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Complex Picture of Information Technology and Employment Emerges

Issue Brief

Prepared by:

Michael J. Handel

Consultant to SRI International

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SRI International
1100 Wilson Boulevard, Suite 2800 ■ Arlington, VA 22209-3915 ■ 703-524-2053

This issue brief was prepared by:

Michael J. Handel
University of Wisconsin at Madison and
Levy Economics Institute
As a consultant to the Science and Technology Policy Program of
SRI International, Arlington, Virginia

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Questions or comments may be addressed to:

Michael Handel, at mhandel@ssc.wisc.edu

Lori Thurgood, at thurgood@wdc.sri.com

ISSUE BRIEF

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Michael J. Handel
Consultant to SRI International

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The extraordinary diffusion of computers and information technology (IT) during the past 20 years has prompted questions about IT's effects on employment levels, skills in demand, and earnings. This issue brief summarizes key findings about these questions from a review of empirical research literature, *Implications of Information Technology for Employment, Skills, and Wages: A Review of Recent Research.*[1]

Information Technology in the Workplace

Much of the attention IT has garnered is due to its unique power and speed, the diversity of IT applications in the workplace, and its recent, pervasive presence. Although many definitions are possible, IT can be defined as capital equipment that makes extensive use of microelectronics and programmed instructions or software. IT systems are often flexible, reprogrammable, and automatic or self-acting. They can record, process, communicate, and react to vast amounts of information entered by users, received from the environment, or stored internally.

Prominent examples of IT specific to manufacturing and similar blue collar jobs include numerically controlled and computer numerically controlled machine tools,

[1] Available at http://www.sri.com/policy/csted/reports/sandt/it .

robots, computerized diagnostic and testing equipment, manufacturing process controls such as programmable logic controllers, automated material handling equipment, automated guided vehicles, factory local area networks (LANs), computer-aided design and manufacturing (CAD/CAM), material resource planning software to manage supplies and inventory, and flexible manufacturing systems that integrate many of these technologies into more fully automated systems.

Prominent information technology applications in office and service sector environments include common desktop applications such as word processors, spreadsheets, databases, e-mail clients, and Internet browsers; data entry and transactions processing systems (e.g., payroll, billing, bank transactions, and insurance claims); LANs; CAD; automatic teller machines; bank networks for electronic funds transfer; electronic data interchange for automated ordering and payment between purchasers and suppliers; barcode scanners; and point-of-sale devices.

Survey data indicate that the share of workers using computers with video screens and keyboard input on the job rose from roughly 25 percent to 50 percent between 1984 and1997 (see table 1). Popular applications include word processors, database and spreadsheet programs, and, more recently, e-mail clients and Internet browsers. Much less systematic data exist on most of the other applications noted above.

Additional tabulations not shown here indicate that white collar workers, more-educated workers, women, and whites are significantly more likely to use computers than others. Perhaps contrary to stereotype, workers between the ages of 25 and 54 use computers at roughly similar rates and are significantly more likely to use computers than workers who are either younger or older.

Table 1. Trends in the Percentage Share and Annual Growth Rate of Workers Using Computers at Work for Any Task and for Specific Tasks: 1984–97

	Percentage				Annual Growth Rate		
	1984	1989	1993	1997	1984–89	1989–93	1993–97
Use Computer at Work	25.49	37.92	47.06	50.47	2.49	2.29	0.85
Specific Tasks							
Word Processing		15.14	20.46	28.28		1.33	1.96
Spreadsheet		8.43	10.81	15.99		0.60	1.30
Database		10.33	16.16	16.83		1.46	0.17
E-mail		5.83	10.38	23.66		1.14	3.32
Internet use		n.a.	n.a.	16.29		n.a.	n.a.
Bookkeeping		9.23	11.10	13.92		0.47	0.71
CAD		3.41	3.44	n.a.		0.01	n.a.
Programming		7.20	6.11	7.49		–0.27	0.35
Inventory		9.58	11.73	14.28		0.54	0.64
Invoice		6.19	8.68	11.10		0.62	0.61
Sales		5.57	6.47	10.27		0.23	0.95

Source: U.S. Census Bureau, Current Population Survey, October Supplements 1984–97. Author's calculations from Handel (2000). All figures weighted. Specific computer task items not asked in 1984. Internet use not asked in 1989 and 1993. CAD use not asked in 1997.

