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THE FUTURE OF TECHNOLOGY AND WORK

Research and Policy Issues

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Edited by Bruce E. Henderson and David C. Mowery

Proceedings of a Conference
Sponsored by the Panel on Technology and Employment
Committee on Science, Engineering, and Public Policy
National Academy of Sciences
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Institute of Medicine

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Academy-Industry Program, which seeks annual contributions from companies that are concerned with the health of U.S. science and technology and with public policy issues that have technology content; and the National Academy of Sciences and the National Academy of Engineering endowments.

Preface

In June 1987 the Panel on Technology and Employment released its report, *Technology and Employment: Innovation and Growth in the U.S. Economy*.[1] The Panel on Technology and Employment was created in 1985 by the Committee on Science, Engineering, and Public Policy (COSEPUP), a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The panel was charged by COSEPUP with the task of "analyzing the contribution of technological change to employment and unemployment."

On October 28, 1987, a one-day conference was held in Washington, D.C., to explore research and policy issues arising from the panel's report. The meeting brought together more than 100 individuals from government, labor, business, and academia who were concerned with the relationship between new technology and work. The conference consisted of four panel discussions, opening and closing remarks, and a keynote address.

This summary of the proceedings presents the main points and questions from each session. As the conference made eminently clear, the employment effects of technology require considerable

[1]The report is available from the National Academy Press, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

additional research and analysis. Although the conference was sponsored by the Panel on Technology and Employment, neither the views expressed at the conference nor the conclusions presented in this booklet should be construed as representing the views of the panel. This booklet also does not represent a statement of the views of the National Academy of Sciences, the National Academy of Engineering, or the Institute of Medicine on the policy issues discussed. Views expressed are those of the individuals concerned, and do not necessarily represent the positions of their organizations or the views of the Economic Development Administration and other sponsors of the panel.

Conference Program and Contents of This Volume

1..

1
The Issue

In his opening remarks, Robert M. White, president of the National Academy of Engineering, recalled that the Panel on Technology and Employment's study had been initiated as a result of concern about the need for improved understanding of the relationship between technological change and employment. White noted that the panel's report had stressed the complexity of the technology-employment relationship. For example, there are few good measures of the rates of technological change; but in order to examine the effects of technological change on employment, measures of rates of technological change are needed. Employment trends also are affected by so many factors—technological change being only one of them—that the separation of the effects of technological change on employment from the employment effects of other economic forces is difficult.

The national and international economic environment, White suggested, also make it imperative to improve public understanding of the relationship between technology and employment. The international competitiveness of U.S. industry now is an important topic of debate in Washington, D.C., and throughout the country. Technological change is only one aspect of international competitiveness, but it is a key aspect. Without technological change, the United States cannot retain its competitiveness.

White concluded:

We are forced to address the issue of technology and employment in many different ways. If you assert—and we believe it is true—that technological change is essential if U.S. industry is to remain competitive in a global economy, and fostering technological change as a consequence is an important policy objective, then it becomes critical to look at the impacts of technological change on employment and to address the issues raised.

While our report has tried to summmarize what we know about the relationship between technological change and employment it is clear that only the surface has been scratched. The problems are deep. Further research is essential to improve our understanding and to lay the basis for wise public policy.

2
An International Perspective

The technology and employment issue has been a major concern in Western Europe and Canada as well as the United States during the past decade. The first panel, chaired by David Mowery of Carnegie-Mellon University, study director for the Panel on Technology and Employment, discussed and compared reports on the employment-related effects of technology conducted by Canadian and European researchers. In addition to contrasting the substantive conclusions and policy recommendations of each report, speakers were encouraged to consider the ways in which the specific national, labor market, and institutional contexts of the region covered by each report affected its conclusions.

The Canadian Experience

Keith Newton, of the Economic Council of Canada, discussed the council's recent study, for which he served as director.[2] The

[2]Economic Council of Canada, *Working with Technology: A Survey of Automation in Canada* (Ottawa: Canadian Government Publishing Centre, 1986); idem, *Making Technology Work* (Ottawa: Canadian Government Publishing Centre, 1987); idem, *Innovation and Jobs in Canada* (Ottawa: Canadian Government Publishing Centre, 1987).

Canadian project was both retrospective and prospective in its approach. The study made projections of the diffusion of important innovations in the Canadian economy and the potential labor market effects of these innovations through 1995. The project examined the employment and income effects of the technologies adopted within Canada during the past decade. The quality of the jobs created by new technology, the quality of working life, skill impacts, education and training implications, and technology's effects on industrial relations also received attention in the study's retrospective analysis.

Newton presented an overview of the main conclusions of the Canadian studies. Among the salient points raised in these studies were the following:

- *Employment effects.* During the period 1979–1981, while employment in Canada's overall economy grew at a rate of approximately 3.1 percent per year, employment in the high-technology sector grew at around 4.9 percent. Even in the period 1981–1985, which included a recession, the high-technology sector outstripped the overall pace of Canada's employment gains. Moreover, the Canadian analysts, in looking to 1995, projected considerable net additions to total employment from the adoption of new technologies. Still,

> we are rather guarded in our enthusiasm, because one of the important findings is that, of course, the impact of technological change is typically uneven. It is the potential for disruption, and therefore the need for labor market adjustment, which we emphasize when talking about the employment impacts.

- *Skill and income effects.* To date there is little evidence supporting the argument that new technologies are polarizing the distribution of skills and income and contributing to the so-called decline of the middle class.

- *Where is innovation occurring?* The Economic Council study concluded from its 1985 survey of 1,000 Canadian companies that approximately two-thirds of the innovations were in office settings; only about a third of the innovations surveyed were adopted in manufacturing processes.

• *Who are the innovators?* The big firms in Canada do most of the innovating. A larger share of the U.S. companies operating in Canada reported that they had introduced innovations during 1981–1985 than was true of Canadian-owned firms.

• *Managing innovation.* Planning was a critical factor in the successful introduction of new technologies; technological change and organizational change go hand in hand. Alluding to case studies of 10 Canadian organizations, Newton reported that in almost all cases, training was an essential complement to the introduction of new technology.

• *The organizational impact of technological change.* Quality circles, which have received considerable attention in the literature, were less prevalent in the 1985 survey than the analysts had expected. Nevertheless, organizational change was an integral part of technological change. The study found

> three types of organizational innovation: first, innovations with respect to remuneration in the workplace; secondly, innovations with respect to job design and the organization of work; and, thirdly, innovations with respect to exchange of information and collaborative structures within the workplace.

• *The impacts of technological change on women, youth, and minorities.* Will new technology help women in the labor market, or will it exacerbate the traditional problems that women have faced? The high-technology sector tended to reproduce the concentration of women in clerical and service and sales occupations that is found in the labor force at large. The Canadian researchers argued that new technologies also facilitated increased reliance on part-time workers. In some occupations as many as 35 percent of the women were employed part time—almost a third of them involuntarily.

When the researchers compared the average earnings of women employed in the so-called high-tech, mid-tech, and low-tech sectors (groups of industries categorized according to their research and development spending) of the Canadian economy, average female earnings were slightly lower in the high-tech sector than in the mid-tech sector. The analysts speculated that this might be related to the fact that the average high-tech firm is relatively young, and therefore its employees do not yet have the experience and seniority that usually lead to higher earnings. This phenomenon also may be related to the low penetration of labor unions in the high-tech sector. The Canadian researchers expressed concern about the quality of the emerging job structure for women.

The study also examined technology's implications for young people entering the labor force and older workers faced with new demands. Will new technologies exacerbate the traditional problems of transition from school to work? How can one prepare for a labor force in which the rate of skill obsolescence is rapid? What about older people, who face the prospects of having to be "retooled" at an advanced stage in their careers? Will new technologies improve the employment prospects of disabled people? What about the native peoples in Canada?

