THE DECLINING PRICE OF PERSONAL COMPUTERS THE QUESTION OF WHEN TO INVEST

by

Boaz Ronen
Recanati Graduate School of Business
Tel Aviv University
Tel Aviv, 69978 Israel

Henry C. Lucas, Jr.
Leonard N. Stern School of Business
Information Systems Department
New York University
90 Trinity Place
New York, NY 10006

and

Yoram Eden
Recanati Graduate School of Business
Tel Aviv University
Tel Aviv, 69978 Israel

April 1989

Center for Research on Information Systems
Information Systems Department
Leonard N. Stern School of Business
New York University

Working Paper Series

CRIS #207
STERN #89-47

THE DECLINING PRICE OF PERSONAL COMPUTERS: THE QUESTION OF WHEN TO INVEST

ABSTRACT

When should a manager invest in new technology? This paper provides guidelines for deciding when to invest in microcomputers. The authors argue that the technology and marketplace of micros today fits the conditions of the declining cost paradox observed by Eden and Ronen (1988). Under these conditions, a decision to defer purchasing equipment until the future to take advantage of hardware price decreases may lead to higher overall costs. The paper concludes with recommendations for the manager confronted with the decision of when to purchase microcomputer technology.

INTRODUCTION

Managers confront the decision of when to buy new technology when considering the purchase of personal computers. The user requesting personal computers wants to take advantage of improved computer performance. If the firm does not buy now it will lose the advantages it might gain from the new technology. The financial manager, however, may argue that the price of personal computers is droppping and that the organization should wait to purchase until some time in the future when the required investment will be less. The purpose of this paper is to offer an approach to the decision of when to buy personal computers in the face of declining hardware costs.

THE DECLINING COST PARADOX

In an earlier paper, Eden and Ronen (1988) developed a model of when to invest in technology in general under

conditions of declining costs. In their research, the authors found a paradox: under certain conditions total costs might actually increase by waiting to purchase to take advantage of declining hardware costs! As stated by Eden and Ronen:

> The greater the decline in the cost of a particular technology, the more urgent it may be to purchase the technology now.

The paradox only holds under certain conditions, and these conditions appear to characterize the current personal computer industry.

Conditions of the Paradox

1.) The first condition required by the paradox is a decline in the expected cost to invest in the technology in the future. Certainly, for personal computers, there has been a steady reduction in the cost of individual components like the CPU, memory, diskette and disk drives, and so on. (There have been temporary increases in component prices due to government trade policies and shortages, for example, the recent shortage and increase in the cost of 32 bit DRAMS. However, over the long run, costs have been declining as power has increased.)

2.) The second factor which contributes to the paradox is postponed or foregone benefits from the technology. The user must incur a cost by waiting for new technology. He or she has to postpone a planned application. The cost of being the fourth rather than the first airline reservations system to install personal computers in travel agents'

offices is likely to be quite high. On the other hand, the cost of waiting for a 386 based machine to replace an 8088 PC for word processing is quite low.

3.) Eden and Ronen observe that there is tendency to spend about the same amount on a system despite the fact that components are dropping in price. Part of this tendency is forced on the consumer by vendors; it is very hard today to find an 8088 PC that comes with 64K bytes of memory; vendors package machines with 256K or more memory, typically 512K or even 640K bytes. While two diskette machines are available, most corporate buyers will opt for a hard disk unless the machine is to be a diskless workstation on a network.

The appeal of advanced features to users also encourages the tendency to buy more in the face of declining prices. In 1988 the Leonard N. Stern School of Business at NYU adopted a hard disk, color monitor system as its recommended computer for students in the Graduate Division. This configuration costs essentially the same as a two diskette model recommended the previous year. Both vendor offerings and the appeal of more powerful features to users encourage the purchase of systems whose total price does not decline as rapidly as the prices of their individual elements.

4.) Software advances have accompanied advances in hardware. New versions of software and entirely new types of programs are available for the user. In addition to the

purchase price, users have a significant learning cost for software. The longer one waits to adopt the technology, the greater the learning costs are likely to be. The user who bought an early PC and learned to use Lotus version 1A can make the transition to version 2 easily. The user who waited to buy a PC until version 2 of Lotus became available will have to learn a more complex piece of software.

5. The cost of PC software has not declined significantly. If anything, prices of software are rising as developers add more capabilities to their programs. The user who buys earlier can generally upgrade to subsequent versions of a package for a fee that is less than the purchase price of the new version.

The Tradeoffs

The Eden and Ronen model demonstrates under what conditions one should buy today rather than postpone a purchase. Intuitively, their model trades off the decline in the cost of technology against greater learning costs from postponing the purchase of a system. Foregone or postponed benefits are an important component of the model. The user who postpones purchase is likely to encounter steeper learning costs because advances in software will produce more complex and difficult to learn applications.

The model also suggests that the decline in the costs of technology are partially offset by the tendency to purchase more powerful systems. As mentioned above, organizations today generally purchase a hard disk system as

opposed to the original PC with diskette drives. (The hard disk system is also more complex to use than a two diskette PC.)

Figures 1 and 2 illustrate the tradeoff between the declining price of technology and the increasing costs of learning. In the figures the declining cost of hardware has been modeled by a curve of the form:

(1) $\text{beta1} + \text{beta2} * e^{-\text{alpha } t}$

where t is time and alpha, beta1 and beta2 are parameters. Prices are expected to drop quickly and reach an asymptote where further reductions are unlikely using current technology.

The learning cost curve is modeled by:

(2) $\text{theta} + \text{gamma} * \log(t)$

where t is time and theta and gamma are parameters. The total cost curve is the sum of the technology cost and learning cost curves. This illustration does not include considerations of postponed benefits; it simply shows the tradeoff between decreasing hardware costs and increasing learning costs over time.

Ignoring postponed benefits, in Figure 1 the minimum purchase cost comes around time 4; here the decision maker would have to consider postponing a decision to purchase until that time depending on the advantages accruing from purchasing earlier. In this example, costs for the technology drop more rapidly than the learning cost curve rises. In Figure 2, the shape of the curves suggests that

based on technology cost declines and learning costs, one should purchase now.

