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Not Only Microsoft: The Maturing of the Personal Computer Software Industry, 1982–1995

In the thirteen years following the introduction of IBM's first personal computer in 1982, Microsoft rose from being a small concern to become the colossus of the PC software industry. However, Microsoft was not the only software company to profit from the PC-software boom: firms like AutoDesk, Lotus Development, WordPerfect Corp., Ashton-Tate, Novell, Borland, Adobe Systems, Aldus, Symantec, and the Santa Cruz Operation all had their time in the sun. Whereas some of these firms lost their markets to Microsoft or stumbled through strategic errors, others remained hugely successful, and their relative obscurity is largely due to the contemporary obsession with Microsoft and its billionaire founder.

The early history of the personal computer is well known. It has featured in the press, in numerous popular histories of computing, and in television programs such as Robert X. Cringley's "Triumph of the Nerds."[1] Within the business history community, the story is known at a deeper level, partly through the inevitable osmosis that accompanies the daily use of a personal computer, but also through articles such as Richard Langlois's study of the microcomputer industry,

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[1] The television series was based on Robert X. Cringley's magazine articles and his book, *Accidental Empires: How the Boys of Silicon Valley Make Their Millions, Battle Foreign Competition, and Still Can't Get a Date* (Reading, Mass., 1992).

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which appeared in *Business History Review* as long ago as 1992.[2] The familiar contours of the story are as follows. After the modest success of the original Altair 8800 microcomputer in 1975, Steve Jobs established the personal computer as a consumer product with the Apple II in 1977. With the arrival of applications software, such as the VisiCalc spreadsheet and the WordStar word processor in 1979 and 1980, the personal computer came to the office. In August 1981, IBM announced its PC, which fully legitimated the industry and unleashed the desktop revolution.

Another, less familiar, story unfolded from 1982 to 1995: that of the post–IBM PC period. During this time, software captured much more popular interest than did hardware, and Microsoft rose from being an obscure software specialist with annual sales of $16 million to become a corporate giant with revenues of over $6 billion and a familiar name around the planet. There have been numerous histories of Microsoft, many of which pay less attention to the corporate environment than to founder Bill Gates's go-getting personality. A more holistic view of the personal computer software industry is depicted here, one that inevitably focuses on Microsoft as the major player but also discusses its competitors—as firms in their own right rather than as mere bit players on the Microsoft stage.

I have taken 1995 as the cut-off date for this article because—writing in the year 2000—there is a widely held view that, with the rise of the Internet and the World Wide Web, a new historical period in the software industry has begun. One recent well-regarded book has dubbed this new period the "Internet Era" of software and value-added services.[3] Since 1995, the rise of the Internet has produced two major changes in the software-products industry. First, the electronic delivery of software is starting to replace the sale of "boxed" software through conventional retail channels, which will have a profound effect on the cost structure of the industry. (The same is happening in the recorded-music industry, which has attracted much recent media attention.) Second, the once-sharp segmentation of vendors of enterprise software such as Computer Associates, which sell to the information systems departments of major corporations, from PC-software vendors such as Microsoft, which sell to all sizes of organization and to consumers, has

[2] Richard N. Langlois, "External Economies and Economic Progress: The Case of the Microcomputer Industry," *Business History Review* 66 (Spring 1992): 1–50.

[3] Detlev J. Hoch, Cyriac R. Roeding, Gert Purkert, and Sandro K. Linder, *Secrets of Software Success: Management Insights from 100 Software Firms Around the World* (Boston, Mass., 2000).

become blurred. Today, while Computer Associates and Microsoft remain very different types of firm, they increasingly compete in software markets where once their paths never crossed.

Microsoft and the Software Industry

Microsoft is undoubtedly a software phenomenon, but its history is more complex than the popular literature suggests. A great deal of the interest in Microsoft stems from the fact that its founder and major stockholder, Bill Gates, has become the richest man in the world. Another reason for the interest in Microsoft is that while most computer users never come into personal contact with the products of corporate software firms of comparable size—such as Oracle or Computer Associates—they are in intimate daily contact with Microsoft's products when using a word processor, a spreadsheet, or an Internet browser. For many—perhaps most—people, Microsoft *is* the software industry.

Microsoft has captured public awareness perhaps more than any other late twentieth-century company. One measure of the extraordinary interest in Microsoft is the number of books published about the company and its founder. I know of no complete list—books have been published in England, France, and Japan, as well as America—but at the time of writing, the Library of Congress lists no less than twenty monographs on Bill Gates and Microsoft. There are more books about Microsoft than about the rest of the entire software industry.[4]

Microsoft is often perceived as being a latter-day IBM, completely dominating the software industry. This is simply not true. At its peak in the 1960s, IBM had a three-quarters share of the worldwide computer industry—hardware, software, and services. Microsoft has achieved nothing like the same dominance of the industry and has never even had a 10 percent share of the software market alone. For example, although by 1990 Microsoft was unquestionably the best-known software

[4] The literature on Microsoft is not rewarding to study in its entirety. The best semitechnical account of the development of Microsoft and its products is by Daniel Ichbiah and Susan L. Knepper, *The Making of Microsoft* (Rocklin, Calif., 1991). Good economic perspectives are provided by Randall E. Stross, *The Microsoft Way* (Reading, Mass., 1996), and Stanley J. Liebowitz and Stephen E. Margolis, *Winners, Losers and Microsoft: Competition and Antitrust in High Technology* (Oakland, Calif., 1999). Of the journalistic accounts, the two best are: James Wallace and Jim Erickson, *Hard Drive: Bill Gates and the Making of the Microsoft Empire* (New York, 1992); and Stephen Manes and Paul Andrews, *Gates: How Microsoft's Mogul Reinvented an Industry—and Made Himself the Richest Man in America* (New York, 1994). In a different genre, but containing many historical insights, is the excellent book by Michael A. Cusumano and Richard W. Selby, *Microsoft Secrets* (New York, 1995).

firm in the world, its sales of $1.18 billion constituted a bare 3 percent of the $35 billion worldwide market for software products, and only an eighth of IBM's $9.95 billion software sales. By 1995, although Microsoft's revenues had grown fivefold, to $6.08 billion, it was still less than 10 percent of the worldwide software market, and still well below IBM's $12.9 billion sales. Yet very few people outside the software industry think of IBM as being in the software business at all. It was only in 1998 that Microsoft's software sales exceeded those of IBM for the first time. In 1999, Microsoft became the most valuable company in the world by stock-market valuation, but its total revenues of $17.2 billion were dwarfed by IBM's total sales of $84.4 billion. IBM was the third most valuable company. What these figures tell us, of course, is that the stock market perceived Microsoft as the faster-growing and more profitable company. IBM's software is very profitable too—one can speculate, perhaps as profitable as Microsoft's (IBM does not disclose profit margins of its individual businesses). IBM's software sales, however, are overshadowed by much less profitable activities—the physical manufacture of computers and peripherals and labor-intensive computer services.

Table 1 provides an array of statistics on Microsoft. Table 1A shows Microsoft's revenues, revenue growth, and number of employees. Microsoft has been the fastest-growing and most impressive of all the personal computer software firms throughout its twenty-five-year history. Its annual revenue growth has been truly spectacular—often exceeding 50 percent a year, even when it was a mature company, and never falling below 25 percent. Its competitors have certainly achieved impressive growth rates for extended periods of time too, but none has achieved uninterrupted revenue growth for a quarter of a century. Detailed financial data on Microsoft have only been publicly available since its initial public offering in 1986 (see Table 1B). Microsoft is an extraordinarily profitable company, with earnings typically in the range of 30 to 40 percent of its revenues. Remarkable as this may seem outside the personal computer software industry, Microsoft's earnings have not been so much better than its competitors'. Microsoft has come to dominate its sector, not through profitability per se, but by its ability to gain market share. Since the early 1980s, the personal-computer software market has been relatively concentrated, with between ten and twenty firms having 80 percent of the market. Microsoft's growth in market share has been by far the greatest. While Microsoft had about a fifth of the market for PC software in 1983, by 1990 it had a third, and by 1995 a half. Thus, within the narrow sec-

Table 1
Microsoft Statistics

A. Revenues, Revenue Growth, and Employees

Year	*Revenues ($ million)*	*Annual Growth (%)*	*Employees (no.)*
1975	0.016		3
1976	0.022	38	7
1977	0.382	1,636	9
1978	1.356	255	13
1979	2.390	76	28
1980	8	235	38
1981	16	100	130
1982	24	53	220
1983	50	104	476
1984	97	95	778
1985	140	44	1,001
1986	198	41	1,442
1987	346	75	2,258
1988	591	71	2,793
1989	805	36	4,037
1990	1,186	48	5,635
1991	1,847	56	8,226
1992	2,777	50	11,542
1993	3,786	36	14,430
1994	4,714	25	15,257
1995	6,075	29	17,800

B. Revenue Breakdown

Year	*Revenues ($m)*	*Systems (%)*	*Applications (%)*	*Other (%)*
1986	198	53	37	10
1987	346	49	38	13
1988	591	47	40	13
1989	805	44	42	14
1990	1,186	39	48	13
1991	1,847	36	51	13
1992	2,777	40	49	11
1993	3,786	34	58	8
1994	4,714	33	63	4
1995	6,075	31	65	4

Sources: Michael A. Cusumano and Richard W. Selby, *Microsoft Secrets (New York, 1996)*, 3–5; Microsoft, *Fiscal Year Financial History* and *Business Division and Channel Revenue*, http://www.microsoft.com/msft/history.htm—accessed December 2000.

tor of the PC-software industry, Microsoft does indeed have an IBM-like dominance.

In the popular histories of Microsoft, the company is usually portrayed as aggressive and predatory, driving competitors out of the busi-

ness. This is undoubtedly true, but it tells only half the story. At least as many firms were driven out of the business by strategic errors and plain old market forces. This was well in evidence in 1984, with the first widely reported shakeout of the personal computer software industry. For example, *Business Week* noted:

> No one expected the halcyon days of the personal computer software business to pass so quickly. Industry experts had projected that this market would continue to double annually, and 3,000 hopefuls, as a result, had jumped into the fray. But the glut of suppliers, along with the soaring cost of marketing new products and a flood of me-too programs, is changing the picture dramatically.[5]

Perhaps the biggest reason for the hundreds of firm failures was the explosion in the number of competing software packages for office workers—the so-called "productivity applications":

> At the last count, there were 200 or more word processors, 150 spreadsheets, 200 data base programs, and 95 integrated packages that offer at least three functions. Moreover, distributors report that of the 20,000 programs on the market, a mere 20 make up as much as half of their total business.[6]

Of the nine largest firms of 1983 (see Table 2), five were in a terminal condition by the summer of 1984. VisiCorp and MicroPro, publishers of the leading spreadsheet and word processor, had lost market share to Lotus Development and the WordPerfect Corporation, respectively. Digital Research had lost operating-system sales to Microsoft. Peachtree, having been acquired by Management Sciences America in 1981, was losing money and was shortly sold off, essentially disappearing from view for a decade. Sorcim, another victim of the productivity application wars, was bought by mainframe software maker Computer Associates during its first foray into microcomputer software. Note that only one of these exits was due to Microsoft.