The characteristic shared by members of all of these groups that face labor market problems, Newton observed, was below-average levels of educational attainment. Other findings suggest that there is a systematic relationship between educational attainment and labor market success. Improving the educational attainment of these groups and improving the quality of the education they receive are thus key components of policies designed to assist worker adjustment to new technologies.

Newton concluded by summarizing the central policy recommendation of the Economic Council study:

> The main one . . . in our case had to do with the necessity of recognizing that rapid technological advance and labor-market adjustment must be seen as going hand in hand; that, in fact, we put in place labor-market adjustment policies and programs, not only for equity reasons, but for sound efficiency reasons as well. This is, possibly, one of those rare occasions in economics where the efficiency and equity criteria seem to go hand in hand, rather than working against each other.

International Comparisons of the Employment Effects of Microelectronics in the Auto Industry

Susumu Watanabe, of the International Labor Office's (ILO) World Employment Program, discussed the ILO's recent study of the employment impacts of microelectronics within the global automobile industry.[3] The study covered automobile and auto parts manufacturing, with Japan, the United States, France, and Italy chosen as country case studies. Study contributors also visited Sweden and the United Kingdom and used material from West Germany, Brazil, South Korea, and Mexico.

The study found that the employment impacts of microelectronics differed substantially from country to country, from company to company, and even within a single firm. These differences reflected two major factors: differences in the areas of application of microelectronics and differences in the conditions existing before its application. Watanabe focused on the influence of the second factor, the initial conditions, in discussing the different employment effects of microelectronics technologies.

The employment effects of microelectronics process technologies are heavily influenced by the level of automation achieved before the introduction of the new technology. For example, in some companies or countries spot-welding robots have replaced automatic welders, increasing unit labor requirements. Elsewhere, however, spot-welding robots replace manual spot-welding, which may have substantial labor-saving or labor-displacement effects.

Other factors that affect employment impacts include the quality of the labor force. According to Watanabe, a high-productivity labor force experiences less displacement from the adoption of microelectronics-based process technologies than does a less productive plant workforce. The efficiency of work organization has a similar effect. Plants that are efficient before the introduction of these technologies experience less dramatic productivity gains, and less displacement, following the adoption of microelectronics technologies than do plants with low levels of efficiency prior to adoption.

The ILO study found that U.S. industry used robots primarily to save labor and secondarily to improve product quality. Japanese firms, however, more frequently employed robots to increase product quality, production flexibility, or workplace safety. This is because (a) during the 1960s and early 1970s the Japanese invested heavily in "stand-alone" automated manufacturing process machinery (e.g., numerically controlled machine tools) and now

[3] S. Watanabe, ed., *Microelectronics, Automation and Employment in the Automobile Industry* (New York John Wiley, 1987).

are replacing these machines with robots or machine tools; and (b) workplace safety and health issues now are more significant influences on technology adoption decisions because of the aging of the Japanese labor force.

Swedish firms have pursued both reductions in direct labor requirements and improvements in working conditions of work through the introduction of robots. This motive reflects the fact that worker absenteeism is a significant problem in Swedish manufacturing. Firms overcome the problem by replacing workers with machines or making the tasks of workers easier. In one plant in the United Kingdom, the objectives of robotization were reductions in direct labor requirements and improvements in product quality. In the newly industrializing countries of Korea, Brazil, and Mexico, microelectronics technology has been used to improve product quality in order to facilitate the rationalization by multinational corporations of global production and sourcing of components.

The labor-saving impacts of factory technologies in some countries are significant and in others, notably Japan, are minor. For example, in some European countries the average robot is expected to replace up to three or four workers, but in Japan there is a general consensus that the average robot replaces only 0.7 workers. This difference reflects the fact that many European plants were not highly automated or efficient before the introduction of robots. European robots in many cases are replacing workers, while in Japan they are replacing machines.

Even where the sectoral labor-saving effects of new technologies have been substantial, the aggregate employment impact has been marginal. Television and press reports, Dr. Watanabe asserted, tend to exaggerate the negative employment impacts of new technology by not reporting many other changes that are taking place simultaneously.

Dr. Watanabe closed by stressing the importance of intelligent management of technology adoption:

> In many cases . . . people argue that the new technologies are essential to increased or improved competitiveness. They further argue that, because new technology helps improve international competitiveness for the industry, this is good for employment. To me, this is too simplistic. It is true that, if you do not use new technology, your international competitiveness will keep going down, and probably would be lost

> forever. But the application of new technology will not necessarily guarantee the improvement in your competitiveness, because all your . . . rivals are also using it. The question is how wisely you use it. Efficiency in the use of new technology is a key factor in improving your competitiveness.

Comparing the Employment Effects of Technology in European Economies

Luc Soete, of the State University of Limburg in the Netherlands, discussed a recent series of studies of the employment-related effects of new technology (known as the TEMPO studies) that were conducted by the Science Policy Research Unit of the University of Sussex.[4] Professor Soete noted that the employment effects of technology in an open economy—that is, an economy in which international trade plays a major role—can differ fundamentally from the effects in a closed economy. For the small, open economy, the Sussex TEMPO studies share with the report of the Panel on Technology and Employment a generally positive view of technology's economic impacts, but qualify some of the conclusions of the U.S. study. Because trade provides a strong incentive for increased efficiency in a small, open economy, small, open economies often reap the biggest efficiency gains from international trade. Specialization forces reallocation of resources and continuous upgrading of production processes. Nonetheless, during periods of cyclical downturn, Soete argued, small, open economies can suffer because their specialization patterns cannot be shifted quickly.

According to Soete, small, open economies such as those of Belgium, Holland, and Denmark, which have specialized in the production of goods that utilize highly automated processes, today are confronted with a massive adjustment problem—"an adjustment problem in which they could not go from an iron- and

[4] C. Freeman and L. Soete, eds., *Technological Change and Full Employment* (New York: Blackwell, 1987). The sectoral studies in the TEMPO series are as follows: K. Guy, ed., *Basic Consumer Goods* (Brookfield, Vt.: Gower, 1984); J. Clark, ed., *Basic Process Industries* (Brookfield, Vt.: Gower, 1984); L. Soete, ed., *Electronics and Communications* (Brookfield, Vt.: Gower, 1985); C. Freeman, ed., *Vehicles and Engineering* (Brookfield, Vt.: Gower, 1985); H.D. Smith, ed., *Commercial Service Industries* (Brookfield, Vt.: Gower, 1985); P. Patel, ed., *Other Industries* (Brookfield, Vt.: Gower, 1986).

steel-making and metal-making industry to an electronics industry, because there was no electronics industry." This is reflected in their high domestic unemployment. Unemployment in the Netherlands reached 20 percent earlier in this decade and is still at 14–15 percent. In Belgium, unemployment, which had reached 16 percent, remains high at roughly 12 percent.

The TEMPO studies concluded that manufacturing will not be the sector in which technical change will produce employment gains within the Western European economies. This argument, Soete contended, is supported by the results of simulation exercises conducted by the Organization for Economic Cooperation and Development (OECD), which suggest that "the various compensation effects which economists like to talk about—such as demand compensation, income compensation, and substitution effects—are insufficient to actually increase employment [in manufacturing]. . . . So, clearly, the solutions [to] our unemployment problems in the European context lie not in increased technological change in manufacturing." The major employment gains from the application of new technologies, according to Soete, lie in the service sector in these economies.

