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Market Penetration of Office Automation Equipment; Trends and Forecasts

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ABSTRACT

This article identifies the major factors that are influencing the rate of market penetration of office automation equipment, presents trend data on national and industry investment in office automation and other equipment, extrapolates these trends to 1995, and compares several recent penetration forecasts against the trend data. The data show that office-intensive industries such as finance are rapidly increasing their capital/labor ratios, and that office automation equipment represents a significant portion of this total investment (about 40%). The relative importance of equipment costs in determining the penetration rate is likely to decline as training and implementation costs increase and become more visible, and as more managerial and professional tasks become automated.

Investment trends offer a useful basis from which to analyze and assess market penetration forecasts. The plausibility of forecasts can be judged by comparing them against extrapolations of past investment behavior, particularly the ratio of investment in equipment of all kinds to industry product or GNP. A forecast that appears plausible on these grounds must be examined further to determine whether it accounts for the effects of other costs that are more difficult to measure, and for less quantifiable factors that, overall, could play a dominant role in shaping market penetration patterns and rates.

Introduction

Office automation (OA) technologies promise a revolution in the way offices are organized, staffed and managed. The "revolution" is just beginning, and its pace is, as yet, uncertain. The problems faced by information system managers, human resource professionals, and top management in office-dominated industries will differ dramatically, depending on whether the new technology spreads rapidly or slowly. Sooner or later, of course, jobs will be transformed, skill requirements will change, and white-collar productivity will increase. But if market penetration[1] is rapid, as several recent employment forecasts suggest (Roessner, et al., 1985; Leontief and Duchin, 1984; Drennan, 1983), human resource professionals could be faced with large numbers of clerical workers whose skills are no longer needed by their employers. Retraining may be too expensive or infeasible, and layoffs problematic. Top managers will be forced to consider quickly the implications of the new technology for their firms' productivity and competitive position, and for the organization of office work (Strassmann, 1985). Rapid change will permit fewer mistakes and potentially offer greater opportunities than if the new technology spreads more slowly, allowing incremental adjustments. Finally, information system managers could face rapid changes in skill requirements and problems in implementing the new technology for which they are ill-prepared. For these reasons, it is desirable to anticipate as accurately as possible the pace with which OA technology will spread among its potential markets.

Unfortunately, forecasting the market penetration of new technology is more art than science (Warren, 1980). In

the absence of general models, an analyst's best course is eclectic: use multiple techniques and information sources to analyze the features of each type of technology and its potential markets (Roessner, 1980). Forecasts of the spread of office automation vary widely, and it is difficult to identify readily the most credible ones. In this paper I identify several of the major factors that are influencing the spread of office automation equipment, present trend data on investment in office and other equipment and extrapolate these trends to 1995, and compare several recent penetration forecasts against the trend data. This approach can be used to identify forecasts that imply implausibly large shifts in investment levels by individual industries or by the nation as a whole. Forecasts that seem plausible on the basis of their implied level of investment in capital equipment can be further analyzed for their consistency with other factors expected to play major roles in shaping the penetration rate.

Historical Trends in Office Automation Use

The National Income and Product Accounts show that sales of "office and computing machines as producer durables" grew from $3.2 billion in 1967 to nearly $33 billion in 1983, an average annual rate of 16% (Figure 1). Other government sources, the Census Bureau's *Current Industrial Reports* and *Annual Survey of Manufactures*, show close agreement with these figures. (The Current Industrial Reports defines "office, computing, and accounting machines" to include the following major products: electronic computers and peripheral equipment, parts and attachments for electronic computers and peripheral equipment, automatic typing and word processing machines, accounting machines and cash registers, and typewriters, dictating, transcribing, recording machines.) A second source, the International Data Corporation (*Predicasts Basebook*, 1984), shows sales to business and industry of "computers and auxiliary equipment" rising from $3.1 billion in 1967 to $36.5 billion in 1983, an average annual rate of nearly 17% (Figure 1).[2] For comparison, over the period 1970 to 1983, total business investment in equipment of all types rose from $65.2 billion to $223.2 billion, an average annual increase of 9.9%. Interestingly, the same source shows "staff-related expenditures" by computer users also increasing at about 13% annually but totalling substantially more than the hardware expenditures in every year (Figure 1).

In 1983 U.S. expenditures for "office and computing machines" represented nearly 15% of total business expenditures for equipment, (*Economic Report of the President, 1985*), a proportion that has more than doubled since 1977 (see below, Table 3). The increasing national investment in automated office equipment has been led by office-intensive service industries, particularly finance. Between 1963 and 1980, the finance, insurance, and real estate industry increased its annual investment in "office, computing, and accounting machines" from $318 million to more than $5.5 billion (Table 1), an average annual growth rate of 18.1%. The wholesale and retail trade industry increased its investment over the same period from $189 million to more than $1.5 billion (a 13% average annual rate of increase). Manufacturing expenditures for equipment of all kinds grew at an average of 7.3% annually over this period.

Capital Constraints on the Market Penetration of Office Automation Equipment

Firms will expend capital to automate their office functions in two major categories: equipment (including software) and implementation. Implementation costs include the costs of training employees to use the new equipment, the costs of reorganizing work to realize the full benefits of OA beyond its impact on clerical functions, and some of the costs of retraining workers displaced by the new technology. A firm's decision to automate its offices does not, of course, lead to a single, lump equipment purchase. Capital expenditures, maintenance costs, and support costs (e.g., training, software updating) will be ongoing. From a budgetary perspective, office automation involves deciding what percentage of the budget will be devoted to OA over an extended period. Implementation costs may equal or exceed the costs of hardware, and continuing support costs may be equally large. This section presents historical data on indicators such as investment by industry in equipment as a proportion of industry product that, if extrapolated, could be used to determine whether a forecast of OA penetration falls within the bounds of past investment behavior.