For most of the 1980s, Microsoft grew primarily on the strength of its operating system for IBM-compatible personal computers (MS-DOS, for MicroSoft–Disk Operating System), which probably generated 40 to 50 percent of its revenues. While they did not always grow as fast or consistently as Microsoft, by any normal measure the second-tier firms, such as Lotus, WordPerfect, Borland, and Adobe Systems, also expanded remarkably. WordPerfect, for example, quadrupled its

[5] Anon., "The Shakeout in Software: It's Already Here," *Business Week*, 23 Aug. 1984, 96–8.
[6] Ibid.

Table 2

Top Ten Personal Computer Software Companies, Revenues ($ million)

1983		*1987*	
Microsoft	70	Lotus Development	396
VisiCorp	60	Microsoft	301
Lotus Development	48	Ashton-Tate	267
MicroPro	45	WordPerfect Corp.	100
Digital Research	38	Borland	56
Ashton-Tate	30	Autodesk	52
Peachtree	24	MicroPro	41
Sorcim	10	Aldus	40
Software Publishing	10	Software Publishing	39
		Adobe Systems	39
1991		*1995*	
Microsoft	1,801	Microsoft	7,271
Lotus Development	829	Novell	1,900
WordPerfect Corp.	603	Adobe Systems	762
Novell	571	Autodesk	544
Borland	502	Symantec	438
Autodesk	238	Intuit	396
Adobe Systems	230	Borland	208
Symantec	196	Corel	196
Aldus	164	Claris	184
Software Publishing	141	Santa Cruz Operation	178

Sources: 1983: Efrem Sigel and the Staff of Communication Trends Inc., *Business/Professional Microcomputer Software Market* (White Plains, N.Y., 1984), 19; 1987, 1991, and 1995: *Software Magazine* (May 1988, June 1992, and July 1996). Some missing companies have been interpolated by the author. Inconsistencies between revenues as published in *Software Magazine* and company annual reports have not been corrected.

sales from $100 million to over $400 million in an amazing growth spurt between 1986 and 1990. From about 1990 on, much of Microsoft's growth was achieved by publishing applications packages in addition to systems software (Table 1B).

By 1995 the situation in personal computer software was reminiscent of the 1960s computer industry—characterized as "IBM and the seven dwarfs." Microsoft dominated every market in which it operated—operating systems, programming languages, and productivity applications. Its competitors survived—in some cases prospered—by operating in markets where Microsoft did not participate (yet). For example, Autodesk produced the best-selling computer-aided design (CAD) draft-

ing program, Aldus was successful in desktop publishing, while Adobe Systems created the market for laser-printer software. Novell and the Santa Cruz Operation (SCO) sold networked and Unix operating systems, respectively. To a greater or lesser extent, all of these firms were one-product operations and therefore vulnerable to a competitor, particularly one that turned out to be Microsoft. There was some noticeable concentration through merger and acquisition in the 1990s, as Lotus was bought by IBM, Ashton-Tate by Borland, WordPerfect by Novell, and Aldus by Adobe Systems. In most cases, the buyers were one-product companies seeking to diversify. A minority of firms made merger-and-acquisition activity their prime strategy for coexisting with Microsoft. Symantec, for example, effectively became a portfolio operator, selling a range of products from many sources, none of which amounted to more than 10 percent of its revenues.

The concentration of the PC-software market was perhaps its most noticeable feature. It was characterized as a winner-takes-all market. While Microsoft was the biggest winner, the second-tier companies were also very successful at monopolizing their markets. This was a different situation from that of the mainframe software industry, which was much less concentrated and had several competing suppliers of a comparable scale in every sector; there, a 20 percent market share was the mark of a successful company, and a 50 percent market share was almost unheard of.[7] By contrast, it was quite typical for the major personal computer software firms to dominate their individual sectors with a 60 or 70 percent market share. This phenomenon was so remarkable that it was investigated by academic economists, who described it as the "economics of increasing returns." In the business press, it became known as a "Microsoft economics."[8]

The IBM-Compatible PC Standard

Toward the end of the 1970s, a number of academic economists became increasingly interested in the economics of increasing returns, which appeared to explain the market behavior of technological and in-

[7] For a history and discussion of the corporate software industry, see Martin Campbell-Kelly, "Development and Structure of the International Software Industry, 1950–1990," *Business and Economic History* 24 (Winter 1995): 73–110; W. Edward Steinmueller, "The U.S. Software Industry: An Analysis and Interpretive History," in *The International Software Industry: A Comparative Study of Industry Evolution and Structure*, David C. Mowery, ed. (New York, 1996); and U.S. Department of Commerce, *A Competitive Assessment of the United States Software Industry* (Washington, D.C., 1984).

[8] James Aley, "The Theory that Made Microsoft," *Fortune*, 29 April 1996, 23–4.

formation firms better than the classical economics of decreasing returns.[9] According to this school of thought, high-tech markets tended to produce natural monopolies in which a single technological "platform" dominated. High-tech goods—such as aircraft, computers, and nuclear power stations—were characterized by very high front-end research and development costs and relatively low manufacturing costs. For example, in the 1960s, IBM's manufacturing costs for its System/360 mainframe computers were said to be about 20 percent of the selling price, so that each incremental sale of a computer was enormously profitable. Profits were fed back into the development of software (then given away free) and product improvement, which had the effect of making System/360 more attractive to customers; the result was more sales and profits to be invested in further software development and product improvement. It was a virtuous circle, which gave IBM its 75 percent share of the mainframe market.

By the time IBM unbundled its software in 1970, System/360 was already a standard platform, and independent software vendors produced software for the IBM platform in order to maximize their sales. These "network effects" further enhanced the desirability of the IBM mainframe. It should be noted that the success of System/360 was largely independent of its original technical merits. The mere fact of its being a standard platform made it desirable. IBM's market dominance could only be partially explained in terms of the economics of increasing returns. In many respects, IBM was also subject to decreasing returns. For example, selling costs tended to rise at the margin, and IBM had constraints in terms of marketing resources and manufacturing facilities. This left sufficient room in the marketplace for competitors like Univac, NCR, and Burroughs.

Microprocessors and software, however, were essentially information goods, whose marginal manufacturing and distribution costs were close to being negligible. The economics of increasing returns facilitated the creation of a dominant, IBM-compatible PC standard that, over a period of years, accounted for more than 80 percent of the market. However, the creation of the IBM PC standard took longer than is commonly supposed. Although IBM introduced its personal computer

[9] Brian W. Arthur, "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *Economic Journal* 99 (1989): 116–31; "Positive Feedbacks in the Economy," *Scientific American* (Feb. 1990): 92–9; "Increasing Returns and the New World of Business," *Harvard Business Review* (July–Aug. 1996): 100–09; Jeffrey Church and Neil Gandal, "Network Effects, Software Provision, and Standardization," *Journal of Industrial Economics* 60 (1992): 85–103.

Table 3

U.S. Personal Computer Shipments and Installed Base, 1981–1992

	PC Shipments			*Installed Base*		
Year	*Total (000s)*	*Intel (000s)*	*Intel (%)*	*Total (000s)*	*Intel (000s)*	*Intel (%)*
1981	780	35	4.49	1,740	35	2.01
1982	3,040	192	6.32	4,780	227	4.75
1983	5,450	698	12.81	10,200	925	9.07
1984	6,660	1,942	29.16	16,810	2,867	17.06
1985	5,760	2,518	43.72	22,270	5,385	24.18
1986	6,850	3,334	48.67	28,190	8,719	30.93
1987	8,320	6,081	73.09	35,120	14,800	42.14
1988	8,649	6,769	78.26	44,988	23,538	52.32
1989	8,985	7,371	82.04	52,128	30,592	58.69
1990	9,337	7,835	83.91	54,807	37,391	68.22
1991	9,399	7,904	84.09	59,303	42,792	72.16
1992	10,103	8,367	82.82	63,045	48,105	76.30

Source: Derived from John Steffens, *Newgames: Strategic Competition in the PC Revolution* (Oxford, 1994), 210–11.

in August 1981, it was five years before IBM-compatible PCs accounted for 50 percent of new purchases. And, if one considers the installed base of personal computers, it was not until 1988 that the 50 percent level was reached (see Table 3).

Intel's sixteen-bit microprocessor sold sufficiently well that the company was able to plough back profits to create a rapid product evolution, with a new microprocessor generation appearing at approximately three-year intervals (see Table 4). With each new product generation, the old microprocessor continued to be sold alongside the new; supply and demand was balanced by careful pricing. Thus, in 1984, the original 8088/86 was superseded by the 80286; in 1986, the 80386 superseded the 80286; the 80486 and 80586 (Pentium) were introduced in 1989 and 1992, respectively.[10] With each new product generation, speed and architectural improvements led to a performance improvement of an order of magnitude. In between product generations, low-cost versions (the 80386SX and the 80486SX) were introduced to exploit the lower end of the market.

The IBM-compatible PC standard consisted of the Intel microprocessor and the Microsoft MS-DOS operating system, both of which

[10] John Steffens, *Newgames: Strategic Competition in the PC Revolution* (Oxford, 1994), 211–16.

Table 4
Intel and MS-DOS Product Improvements

Year	*Intel Microprocessor*	*MS-DOS Versions*
1981	8088/86	1.0
1982	—	1.1 and 1.25
1983	—	2.0
1984	80286 (1 mip)	2.11, 3.0, and 3.1
1985	—	—
1986	80386 (5 mips)	3.2
1987	—	3.3
1988	80386SX	4.0
1989	80486 (20 mips)	—
1990	—	—
1991	80486SX	5.0
1992	—	—
1993	80586 (100 mips)	6.0
1994	—	6.22

Sources: Intel microprocessor: John Steffens, *Newgames: Strategic Competition in the PC Revolution* (Oxford, 1994), 210–16. The dates given are when the microprocessor model was shipped in volume for standard PCs. This was up to two years later than the manufacturer's announcement. MS-DOS: Daniel Ichbiah and Susan L. Knepper, *The Making of Microsoft* (Rocklin, Calif., 1991): Appendix A, "Versions of DOS." Some minor DOS releases have been omitted. For further MS-DOS minutiae, see www.pcbiography.com—accessed December 2000.

were susceptible to imitation. Intel had relatively few imitators because the extreme capital intensity of microprocessor fabrication was a major barrier to entry. A "fab" plant cost about a billion dollars before the first microchip rolled off the production line, and this limited competition to a few major players, such as Advanced Micro Devices, Inc. (AMD) and Cyrix. By contrast, Microsoft had numerous competitors because the capital requirements for producing an operating system were relatively modest. Microsoft's original MS-DOS (version 1.0) contained just 4,000 lines of code, had taken less than a programmer-year to develop, and was not by any standard a sophisticated program.[11] It was therefore possible for any two-person operation of reasonable competence to come up with an imitative product, and lots did. The two most serious competitors were Digital Research's sixteen-bit, general purpose operating system, CP/M-86, and SofTech's USCD p-System. These were both offered as alternatives to MS-DOS by IBM. However, CP/M-86 was not available until several months after the launch of the IBM PC, giving MS-DOS an insuperable first-mover advantage. More-

[11] Tim Paterson, "An Inside Look at MS-DOS," *Byte* (June 1983): 230*ff*.

over, Digital Research made a strategic error by pricing its CP/M-86 at $240, four times the price of MS-DOS. Although the price was later cut to $60, in line with that of MS-DOS, by then it was too late, and the product was still not sufficiently cheap to tip the market in its favor. While there are no reliable time series in the public domain for Microsoft's share of the IBM-compatible PC operating-system revenues, there is overwhelming anecdotal evidence that MS-DOS accounted for 90 percent of machines.[12] Incidentally, the ease with which Microsoft and many other firms were able to supply an operating system for the IBM PC begs the question: Why did IBM not write the operating system itself and retain full control over its computer? While some authors have hypothesized that IBM made the decision in order to avoid the antitrust authorities (IBM's long-running antitrust trial was still ongoing at the time of the PC development) the best-regarded history suggests nothing more sinister than an aggressive development schedule.[13]

Although Microsoft's operating-system activity came to be associated largely with MS-DOS, the history is more complex. Microsoft's decision to enter the operating-system market predated the launch of the IBM PC. In February 1980, Microsoft had negotiated a license for the industry-standard Unix from AT&T and had begun to develop XENIX, a microcomputer version of Unix, which it believed would ultimately become the standard for sixteen-bit microcomputers. Thus MS-DOS was initially a pragmatic product tailored to the IBM PC. According to Tim Paterson, the developer of MS-DOS, the main design goal was to enable existing software packages to run on the new Intel microprocessor.[14] Thus MS-DOS enabled prominent software vendors, such as VisiCorp, MicroPro, and Software Publishing, to make their top-selling programs immediately available for the IBM platform. During 1982, minor upgrades were made to MS-DOS, primarily so that it could handle new-style disk drives (see Table 4).