Many Studies, Common Themes

Alan Fechter, executive director of the National Research Council's Office of Scientific and Engineering Personnel, compared the findings of the three studies. Fechter noted that the technology and employment issue is a recurrent one, having been a topic of public debate in the United States during the early 1960s.

The three studies discussed by panel members differed greatly in their methodology and frame of analysis. One focused intensively on a single national economy, another traced the effects of a single technology within a single industry in numerous different national economies, and the third adopted a very broad analytic framework, tracing the sectoral effects of a number of different technologies within a multinational regional economy.

Despite these differences, the studies contained some strikingly similar themes. The first of these, Fechter suggested, was the complexity of the effects of technology on employment: the introduction of new technologies has a number of different and offsetting effects on employment and incomes within an economy. The complexity, number, and offsetting character of these effects frequently mean that the effects of new technologies on the aggregate levels of employment or unemployment are modest. Instead, the technology affects the distribution of employment and, therefore, of incomes. Adjustment and distributional issues thus are central to analysis and policy: how can the adverse effects experienced by some citizens be ameliorated and the adjustment of these individuals to new technologies be aided?

Another issue that is common to several of the studies is the question of whether new technologies are polarizing the occupational structure of the economy and increasing the inequality of distribution of incomes and earnings. Fechter suggested that the studies produced little evidence to suggest that technology was causing such polarization. On the other hand, they produced little evidence to refute this argument. The issue thus remains unresolved and will require close monitoring in the future.

Finally, Fechter noted, all of the studies considered the effects of new technologies on the nature of work. This question is very difficult to answer because of the absence of reliable data that trace the effects of technology on the content and skill requirements of individual jobs. Occupational data are especially treacherous, because they do not allow one to track changes in the character of the work performed by members of a single occupation:

> If, for example, we are talking about the impact of information technologies in the form of PCs and other forms of information technologies on the demand for secretarial and clerical labor, one of the major impacts is not so much a decrease in the demand for secretaries, but a very dramatic change in what secretaries do. We may therefore be missing an important element of what we need to know in order to be able to formulate proper training or retraining policies for this particular group of individuals.

3
The Organizational and Skill Effects of Technology: Issues for Training and Education

Marta Tienda, of the University of Chicago, a member of the Panel on Technology and Employment, chaired the panel discussion of the organizational and skill effects of technological change. Dr. Tienda noted that these effects are realized both through changes in the nature and environment of work and through changes in the occupational structure of the economy. Such a discussion raises other questions. How well prepared is our labor force to cope with these changes? Who gains and who loses—and why? Are we equipped to meet the skill and training demands of technological change?

The Case for Uncertainty

Kenneth Spenner, of Duke University,[5] examined three questions: What do past studies tell us about how technological change alters the skill requirements of work? How does past knowledge

[5]See K. I. Spenner, "Technological Change, Skill Requirements, and Education: The Case for Uncertainty," forthcoming in R.M. Cyert and D.C. Mowery, eds., *The Effects of Technology on Employment and Economic Growth* (Cambridge: Ballinger Publishing Company, 1988) for a more detailed discussion.

apply to the near future? What do the answers to these questions imply for education and training policies?

Spenner argued that

> uncertainty dominates the answer to each of the questions. Past research contains considerable gaps . . . ,[and] judgments about how technological change affects work contain substantial uncertainty. Much of what we do know suggests an uncertain, complicated, and contradictory relationship between technological change and the skill requirements of work. Technology has substantial effects on the composition and content of work in the economy, but these effects vary for different dimensions of skill, for different jobs, occupations, industries; even for different countries, technologies, and at different stages in the life cycles of products and technologies.

The effects of new technologies on the skill requirements of employment involve offsetting changes in occupational structure and in the content of work, changes that include both skill upgrading and downgrading. The effects of technological change on the skill requirements of work are influenced heavily by the larger context of market forces, managerial discretion in the implementation of technologies, and organizational factors.

The evidence on the skill effects of technological change is extremely limited. There exists no complete spatial or temporal map of changes in the skill requirements of jobs in the U.S. economy since the turn of the century. There also are few if any direct measures of skills. Indeed, the concept of work-related skills incorporates two dimensions of skill that must be separated for analytic purposes. These two dimensions are

> the "substantive complexity" of work—the level, scope, and integration of mental, manipulative, and interpersonal tasks in a job; and second, . . . "autonomy control." By "autonomy control" I mean the elbow room, the leeway, the extent to which the work role or the job allows room to control the content, manner, and speed with which a task is done.

The first and possibly the most important conclusion from case studies and analyses of aggregate occupational data is that no firm conclusion is possible. Aggregate studies indicate that technology produces a slow upgrading over time in the substantive complexity of jobs. On the other hand, case-study evidence suggests that the degree of autonomy control in jobs in the U.S. economy may have been reduced somewhat below its level of 80 or 100 years ago.

According to Spenner, engineers illustrate these contradictory skill-shift hypotheses. Engineers of 100 or so years ago tended to be entrepreneurs, rarely specializing in a single field and involved in a broad range of activities, from selling their services or products to drafting specifications or working on a construction crew. Engineering today is much more fractionated—engineers specialize in aeronautical engineering, civil engineering, or one of countless other specialties. The substantive complexity of engineering thus has increased substantially as a result of technological change. On the other hand, modern engineers tend to be employed by large firms. Some case studies suggest that engineers face greater constraints on their jobs as a result of being situated in bureaucracies. This may indicate a slight downgrading of autonomy control.

The analysis of technology and skills is complicated further by the fact that managerial discretion heavily influences the ways in which new technologies are employed. The same technology employed in different firms can result in any of three different outcomes concerning the content and character of work—upgrading, downgrading, or no effect

What does all this imply for education and training policy? Spenner concluded that "there is no single, simple, or unitary answer to the question of optimal education and training." The match between the skills that workers bring to jobs and the skill demands of jobs is notoriously loose—so loose, Spenner added, that the payoffs from improving the quality of the match might exceed those from across-the-board increases in the level or quality of education and training. Education affects this match, but its effects are uncertain and are realized only gradually. Therefore, the extent to which changes in education and training policy can alter workers' job performance and employment prospects may be quite limited in the short run.

Education and training a , not closely related to job performance. They predict who gets access to jobs far better than they predict levels of job performance. Education does not predict differences in productivity among workers within an occupation.

Finally, managers and organizations do not always operate in the rational manner suggested by the textbook images. It is important to distinguish the acquisition of human capital from its effective use in the workplace. There is considerable flexibility in the organization of work and the use of workers and technology, as Dr. Watanabe noted in his earlier remarks. The productivity, attractiveness, and skill requirements of jobs all are sensitive to the organization of work and therefore are not easily predicted from the characteristics of the production technology alone. As a result, Spenner found little evidence

> that would call for across-the-board increases in pre-labor force education—with perhaps three important exceptions. Those involve literacy, the capacity and ability of workers to adapt to technological change, and training for managers.

The evidence suggests that those individuals lacking basic language, reasoning, speaking, and writing skills are left out of the labor force entirely—not so much because they cannot get high-technology jobs but because they cannot participate in the labor market at all. The importance of these basic skills appears if anything to be greater in the modern economy than in the past. Workers with basic skills adapt faster and more effectively to technological change in the workplace. If laid off, they suffer less psychological, familial, and economic disruption and experience shorter spells of unemployment following displacement. They are better able to shift careers and move on with their lives.

Managers also need education and training. Although middle and upper-level managers in large firms often express great confidence in the positive contributions of technology to the quality of jobs, they are very uncertain about how best to adopt and employ new technology. They often do not know, for example, whom to consult on these issues. The timing and the means for bringing workers—the people who would be using the machinery—into the adoption process also are not well understood.