Table 2 shows trends in the value of net equipment stock[3] (in current dollars) per employee in manufacturing, finance, and trade industries over the period 1950-1980. Clearly, the finance industry is now accumulating net stock per employee at a much higher rate than the average for all manufacturing industries or for wholesale and retail trade. These figures indicate that the 1980 net value of capital stock per employee in the finance industry was about $17,000, in contrast to an average of $23,000 per employee across all manufacturing industries. If, however, we consider that, according to the Commerce Department's Survey of Current Business, only about 70% of manufacturing employees are engaged in production, the value of capital stock per *production* worker in manu-

Table 1

Investment in Office, Computing, and Accounting Equipment, Finance and Trade, 1963–1980
(millions of current dollars)

Year	*Wholesale & Retail Trade*	*Finance, Insurance, and Real Estate*
1963	188.8	318.3
1967	291.7	652.4
1972	332.6	1212.9
1975	522.2	1587.9
1976	651.7	1839.6
1977	743.2	2545.1
1978	920.4	3484.7
1979	1197.6	4655.4
1980	1540.1	5541.1

Source: U.S. Department of Commerce, Office Business Analysis, Office of Research, Analysis, and Statistics

Table 2

Net Capital Equipment Stock Per Production Employee, Various Industries
1950–1983

	MANUFACTURING				TRADE				FINANCE			
	Net Equipment Stock (a) (billions of current dollars)	Total Employment (b) (millions)	Production Employment (c) (millions)	Net Equipment Stock per Production Employee (thousands of dollars)	Net Equipment Stock (billions of current dollars)	Total Employment (millions)	Production Employment (millions)	Net Equipment Stock per Production Employee (thousands of dollars)	Net Employment Stock (billions of current dollars)	Total Employment (millions)	Production Employment (millions)	Net Equipment Stock per Production Employee (thousands of dollars)
1950	31.6	15.2	NA	—	12.1	9.4	NA	—	0.9	1.9	NA	—
1955	51.9	16.9	NA	—	18.2	10.5	NA	—	2.5	2.3	NA	—
1960	76.1	16.8	NA	—	23.6	11.4	NA	—	4.4	2.3	NA	—
1965	91.6	18.1	NA	—	29.7	12.7	NA	—	8.1	3.0	NA	—
1970	145.6	19.4	14.0	10.4	45.9	15.0	13.4	3.4	15.9	3.6	3.7	4.3
1975	253.4	18.3	13.0	19.5	71.7	17.1	15.0	4.8	39.0	4.2	4.3	9.1
1980	462.6	20.4	14.2	32.6	125.7	20.3	17.9	7.0	90.9	4.2	5.4	16.8
1983	NA	18.5	12.6	—	NA	20.8	18.2	—	NA	5.5	5.8	—

Sources: (a) U.S. Department of Commerce, Office of Business Analysis, Office of Research Analysis, and Statistics
(b) U.S. Department of Labor Bureau of Labor Statistics, *Employment and Earnings*
(c) U.S. Department of Commerce, Current Industrial Reports, Survey of Current Business.

Note: The BLS Occupational Employment Survey and the Commerce Department's Survey of Current Business sample households and business, respectively, yielding different figures for total employment. Thus, "production" employment (jobs) slightly exceeds total employment (full-time equivalent).

Table 3

Office, Computing, and Accounting Investment As a Proportion of Total Investment in Equipment, Various Industries, 1963–1980

Year	*Wholesale and Retail Trade*	*Finance and Insurance*	*Motor Vehicles*	*Chemical & Allied Products*
1963	5.1%	35.8%	3.8%	1.9%
1967	5.9	36.2	3.3	1.7
1972	4.2	27.3	0.6	0.9
1975	5.3	29.4	0.6	0.5
1976	5.6	32.1	0.8	0.4
1977	5.3	33.4	0.8	0.4
1978	5.3	33.4	0.8	0.4
1980	7.9	41.2	1.0	0.5

Source: U.S. Department of Commerce, Office of Business Analysis, Office of Research, Analysis, and Statistics.

