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ABSTRACT

This report was written for the Technology Policy Task Force of the Committee on Science, Space, and Technology, U.S. House of Representatives. The report examines the nature and history of technological change, its impact on large and small firms and their workers, and its policy implications. The paper stresses that individuals, schools, firms, and public agencies must recognize the importance of basic skills in adapting to change. It urges parents to monitor the schools and help them provide their children with the reading, writing, and problem-solving skills needed to enter and remain in the economic mainstream. The report notes that firms consistently offer to provide specific training to motivated new workers with basic skills. In addition, federal programs such as the Job Training Partnership Act and Trade Adjustment Assistance are needed to assist displaced workers. However, it was found that major programs providing incentives for companies specifically to retrain their workers in new technologies have yet to be developed at the federal level (although several states have initiated such programs). The report concludes that government at all levels should aid industries and individuals adjusting to new technologies; however, those assisted must use available resources conscientiously to help themselves. (KC)

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TECHNOLOGY AND EMPLOYMENT POLICY

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The National Commission for Employment Policy (NCEP) monograph series is dedicated to exploring important issues that influence employment and training policies and programs. The objective is to enhance public discussion concerning these issues and to assist decisionmakers involved with the Nation's employment and training agenda.

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EXECUTIVE SUMMARY

There has been renewed concern during recent years about the effects of technological change on jobs and workers. This paper discusses the ways in which technology affects the labor market, with examples drawn from 200 years of industrial development. Technological change is one kind of structural change, manifested by worker displacement, retraining, and organizational changes within the firm to take better advantage of the new products and processes.

The benefits of these new products and processes are often distributed very differently from the costs imposed by technological change on workers, firms and communities. Among these costs are structural unemployment and lowered earnings prospects for displaced workers. A major policy implication is the need for effective training and retraining programs, enabling workers to obtain and maintain the basic skills needed to be productive in a dynamic economy. The pressure of international competition makes it even more costly for a firm or nation to lag behind in the implementation of new technology.

DIMENSIONS OF TECHNOLOGICAL CHANGE

The Technology Policy Task Force of the U. S. House of Representatives has expressed particular interest in the circumstances facing workers and firms in the "traditional manufacturing industries." This paper takes a wider perspective, addressing the ways in which new technology changes workplaces across the entire economy, and thus makes possible new industrial alignments. Such alignments include the incorporation of microprocessors into a variety of products and processes that change the way work is done, and the establishment of new communications networks that change where work is done.

Technological change is one kind of structural change in the economy. Structural changes are generally irreversible, in contrast to cyclical changes. A useful analogy is the distinction between changes in the climate and changes in the weather. Weather forecasts attempt to predict cyclical phenomena to which people are accustomed to adapt--e.g., do I need to take an umbrella? Climatic changes require major, once-for-all kinds of adaptations, and not all of those affected by them will be capable of adapting. Similarly, firms, industries and nations whose characteristics are a good match for the new economic environment will do well, while those unable or unwilling to adapt will experience relative if not absolute decline in their fortunes. The difference between making policy for the economic world and the scientific view of how species adapt is that the current actors in the economy have greater potential for control over their own destiny when facing economic shifts than do current members of species confronted with environmental and climatic shifts.

New technologies and responses to them can only be implemented by human decisions. These decisions have consequences (intended and unintended) for the distribution of the benefits and costs of change. Benefits include the economic growth made possible by greater productivity, and the improved quality of work life in safer and more pleasant surroundings experienced by those for whom jobs are created or upgraded by technological change. Costs include displacement, extended unemployment and reduced earnings prospects, and are concentrated on those with characteristics less suited to the new technology than the old, such as low levels of literacy. Decisions that take human resource impacts into account, by providing upgrading and retraining opportunities, for instance, could reduce these costs and redistribute them more in line with the distribution of the benefits of technological change.

A major problem for both analysts and policymakers is that technological change, and resultant labor market change, are anticipated very imperfectly. This is not so much a failure to develop better forecasting techniques as it is the very uncertainty that is inherent in the process of innovation. The ability of researchers to devise new or improved processes or products is itself chancy. In addition, the extent to which innovations diffuse throughout the economy involves customer preferences and relative costs as well as the technological possibilities. As a consequence, older and newer technologies coexist in the market for considerable periods of time.

During such transition periods, there are several ways in which changes affect labor markets. First, there is displacement of some workers from jobs, and the consequent need for reemployment. Second, other workers are hired or retrained to work with the new equipment, with effects on the career paths and wage structure within the firm. Third, in many cases, the internal organization and behavior of the firm need to change if it is to take fuller advantage of the new capabilities.