In March 1983, Microsoft released MS-DOS 2.0, a much more sophisticated system that contained 20,000 lines of code and represented an investment of several programmer years. A major aspect of the design was to provide a smooth migration path to XENIX, Microsoft's ul-

[12] Richard J. Gilbert "Networks, Standards, and the Use of Market Dominance: Microsoft (1995)" in John E. Kwoka, Jr. and Lawrence J. White, *The Antitrust Revolution: Economics, Competition and Policy* (Oxford 1999), 409–29.

[13] James Chposky and Ted Leonsis, *Blue Magic: The People, Power and Politics Behind the IBM Personal Computer* (New York, 1988).

[14] Paterson, "Inside Look at MS-DOS."

timate goal. During 1983, Microsoft advertised MS-DOS for ordinary IBM-compatibles and XENIX for high-end machines in the major industry magazines:

> If you write and sell 16-bit software, MS-DOS and XENIX give you the largest installed base. In fact, over fifty 16-bit manufacturers offer their microcomputers with MS-DOS or XENIX. IBM, Victor, Altos, Wang, Radio Shack, Zenith and Intel, to name just a few. And the list is growing. That means there's a ready and expanding market for your 16-bit applications software.[15]

There was a considerable market uncertainty in the industry, and within Microsoft, as to whether MS-DOS would forever be a product in its own right or would eventually be subsumed into a Unix-style operating system.

Microsoft experienced considerable competition for both MS-DOS and XENIX. There were no less than two dozen operating systems competing with MS-DOS from some twenty vendors (see Table 5). Several of these systems were technically superior to MS-DOS. For example, Digital Research's original CP/M-86 had been superseded by Concurrent CP/M-86, and its "marketing strategy was to hit at MS-DOS's lack of networking facilities."[16] Digital Research had also produced another operating system, Concurrent DOS, that offered a rudimentary graphical user interface (often abbreviated as GUI, pronounced "gooey"). In the Unix market there were much bigger competitors: IBM had produced its own version of Unix, PC/IX, while the newly deregulated AT&T, inventor and owner of Unix, had gone into PC manufacture and was offering its own version of Unix.

As a result of this competition and the "fading future hopes of XENIX," Microsoft decided to enhance MS-DOS, while simultaneously developing a compatible graphical user interface to be sold as Windows.[17] It would not be until 1990 that Windows emerged as a successful product, however. Meanwhile, MS-DOS was periodically upgraded to accommodate the evolving hardware and software technologies. In August 1984 there was a major upgrade, MS-DOS 3.0, which now consisted of 40,000 lines of code. This was followed later in that year by MS-DOS 3.1, which had networking capabilities. At that point, MS-DOS stabilized for a couple of years with only minor incremental

[15] The advertisement quoted appeared in *Byte* (May 1983).

[16] Robert T. Fertig, *The Software Revolution: Trends, Players, Market Dynamics in Personal Computer Software* (New York, 1985), 118.

[17] Ibid., 132.

Table 5
Principal Sixteen-Bit Operating Systems Competing with MS-DOS, 1985

Vendor	*Operating System*	*Vendor*	*Operating System*
Alpha Micro	AMOS	Motorola	VERSAdos
Digital Research	CP/M-86	Phase One	Oasis-16
Digital Research	MP/M-86	Pick Systems	Pick
Digital Research	Concurrent CP/M-86	PMS	1-DOS
Digital Research	Concurrent DOS	Ryan McFarland	RM/COS
G&G Engineering	MP/M-8-16	Silicon Valley Software	Merlin
Hemmenway	MRP	SofTech	USCD p-System
Hunter & Ready	VRTX	Software 2000	TURBOdos-16
Industrial Programming	MTOS	Systems & Software	REX-80/86
Intel	iRMX	Wicat	MCS
JMI Software	C Executive	Zenith Data Systems	ZDOS
Micro Digital	E.86	Zilog	ZERTS

Source: Robert T. Fertig, *The Software Revolution: Trends, Players, Market Dynamics in Personal Computer Software* (New York, 1985), 110.

upgrades. During this period, MS-DOS was enormously profitable. Although the retail price of MS-DOS was $60 dollars, most sales were direct to computer manufacturers, and Microsoft received royalties estimated at $10 a machine.[18] However, the volume of sales was such as to make MS-DOS by far its most profitable product. In June 1986, Microsoft announced that half of its annual revenues came from MS-DOS (about $100 million); this number would have corresponded to about ten million sales worldwide. In mid-1988, another major release, MS-DOS 4.0, incorporated the ability to use a mouse, though it fell short of a complete graphical user interface. As late as 1990, it was reported that MS-DOS still accounted for nearly 20 percent of Microsoft's revenues.[19] Subsequent major releases of MS-DOS came with version 5.0 in mid-1991, and with version 6.0 in 1993. By that time, however, Microsoft was earning far higher revenues from Windows.

At this point in the story, it is appropriate to note that there is relatively little academic literature on the development of PC platforms and software. Thus, for the historical facts, one is forced—as in the

[18] Efrem Sigel and the staff of Communications Trends, *Business/Professional Microcomputer Software Market, 1984–86* (White Plains, N.Y., 1984), 32.

[19] This and the foregoing statistics appear in Ichbiah and Knepper, *The Making of Microsoft*, 86*ff*.

above discussion of MS-DOS—to use the business and trade press and the reports of industry analysts. It is to the academic literature that one turns for a more profound analysis of innovation and economics.

In this context, the theory of increasing returns discussed above offers some insights into the emergence of dominant platforms, such as System/360, the IBM-compatible PC, and software packages, such as Microsoft Word. For example, the theory helps us to understand how users can become "locked into" a particular platform, even though it is suboptimal. Perhaps the classic account of the lock-in phenomenon is Paul David's study of the QWERTY keyboard.[20] This inconvenient keyboard layout was conceived in the 1870s to overcome certain mechanical difficulties in typewriter construction, which soon became irrelevant, but not before the world had become locked into QWERTY and there was simply no escape. However, recent analysis suggests the QWERTY keyboard is an historically flawed example because empirical studies have shown that the arrangement is only a few percent less efficient than more convenient layouts.[21] Thus, a possible reason we still have QWERTY is not historical lock-in but rather the fact that the switching costs are out of proportion to the benefit that would be gained by adopting a new layout. Another phenomenon explored by the increasing-returns economists is that of "tipping," whereby a vendor can facilitate the adoption of a new platform by pricing it at an artificially low level. Then, when the platform has secured a self-sustaining user base, the vendor can raise prices to recoup the original investment and potentially much, much more. It is self-evident that such pricing strategies are used in the PC software industry to establish new platforms and products, but the practice goes on in the old economy too, where it is used for promoting new products and services, from toothpaste to automobile servicing. What the increasing-returns model suggests is that this age-old pricing tactic has a new significance in the new economy.

Both detractors and defenders of Microsoft have postulated the company's use and abuse of the increasing-returns model to account for its inexorable rise. However, they are not so good at explaining why Microsoft has been uniquely successful while many of its competitors, apparently no less savvy, have stumbled. The view I am adopting here

[20] Paul A. David, "Understanding the Economics of QWERTY: The Necessity of History," in *Economic History and the Modern Economist*, William N. Parker, ed. (Oxford, 1986), 30–49.

[21] Stan J. Liebowitz and Stephen E. Margolis, "The Fable of the Keys," *Journal of Law and Economics* 33 (1990):1–26. Reprinted in Leibowitz and Margolis, *Winners, Losers and Microsoft*, 19–44.

is that, pending deeper analysis, the increasing-returns model offers a partial explanation of the economics of software products. Moreover, at least some vendors consciously, if intuitively, applied increasing-returns ideas, even though they lacked the academic vocabulary to express them. Hence, beyond the debate about the explanatory power of increasing-returns economics, there is an interesting historical phenomenon worthy of study in its own right.

Strategic Understanding in the Personal Computer Software Industry: The Case of Autodesk

There were several thousand entrants into the personal-computer software industry in its first ten years. Of these, fewer than a hundred became major companies with a turnover exceeding $50 million. Why did some firms exceed wildly, while the great majority either became no more than small businesses employing a dozen or so people or failed entirely?

Brian Arthur has argued that an understanding of the increasing-returns economy was the crucial factor leading to success:

> What counts to some degree—but only to some degree—is technical expertise, deep pockets, will, and courage. Above all, the rewards go to the players who are first to make sense of the new games looming out of the technological fog, to see their shape, to cognize them. Bill Gates is not so much a wizard of technology as a wizard of precognition, of discerning the shape of the next game.[22]

It is clear from his book *The Road Ahead* (1995) that what Gates calls "positive feedback" is an intuitive and informal equivalent to the increasing-returns model of the academic economists.[23] We also know, from a memorandum dated June 1985, and subsequently published in a history of Apple Computer, that Gates was aware of the importance of network effects for establishing an operating-system standard.[24] But until (and if) Microsoft opens its archives to independent scholars, we only have some tantalizing hints of the company's strategic thinking and the extent to which Gates was responsible for it.

In the meantime, another firm, Autodesk, has made its early strategic thinking publicly available in a book titled *The Autodesk File.* From

[22] Brian W. Arthur, "Increasing Returns and the New World of Business."

[23] Bill Gates, *The Road Ahead* (New York, 1995).

[24] Jim Carlton, *Apple: The Inside Story of Intrigue, Egomania, and Business Blunders* (New York, 1997), 40–3.

1987 to the present, Autodesk—manufacturer of the leading CAD package—has consistently figured in the top ten players of the personal-computer software industry. Much more than post hoc recollections, *The Autodesk File* consists of contemporary and unedited strategic position papers produced over a ten-year period. *The Autodesk File* was published as a 600-page book in 1989 and subsequently updated and published on the World Wide Web in 1994.[25]

The Autodesk File was edited by Autodesk's cofounder John Walker, and it contains, among other things, his long, sometimes rambling, "Information Letters," in which he communicated Autodesk's strategic thinking to his coworkers. In these papers, we can see at work several of the mechanisms identified by the increasing-returns economists as enhancing the survival chances of a standardized software product: the constant reinvestment of profits into product improvement; the creation of complementary products and a network of vertical application developers; and the establishment of training networks to diffuse the standard and lock-in users.