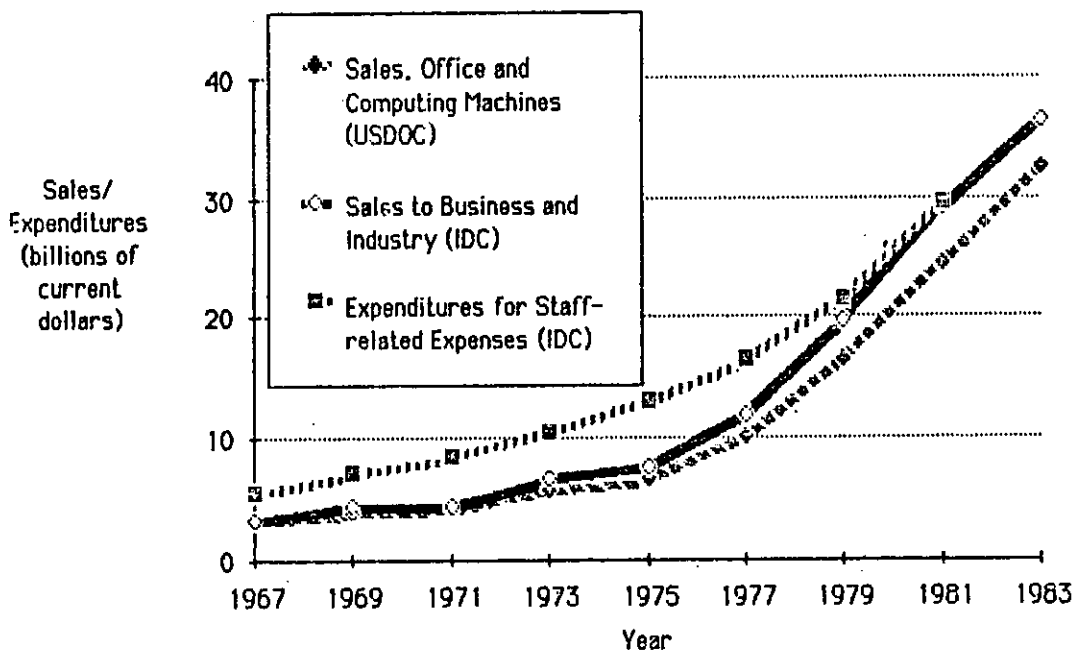

Figure 1

Sales/Expenditures for Computers and Office Equiment

Source: U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports EDP Industry Report, 1983

facturing in 1980 was roughly $33,000. Virtually all employees in the finance industry are "production workers" (92% are managers, professionals, sales, or clerical workers), so the equivalent figure for finance remains at about $17,000 per "production" employee.

Most estimates of the relative capitalization of manufacturing and office-intensive industries differ widely from this. They suggest that capital per employee in manufacturing is at least five times that of office-intensive industries. Several reasons account for the discrepancies, including differences in the definitions of production equipment in manufacturing and finance, and differences in how firms in the two industries treat office expenses for tax purposes (Uttal, 1982: 178). For example, the extent to which various kinds of office furniture should be considered as "production equipment" in an insurance company or bank is debatable. According to Commerce Department data, in 1980 40% of the finance industry's investment in new equipment was spent on "office, computing and accounting machinery." This proportion has remained around 30-35% since 1960 (see Table 3). On the other hand, in 1980 the motor vehicle industry spent nearly 90% of its total expenditures for equipment on production machinery, but only 1% for office, computing, and accounting machines (calculated from U.S. Department of Commerce data). My point here is not to develop accurate figures for capital per employee in different industries, but to suggest that the gap in capitalization between manufacturing and some office-intensive industries may be smaller than many suppose, and that, in the case of the finance industry, the gap is closing rapidly.

Industry's past rates of investment in new equipment offer another possible indicator of future constraints on the market penetration of OA equipment. Figure 2 shows trends in annual investment in new equipment in manufacturing, wholesale and retail trade, and finance, as a proportion of each industry's gross domestic product (in current dollars). For comparison, data on total investment in producers' durable equipment as a proportion of gross national product (GNP) are presented as well. During the decade 1970-1980, this ratio increased from 6.5% to 9.7% in manufacturing, an average annual rate of 4.1%; in wholesale and retail trade it rose from 3.9% to 4.5% (1.4% annually); In finance the ratio more than doubled, increasing from 2.0% in 1970 to 4.7% in 1980 (8.9% annually). There is no particular reason to expect that the ratio of annual investment in new equipment to gross domestic product should be similar across industries, although it is entirely possible that office-dominated industries such as finance will approach the level of investment exhibited by manufacturing. Projections of investment in new equipment by industry and for the nation, coupled with estimates of the proportion of that investment spent on office automation equipment, offer one basis for setting the bounds within which market penetration forecasts for office automation should fall. Figure 3 illustrates the same trends as Figure 2, expressed in constant 1972 dollars. This enables BLS projections of investment in equipment to be incorporated into the figure.

Although the ratio of investment in new equipment to GNP has remained between roughly 6.5% and 7.5% since 1970, and is projected at between 7.5% and 9%, the proportion of that investment devoted to office automation has doubled since 1970 from 6% to nearly 15% in 1983 (Figure 4). It appears that this steeply rising investment curve will continue, at least for the next several years.

The penetration of office automation technology will depend directly upon decisions about the relative proportion of total investment in all types of equipment to be allocated to OA. For the economy as a whole, BLS projects GNP and gross private investment in equipment (Table 4) for 1990 and 1995 under three different economic scenarios. Investment in equipment as a proportion of GNP is projected to grow to between 7.5 and 9% by 1995 (current dollars). These ratios can be used to project expenditures for office automation equipment under different assumptions about changes in the ratio of investment in OA to total investment in equipment; as we have seen, the ratio is now about 15% and rising steeply; it could easily attain 20% or even 25% in the next decade. The results of such calculations are shown in Table 5 expressed in constant 1972 dollars and current dollars, assuming an average of 6% inflation since 1980. Other inflation rates could be assumed, of course. These kinds of estimates can be used to generate a series of "envelopes" within which office automation equipment sales forecasts might be expected to fall. The envelope using the estimates of Table 5 appears in Figure 5.

Training and Implementation Costs

The rate of capitalization will be influenced to some extent by overall wage levels. As the impact of office automation shifts from clerical to managerial functions, overall wage levels in the economy, not just clerical wages, will be relevant. However, a decision to automate an office function is not a simple tradeoff between the cost of the equipment (and its implementation) and the wages paid workers who perform that function. Instead, it is increasingly clear that firms do not invest in office automation simply to reduce labor costs or increase efficiency (Curley and Pyburn, 1982; Kettinger, 1983). As the International Data Corporation put it, "Justification for office systems can come only in part from direct labor savings. The rest must come from better turnaround times, increased responsiveness to customers, and smarter decisions" (IDC, 1983: 102). They punctuate this comment by estimating that an expected level of invest-