Benefits

Based on costs alone, Figure 1 suggests that the decision maker may want to wait to invest in new technology. Whether or not one should wait to buy depends on the benefits expected from investing in the technology. What benefits would accrue to the organization from having the technology now rather than at time 4?

Figure 3 attempts to answer this question. Assume that two decisions are possible: purchase at time 1 or time 4. Figure 3 shows two identical benefits curves for purchasing at these two times; it assumes that there are declining benefits from the investment and that if one waits until time 4, the benefits curve will start at the same level as purchasing at time 1. At time 8, the organization which purchased at time 1 will have obtained the benefits under the "purchase now" curve from times 1 to 8. The organization which waited will have obtained only the benefits from time 4 to 8 under the "Purchase Later" curve.

The decision maker will have to balance the additional benefits of purchasing now against the cost savings from waiting until later to invest in the technology.

COMPONENTS OF THE PARADOX

The paradox is based on five conditions described earlier. What is the evidence for the conditions leading to the Paradox for personal computers?

Declining Hardware Costs

The decline in PC hardware costs is well-known in the industry. The steady trend is to place more circuits on a chip which has helped to reduce the costs of computation. The decrease in cost per MIP is fairly steep and does not appear to approach an asymptote. While it is expected that silicon may reach a limit, faster chips are being fabricated out of galium arsenide. Laboratory researchers are working on heterojunction transistors which have attained switching speeds of 2 picoseconds or two orders of magnitude faster than silicon chips. For the logic chips for PCs, costs have been decreasing as power has increased. In general the same trend has been observed for primary memory and disk storage.

Benefits

As described above, the benefits from adopting the technology now rather than postponing the investment depend on the user and the organization; these benefits are unique to each purchase decision.

Declining Costs, Steady Prices

The third condition of the paradox is the tendency for system costs to decline much more slowly than component costs because 1) vendors include more standard features in

their products and 2) users are attracted to more advanced features.

Table 1 illustrates the costs of a typical PC-based workstation from 1983 through 1988. During this period the capabilities of the workstation have expanded as the total system cost has stayed nearly constant. The typical system doubled in memory and added a hard disk. Companies have gone from a two diskette system to a 20 or 40 megabyte hard disk XT or AT with enhanced color graphics as their standard machine.

Table 2 adds software to the analysis; software costs have fluctuated, but in general have not declined dramatically. New operating systems like OS/2 are considerably more expensive than their predecessors, especially if the Presentation Manager is included.

Tables 2 and 3 illustrate that if one prices the systems that firms have typically adopted as their standard over time, system costs have not decreased as dramatically as the costs of individual components.

Greater Complexity

Greater complexity of systems and software lead to an increasingly steep learning cost curve. The demands on organizations for training and personal computer support are high. The greater the complexity of the software, the more difficult and costly it is likely to be to learn. The manager who postpones acquiring the technology until some

time in the future will purchase hardware and software which will confront users with greater complexity.

The IBM PS/2 is a more complex machine than the original PC. The system features 3.5" instead of 5.25" diskettes and has a new bus called the microchannel. The system can be configured using software commands rather than hardware switches. When combined with new operating systems, the PS/2 should be capable of multiprocessing and multitasking. While the machine can be run as a first generation PC, its advanced features introduce new complexity for the user.

Tables 3 through 5 show changes in several popular software packages as they have passed through different versions. Between Lotus 1A and 2.01, Lotus added a number of features and commands. Among the more notable addtions are matrix calculations and a regression procedure. Lotus 2 also provides string variables in addition to labels and values as data types.

Word Perfect has progressed from versions 3 through 5 over a relatively short period of time. A perusal of Table 4 shows that this application has grown from a relatively simple word processor to a package approaching the capabilities of desk top publishing software.

Table 5 contains changes in the database management system, DBASE, over time. Note that the manual for this popular database package has increased in size from 375 pages to over 1000. DBASE III+ has a screen painter and

custom forms capability. DBASE III has 52 more commands than its predecessor while DBASE III+ has 104 more commands than version III. DBASE IV is in early release; advanced publicity indicates that it will be even more complex as it adds an SQL interface among other new features.

An analysis of these three products supports the contention that software is becoming more complex. These popular products do suggest a sharply increasing learning cost curve. The user who waits to invest in PC technology will be likely to encounter more complex software that is more difficult to learn than the early adopter of the technology. The later one purchases a system in general, the more difficult and costly to learn how to use it.

Many times decision makers do not take learning factors into account in analyzing the purchase of technology. While an emphasis on "user friendly" interfaces does facilitate familiarization with a system, learning to use the interface is only one part of learning to use a system or application. While software is becoming more friendly, designers are adding more features and options which increase the learning task.

Software Prices

Table 2 shows a modest decline in the price of software packages, though the decline is not dramatic. For some packages prices have remained the same or risen slightly with new releases. The expectation of declining software

prices is certainly not a good reason to postpone investing in new PC technology.

Summary

For personal computers, the evidence suggests that the price of a typical PC system has remained steady because the vendor tends to add more features and the user tends to purchase systems with greater capabilities. Thus, while component prices are declining, system costs decrease less rapidly.

Workstations with more features and new releases of software are more complex, giving support to a rising learning cost curve. Over time, one can expect to pay more for training and lost time. One would also expect that upgrading from one version of a piece of software to the next would be easier than learning the most advanced version from scratch.

Software costs have not decreased as rapidly as hardware; in addition some software packages have experienced price increases.

Based on all of the evidence, it appears that conditions in the personal computer field meet the requirements for the declining price paradox to apply.

IMPLICATIONS

This paper has argued that just because hardware prices are expected to decrease in the future, one should not necessarily wait for these lower prices to purchase a

personal computer system. Declining hardware costs must be traded off against:

1. Postponed benefits from waiting to adopt the technology.

2. The tendency for system costs to stay about the same.

3. Increasing system complexity leading to higher learning costs.

4. Minor changes in software costs.

What should a manager do when confronted with the question of when to invest in new PC technology? The first step is to estimate the benefits from acquiring PCs. Benefits include:

1. Greater productivity

2. Better communications

3. Reorganization of work

4. Faster response

5. Competitive advantage

6. Cost savings.

Estimate the benefits from adopting the technology now and the benefits of waiting, following the curves in Figure 3. Select an arbitrary point and assume that all of the benefits from both options are received at this point; in Figure 3 one might choose time 8 or 10.