Autodesk was founded in January 1982 by Walker, his colleague Dan Drake, and a group of approximately a dozen entrepreneurial programmers in the San Francisco area. Walker and Drake were then the principals of a failing computer hardware company, Marin Systems, founded in 1977. Marin Systems was failing because the hardware business was both very competitive and capital intensive. They therefore decided to switch from hardware to software. Walker believed that he and his colleagues stood at a unique moment in time: the door was closing on the period when it was possible for a couple of programmers to create a viable software product in a couple of months, and opening on a period in which software would require significant venture capital for development and promotion. He wrote in a memo, dated January 12, 1982:

> Products like Wordstar are selling in the $10–20 million per year range today. Bear in mind—this is a product that any of us could write in about two months. We should consider ourselves extremely lucky to be in this business at this time in history. It's a rare piece of luck to have the field you've chosen as your career explode into the hottest growing entrepreneurial arena just as you hit your prime, and we're now at the point that if we want a chance to get involved

[25] John Walker, ed., 4th ed., *The Autodesk File: Bits of History, Words of Experience* (no publisher stated, 1994): http://www.fourmilab.ch/autofile/; 3rd ed. published by New Riders Publishing, Thousand Oaks, Calif., 1989. See also Jonathan Richardson, "A Decade of CAD," *CAD User* (March 1998): 20–2, 26, 28.

> we have to act immediately. The game has changed and the pace is accelerating very rapidly. This business is getting very big and very professional, and within one year the chances of success of a tiny, heavily technically oriented company will be nil. If we move now, if we move fast, and if we react extremely rapidly and work ourselves to the bone, we can grab a chunk of this business before it slips away.[26]

Aware that technical competence was no guarantee of a hit product, Walker proposed a scattershot approach. They would form a cooperative partnership that would publish several products, determine their market acceptance, and then aggressively develop and promote one or two of the most promising.

Autodesk began operations with a portfolio of actual and potential products created by the partners, which included a CAD package (called Interact), a personal database (called Selector), translators for various programming languages, a sort program, and several other application programs and utilities. All the partners worked for Autodesk part-time at this stage, most in addition to their full-time jobs. Seven products were introduced at the fall 1982 COMDEX—the Computer Dealers Exposition, the major PC-industry trade show. Each package was renamed and given an "Auto-" prefix in the fashion of the "Visi-" prefix of VisiCorp: the CAD system was renamed AutoCAD; the personal database, AutoDesk; a screen editor was called AutoScreen, and so on. While there had been high hopes for AutoDesk (which gave the company its name), it was AutoCAD that overwhelmingly grabbed attention.

Following COMDEX, essentially all the resources of Autodesk went into promoting AutoCAD. While AutoCAD had originally been envisaged as a modest "word processor for drawings," Autodesk now found itself thrust into the CAD industry. This was a major sector of the corporate software world, occupied by suppliers such as ComputerVision, Intergraph, Calma, Applicon, and several others The partners had little, if any, experience of the new world in which they found themselves, and they had to learn fast. Autodesk—still a tiny firm with just five full-time employees—took a booth at the CAD industry fair, CADCON, in January 1983. There they discovered that corporate and personal CAD were two different worlds, far apart in their culture and markets. Autodesk achieved far greater sales and visibility at COMDEX and other PC fairs. Autodesk did not return to

[26] Walker, *The Autodesk File*, 24.

CADCON for several years, and it was able to evolve out of sight of the big CAD players.

AutoCAD was untypical of most PC software in that it was priced high and marketed primarily through specialist dealers, who often supplied a computer system and AutoCAD as a bundle. The AutoCAD software package retailed at about $4,000, from which Autodesk derived an average return of $2,000 on each copy sold. When combined with a high-end personal computer, a complete AutoCAD drawing system cost about $10,000, but that was perhaps a twentieth of the cost of a system from ComputerVision. AutoCAD dealers provided after-sales support and training for what was a very complex software system compared with a word processor or spreadsheet. Autodesk produced dealer training manuals and later organized dealer training courses, which had the side benefit of locking dealers into AutoCAD—as firmly as they had cinched their customers—making it less likely that they would switch to distributing an alternative package.

There turned out to be a huge market for a low-cost engineering drawing package. Walker liked to quote the statistic that the United States had over 600,000 manufacturing enterprises, of which 85 percent had ten or fewer employees and did all their drawing manually.[27] Again, there was a vast number of architectural practices and design consultancies that were potential AutoCAD users. In September 1984, AutoCAD made its first major promotion with a two-page color advertisement in *Scientific American*. At this time, the IBM-compatible PC standard was not yet fully established, so Autodesk aimed to supply AutoCAD on every significant platform in order to become the dominant CAD standard. By spring of 1984, the program ran on thirty-one different desktop systems. This was a maintenance burden that diminished as the IBM PC standard began to dominate.

During 1985 and 1986, Autodesk's growth was exponential, exceeding $1 million in sales in 1985 and reaching $10 million in 1986 (see Table 6). By this time, AutoCAD had been regularly upgraded so that it now represented an investment of seventy-six programmer years and 200,000 lines of code. The AutoCAD standard was consciously promoted by building a network of complementary products, dealers, and training agencies. Besides Autodesk's own add-ons, dozens of third-party software developers for vertical markets were promoted in the *AutoCAD Applications Catalog*, which listed over 150 programs. There were 1,300 authorized dealers—all of whom were required to

[27] Ibid., 299.

Table 6
Autodesk Statistics

Year	*Revenues ($ million)*	*Annual Growth (%)*	*Employees (no.)*
1983	0.014	—	26
1984	1.2	8,471	104
1985	8.5	608	190
1986	29.5	247	313
1987	52.3	77	399
1988	79.2	51	414
1989	117.0	48	576
1990	178.6	53	905
1991	237.8	33	1,100
1992	285.0	20	1,310
1993	353.0	24	1,510
1994	405.6	15	1,700
1995	454.6	12	1,751

Source: Jonathan Richardson, "A Decade of CAD," *CAD User* (March 1998): 20*ff*.

attend training courses to obtain and retain their dealerships. There were forty-three authorized training centers to introduce new users to the complexities of AutoCAD. Over 600 educational institutions taught engineering drawing using subsidized AutoCAD software—thus locking in the rising generation of engineering graduates.[28] During the next few years, Autodesk continued to perfect AutoCAD until, by 1990, the program had grown to a million lines of code. With no major competitors in its PC-CAD software niche, Autodesk had a turnover of $179 million, was a global player in the CAD market, and was probably more profitable than any of its mainstream competitors.

Paradigm Shift: The Graphical User Interface

By 1982 the personal computer paradigm had reached technological "closure," based on the IBM-compatible PC equipped with an Intel 8086 or 8088 microprocessor and the MS-DOS operating system. In the classic way in which technologies are shaped, however, no sooner had this technical closure been achieved than a new "critical problem" came into view.[29]

[28] Ibid., 296–304.

[29] The concepts of paradigm shift, technological closure, and critical problems are informed by the works of Kuhn, Hughes, and Rosenberg, among others. See Thomas Kuhn,

The most commonly perceived problem with the PC was the lack of "multitasking"—the ability of a user to work simultaneously with two or more applications. The scenario most commonly envisaged was of a manager who wanted to process data using a spreadsheet, express the results visually using a pie chart, and then incorporate the pie chart into a word-processed document. To do this, the user had to perform the following sequence of operations: fire up the spreadsheet, extract data from a file, process the data in the spreadsheet, save the results in a file, and then close the spreadsheet application; a similar sequence was then repeated, in turn, with the graphics drawing package and word processor. Lotus 1-2-3 was one of the first products to address the problem of switching between programs by integrating three applications (a spreadsheet, a graphics package, and a simple word processor) in a single program. However, the preferred approach would allow the user to have several applications active simultaneously and to be able to switch rapidly from one to the other, thus permitting data to be shared between them. This was multitasking.

During 1982–83, a consensus emerged that the best way to achieve multitasking was by means of a windowing system. A windowing system allowed several applications to coexist, each in a separate window on the computer screen; one application would command the user's attention at any moment, and by choosing to focus on a different window, the user could effortlessly switch to another task and then back to the original one. The concept of a windows-based operating system had originated with a classic innovation at Xerox's Palo Alto Research Center (PARC) in the 1970s.[30]

This research originated most of the ideas that are now standard in the graphical user interface—overlapping windows, pull-down menus, and point-and-click task selection using a mouse. The work had resulted in the Xerox Star, which was announced in May 1981, but the product was a marketing failure, primarily because the cost of $40,000 was much too high for personal computers. The concept of the graphical user interface was also adopted by Apple Computer for its Lisa computer, launched in May 1983. Although universally regarded as a path-breaking product, the Lisa also failed in the marketplace because

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The Structure of Scientific Revolutions (Chicago, 1962); Thomas Park Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, 1983); and Nathan Rosenberg, *Inside the Black Box: Technology and Economics* (Cambridge, 1982).

[30] Douglas K. Smith and R. C. Alexander, *Fumbling the Future: How Xerox Invented, Then Ignored, the First Personal Computer* (New York, 1988); Michael A. Hiltzik, *Dealers of Lightning: Xerox Parc and the Dawn of the Computer Age* (New York, 1999).

of its high ($16,995) price. Apple Computer's second attempt with the more modestly priced $2,500 Macintosh, launched in January 1984, was much more successful. The machine was positioned as an "insanely great" computer, and its unique selling point was its user-friendly interface.[31] The Macintosh succeeded in capturing some 5 to 10 percent of the personal computer market for the next decade. But because it was a proprietary system, it never attracted a network of software and hardware suppliers to anything like the extent achieved by the IBM-compatible PC.

As a result of the rise of the graphical user interface, the critical problem of multitasking became conflated with the secondary issue of user friendliness. In 1983, several software firms were developing windowing systems for the IBM-compatible PC, and their distinguishing characteristics tended to relate to ease of use—for example, whether the system used a mouse to point and click or required the user to navigate by means of keyboard function keys or obscure keystrokes.[32] Table 7 shows the principal windowing systems produced during the 1983–85 time frame. In all cases, the development of a windowing system was highly speculative—in terms of both marketplace uncertainty and the challenge of creating an unfamiliar technology.

Most of the media attention focused on three companies: VisiCorp, Microsoft, and Digital Research. VisiCorp was the first to announce a windowing system, at the November 1982 COMDEX. VisiCorp was then the leading personal-computer software company in terms of revenues, and so its windowing product, VisiOn, attracted intense interest. VisiOn was designed as an environment that would sit between the MS-DOS operating system and ordinary applications. The project turned out to be far larger than originally envisaged. The development began in early 1981, and by the time it was shipped three years later, it reportedly had been rewritten from the ground up three times at a cost of $10 million.[33] It was necessary for software publishers to rewrite their applications to run under VisiOn, but despite VisiCorp's encouragement, none chose to make the investment. When released in January 1984, the only products available for VisiOn were VisiCorp's own productivity applications, such as VisiOnCalc and VisiOnWord. VisiOn was priced at $495, while the applications averaged $400 each. Luke-

[31] Steven Levy, *Insanely Great: The Life and Times of Macintosh, the Computer that Changed Everything* (New York, 1994).

[32] See, for example, Anon., "A Fierce Battle Brews Over the Simplest Software Yet," *Business Week*, 21 Nov. 1883, 61–3.