These dimensions of change can be illustrated by the case of the "machine vision" industry. Machine vision is computerized image acquisition and analysis: examples include "eyes" for robots and quality control inspection of silicon chips. The industry supplies production equipment to other manufacturing industries. Its growth is evidenced by the increasing numbers of technologically-oriented workers machine vision firms employ, even in nontechnical jobs such as marketing. The proportion of skilled and semiskilled blue collar workers in this high-tech industry is much smaller than in traditional manufacturing industries.

In the industries that are purchasing machine vision systems, such as automobile manufacturing, demand for semiskilled workers is lower and skill requirements higher for those employees working with the new systems. There is little evidence of auto production workers who were displaced by the new technology moving into the machine vision industry, even when the new and old industries co-exist in the same region. There appears to be a need for "technology management" as a separate managerial skill, particularly in a swiftly-changing industry in which knowledge rapidly becomes obsolete. (Chen and Stafford, 1986).

Both the high-tech and the user industry require people who are not just trained, but capable of being retrained as the technology evolves. An experienced assembly worker is fortunate if he or she is retained and retrained to work with the new equipment, since the probability of direct transfer to the new industry is low, and the number of jobs small relative to the numbers eliminated in industries such as automobiles. On-the-job training provided to the upgraded assembly worker will represent an addition to the bundle of skills needed for the occupation, but not involve a major transformation of his or her required skills.

This situation is likely to characterize 95 percent or more of the workers using computers and computer-based equipment as part of their job duties. That is, adaptation to new technologies such as machine vision represents a relatively minor extension or modification of occupational skills for the vast majority of still-employed workers, rather than a major shift in the kinds of skills required. However, the ability to adapt requires that a worker be functionally literate, at a minimum, in order to learn to use the new equipment. Displacement strikes particularly hard at those who are functionally illiterate because they lack the necessary learning skills. The problem is not restricted to the functionally illiterate, however. Improvement in basic skills is needed throughout the workforce in order to be able to respond to job content changes as they diffuse throughout the economy. (Goldstein and Fraser, 1985)

To say that technology is likely to have a relatively minor impact on the skills demanded of workers in most occupations is not to say that the occupational mix and staffing patterns used by firms will only vary marginally as new technolgy is introduced. Because of improvements in the ability to transfer information quickly, for instance, data entry operations and other "back office" tasks are being separated geographically from the location of the ultimate users in the upper echelons of the firm or from the customers. Airline reservations, stock transfers and legal abstracts are examples of operations that have been moved to areas of lower wages, including in some cases to locations overseas. The development of computer-controlled machine tools allows a worker to monitor more machines than could be operated by one person using the old technology. Here, diagnostic and trouble-shooting skills are needed when a machine goes down, so that fewer people with an expanded range of skills are required compared to the former staffing pattern.

HISTORICAL PERSPECTIVES ON TECHNOLOGICAL CHANGE

Even revolutionary innovations take some time before they are widely adopted. Often, improvements and modifications are needed to make the product more suitable, e.g., there were several hundred patented modifications to the original Howe sewing machine. A period of "learning by using" is needed to discover many of the advantages of the new technology. Industry standards need to be developed, and buyers may wait until such standards are in place. In the development of electric power, for instance, over twenty years passed before the "battle of the currents" between Edison's direct current and Westinghouse's alternating current was resolved in favor of the latter.

Central innovations can spur a cluster of innovations in related fields, so that there are "ripple" effects throughout the economy, which take longer to diffuse. The structure of industries is also likely to be affected. The telegraph improved communication, both reducing the monopoly power of local firms and helping make possible the development of nationwide market power through the ability to coordinate widespread operations.

Improvements in the existing technology and reductions in its price can keep it competitive. Electricity did not provide the majority of power to manufacturing until after World War I, as steam engines continued to improve during the late 19th and early 20th centuries. In other cases, geographic and demographic factors impeded mobility for some workers employed in the industries affected by new technology. Adult male hand loom weavers who stayed in their rural areas, for instance, could not match the reduced prices of the urban mills using power looms, that primarily employed women and children at lower wage rates.

The net employment effects of these historic major technological changes were small. While fewer workers were needed to produce the former level of output, increased productivity and the consequent cost reduction allowed that output to be sold at lower prices. An increase in sales at these lower prices meant increased industry demand for labor in a growing economy. (The preceding four paragraphs are based on John A. James, 1984)

There are clear echoes of these earlier effects in the current processes of innovation for computers and other new technologies. A major goal of improvements in technology applied to production processes is to lower costs and reduce demands for factors of production that are particularly costly. If cost reduction makes possible the sale of additional output at lower prices, the initial reduction in labor demand is at least partially offset.

Employment growth for the adopters of a new technology is likely to be greatest if the firm or nation is among the first to do so. Followers who adopt the new technology as a defensive tactic to avoid further erosion of their markets can never reap that initial advantage of both increased share of the original market and early capture of new sales.

