courts in its attempt to break Microsoft into separate operating-system and applications-software companies, the Justice Department negotiated a settlement that required Microsoft to abandon certain sales practices and to provide access to the necessary codes and interfaces for competitors in middleware and applications software markets. The government's case was predicated on the theory that Microsoft used various tactics, including bundling, to prevent Netscape—an Internet browser company—from developing a middleware platform that could compete with Microsoft Windows and provide access for competing applications software producers. The government argued that "network effects" would make entry of competing operating systems and Internet browsers very difficult; therefore, Microsoft's bundling of its Internet Explorer was designed to destroy Netscape, cutting off potential entry into operating systems and applications software. Has the government's theory been borne out? Rival operating systems, Internet browsers, and web-based applications software are growing despite the disappearance of Netscape. Did the behavioral decree accelerate this entry? We propose to offer at least preliminary answers to these questions.

II. The *IBM* Case

In January 1969, the U.S. Department of Justice filed a Section 2 Sherman Act case against IBM, alleging that IBM had monopolized and attempted to monopolize the market for "general service digital computer systems."[15] This monopolization was allegedly achieved by bundling hardware, software, and "related support" so as to limit the development of independent software and computer support, which in turn limited the ability of other computer manufacturers to compete with IBM. In addition, Justice alleged that IBM introduced new models and prematurely promised to introduce others so as to restrain entry and granted discriminatorily low prices to educational institutions so as to influence their graduates' future purchases of computer systems. Finally, IBM was alleged to have monopolized the market for peripheral equipment—tape drives, disk drives, and add-on memory devices—further reducing the ability of independent computer manufacturers to compete in the market for digital computer systems.

The *IBM* case was remarkable for several reasons. First, it was brought in the last week of the Johnson Administration, just before the inauguration of a new President. Second, it did not go to trial until 1975, more than six years after the Complaint was filed despite the fact that the computer industry is and was one of rapidly-changing technology, products, and competitors. Third, the trial lasted for more than six years and was still without resolution more than twelve years after the complaint was brought. Finally, four Presidents and thirteen years later, the new Attorney General in the Reagan Administration asked the court to dismiss the case because it

[15] United States District Court for the Southern District of New York, Amended Complaint, *U.S. v. IBM,* Civil Action No. 69 CIV 200, Filed January 17, 1969.

was "without merit."[16] The modern microprocessor was invented two years after the suit was filed, and the IBM personal computer came to market a decade later in 1981—a year before the suit was dismissed. IBM introduced the 370/145 computer in 1970. A 370/145 with 112K bytes of memory cost about $700,000; the original PC with 16K bytes of memory cost about $1,500.

Before looking at the developments that occurred while the *IBM* case slowly moved forward, imagine that the current Justice Department brought an analogous case against, say, Google, Apple, or Cisco—we consider Microsoft later in this paper—launching a thirteen-year legal odyssey. Could it possibly begin to predict what the online search, media devices, or network equipment markets would look like in thirteen years? Could it suggest any form of relief that, should it win in court, could conceivably improve market performance? It would have to adjust its case continually to new developments in any one of these markets, some of which may not even survive for thirteen years.

The Government's Proposed Relief

The Justice Department's proposed relief in its initial complaint focused on IBM's bundling of software, peripheral equipment and customer support with its computers; its use of special allowances and research grants; and its use of premature product announcements.[17] Specifically, the government asked the court to force IBM to "price and to offer to sell or lease separately . . . (a) general purpose digital computer systems; (b) peripheral equipment; (c) computer software; and (d) other customer support . . . "[18] In addition, IBM would be required to refrain from offering special allowances or research grants that unfavorably affected competitors.[19]

Two other aspects of the proposed relief are more surprising. First, the government asked that IBM be barred from introducing hardware "which is not likely to result in returns reasonably to returns from other computer hardware products" sold by IBM.[20] Presumably, this provision was intended to bar IBM from introducing "fighting" machines, *i.e.*, machines whose principal purpose is to compete aggressively with rivals' new offerings. But such a provision, if enforced, would arguably have prohibited IBM from competing with new computer products, such as the personal computer products developed by Apple, H-P, and Compaq. Second, the government asked that IBM be barred from announcing the development of new products until the product had been subjected to normal testing.[21] This provision was included under the theory that IBM's market position had been strengthened by premature announcements of product introductions that it subsequently had to delay or cancel—hardly a rational strategy if repeated. Both of these

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16 United States District Court for the Southern District of New York, Stipulation of Dismissal, *U.S. v. IBM*, Civil Action No. 69 CIV 200, January 8, 1982.

17 United States District Court for the Southern District of New York, Amended Complaint, *U.S. v. IBM*, Civil Action No. 69 CIV 200, Filed January 17, 1969, Prayer (for relief).

18 *Id.*, Prayer, ¶ 3.

19 *Id.*, Prayer, ¶ 4.

20 *Id.*, Prayer, ¶ 5.

21 *Id.*, Prayer, ¶ 6.

provisions would undoubtedly have precluded or delayed IBM's introduction of many new products in this changing, high-technology industry.

Finally, the government reserved its right to seek divestiture or reorganization of IBM in some unspecified manner. Presumably, this provision would have led the government, if it were victorious, to consider asking the court for divestiture of IBM's peripheral equipment manufacturing or even its customer support operations from its core computer manufacturing operations.

The Evolution of the Computer Industry during the Litigation of the IBM Case

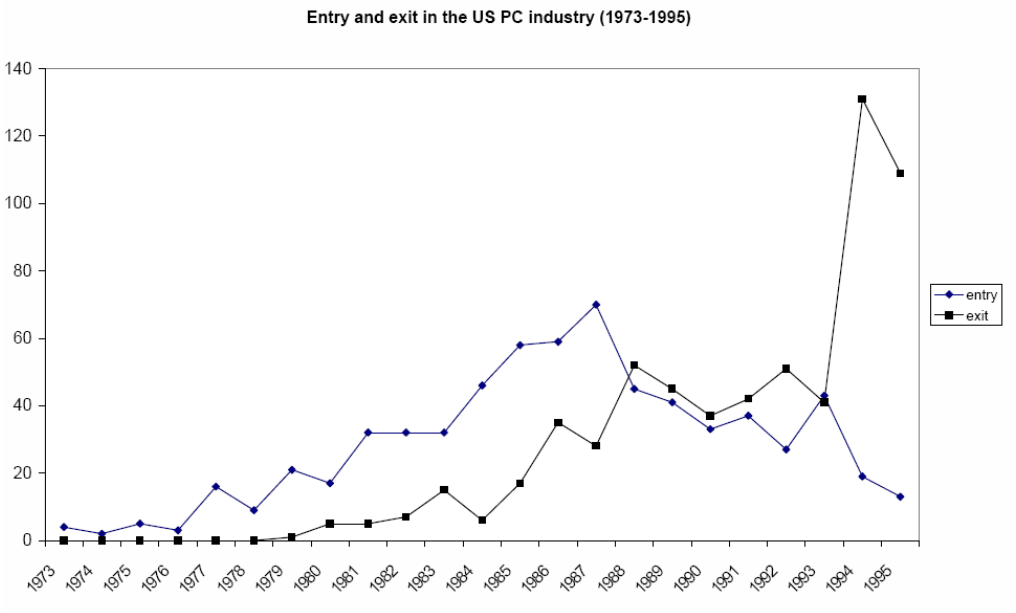
Obviously, we cannot possibly know how any prospective government victory and subsequent relief in *IBM* would have affected the computer industry because the government did not pursue the case to its final conclusion. However, we can examine how the industry developed during the thirteen years of litigation. IBM may have been restrained during this period by the pendency of a court outcome.[22] It is clear in retrospect, as Appendix Table 1 shows, that the industry was changing dramatically during this period and that many of the players in 1982 were not those who were competing in 1969 when the case was brought.

The snapshots provided by Appendix Table 1 and Figure 1 show that entry began slowly during the pendency of the IBM suit but then began to grow rapidly. But this entry was not focused on the large plug-compatible general purpose computers that IBM was producing in the 1960s. Rather, it was heavily concentrated in the "microcomputers" or PCs that were becoming possible because of rapid technical change in the production of microprocessors and memory chips.[23]

[22] See Kovacic (1999).

[23] Somewhat earlier, entry occurred in the form of "minicomputers" offered by such firms as Digital Equipment, Data General, and Prime Computer. These were somewhat smaller machines than the general purpose business computers produced by IBM, Univac, and Burroughs, but their circuitry was about two generations behind that of the microcomputers of the 1980s. The operating systems of early microprocessors were modeled on the operating systems used by the smaller minicomputers.

Figure 1



Source: Mazzucato (2002)

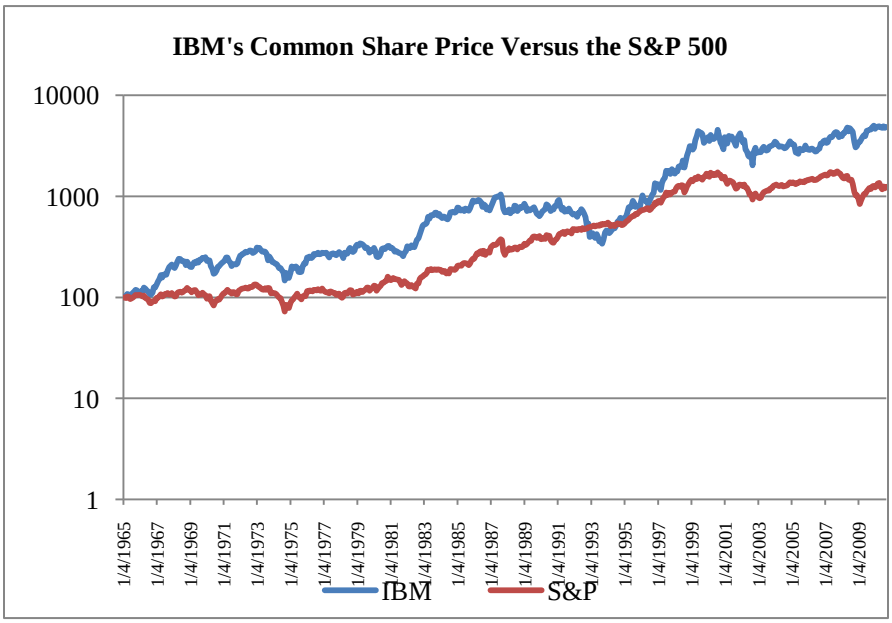
In their retrospective on the *IBM* case, Professor Franklin Fisher and his associates (who provided expert testimony on behalf of IBM) discussed the competitive environment in the computer industry at the time.[24] There are extensive references to IBM and its competitors: Burroughs, CDC, Data General, DEC, GE, Honeywell, NCR, RCA, SDS, and Univac (Sperry Rand), as well as Hitachi, Fujitsu, and Datapoint, most of whom exited the computer industry long ago. However, there is no mention of Apple, Atari, Commodore, or any of the other entrants into the small, personal computer market that was developing in the latter years of the IBM litigation, even though their reflections were published in 1983. In part, this focus is the result of the government's attempt to define the market narrowly as that of "general purpose computers" for business use.

The new entrants in the 1970s were beginning to target the household market for "personal computers," which at first would not compete directly with IBM's general purpose mainframes. At times, Wang, Prime, and Tandem were mentioned in the litigation as possible competitors, but most of the new entrants offering personal computers were not. Yet it was the development of these new personal computers with rapidly expanding capabilities and even more rapidly expanding memory that eventually eroded IBM's market power. As Figure 1 shows, the number of entrants into the production of personal computers rose steadily from 1976—the year Apple was founded—through 1987. The IBM suit continued to be litigated for first six of these years. But Figure 2 shows that IBM's share price did not begin to lag until after the suit was dropped. Between January 1969 and January 1981, the price of IBM's common equity rose by 60 percent while the S&P rose by just 17 percent! For the next ten years, a period that includes the *dismissal*

[24] Fisher, *et.al.* (1983).

of the IBM suit, IBM's share price rose by only 108 percent while the S&P rose by 240 percent. During this latter period, IBM introduced its first PC—five years after Apple's first computer.

Figure 2



Source: www.finance.yahoo.com

Approximately 16–18 years after the filing of the antitrust suit and 3–5 years after the suit was dismissed, IBM's share price began to decline relative to the S&P 500 as the new competitors in personal computers began to erode IBM's market position. It is difficult to see how an antitrust action brought in 1969 and dismissed in 1982 could have been a major contributor to these dramatic changes brought on by the development of the PC.

In 1965, Gordon Moore, one of the founders of Intel, expressed a view that became known as Moore's law—that the number of components on a semiconductor chip had been doubling every two years and would continue to do so for at least 10 more years. That trend had two clear implications. First, if that trend translated directly to a decrease in the cost of systems, such as computers built with semiconductor chips, then a computer costing one million dollars in 1969 would cost about $30,000 in 1979 and only about $1,000 in 1989. Second, it implied that the computer industry's future would be driven by the firms that were best at designing and manufacturing semiconductors. Thus, even in 1969, some foresaw that revolutionary technological changes were in store for the computer industry and for IBM, which was to be transformed from a computer equipment producer in 1969 to largely a service company today.