[33] Phil Lemmons, "A Guided Tour of VisiOn," *Byte* (June 1983): 256*ff*.

Table 7
Windowing Systems for the IBM-Compatible PC, 1984–1985

Publisher	*Product*	*Price ($)*	*Announced*	*Released*	*Notes*
VisiCorp	*VisiOn*	495	November 1982	January 1984	Price reduced to $95
Digital Research	*GEM*	399	November 1983	September 1984	Price included Concurrent DOS
Microsoft	*Windows 1.0*	95	November 1983	November 1985	—
IBM	*TopView*	149	August 1984	February 1985	—
Quarterdeck	*DESQ*	399	Spring 1983	May 1984	—

Sources: John Markoff, "Five Window Managers for the IBM PC," *Byte Guide to the IBM PC* (Fall 1984): 65–7, 71–6, 78, 82, 84, 87; Irene Fuerst, "Broken Windows," *Datamation*, 1 March 1985, 46, 51–2; Allen G. Taylor, "It's Gem vs. TopView as IBM, DRI Square Off," *Software News*, Aug. 1985, 71–3; Ken Polsson, *History of Microcomputers: Chronology of Events*, http://www.maxframe.com/HISZCOMP.HTM—accessed December 2000.

warm reviews and the absence of any applications except VisiCorp's own resulted in a very slow rate of adoption, despite a cut in VisiOn's price from $495 to $95 within a month.

Microsoft announced its intention to develop a windowing system in November 1983. Like VisiOn, the intent was for Microsoft Windows to be a software layer between MS-DOS and ordinary applications. The November announcement stated that Windows would be available by spring 1984, with the expectation that it would be running on 90 percent of MS-DOS computers by the end of the year. The Windows development turned out to be much more complex than originally expected, and its release date was put back to May 1984, then August, then January of the following year. By then, Windows had become Microsoft's largest development project, with two dozen developers and half as many again producing documentation. Windows finally arrived in November 1985. Priced at $95, the package was launched with the biggest publicity campaign in Microsoft's short history, complete with full-color, eight-page inserts in leading computer magazines.

Although Digital Research had been eclipsed by Microsoft in 1983, it remained a significant and growing company; its annual revenues, exceeding $50 million, derived mainly from its eight-bit control program for microprocessors, the CP/M operating system. In late 1983, it announced the development of the Graphics Environment Manager (GEM) in response to the market clamor for a graphical user interface. GEM was adopted for a Macintosh-like computer, the Atari ST, but it

was never able to penetrate the IBM PC market significantly. Although VisiCorp, Microsoft, and Digital Research were the three most reported windowing systems, there were several other well-publicized entrants. These included an IBM system called TopView, and DESQ, produced by a Santa Monica start-up called Quarterdeck. These were market failures too.

The failure of all the windowing systems came as a surprise. The business and computer press had anticipated a "fierce battle" for this new territory, and 1984 had been "heralded as the year of the window."[34] In fact, there never was much of a battle, for the rather mundane reason that most of the products limped into the market after long development delays, and none performed acceptably. With the low-powered 8088/86 microprocessors, the systems were "unbearably slow" and left reviewers "begging for faster hardware."[35] This was true even on the new Intel 80286 microprocessors. The disappointing results illustrated how immature the PC software industry was, revealing its inability to estimate realistically either project development times or software performance. Some of the vendors of windowing systems paid a high price for their inexperience. In the summer of 1984, the failure of VisiOn obliged VisiCorp to lay off half of its 110 workers and then to submit to a takeover by a small company, Paladin Software, a step it viewed as preferable to the "ignominy of Chapter 11 bankruptcy."[36] The rights to VisiOn were sold off to the mainframe maker Control Data Corporation (CDC). It was an extraordinary about-face for a firm that had been number two in the industry in 1983. Digital Research was unable to restore its fortunes with GEM or any other of its operating-system developments. In 1985 its income dropped $20 million, from a peak of $56 million in 1984, and it cut its 600-member workforce by half. Gary Kildall, the founder of Digital Research, resigned in mid-1985.

Only Microsoft and IBM would have the resources to persist with a graphical user interface, which would have to wait for the next generation of Intel microprocessors. In any case, a simple GUI enhancement of MS-DOS was not the only egg in their baskets. Microsoft and IBM had begun the joint development of a new operating system in early 1985, which was intended to be the long-term replacement for MS-DOS.

[34] Irene Fuerst, "Broken Windows," *Datamation*, 1 March 1985, 46, 51–2.

[35] John Markoff, "Five Window Managers for the IBM PC," *Byte Guide to the IBM PC* (Fall 1984): 65–6, 71–6, 78, 82, 84, 87.

[36] Efrem Sigel, "Alas Poor VisiCorp," *Datamation*, 15 Jan. 1985, 93–4, 96.

Meanwhile, inside Microsoft, development of Windows continued under its own momentum. In late 1987, Windows 2.0 was released with modest acclaim. The interface had been considerably polished, and its main visual elements were almost indistinguishable from those of the Macintosh. Although Microsoft had obtained a license with Apple Computer for Windows 1.0, version 2.0 so closely emulated the look and feel of the Macintosh that Apple sued for copyright infringement in March 1988. The Apple–Microsoft lawsuit consumed many column inches of reportage and rattled on for three years before a settlement in Microsoft's favor was reached in 1991.[37] So far as can be ascertained, the lawsuit was something of a sideshow that had little bearing on Microsoft's, or any other company's, technical or marketing strategy.

Within a few months of the introduction of Windows 2.0, Microsoft and IBM announced the completion of their joint project: a new operating system, called OS/2. However, the operating system was yet another product failure, on account of its high price ($325), incompatibility with existing applications, and only marginal advantages over MS-DOS.[38] At this point, Microsoft decided to cut its losses, withdraw from the partnership with IBM, and pursue Windows. It had not, in any case, been a happy experience because of the insurmountable cultural differences between the two firms. Although sales of Windows 2.0 could not begin to compare with those of an MS-DOS—now running at over five million copies a year—it was doing much better than OS/2, confirming the advantages of a migration path that maintained user lock-in by augmenting MS-DOS rather than replacing it. In 1988–89, several mainstream application publishers converted their products to run under Windows, and by early 1989, two million copies of Windows 2.0 had been sold.

With this positive response to Windows, more resources were poured into the development, and a new version was launched in May 1990, with a reported $10 million spent on a worldwide publicity splash. Windows 3.0 received unequivocal market acceptance, and the paradigm shift had finally occurred. A writer for *PC Computing* caught the moment well:

> When the annals of the PC are written, May 22, 1990, will mark the first day of the second era of IBM-compatible PCs. On that

[37] Lawrence D. Graham, *Legal Battles that Shaped the Computer Industry* (Westport, Conn., 1999), 35–41.

[38] The best account of the complicated history of OS/2 appears in Paul Carroll, *Big Blues: The Unmaking of IBM* (New York, 1993).

> day, Microsoft released Windows 3.0. And on that day, the IBM-compatible PC, a machine hobbled by an outmoded, character-based operating system and seventies style programs, was transformed into a computer that could soar in a decade of multitasking graphical operating environments and powerful new applications. Windows 3.0 gets right what its predecessors—VisiOn, GEM, the earlier versions of Windows, and OS/2 Presentation Manager—got wrong. It delivers adequate performance, it accommodates existing DOS applications, and it makes you believe that it belongs on a PC.[39]

In hindsight, it seems extraordinary that Microsoft's development processes and technical competence were such that it simply kept improving and relaunching Windows until it was finally in harmony with the technology and the marketplace. Yet that was the essential truth. Microsoft was a very young company that had surprisingly little technological depth. It was better characterized as a "learning organization"—an organization that fumbled its way to success by making mistakes, learning, and then making fewer mistakes.[40] Microsoft's three attempts to produce Windows were mirrored by just as many attempts to produce application software.

Microsoft and Productivity Applications

One can best observe Microsoft's domination of the software market through the sector of productivity applications, a market in which it had virtually no presence in 1983 but had come to dominate by 1995.

Microsoft's strategy has been to use the revenues from its successful systems products to develop applications software, without regard to short-term profitability. Invariably, these packages have only been successful at the third or subsequent product launch. Having a good product was never sufficient in itself to dislodge any of the incumbents in productivity applications: the Lotus 1-2-3 spreadsheet; the WordPerfect word processor; or the dBase database system. However, at some point in their history, all these firms temporarily lost their hold on the market, opening a window of opportunity for Microsoft. For example, all three firms had development debacles in the late 1980s, resulting in products that were either late or unreliable. They also all misjudged the impact of Microsoft Windows, betting instead that OS/2 would become the dominant platform.

[39] As quoted in Wallace and Erickson, *Hard Drive*, 362.
[40] Cusumano and Selby, *Microsoft Secrets*.

In short, Microsoft has played a waiting game by having excellent products that were ready to replace an incumbent when the opportunity came. Had history unrolled differently—for example, had OS/2 and not Windows become the dominant platform—the story might have unfolded differently, but the outcome mostly likely would have been much the same.

Lotus 1-2-3 and Excel

The Lotus Development Corporation was perhaps the premier example of a firm dominating its sector. Lotus launched its 1-2-3 spreadsheet in January 1983 at the same time that the IBM-compatible PC was emerging as a standard. By the end of 1984, Lotus had revenues of $156 million, making it the leading personal computer software company, ahead even of Microsoft, whose sales were $97 million (see Table 8). All this was on the basis of a single product. Lotus 1-2-3 so completely eclipsed VisiCalc that its publisher, VisiCorp, and its developer, Software Arts, were driven out of the business. VisiCorp, unable to restore its competitive position with VisiOn, had been taken over by Palladin Software in 1985, while Software Arts was acquired by Lotus for $800,000, and the creators of VisiCalc, Dan Bricklin and Bob Frankston, became employees of Lotus. VisiCalc was withdrawn from the market in mid-1985, and its users were offered a half-price upgrade to Lotus 1-2-3.[41]

With Release 2 of 1-2-3 in September 1985, Lotus's fortunes continued to soar, and the package dominated the software charts for the next two years. In 1987 it had a 70 percent share of a spreadsheet market estimated to be worth $500 million. A total of three million copies of Lotus 1-2-3 had been sold, and its lock on the market was consolidated by a range of complementary products from other vendors—called "add-ins" by Lotus—such as Funk Software's Allways and Personics Look&Link. These had become major products in their own right.[42]

Lotus's first major setback came with Release 3 of 1-2-3: "the spreadsheet that nearly wore Lotus out."[43] For this release, Lotus decided to rewrite the program from the ground up, not reutilizing any of

[41] Peter Petre, "The Man Who Keeps the Bloom on Lotus," *Fortune*, 10 June 1985, 92–4, 96, 98, 100.

[42] Kelly R. Conatser, "1-2-3 Through the Years," *Lotus* 8 (June 1992): 38–45.

[43] Keith H. Hammonds, "The Spreadsheet That Nearly Wore Lotus Out," *Business Week*, 3 Jul. 1989, 50–1.