Next, estimate from forecasts the extent to which system costs are likely to decline. Also predict the learning effort and costs for the intended users of the technology. Try to construct curves like Figures 1 and 2.

At the completion of the estimating process, the decision maker should have the following information:

An estimate through some future point in time of the benefits from purchasing now

An estimate of the benefits through some future point in time of waiting for a specified time period before purchasing, say time t

The current purchase price

The estimated purchase price at time t

The estimated learning costs now

The estimated learning costs at time t

Next subtract the costs associated with purchasing now from the benefits and do the same for purchasing later. If the later purchase is a year or more in the future, it may be necessary to apply a discounting factor to the future costs and to the benefits numbers. A comparison of the results should help the manager decide when to invest in new technology.

Consider the following numerical example:

Estimated benefits from purchasing now realized through month 12 = 200

Estimated benefits through month 12 of waiting to purchase in month 6 (time t) = 175

The current purchase price = 75

The estimated purchase price in 6 months = 50

The estimated learning costs now = 50

The estimated learning costs in 6 months = 70

Total current costs = 75 +50 = 125

Purchase now benefits - costs = 200 - 125 = 75

Total future costs = 50 + 70 = 120

Benefits of waiting 6 months = 175 - 120 = 55
(ignoring discounting)

In this example, the estimates suggest that the expected decrease in investment cost in six months does not offset higher learning costs and postponed benefits. In theory, one should apply a traditional discounted cash flow analysis to the numbers. However, given the tentative nature of the estimates and the short time times that will generally be involved in contemplating PC purchases, such added sophistication is probably not warranted.

The manager can conduct an analysis of the type suggested above to gain insight on the purchase decision. Intangible factors need to be combined with any numerical calculations. The purpose of such an analysis is to demonstrate that the idea of waiting for declining prices will not necessarily result in lower total system costs due to the declining cost paradox.

CONCLUSIONS

The purpose of this paper was to offer guidelines on the timing of an investment in PC technology when hardware component costs are declining. Because of the declining cost paradox, it does not follow from decreases in hardware component costs that one should necessarily wait to invest.

The paper identifies a number of factors to be considered by the decision maker in choosing when to invest in the technology. One must balance the declining costs of

hardware components against greater learning costs from waiting to invest and against lost opportunity costs. Also, the decision maker should be aware that the cost of a total system tends not to decrease as rapidly as component costs and that software costs may not decline at all. Based on the evidence presented in this paper, for personal computers it appears that often the decision will be to invest in new technology sooner rather than later.

REFERENCES

(1) Bendre, Eric. "Ashton - Tate dBase 111 + Scheduled for Comdex Rollout," Computerworld, Nov. 18, 1985, p. 6.

(2) Birmele, Ricardo. "Software Review: WordPerfect," Byte, Dec. 1984, pp. 277-288.

(3) Bond, George. "A Database Catalog," Byte, Oct. 1984, pp: 227-288.

(4) Byers, Robert A. dBase III for Every Business, Culver City: Ashton - Tate Publishing Group, 1985.

(5) Currie, Steven. Understanding and Using dBase III on the PC, New York: Holt, Rinehart, and Winston, 1986.

(6) Eden, Yoran and Boaz Ronen. "The Declining Cost Paradox of New Technologies", Working Paper, Faculty of Management, Tel Aviv University, Dec. 1988.

(7) Emerson, Sandra L. and Marcy Darnovsky. Database for the IBM PC, Reading: Addison - Wesley Publishing Company, 1984.

(8) Hession, William. Performance Guide to Word Processing Software, New York: McGraw-Hill, 1985.

(9) Jacobson, Bill. "DataEase vs. Condor and dBase 11," Byte, Oct. 1984, pp: 289-302.

(10) Jones, Mitt. "WordPefect 4.2 Improves Indexing, Adds Document Preview, Hidden Notes," PC Magazine, Jan 27, 1987, p. 48.

(11) Kruglinski, David. "Update on Six Database Managers," Byte, Fall 1984 (special issue), pp: 187-196.

(12) LeBlond, Geoffrey T. et al. Using 1-2-3, 1st ed., Indianapolis: Que Corp., 1983.

(13) LeBlond, Geoffrey T. et al. Using 1-2-3, 2nd ed. Indianapolis: Que Corp., 1985.

(14) Liskin, Miriam. Advanced dBase III: Programming and Techniques, Berkeley: McGraw-Hill, 1986.

(15) McMahon Marilyn et al. Report Writing in dBase II, Arlington, Mass.: SoftwarBanc; Englewood Cliffs, N.J.: Prentice-Hall, 1984.

(16) Microworld: Software/Hardware Selection Guide, Pennsauken, N.J.: Auerbach Publishers.

(17) Nelson, Robin. "dBase III: A Data Base fro Real People," Personal Computing, Oct. 1984, pp: 259-268.

(18) Poor, Alfred. "Database Power Puts on An Easy Interface." PC Magazine, Jan. 27, 1987, pp: 109-117.

(19) Porter, Kent. "dBase III Plus for Nonprogrammers." Business Software, August 1986, pp: 66-77.

(20) Simpson, Alan. Understanding dBase II. Berkeley: Sybex, Inc., 1984.

(21) Simpson, Alan. Understanding dBase III Plus, Berkeley: Sybex, Inc., 1986.

(22) Taylor, Jared. "Lotus Makes New Waves," PC Magazine, 26 Nov. 1985, pp: 35-36.

(23) Urschel, William. "Data Base Management Software." Personal Computing, March 1985, pp: 241-249.

(24) Wiswell, Phil. "Word Processing: Eighteen popular word processors get a thorough workout..." PC Magazine, Aug. 20, 1985, pp: 110-134.

(25) Zilbergeld, Bernie. "WordPerfect 4.1: The Best Improved." Infoworld, Nov. 4, 1985, pp: 41-43.