New technology also generates new products that compete against established goods and services. (Trade acts as a "new product" technology by introducing competitors to domestic products.) Home video cameras for the U.S. market are competing against movie and still photography, for instance, and may have adverse impacts on jobs in photo labs and camera stores, as well as affecting markets for types of film and cameras manufactured in the U.S. versus those made abroad. Video rental stores build on the new product technology to compete against motion picture theaters.

IMPLEMENTING TECHNOLOGICAL CHANGE

Within an individual firm, implementation of new technologies has the three major implications already discussed: displacement of some employees, education and training for other employees, and, often overlooked, changes in how the firm functions. A National Academy of Sciences panel that studied the requirements for effective implementation at the request of the National Commission for Employment Policy concluded that, "...a critical mass of interrelated changes is required in seven areas of human resource practices: planning; plant culture; plant organization; job design; compensation and appraisal; selection, training and education; and labor management relations." (National Academy of Sciences, 1986, p.2)

The need for organizational changes that involve managers and unions as well as nonsupervisory employees (both unionized and nonunionized) is an example of the underappreciated role of human choice in implementing technological change. The technology of computer controlled machine tools, for instance, does not force firms to staff work stations with computer science graduates or with experienced machinists. The choice of whether to upgrade machinists by providing training in computers, or to bring in persons familiar with computers but unfamiliar with machining operations, or some combination, is a choice made by managers for reasons that are partly related to the technology, but that also include basic firm philosophies, labor-management relations, expected productivity and cost differentials, and strategies for further automation.

The National Academy of Sciences committee found that effective implementation of computer-based technology for manufacturing implied the need for organizational policies that were also optimal from the point of view of responding to increased international competition and to the expectations of a better-educated work force. The characteristics of such organizations include:

- a highly-skilled, flexible, problem-solving, interacting, and committed work force;
- a flexible, humane, and innovative management organization with fewer levels and job classifications;
- a high retention rate of well-trained workers; and
- a strong partnership between management and labor unions--where unions represent the work force.

While these goals are relevant to all organizations, payoffs from pursuing them appear to be greater in those organizations on the frontier of technology implementation. Greater flexibility and problem-solving capacity are necessary because of a greater degree of interdependence in computer-based production. Employee discontent has a higher cost, in terms of damage and downtime, in such plants, hence the emphasis on fostering employee commitment and a humane management organization. Turnover is more costly in advanced-technology situations, because of the need to invest more in employees who can run unique operating systems. Where a union is involved there is the need to provide it a stake in a successful outcome, rather than to regard collective bargaining as a zero sum game between adversaries. (National Academy of Sciences, 1986)

WORKER DISPLACEMENT

The alternative to effective implementation in a growing market consists of those firms and industries facing shrinking markets, and thus reducing overall demand for labor. For a more recent example than the historical ones discussed above, during 1979-84, primary iron and steel manufacturing experienced a 40 percent drop in employment, losing about 350 thousand jobs over the five year period, according to a recent analysis of the effect of increased internationalization on U.S. employment. The steel industry decline was the largest single industry employment loss during the period, which included the most severe recession since World War II. In the industries with lower employment in 1984 than in 1979, a total of 2.5 million jobs were lost, about an 11 percent reduction over the five years. This was more than offset by an 8.1 million job gain (about 13 percent of 1979 employment) for expanding industries, for a net employment gain of 5.6 million jobs. (Stone and Sawhill, 1986)

The estimate of 2.5 million jobs lost in shrinking industries from 1979 to 1984 can be compared to the estimated 10.9 million workers who reported being displaced during the January 1979-January 1984 period, based on a Bureau of Labor Statistics special survey analyzed for the Commission. (Podgursky and Swaim, 1986) This difference between estimates testifies to the "churning" that takes place in the labor market. The gross number of job losses in the whole economy is a multiple of the net reduction in those industries that actually had absolute declines in employment, because losses in particular firms, industries or regions are largely offset by gains elsewhere in the economy.

It might be thought that workers displaced from a growing industry would have greater reemployment prospects in that same industry or firm than would workers unemployed from industries experiencing decline. One recent study found the reverse: workers unemployed from a declining industry were more likely to be rehired by the same firm than workers whose unemployment started from a job in an industry that was expanding. Further, return rates were higher for women than for men, for older than for younger workers, and for the dominant (declining) industry in the three States studied than for other industries. A rationale for this counter-intuitive finding is that many jobs lost from declining industries, especially from the locally-dominant industries, are better than most available alternative jobs for these workers. Hence, they remain ready for recall when normal turnover generates job openings in firms that remain in operation even at lower levels of employment. (Crosslin, Hanna and Stevens, 1986. The dominant industries and States were auto assembly in Missouri, steel in Pennsylvania, textiles in South Carolina.)