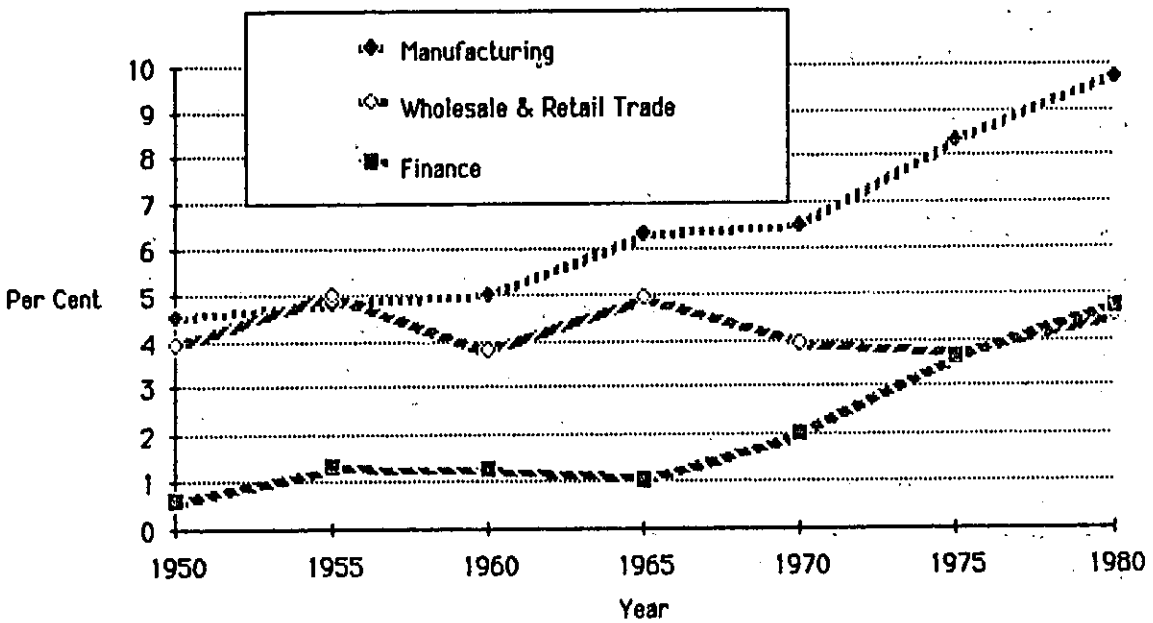

Figure 2

Investment in Equipment as a Proportion of Industry Product
(current dollars)

Source: U.S. Department of Commerce, Office of Business Analysis, Office of Research, Analysis, and Statistics
Economic Report of the President, 1985

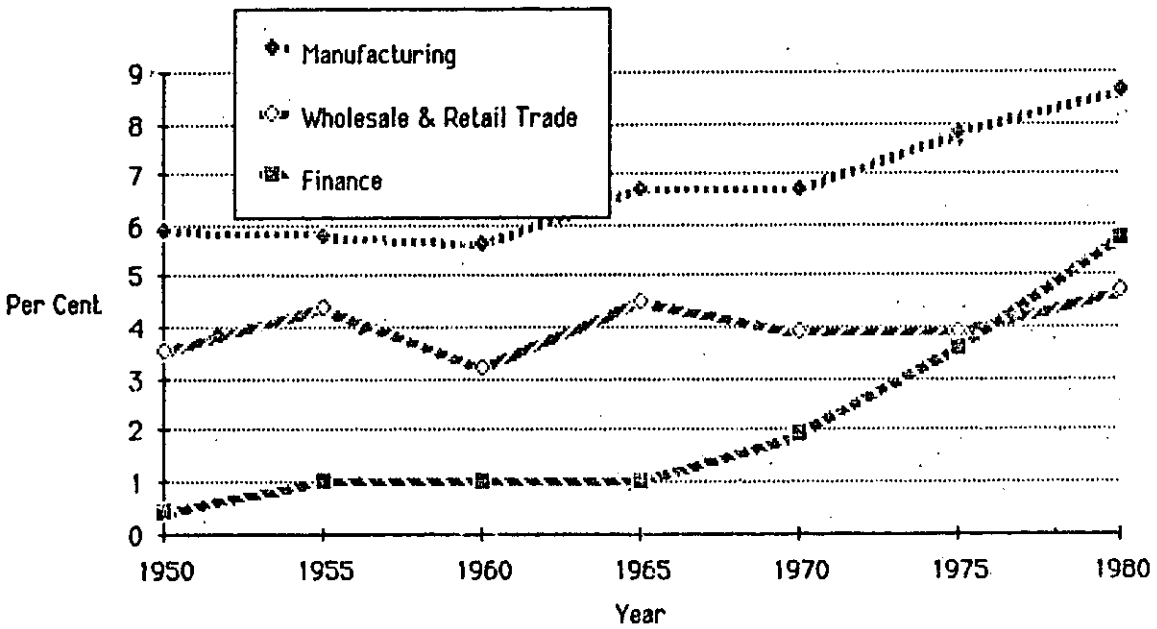

Figure 3

Investment in Equipment as a Proportion of Industry Product
(billions of constant 1972 dollars)

Source: U.S. Department of Commerce, Office of Business Analysis, Office of Research, Analysis, and Statistics
Economic Report of the President, 1985