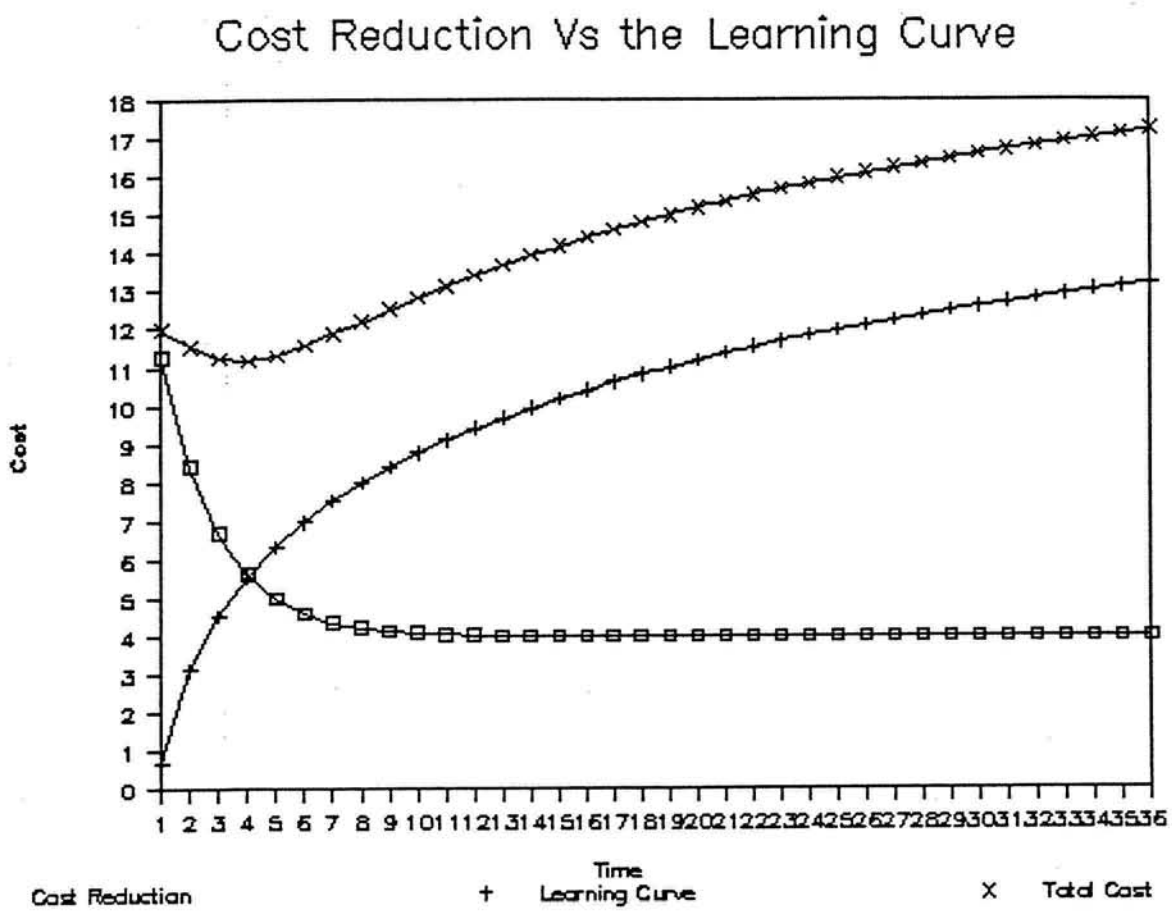

Figure 1

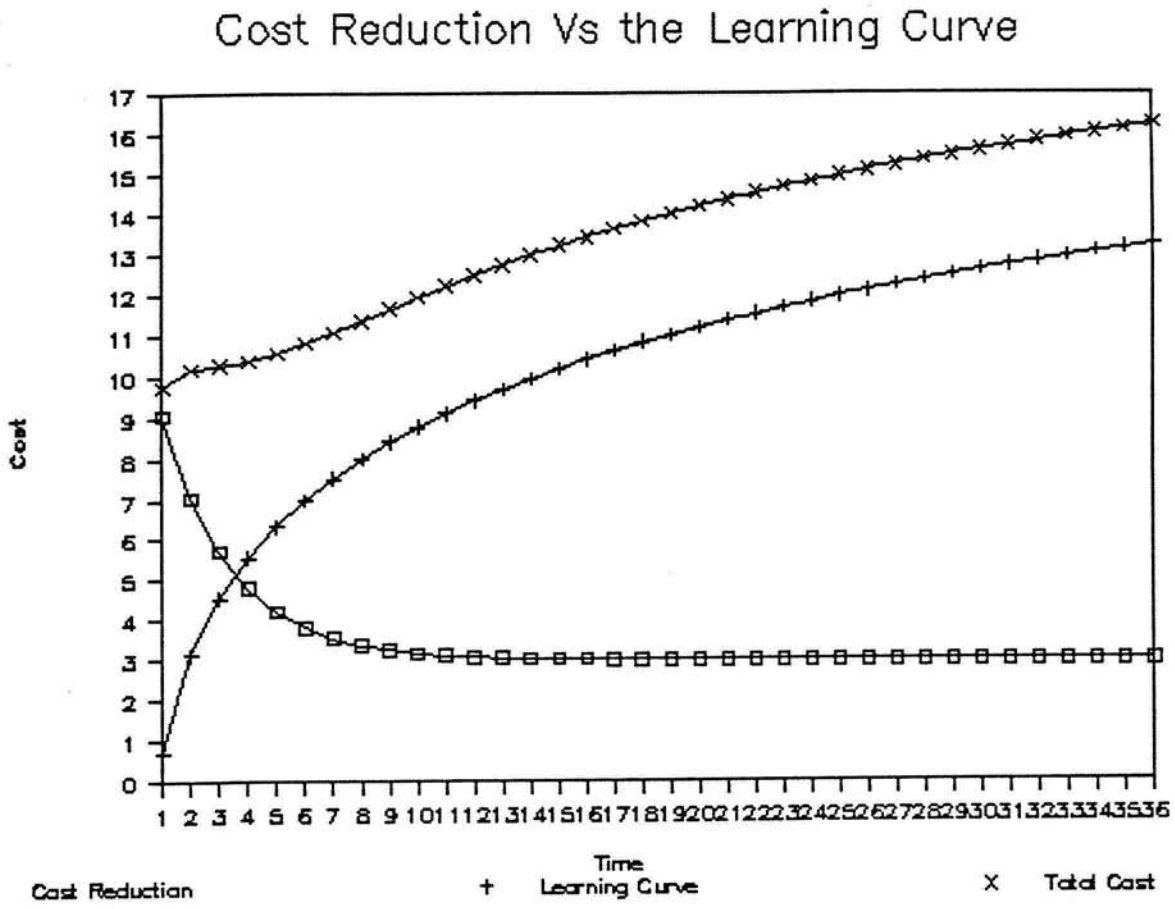

Figure 2

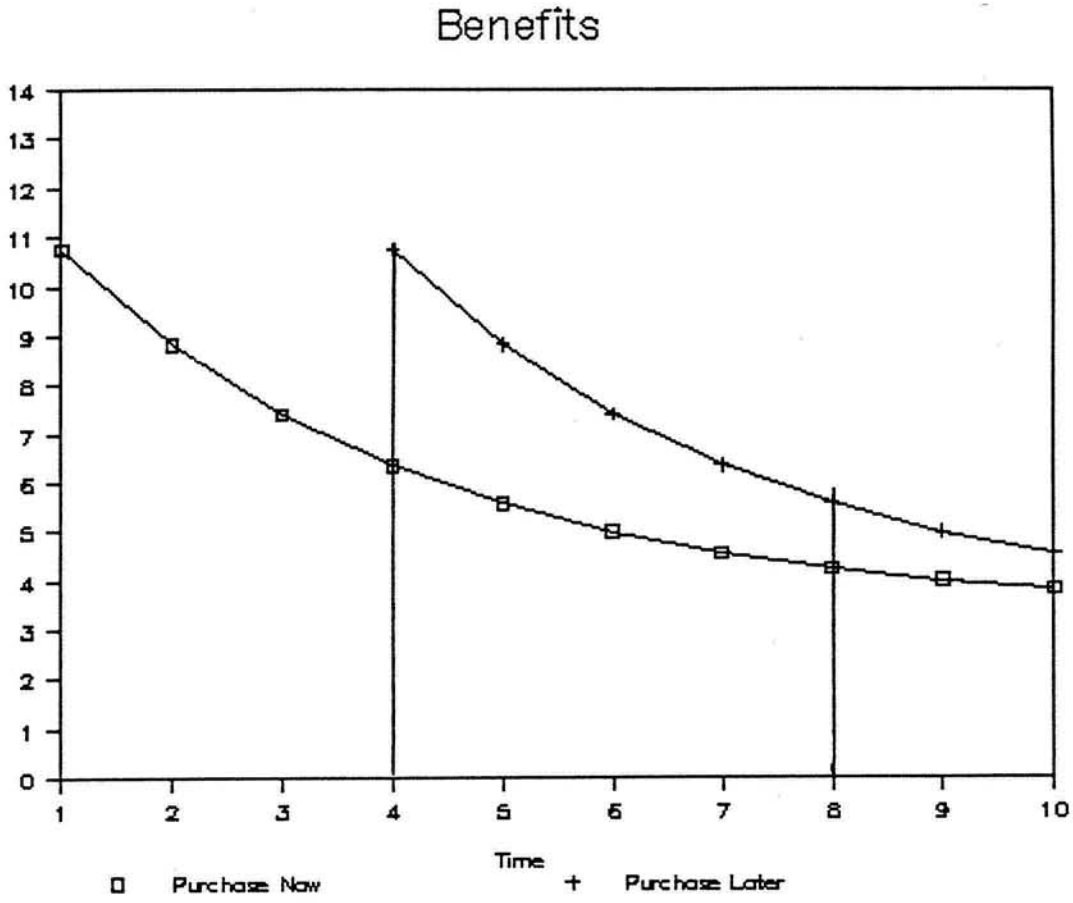

Figure 3

TABLE I

TRENDS IN PC COSTS

(When a category has more than one model the latest model and price are used in calculation of total prices).

PRODUCT (HARDWARE)	1983	1984	1985	1986	1987	1988
IBM PC (256K 2 DR. MONO DISP)	3430					
SAME ABOVE + 128K		3000				
SAME ABOVE + 256K 10Mb HARD			2800	1826		
IBM XT 10Mb HARD + 256k			3450	2713	1483	
IBM AT 20Mb HARD + 512 + 1.2Mb FLOPPY MONO DISP				4522	3331	
DELL 286/220, 4MEG HARD, VGA COLOR						3299
EPSON FX80	579	579	389	375		
EPSON FX85				353	336	
EPSON FX86e					384	
EPSON LQ-2550						939
IBM MONO DISP	335	335	248	234	223	
IBM COLOR			589	603	538	
IBM ENHANCED COLOR					665	
IBM PRINT ADPT	234	234	234	218		
IBM CGA			219	226		
IBM EGA					400	
SMARTMODEM 300	234	211	197	137	129	
1200	533	506	457	381	385	
1200B		472	376	339	338	
2400						449
AST 6PAKPLUS 64K		277	262	228	169	
ABOVE BOARD 2 INTEL						479