Between 1983 and 1987, IBM clearly struggled in the PC market, and its share price declined substantially. The reason, as explained by Bresnahan and Greenstein (1999) was that IBM lost

control of the new PC platform and the client/server platform that evolved from it. In 1981, when IBM first began producing PCs, it chose to accelerate its entry by using Intel's chips and contracting with Microsoft for its operating system software. In 1985, it chose not to adopt Intel's new 32-bit microprocessor, the 80386. These decisions and IBM's lack of dominance in the production of "minicomputers," which evolved into the servers that combined with PC clients in the new client/server architecture, sealed IBM's fate. It in effect ceded leadership to Microsoft, Intel, Oracle, and Sun, leading to a sharp decline in its market position and the relative price of IBM shares.

The Proposed Relief in *IBM* and Subsequent Developments

Understandably, the government's proposed relief in its amended complaint in the *IBM* case was focused on IBM's dominant platform in the computer industry at the time (the late 1960s. At trial, the government sought to exclude the newer minicomputer manufacturers from the defined market that IBM had allegedly monopolized, but the newest platform— the microcomputer— was only beginning to be developed and was apparently not an issue in the litigation.

But could any relief in the *IBM* case have stimulated entry into general-purpose, "mainframe" computer production in the 1960s? Bresnahan and Greenstein (1999) have argued that entry into the mainframe computer platform case was extremely difficult because of the existence of large endogenous sunk costs. Drawing on Sutton's (1991) work, they concluded that it was inevitable that the market for this platform would be highly concentrated, a position similar to the one expounded by Epstein (2007) in his analysis of *AT&T* and *Microsoft*. Given these endogenous sunk costs in the mainframe platform and the rapid rate of technical change in electronics and computers that was underway, competition was more likely to come from those developing new *platforms*, not from new or existing producers of mainframe computers.

Moreover, it is far from obvious that a different outcome to the *IBM* suit would have affected the changes in the computer industry that took place in the late 1970s and 1980s. Even if the government had achieved its objectives of requiring that IBM sell or lease its various system components on an unbundled basis, refrain from offering new "unrelated" products, refrain from preannouncing new systems, or even divest itself of various operations, it is difficult to see how this would have had any effect on the PC revolution that was starting at firms like Apple, Intel, Microsoft, Hewlett-Packard, Compaq, and elsewhere.[25]

Indeed, although IBM began to produce the new personal computers in 1981 and initially obtained a substantial market share of PC sales, it had very little control over the subsequent development of this platform in the 1980s and 1990s. It relied on Microsoft for its operating system software, on third parties for the bulk of applications software, and on Intel for

[25] The fundamental change was the exponential decline in cost of hardware. PCMs such as Amdahl and Fujitsu never had the market impact that Apple did.

microprocessors. And it chose to adopt an open architecture.[26] These choices allowed IBM to bring a product to market quickly and allowed the IBM PC to capture a substantial share of the personal computer market. However, the hardware and software inputs were available to others, and companies such as Compaq were able to compete aggressively in the market for personal computers with products that were compatible with the IBM PC. When these new PCs were combined with the servers offered by minicomputer producers, the client/server architecture began to replace the IBM mainframes, and IBM was similarly unable to prevent the new PC producers, Microsoft, Intel, Sun, Oracle, and others from competing aggressively in this new platform. The government did not predict this evolution of the computer industry in 1969 and therefore did not foresee that its proposed relief would be largely irrelevant to future technical and competitive developments.

Kovacic (1999) made a partial attempt to rescue the *IBM* case by arguing that the Justice Department's lawsuit was itself a "remedy" of sorts because it dulled IBM's incentive to make "decisive commercial adjustments" (*i.e.,* invest in new technologies) and forced IBM to concentrate on its defense of the suit, thereby distracting its top management. Even if true, such an argument suggests that a "benefit" of such litigation is the reduction in animal spirits and innovation of a large, successful high-technology company, surely a dubious proposition. But Bresnahan and Greenstein provided a cogent rebuttal to Kovacic's view that the antitrust suit was to blame for IBM's failure to seize control of the new PC market. Thus, even if IBM was tamed and distracted by the mammoth Section 2 case suit faced for thirteen years, this suit was not the principal reason that it lost its dominant position in computers in the 1980s and 1990s.

III. The AT&T Case

In 1974 the Ford Administration filed a Section 2 antitrust suit against AT&T, Western Electric, and Bell Laboratories. AT&T was the holding company that owned or controlled local telephone companies serving about 80% of the population of the United States and operated a long-distance network; Western Electric was an equipment manufacturing firm owned by AT&T, whose principal business was the supply of equipment to the local telephone companies; Bell Laboratories conducted various research and design activities in support of Western Electric, developed software systems for use by the telephone companies, and had an outstanding program of fundamental research. The entire enterprise was often referred to as the Bell System. We refer to the defendants collectively as AT&T. The complaint alleged that AT&T monopolized a variety of telecommunications services and equipment and thereby violated Section 2. The complaint asked for relief in the form of the divestiture of the operating companies and Western Electric from the holding company.

[26] There were three operating systems available for the early IBM PCs

U.S. v. AT&T was filed in 1974, five years after the Federal Communications Commission (FCC) had opened the interstate telecommunications sector to a modicum of competition. Microwave Communications Services, later "MCI," was allowed to offer a limited business private-line service, but it was not granted entry into ordinary, switched long-distance services. In 1971, entry was opened to other similar "specialized carriers."[27] Subsequently, MCI entered the switched long-distance services market by connecting to AT&T's local circuits using a form of interconnection that AT&T had previously used only for large corporate and government customers. The FCC's response was to attempt to block MCI's attempt to enter the long-distance market, but it was rebuffed by the appellate courts.[28] As a result, entry into interstate long-distance began in the mid 1970s, but the entrants were unable to gain more than a modest market share because AT&T resisted providing the necessary local interconnection for their calls through their local operating companies.

Equipment markets were also changing. In 1956, the Court of Appeals ordered the FCC to require AT&T to allow the interconnection of terminal equipment that was consistent with the telephone subscriber's right reasonably to use his telephone in ways that are privately beneficial without being publicly detrimental.[29] Subsequently, in 1968, the FCC adopted its Carterfone order, which endorsed the principle that users should be able to interconnect equipment of their choice to the network. In June 1972, the FCC initiated a proceeding looking to allow more general and flexible interconnection of equipment to the network.

It was relatively clear by 1974 that it was highly likely that the market for user equipment was going to be fully opened to competition. There was already substantial competition in the more expensive terminal equipment such as office PBX systems and specialized equipment such as data terminals and modems. AT&T's historical practice of buying terminal equipment from Western Electric and bundling the rental of terminal equipment with local telephone service now looked suspiciously like an attempt to use its monopoly in local telephone service to maintain market share in terminal equipment. Moreover, the operating companies bought switching and transmission equipment almost exclusively from Western Electric.

In 1974, there was no wireless cellular service. Cable television was limited by the FCC to a simple service of retransmitting a limited number of off-air television signals. Therefore, AT&T enjoyed a "bottleneck" monopoly in local telephony, quite unlike the situation faced by major local carriers today. AT&T's local bottlenecks were a serious problem that impeded competition in long-distance and terminal equipment markets. Initially, MCI brought suit, alleging that AT&T was preserving its monopoly in both markets by denying competitors access to their local circuits. These suits were followed in 1974 by the Sherman Act suit filed by the Justice

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[27] *Microwave Communications, Inc.*, 18 FCC 2d 955 (1969).

[28] *MCI v. FCC*, 561 F. 2d 365 (D.C. Cir. 1977).

[29] Hush-A-Phone Corporation v. United States, 238 F. 2d 266 - Court of Appeals, Dist. of Columbia Circuit 1956.

Department.[30] After eight years of legal proceedings, including the government's presentation of its case in Federal District Court, AT&T and the Justice Department negotiated a consent decree that would require AT&T to divest itself of its local bottleneck operating companies, including the wireless operations. AT&T would keep the long-distance operations, a large share of the research capabilities of Bell Laboratories, and the manufacturing operations, known then as Western Electric.

The Early Results of the Divestiture

We will not review in this paper the entire history of antitrust and regulation in the U.S. telecommunications sector that culminated in the filing of the *AT&T* case.[31] It is sufficient to note that the case was brought because AT&T, a regulated firm, was allowed by its (federal and state) regulators to engage in strategies that allegedly reduced competition in the markets for long-distance services and terminal equipment. In part, the FCC and state regulators were motivated in this regard by a desire to let AT&T reap substantial rents from long-distance services so as to keep local rates low, particularly in rural areas, a policy of cross subsidy often defended as one that promotes "universal service." In terminal equipment, however, the federal courts rejected the last challenge to the FCC's decision to allow competing equipment to be connected to AT&T's local lines. By the time of divestiture, therefore, the focus was squarely on long-distance and related services, and the mechanism chosen to create competition in such services was to isolate the monopoly local bottlenecks that AT&T had used to frustrate the development of long-distance competition.

The decree that divested AT&T's operating companies from the parent required that the divested local Bell Operating Companies establish equal access to their local circuits for all long-distance carriers. Once this access was established, access charges had to be set for interstate calls by the FCC. Before divestiture, there were no such explicit charges for AT&T's long-distance operations; long distance revenues were apportioned to local and long-distance operations by a rather opaque regulatory "settlements" process. Through this process, the local companies defrayed a large share of their non-traffic sensitive operating costs from overpriced long-distance calls and, therefore, were able to keep local charges rather low. After the divestiture in 1984, however, the FCC was required to establish explicit interstate access charges that would be paid by the long-distance carrier, AT&T, and its competitors to the divested local Bell operating companies. The FCC realized that it would have to set these access charges far above the long-run incremental cost of originating or completing long-distance calls if it were to maintain the *status quo*. Deciding, quite reasonably that maintaining high access charges was inefficient, the Commission established a policy of reducing interstate access charges (from a level of about 36 cents per minute in 2010 dollars at each end of the call) and transferring the burden of non-

[30] *United States v. AT&T*, 552 F Supp 131 (D DC 1982).

[31] For the details, see Crandall (1991) and Kellogg, Thorne, and Huber (1992).

traffic-sensitive costs to fixed monthly subscriber fees. Today, these access charges are approximately 0.5 cents per minute.

The Effects on Long Distance Services

After the 1984 divestiture, AT&T's share of long distance revenues began a long, slow decline as Table 1 shows. It would require more than twelve years for its competitors to wrest half of its market share from it, but thereafter the rate of decline accelerated because long-distance calling shifted away from these carriers to the wireless (cellular) carriers due to a pricing innovation introduced ironically by AT&T Wireless. In 1998, AT&T Wireless began to offer its Digital One Rate plan, which allowed subscribers to call from anywhere in the United States to anywhere in the United States at the same rate per minute, thereby ending the distinction between "long distance" and "local" calling. This innovation was matched by its competitors in 1998–99, resulting in massive migration of "long-distance" calling from the traditional long-distance carriers, AT&T, MCI, WorldCom, Sprint, and the rest, to wireless carriers.

Table 1

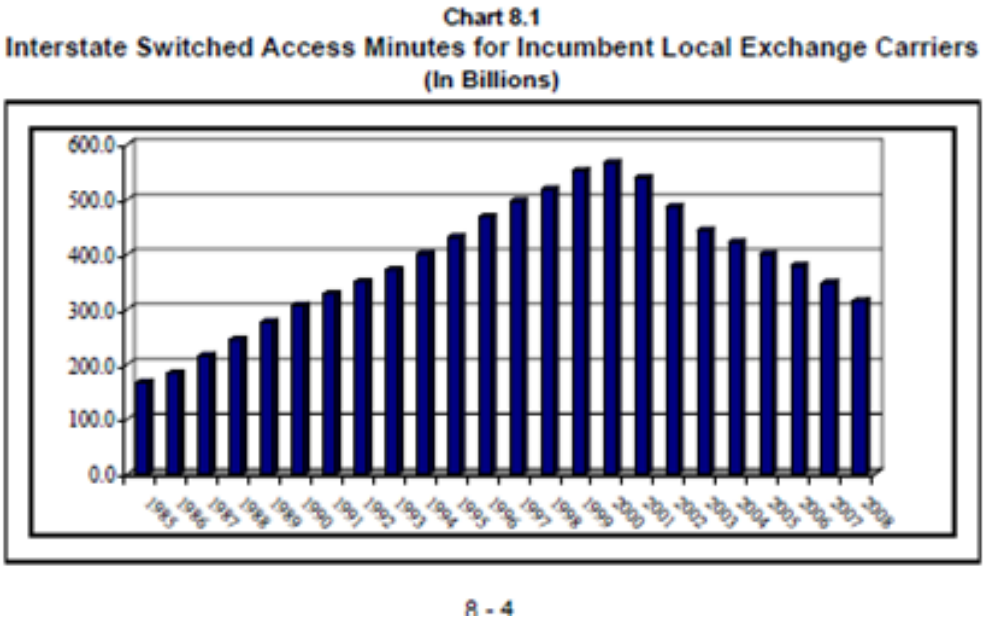
Shares of Total Long Distance Carrier Revenues, 1984–2001 (%)

Year	AT&T	MCI	Sprint	Others[a]
1984	90.1	4.5	2.7	2.6
1985	86.3	5.5	2.6	5.6
1986	81.9	7.6	4.3	6.3
1987	78.6	8.8	5.8	6.8
1988	74.6	10.3	7.2	8.0
1989	67.5	12.3	8.4	11.8
1990	65.0	14.5	9.7	10.8
1991	63.2	15.6	9.9	11.3
1992	60.8	18.1	9.7	11.5
1993	58.1	19.7	10.0	12.3
1994	55.2	20.7	10.1	14.0
1995	51.8	24.6	9.8	13.8
1996	47.9	25.6	9.7	26.8
1997	43.8	25.6	9.5	21.0
1998	43.1	23.5	8.5	24.9
1999	40.5	23.7	9.8	26.0
2000	37.9	22.4	9.0	30.7
2001	37.4	23.4	9.3	23.8

a – Includes wireless long-distance revenues. Source: FCC.