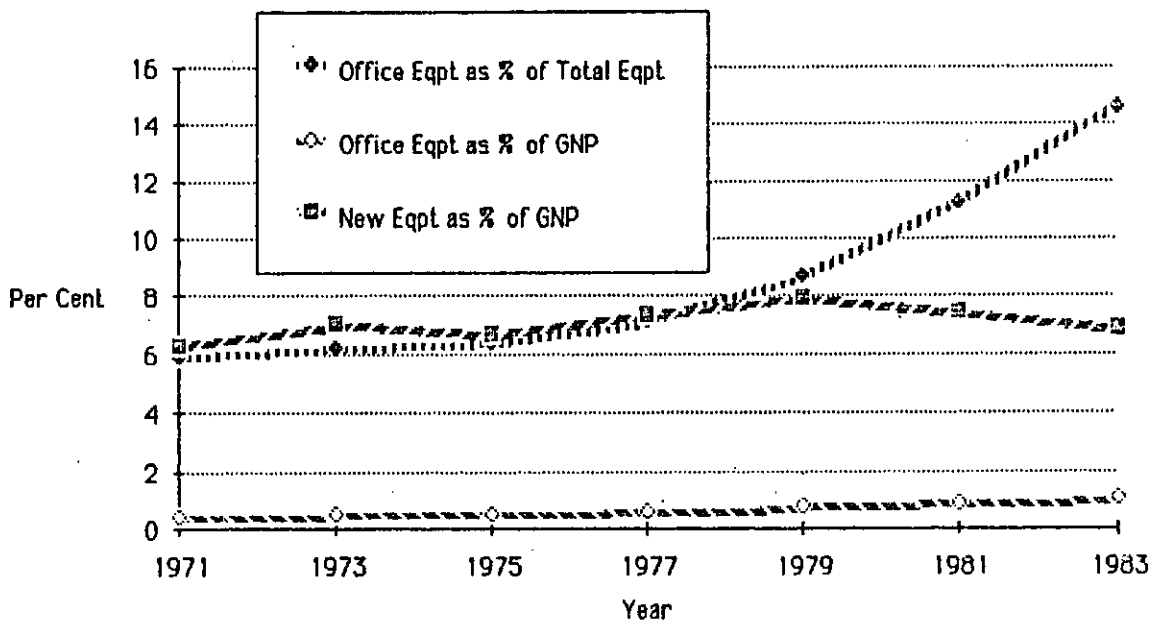

Figure 4

Ratio of Investment in Equiment and OA Equipment to Various Bases
(current dollars)

Source: U.S. Department of Commerce, Bureau of the Census, Current Industrial Reports
Economic Report of the President, 1985

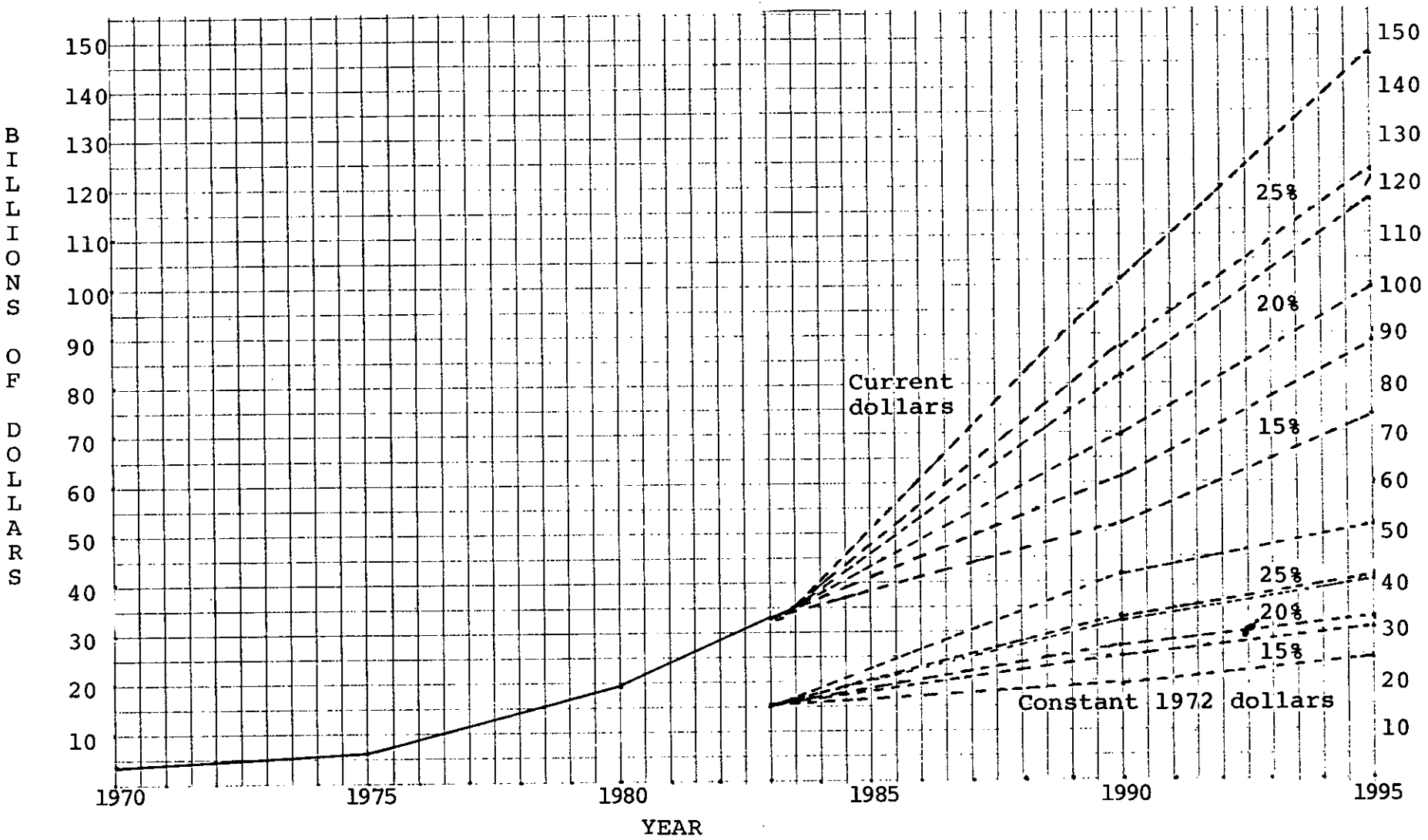

Figure 5

U.S. Sales of Office and Computing Machines, 1970–1983, and Projections to 1995 Under Various Assumptions About the Ratio of Investment in Office Automation Equipment to Total Investment in Equiment