Crosslin, Hanna and Stevens also found that workers who did return to their former firms did not simply "wait out" an extended period of unemployment, but had shorter periods of initial unemployment than did workers who did not return to the former firm. That is, a typical pattern for such workers was securing an interim job or jobs before ultimately rejoining the initial employer. Those workers who did not return to their former firm or industry (about 15-20 percent of the sample) constitute the truly displaced. They also tended to have the longest duration of unemployment and least favorable earnings experiences on subsequent jobs.

Worker mobility and retraining, and structural adjustment generally, are the areas in which employment and training strategies are most needed for the truly displaced. Introduction of new processes and products via technological change is an important influence on the composition of demand for workers with different occupational and personal characteristics. These demand shifts enhance the employment and earnings prospects of workers with certain attributes, while diminishing the prospects of others. The functionally illiterate are likely to be especially adversely affected by technological changes that require retraining.

The net change in level of national employment due to technological change is likely to be small, however, as long as the level of aggregate demand is kept constant through macroeconomic policy. To the extent that displaced workers find it difficult to acquire the characteristics increasingly in demand, there is a potential for increased structural unemployment. It is this structural unemployment (and underemployment) that employment and training programs are meant to reduce. In the longer run, of course, technological change is essential to employment growth as well as to higher real incomes.

POLICY IMPLICATIONS

Most nations realize that technological change cannot be effectively reversed, and thus needs to be effectively managed. It is a structural rather than a cyclical phenomenon--in a very real sense the climate is changing.. For an industry to be viable in world competition, it must not lag in the adoption of world class technology. While technological change is irreversible, it is proceeding in the United States economy at a rate which is managable, given intelligent and well-informed preparation. Aid to industries and individuals adjusting to new technologies and new market structures is an appropriate policy strategy for governments at all levels. Those aided, however, have the responsibility to make conscientious use of public and private resources to prepare themselves for the changing economic environment.

The most important response, for individuals, schools, firms and public agencies, is to recognize that basic skills are basic to the ability to adapt to change. Parents have the special responsibility of monitoring and helping the schools prepare their children for the changes to come, knowing only that they will come, but not their precise nature. Effective reading, writing and problem-solving skills are the prime requisites for successfully entering and staying in the economic mainstream. Firms consistently say when asked that they will provide specific skills if newly-hired workers arrive with basic skills and motivation.

Many firms provide substantial amounts of training and retraining to their employees in the course of implementing new technology. Such training and retraining is more prevalent in larger firms than in smaller firms. Smaller firms may tend to underinvest in such training, from a social point of view, because they feel more likely to lose the workers they have trained than do larger firms who have more internal mobility options. The major Federal aid to such firm-based training is through tax incentives, by not considering firm training expenditures as income to employees.

Federal programs that presently exist for displaced workers, such as the Job Training Partnership Act and Trade Adjustment Assistance, are needed and have been targeted for substantial increases in fiscal year 1988. Programs that provide incentives for upgrading investments in continuing employees, complementary to firms' investment in new technologies, have yet to be developed at the Federal level, although several States have initiated programs. Focusing resources on small to medium-sized firms that are competing in international markets has been advocated in one recent paper. (Menzi, 1987)

Small firms, especially innovative small firms, face a number of demands on their managerial and financial resources, of which investment in worker training is but one. Among the other needs that can constrain growth are venture capital, specialized equipment and materials, and marketing channels. While the debate over the role of small firms versus large firms in overall job growth is outside the scope of this paper, it should be mentioned that "ease of exit" has particular importance to innovative firms, which may have a higher likelihood of failure. If firms must make long term labor commitments, or if bankruptcy has significant social as well as economic costs to the entrepreneur, then new firm creation may well be deterred. (Chesnais, 1986, pp 115-16)

Changes in the labor market due to new technologies (in both new and old firms) have their primary effects on redistribution of job opportunities among firms, industries, occupations, geographic areas and demographic groups. Computerization, for instance, has provided more jobs for technical and professional workers and fewer jobs for semi-skilled production workers, and would have done so under whatever feasible macroeconomic scenario had been played out. The pressure of international competition means that leaders in the implementation of new technologies will be at an advantage compared to countries that lag behind, both in terms of protecting their own markets and winning more sales abroad.

In the United States, such technological leadership can be facilitated by a strong domestic economy that provides innovative firms an initial market and that lowers resistance to change if displaced workers have new jobs to which they can move. Progress toward full employment in the U.S. over the last four-plus years has been unevenly distributed geographically and demographically. Areas with tight labor markets still have labor force members, especially minority youth, who are not fully participating in the local economy, while those areas that have been adversely affected by structural change have severe underutilization of their human resources. Policies that increase the access of disadvantaged and displaced workers to good jobs reduce the potential for inflationary bottlenecks that can put full employment at risk. Policies that improve the functioning of the labor market in response to technological change also advance national equity and efficiency goals without sacrificing the dynamism and positive attitude to innovation that are major sources of our economic and political strength.

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