Spenner concluded that public and private policies for education and training must recognize and adapt to these uncertainties:

> To be avoided are education and training policies that assume a simple, single, or unitary effect of technological change on the number or the quality of jobs.

The Military, Technology, and Skills: False Alarms and Hangar Queens

The U.S. military has a long history of producing and introducing advanced technology. The military also has invested large sums in predicting and managing the effects of these technologies on the skill requirements of its "employees," uniformed servicemen and women. Martin Binkin, of the Brookings Institution, found that the high level of uncertainty in the links among military technology, skill and manpower requirements, and projections of these requirements had hampered the military's management of technological change. The paper prepared by Binkin for the Panel on Technology and Employment[6] contained several lessons from the military experience with advanced technologies.

Lesson One. In spite of the fact that the armed forces have been one of the heaviest users of high technology, their ability to project the implications of technology for skill requirements has been rudimentary at best.

Lesson Two. Promises that technology will diminish the requirement for skilled military personnel should be viewed with skepticism. While some newer systems are indeed more user-friendly to operate than their less sophisticated predecessors, they have proven more difficult to maintain. The Air Force's F15 aircraft avionics package provides a good example. Binkin quoted William Perry, former Under Secretary of Defense for Research and Engineering, in a description of the ways in which the complex instrumentation of the F15, an advanced fighter aircraft, was designed to accommodate a projected decline in the supply of both pilots and maintenance personnel. The goal was to reduce flight-line tests, provide built-in test equipment, and simplify support tasks—thereby requiring fewer personnel and less training. Binkin found that the F15 design unfortunately fell far short of this goal:

> The F15 was designed around what is called the "remove and replace" maintenance philosophy. Forty-five so-called black boxes in the avionics suite of the F15 contain roughly 500 electronic cards. . . . Built-in test equipment aboard the aircraft monitors the components, and red lights indicate to the maintenance person when a black box has malfunctioned. The idea is that you remove and replace the black box, which does not take a lot of talent. You . . . put a new box in, and send the malfunctioning box back to an avionics intermediate shop. . . . Unfortunately, the system has not worked as

[6] M. Binkin, "Technology and Skills: Lessons from the Military," forthcoming in R.M. Cyert and D.C. Mowery, eds., *The Effects of Technology on Employment and Economic Growth* (Cambridge: Ballinger, 1988).

> planned. . . . The avionics intermediate shop turned out to have twice as many parts associated with it as the aircraft itself. . . . Especially disappointing has been the built-in test equipment on the aircraft. . . . The problem has been not only low fault detection rates . . . but, just as important, in some cases very high false-alarm rates. . . . The net result has been . . . that technicians have to be better qualified than they were before. . . . On balance, we have not seen the manpower savings to date in the military community that had been promised by the technologists.

Lesson Three. The size and skill distribution of the military workforce depends to a large degree on the complexity of the systems that are being put in place. Generally speaking, more complicated equipment breaks down more often and takes longer to repair, no matter how highly automated its self-diagnostic capabilities. The military has largely failed to train people as back-ups to the automated test equipment. Instead, advanced technology has been used to replace human judgment, with unfortunate results.

Lesson Four. Military training methods have failed to keep pace with changes in technology. The private sector appears well ahead of the military in the application of advanced training techniques and hardware.

Lesson Five. The military's preoccupation with system performance at the expense of reliability and maintainability has hampered its exploitation of America's technological edge. Inattention to manpower, personnel, and training considerations in the weapons-acquisition process has resulted in a mismatch between weapons and skills. Many of the high-performance weapons systems developed at great cost for the national defense wind up as "hangar queens."

Plant-Level Practices in Technology Adoption

Gerald Susman, of the Center for the Management of Technological and Organizational Change at Pennsylvania State University, directed a recent study by the Manufacturing Studies Board of the National Research Council on human resource practices for implementing manufacturing technology.[7] The study involved 24 manufacturing companies that were technologically and organizationally innovative. Sixteen of the companies offered sites for the researchers to visit. About half of the plants visited were "greenfield" sites—new plants—and the other half were older plants that were being converted to apply advanced manufacturing technologies. The study examined the adoption of a variety of computer-aided manufacturing (CAM) technologies, including numerically controlled machines, automatic storage and retrieval systems, automatic guided vehicles (AGVs), robots, and flexible manufacturing systems that can produce a variety of products with minimal setup times.

The companies did not always invest in new technology solely to reduce labor costs, Susman reported, but also wanted to improve product quality and to reduce lead times for the development and manufacture of new products. In some plants, many of the changes in employment levels, job classifications, and worker skills that were associated with the adoption of new technology resulted from the new organizational structures and operating practices that were necessary to implement the technology effectively, rather than being determined solely by the technical characteristics of new processes.

The plant-level changes associated with the adoption of new CAM technologies included the following:

Broader jobs and fewer job classifications. One new, automated automobile parts plant had only three job classifications in the entire plant, two of which were skilled and one unskilled. Another new plant making diesel engines had only two job classifications—resource person and technician. In a third plant, which produced military tanks and personnel carriers, there was only one job classification—system operator. An established electronics plant making computer boards reduced its job classifications from seven to one following the introduction of new process technology. An automobile plant that adopted CAM processes reduced its job classifications from 200 to 34.

[7]National Research Council, Committee on the Effective Implementation of Advanced Manufacturing Technology, *Human Resource Practices for Implementing Advanced Manufacturing Technology* (Washington, D.C.: National Academy Press, 1986).

Compensation based on expertise. Many of the plants had adopted a new pay system called "pay for knowledge," under which "You get paid for what you know rather than what you are currently doing." If there are only two job classifications in a plant, a worker increases his or her pay by moving through a series of learning "modules." For instance, in the diesel engine plant that had only resource persons and technicians, there were [illegible] modules covering six levels that a worker in the technician position could move through. As an individual learned a module, he or she qualified for that module and received a pay increase.

Managers need not pursue a strategy of broadening and upgrading worker skills in order to utilize CAM technologies, but can opt instead for a strategy of downgrading required worker skills. The choice is an organizational one, rather than one dictated by the characteristics of the technology.

The choice of a downgrading strategy carries benefits and risks. Susman stated the benefits:

> You can lower skill, and you will pay people less money. . . . You can afford the turnover because it does not take as long to train people.

What are the risks of this strategy? Because workers are less knowledgeable about new technology, errors and downtime are more frequent and costly. Overhead costs are higher because the plant needs more staff for production planning and design. Since production workers do not learn and pass information on to staff employees and production engineers, organizational learning is reduced.

The plants studied by the NRC panel had chosen the upgrading approach. These establishments reduced the number of job classifications, increased the skills of their production workers, and reduced supervisory and middle management positions, cutting overhead costs. Upgrading resulted in higher productivity and quality, reflecting the fact that in an automated plant, greater interdependence among functions means that errors in any single operation increase costs or impair quality more substantially. Rather than investing in expensive support systems and staff to minimize worker errors, overhead can be kept under control by building up the capability of production workers to monitor the quality and pace of production. Paraphrasing the view of managers who pursue the upgrade strategy, Susman said:

"If we [management] rely on a group of people somewhere higher up to make decisions, and we add more of those people, then that is just a very expensive and inefficient system to operate." So these companies have said, "Look, there is another alternative to this. What we can do is build up the capability at the first level and shrink the second or third level, and move more things down to the shop level."

Training costs in some of the companies studied by the NRC panel reached 10 percent of the total payroll, nearly three times the national average. One implication of the upgrading approach, Susman observed, is that if companies make a significant investment in training they must give more thought to retaining the people they've trained.

> If you invest that much in people, then you really have a premium in wanting to keep those people. You have to integrate them into the organization.