Between 2000 and 2008, so much traffic shifted to wireless carriers and VoIP services (such as Vonage or Skype) and cable telephone services that the traditional local fixed-wire carriers' interstate access minutes fell by nearly one-half (See Figure 3).[32]

Figure 3



Source: FCC, December 2008 Monitoring Report, available at http://www.fcc.gov/wcb/iatd/monitor.html.

The new competition in long-distance services and the steady decline in interstate access charges obviously led to steadily declining long-distance rates. But the real price of telephone services had already been declining before divestiture, as Figure 4 shows. This decline in the overall price of telephone service was actually reversed during the process of divestiture but then returned to its pre-divestiture pace after 1985.[33] Why was there no acceleration in the decline of consumer telephone rates as competition in long-distance blossomed? The answer is rather simple: because most of the decline in long-distance rates was achieved by the regulatory rebalancing of rates. Long-distance access charges were reduced and the resulting reduction in local-carrier revenues was fully offset by increased fixed monthly (local) charges.[34] This rebalancing was clearly welfare enhancing, but it did not result in any acceleration of the price decline that was already

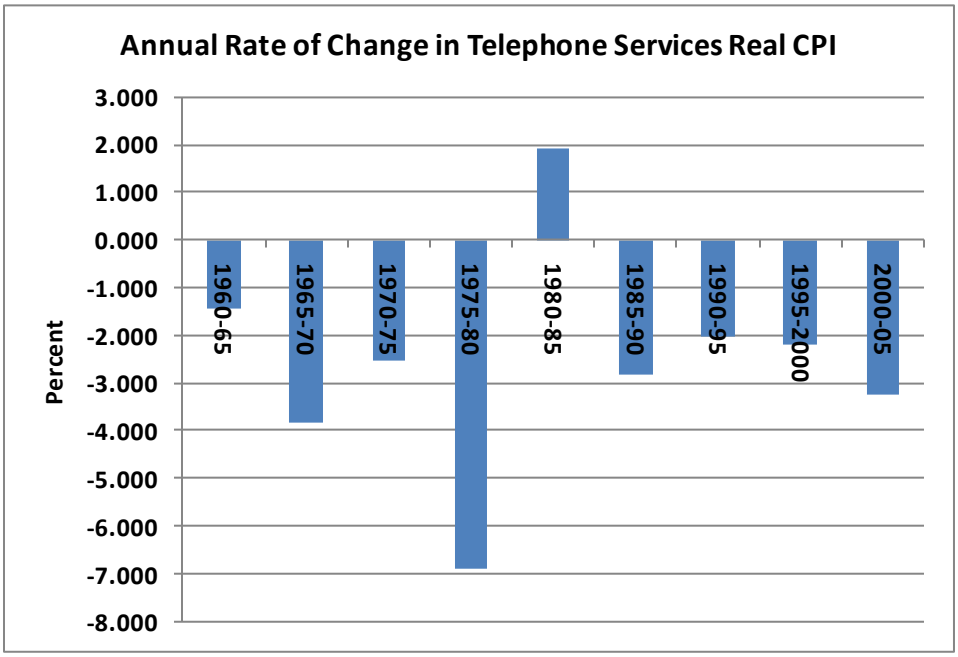
[32] The decline in access minutes routed over ILEC networks flows from two causes. First, many long-distance calls to wireless users avoid the ILEC networks altogether. Second, long-distance calls routed over VoIP connections are currently treated as information services and do not incur access charges. Thus, if a telephone user changes from a traditional long-distance carrier to a new VoIP carrier and maintains exactly the same calling pattern, ILEC access minutes will decline.

[33] See Crandall (1991) for a discussion of the cost of the divestiture.

[34] The reduction may also be masked by problems with the calculation of the CPI caused by the introduction of new pricing plans. Moreover, the CPI probably did not account for changes in the quality of telephone service caused by the shift to digital technology. See Hausman (2003) for a discussion of bias in the CPI.

occurring in post-1960 telephony. Thus, the principal intermediate term benefit of the *AT&T* case was to reverse the distorted regulatory pricing erected by the FCC and state regulators in the name of universal service. This suggests that the FCC, not AT&T, should have been the target of the Justice Department.

Figure 4

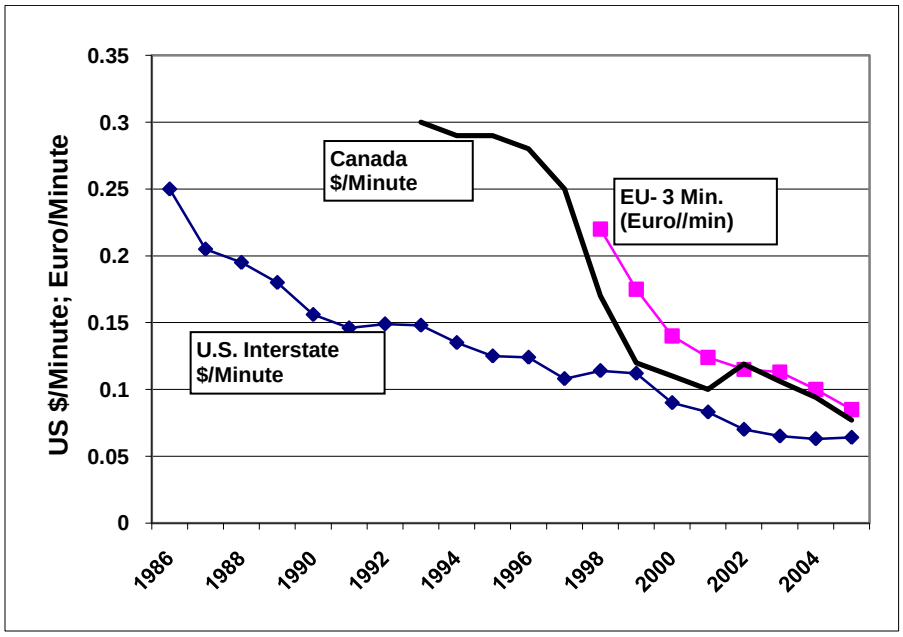


Source: BLS

The divestiture of AT&T's operating companies was sought by Assistant Attorney General Baxter as the mechanism to assure that the operating companies would not discriminate against non-AT&T long-distance carriers or non-Western Electric manufactures, but was such a remedy necessary? Elsewhere, one of us has shown that subsequent to the AT&T divestiture, Canadian and EU authorities achieved a much more rapid rate of price decline in long-distance services by simply mandating equal access.[35] (See Figure 5.) Neither jurisdiction sought a breakup of their national incumbent carriers. Of course, both jurisdictions had the benefit of observing the costs and subsequent difficulties of enforcing the *AT&T* decree, and both were able to see that mandating equal access was the key to stimulating long-distance competition.

[35] See Crandall (2005).

Figure 5
Long-Distance Rates in the United States, the European Union, and Canada



Sources: U.S. – FCC; EU –European Commission, Information Society, 9th and 11th Implementation Reports; Canada –CRTC, Competition Reports, available at http://www.crtc.gc.ca/PartVII/eng/monitor/pub_arch.htm

Competition in Local Access Services

Although the divestiture and equal access provisions of the decree unleashed competition in the long-distance sector, there was limited entry into local exchange services for the entire fourteen-year duration of the decree. There were two forms of such entry. New local competitors sometimes called competitive access providers (CAPS) built fiber networks in areas with concentrations of large office buildings such as Manhattan or the Chicago Loop. The primary service offered by these firms was the connection of large enterprises to long-distance networks bypassing the access services of the local exchange carriers. The second source of competition, wireless services, developed slowly because of its high costs, the difficulty of building out the necessary infrastructure, and the fact that the FCC limited the number of licensees to two per local market until 1995. The long-distance carriers and competitive access providers did not enter local low-density fixed-wire service markets because presumably they did not view these markets as contestable. Instead, the long-distance carriers and the divested regional Bell operating companies (RBOCs) devoted a substantial amount of resources to arguing about the line-of-business restrictions placed on the RBOCs by the decree. These debates would shift to the FCC after the decree was vacated and replaced by the 1996 Telecommunications Act.

One further aspect of the *AT&T* decree deserves comment. When the divestiture of AT&T's operating companies was being discussed by the Justice Department and AT&T, wireless cellular service was in the process of being deployed for first time. The consent decree breaking up AT&T left the wireless licenses with the local operating companies. At the time, few—including the Justice Department—could have foreseen the competitive potential of wireless.[36] Had the Justice Department anticipated that wireless would be the route to weakening the local exchange companies' bottleneck grip on local access, it could have insisted that the wireless operations remain with the parent, AT&T. On the other hand, AT&T Chairman Charles Brown may have foreseen the potential of wireless. If so, he might have acquiesced in giving these licenses to the local operating companies because such a decision would redound to the benefit of the AT&T stockholders, who would receive shares of the operating companies and the new AT&T on January 1, 1984.

The Divested Manufacturing Business

AT&T was not required to divest Western Electric, because the divestiture of the operating companies severed the corporate link between Western Electric and the local operating companies from which it derived approximately 80 percent of its sales. Twelve years after divestiture, AT&T spun off its manufacturing activities, including Bell Labs, into a new firm named Lucent Technologies. AT&T's stated rationale for this further divestiture was that many of the potential customers for its network equipment operated networks that competed with AT&T's network service and were therefore reluctant to do business with a competitor.

In 1989 one of us reviewed the immediate postdivestiture manufacturing market and concluded that "divestiture opened up rather aggressive competition in the central office market between AT&T and Northern Telecom" and "divestiture has worked to free the BOCs to purchase equipment from other, perhaps lower cost, suppliers."[37] Between 1982 and 1995, Lucent grew steadily as it expanded its sales to a variety of competitive network operators.[38] Thereafter, however, it made the mistake of financing the sales of equipment for the new Competitive Local Exchange Carriers (CLECs) that entered local telecom markets as the result of the 1996 Telecommunications Act. When these CLECs began to fail and the telecom stock bubble burst, Lucent's stock price collapsed, falling by more than 98 percent between December 1999 and

[36] McKinsey and Company famously predicted that total U.S. cellular subscriptions would total no more than 1 million by 2000.

[37] Crandall and Flamm, (1989), p. 139.

[38] Lucent's 1996 SEC Form 10-K displayed pro-forma income statements for 1992 through 1995, when the manufacturing activities were still part of AT&T. Manufacturing revenues in 1995 were $21.4 billion. The BLS PPI for Telephone and Telegraph Apparatus increased by 1.182 from December 1985 to 1995. Projecting that increase back linearly to mid-1982 gives a PPI increase of 1.28 from 1982 to 1995. Using this PPI factor, Western Electric's 1982 sales would have been valued at $16.1 billion in 1995. Therefore, the separated manufacturing operations were able to grow in real terms.

September 2002. Ultimately, Lucent was forced into a merger with Alcatel, the French equipment manufacturer, a merger that was completed in 2006.