Table 4

Estimated GNP and Gross Private Investment in Equipment, 1990 and 1995

Year	*GNP (constant 1972 dollars)*	*Gross Private Investment in Equipment (billions of constant 1972 dollars)*	*Investment as % of GNP (1972 dollars)*	*GNP (billions of current dollars)*	*Gross Private Investment in Equipment (a) (billions of current dollars)*
1982	1485.4	112.7	7.6	3069.3	—
1990 (LO)	1857.9	132.4	7.1	—	347.3
1990 (MOD)	1915.5	149.1	7.8	—	381.6
1990 (HI)	2004.2	166.2	8.3	—	406.0
1995 (LO)	2126.7	159.6	7.5	—	491.0
1995 (MOD)	2166.9	177.2	8.2	—	536.8
1995 (HI)	2264.6	202.8	8.95	—	585.9

(a) Assumes 6% average annual inflation rate after 1982.

Source: U.S. Department of Labor, BLS Bulletin 2197, 1984:14.

Table 5

Estimated U.S. Investment in Office Automation Equipment, 1990 and 1995

	Investment in Office Automation Equipment					
	Billions of Constant 1972 Dollars			Billions of Current Dollars(a)		
	Office Equiment as Percentage of Total Investment in Equipment:			Office Equipment as Percentage of Total Investment in Equipment:		
Year	*15%*	*20%*	*25%*	*15%*	*20%*	*25%*
1990 (LO)	19.86	26.48	33.1	52.1	69.5	86.8
1990 (HI)	24.93	33.24	41.55	60.9	81.2	101.5
1995 (LO)	23.94	31.92	39.9	73.65	98.2	122.75
1995 (HI)	30.42	40.56	50.7	87.9	117.2	146.5

(a) Assumes average 6% inflation rate after 1982.

Source: Calculated from data in Table 4.

ment in office automation of $195 billion over the period 1983-1987 will yield labor savings of only $110 billion.

Expenditures for office automation must include the wages of skilled operators and trainers. Various sources seem to agree that implementing office automation equipment costs at least as much as the equipment itself. Past trends in industry expenditures for training offer some guide as to what levels might be expected in the future. The availability of workers possessing the requisite fundamental skills such as analytical sophistication, problem diagnosis and problem solving, ability to synthesize disparate materials, and communication skills could place serious constraints on the pace of market penetration. Industry representatives seem to agree that all office workers, managers and clericals alike, will need to acquire numerous new skills that are not now needed to perform their duties (Roessner, et al., 1985).

The American Society for Training and Development estimates that industry spends $40 billion annually on education and training for employees (U.S. Congress, OTA, 1983: 33). Approximately 11 million workers are receiving job-related training; two-thirds of these participate in in-house programs, while the remainder are enrolled in programs provided by colleges and universities, vocational schools, unions, government agencies, and community-based organizations (U.S. Department of Labor, BLS Bulletin 2206, 1984). Carnevale and Goldstein (1983: 80) estimate that, if the average cost per course is about $670, total expenditures by business firms for *in-house* training amounted to about $12 billion in 1981, including salaries and benefits of trainees. Despite these impressive numbers, there is a general consensus that job-related training is a rarity among U.S. workers. The Commerce Department estimates that, through 1978, about 6% of all employees between the ages of 25 and 49 received job-related training from their employers (Bikson and Gutek, 1983-2).

Many employers are relying on vendor-provided training during this early period of penetration of OA equipment. Vendors provide training for their dealers, and some offer seminars and classes at their local offices or at dealer offices. As vendors seek to shift training costs to purchasers of their equipment, self-paced training packages (cassettes, manuals, exercise workbooks) are becoming more popular (Friedman, 1982). But evidence is growing that this approach will not suffice, particularly as the focus of training programs moves from clerical workers to managers and other professionals.

A survey of *Training/HRD* magazine found that, even when training was supplied to workers, it tended to emphasize short-term objectives and failed to reflect planning or systematic program development on the part of managers (cited in Bikson and Gutek, 1983-1). Preliminary results of the Rand Corporation's study of OA implementation in 55 work groups (Bikson and Gutek, 1982-1) offer some basis from judging the future of employer-based training for OA. Bikson and Gutek concluded that:

- vendors who supply flexible, comprehensive training rather than training for only initial use of their products or self-instruction programs will have a competitive advantage.
- changes will occur in current training practices as higher-paid workers require training.
- as organizations recognize that technological change occurs rapidly, necessitating continual training, they will be more willing to invest in longer-term programs.

As I noted earlier, casual estimates of the cost of implementing OA tend to approximate the cost of OA hardware. Using the data of Figure 1, this means that employers may have spent as much as $20 billion in 1982 to train employees to use OA equipment and to implement OA systems. If this pattern continues, and vendors successfully transfer the bulk of training costs to end users (as seems likely), then training and implementation costs could have a significant retarding effect on the rate of penetration of OA equipment. Whether this actually occurs will depend on many factors, including whether training costs are included in a firm's initial decision to purchase OA equipment, the software's degree of sophistication (its "friendliness"), and whether cost savings rather than competitive pressures based on quality of service are the driving force behind the decision.