The "pay for knowledge" system also has significant organizational implications. It leads to much greater variation in pay, reflecting differences in individuals' motivation to learn. Because workers become more valuable to the company and are themselves earning more money, they are less likely to leave.

> For those who remain in such plants . . . the jobs may be relatively skilled and rosy. . . . [But hiring] from within, which is a consistent policy in all these companies, would make it very tough for somebody displaced elsewhere to get in.

Need for Education

Arnold Packer, former Assistant Secretary of Labor for Planning and Research, now is at the Hudson Institute, where he served as codirector of a study of the U.S. workforce in the year 2000 for the Department of Labor.[8] Dr. Packer took issue with Spenner, arguing that technology unambiguously increases the skill requirements of employment. Literacy requirements in the United States have gone up over the last century. In the 19th century one could work on a farm or get many a job elsewhere without being able to

[8] *Work Force 2000: Work and Workers for the Twenty-First Century* (Washington, D.C.: U.S. Government Printing Office, 1987).

read. This is no longer the case: "improving technology requires more skill than we have had before." More than basic literacy is required. It is not just the ability to read, but the ability to read in context that is important.

Challenging Spenner's thesis of uncertainty, Packer asked how new technologies could reverse the

> experience of the last couple of thousand years. . . . The alphabet was new technology. The automobile was a new technology. It . . . yielded a demand for people who understood the internal combustion engine. Computers will do the same thing, and so will superconductors.

Defending his thesis, Spenner made a distinction between the skills that workers may acquire and the skills that jobs may require:

> No question, over the very long sweep [of history], that people have [required] increased capacities to read, write, reason. . . . But I think that your argument commits [a] serious flaw by way of equating skill capacities of workers with what jobs demand. . . . If that is the case, then you can simply look at the schooling distributions in the U.S. in the last 60 or 80 years, and conclude, on the basis of that, that [the skill requirements of] jobs are up tremendously because workers have more schooling. But if you look at studies that involve estimates of [the skill requirements of] jobs, you do not see anywhere near that much change, at least in recent history, the last 40 to 60 years.

In rebuttal, Packer cited his study for the U.S. Department of Labor, which projected shifts in America's employment mix to the year 2000. The projected changes in occupational structure, he reported, indicate substantial increases in the education necessary for those new jobs. Between now and 2000, 25–26 million Americans will need to be trained:

> The remark has been made that the Japanese are so successful because they have the smartest bottom half [of the labor pool] in the world. . . . Clearly, we are going to have to change the way we do education and training . . . to enhance the information-processing capacity of individuals—that is, their ability to look at prose or documents, whether those documents are paper invoices or data on a computer screen, and solve problems with that information.

4
Demographics, Capital Formation, and Competitiveness

What are the factors that both call for and encourage technological innovation? Keynote speaker Kenneth McLennan, president of the Machinery and Allied Products Institute, cited two: demographics and competitiveness. Changing demographics in the United States—an aging society and fewer young workers—will demand innovation in order to maintain productivity.

The major threat to America's relatively high standard of living, Dr. McLennan suggested, does not originate in conflict or misunderstanding between labor and management. Rather, it stems from the failure of public policies 1) to recognize the long-run implications of demographic trends and 2) to provide the environment in which U.S. industry can restore its competitiveness.

The U.S. population is aging rapidly. The proportion of the population 65 years of age or older was about one in 10 in 1970; by the time the baby boom generation retires in 2030, the elderly population will account for about one in five U.S. citizens. Life expectancy is also increasing, which means that the numbers of the very old, those 80 years of age and older, will grow substantially. Simultaneously, the rate of growth in the working population—ages 18 to 64—is slowing. Between 1990 and 2010, the average annual rate of growth in the working population will be only about 0.8 percent. As the baby boomers retire between the years 2010 and 2030, the size of the working population will actually shrink. This means that the ratio of the working population to the elderly will drop from about five to one at present to three to one by the year 2030.

McLennan noted that over the past fifteen yea U.S. industry has experienced significant problems in competing internationally. Although the recent productivity growth rates in U.S. manufacturing have been superior to productivity growth in the 1970s, other countries have begun to match U.S. productivity levels after many years during which they exceeded U.S. rates of productivity growth. For example, in 1965 Japan's labor productivity in manufacturing was about one-third the level of U.S. manufacturing productivity. But after years of productivity growth rates that exceeded U.S. rates of growth, the Japanese have matched, and may have exceeded, U.S. levels of labor productivity. These trends make it difficult for U.S. industry to pay high wages and still compete internationally.

Nor are Japan and some European countries now our only competitors. By 1980 Taiwan exported more to the United States than any European country except West Germany. These exports consisted of much more than simple textiles and included the products of industries that rely on relatively sophisticated technology. The same can be said of South Korea.

One explanation for these trends is higher levels of foreign investment in R&D and, especially, in plant and equipment. High levels of productivity do not depend solely on capital investment; other factors are involved. But if a country wants to introduce state-of-the-art technology, it must have a high rate of capital investment and investment in R&D. McLennan argued that

> capital investment may not be a sufficient condition to raise productivity levels, but it is a necessary condition. We certainly have to improve that in the U.S. economy.

The need for higher rates of capital formation in this economy presents the U.S. political systems with difficult choices. A balanced budget must be achieved at the same time that the federal budget expands incentives for R&D, for education, and for investment in plant and equipment. Although higher taxes may be necessary to reduce the deficit, McLennan argued, the burden of any tax increases should fall on consumption rather than on savings.

Technological innovation and implementation depend in large measure on social, economic, and political considerations. Unless, for example, fiscal policies recognize the importance of increased savings and investment in innovation and productivity growth, the quality of life of future generations of workers and of the elderly in the United States will be adversely affected:

> In an increasingly interdependent world, the greatest threat to the future quality of work and the U.S. standard of living comes not from innovation that occurs too rapidly, but from innovation that is diffused too slowly throughout the economy.

5
Technology Policy and Regional Economic Growth

The first afternoon session was chaired by Richard M. Cyert, president of Carnegie-Mellon University and chairman of the Panel on Technology and Employment. Speakers dealt with federal, state, and local strategies to harness technology for economic development.

Patrick Windham, a member of the staff of the U.S. Senate Committee on Commerce, Science, and Transportation, noted that U.S. competitiveness is a central concern of the 100th Congress. Many Senators believe that the United States is not reaping the full economic gains from its scientific and engineering prowess. Quoting Senator Ernest Hollings, Chairman of the Senate Commerce Committee, he observed, "We get the Nobel Prize and the Japanese get the profits." There is no consensus, however, in Congress or the country about the appropriate federal role in industrial technology. The Senate Technology and Competitiveness Act, introduced in April 1987, takes an incrementalist approach, proposing, among other things, to turn the National Bureau of Standards into a National Institute of Technology, charged with supporting the adoption of new technologies through research and applications engineering.

A key concern of Commerce Committee members is the technological performance of small and medium-sized U.S. enterprises:

> In fact, one of the most distressing statistics we heard in testimony this year is that only about 10 percent of the country's small manufacturers—the job shops and the small machine tool companies—have seriously begun to automate. . . . There seems to be a big gap between what our best universities and our best companies can do and what the small guys, who are facing the most competition, are doing.

Several proposals have been made recently for federal technology-extension services that would complement the many new state programs, in the hope that improving the flow of technological information to small firms would improve their performance. One proposal that was passed by the Congress is the 1986 Technology Transfer Act, described by Windham as an attempt to open up 700 federal laboratories to state and industrial use and to encourage cooperative research between the labs and industry: "When you have 29,000 federal patents, of which fewer than 5 percent have ever been commercialized, you can see that there is an opportunity to tap some federal technology." Similar efforts now are underway at the state and local governmental levels; Windham cited a report by the Congressional Office of Technology Assessment that concluded that effective regional economic development strategies in many areas do not rely on attracting new, high-technology companies, but try instead to modernize existing companies and to create as many spin-offs as possible, often in conjunction with universities.