Table 8
Lotus Statistics

Year	*Revenues ($ million)*	*Annual Growth (%)*	*Employees (no.)*
1983	53	—	291
1984	156	194	750
1985	226	45	1,050
1986	283	25	1,400
1987	396	40	2,100
1988	469	18	2,500
1989	556	19	2,800
1990	685	23	3,500
1991	829	21	4,300
1992	900	9	4,400
1993	981	9	4,738
1994	971	−1	5,522
1995	1,150	18	6,000

Source: *Hoover's Guide to Computer Companies* (Austin, Tx., various years).

the code from the previous releases. It was a scale of development to which Lotus was unused, and, in the midst of what turned into a crisis, an IBM development manager was hired to establish bureaucratic processes for controlling the project and its thirty-five developers. Originally scheduled for mid-1988, the program's release date slipped three times before it finally appeared in June 1989. The new release of Lotus 1-2-3 contained 400,000 lines of code, compared with 20,000 in the first version. Lotus had staked its future on OS/2 as the successor to MS-DOS, and 1-2-3 could run with either. Although Lotus maintained its sales volume during the Release 3 debacle, it was forced to cut the price in order to maintain competitiveness against products like Microsoft's Excel and Borland's Quattro. This dramatically affected Lotus's profits, causing its share price to fall nearly 60 percent during 1988.

Microsoft's spreadsheet, eventually to become Lotus 1-2-3's main competitor, had started life in 1980, when founders Bill Gates and Paul Allen decided to diversify into applications to reduce their dependency on systems software. Microsoft's first spreadsheet, then known as MultiPlan, was released in the second half of 1982, with versions for the Apple II and the IBM PC. Although the product got excellent reviews (including a "software of the year" award), it made little headway against 1-2-3. Lotus was making more money on its single program than Microsoft was making on its entire product line. Accepting the impossibility of competing with Lotus 1-2-3 head on, Microsoft

decided to develop a GUI-based spreadsheet for the Macintosh. In effect, this strategy would shield it from Lotus competition and allow Microsoft to perfect its spreadsheet and interface technology. The new Macintosh spreadsheet, now called Excel, was released in September 1985 and quickly secured 90 percent of Macintosh spreadsheet sales.

When Windows 2.0 was released in October 1987, Excel for Windows was released at the same time, and, in the absence of competitors, became the preferred spreadsheet for Windows. However, to most observers, including Lotus, the more likely successor to MS-DOS would be OS/2. Hence, when Windows finally took off with version 3.0 in 1990, Lotus and many other software makers were caught off guard with no Windows versions of their products. Excel filled the spreadsheet vacuum created by Windows. When Lotus 1-2-3 for Windows was finally released in 1991, Excel had the first-mover advantage on what was rapidly becoming the dominant platform. Lotus 1-2-3 never recovered its former market share: by 1995 Excel had over 70 percent of the world-market revenues for spreadsheets, while Lotus had less than 20 percent.[44]

WordPerfect and Microsoft Word

In 1984 WordPerfect had less than 1 percent of the market for personal computer word-processing software, while MicroPro's WordStar had 23 percent. Two years later, their positions would be reversed, with WordPerfect having a 30 percent share and rising, and WordStar half as much and falling. By 1986 MicroPro's revenue had fallen from a peak of $67 million in 1984 to $38 million, and it was experiencing a $1.2 million loss. Satellite Software International, the manufacturer of WordPerfect, was renamed the WordPerfect Corporation in 1986. By 1987 WordPerfect was the top-selling personal computer software package in volume terms, ahead even of Lotus 1-2-3 and dBase III.

The WordPerfect Corporation was one of the very few personal computer software publishers that had its origins in the world of corporate computing. The firm was incorporated as Satellite Software International (SSI) in 1979 by Alan Ashton, a computer science professor at Brigham Young University, Utah, and his graduate student, Bruce Bas-

[44] For spreadsheet sales statistics for 1988–97, see Liebowitz and Margolis, *Winners, Losers and Microsoft*, 175–6.

tian.[45] In the summer of 1977, Ashton had developed a word-processing program essentially as an academic exercise for the long vacation. This was subsequently enhanced by Bastian and packaged for the Data General minicomputer for a client in Orem, Utah. In March 1980, the package, named SSI*WP, was made available to Data General resellers, which sold two or three copies a month at a retail price of $5,500. By the end of 1981, SSI was a modest success with a turnover of $850,000. As such, it was similar to at least fifty small firms that were developing word-processing software for minicomputers and was competing with major players such as Wang and Lanier.[46] The fact that SSI was able to move eventually into PC software, unlike most other corporate software firms, was probably because it was young, very small, and had few institutional rigidities.

Up to this time, SSI had not considered entering the personal computer word-processor market, nor had it even been aware that this was a goal worth pursuing. In 1982, however, the firm acquired its first IBM PC and decided to convert SSI*WP for use on it, not least because some of their Data General–owning clients were also acquiring IBM PCs and wanted a compatible word processor. The word processor for the IBM PC, essentially identical to the one designed for Data General, was renamed WordPerfect and launched in October 1982. The product made very little impact at first, mainly because the firm's only experience of direct selling was to the corporate computer market, possessing neither the capability nor the advertising budget to address the retail sector. However, as they built up experience in selling through ComputerLand and other PC retailers, sales began to rise. Press reviews of WordPerfect were highly favorable, singling out for special praise the toll-free help lines that enabled users to obtain technical support and the fact that the software supported over 200 different printers. The product quickly gained a word-of-mouth reputation for solid dependability,

The turning point for WordPerfect occurred when MicroPro replaced its aging WordStar with WordStar 2000 in late 1984. MicroPro made a classic error. Rather than carrying out an evolutionary upgrade, WordStar 2000 used an entirely new interface and was bigger and slower than the previous version. Because of the new interface, WordStar lost its lock on the market and users switched to other products.

[45] W. E. Pete Petersen, *AlmostPerfect: How a Bunch of Regular Guys Built WordPerfect Corporation* (Rocklin, Calif. 1994).

[46] Frost & Sullivan, *The Text Processing Market in the U.S.* (New York, 1982).

Many of these switchers chose WordPerfect 4.0, a major new release that had fortuitously appeared just a few weeks earlier and was probably the best available option to WordStar on the market.

Following its initial release in 1982, WordPerfect had undergone constant revisions, and major or minor upgrades were announced every year at the fall COMDEX. By 1987, however, WordPerfect was in need of a major rewrite because competitive threats were coming from two directions. The first was from Microsoft Word, which at that point was taking 10 percent of word-processing unit sales.[47] The second came from desktop publishing packages, such as Aldus Pagemaker and Adobe Illustrator, that offered the ability to integrate text and pictures and supported the new generation of laser printers. Version 5.0 was the WordPerfect Corporation's biggest undertaking so far; they had little experience of major development projects, and so the schedule slipped month by month. Although well behind schedule, WordPerfect 5.0 was announced at the November 1987 COMDEX in the hope of dissuading users from switching to Microsoft Word. It was eventually released in May 1988 with a large number of bugs, with the result that: "the company got so many calls that the 800 lines into Utah were jammed, cutting off Delta Airlines and the Church of Jesus Christ of Latter-day Saints. AT&T eventually added more 800 lines."[48] Users have proved surprisingly tolerant of unreliable software, so, bugs and all, WordPerfect remained the top-selling word processor, with sales up from the previous year by an astonishing 75 percent. A similar performance followed in 1990, by which time WordPerfect had 80 percent of word-processor revenues.

WordPerfect's growth stalled in 1991 because of competition from Microsoft's Word for Windows. The WordPerfect Corporation, like Lotus, had bet on OS/2 and therefore had no product designed for the Windows platform when Windows 3.0 was released in May 1990. In that same month, WordPerfect, quickly sensing the market acceptance of Windows, announced the postponement of WordPerfect for OS/2 in favor of a Windows version. Intended for release in February 1991, WordPerfect for Windows did not ship until November, and its arrival

[47] Word-processing market shares by units are given in Ichbiah and Knepper, *The Making of Microsoft*, 132, and Petersen, *AlmostPerfect*, passim. Liebowitz and Margolis, *Winners, Losers and Microsoft*, 181, gives market share by revenues, 1988–97. Sales revenues are difficult to interpret in the word-processing market because some high-function packages were much more highly priced than average, while others were priced low to capture market share. Unit sales, used here, was the usual measure.

[48] Sandra D. Atchinson, "A Perfectly Good Word for WordPerfect: Gutsy," *Business Week*, 2 Oct. 1989, 79–80.

was poorly received because of its weak integration with the Windows interface. Meanwhile, as with Excel, Microsoft had perfected Word over a period of years. Following its initial launch in 1983, it had secured a respectable, but modest, 10 percent market share. Again, as with Excel, a version of Word for the Macintosh enabled Microsoft to perfect its graphical user interface and laser-printing technology out of sight of the mainstream IBM PC market. Released in January 1985, Word was consistently the best-selling application for the Macintosh. In December 1989, Word for Windows was released for the IBM platform; this was a very sophisticated product, embodying all Microsoft's Macintosh know-how and containing a quarter of a million lines of code—three times the size of its predecessor. Although its first release had many bugs, Word for Windows 2.0 in 1991 was a highly regarded product that was able fully to exploit the mass acceptance of the Windows platform.

Revenue growth for the WordPerfect Corporation flattened out as the market rapidly switched to Microsoft Word, precipitating management restructuring in 1992.[49] WordPerfect never regained its former prominence, and by the mid-1990s its sales were essentiality vestigial, while Microsoft Word had 90 percent of the market.

Ashton-Tate

In 1983, Ashton-Tate's dBase II was the third-best-selling software product, with cumulative sales of 100,000 copies at a price of $695. While Ashton-Tate owed much of its success to an early start, it was particularly adept at fostering complementary products. By 1984, some 1,800 companies had signed up for its support program to develop dBase II templates for vertical markets, and its *Application Junction* catalog for 1985 listed over 1,700 complementary products.[50] Ashton-Tate's market dominance was consolidated by the release of dBase III in 1985. By then, Ashton-Tate was enjoying an extraordinary 68 percent share of the market for personal computer databases estimated at $150 million.[51] The rest of the market was shared by more than sixty competitors. Of these, the most important were Ansa's Paradox, Micro-

[49] Kathy Rebello, "The Glitch at WordPerfect," *Business Week*, 17 May 1993, 56–7.

[50] Robert A. Sehr, "Beefing Up Software," *Datamation*, 15 Feb. 1985, 148.3–148.6; David W. Carroll, "The dbase Phenomenon: Nurtured by dBase II, Another Aftermarket has Developed," *Software News*, Aug. 1985, 62–4.

[51] Market data, attributed to IDC, in Patrick E. Cole, "dBase IV is a Godsend—To the Competition," *Business Week*, 13 Nov. 1989, 79.

rim's R:base, Fox Software's Foxbase, and Information Builders' PC/Focus. Beneath them were myriad personal filing systems, exemplified by Software Publishing's Pfs:File.

Although Ashton-Tate had begun as a software publisher rather than as a developer, it established its own software-writing capability during 1984 and thus was able to produce dBase III in house. In 1986, development work started on dBase IV. This was a very ambitious product that was to result in a program containing some 450,000 lines of code produced by seventy-five developers. Like Lotus and WordPerfect, Ashton-Tate was overwhelmed by the unfamiliar scale of development. Ashton-Tate's vice president of programming, Wayne Ratcliffe, the developer of the original dBase II, resigned amid the chaos, acrimoniously claiming that Ashton-Tate "did not understand the software development process."[52] After considerable slippage in the schedule, dBase IV was released in October 1988 as a gargantuan product that shipped on fourteen floppy disks.