Clearly, different computer applications are likely to have different effects on the labor market. They may vary in the extent to which they substitute for human labor and stimulate the demand for more-skilled workers. It is also important to consider that the complexity of computers as a product does not necessarily imply anything about the level of skill required to operate computers or work in a computerized environment. The majority of people who use electrical devices or drive automobiles do not have a sophisticated understanding of their underlying principles. Whether high-technology equipment is associated with high-technology or highly skilled jobs is an empirical question.

Computers and Overall Employment Levels

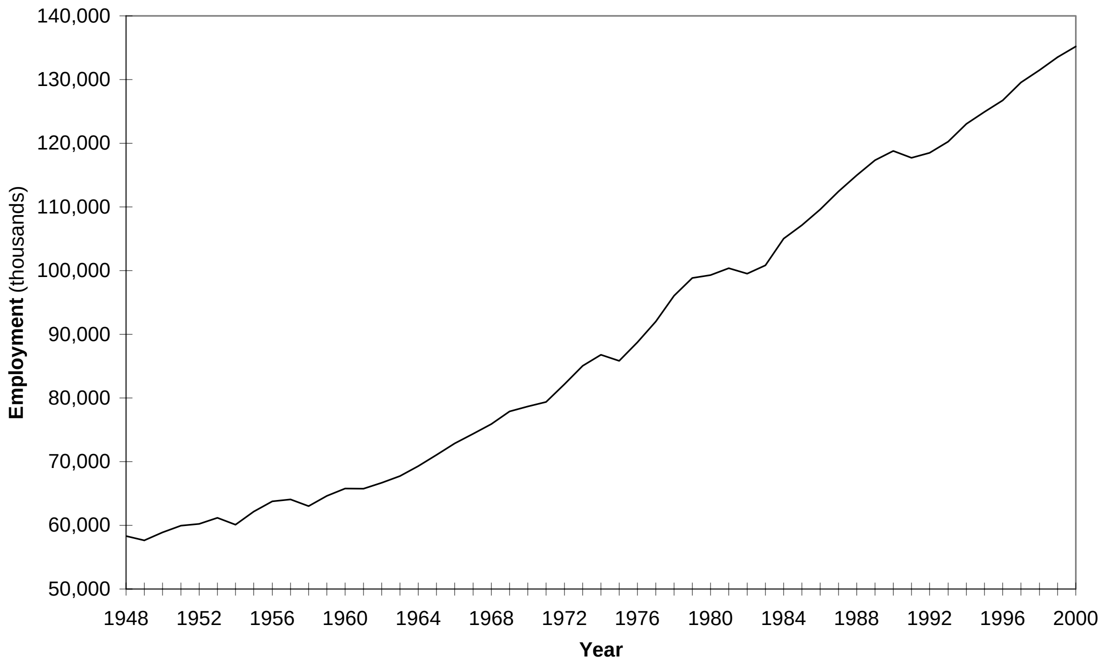
Predictions that automation would lead to mass unemployment have persisted for many years, as early as the Great Depression in the twentieth century and resurfacing in the mid-1950s to early-1960s, when a combination of relatively high unemployment and new production technologies led many to argue that a causal connection existed between the two. These concerns reemerged in the initial years of the recovery from the recession of the early 1990s when the relatively slow decline in unemployment prompted fears of a "jobless recovery" or even the "end of work."

Although certain populations and jobs in certain industries may be disproportionately affected by technological change, in retrospect, most believers in technology-induced mass unemployment seem to have mistaken fluctuations in the business cycle for more fundamental transformations of the workplace and labor market. Although periods of high unemployment are painful, they have reflected mostly oscillations in general business activity rather than the effects of abrupt technological change. When macroeconomic conditions have improved, unemployment has declined. Despite the unprecedented diffusion of information technology since 1980, employment in the late 1990s was better than at any time in the previous 30 years.