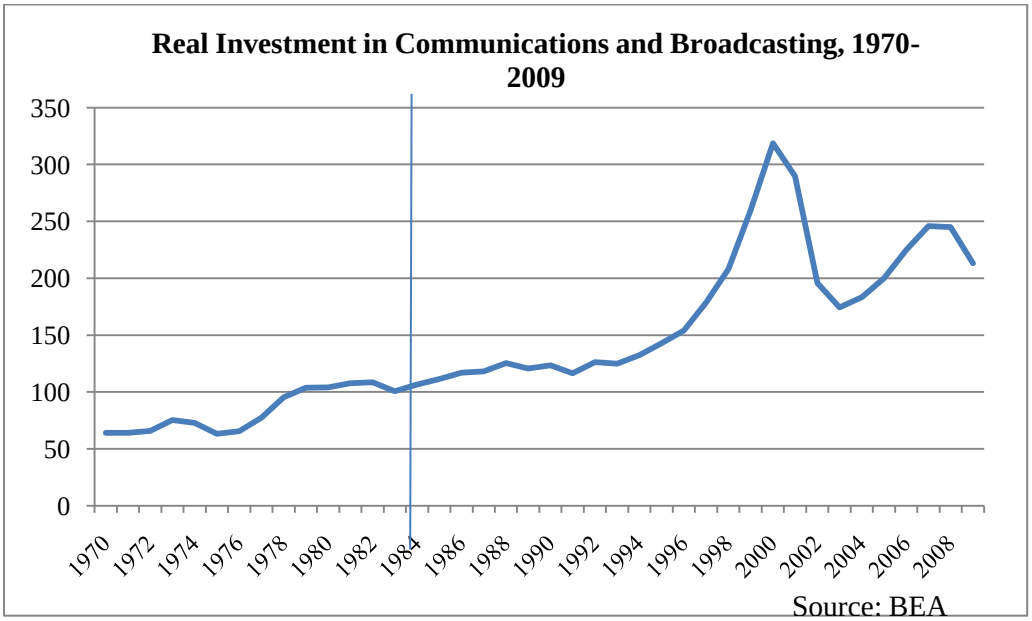
The Longer Run Changes in Industry Structure and Competition

Stunning changes in telecommunications did not occur in the immediate wake of the 1984 AT&T divestiture. Rather, they occurred in the 1990s as wireless became a full-fledged competitor of the fixed-wire platform and a completely new service emerged—high speed Internet access. These developments occurred after the 1996 Telecom Act replaced the 1982 *AT&T* decree.

One glance at Figure 6 is sufficient to suggest that a sea change occurred in the telecommunications and cable television sectors in the mid-1990s. This figure shows total capital expenditures by telecom, cable television, and broadcasting firms as compiled by BEA. Off-air broadcasters account for very little of this investment; it is driven by fixed-wire telecommunications, wireless services, and cable television. The surge in capital expenditures after 1995 came largely from the divested Bell operating companies, the long-distance carriers, the wireless (cellular) carriers, and the cable television companies. Except for the wireless carriers, these companies were attempting, in one way or another, to capture the new demand created by the Internet. The capital spending, particularly by the long-distance carriers, was driven in part by excessive estimates of the growth of telecom traffic likely to be created by the Internet. This spending resulted in the development of three platforms that would eventually compete for the mass market in voice, data, and video communications.

It is not necessary to analyze this post-1995 development of competition in the communications sector in this paper. It is sufficient to point out that it began to occur more than a decade after the AT&T divestiture and that the *AT&T* decree had only a limited effect in driving the post-1995 changes. The surge of entry into local telecom services spawned by the 1996 Act was heavily financed by Lucent and Nortel, who eventually were forced to write off billions of dollars of these loans when the new CLECs collapsed after 2000. The equipment producers, particularly Lucent, would likely have been much less willing to make these loans absent the 1984 AT&T divestiture, but without the divestiture there would not have been a 1996 Act to unleash the new CLECs.

Figure 6



When full-blown platform-based competition came to the local mass market, it developed from the cable television companies and the wireless carriers. It now seems clear that the FCC's decision in 1970 to bar the telephone companies from cable TV, and thus to allow the cable industry to evolve in parallel to the telephone network, did more to determine the competitive structure of today's telecommunications industry than did the AT&T divestiture. Similarly, the FCC's release of 120 MHz of spectrum for wireless services in 1995 made possible a substantial expansion in wireless capacity and permitted several firms to have sufficient spectrum to operate at an efficient scale.

Once the requisite technology emerged, cable television firms raced to modernize their distribution plant to enable it to carry two-way, high-speed Internet services, which eventually allowed them to offer voice communications through Voice over Internet Protocol (VoIP). In 2010, the Massachusetts Department of Telecommunications and Cable reported that cable-based telephone service was available to 97.1 percent of households in the state and that about one out of every three residential households with wireline telephone service had cable phone service.[39] The wireless carriers embraced the opportunity to purchase new spectrum auctioned by the FCC and to convert their services from analog to digital. The long-distance carriers, once seen as potential entrants into local telecommunications, found it uneconomic to overbuild the RBOCs and impossible to compete in just long-distance services after the broadband Internet

[39] Massachusetts Department of Telecommunications and Cable Competition, *Status Report*, 2010 at p. 12, and 23.

revolution was underway. The two largest long-distance carriers were acquired by AT&T's progeny, the RBOCs, by 2005.[40]

While the residential voice business has been transformed by wireless and VoIP over broadband access, the business communications world has been transformed by the competitive access providers, now called CLECs, firms offering collocation/hosting, and multiple specialized suppliers. As discussed above, CLECs operate fiber networks in areas with a large concentration of office buildings, and, as a result, a significant fraction of the nation's largest office buildings are served by fiber from more than one carrier.[41]

Collocation and hosting companies provide small and medium size firms with the efficiency advantages of large data centers. These companies operate specialized facilities that can support thousands or tens of thousands of servers and that are connected to multiple fiber carriers. Not only do these firms offer firms the advantages of secure buildings, highly reliable power supplies and air conditioning systems, they also eliminate the cost of local communications from the server to the fiber network.[42]

There are also multiple nationwide fiber networks—including Global Crossing, Qwest, Sprint, and Level 3 as well as AT&T and Verizon. AT&T and Verizon offer both wireless and wireline services nationwide. AT&T now owns the facilities of Teleport Communications giving it fiber in Manhattan and a number of other large cities outside the service areas of the divested Bell operating companies (SBC, PacTel, BellSouth, and Ameritech) that comprise the current AT&T. Verizon now has the local operations that MCI had acquired. Consequently, Verizon has fiber in many urban areas outside the service areas of the local telephone companies (Bell Atlantic, Nynex, and GTE) that are now part of Verizon. For example, MFS, one of the early CLECs, built a fiber system serving the Loop area in Chicago. MFS was acquired by WorldCom in 1996 and passed to Verizon when Verizon acquired WorldCom (by then renamed MCI). This competitive evolution of the business telecommunications market thus has its antecedents in the breakup of AT&T. But the AT&T divestiture was surely not a prerequisite for the competitive entry into national fiber networks, local fiber rings, or collocation/hosting that has developed over the last quarter century.

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[40] Sprint survives and offers long-distance service. See http://shop.sprint.com/en/solutions/unified_communications/index.shtml.

[41] One such CLEC, TW Telecom illustrates the general nature of such firms. TW Telecom offers service to business customers in 75 cities and has revenues of about $1.2 billion per year from slightly fewer than 30 thousand customers (about $40K/year per customer). It has fiber to about 11 thousand buildings and has about 27 thousand route miles of fiber. See http://www.twtelecom.com/Documents/Investors/Presentations/2010/TWTCInvestorPresentation_Sept2010.pdf

[42] Equnix provides a good example of a hosting/collocation firm. Equnix claims to have about 600,000 square feet for peering and collocation near Washington DC's Dulles airport (eight buildings in Ashburn, Reston, and Vienna), 400,000 square feet in Los Angeles, and almost a million square feet in the New York/Northern New Jersey area). These are warehouse-like buildings filled with racks of computers and connected to all the major fiber networks.

The competitive evolution of telecommunications was aided by two FCC policies and severely impaired by another. We have already mentioned the FCC's earlier decision to keep the telephone companies out of cable television, thereby facilitating platform competition in narrowband and broadband services beginning in the mid-1990s. Another factor driving the evolution of the market were the rules adopted in the FCC's Computer Inquiry II in 1980. These rules had the practical effect of deregulating advanced computer networking. As a consequence, the Internet services industry grew up almost entirely outside economic regulation. Unfortunately, the FCC failed to require the local telephone companies to interconnect with all long-distance companies in the same fashion. Such interconnection could have been required by regulation or statute, substantially reducing the need for antitrust intervention. [43]

The *IBM* and *AT&T* cases are far more similar than most observers would think. The government dropped the *IBM* case, but it achieved a major victory in *AT&T*. Both industries morphed from a highly concentrated market structure to a much more competitive one about 15 years or so after the Section 2 case was filed. In one case—*IBM*—there was no remedy, no decree. In the other, the government succeeded in obtaining a draconian structural remedy, the breakup of AT&T. But the ultimate market evolution in both cases, achieved through entry and the deployment of new technologies, had less to do with the Section 2 Sherman Act cases than with rapid technical change.

The antitrust authorities could not conceivably have predicted how the computer or telecommunications industries would change ten or fifteen years after they drafted their complaints. Nor could they possibly fashion decrees that would improve upon the outcomes ultimately achieved in the marketplace in these two high-tech industries. One should question, therefore, whether Section 2 is a useful tool for attacking monopoly power in such industries.[44]

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[43] Equal access could have been created by regulation or statute. Indeed, equal access legislation passed the Senate (S898) in 1981. See http://thomas.loc.gov/cgi-bin/bdquery/z?d097:SN00898:@@@D&summ2=m& for a summary) and the House Commerce Committee (HR6121) in 1980.

[44] There was another thread to the Section 2 litigation against AT&T. At the time of divestiture, the Bell System was the nation's largest business firm. It accounted for a little more than two percent of GNP. Some were concerned that such a concentration of private power was unacceptable in a democracy. Judge Greene's order adopting the Modified Final Judgment explicitly referred to such concerns. Concluding a two-page discussion of the degree to which the antitrust laws are hostile to concentrations of private power, Judge Greene wrote,

"In any event, it is antithetical to our political and economic system for this key industry to be within the control of one company…. For these reasons, the Court concludes that the loosening of AT & T's control over telecommunications through the divestiture of the Operating Companies will entail benefits which transcend those which flow from the narrowest reading of the purpose of the antitrust laws." (552 F.Supp. 131 (1982) at 165)

IV. Microsoft

In 1994, the Department of Justice filed a Section 1 and 2 Sherman Act suit against Microsoft, alleging that its long-term per-processor contracts with computer companies and its non-disclosure agreements with independent software vendors effectively foreclosed entry into the market for personal-computer operating systems. This suit was settled by a consent decree in 1994 that barred Microsoft from requiring computer companies to pay a license fee for Microsoft's operating system on each computer that it shipped even if some computers did not have the Microsoft software on them. In addition, the decree limited the time period for non-disclosure agreements with independent software vendors.

When Microsoft released a new Windows operating system in 1997, it required computer manufacturers to install its new browser, IE4, with the operating system. This led the Justice Department to file a complaint with the District Court that the tying arrangement violated the 1994 consent agreement, a contention that was rebuffed by the U.S. Court of Appeals.[45] This reversal, in turn, led the government to file a new Sherman Act suit against Microsoft in May 1998. After a full trial on the merits of the case, Judge Robert Penfield Jackson issued his opinion, finding that Microsoft had violated Section 2 of the Sherman Act.[46] Subsequently, and without a formal hearing, Judge Jackson ordered that Microsoft be broken up into two separate companies—one for its Windows operating system and one for its application software.[47]

Judge Jackson's order to break up Microsoft was reversed on appeal, and Jackson was removed from the case by the U.S. Court of Appeals because of his improper contacts with the press and the public as he considered the case.[48] Two years later, a new judge issued a decree that represented the results of extensive bargaining between the Justice Department, Microsoft, and several litigating states.[49] This decree had three sets of provisions: one prohibited a variety of business practices that Microsoft could use to maintain its market power in operating systems or use that market power to advantage Microsoft in other markets; a second set imposed disclosure and licensing requirements regarding interconnection standards and related intellectual property; and a third consisted of an exemption from the disclosure obligations if such disclosure would threaten various security needs. The consent decree was time limited—reducing the risk that changing technology and markets would make it more damaging.

Microsoft has also been the target of continuing antitrust enforcement actions in the European Union. The EU's antitrust enforcement arm, the Directorate General for Competition (DG Competition), pursued concerns regarding Microsoft's behavior that paralleled those of DOJ. As a result, DG Competition and DOJ coordinated their activities on the Microsoft case.

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45 United States v. Microsoft Corp., 147 F.3d 935 (D.C. Cir. 1998)

46 *U.S. v. Microsoft* and *State of New York v. Microsoft*, 87 F.Supp 2d 30 (D.C. D.C. 2000)

47 *U.S. v. Microsoft* and *State of New York v. Microsoft*, 97 F.Supp 2d 59 (D.C. D.C. 2000)

48 *United States v. Microsoft Corp.*, 253 F.3d 34 (D.C. Cir. 2001)

49 *United States v. Microsoft Corp.*, 2002 WL 31654530 (D.D.C. Nov. 12, 2002) *(Final Consent Decree)*

The 1994 Consent Decree mentioned above was negotiated by Microsoft on one side and DG Competition and DOJ on the other. In 1998, Sun Microsystems Inc. filed a complaint at the EU against Microsoft alleging that Microsoft was failing to disclose interoperability information needed for others to connect desktop PCs to servers efficiently. In February 2002, the EU began its own investigation of Microsoft.[50] In May 2004, the EU concluded that Microsoft had abused its dominant position in the market by (a) failing to supply necessary interoperability information needed to interconnect PCs running the Windows operating system with work group servers and (b) bundling Windows Media Player with the Windows operating system.[51] The EU fined Microsoft 497.2 million Euros and directed Microsoft to supply the necessary interconnection information and to stop bundling Windows Media Player with the operating system.