The availability of persons in the labor force with requisite skills may, in some regional labor markets, prove significant for the spread of office automation. On the one hand, demographics alone may stimulate some companies to automate. The combination of labor migration patterns and a declining rate of new entrants into the labor force following the "baby boom" may leave certain local labor markets (e.g., the midwest and New England) with a shortage of labor at all skill levels. Large firms, unable to relocate but facing a tight local labor market, may choose OA as the only way to expand business output (R. Peabody, personal communication, 1984). There may be an opposing force, however, that may not become manifest until well into the 1990s and beyond: the inadequacy of secondary and high school education for the computer age. The issue goes well beyond computer literacy to the concern, expressed in recent reports on the state of American education, that fundamental skills such as communication, analysis, and "common sense" will become crucial if computers are to be used effectively. Future OA systems will be very user friendly, will possess enormous computational power, and will provide volumes of data on command. The central issues for

users will involve knowing what questions to ask, what the data mean, and when the output simply doesn't make sense. Teaching persons these fundamental skills is not easy, yet locating workers who possess them will be increasingly important for office managers. Short, remedial training courses are unlikely to suffice.

Forecasts of the Penetration of Office Automation Equipment

Forecasts of OA market penetration take two major forms: (1) the dollar value of manufacturer shipments and/or sales of particular products, and (2) the number of units of products shipped or in place (installed base) in a given year. Each is useful for different purposes, and different data can be brought to bear to assess the credibility of forecasts or to help set the context for additional forecasts. In particular, sales forecasts obviously are useful for estimating the implications of OA for the national economy, for vendor/dealer revenues, and for end used expenditures. For these forecasts, trend data and extrapolations of annual expenditures by industry for new equipment offer one means of bounding estimates of future expenditures by users for OA equipment. Forecasts of unit penetration, especially installed base, can be compared with the number of likely users to gain some idea of current and projected market penetration of the total eventual market. In the following sections I pursue both approaches, beginning with forecasts of the installed base of OA equipment.

Installed base. One difficulty with interpreting most market penetration forecasts is taht it is very difficult to specify *in advance* what the size of the eventual market will be. (In the 1950s IBM thought they would sell only a few mainframe computers, primarily to government.) Thus, during the initial stages of the diffusion of an innovation, it is difficult to specify what level of penetration (as a proportion of the total potential market) has been achieved, or what level of penetration a particular forecast (measured in sales or number of units) represents. In the case of office automation technology, however, we do know how many of what types of office (white collar) workers are in the labor force. The Bureau of Labor Statistics (BLS) prepares projections of employment by major occupational category (managers, clerical workers, etc.). Table 6 shows 1982 levels and projections for 1990 and 1995 for the four categories of white collar workers.

The IDC states that by the end of 1983 there were about 18.5 million electronic keyboard devices (PS's, other computers, terminals, and word processors) in use, or about one for every three of the 55 million white collar workers. By 1987, they forecast 54 million electronic keyboard devices, or virtually one for every white collar worker (IDC, 1983: 94)[4] They further forecast an installed base of about 19 million PC's in the U.S. business/professional market by 1987, or about two PC's for every three managers and professional workers, assuming these occupations are the first to enjoy the benefits of the PC (*EDP Industry Report*, July 8, 1983: 2). At this rate of market penetration, by 1990 virtually all white collar workers in the United States would be working with electronic keyboards, and most, if not all, nonclerical white-collar employees would be working regularly with a PC or electronic workstation (see Figure 6). by 1995, every manager, professional/technical worker, and office salesperson would be working with an electronic workstation. (This represents an installed base of between 30-40 million PC/workstations.)

The IDC forecast is consistent with that of the firm Future Computing, which calls for an installed base of 9-10 million PC's in 1985, 32-33 million by 1990, and 53-54 million by 1995. Future Computing used BLS forecasts of occupational employment to generate its forecasts. In their view, by 1995 50-60% of office workers will have personal computers, with 25-30% having more than one (Biagiotti and Ablondi, 1984: 59).

By about 1990, analyses of the impact of office automation on office work and workers should shift from consideration of the shock of, and resistance to, initial exposure to OA equipment, to how, and how rapidly, office work and occupations will be restructured to take advantage of the continuously-improving office technologies that will be available. Stated differently, future OA sales will be a function of the replacement rates for in-place, automated equipment rather than of the rate of acceptance of OA equipment among the uninitiated. If these forecasts are prescient, this transition will occur about 1990 for OA equipment intended to perform or complement clerical functions, and will occur about 1995 for OA equipment intended to perform or complement managerial and professional/technical functions.

Sales forecasts. Most OA sales forecasts, many of which appear in the trade literature, that are supported by analytical work actually are based on a very small number of sources. Firms such as Predicasts, Inc., International Data Corporation, and International Resource Development, Inc., develop and sell market analyses and forecasts. While the number of different OA forecasts is small, their accessibility is problematic because of their high cost. I have had to rely on summaries of larger studies appearing as advertisements (IDC, 1983) or on references to these studies that appear in other publications (IRD, 1983; Predicasts). This is adequate for the present purpose, which is to illustrate the utility of the preceding trend data for analyzing and assessing OA market penetration forecasts.