State Support for University-Industry Programs

Irwin Feller, of the Institute for Policy Research and Evaluation at Pennsylvania State University, discussed new state government initiatives in technology and economic development. The states recently have devoted even more attention to economic development, focusing on advanced technology industries as a replacement for "smokestack industry." Many states are trying to diversify their economies and to replicate California's Silicon Valley or North Carolina's Research Triangle. The outlays are modest—ranging from around $1 million to $30 million in operating budgets—but the activity is ubiquitous.

State programs to encourage advanced technology usually contain six elements: R&D, education and training, high-technology parks and facilities, financial assistance to innovative firms, technical assistance, and entrepreneurship training and assistance. Professor Feller focused on R&D within this menu of state programs. State R&D programs include the Thomas Edison Program in Ohio, the Ben Franklin Partnership of Pennsylvania, public financial support for centers of excellence and the Microelectronics Center in Massachusetts, and the Advanced Technology Center in New Jersey. In all of these programs, the states contribute funds to encourage R&D that (it is hoped) will support economic development.

Many of these state R&D programs have close links to regional universities. According to Feller, academic institutions are given a central role "in not only generating new technology, but also in transferring technology." Industry also plays a prominent role in most state R&D programs. Most programs require that universities obtain matching funds from industry in order to get state dollars. Industrial funding indicates that the research is commercially relevant. This expression of interest is especially important in the face of suspicion in program and legislative staffs that universities will use economic development arguments to gain increased funding with little regard for the impact of the funding on regional economic development.

Although all of these programs have economic growth as a general objective, their immediate goals vary. Some programs are intended mainly to create jobs, others are designed to encourage the formation of new firms, and still others are expected to develop an infrastructure for knowledge-intensive regional development. The Pennsylvania strategy, which relies on the Ben Franklin Partnership, emphasizes short-term R&D contracts that will create jobs in manufacturing within the state. North Carolina has developed a world-class microelectronics research facility in the Research Triangle not to develop commercial applications of new technologies that will create jobs locally, but to develop a pool of qualified technical personnel, faculty, and students that will attract high-technology industry.

The Massachusetts Microelectronics Center, on the other hand, is intended to ease a current bottleneck in the state's continued industrial expansion—a shortage of trained technicians and engineers. The center is a consortium of public and private universities that uses state dollars to improve the "human capital" of

Massachusetts. Florida uses its state funds to establish university-industry contracts that will improve the quality of research and graduate education at Florida universities.

Notwithstanding the support they have received, a number of questions surround these state R&D programs. One concerns the validity of the underlying rationale. The linkages between R&D and economic develoment are not well understood, despite the zeal with which states have pursued new technology to support economic development. As Feller noted:

> We heard a number of presentations this morning about the limits to our knowledge. Those tended to be from academicians. When you are running a state program, you are an advocate, you are a manager, and, clearly, you believe.

State programs give great importance to involving new, small firms, in the belief that new firms are the source of most jobs. Yet that theory is disputed. New firms create jobs but also fail (and eliminate jobs) in greater numbers than large firms. Some companies may have contributed funds to state programs less out of an expectation of commercial product development than because they have longstanding ties with a particular institution.

For all the publicity that the state programs garner for governors and university presidents, are such programs more effective tools of economic development than an alternative, generic research? Would states do better simply to build up their traditional research infrastructures—their faculties, laboratories, graduate programs?

Little evidence is available to answer these questions. Still other issues involve the complex relationship between economic development and regional academic excellence. Most of these state programs are presented as a means to achieve both economic growth and academic excellence. As universities get involved, the argument goes, they do additional research and at the same time contribute to state economic development. Industry gets state-of-the-art research, and university basic research receives financial support. Feller nonetheless sounded a note of caution:

> As they [universities] begin to take on responsibility for interaction with a larger number of firms, particularly small firms, they become involved in types of R&D activities or technology-transfer activities which begin to strain at the link between R&D commercialization activities and internal activities. The

> key here is that firms differ in their ability to assimilate R&D. . . . What we may be dealing with is that point at which universities are creating R&D and firms participating in these state programs lack the ability to assimilate the information. Then the university becomes obligated to take that further step and do firm-specific technical assistance, which enhances economic development for that firm, but creates internal pressures in the university.

According to Feller, there is general agreement among analysts that it is both extremely difficult and too early to evaluate these state programs. He offered a qualitative assessment of the potential positive and negative impacts of the state programs. On the positive side, they facilitate the movement of knowledge from industry into the university, which helps redefine and upgrade the university's R&D agenda.

The programs can strengthen political coalitions at the state level that can increase public investment in the whole gamut of knowledge-creating activities, from basic education through research laboratories. Nevertheless, such programs also may interfere with existing relationships between universities and industry, or may undermine the educational and research goals of the universities. Feller stated that he was

> very much concerned about the overextension of university commitments, if universities are beginning to jump on a political bandwagon and make commitments as to their capabilities and effectiveness which they do not have the ability to deliver, or where they would have to engage in so many internal changes as to fundamentally alter the character of the universities.

Regional Economic Development Strategies and Local Government

Richard Cyert suggested that there are four types of regional economic growth that must be considered in developing a strategy. First, established firms in the area may expand their regional activities and employment. Second, plants or firms may be attracted to the area from another area. Third, a program can help develop new firms and encourage them to stay in the area. A fourth strategy focuses on attracting large government research installations that generate spin-offs and thereby support regional economic growth.

A key factor in planning regional economic development is the dependence of modern technology on knowledge. Modern technology enables firms in many manufacturing industries to ignore proximity to natural resources in choosing a location, but the salience of technology means that these firms require access to brainpower. That is why universities increasingly are involved in regional economic growth strategies. As Dr. Cyert asserted:

> In a real sense, it is impossible to have economic growth that is really technology-induced in a particular region without a university that has some strong advantage in a particular kind of technology.

According to Cyert, most plans for regional economic growth lack a strategic vision. Strategic planning requires that one assess the comparative advantages of a region: What are the specific strengths of a region for economic development? What type of firm or industry would find these strengths most attractive? All too often, state policymakers frustrate the development of regional comparative advantages by succumbing to political demands that all regions within a state be treated identically or share equally in expenditures on higher education for economic development:

> The notion here is that, somehow, if economic growth is going to take place, all of these universities are equally capable of doing it. That is, in my view, the wrong way to go about it. I think we should support universities, but I think what we need is a plan so that we say university X is very strong in materials science; let's put funds into that area and try to establish a world-class position in that field. . . . But wherever politics are determining the allocation of resources, I think you are going to find this tendency to want to try some sort of equitable treatment, so that no votes are lost in the process.

The inability or unwillingness of unemployed workers to move may create other tensions within regional economic development strategies, resulting in proposals for subsidies or financial support for the recapitalization of a local firm that is bankrupt. Cyert argued that there should be no illusions about the potential of a well-conceived regional economic development strategy to assist all of the currently unemployed:

> To do the kind of planning that I am talking about will not necessarily result in [attracting] industry that is going to deal with those workers who are unemployed and who are

> immobile. Obviously, the only hope for dealing with those people is through retraining and education programs. We do not have good knowledge of how well we can do with respect to people of a certain age and a certain educational background. So that, I think, is a real problem. I do not think it can be dealt with by economic growth. I think it has to be dealt with with the kind of adjustment assistance that we are going to be talking about in the next panel.