In November 2005, responding to complaints from Sun and others, the EU found that the interconnection information supplied by Microsoft was "neither accurate nor complete."[52] The EU also found that Microsoft's proposed royalty schedule for licenses to Microsoft intellectual property used in such interconnection were excessively high. The EU imposed a fine of two million Euros per day for every day beyond December 15, 2005 that Microsoft continued to fail to comply. In July 2006, the EU found that Microsoft had not delivered the necessary information by June 20, imposed an additional fine of 285.4 million Euros and increased the daily fine for non-compliance to three million Euros per day. In February 2008, the EU found that Microsoft had been in compliance only as of October 22, 2007, resulting in a fine of another 899 million Euros.

One month earlier—in January 2008—the EU had opened another investigation of Microsoft in response to a complaint by Opera, a firm that sold a browser competing with Microsoft's Internet Explorer browser. This investigation focused on the extent to which Microsoft was tying the sale of certain browsers to sales of the Windows operating system. In December 2008, the EU accepted Microsoft's commitment to unbundle its browser from the operating system. This unbundling was even retroactive as Microsoft modified the Windows update service so that users of recent versions of Windows whose software was configured to use Microsoft's web browser would be presented with a choice page allowing the user to pick a preferred browser from a set of twelve browsers. Microsoft also created a website (www.browserchoice.eu) that gave users a simplified means for downloading and installing one of the 12 browsers. Soon after this choice mechanism became effective in early 2010, some browser suppliers reported that downloads had more than doubled.[53]

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[50] This account of the EU Microsoft case is based on *Final report of the hearing officer in Case COMP/C-3/37.792 — Microsoft.* Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52007XX0206(03):EN:NOT

[51] *Commission Decision of 24 May 2004.* Available at http://ec.europa.eu/competition/antitrust/cases/dec_docs/37792/37792_4177_1.pdf. .

[52] *Commission Decision of 10.11.2005*

[53] See http://abcnews.go.com/Technology/wireStory?id=10135698.

Observations on the Antitrust Issues

The two key steps in a Section 2 analysis are defining the relevant product market and determining which of the defendant's actions constitute anticompetitive conduct. The market definition used by DOJ was narrow and archaic; it did not properly describe the products at issue. Given that definition, it was almost impossible for Microsoft not to engage in various forms of "anticompetitive behavior." Microsoft's alleged anti-competitive actions included developing, promoting, and distributing its own web browser, Internet Explorer, and developing and distributing a variant of SUN's Java technology.

1. Defining the Product Market

Perhaps the most interesting issue in the Microsoft cases is the proper definition of the product market. The objections to Microsoft's bundling of its web browser (Internet Explorer) and media player (Windows Media Player) with its operating system derived from the allegation that Microsoft was tying a competitive product to a monopoly product and thus extending its market power. For example, Franklin Fisher, DOJ's Expert Witness on economic issues, criticized Microsoft's contractual provisions limiting the extent to which computer manufacturers could pre-install alternate browsers on Windows. He asserted that "Their purpose and effect are to weaken Microsoft's browser competition in order to protect Microsoft's business in operating systems."[54] That assertion makes sense only if the browser is not part of the operating system.

The Consent Decree in the Microsoft case defined an operating system in the following manner:

> "'Operating System' means the software code that, inter alia, (i) controls the allocation and usage of hardware resources (such as the microprocessor and various peripheral devices) of a Personal Computer, (ii) provides a platform for developing applications by exposing functionality to ISVs through APIs, and (iii) supplies a user interface that enables users to access functionality of the operating system and in which they can run applications."

But a quite different definition is offered by the Free Software Foundation (FSF):

> Unix-like operating systems are built from a collection of libraries, applications and developer tools — plus a program to allocate resources and talk to the hardware, known as a kernel.[55]

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[54] *Declaration of Franklin M. Fisher* at p. 8.

[55] See www.gnu.org. The FSF is an organization that develops and distributes free system software. They maintain that "The combination of GNU and Linux is the GNU/Linux operating system, now used by millions and sometimes incorrectly called simply 'Linux'".

FSF also states,

> "A Unix-like operating system is much more than a kernel; it also includes compilers, editors, text formatters, mail software, and many other things. Thus, writing a whole operating system is a very large job. We started in January 1984. It took many years. The Free Software Foundation was founded in October 1985, initially to raise funds to help develop GNU."[56]

> "By 1990 we had either found or written all the major components except one—the kernel. Then Linux, a Unix-like kernel, was developed by Linus Torvalds in 1991 and made free software in 1992. Combining Linux with the almost-complete GNU system resulted in a complete operating system: the GNU/Linux system. Estimates are that tens of millions of people now use GNU/Linux systems, typically via distributions such as Slackware, Debian, Red Hat, and others."[57]

For the past two decades, the definition offered by FSF has been closer to actual practice than the definition used in the consent decree and by DOJ in the Microsoft litigation. The software element, referred to as a kernel by FSF, is defined by DOJ as an operating system . A plain English definition of desktop operating system that reasonably describes products like Windows 7, Apple's OS X, Sun Solaris, or Red Hat Enterprise's Linux 5 Desktop is as follows:

> That bundle of software including a kernel, user interface systems such as command line interfaces or graphical user interfaces, basic system utilities such as simple editors, compilers, backup software, file system managers, and commonly used applications such as low-end word processing software, calculators, and web browsers that desktop computer users often use or find essential to the operation and management of the computer system.

The bundle of software that is called an operating system has clearly expanded over time. The history of Microsoft Windows illustrates this well. Windows 1.0 was a separate program that ran as an application on MS DOS. Examples of operating system elements or capabilities that were originally available as separate products from vendors other than Microsoft, but are now integral parts of operating systems, include the following:

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56 *Id.*

57 See http://www.gnu.org/gnu/gnu-history.html.

Graphical User Interface

Disk Compression

Large Font Libraries

Networking

TCP Networking

Remote Terminal Software

Four of these, disk compression, font libraries, and networking/TCP networking, appear to fit the more narrow definition of an operating system even though they first appeared as separate products.

It is less clear that remote terminal software or a graphical user interface fits that definition. Microsoft describes the HyperTerminal tool that was bundled with several versions of Windows as:

> HyperTerminal is designed to be an easy-to-use tool and is not meant to replace other full-feature tools available on the market. You can use HyperTerminal to perform the specific tasks described above, but do not attempt to use HyperTerminal for more complex communication needs. For more information on what HyperTerminal does and does not support, see the HyperTerminal frequently asked questions list at the Hilgraeve Web Site. [58]

Products like HyperTerminal allow users to dial in to computer bulletin boards or other character-based information sources such as early CompuServe. HyperTerminal was not developed by Microsoft; rather, Microsoft licensed the software from Hilgraeve Inc. and resold it. HyperTerminal is not bundled with the more recent versions of Windows (Windows Vista and Windows 7); it can be purchased from Hilgraeve for $59.[59] Windows 7 includes a program named WinRS that offers a more focused capability that probably fills many of the needs that HyperTerminal would be used for today. When Microsoft and Apple included disk compression and fonts in their operating system products, the sales of stand-alone disk compression and font packages shrank markedly. The price of stand-alone disk compression and font management software was a substantial fraction of the cost of a copy of the Microsoft operating system. In 1990, the combined price of terminal software, a font library, and disk compression software was roughly the same as the cost of a copy of the Microsoft operating system.[60]

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[58] http://technet.microsoft.com/en-us/library/cc736511(WS.10).aspx.

[59] See https://store.hilgraeve.com/order/index_html. On October 9, 2010, the Hilgraeve website offered an electronic download version of HyperTerminal for $59. To put that price in perspective, on that same day Amazon offered Windows 7 Home Premium for $176.99 and Windows 7 Ultimate for $269.99.

[60] An article in *Infoworld*'s February 15, 1993, issue stated that the list price for Stacker 3.0 (disk compression software) was $149. An article in *Infoworld*'s August 29, 1994, issue stated that the street price for the

The expansion of the bundle of software included in the packages sold as "operating systems" has continued. Currently, Apple's OS X includes a calculator, a chess game, the *New Oxford American Dictionary* and *Oxford American Writer's Thesaurus*, a DVD player, a font manager, media center software (Front Row), a personal calendar application, Apple's iTunes digital jukebox, email software, software for limited editing of PDF files, the Safari web browser, a simple text editor that includes such features as smart quotes and kerning, a backup application, a data and equation graphing application, and an X11 windowing package. The web page listing these software packages is titled *All Applications and Utilities* and lists 25 software packages under the heading applications.[61]

Apple describes the backup software of OS X saying, "What makes Time Machine different from *other backup applications* is that it remembers how . . ."[62] That phrasing indicates that the Apple copyrighter thought of Time Machine as an application—not just a component of a limited operating system. The graphing application was originally sold as a stand-alone product Curvus Pro X with a $39 licensing fee. X11 windowing software is not provided as part of Microsoft Windows but can be purchased from third-party vendors. One such product, X-Win32 from Starnet Communications, sells for $285 to commercial customers; another, Open Text's Exceed, costs $545 in single unit quantities.[63] There are also free versions of X11 windowing software available for Windows.[64]

Microsoft Windows does not contain many of the applications bundled with the Mac's OS X. In fact it contains fewer of those applications than it once did. For example Windows 7 does not include the email package or the messaging software that was included in Windows XP. Both of these applications are available for free to users of Microsoft Windows.[65] They can be downloaded together with some other basic applications from the Microsoft web site. It seems curious that this software is not included on the distribution DVD for Windows 7—it does not occupy much space and the DVD used to install Windows 7 is only about 60% full—therefore, there is plenty of room for Microsoft to distribute these applications with the operating system rather than merely make them available for download for free. Microsoft Security Essentials, discussed in greater detail below, is another free software package available from Microsoft for use with Windows but that is not packaged on the Windows installation disk. Some consumers who would benefit from using these programs will be unaware of the option to download them; other users will lack the skills or Internet access needed to download the programs. It is hard to

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upgrade to MS-DOS version 6.22 was $40 to $50. An article in *Infoworld*'s October 29, 1990, issue stated that the price for Adobe Type Manager was $99.

61 See http://www.apple.com/macosx/what-is-macosx/apps-and-utilities.html.
62 Ibd. Emphasis supplied.
63 See http://connectivity.opentext.com/buy-online.aspx. Price observed on 10 October 2010.
64 See, for example, http://www.straightrunning.com/XmingNotes/.
65 See http://windows.microsoft.com/en-US/windows7/products/features/windows-live-essentials.

see how consumers benefit from Microsoft's decision to withdraw these features from the operating system or what financial motive Microsoft had to withdraw them.

The narrow market definition used by DOJ and the EU was necessary if they were to assert that Microsoft was attempting to use market power in the operating system market to gain market share in applications software markets, but that definition implies a static view of both technology and consumer expectations. The early versions of Microsoft operating systems were distributed on floppy disks that stored about 360 kbytes of data. The PCs on which they were used had limited memory (perhaps 64 kbytes) and often did not have hard disk drives. Obviously, bundling multiple applications on a single disk would have been a substantial challenge. As time passed both distribution media and computers improved as did the scale of the computer industry and consumer expectations. Modern desktop computers typically have a gigabyte (a million kbytes) or more of memory and more than a hundred gigabytes of disk storage. MS Windows is now distributed on DVD disks that can store almost five gigabytes of data. As the examples of common applications distributed as part of Apple's desktop operating system show, consumers have come to expect that operating systems will be far more than simple kernels.

One possible consequence of the market definition used by DOJ and the EU and their treatment of additions to the package of software sold as a Microsoft operating system is that Microsoft will fail to increase the capabilities of its operating system products as fast as would be most efficient given the changes in technology and consumer demand. No doubt this would be good news for Apple and vendors of software packages that offer capabilities that would be part of the Windows operating system in a more efficient world. But it would be a loss for consumers. Given that the various versions of the Microsoft operating system are, by far, the most widely used operating system for personal computers; the resulting consumer losses could be substantial.

2. Microsoft Security Essentials

Such harmful restrictions on the capabilities of Microsoft operating system products may have already occurred. Microsoft offers a free antivirus and computer security software package called Microsoft Security Essentials.[66] It can be downloaded from the Microsoft web site and has received positive reviews.[67] As best we can tell it is a sound product. It installs from an 8.3 megabyte file; therefore, space constraints on the distribution media do not prevent Microsoft from bundling it with its operating system products. As with the programs distributed as Microsoft Live Essentials, it is hard to understand how consumers benefit from Microsoft's decision not to bundle Microsoft Security Essentials with the Windows operating system.

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[66] See http://windows.microsoft.com/en-US/windows7/what-is-microsoft-security-essentials and http://www.microsoft.com/security_essentials/.

[67] See http://www.infoworld.com/d/windows/microsoft-security-essentials-free-so-whats-the-catch-105?page=0,1.

Moreover, the use of such security software creates benefits for others. Anderson and Moore summarized this well saying, "Network insecurity is somewhat like air pollution or traffic congestion, in that people who connect insecure machines to the Internet do not bear the full consequences of their actions."[68] To the extent that Microsoft's decision not to include this software with its operating system products results in a larger number of poorly secured computers connected to the Internet, even consumers who do not use Microsoft products may suffer.