Alas, dBase IV was very unreliable. One hundred and five bugs were reported; of these, Ashton-Tate conceded to forty-four.[53] Bug-ridden products were by no means unusual in the maturing personal computer software industry, and Microsoft, Lotus, and WordPerfect, had all shipped products that had to be withdrawn or remedied by free upgrades. However, while a word processor or spreadsheet that froze up could be tolerated, loss of computer data could not. Probably the risk of data loss was exaggerated, but users stopped buying dBase IV. Fortunately, Ashton-Tate's revenues declined less savagely than might have been predicted, largely because a subindustry of complementary product makers mediated between Ashton-Tate and its customers, and thus were able to sustain their own businesses on the basis of the aging dBase III. However, by the time a reliable version of dBase IV was released in July 1990, many users had switched to competing products, and Ashton-Tate itself was running up losses of $20 million a quarter. In 1991, the loss-making Ashton-Tate was acquired by Borland—a much smaller company—in a stock swap for $439 million. Although dBase IV continued to sell acceptably on the basis of its historic customer base, it had lost its allure and never recovered.

It should be noted that, in the demise of Ashton-Tate, no smoking gun could be traced to Microsoft. Top-selling products, such as dBase

[52] Patrick E. Cole, "dBugs in dBase IV Spread to the Bottom Line," *Business Week*, 17 July 1989, 78–9.

[53] Cole, "dBase IV Is a Godsend—to the Competition," 79.

IV—or VisiCalc or WordStar, for that matter—could fall from grace because of obsolescence or unreliability, quite independently of Microsoft.

Product Integration and Office Suites

Although Lotus, WordPerfect, and Ashton-Tate could be fairly described as one-product companies—in that 80 percent or more of their sales came from a single program—this was not by choice. Having succeeded on one front, they all sought to diversify into other productivity applications, partly to achieve corporate growth but also out of an awareness that the market was inherently unstable and today's hit could easily become tomorrow's also-ran. Early on, the two market leaders, VisiCorp and MicroPro, had tried to create a brand image and a portfolio of products to complement their top-selling package: thus VisiWord and VisiFile complemented VisiCalc, and CalcStar and DataStar enhanced WordStar. None of these diversification attempts were successful because even attractive pricing was not enough to persuade the market to switch from a known and trusted product.

In 1984, both Lotus and Ashton-Tate attempted to augment their hit products with integrated packages that would offer the three main productivity applications in a single program. Lotus 1-2-3 was, of course, itself an integrated package to the extent that it contained basic charting and word-processing capabilities. However, Lotus's new product, Symphony, would incorporate a spreadsheet with a full-strength word processor, a database, and a communications program. Lotus spent a reported $14 million on the program, including $8 million for an advertising blitz that "included a [TV] spot during the Summer Olympics."[54] At the same time, Ashton-Tate was working on an integrated package, Framework. Ashton-Tate's package aggressively targeted Symphony, even matching its price of $685 and its launch date of July 1984.[55] Ashton-Tate assiduously courted its hundreds of complementary product suppliers to encourage them to create vertical applications. Ashton-Tate spent a reported $10 million on Framework, much of it going to publicity. However, Symphony and Framework, as well as dozens of imitators, were all product failures. Within a year, the integrated-product fad evaporated, and "with about 70 integrated software packages on the market," *Datamation* noted, "software companies have been failing with the regularity of Philadelphia commuter

[54] Peter Petre, "The Man Who Keeps the Bloom on Lotus."
[55] Anon., "A Toe-to-Toe Duel in Personal Software," *Business Week*, 9 April 1984, 52–3.

trains and new Italian restaurants."[56] WordPerfect was mercifully then too small to be distracted by the integrated application craze, though it had begun to develop complementary spreadsheet and drawing programs, PlanPerfect and DrawPerfect, neither of which reached the market. For the next five years, the stand-alone application dominated the market.

In 1990, however, Microsoft introduced a devastating marketing strategy. In a single shrink-wrapped box called "Office," it bundled all its productivity applications for Windows at a price of $750, which was not much more than the cost of one of the individual programs. Microsoft had tested this approach with Office for the Macintosh in 1988, bundling Excel, Word, and its newly developed presentation graphics program, PowerPoint, with excellent results.[57] In 1990, Microsoft Office was introduced for Windows with the same three productivity applications. With the graphical user interface environment of Windows, Office provided a degree of integration that had not been possible under MS-DOS. Lotus was obliged to follow suit by introducing its SmartSuite in 1991, which consisted of Lotus 1-2-3, the AmiPro word processor (acquired from Samna in 1990), Freelance presentation software, and a personal database. In 1992 Microsoft acquired Fox Software (the maker of the Foxbase database program) and subsequently added a database program, Access, to the "professional"—and high-priced—edition of Office In 1993, Borland—which owned the Quattro spreadsheet and the two leading database packages, dBase IV and Paradox, but no word processor, cooperated with the WordPerfect Corporation to publish Borland Office, consisting of WordPerfect, the Quattro Pro spreadsheet, and the Paradox database.[58]

The strategy behind Office has never been explicitly described by Microsoft, although analysts have speculated that the package enabled the company to push loss-making applications, such as PowerPoint, onto people's desktops and gain market share from its one-product competitors while incurring relatively little collateral damage to itself. At all events, by the fall of 1993, Office accounted for more than half of Microsoft's productivity application sales and was increasingly positioned as Microsoft's "primary application," rather than as "simply a way of marketing a group of applications."[59] Intense competition between the three office suites saw prices fall to the $300 level during

[56] Irene Feurst, "So Where is the Market?" *Datamation*, 1 April 1985, 45, 48
[57] Richard Brandt, "Software Will Play Hardball Again," *Business Week*, 10 Jan. 1994, 48.
[58] Amy Cortese, "Once Again, Software Is Seething," *Business Week*, 9 Jan. 1995, 46.
[59] Stross, *The Microsoft Way*, 56.

1993–94. Microsoft Office massively outsold the others, gaining an estimated 90 percent market share compared with Lotus SmartSuite's 8 percent and Borland Office's 2 percent.[60] Experiencing collapsing profits, WordPerfect was acquired by Novell for $800 million in 1994. In 1995 IBM acquired Lotus for $3.5 billion, not for its spreadsheet but for its personal computer software development know-how and some interesting products then under development.[61] Perhaps the biggest casualty was the Software Publishing Corporation, whose low-cost Pfs programs lost the price advantage that had sustained its market niche for a decade. In 1993, the company had to lay off 140 employees, over 20 percent of its workforce, and was soon lost from sight as a significant software company.

Competing with Microsoft

Between 1983 and 1995, Microsoft came to dominate the personal computer software industry to an extent that has no parallel in the corporate software industry. However, although Microsoft bestrode its world like a colossus, other firms have been able to compete successfully. While Microsoft enjoyed an approximately 50 percent share of the market for personal computer software in 1995, the top half-dozen firms after Microsoft enjoyed shares of between 2 and 10 percent (see Table 2). These were successful firms by any standards. And beneath them were hundreds of lesser, but moderately successful, firms. One can recognize four distinct strategies adopted by these firms, which have allowed them to coexist or compete with Microsoft.

First, firms have been able to coexist by publishing products complementary to Microsoft's top-selling packages. Perhaps the best-known example of this strategy was followed by Peter Norton Computing. Peter Norton established his firm in 1982 with the tiny idea of enabling MS-DOS users to restore files that they had accidentally deleted. Five years later, in 1987, "close to a million of the fumble-fingered, fatigued, or forgetful now reach for the $100 Norton Utilities as if it were aspirin," and Peter Norton Computing was a fifty-employee firm with annual sales of $10 million.[62]

From Microsoft's perspective, Norton Computing was little more than a speck of dust. At the other end of the spectrum, however, Novell—

[60] Bill Lawrence, "Three Suite Deals," *Byte* (March 1994): 120–4, 6.

[61] Amy Cortese and Ira Sager, "Gerstner at the Gates," *Business Week*, 19 June 1995, 30–2.

[62] Patrick E. Cole, "Lost a Computer File? Call on Dr. Norton," *Business Week*, 23 May 1986, 116.

which complemented MS-DOS with networking software—became the number two firm in the industry. Originally a hardware firm, Novell introduced its NetWare software product in 1987. Once it succeeded in integrating isolated desktop computers into corporate networks in the late 1980s and early 1990s, the company grew very rapidly.[63]

Complementers, however, always run the risk that Microsoft will incorporate the functions contained in their software into its own products, either by internal development or by acquiring the technology through a takeover. This is what happened in Novell's case. There were merger talks between the two companies in 1990, which fell through. Microsoft subsequently introduced networking capabilities into its operating systems in the early 1990s, thereby entering into intense competition with Novell. On the other hand, with Norton Utilities, Microsoft has shown the tolerance of an elephant for the tikka bird on its back, allowing Peter Norton Computing "deep into the innards of the operating system" and fostering "tremendous personal relationships between their development teams."[64] This is probably because Norton Utilities complements Microsoft's operating systems, adding to their value—by providing antivirus facilities, for example—in a way that Microsoft's relatively bureaucratic development processes would find difficult or uneconomical.

A second way of coexisting with Microsoft has been to occupy niche markets where Microsoft has no presence. A classic example of this was Borland, which introduced Turbo Pascal in 1982. It happens that developers prefer particular programming languages for reasons that are more religious than rational. Thus Pascal was an elegant programming language favored by academics and idiosyncratic firms like Apple Computer, whereas Microsoft and most software developers preferred the more prosaic Basic or C programming languages. As a result, Borland experienced no competition from Microsoft, whose forte was programming languages; had Microsoft ever produced a Pascal system, it would surely have eclipsed Turbo Pascal. There were other successful niche players among the top ten firms: AutoDesk, specializing in CAD software; Adobe Systems, in printing software; Aldus, in desktop publishing; Corel with its Draw! package; Intuit, in personal finance software; and SCO, in Unix-on-Intel operating systems. All of these have been vulnerable to Microsoft's occupying their niche with

[63] Evan L. Schwartz, "The Industry Needs an Alternative—But Will it be Novell?" *Business Week*, 1 Feb. 1993, 48–9.

[64] Interview with Gordon Eubanks, in Rama Dev Jager and Rafael Ortiz, *In the Company of Giants: Candid Conversations with Visionaries of the Digital World* (New York, 1997), 55.

its massive development and marketing resources. This has already happened in the case of both Adobe Systems and Intuit.

Adobe Systems was formed by John Warnock and Charles Geschke, who pioneered laser printing technology at Xerox PARC in the late 1970s. In 1982, when Xerox had failed to market the technology, Warnock and Geschke started their own company.[65] The firm grew rapidly, supplying a software technology known as Postscript for laser-printer manufacturers and for the Apple Macintosh. That the Macintosh was subsequently able to dominate the high-end desktop publishing (DTP) market was largely due to Adobe's technology. By 1984, half of Adobe's income came from Apple royalties. By the late 1990s, however, its Postscript technology was no longer unique, as both Apple Computer and Microsoft had developed their own systems. Recognizing that its niche in printing software was evaporating, Adobe made a number of strategic acquisitions to diversify into the niches of DTP and electronic document distribution.