TRENDS IN SOFTWARE COSTS

TABLE 2

ACTUAL SELLING PRICES

(When a category has more than one model the latest model and price are used in calculation of total prices).

PRODUCT (SOFTWARE)	1983	1984	1985	1986	1987	1988
dBASE II	469	424	289	294	294	——
dBASE III			379	383	——	——
dBASE III+					390	365
LOTUS 123	339	339	304	316	316	298
WORDPERFECT	350	350	290	224	196	242
HARVARD PROJECT MGR			258			
HARVARD TOTAL P.M.				275	311	350
HARVARD GRAPHICS						272
MICROSOFT CHART			173	182	178	——
PEACHTREE ACCT SYS	1200	1200	900	900	199	——
DACEASY (3)						163
HAYES SMARTCOM II		84	96	95	85	——
SIDEKICK			41	38	47	——
SIDEKICK PLUS						65
SIDEWAYS		45	46	37	41	42
NORTON UTILITIES	65	60	58	58	50	——
NORTON UTILITIES ADVANCED						79
COPY II PC	35	32	30	28	22	22
PC TOOLS				22	21	36
PROKEY		57	87	87	75	——
THINKTANK			136	105	——	——
FLIGHT SIMULATOR	35	34	36	31	29	29
SUBTOTAL (SOFT)	$2,493	$2,625	$2,834	$2,781	$1,960	$1,963
SUBTOTAL (HARD)	$5,111	$4,897	$5,285	$6,271	$5,089	$5,166
TOTAL	$7,604	$7,522	$8,119	$9,052	$7,049	$7,129