Regional economic growth strategy, Cyert concluded, has two principles: finding a comparative advantage and concentrating resources on that comparative advantage.

A Skeptical View

Christopher Hill, Senior Specialist in Science and Technology Policy at the Congressional Research Service, presented a contrasting view of the role and effectiveness of strategic planning for economic development. Dr. Hill argued that nothing is more likely to inhibit the emergence of new technologies and firms than a plan that purports to determine in detail where they are going to come from and what shape they are going to take:

> No one is smart enough to know how to do that. Certainly, they are not smart enough on Wall Street, they are not smart enough in Washington . . . and they certainly are not smart enough in the Soviet Union to figure that out. . . . you cannot plan for technological development in a centralized, consistent, coherent way. It is something that has to come up from the bottom, and not down from the top. That does not mean that you do not try to plan, but you cannot believe in it.

Nor is basic research always essential to the process of technology-based economic development. Basic research, as Hill saw it, is something that usually comes along after the development of a technology, not before. Basic research is a way to "improve on the margin what you have already learned to do. But the cases in which basic research was the first step in technology development are rare. They are, unfortunately, also highly visible, and so we get misled by them." There is also widespread misunderstanding of the role of defense R&D in commercial innovation. Rarely does defense R&D contribute to anything beyond the defense mission to which it is directed.

Why does U.S. policy rely so heavily on the strategies of supporting basic and defense research? According to Hill:

> What we have seen is political manipulation of these perceptions, through several manifestations. One is what has been called pork-barrel science—that is, a growing interest on the part of legislators, and on the part of states, governors, and universities, to use the alleged relationship between basic research and economic development to seek out special appropriations from Congress to support their favorite programs. This is not entirely misguided. . . . There is some reason to believe that federal facilities and federally supported facilities at universities contribute not only jobs in the short run, but economic development in the long run.
>
> There is also a lot of interest in the spinoff from DOD [Department of Defense], motivated heavily by DOD's own interest in protecting its own budget. . . . Interestingly, then, what we are trying to do in this country is exploit science—science performed for other purposes—for economic development.

This whole area, Hill argued, needs much more research and analysis. We do not really know, for example, whether coupling universities to local small businesses improves the innovative performance and economic prosperity of these firms. We do not know whether the opportunity costs of such a strategy, i.e., the returns that this investment of public resources could reap elsewhere, are higher than the benefits.

Hill offered some criteria for the design of government programs of support for industrial technology. Flexibility of program design and implementation is desirable; in view of the numerous uncertainties in this area, it is essential that we try to learn from programs and modify them. Such learning requires greater investments in evaluation of such programs. Ideally, one would develop real-time evaluation of these programs, assessing program operations and addressing weaknesses as they proceed. Edwards Deming, the father of modern quality control, said that anything you measure gets better; the same applies here.

Hill concluded with some provocative comments on the role of universities in supporting commercial innovation and competitiveness:

> First, I do not believe that the universities are essential to regional economic development programs. I think they are a

> nice part of it, and they often play a key role . . . but right now the initiative lies with industry.

He expressed concern that the price of closer university-industry cooperation might be the loss of the role of universities as sources of critical thought:

> In each of the eras that I have just roughly sketched out, the universities have not been able to be critical, in the best sense, of that part of the society with which they were most closely associated. In the Renaissance, they could not be critical of the priesthood. Military academies have not been able to be critical of the military. Law schools cannot be critical of lawyers. Medical schools cannot be critical of doctors. I am concerned that the departments of science, engineering, mathematics, and computer science are not going to be in a position to provide the kind of critical analysis of modern technological society for which we would look to them.

Responding to Hill's remarks, Cyert commented that strategic planning need not mean rigid planning. "But I think it is clear that we can plan funding in particular areas and have a reasonably high expectation of results flowing from those." For example, in putting funds into biology and biochemistry research, "I cannot say specifically there is going to be a cure for cancer, but we can say there are going to be developments along the line of genetic engineering that are going to have some impact on health." Strategic planning does not mean trying to predict the industries that are going to survive or forecasting in precise terms the innovations that will emerge in the future, but instead should try to create an environment that can support innovation and regional and national economic growth. Cyert also noted that not all universities are involved in pork-barrel science—the American Association of Universities, comprising some 56 major public and private research universities, has taken a strong stand against it.

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Displaced Worker Adjustment Assistance

Judith Gueron, President of the Manpower Demonstration Research Corporation and a member of the Panel on Technology and Employment, chaired the discussion on public policies for displaced worker adjustment assistance. Dr. Gueron pointed out that although it is essential to economic growth, technological change does inflict economic losses on some individuals. For example, workers can suffer severe financial losses from layoffs or plant closings. Given this fact, the panel recommended that the nation implement policies to help displaced workers, compensating the losers and sharing the costs "both because we thought about the equity issues and also because we thought this would facilitate the implementation of technological change and the support for change."

The panel also concluded, however, that too little was known about the effectiveness of alternative approaches to displaced worker assistance, and that "it was very important to learn more."

Comparing Displaced Worker Adjustment Assistance Programs

Jane Kulik of Abt Associates, Inc., an evaluation research firm that has studied worker adjustment assistance programs, discussed evaluations of three programs designed to facilitate the reemployment of dislocated workers. One was the Downriver Community Conference Readjustment Project, which counseled more than 2,100 individuals who were laid off from five automotive plants that closed between 1979 and 1981 in the Detroit metropolitan area. These dislocated workers were working-age males who had some schooling beyond high school, had been in their jobs for more than ten years, were earning more than $10 an hour, and had been employed primarily in operative and assembly positions. The Downriver program was novel in that it offered a comprehensive menu of services to these workers that was based on a thorough assessment of their needs. The assessment tried to determine the workers' transferable skills and to identify those individuals for whom training would probably be necessary in order to avoid long-term or permanent loss of earnings.

The second project was undertaken by the U.S. Department of Labor in 1982 to both replicate and test alternatives to the Downriver approach. This program operated in six sites across the country, including the Lehigh Valley in Pennsylvania; Buffalo, New York; and Yakima, Washington. The program in Buffalo was the subject of an intensive evaluation by Mathematica Policy Research, Inc. As in the Downriver program, displaced workers in Buffalo were relatively well-educated and were drawn largely from high-wage manufacturing—in the case of Buffalo, the auto and steel industries. The Buffalo assistance program provided a careful assessment of the needs of individual workers, followed by job search assistance, counseling, and retraining as needed.

The third evaluation studied a project administered by the state of Texas between 1984 and 1986 using funds provided under Title III of the Job Training Partnership Act (JTPA). This program differed from the others in its use of a two-tier approach to reemploying dislocated workers. All program participants were offered job search assistance for a period before receiving more intensive and expensive services, such as retraining in the classroom. The theory behind this two-tier approach was that many dislocated workers could be aided by intensive job search assistance alone. Some fraction of the displaced worker population, however, would be unable to find employment without training or retraining. The two-tier process could identify individuals who needed retraining.

Evaluations of these three programs suggest that programs for dislocated workers can increase by 10 to 30 percent the proportion of the displaced worker population that is reemployed. Such programs also increase the duration of employment in their new jobs by 5 to 20 percent. The programs yield increases in average weekly earnings of from $50 to $100. These earnings effects, however, do not appear to persist over an extended time period, although evaluations rarely monitor individuals for more than one year following completion of a program of job search assistance or retraining.