Microsoft's decision not to bundle this product with the operating system may well flow from antitrust concerns. Microsoft's bundling of a web browser and of a media player were key elements of the antitrust cases against Microsoft. Nevertheless, the Microsoft consent decree attempts to mitigate the potential damages from limiting the scope of Microsoft's Windows operating system. It states, "The software code that comprises a Windows Operating System Product shall be determined by Microsoft in its sole discretion."[69] However, there are indications that providers of antivirus software products did see such bundling as a potential antitrust issue.[70] For example, the spokesman for one firm stated, "I am no expert on such things, but provided Microsoft does not bundle 'Morro' [an earlier name for Microsoft Security Essentials] in with its operating system I would be surprised if there were antitrust issue." The implicit threat in such a statement together with the historical example of antitrust attack on the inclusion of new features in Windows could be the cause of Microsoft deciding to deny consumers substantial benefits from such bundling.

3. The Browser as an Alternate Operating System

A key element of DOJ's arguments against Microsoft's bundling a web browser with Windows was that widely used, non-Microsoft browsers offered a potential competitive alternative to Microsoft's operating system products. Evidence produced at the trial indicated that Microsoft seemed to believe that such competition was possible. However, this notion appears weak in retrospect. At the time the suit was filed, the X window system, discussed above, already offered such a uniform platform for interconnecting with remote systems. It was (and still is) widely used to access programs running on Unix servers.

During the trial, it was asserted that Microsoft's bundling of its web browser with its operating system product was anti-competitive because Microsoft was giving its browser away for free or even paying manufacturers to install it on their computer products. It was providing the web browser at a low or negative price, even though it was spending about $100 million per year on developing that software. Fisher and Rubinfeld characterized this behavior saying,

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[68] "The Economics of Information Security," Ross Anderson and Tyler Moore, *Science*, 27 October 2006: Vol. 314. no. 5799, pp. 610–613, DOI: 10.1126/science.1130992

[69] Consent Decree, VI(U).

[70] See http://news.cnet.com/8301-13860_3-10101652-56.html.

> "Without the gain to Microsoft that would result from preserving its highly profitable operating system monopoly and from monopolizing the browser market, Microsoft's conduct does not make good business sense. It was giving away something that it had spent a lot of money to develop and distribute and something for which the leading competitor was charging."[71]

Fisher testified,

> Indeed, by bundling its browser with its operating system and giving away its browser for "free," Microsoft effectively prevents companies from successfully entering the browser market unless they successfully enter the operating system market at the same time.[72]

This analysis ignored a few key facts and was contradicted by subsequent events. At the time Microsoft introduced its browser, Netscape was giving its browser away to home users, but not to business users and was permitting users to download copies for a free trial with no automatic mechanism other than consumer respect for copyright to terminate use of the software at the end of the trial.[73] Although browser sales to businesses did provide significant revenue for Netscape, it was probably the case that many business users actually installed the free home edition. NCSA also provided its Mosaic browser for free for non-commercial use.[74] Thus, Microsoft had entered a "market" where the price for a significant fraction of the products sold was zero. Whatever logic induced Netscape to give away its browser for free to residential users probably applied to Microsoft as well.

Looking back today, Microsoft's practices do not appear as anticompetitive as they were portrayed at the time. Mozilla now distributes, for free to all comers, the Firefox browser. Firefox is widely believed to be the second most widely used web browser after Microsoft's Internet Explorer browser. The Mozilla Foundation has an income of about $100 million per year from licensing its browser and has total expenses of about $50 million per year.[75] The Mozilla Corporation, a wholly owned taxable subsidiary of the foundation, actually provides the browser. One might ask, why does Mozilla give its product away for free? Where does the revenue come from? Mozilla explains, "The majority of this revenue is generated from the search functionality in Mozilla Firefox from partners such as Google, Yahoo, Amazon, EBay, and others."[76] That is, Google pays Mozilla for distributing Firefox configured with Google as the default search engine.

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[71] Fisher and Rubinfeld at p. 21.

[72] Direct Testimony of Franklin M. Fisher, at p. 34.

[73] Netscape Communications Corp. SEC 10-K for 1996 at p. 36.

[74] Netscape Communications Corp. SEC 10-K for 1996 at p. 32.

[75] The Mozilla Foundation's 2008 audited financial statement showed royalty income of $83.6 million and software development expenses of $31.3 million.

[76] See http://www.mozilla.org/foundation/documents/mozilla-2008-financial-faq.html.

Given that Microsoft's share of the browser market is substantially larger than that of Firefox, Microsoft should be able to obtain benefits in excess of $100 million per year from its browser product. A similar motive likely explains Apple's development and distribution of a version of its (free) Safari browser that runs on Microsoft Windows.[77]

Firefox and Safari are not the only competing (free) browsers. Two years ago, Google began distributing its Chrome browser.[78] Since one of Google's primary activities is serving web pages to web browsers, it benefits from improvements in browsers that reduce the load a browser places on a web server. And, because web browsers are an essential complement to Google's services, better web browsers benefit Google. Moreover, Google's payments to Firefox probably go down if Firefox's market share declines. Google should have substantial incentives to develop and distribute high-quality browsers. It appears to be is doing so. Google's Chrome browser appears to have about a ten percent market share today up from 0 percent two years ago.[79]

4. Java Technology

In the early 1990s, Sun Microsystems released Java—a set of programming and software tools that combined a programming language, an extensive software library, and a technology (the Java Runtime Environment or JRE) that allowed Java programs to run on different computer operating systems without change. Java has many positive features but the one that was relevant to the Microsoft antitrust case was that it greatly facilitated the development of software that could run on both Microsoft Windows and other operating systems. Undoubtedly, tools that make it easier to develop and deploy application software in a form that can run on many operating systems pose a threat to Microsoft. When individuals and organizations consider buying a new computer system they take into account the extent that the software that they have purchased and the training they have invested in learning that software can be used with the new computer. Professor Fisher referred to this as *the applications programming barrier to entry.*[80] Technologies such as Java erode that barrier.

DOJ alleged that Microsoft tried to sabotage the development and adoption of Java for fear that widespread use of Java would weaken the application lock-in that made it hard for users to switch to other operating systems. Microsoft's alleged abusive actions included developing a variant of Java that was optimized to run on the Windows operating system and its distribution of Internet Explorer, which included the runtime-software for Microsoft's variant of Java. (Netscape's browser included the Java Runtime Environment.)

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77 See http://www.apple.com/safari/download/

78 http://googleblog.blogspot.com/2008/09/fresh-take-on-browser.html.

79 See http://www.pcworld.com/businesscenter/article/207082/browser_market_share_is_in_the_eye_of_the_beholder.html.

80 Direct Testimony of Franklin Fisher at p. 27.

The logic of some of the allegations against Microsoft's Java-related actions is hard to follow. For example, in describing Microsoft's efforts to undermine Java, Fisher referred to Microsoft's efforts to get Apple to adopt Microsoft's version of Java (J/Direct) as an example of that effort.[81] Recall that the theory of the alleged violation was that Microsoft was attempting to forestall the development of a technology (Java) that would permit application software to run on multiple operating systems. Convincing Apple to deploy a technology (Microsoft's variant of Java) designed to permit application software to run on multiple operating systems appears to be an ineffective way to prevent Apple and others from adopting technologies designed to permit application software to run on multiple operating systems. In this specific instance, the antitrust abuse appears to be inducing Apple to do what Microsoft is accused of preventing firms from doing.

In March 2002 Sun Microsystems filed a private antitrust suit against Microsoft. Twenty pages of Sun's 104 page complaint were devoted to Microsoft's anticompetitive acts against the Java Platform. Many of Sun's allegations of improper conduct paralleled those in the DOJ suit. In 2004, Microsoft and Sun settled that litigation with Microsoft paying Sun $700 million to resolve the antitrust issues.[82]

Assessing the Results of *U.S. v. Microsoft*

We now turn to an analysis of the provisions of the *Microsoft* consent decree and offer our views regarding their effects.

1. Interconnection Requirements

Three provisions in the consent decree facilitated interconnection with Microsoft's desktop operating system. Section III.D required Microsoft to disclose the application programming interfaces (APIs) used by software packages such as browsers and media players to communicate with the operating system. Section III.E required Microsoft to disclose communication protocols used to communicate between end-user machines and Microsoft servers. Section III.I required Microsoft to offer reasonable and non-discriminatory licenses to third parties to use any intellectual property necessary to use these APIs and communications protocols. Similarly, the EU's 2004 decision required Microsoft "to disclose complete and accurate interface documentation which would allow non-Microsoft work group servers to achieve full interoperability with Windows PCs and servers."[83]

These consent decree provisions appear to us to be provisions that enhance competition and probably contribute to economic efficiency. There is a strong parallel between these provisions and the equal access provisions imposed on the RBOCs in the AT&T divestiture. As we stated above, interconnection requirements, whether imposed by statute, the regulators, or an antitrust

81 Ibid, pp. 95-97.
82 http://www.microsoft.com/presspass/press/2004/apr04/04-02SunAgreementPR.mspx
83 See IP/04/382, Brussels, 24 March 2004

decree, were the key element in creating competition in long-distance telecommunications. Similarly, absent interconnection with fixed-wire networks, cellular firms would never have succeeded.

The disclosure obligations imposed on Microsoft appear to be working. Apple advertises that its Mac has built-in support for Microsoft Exchange and that the Mac can view shared files on PCs running Windows.[84] A 2006 brochure from Linux vendor Red Hat stated that "Windows users can access files and storage space through Red Hat Enterprise Linux file servers the same way they do with Windows-based file servers: "My Network Places" or "Map Network Drive"".[85] One of us has successfully accessed files shared using Windows from computers running Linux.

Perhaps the most convincing characterization of the effectiveness of Microsoft's disclosures was given by Andrew Tridgell. In the early 1990s, Tridgell reverse engineered some of Microsoft's networking protocols and developed software that could interoperate with them. His software evolved to become a software suite and open-source software project, named Samba.[86] Samba is the most widely used non-Microsoft implementation of the Microsoft networking and file sharing protocols.[87] Mr. Tridgell participated in the proceeding in the Court of First Instance (essentially the court appeal of the EU decision) that upheld the EU's 2004 decision.[88] After that decision, Mr. Tridgell became involved in negotiations with Microsoft that resulted in agreements that simplified the licensing of Microsoft protocols to the open source community and that made it easier for the open source community to understand the range of Microsoft's patent rights regarding implementations of these protocols. At the time of the agreements, Mr. Tridgell wrote, "Writing code which interoperates with Microsoft operating systems just got a lot easier."[89] In a conference presentation given in late 2008, Mr. Tridgell characterized the present state of affairs as "A huge opportunity" characterized by three features—documentation of Microsoft protocols, well-defined patent boundaries, and good support from Microsoft engineers.[90]

Although the requirements for disclosure of APIs and protocols facilitates competition with Microsoft in both the personal computer operating system market and the workgroup server market (the original purpose of requiring these disclosures), they have other impacts as well. Most important, they make it easier for firms to supply complements to Microsoft desktop operating systems products. Moreover, by opening and expanding the market for Microsoft-compatible networking, they attenuate the incentives others have to develop alternative networking standards. Microsoft has always understood the importance of a good supply of complements to their success. Indeed, it is the existence of such complements that creates many

84 http://www.apple.com/macosx/compatibility/
85 http://www.redhat.com/f/pdf/rhel/infosheet_fileserver.pdf
86 See www.samba.org.
87 A search on the IBM website for the term Samba returns 38,000 documents.
88 An account of Mr. Tridgell's involvement is given at http://samba.org/samba/PFIF/PFIF_history.html.
89 See http://samba.org/samba/PFIF/PFIF_history.html.
90 See http://samba.org/~tridge/talks/wspp.pdf.

of the network effects that benefit Microsoft. Microsoft has long invested significant resources into facilitating and expanding the supply of software products that run on Microsoft operating systems. Thus, the outcome of the required disclosures may well be both the enabling of competitors and the strengthening of Microsoft.

2. Contractual Restrictions

The various limits on Microsoft's ability to contract with equipment manufacturers, such as the prohibition on retaliating against a manufacturer because that manufacturer sells or distributes products that compete with Microsoft products appear unexceptionable. The consent decree also required that Microsoft enter into uniform license agreements with its original equipment manufacturer customers. This provision was more problematic than the others as situations vary and such uniformity may restrict Microsoft from pursuing a variety of innovative promotional and distribution agreements. However, this provision was eliminated when the consent decree was modified and the term of most of the requirements extended.