LOTUS FEATURES

TABLE 3

LOTUS FEATURE	LOTUS VERSIONS 1A	2.01
COST	$495	$495
MINIMUM MEMORY REQUIRED	192K RAM	256K RAM
MAXIMUM MEMORY POTENTIAL	640K RAM	4 Mbyte
TUTORIAL DISK	YES	NO
NO. OF DISKS	5	6
PAGES IN MANUAL	362	350
8087 OR 80287 CHIPS	NO	YES
DIRECT LOAD FROM HARD DISK	NO	YES
ROWS IN WORKSHEET	2048	8192
DIRECT ACCESS TO DOS WITHOUT LEAVING LOTUS	NO	YES
TRANSFER FILES BETWEEN dBASE II AND LOTUS	YES	YES
TRANSFER BETWEEN dBASE III AND LOTUS	NO	YES
PASSWORD PROTECTION	NO	YES
PAGE BREAKS	NO	YES
SAVE BLANK CELLS	YES	NO
OPTION TO ADD OWN FILE EXTENSION	NO	YES
MAIN MENU COMMANDS	9	10
SYSTEM COMMAND	NO	YES

LOTUS FEATURE	LOTUS VERSIONS 1A	2.01
SUBOPTIONS IN /WORKSHEET	68	115
IN/RANGE	31	42
IN/FILE	25	27
IN/PRINT	32	32
STATISTICAL	7	7
DATA BASE STATISTICAL	3	4
SPECIAL	4	11
MACROS: KEYWORK REPRESENTATIONS	22	25
COMMANDS	8	48
PAGES IN MANUAL	13	57
IN/GRAPH	99	108
IN/DATA	26	48
GRAPH TYPES	5	6
HIDDEN CELLS AND COLUMNS	NO	YES
RANGE TABLES	NO	YES
TRANSPOSE ROWS/COLUMS	NO	YES
CONVERTS FORMULAS TO VALUES	NO	YES
HIDDEN FORMATS	NO	YES
DATE FORMATS	3	5
TIME FORMATS	NO	YES
CLOCK/CALENDAR IN LOWER LEFT CORNER	NO	YES
MATRIX OPTION	NO	YES

LOTUS FEATURE	LOTUS VERSIONS 1A	2.01
REGRESION	NO	YES
PARSING	NO	YES
INTERNATIONAL PUNCTUATION	NO	YES
INTERNATIONAL DATE/TIME	NO	YES
INTERNATIONAL CURRENCY	NO	YES
@SIGN FUNCTIONS: MATHEMATICAL	17	17
FINANCIAL	5	11
LOGICAL	1	3
STRING	0	17
DATE AND TIME	5	11

LOTUS: LEARNING 1A FROM SCRATCH

NUMBER OF DISKS	5
PAGES IN MANUAL	362
MAIN MANU COMMANDS	9
FUNCTION KEYS USED (combo of keystrokes)	11
WORKSHEET OPTIONS	68
RANGE OPTIONS	31
FILE OPTIONS	25
GRAPH OPTIONS	99
DATA OPTIONS	26
MACRO COMMANDS	8
PAGES IN MANUAL ON MACROS	13
@SIGN: MATHEMATICAL	17
FINACIAL	5
LOGICAL	1
STRING	0
DATE AND TIME	5
STATISTICAL	7
DATA BASE STATISTICAL	3
SPECIAL	4
INTERNATIONAL OPTIONS IN SPREADSHEET	0
INTERNATIONAL OPTIONS IN GRAPH SCALING	0
DATE FORMATS	3

LOTUS: LEARNING 1A FROM SCRATCH

TIME FORMATS	0
GRAPH TYPES	5

LOTUS: ADITIONAL, FROM 1A TO 2.0

NUMBER OF DISKS	1
PAGES IN MANUAL	12
MAIN MENU COMMANDS	1
FUNCTION KEYS USED (combo of keystrokes)	1
WORKSHEET OPTIONS	47
RANGE OPTIONS	11
FILE OPTIONS	2
PRINT OPTIONS	0
GRAPH OPTIONS	9
DATA OPTIONS	22
MACRO COMMANDS	40
PAGES IN MANUAL ON MACROS	44
@SIGN: MATHEMATICAL	0
FINANCIAL	6
LOGICAL	2
STRING	17
DATE AND TIME	6
STATISTICAL	0
DATA BASE STATISTICAL	1
SPECIAL	7
INTERNATIONAL OPTIONS IN SPREADSHEET	28
INTERNAITONAL OPITONS IN GRAPH SCALING	4

LOTUS: ADITIONAL, FROM 1A TO 2.0

DATE FORMATS	2
TIME FORMATS	4
GRAPH TYPES	1

WORDPERFECT FEATURE

TABLE 4

WORDPERFECT

VERSIONS

FEATURE	3.0	4.0	4.1	4.2	5.0
FOOTNOTE SEARCH	NO	NO	NO	YES	YES
HEADERS/FOOTERS SEARCH	NO	NO	NO	YES	YES
SEARCH FOR COMBINATION OF WORDS	NO	NO	YES	YES	YES
SPLIT-SCREEN HORIZONTAL	NO	NO	YES	YES	YES
DRAWS VERTICAL AND HORIZONTAL LINES	NO	NO	YES	YES	YES
CAN DO CENTER AND FLUSH RIGHT IN BLOCK	NO	NO	YES	YES	YES
SORTING	NO	NO	YES	YES	YES
DOCUMENT SUMMARY OPTION	NO	NO	NO	YES	YES
CREATES TABLE OF REFERENCES	NO	NO	NO	YES	YES
AUTOMATIC REFERENCE TO PAGE NUMBER BY NAME	NO	NO	NO	YES	YES
COLOR GRAPHICS CAPABILITIES	NO	NO	NO	NO	YES
DESKTOP PUBLISHING	NO	NO	NO	NO	YES
FLEXIBLE STYLE SHEETS	NO	NO	NO	NO	YES
STYLES CREATION	NO	NO	NO	NO	YES
MASTER DOCUMENT	NO	NO	NO	NO	YES
KERNING OPTION	NO	NO	NO	NO	YES