One unresolved issue concerns the impact of training and retraining, as opposed to simple job search assistance. Does retraining yield benefits in both the short and long run, or is it better simply to help a displaced worker go out and find a job? Analyses of data from the Downriver and Buffalo studies that controlled for differences among individuals in age and education, as well as other factors, suggested that training made some difference. But the evidence is by no means conclusive. In Texas, individuals were assigned randomly to a group that received job search assistance in addition to classroom training, and one that received job search assistance only. As Dr. Kulik reported:

> In Texas, we found no impact. But this is attributable, in large measure, to a mismatch between the skills, interests, and abilities of the workers and the type of training that was offered. In Texas we were dealing with individuals who were laid off, by and large, from petrochemical industries. These were individuals who were highly educated, who had been on their . . . jobs for a substantial period of time, who were basically prime-age or younger-age males. The type of training that was offered was . . . for substantially lower-skilled occupations, and individuals, by and large, did not take this training up. As a result, we found no incremental impact over and above simple job search assistance alone.

Mismatches between the types of training offered and the skills and needs of displaced workers are widespread within worker adjustment assistance programs, as Kulik noted:

> If what we find in Texas is characteristic of what we find in the JTPA system—that is, program operators do have difficulty identifying the types of training that are appropriate for the dislocated workers—then this in itself is a very important finding. If . . . this is the reason that training is yielding no

> impact, then we ought to know that and . . . do something about it.

Given the benefits that accrue to workers participating in job search assistance programs, and comparing those with their costs, Kulik and her colleagues concluded that cost-effective adjustment assistance can be provided to dislocated workers:

> The types of interventions that have been carried out to date have gotten people back to work more quickly than might have been expected otherwise, yielding short-run increases in earnings and reductions in unemployment insurance benefits paid. It is also clear that early intervention stimulates participation . . . job search assistance interventions are also cost effective. Training-intensive interventions, however, have not proved cost effective.

Kulik argued that the evidence provided an insufficient basis for better program design:

> We still have a lot to learn, in terms of what works best for whom, what types of service-delivery strategies are most appropriate, and, perhaps more important, what we can say about the long-run impacts of these programs.

Kulik suggested five areas in which further research and experimentation are needed. First, the characteristics of the displaced worker population must be better understood in order to improve program design and service delivery to this population. Second, the factors that affect participation in adjustment assistance programs must be analyzed. Third, the reasons why specific subgroups appear to experience labor market problems and the types of intervention that can meet their needs must be pinpointed. Fourth, we need to assess rigorously the value of training and the types of service-delivery models that can be employed in providing training—voucher systems, for example. Finally, the long-run impact of assistance on reemployment and earnings must be better understood.

A View from the States

Christopher King, of the Center for the Study of Human Resources at the University of Texas at Austin, discussed the operation of state adjustment assistance programs in Texas. King agreed with Kulik's concluding comments that more research is needed on the effects and design of displaced worker adjustment assistance programs. Evaluation research, he noted, often has been cut by the same federal agency that also insists on stronger evidence that adjustment assistance programs are effective—the Office of Management and Budget.

King pointed out that with the exception of Title III of JTPA, employment assistance programs in this country are largely geared toward disadvantaged workers, individuals who lack the skills to obtain entry-level jobs or for other reasons have little or no work experience:

> If you are long-term unemployed and very poor, we can probably come up with something for you. If you have been displaced—whatever "displaced" means . . .—we have a little pot of money that might be able to create job training programs for you, but not a whole heck of a lot. I think, for Texas, our programs for the economically disadvantaged were on the order of $140 million. . . . In the same time period, for dislocated workers it was about $2.5 million.

As a result of this limited experience in operating programs for displaced (rather than disadvantaged) workers, state policymakers had little knowledge on which to base their design of JTPA programs after the passage of JTPA in 1982. This period also was one of severe recession, and public and elected officials demanded a rapid and effective response to worker displacement.

In Texas, policymakers responded by designing programs for displaced workers that also would yield useful evaluation data. The Abt evaluation of Texas JTPA programs that was discussed by Kulik was one result of this approach. The Texas experiments showed that job search assistance was more effective than intensive retraining. These findings were qualified, however, by the acknowledgement that the mismatches between worker needs and the types of training mentioned by Kulik prevented a fair test of the two types of adjustment assistance. In addition, many of the workers involved in the Texas programs had nearly exhausted their unemployment insurance benefits, meaning that longer-term assistance, such as retraining, was far less attractive to them. The Texas experiments also demonstrated the value of careful construction of a control group through random assignment of individuals to the experimental and control populations.

King highlighted several additional areas in which knowledge about adjustment assistance is lacking. The value (measured in terms of shorter unemployment and higher earnings once reemployed) of improved basic skills has not yet been demonstrated rigorously. The effectiveness of experimental adjustment assistance programs, which are far more expensive and often more heavily staffed, and which intervene in specific crises (e.g., a major plant closing), must be distinguished from the effects of ongoing programs that receive less publicity and possibly less funding. The results of evaluations of the experiments must be brought into the ongoing programs, but this is occurring very slowly.

King concluded by noting that the desire for better data on displaced workers and adjustment assistance programs must be tempered by a recognition of the pressures for an immediate response to major economic dislocations in states and regions:

> Even though we can learn some things about what works for whom, there are some things we may not be able to get a fix on. . . . When a plant is shutting down, it is very different from having a large group of people who have been unemployed for a long time. The pressures to do something quickly, regardless of how well it may work out in the long term, are pretty stiff. You try telling the county judge and the governor that we are going to have to sit down and think about this for a while. I did it, and I am not going to do it twice.

The New Jersey Adjustment Assistance Experiment

Walter Corson, of Mathematica Policy Research, an evaluation research firm, discussed a New Jersey project that tested early intervention strategies for displaced workers. The New Jersey program identified displaced workers through the unemployment insurance system. Most dislocated workers "are coming through that system, and the idea is to try to identify them and offer them services." Letters were sent to those workers who had applied for unemployment benefits and displayed the characteristics of a displaced worker. This strategy was quite successful; a large proportion of the individuals responded to offers of assistance, and on average, job assistance services were delivered in the fifth week of unemployment.

The New Jersey project tested three packages of services. A basic package emphasized job search assistance, including an orientation session, testing, a job search workshop, counseling, and periodic follow-up sessions as long as the individual was on unemployment insurance. This package differed in an important respect from many dislocated-worker programs: participation was mandatory. If a person refused to report for job assistance services, he or she would be denied unemployment insurance benefits.

The other two New Jersey packages offered additional services that were not mandatory. One offered training to individuals who could benefit from classroom training. The third package tested a reemployment bonus that, Corson explained, was a cash bonus for individuals who found a job and held it for a certain period:

> The [New Jersey] project began enrolling individuals in July 1986, and just finished. . . . We do not yet know very much about the outcomes. The only thing we have been able to do up to this point is monitor the impact of the demonstration on receipt of unemployment insurance, both in dollars and in weeks collected. We clearly are having an impact. The people in the treatment groups are reducing their duration on unemployment insurance relative to the control group.

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Conclusion

Richard Cyert closed the conference by expressing the view that the problem of technology and employment will remain a central topic of public debate in the United States for some time to come. The U.S. external debt that has resulted from the nation's trade deficits is going to continue to put pressure on the United States to increase productivity. One means to improve productivity growth is the more rapid development and adoption of new technology. The problems of technology and employment that were discussed at this conference will remain extremely important. As Cyert noted:

> The Panel [on Technology and Employment] that I chaired emphasized the fact that technological change, along with humane policies to buffer that change, was critical for the long-run health of our society. I think the emphasis that we have had today, particularly in this last panel, on adjustment policies, the emphasis on the skills aspect of retraining, as well as technological change and its impact on employment and on economic development, are all integral parts of the total problem
>
> I think we had a good one-day assessment of what is going to continue to be a major problem in the United States.

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