These contractual restrictions may have had a limited effect in the marketplace. For example, Dell and HP now sell personal computers that use the Linux operating system.[91] However, HP's website does not create the impression that HP is making a significant effort to push the sales of desktops running Linux. Nevertheless, many HP PCs have a dual-boot feature that permits the computer to boot up quickly into Linux and run a reduced set of key applications (email, web browser, calendar, Skype, etc.) or to boot more slowly into Windows and to run all the installed Windows applications. HP calls this capability QuickWeb and does not even promote the fact that this capability uses the Linux operating system.[92] The Microsoft consent decree prohibited Microsoft from blocking the use of such dual-boot features.[93]

3. Competition in Desktop Operating Systems

The consent decree seems to have had little impact on Microsoft's market share in desktop operating systems which appears to remain near ninety percent. However, Microsoft's share in the operating systems used by consumers on personal computing *appliances* has declined substantially. Although various versions of Microsoft Windows are available for smartphones, few smartphones run the Microsoft operating system. Far more people use smartphones that have operating systems from Apple, Google (Android), RIM (Blackberry), and Symbian (Nokia). A Gartner Research report that was released September 2010 forecast that the market share of Windows in the smartphone operating system market would decline to 3.9 percent in 2014 from

[91] See http://content.dell.com/us/en/enterprise/linux-the-value-of-linux.aspx and http://h20331.www2.hp.com/hpsub/cache/537200-0-0-225-121.html.

[92] See http://h71036.www7.hp.com/hho/us/en/pclc/articles/quickweb.html

[93] See Microsoft Consent Decree at III(C)(4)

its relatively anemic 8.7 percent share today.[94] A more recent Gartner report states that Google's Android operating system was installed on 20 million smartphones that shipped in the third quarter of 2010. In contrast, Microsoft Windows Mobile was installed on only 2 million smartphones.[95] To put these numbers in perspective, Gartner reported that worldwide PC shipments in the third quarter of 2010 totaled 88 million units of which 2 million were from Apple.[96] The Android operating system is shipping at a little over 20% of the rate of Microsoft Windows—impressive given that Android was first announced in November 2007.

This competition from a new technology based on smaller systems parallels the developments in the mainframe computer business. Just as personal computers based on microprocessors transformed the computer industry, smartphones and other personal information appliances such as iPads and Kindles appear to be on the verge of restructuring personal computing.[97] But, if this happens it will owe little to antitrust enforcement and much to changing technology and the existence of a competitive wireless industry. We should note that applications for the Android operating system are developed in Java.[98] But, it is likely that Java was chosen not because there was a large stock of Java applications that had been developed for Windows that could easily be ported to Android, but because it was a sound tool for the purpose.

4. Competition in Operating Systems for Servers

Although Windows has a respectable share of the server operating system business, its share is not nearly as dominant as it is in the desktop marketplace. Determining market share for server operating systems poses some difficulties. Counting unit sales is difficult because copies of the Linux operating system can be installed multiple times. Moreover, those copies do not generate any associated revenue. Nevertheless, some information on market shares is available. We show IDC/s latest estimates in Table 3.[99] In 2002, IDC reported that Microsoft's server operating market share was forty-nine percent—so, for all practical purposes, Microsoft's share has remained almost unchanged since the decree.

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94 "Gartner Says Android to Become No. 2 Worldwide Mobile Operating System in 2010 and Challenge Symbian for No. 1 Position by 2014," Press release, Gartner Research, September 10, 2010. Available at http://www.gartner.com/it/page.jsp?id=1434613.

95 See http://www.gartner.com/it/page.jsp?id=1466313

96 See http://www.gartner.com/it/page.jsp?id=1451742.

97 Both the Kindle's operating system and Google's Android operating system for smartphones are based on Linux. Applications for the Android operating system are developed in Java.

98 See developer.andrioid.com.

99 See http://www.idc.com/getdoc.jsp?sessionId=&containerId=prUS22467210&sessionId=95C59D87276DAF335C74B10A8294F8C9. See also http://www.zdnet.com/blog/microsoft/behind-the-idc-data-windows-still-no-1-in-server-operating-systems/5408.

Table 3

Server Operating System Market Shares, 2010

Operating System	Revenue Share
Windows	46.5%
Unix	26.2%
Linux	16.8%

Source: IDC

In contrast, Netcraft uses automated techniques to measure the web server software being used at some 200 million websites[100]. Its September 2010 survey, based on the million busiest web sites and reproduced in Table 4, showed that Microsoft has a rather small share of the market of the web server market.

Table 4

Server Operating System Market Shares, One Million Busiest Web Sites

Developer	August 2010	Percent	September 2010	Percent	Change
Apache	662,261	66.72%	662,006	66.66%	-0.05
Microsoft	167,429	16.87%	166,577	16.77%	-0.09
nginx	53,357	5.38%	54,560	5.49%	0.12
Google	18,929	1.91%	19,128	1.93%	0.02

Source: Netcraft

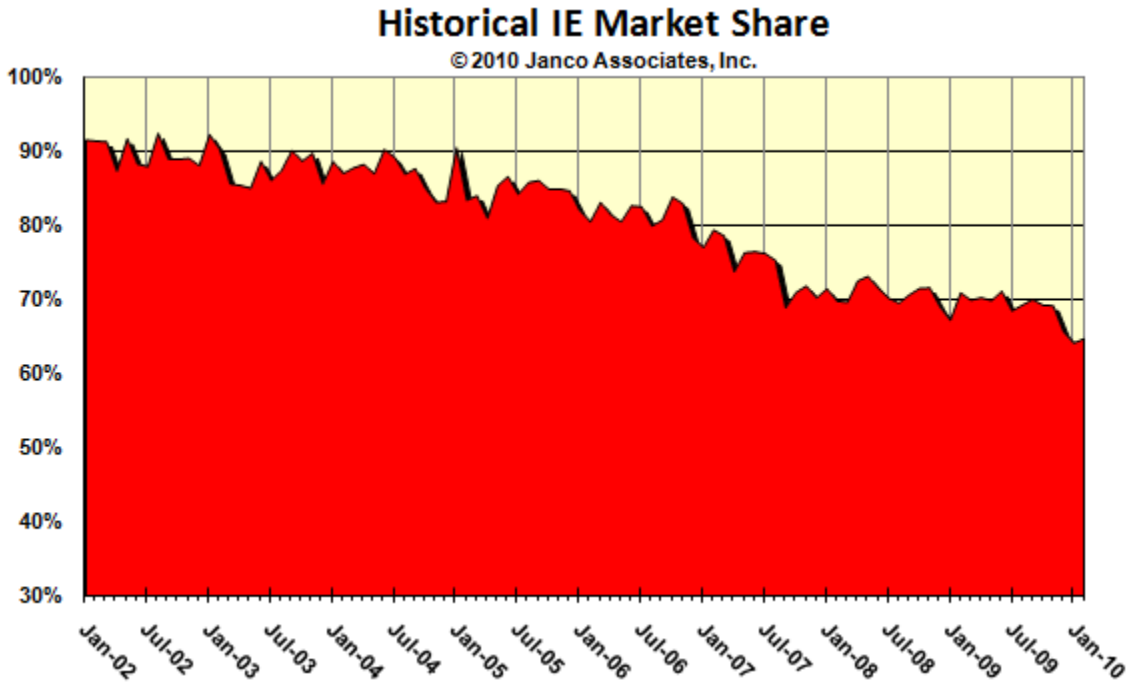
The Apache web server software can run on Windows, but it is most commonly run on Linux or Unix. Even though Microsoft's server business is apparently quite substantial, it has not been able to leverage its position in the desktop market to obtain a dominant position in the server market. It is unclear to us the extent to which the disclosure requirements resulted in this outcome. The server operating system market is quite unlike the desktop operating system market. Buyers tend to be larger organizations with more ability to analyze market alternatives. Some well-regarded server products, such as IBM's System z mainframes, do not run Microsoft operating systems. Widely used database systems such as Oracle and DB2 run well on Unix and Linux machines, and many servers are dedicated to a single task (web server, email server) or a few tasks so the availability of a wide range of application software is not important.

[100] http://news.netcraft.com/archives/2010/09/17/september-2010-web-server-survey.html#more-2807

4 . Competition in Browsers

It appears that Microsoft's share of browsers is declining (See Figure 7), but there is little evidence that the U.S. or EU decrees are having much effect on browser market shares[101] A market research firm, StatCounter, recently claimed that the global market share of Microsoft's web browser had fallen below 50 percent in September, 2010—a significant decline from 67 percent two years earlier.[102]

Figure 7



Source: http://www.psrinc.com/browser.htm

Microsoft's declining share changes the incentives faced by web site operators and Microsoft itself. When Microsoft had a ninety percent share of the browser market, it could introduce extensions to web standards that worked well with the Microsoft browser but that failed to work properly with other browsers. Even today there are many websites that do not display properly using a non-Microsoft browser. But, with Microsoft's browser share near fifty percent, the operator of a public website is unlikely to be willing to include features on the website that cannot be rendered properly by a significant fraction of browsers. This in turn creates pressure for Microsoft to conform its web server product to industry standards in order to maximize the value delivered to its customers. We expect that the net result of these pressures will be that

101 http://marketshare.hitslink.com/features.aspx.

102 http://gs.statcounter.com/press/microsoft-internet-explorer-browser-falls-below-50-perc-of-worldwide-market-for-first-time.

many web browsers will display standards-conforming web pages correctly. Browser competition will shift to consumer choices based on the user interface, speed, security, range of features, and reliability of web browsers.

It is difficult to determine how much of the change in the browser market derives from the various antitrust actions and how much arose from market forces. As discussed above, the Firefox web browser generates revenues well in excess of its running development costs.

5. Browser Wars and Cloud Computing

The theory that the Netscape browser and Java offered any short-term threat to the Windows desktop seems somewhat quaint today. Nevertheless, various elements of that scenario are now coming to fruition. Most important, cloud computing appears to offer a real threat to the desktop dominance of Microsoft. Many people may be able to meet most of their computing needs with a laptop or tablet computer and high-speed Internet access that allows them to use applications based on remote servers. Cloud computing is somewhat reminiscent of the centralized timesharing computer services of the 1970s. It offers many advantages over traditional desktop PCs with respect to administration, maintenance, and reliability for small and medium sized businesses. The key change in the environment that is contributing to cloud computing is the widespread availability of high-speed Internet access, including wireless Internet access, not the availability of competitive browsers. Standardized web browsers may be helpful in the adoption of cloud computing, but they are a distant second to high-speed networking as facilitators of cloud computing.

Java has turned out to be quite successful and is now widely used with web applications and proprietary software used inside organizations. Java's popularity can be judged from the fact that a search on the IBM website for the word *Java* returned five million hits.[103] Oracle claims that Java runs on 1.1 billion desktops and on three billion mobile phones.[104] Java is a key building block in many cloud-computing applications.

Java is just one of several application development frameworks—systems that provide a combination of programming and runtime environment. Eiffel permits development of applications that run on Windows, Linux, and Apples OS X.[105] The Python programming language is widely used for cloud computing and web applications. For example, Google allows use of Java and Python to program applications for the Google App Engine. Just as the application barrier to entry benefits Microsoft it harms application providers. An application provider who develops software that runs only on Microsoft Windows cannot easily sell that application to customers who use Apple Macs, Linux machines, or mainframe systems. Thus, many developers have a significant incentive to use a platform-independent development

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103 A search conducted November 29, 2010 found 4,790,000 results.

104 See http://www.java.com/en/about/.

105 http://www.eiffel.com/what-is-eiffel.html.

framework. This incentive may not be huge but is not negligible. Aggregating this demand across the entire universe of developers creates enough demand to support the development and distribution of multiple platform-independent application development frameworks. Looking back we cannot discern the extent that the remedies contained in the Microsoft consent decree facilitated the widespread adoption of Java. Certainly, the ease of downloading the Java Runtime Environment (JRE) over high-speed Internet access is a more important factor in the widespread availability of the JRE on desktop computers than is the consent decree's prohibition of Microsoft entering into contracts with computer manufacturers that precluded installing of JRE before sale.

Another factor that is changing the desktop operating system market is the development of high-quality virtualization environments such as VMware and Xen. It is now possible for a user to buy an Apple Mac and run Microsoft Windows in a virtual machine hosted on the Mac. This allows a user to switch from a Windows software platform to an Apple OS X platform but to retain access to a few key software tools that would be difficult or expensive to obtain in the Apple world. Thus, virtualization weakens the network effects that tie users to any single operating system. Similarly, the developer of a specialized application that runs only in Linux can create a virtual appliance that runs the application on a desktop running Windows.[106] The key technological advance making virtual appliances possible was the development of much larger hard disk drives—with the cost of disk storage having fallen to the pennies per gigabyte range. A virtual appliance that simulates a Linux machine with a twenty-gigabyte hard drive now occupies one or two dollars' worth of hard disk storage. Another important technological development was the creation of efficient virtual machine hypervisors that could run on desktop computers. Virtual appliances are still in their infancy, and it is too early to tell what impact they will have, but they offer a route to operating system competition completely different from that envisioned in the antitrust proceedings.

6. Summary: The Apparent Effect of the Decrees

To sum up, there are three emerging technologies that threaten Microsoft's comfortable position in desktop operating systems—smartphone operating systems, cloud computing, and virtual appliances. None of these appears to owe its emergence to the antitrust remedies. One might argue that cloud computing, to the extent that it depends on web browsers for access to the cloud, was facilitated by the antitrust remedies. However, as we showed above, both Firefox and Google have strong incentives to distribute competing browsers even when competing against Microsoft's zero-priced browser. Moreover, the web browser is not an irreplaceable building

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106 A virtual appliance is a virtual machine that is configured to run a specific application. There is a good exposition regarding virtual appliances at http://www.vmware.com/appliances/. An example of such an application is given by the Bluesocket wireless LAN product.[106] See http://www.bluesocket.com/news/news/bluesocket_introduces_vmware_ready_WLAN.

block in cloud computing. There are a variety of other software packages, such as X11, that could be used to convert a computing device into a client for cloud computing. And, even if Microsoft had a monopoly on browsers, a vendor of cloud computing services could easily develop client software that the user could download and install using their Microsoft web browser.