FEATURE	VERSIONS 3.0	4.0	4.1	4.2	5.0
VARIABLES OF SUBROUTINE MACROS	NO	NO	NO	NO	YES
CUSTOM MENUS CREATION	NO	NO	NO	NO	YES
MNEMONICS ABREVIATED SUBMENUS	NO	NO	NO	NO	YES
CURSOR MOVEMENT:					
TOP/BOTTOM SCREEN	YES	YES	YES	YES	YES
END/BEGIN LINE	NO	YES	YES	YES	YES
ENDS OF DOCUMENT	YES	YES	YES	YES	YES (HALF LINES)
DELETION:					
FOOTNOTES BY WORD	YES	YES	YES	YES	YES
BY SENTENCE	NO	YES	YES	YES	YES
BY PARAGRAPH	NO	YES	YES	YES	YES
BY LINE	YES	YES	YES	YES	YES
BY BLOCK	YES	YES	YES	YES	YES
UNDELETE	NO	YES	YES	YES	YES
3 LEVEL UNDELETE	NO	NO	YES	YES	YES
PROPORTIONAL SPACING	NO	YES	YES	YES	YES
REPAGINATION	NO	YES	YES	YES	YES
INDEXING FUNCTION	NO	YES	YES	YES	YES
KEYBOARD INPUT WHILE PRINTING	NO	YES	YES	YES	YES
IMPORT/EXPORT FILE CONVERSION	NO	YES	YES	YES	YES

FEATURE	VERSIONS 3.0	4.0	4.1	4.2	5.0
CONCORDANCE FILES FOR AUTOMATIC INDEXING	NO	NO	NO	YES	YES
OPTION TO EMBED/DISPLAY COMMENTS	NO	NO	NO	YES	YES
PREVIEW DISPLAY OF PRINT FORMAT OF DOC.	NO	NO	NO	YES	YES
WILD CARD SEARCH	NO	YES	YES	YES	YES
DOCUMENT NAME DISPLAY	NO	NO	NO	YES	YES
GRAPHIC FILE NAME DISPLAY	NO	NO	NO	NO	YES
PRICE	$495	$495	$495	$495	$495
NO. OF DISKS (5 1/4)	2	4	4	4	12
MICROPROCESSOR	16 BIT	16	16	16	16
VIRTUAL MEMORY	YES	YES	YES	YES	YES
FUNCTION KEY DRIVEN	YES	YES	YES	YES	YES
SUBMENUS (CHOOSE BY LETTERS)	YES	YES	YES	YES	YES
MINIMUM MEMORY	128K	192K	256K	256K	384K
SCREEN-ORIENTED	YES	YES	YES	YES	YES
ON LINE TUTORIAL	NO	NO	NO	YES	YES
WORD DICTIONARY	30,000	100,000	120,000	120,000	120,000 +
ENCRYPTION/ PASSWORD	YES	YES	YES	YES	YES
MACROS	YES	YES	YES	YES	YES

FEATURE	VERSIONS 3.0	4.0	4.1	4.2	5.0
AUTOMATICALLY CORRECTS MISSPELLED WORDS	NO	NO	NO	NO	NO
INDICATES CORRECT SPELLING IN LOWER HALF OF SCREEN WORD FOR CORRECT SPELLING	NO	YES	YES	YES	YES
HAVE TO LOOK UP WORD FOR CORRECT SPELLING	YES	NO	NO	NO	NO
ALLOWED TO EXIT DICTIONARY AT CHOICE	NO	NO	NO	NO	YES
THESAURUS	NO	NO	YES	YES	YES
CURSOR MOVEMENT:					
BY WORD	YES	YES	YES	YES	YES
BY SENTENCE	NO	YES	YES	YES	YES
BY PARAGRAPH	NO	YES	YES	YES	YES

TABLE 5

DBASE FEATURES

dBASE FEATURE	VERSIONS II	III	III+
COST	$495	$695	$695
MINIMUM MEMORY	128K	256K	256
NO. OF COMMANDS	82	114	228
PAGES IN MANUAL	375	>600	>1000
ON LINE TUTORIAL	NO	NO	NO
RUN DOS FROM INSIDE	NO	YES	YES
MICROPROCESSOR SPEED	8 BIT	16 BIT	16 BIT
ASSIST MODE	NO	YES	YES
PULL DOWN MENUS	NO	NO	YES
DISPLAYS CONTENTS OF FIELD, EXPRESSION, ETC. W/O STARTING NEW LINE	NO	YES	YES
AVERAGING	NO	YES	YES
SHOWS FILES ON DISK	NO	YES	YES
INSERTS RECORDS	NO	YES	YES
CAPABLE OF RECREATING ACTIVE INDEXES	NO	YES	YES
OPTION FOR ERASING CURRENT MEMORY VARIABLES	NO	YES	YES

Chart sources (references): 1, 3, 4, 5, 7, 9, 11, 14, 16, 17, 18, 19, 20, 21, and 23.

dBASE FEATURE	VERSIONS II	III	III+
ALLOWS USER TO SELF PROGRAM FUNCTION KEYS	NO	YES	YES
CHARACTERS PER FIELD	254	254	5,000
MAX. CHARACTERS PER RECORD	1,000	4,000	4,000
MEMO FIELDS	NO	YES	YES
DATE FIELDS	NO	YES	YES
MAXIMUM FIELDS PER RECORD	32	128	128
RECORDS PER FILE	65,535	UNLIM.	UNLIM.
MULTIPLE RECORDS SHOWN FOR EDITING	NO	NO	NO
CAN UNDO CHANGES	NO	YES	YES
"MODIFY STRUCTURE" ERASES ALL RECORDS	YES	NO	NO
INTERNATIONAL DATE FORMATS	NO	NO	YES
SET JUSTIFICATION	NO	NO	YES
HEADING AND FOOTINGS	NO	YES	YES
SCREEN PAINTER FOR CUSTOM FORMS	NO	NO	YES
FILES THAT CAN BE OPEN SIMULTANEOUSLY	2	10	10
STORABLE MEMORY VARIABLES	64	256	256
MATHEMATICAL OPERATIONS	4	6	6
EXPONENTIAL AND LOG	NO	YES	YES