Data on total employment in the United States show robust and nearly uninterrupted growth between 1948 and 2000 (see figure 1). During this period of rising productivity, mechanization, and computerization, total employment more than doubled from less than 60 million to more than 135 million, and there has been no obvious slackening of the pace in the past two decades, during which computers became much more common in the workplace. Trends in unemployment and in the employment/

population ratio also do not suggest a general tendency for large numbers of workers to be made redundant.

Figure 1. Total Employment: 1948–2000



Source: *Economic Report of the President* (1989, 2000), Washington, DC: Government Printing Office.

Trends in Demand for Information Technology Skills

In the mid- to late 1990s, some observers expressed concern about perceived shortages of IT professionals. These are the highly skilled engineers, software developers, systems analysts, and programmers who are responsible for the health of the IT industry and computer systems within non-IT firms. These workers create, implement, and maintain computer hardware and software.

A trade association first expressed fears publicly about a possible shortage. Attention soon shifted to the stagnant or declining numbers of college degrees awarded in IT fields despite apparent increasing need. Employers argued for lifting temporary work visas for foreigners with high-level IT skills, while employees argued that there was abundant talent in the U.S. IT workforce and that employers preferred to hire inexpensive foreign labor rather than retrain domestic IT professionals in the latest technical developments.

However, a number of studies disputed whether a shortage even existed. A large fraction of IT professionals receive their training through course taking, non-BA credentialing institutions, or on-the-job experience. Government data do not indicate stronger wage growth for IT professionals than for all occupations between 1983 and 1998 and show slower growth than for lawyers and doctors, although some pick-up occurred during the boom years between 1995 and 1998. The unemployment rate for IT professionals was about 0.5 percentage points below that for all professionals between 1993 and 1998, falling to about 1.5 percent by 1998. This suggests a generally tight labor market but not dramatically tighter than for all professionals for whom there has been no similar level of concern about a general shortage. Although spot shortages should not be surprising, the tight labor market for IT professionals in the late 1990s may have been just another example of the generally tight labor market of the late 1990s.

In addition, computer engineers, scientists, systems analysts, and programmers made up less than 2 percent of all workers in 1997. The relatively small share of IT professionals in the overall workforce means that any trend for this group likely holds limited implications for the general labor market.

Computers and Earnings Inequality: The Economic Theory of Skill-Biased Technological Change

One of the most notable developments in the U.S. labor market since the late 1970s is the dramatic growth in earnings inequality. Many economists argue that this growth is attributable to IT, which has created an increased demand for skilled workers that has outstripped the growth in supply. Others argue that other structural and institutional factors have played a larger role in increasing earnings inequality than a shortage of skills or human capital.

The precise means by which computers might increase job skill requirements is debated even among advocates of this position. Computers can increase the skill demands within occupations in a number of ways:

- **Computer-specific human capital.** Some argue that learning to operate computer equipment and software requires scarce skills.

- **General human capital—computer users.** Others argue that these narrow skills are less significant than conceptual, abstract reasoning, and problem-solving skills. These skills are important in a computerized workplace because using a computer requires the manipulation of symbols and information and makes it more practical for employers to restructure work in ways that give employees broader job duties, more autonomy, responsibility, and decision-making authority.

- **General human capital—computer users and nonusers.** Others believe that computerization within an organization increases skill demands even for jobs that do not involve working directly with a computer because computerization results in organization-wide changes in job definitions and tasks.

Computers can also increase the demand for skill by altering the distribution of workers between occupations, either by stimulating the growth of more high- and medium-skilled jobs or through automation and other labor-saving technology that eliminates less-skilled jobs.

A large body of literature explores each of these possible causal pathways. Initial studies found that computer users earned wages that were 10–15 percent higher than otherwise similar nonusers, a phenomenon known as the computer wage premium. This premium was interpreted as indicating the importance of computer-specific skills or human capital.