The most problematic element of the Microsoft cases was the market definition used by the government. That definition reflected a static view of technology and consumer needs and appears to be better suited to protecting competitors than protecting consumers. The failure to bundle *Microsoft Security Essentials* with Windows, bundling that appears to us to benefit consumers, is likely due to antitrust concerns. This failure generates dangerous externalities, because it harms not only the purchasers of a copy of Windows but other users on the Internet. Consumers have benefitted enormously as Apple and Microsoft have expanded the bundle of system software, utilities, and applications that are distributed as an operating system. An earlier restriction that prevented Apple and Microsoft from developing and distributing their own font libraries would have given us a world in which a large fraction of computer users would have had to pay a significant fraction, perhaps five or ten percent, of the cost of the operating system for a font library. But, the logic of the antitrust prosecutions is that such improvements to operating systems and consumer welfare are suspect and therefore require potentially draconian remedies.

Concluding Thoughts

The DOJ/Microsoft consent decree restricted Microsoft's ability to engage in a wide range of business practices, such as preventing computer manufacturers from selling software that competes with Microsoft software. Those provisions appear to us to be aimed at conduct that could be used to extend Microsoft's market power in the operating system market to other markets, and these restrictions do not appear to limit either Microsoft's use of technology or Microsoft's product design and development process. Hence, we conclude that these provisions were unlikely to harm the innovation process or to stultify Microsoft's animal spirits and may have furthered competition.

In addition, The DOJ/Microsoft consent decree and the EU's 2004 order required Microsoft to facilitate interconnection with its operating system. Because they required disclosure of trade secrets and the licensing of technology, these disclosure requirements intruded more into the technology of Microsoft's products than did the restrictions on contracting. Thus, there was more of a risk that these requirements would hamper innovation or slow product development. However, the ability to interconnect is central to the operation of complementary products such as software applications and servers. Absent such disclosure, Microsoft would have a powerful mechanism for transferring its market power in desktop operating systems into adjacent

markets.[107] It is likely that the benefits of this mandatory disclosure outweigh the costs and that the disclosure requirements therefore served efficiency.

A third element of both the DOJ and EU proceedings was an attack on Microsoft's practice of including new features, specifically a browser and media player, in the large bundle of applications, utilities, and system software that is currently called an operating system. Such attacks threaten to limit innovation and efficient product development and design by Microsoft. Moreover, we fail to see any substantial benefit from such restrictions. It is relatively easy for a user to download and install a competing browser or media player. Over time the scope of the software package that is called an operating system has expanded. Competing desktop operating systems include many applications including media players and web browsers. Apple lists 23 applications that are part of OS X. In addition, OS X ships with a development environment and a web server. Novell promotes its SUSE Linux Enterprise Desktop saying that it comes with "Dozens of Bundled Applications."[108] Reducing Microsoft's incentives to provide consumers with an operating system product that better meets consumers' needs does not serve efficiency.

V. Lessons Learned

The three seminal high-tech antitrust cases that we have reviewed span a period of 40 years. In one case—*IBM*—the government did not prevail; in the second—*AT&T*—it won resoundingly, obtaining a vertical divestiture of AT&T's local operating companies; in the third—*Microsoft*—the government won on liability but was rebuffed in its attempt to obtain a vertical divestiture similar to the one that settled the *AT&T* case.

Despite the lapse of time and the very different market environments that existed in the three cases, there are some common strands. First, the government reserved the right to seek a divestiture in *IBM* and actually sought divestiture in the other two. Our review of the evidence suggests that with the benefit of hindsight, one may conclude that the breakup of AT&T was not necessary to obtain the competitive benefits that followed.

Second, in each case *interconnection*, in one form or another was a major issue. Interconnection to IBM's mainframes was not mandated because the case was dropped after thirteen years of litigation.[109] Interconnection was mandated in both *AT&T* and in *Microsoft*, and in both cases it has clearly had pro-competitive effects. Indeed, it is our conclusion that mandated

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[107] We are not expressing the view that it would necessarily be rational for Microsoft to exploit such leverage. The key complements to Microsoft's desktop operating system are the thousands of applications that run on it. Failure to disclose APIs and protocols to third-party developers is likely to reduce the quality of these important complements.

[108] http://www.novell.com/products/desktop/features/productivity.html

[109] Several years later, in 1984, IBM settled an antitrust suit with the EU by signing an "undertaking" that it would provide "interface information" to competitors on all new System 370 products offered for sale in the EU See http://openmainframe.org/legal/.

interconnection (equal access) would have been sufficient to obtain most of the benefits that flowed from the *AT&T* decree; vertical divestiture was probably not necessary and triggered substantial costs. We cannot be sure that the requirements that Microsoft provide access to its APIs and communications protocols have delivered benefits in excess of costs, but these requirements appear to be encouraging interoperability among suppliers and, therefore, more competition.

In each of our three cases, the ultimate source of major changes in the competitive landscape appears to have been innovation and new technology – technology that was apparently not unleashed by the antitrust litigation. In each case, the government did not and probably could not see how technology would develop over time. Therefore, it was difficult for the government to design remedies that would accelerate competition when this competition developed from new technologies. Attempting to restructure the defendants so as to increase competition in markets vertically adjacent to those in which they enjoyed substantial market power was therefore a somewhat dubious undertaking because it deprived the firm and therefore consumers of the benefits of vertical integration. Rather, we find that much less intrusive remedies, such as interconnection requirements, are less risky in industries with rapidly changing technology. Such remedies generally require continuing supervision by the courts and are thus often seen as more problematical than the once and for all imposition of structural relief.

Appendix Table 1

Major Computer Industry Developments, 1969-1982[110]

1969	• Honeywell releases the H316 "Kitchen Computer", the first home computer, priced at $10,600. • AMD is founded • IBM builds SCAMP, one of the world's first personal computers. • Intel announces a 1 kilobit RAM chip, which has a significantly larger capacity than any previously produced memory chip.
1970	• Bell Labs develops Unix. • Intel creates the 1103, the first generally-available DRAM chip. • Intel fabricates the first run of 4004 microprocessors.
1971	• Wang Laboratories introduces the Wang 1200 word processor system. • Intel officially introduces the MCS-4 (Microcomputer System 4-bit) microcomputer system.
1972	• Intel introduces its 200 kHz 8008 chip, the first commercial 8-bit microprocessor. • Wang Laboratories introduces its first small business computers, the 2200 series.
1973	• R2E introduces the Micral-N microcomputer, the first commercial non-kit computer based on a microprocessor. • Scelbi Computer Consulting Company offers the first computer kit in the U.S. using a microprocessor, the Intel 8008-based Scelbi-8H, with 1 kB programmable memory for $565. • Micro Computer Machines introduces the MCM-70 personal computer with a Intel 8008 processor, plasma screen, cassette drives, keyboard, 2 to 8 kB RAM, 14 kB ROM.
1974	• Intel releases its 2 MHz 8080 chip, an 8-bit microprocessor. • National Semiconductor introduces the 16-bit IMP-16 microprocessor. • Intel introduces the 3000 series of microprocessor chips. • MITS announces the Altair 8800 computer for $397 in kit form or $439 assembled.
1975	• Bill Gates and Paul Allen license their newly written BASIC, the first computer language program written for a personal computer, to MITS for the Altair computer. • Bill Gates and Paul Allen found Micro-Soft. • Digital Equipment introduces the LSI-11 microcomputer, the

[110] Adapted and greatly reduced from Ken Polsson, "Chronology of Personal Computers." The full timeline is available at http://www.islandnet.com/~kpolsson/comphist/.

	first American microcomputer using a 16-bit architecture. • IMS Associates ships its first IMSAI 8080 computer kits to customers.
1976	• Intel introduces the 5 MHz 8085 microprocessor. • Steve Jobs and Steve Wozniak incorporate the Apple Computer Company. • Texas Instruments introduces the TMS9900, the first 16-bit microprocessor. • Wang Laboratories develops a word processor, using advanced computer technology, later adding a CRT display, large disk storage, and a letter-quality printer. • The Apple I computer board is sold in kit form at a price of $666.66. • Personal computer companies in operation include MITS, IMSAI, Processor Technology, SWTP, The Digital Group, Polymorphic, Ohio Scientific, Cromemco, and MOS Technology.
1977	• Apple Computer introduces the Apple II. • Digital Equipment introduces the LSI-11/2 microcomputer with 8 kB RAM. • Radio Shack (a division of Tandy Corporation) announces the TRS-80 microcomputer.
1978	• Intel begins production of the 8086 microprocessor. • Commodore International introduces the CBM 2020 dot-matrix printer, the CBM 2022 printer, the CBM 2023 printer, and the CBM 2040 dual 5.25-inch floppy drive unit. • Atari unveils its Atari 400 and 800 personal computers, both featuring the 6502 microprocessor.
1979	• Intel introduces its first magnetic bubble memory chip capable of storing up to 1 megabit of information. • Software Arts demonstrates the *VisiCalc* spreadsheet software at the 4th West Coast Computer Faire. • Intel introduces the 4.77 MHz 8088 microprocessor. • Apple Computer introduces the Apple II Plus, with 48 kB memory, for $1195. • Texas Instruments introduces the TI-99/4 personal computer, for an initial price of $1500. • MicroPro International releases the *WordStar* word processor. • Apple Computer releases the word processing program *AppleWriter* 1.0. • IBM introduces the IBM 3800 laser printer, capable of printing 20,000 lines per minute. • IMSAI declares bankruptcy. • Atari begins shipping the Atari 400 and Atari 800 personal computers. • Texas Instruments begins shipping the TI 99/4 personal

	computer. • Sears begins selling Atari home computers.
1980	• Digital Equipment announces the DEC Datasystem 408 computer, with built-in monitor and keyboard, separate dual double density disk drive unit, and printer for $8995. • Hewlett-Packard introduces the HP-85 microcomputer with 5-inch diameter CRT display, small built-in printer, cassette tape recorder, and keyboard for $3250. • Universal Data Systems unveils the103LP 300 bps modem, connecting directly into the telephone line. • Data General announces the Eclipse MV/8000 computer. • Commodore International introduces the CBM 8032 microcomputer. • Apple Computer introduces the Apple III, with a 2 MHz 6502A microprocessor, a 5.25-inch floppy drive and 128 kB RAM for $4500 to $8000. • Seagate Technology announces the first Winchester 5.25-inch hard disk drive. • Onyx introduces the Onyx C8002 microcomputer. • Radio Shack introduces the TRS-80 Model III with a Zilog Z80 processor and 4 kB RAM for $699. • Radio Shack introduces the TRS-80 Pocket Computer with a 24 character display, QWERTY keyboard, and 1.9 kB of programmable memory for $230. • Commodore International announces the CBM 8032 computer with 96 kB RAM. • Panasonic and Quasar unveil handheld computers, made by Matsushita. The units use a 1 MHz 6502 CPU, and weigh 14 ounces. • Apple Computer becomes a publicly held company, selling 4.6 million shares at US$22 per share.
1981	• Commodore announces the VIC-20 personal computer, with full-size 61-key plus four function key keyboard, and 5 kB RAM expandable to 32 kB for $299. • Xerox announces the Xerox 820 Information Processor computer, using the Z80 CPU, CP/M, and BASIC. • The first IBM PC computers are produced in July. • Apple Computer introduces its first hard drive, the Apple 5 Megabyte ProFile, for $3499. • IBM's General Systems Division introduces its first desktop computer, the System 23 Datamaster, with a 16-bit 8086 at a price of $9830. • Tandy and Datapoint announce an agreement to allow Tandy TRS-80 computers to use network technology from Datapoint, to connect up to 255 Tandy computers to central storage or printers, or to Datapoint computers. • Texas Instruments announces it will sell a new line of four small business desktop computers, with 64 kB RAM, costing

	$6200-9900.
1982	• Commodore announces the VIC-20 personal computer, with full-size 61-key plus four function keyboard, 5 kB RAM expandable to 32 kB, 6502A CPU, 22-character by 23-line text display, and color graphics for $299. • Osborne Computer introduces the Osborne 1 Personal Business Computer with a Z80A processor, 5-inch display, 64 kB RAM, keyboard, keypad, modem, and two 5.25-inch 100 kB disk drives for $1795. • Vector Graphic unveils the first personal computer with a built-in hard disk drive for $7950. • Xerox introduces the SAM personal computer with 64 kB RAM for $3000. • IBM announces the IBM Personal Computer, model 5150, with a 4.77 MHz Intel 8088 CPU, 16 kB RAM (expandable to 256 kB), 40 kB ROM, one 5.25-inch floppy drive for $1565. • Apple Computer becomes the first personal computer company to reach US$1 billion in annual sales.

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