Table 6

U.S. Civilian Employment by Occupation, 1982 and Projected 1995
(in millions of workers)

Occupation	*1982*	*Total employment 1995 (low)*	*1995 (med)*	*1995 (high)*
All occupations	101.5	124.8	127.1	129.9
Professional, technical, and related	16.6	21.5	21.8	22.3
Managers, officials, and proprietors	9.5	12.0	12.2	12.5
Salesworkers	7.0	8.5	8.8	8.9
Clerical workers	19.0	23.5	24.0	24.5
Craft and related	11.6	14.5	14.8	15.1
Operatives	13.0	15.0	15.4	15.8
Service workers	16.2	20.4	20.7	21.1
Laborers, except farm	5.9	6.9	7.1	7.2
Farmers and farmworkers	2.7	2.4	2.4	2.4

Source: Silvestri, Lukasiewicz, and Einstein, 1983

Figure 7 depicts the forecasts of three major sources: Predicasts, IDC, and *Electronics* magazine[5]. The Predicasts study, *The Office of the Future*, shows sales of "automated office equipment" (SIC 3570) growing from $15.3 billion in 1980 to $37.6 billion in 1995. Figure 7 shows that this would require the ratio of total national investment in office automation equipment (broadly defined to include all types of computers and office equipment) to total investment in equipment of all kinds to increase from its current value of 15% to 20% by 1995. Given the continuing shift toward a white-collar economy and the current investment behavior of bellwether industries such as banking and insurance, this forecast seems well within the bounds of plausiblity.

The two shorter-term forecasts, by International Data Corporation (IDC) and *Electronics* magazine, depend substantially upon the types of equipment included. IDC defines office automation as:

- personal computers for office and industry
- word processors and electronic typewriters
- private branch exchanges (PBX)
- copiers
- multifunction computer systems and local area networks (LAN).

Electronics magazine's definition is limited to:

- copying equipment
- dictation equipment
- electronic typewriters
- local networks
- word-processing systems.

The two definitions yield 1987 forecasts that differ by a factor of two. If the magazine's "small-business personal computer systems" sales forecasts are added to the office automation results, the IDC and *Electronics* forecasts are comparable in both definition and result (Figure 7). If

sales forecasts of small-business, professional computers are also included the *Electronics* forecast yields 1987 domestic sales of $58 billion (current dollars).

This forecast's 1982 sales figure is about half that of the national income account's 1982 sales figure for "office and computing machines," which includes mainframes but apparently excludes communications equipment, an increasingly large portion of OA expenditures. While full analysis would require detailed information about what types of equipment are included in these or any other forecasts, the enormous increase in investment suggested by the *Electronics* forecast would be plausible only if there is a corresponding decline in sales of other types of office equipment included in the Commerce Department definition (e.g., mainframe computers).

Conclusion

Office-intensive industries such as banking and insurance are rapidly increasing their capital/labor ratios. Office automation equipment represents a significant proportion, now 40% in some service industries, of total annual expenditures for new equipment. Data presented in this paper suggest that differences in the amont of capital per production employee between manufacturing and white-collar industries may be smaller than sometimes claimed, and that these differences are diminishing rapidly in some economic sectors. Although equipment investment levels in wholesale and retail trade are not changing dramatically, they are in finance, insurance, and real estate, where investment in equipment as a proportion of industry product is increasing at a significant faster rate than in manufacturing, trade, or the total economy. The competitive edge that office automation offers through new services and higher quality output is a powerful force working to increase investment in OA equipment in service-producing industries.

The cost and availability of capital are only one of many factors that will determine the market penetration rate and pattern of spread of office automation equipment. Competitive pressures are driving investment in OA now, but the salience of constraints other than equipment costs on penetration is likely to increase. For example, the costs of implementing OA systems, including training, are large but often hidden. Unlike capital costs, implementation costs are elusive and difficult to measure. It seems likely that as managers become increasingly aware of the magnitude of implementation costs, they will slow the rate of investment somewhat. Organizational and behavioral factors such as inertia may exert greater influence as office automation extends from clerical workers to managers. Similarly, training costs will increase as the tasks being automated become more complex, requiring those that use the equipment to assume broader responsibilities and to possess more fundamental skills than before. Such skills are difficult to acquire and in great demand.

Investment trend data offer a useful basis from which to analyze and assess OA market penetration forecasts. Similarly, comparing forecasts of the installed base of individual types of OA equipment against occupational employment forecasts indicates when market saturation is likely to occur. I have shown that economy-wide and industry-level sales forecasts can be examined usefully in terms of the investment levels they would require. Their plausibility can be judged by comparing them against extrapolations of investment behavior, particularly the ratio of investment in all types of equipment to industry product or GNP. A forecast that appears plausible on these grounds must be examined further to determine whether it accounts for the effects of other costs that are more difficult to measure, and for less quantifiable factors that, overall, could play a dominant role in shaping market penetration patterns and rates.

Footnotes

1. Market penetration of a new technology refers to the speed with which the technology is purchased by those who constitute its potential market. Market penetration modeling and analysis of new products has its intellectual roots in research on the diffusion of innovations. See, for example, Midgley, 1977; Hurter and Rubenstein, 1978.

2. The Commerce Department data (National Income and Product Accounts, Census Bureau) include sales of mainframe and other computers that should not be considered part of office automation and may overstate the actual levels of OA sales. The close agreement between the Commerce Department and IDC is probably fortuitous, since the product definitions and markets considered probably differ.

3. Net capital stocks are the cumulation of all past investments adjusted by the discard of worn-out assets and the loss of efficiency (depreciation) of the assets over their service life (U.S. Department of Labor, BLS Bulletin 2034, 1979: 25).

4. Much of the available forecast data are generated by vendors or consultants who sell information to vendors. This could introduce a bias in forecasts toward more rapid penetration.

5. Because of their high cost, I did not have access to the original Predicast or IDC studies. Presumably, these figures are expressed in constant 1972 dollars. The $15.3 billion, in 1972 dollars, is consistent with sales estimates of about $25 billion in 1980 sales expressed in current dollars.

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