dBASE	VERSIONS		
FEATURE	II	III	III+
DATA TYPES	3	5	5
AUTOMATIC INDEX UPDATE	LIMIT.	FULL	FULL
USES IBM FUNTION KEYS	NO	YES	YES
CLEARS ERROR MESSAGES	NO	YES	YES
HANDLING OF DISK OVERFLOW	CRASH	MESSAGE	MESSAGE
PASSWORD PROTECTION	NO	NO	NO
WORD PROCESSING	NO	YES	YES
COMBINE FOR AND WHILE SAME CONDITION	NO	NO	YES
DISPLAYS ACSII VALUE OF CHARACTER	NO	YES	YES
ARE REPORT FILES ASCII FILES	YES	NO	NO
NETWORKING CAPABILITIES	NO	NO	YES
SECURITY LEVELS	NONE	NONE	8
DATA ENCRYPTION	NO	NO	YES
WILDCARD SEARCHES	NO	NO	YES
AUTOMATIC HISTORY STORING OF COMMANDS FOR RECALL	NO	NO	YES
VIEW FILES	NO	NO	YES
SAVES AND RECALLS QUERIES	NO	NO	YES

dBASE II: LEARNING FROM SCRATCH

NUMBER OF COMMANDS	75
EDITING COMMNADS	9
APPEND FUNCTIONS	2
CLEAR COMMANDS	0
COPY COMMANDS	1
CREATE COMMANDS	1
DISPLAY COMMANDS	3
DO COMMANDS	2
MODIFY COMMANDS	3
PROCESSING PROGRAM COMMANDS	14
SORTING COMMANDS	2
COMMANDS FOR LOCATING RECORDS	2
STRING FUNCTION COMMANDS	3
STRING OPERATORS	4
MATHEMATICAL FUNCTIONS	3
MEMORY VARIABLE COMMANDS	9
LIMIT ON MEMORY VARIABLES STORED	64
CHARACTER CONVERSION FUNCTIONS	2
IF COMMANDS	1
DATE AND TIME FUNCTIONS	1
DEBUGGING TECHNIQUES	6
COMMANDS FOR INTERFACING WITH OTHER SOFTWARE	2

ADDITIONAL, FROM dBASE II TO III

NUMBER OF COMMANDS	52
EDITING COMMANDS	3
APPEND FUNCTIONS	1
CLEAR COMMANDS	4
COPY COMMANDS	2
CREATE COMMANDS	2
DISPLAY COMMANDS	1
DO COMMANDS	1
MODIFY COMMANDS	1
PROCESSING PROGRAM COMMANDS	19
SORTING COMMANDS	1
COMMANDS FOR LOCATING RECORDS	2
STRING FUNCTION COMMANDS	6
STRING OPERATORS	0
MATHEMATICAL FUNCTIONS	2
MEMORY VARIABLE COMMANDS	4
STORABLE MEMORY VARIABLES	192
CHARACTER CONVERSION FUNCTIONS	7
IF COMMANDS	0
DATE AND TIME FUNCTIONS	9
DEBUUGGING TECHNIQUES	2
COMMANDS FOR INTERFACING WITH OTHER SOFTWARE	0

dBASE III: LEARNING FROM SCRATCH

NUMBER OF COMMANDS	127
EDITING COMMANDS	12
APPEND FUNCTIONS	3
CLEAR COMMANDS	4
COPY COMMANDS	3
CREATE COMMANDS	3
DISPLAY COMMANDS	4
DO COMMANDS	3
MODIFY COMMANDS	4
PROCESSING PROGRAM COMMANDS	33
SORTING COMMANDS	3
COMMANDS FOR LOCATING RECORDS	4
STRING FUNCTION COMMANDS	9
STRING OPERATORS	4
MATHEMATICAL FUNCTIONS	5
MEMORY VARIABLE COMMANDS	13
STORABLE MEMORY VARIABLES	256
CHARACTER CONVERSION FUNCTIONS	9
IF COMMANDS	1
DATE AND TIME FUNCTIONS	10
DEBUUGGING TECHNIQUES	8
COMMANDS FOR INTERFACING WITH OTHER SOFTWARE	2

ADDITIONAL, FROM dBASE III TO III+

NUMBER OF COMMANDS	104
EDITING COMMANDS	0
APPEND FUNCTIONS	0
CLEAR COMMANDS	2
COPY COMMANDS	0
CREATE COMMANDS	3
DISPLAY COMMANDS	1
DO COMMANDS	0
MODIFY COMMANDS	2
PROCESSING PROGRAM COMMANDS	10
SORTING COMMANDS	0
COMMANDS FOR LOCATING RECORDS	0
STRING FUNCTION COMMANDS	6
STRING OPERATORS	2
MATHEMATICAL FUNCTIONS	4
MEMORY VARIABLE COMMANDS	3
CHARACTER CONVERSION FUNCTIONS	0
IF COMMANDS	1
DATE AND TIME FUNCTIONS	2
DEBUUGGING TECHNIQUES	6
COMMANDS FOR INTERFACING WITH OTHER SOFTWARE	2
QUERY FORM OPTIONS	5
HISTORY COMMANDS	3

ADITIONAL, FROM dBASE III TO III+

---

dBASE III+: LEARNING FROM SCRATCH

NUMBER OF COMMANDS	231
EDITING COMMANDS	12
APPEND FUNCTIONS	3
CLEAR COMMANDS	6
COPY COMMANDS	3
CREATE COMMANDS	6
DISPLAY COMMANDS	5
DO COMMANDS	3
MODIFY COMMANDS	6
PROCESSING PROGRAM COMMANDS	43
SORTING COMMANDS	3
COMMANDS FOR LOCATING RECORDS	4
STRING FUNCTION COMMANDS	15
STRING OPERATORS	5
MATHEMATICAL FUNCTIONS	9
MEMORY VARIABLE COMMANDS	16
CHARACTER CONVERSION FUNCTIONS	9
IF COMMANDS	2
DATE AND TIME FUNCTIONS	12
DEBUUGGING TECHNIQUES	14
COMMANDS FOR INTERFACING WITH OTHER SOFTWARE	4
QUERY FORM OPTIONS	5
HISTORY COMMANDS	3

dBASE III+: LEARNING FROM SCRATCH