However, excitement over this finding quickly subsided when another study using German data found that workers who used a pencil at work or worked sitting down earned premiums comparable to the computer wage premium; similar findings were reported with U.S. and Canadian data that showed large returns for reading letters and using a fax machine at work, respectively. These findings suggested that the initial estimates of the payoff to computer use were inflated by the omission of adequate controls for preexisting worker or employer characteristics.

Attention then shifted to possible alternative causal pathways. Computers were said to require greater cognitive skills because computer work is more intangible and abstract, involving the manipulation of symbols and information rather than physical objects, and because they are often accompanied by complementary organizational changes that broaden job duties and delegate more decision-making and problem-solving responsibility to less-skilled workers. The argument is that working with a computer increases demand for general cognitive skills, such as problem-solving and intellectual flexibility, apart from computer-specific knowledge.

Others extend this thesis by arguing that computerization within organizations has such pervasive effects that the increase in general human capital requirements extends to workers who do not use computers. For both of these views, work in the information economy involves more thinking than before.

Although several case studies and econometric studies are interpreted as supporting this view, questions about the robustness of their results remain. The actual difficulty levels of the new conceptual and literacy skills seem relatively easily absorbed by the existing workforce with little increase in formal educational requirements in most cases, and studies that focus directly on the types of participative management techniques said to result from computerization often find no effect on wages, suggesting that the skill upgrading is modest.

Analyses of national data indicate that increased use of computers in the 1980s and 1990s was associated with greater use of more-educated workers within industries. However, the direction of causality is unclear. It may be that both educational upgrading and greater computer use simply reflect an independent increase in the number of white collar workers within industries, who are the most frequent computer users. It may be that the hiring of more-educated workers, usually office workers, stimulates demand for computers rather than vice versa. In addition, the industries upgrading their educational levels coincident with adoption of computers in the 1980s and 1990s also appear to have been upgrading educational levels before the widespread diffusion of computers.

Although the preceding theories generally examine how computers might change the nature of occupations by increasing their information and problem-solving content, others focus more on the potential for IT to alter the distribution of workers across occupations. Automation may not eliminate massive numbers of jobs, but it may disproportionately eliminate certain types of less-skilled work, such as factory or data entry jobs. Again, the research findings are mixed. Some studies show a correlation between computer use and declines in production worker employment in manufacturing between 1979 and 1992, but almost all of this decline occurred during the deep recession before 1984 and the trend remained flat at least through the late 1990s, so it is hard to attribute the earlier decline to the widespread diffusion of computers. Other studies indicate that the shop-floor automation one would most expect to be associated with declines in the employment of production workers do not have the predicted labor-displacing effect.

With the clear exception of declines in overall clerical employment in banking and insurance, it is not clear that employment in service-sector occupations, such as bank tellers, inventory clerks, or grocery store cashiers, has been affected by the introduction of IT.

Conclusion

The growth and prominence of IT in the workplace has stimulated great interest in its possible effects. Although most researchers believe that fears of massive job displacement have little foundation, many questions about broad labor market effects remain.

Existing research about the effects of IT on employment and work leaves many of these questions unsettled. Results that seem to show a strong relationship among technology, skills, education, occupation, and wages often appear more fragile on closer scrutiny. Many intuitive propositions find only imperfect support in research studies, and there are numerous anomalies and contrary research results. The fact that wage levels rose at the bottom of the distribution, inequality moderated, and unemployment fell to its lowest level in 30 years in the late 1990s, even as IT investment surged and the Internet arrived on the scene, suggests the need for caution in drawing conclusions about the effects of computers on the labor market.

Although many studies support the skill-biased technological change thesis, others draw contrary conclusions and find the evidence for skill-biased technological change fragile and dependent on strong assumptions. Much has been learned about the diffusion of computers and IT and the pattern of growth in earnings inequality, but their possible interrelationship remains unclear and contested.