Intuit was established in 1983 by Scott Cook, a thirty-something former Procter & Gamble brand manager. Intuit's Quicken personal finance software drew ahead of many similar packages through its heavily promoted brand image as much as its intrinsic merits. By 1990 it dominated the modest niche of personal finance with annual sales of $33 million. The following year, Microsoft introduced its Money package. Despite Microsoft's multiple product relaunches, Quicken continued to outsell Money seven to one. In October 1994 Microsoft made a takeover bid, which Intuit accepted. However, before the merger could be consummated in April 1995, the Department of Justice brought an action to prevent the merger on the grounds that it would diminish competition in the emerging markets of personal finance and home banking. Subsequently Microsoft withdrew its offer.[66]

Microsoft has itself made investments in niche firms without actually introducing a product of its own, essentially as a way of gaining market intelligence and potential access to technology. One example is Microsoft's involvement with the Santa Cruz Operation. Formed in 1979, SCO specializes in Unix-on-Intel operating systems. SCO licensed Microsoft's XENIX operating system in 1982 as a reseller. After 1983, as

[65] Interview with John Warnock, in Susan Lammers, *Programmers at Work: Interviews with 19 Programmers Who Shaped the Computer Industry* (Redmond, Wash., 1986), 40–55. Interview with John Warnock and Charles Geschke, in Jager and Ortiz, *In the Company of Giants*, 99–113.

[66] Paul M. Horvitz, "Efficiency and Antitrust Considerations in Home Banking: The Proposed Microsoft-Intuit Merger," *Antitrust Bulletin* (Summer 1996): 427–46.

Microsoft increasingly focused on the high-volume MS-DOS operating system, it effectively chose to eschew a market it had pioneered, leaving SCO free to develop that market. In 1989 Microsoft took an 11 percent equity holding in SCO while still pursuing its non-Unix Windows and MS-DOS operating systems. The investment in SCO has given Microsoft a watching brief in order to gain access to Unix technologies should that ever become necessary. In a similar way, Microsoft made investments in the corporate database provider Sybase, a move that subsequently informed its entry into database technology.[67]

A third way of competing with Microsoft has been to develop packages that run on a range of different operating systems and platforms, typically the big three: IBM-compatible PCs running MS-DOS or Windows, the Apple Macintosh, and Unix. Since the late 1980s, particularly, Microsoft has elected to concentrate almost exclusively on the IBM-compatible PC platform, making only a vestigial commitment to the Macintosh and virtually none to Unix. This strategy has enabled Microsoft to dominate the IBM-compatible market. However, many corporations operate heterogeneous environments where PCs, Macintoshes, and Unix workstations coexist and need to run common applications software. This was increasingly the case following the networking of isolated desktops in the early 1990s and with the emergence of the Internet in the mid-1990s. Developing efficient cross-platform software is technologically very demanding. Microsoft has never mastered the skill, and its few attempts at simultaneous development for the IBM PC and Macintosh platforms have been poorly received.

Adobe Systems was one of the first firms to exploit the trend to heterogeneous environments in 1992, when it launched Carousel, a product that created electronic documents in a portable document format (PDF) that could be used on any of the common platforms. Carousel was initially unsuccessful owing to a flawed marketing strategy that required all users to purchase a viewing package. When the product was relaunched as Acrobat in 1994, it was much more successful because a viewer program was distributed free of charge, while only users wishing to publish documents had to pay for the development tools.[68] Another vendor with a strong cross-platform strategy was Netscape

[67] Richard Brandt, "It's Grab-Your-Partner Time for Software Makers," *Business Week*, 8 Feb. 1988, 52–3.

[68] Katherine M. Hafner, "How Two Pioneers Brought Publishing to the Desktop," *Business Week*, 15 Oct. 1987, 61–2; Richard Brandt, "Does Adobe Have a Paper Cutter?" *Business Week*, 6 Nov. 1992, 98–9; Amy Cortese, "This Acrobat Has Really Limbered Up," *Business Week*, 26 Sept. 1994, 73–4.

Communications, one of the Internet wunderkinds, established in 1994. Netscape developed its Navigator browser software simultaneously for the IBM-compatible PC, the Macintosh, and seven versions of Unix. Although Microsoft introduced its own Explorer browser in 1995 and quickly colonized the PC platform, Netscape's cross-platform capability enabled it to maintain a high market share in heterogeneous environments.[69]

A final way that firms have maintained their market share relative to Microsoft has been through acquisition. By the mid-1980s, it was clear that firm or product acquisition was a much more successful growth strategy than internal development. One reason was that unfamiliar technologies have proved remarkably difficult to develop *ab initio*; often it was not until the second or third attempt that developers managed to get a product's features right. Indeed, so often did Microsoft get a product right only at the third attempt that in 1990 "even Gates mused aloud that if the company did not change, customers would simply skip the first two versions."[70] A second problem was that even a technically sound new product was not guaranteed success in the marketplace. On the contrary, one had only to see the fate of the myriad "me-too" spreadsheets and word processors to see that success for any new product in an existing niche was positively unlikely. Acquiring an already developed product could eliminate either or both of these uncertainties. Microsoft itself was well aware of this, although it generally bought for the technology rather than the brand because its own corporate identity was stronger than almost any individual product name. Two of Microsoft's key products, the Access database and the Internet Explorer, were acquisitions—achieved in the first case by taking over Foxbase, and in the second, by licensing technology from Spyglass. Most of the bigger personal computer software companies have made acquisitions, either for technology or to obtain a successful brand. Adobe, for example, became the market leader in desktop publishing by acquisition. The firm made a strategic decision to diversify into DTP applications after its initial public offering in 1986. Its internally developed Illustrator program was moderately successful, but in 1994–95 it bought a dramatically larger market share by acquiring Aldus, the publisher of the best-selling PageMaker package, and the rights to FrameMaker for $500 million from Frame Technology.

[69] Michael A. Cusumano and David B. Yoffie, *Competing on Internet Time: Lessons from Netscape and its Battle with Microsoft* (New York, 1998).

[70] Cusumano and Selby, *Microsoft Secrets*, 141.

Acquisitions have been most successful when there has been a good strategic fit, beyond mere growth. Novell was much less successful when it tried to grow though poorly judged acquisitions. It first tried to move into productivity applications in 1990 by attempting to take over, unsuccessfully, the Lotus Development Corporation, but it subsequently acquired the WordPerfect Corporation when it was at a low ebb in 1994. The WordPerfect acquisition was spectacularly unsuccessful, and was divested to Corel two years later for $124 million, a sixth of the price Novell had originally paid.[71] Similarly, Borland achieved a growth spurt by acquiring both Ansa, the publisher of the Paradox database in 1987, and Ashton-Tate, the troubled maker of dBase in 1991. This briefly made Borland the number three company in 1992, but several years of losses and downsizing followed, culminating in CEO Philippe Kahn's resignation in 1995.[72]

Perhaps the leading exponent of the successful takeover in personal computer software has been Symantec, whose president, Gordon Eubanks, effectively invented the idea of a portfolio of software brands. Eubanks, a former graduate student of Digital Research founder Gary Kildall, was one of the pioneers of the personal computer software industry.[73] Eubanks was briefly a vice president of Digital Research, before buying and becoming CEO of Symantec in 1983, then a start-up of no consequence. Realizing that he could not compete head on with the likes of Lotus in productivity applications or of Microsoft in systems programs, Eubanks sought to build up a portfolio of successful utilities. Rather like a mini-conglomerate, the products and development teams retained their identities: "There isn't really one Symantec. It's a bunch of people from a bunch of companies. . . . When we acquire we take the core product team and keep them together."[74] Unlike Microsoft, which bought primarily for the technology, Symantec bought as much for the brand. Following its initial public offering in 1990, Symantec made its biggest acquisition to date, Peter Norton Computing. The famous Norton Utilities continued to be marketed as an individual brand, providing some marketing efficiencies and, more important, long-term product refinement to maintain its competitiveness. By the mid-1990s, Symantec had bought twenty companies, giving it a host of products within the niche of IBM-compatible PC utilities.

[71] Kathy Rebello et al., "Novell: End of Era?" *Business Week*, 22 Nov. 1993, 43–4.
[72] Richard Brandt, "A Tricky Tack for Borland," *Business Week*, 2 Aug. 1993, 44–5.
[73] Interview with Gordon Eubanks in Jager and Ortiz, *In the Company of Giants*.
[74] Ibid., 55.

Post Script

While this essay was being written, the long-running antitrust case *U.S. versus Microsoft* drew to a close, although the appeals process and academic analysis will continue to echo long after publication of this article. Microsoft was found guilty of numerous instances of monopolistic behavior. In this respect, it was behaving as it always had, but what was forgivable in a small start-up was unacceptable in a corporate giant. In short, Microsoft had failed to mellow; it was a twenty-five-year-old firm with the bad manners and aggression of a five-year-old. It was also a firm in denial—it never came close to conceding its bad behavior, never mind promising to correct it. In consequence, trial judge Thomas Penfield Jackson decided that a break-up was necessary to curtail Microsoft's excesses. The recommendation was that Microsoft should be divided into two halves—one specializing in operating systems and the other in applications.

What light does this historical study shed on the trial verdict? How much of Microsoft's present success can be attributed to the fact that it controlled both operating systems and applications? It has been shown that Microsoft's success can at best only be partially explained by the formal and informal networks that linked its operating-system and application divisions. The success of the Windows operating system could never have *guaranteed* the success of its applications. We know this because VisiCorp had also tried to produce both an operating system and complementary applications in 1984. The failure of VisiOn brought it close to bankruptcy. The success of Microsoft's Windows and its office applications had more to do with the failure of OS/2 than with the synergy between the two halves of Microsoft. Clearly Microsoft played some part in the failure of OS/2 by withdrawing from the project—but this was a legitimate commercial decision. Microsoft's productivity applications presumably benefited from access to the Windows development team, but the Windows APIs (application program interfaces) were publicly disclosed, and the industry rumors of secret programming codes known only to Windows developers and Microsoft insiders were never substantiated in the trial. What actually happened was that Lotus and WordPerfect staked their future on OS/2, so that when Windows become the dominant platform they lost their first-mover advantage. Microsoft subsequently consolidated its advantage by cycles of product improvement and by bundling its office applications into a single shrink-wrapped box. On the other hand, Microsoft's success has been due in part to its ability to synchronize its operating systems and

applications at a strategic level by creating complementary products that integrate to form a complete technological system. The Windows culture clearly pervades all divisions of Microsoft, and no PC user can be unaware of the uniform look and feel and the tight integration of a Microsoft-only desktop, compared with one that uses software from several different makers.

Turning to the future, however, this observer is left with a feeling that the decision to break up Microsoft may be closing the stable door after the horse has bolted. Clearly, if Microsoft had been broken up in 1990 (say), it is unlikely that it would have risen to its present dominance. It is not obvious, however, that a break-up now will restore a level playing field. First, the legacy of Microsoft's existing products, the tacit knowledge of its workers, and its programming culture will ensure that the "Baby Bills" will be harmonious noncompetitors in their complementary fields, and that Microsoft applications will continue to be the most tightly integrated to the Windows operating system. Second, it seems likely that the new frontier of competition will be the Internet, not the desktop PC. This new market is not yet shaped, but it may no longer involve the sale of software products as individual artifacts but rather as software-based services. In the words of Brian Arthur, the future of Microsoft will depend less on its technological legacy and present corporate structure than on "discern[ing] the shape of the next game." Thus, while the antitrust remedies may have redressed Microsoft's historic market advantage in controlling both operating system and applications, it has done little or nothing to moderate either the firm's monopolistic culture or the vast financial assets that will bankroll its forays into the computing platforms of tomorrow.