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Preface

No technological issue is more prominent today on flickering television screens or in the columns of magazines and newspapers than the effect of technological change on employment. Technological change profoundly affects the types, amounts, and conditions of work in all sectors, public and private.

At the beginning of the Industrial Revolution the factory was regarded as a dehumanizing environment in which workers became "slaves" of machines. Since then, major technological changes from water power to steam engines to electricity and the internal combustion engine have periodically reshaped the structure of modern society and its working conditions, occasioning recurring debate about the benefits and costs of technological change. Developments in electronics, computers, and robotics are again bringing significant change to the workplace and the organization of work in industrial and commercial enterprises. Many see in today's technological changes broad societal implications for employment and unemployment.

There are myriad forces that impinge on the nature of employment and unemployment in the United States. These forces operate at local, regional, national, and international levels. They involve shifts in industrial leadership in various economic sectors from one country to another as low production costs combined with the capacity to absorb and deploy modern technology have their effects on the location of production systems. As a result, technological innovation and its conversion to economic production have become central to the maintenance of industrial productivity. Recognizing this situation, federal as well as state and local governments have moved to adopt policies favoring the development of high-technology industry while attempting to formulate policies that can sustain and revive more mature industries. Central to the concern of government is the provision of jobs for its citizens.

The nation is presented with a dilemma—long lines of unemployed workers released from declining industries while the automated factory of the future complete with robots takes form. The indication is that to remain competitive, U.S. industry will need to continue to automate. But such changes can mean loss of jobs. The dilemma becomes reality.

There is no agreement among economists, technologists, or labor representatives on the impact of the development of new high-technology industries upon employment. Optimists see technological change much as in the past—spawning new industries employing large numbers of people to replace older industries. The adjustment process, while painful, is viewed as inevitable but tolerable by the intervention of government and private action to ameliorate adverse impacts. Pessimists see high-technology industry as providing high-paying jobs for only a small proportion of the work force that has the knowledge and technological ability, leaving lower-paying jobs for the majority.

Some see an era of limited work availability and a need to share jobs with a concomitant increase in leisure activities. Some see high-technology America as a service society. Others take the view that the United States, as a great power, cannot afford to be predominantly a service society because it cannot be dependent upon other nations for its basic industrial output.

The implications of all these developments are neither well understood nor easily forecast. What is necessary is an improved understanding of the processes at work so that public policy formulation can take place with an improved understanding of possible outcomes.

The symposium, "The Long-Term Impact of Technology on Employment and Unemployment," convened by the National Academy of Engineering to commemorate the retirement of NAE President Courtland D. Perkins has been a step to engage leading thinkers about these problems. It is a forum for the presentation and exchange of views that can begin a process of comprehensive study of the nature of the problem by the Committee on Science, Engineering, and Public Policy, a joint committee of the National Academies of Sciences and Engineering and the Institute of Medicine. This volume is a summary of the presentations by participants.

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Introduction

JOHN L. McLUCAS

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The subject of technology and employment is not a new one. The National Academy of Engineering has already initiated a two-year study of technology and its effects on employment and unemployment. We are organizing a panel of approximately 20 persons to study this topic over a period of time, and we will devote Academy resources to dealing with some of the many topics that are involved under this general heading.

There is a continuing debate about how the United States is faring with respect to other nations in terms of high technology. Although for many years we have thought of ourselves as the leaders in technology, we have recently had our comeuppance in many areas of industrial activity.

It is alleged that the Europeans and the Japanese are ahead of us in flexible manufacturing. This is very difficult to determine and seems somewhat questionable as one witnesses a stream of Japanese and others coming to the United States for briefings on the activities here. It is true, however, that visitors to Japan continually observe a serious sense of discipline that seems to permeate their society: If they have a problem, they focus their energies on trying to solve it.

Most of the people who theorize about employment and unemployment are in the upper strata of society: many in management and many in academia. It is likely that over the next few years we are going to see unemployment among some of the people who are currently doing the theorizing.

The era we are entering, with computer technology in a very advanced state and information processing becoming the name of the game, will see what is happening at COMSAT duplicated in other places. For example, right now we are installing personal computers in the offices of most of our key executives in the management wing of the building. Once this is completed, many of the questions normally asked of key staff people will no longer be directed to them because the executives seeking the information will have ready access to those facts in their computers. They will be able to obtain the information, play around with it, analyze it, and extrapolate from it—all on their own. This then relieves the corporation of the high overhead associated with maintaining a staff of several hundred people whose only job is to be smart enough to answer management's questions about what is happening inside and outside the company.

Thus we will see a revolution not only at the level of the work force but also at middle management levels. One can envision the extrapolation of that situation to the point that a single boss is sitting in the front office with a computer, surrounded by empty offices of former assistants, and then way below that the actual workers in the organization. Whether this will actually happen and, if it does, how fast are other questions.

Not long ago, at an informal meeting with a number of the 35 COMSAT lawyers, we decided that if we had the ALEXIS system and access to terminals, we would not need most of the people on the legal staff. Although this was said half-jokingly, some of the lawyers must have left the room with a slightly different perspective about their jobs.

Many people regard the microelectronics revolution as a unique event, as a sort of watershed situation. If we look back to one or two other watersheds, we might gain some clues about how society will be affected by this revolution. A good example is the establishment of railroads and how they not only provided transportation but also caused a reorganization of society. The introduction of electical power had a similar effect.

Today we are facing another radical step that is going to change the face of our society. Although it appears to pose unemployment problems at the outset, its influence does not have to be all bad. It can be almost all good if we take the right actions to anticipate the changes that are bound to be introduced. We cannot ignore that there will be a large fraction of the population whose lives are disrupted, and half of the theorizers will be saying that the introduction of this technology is very bad because of the human dislocation that is brought about.

These same statements have been made now for at least 100 years. Ned Ludd and the Luddites have their modern counterparts, and as we look back we can see that problems were dealt with—perhaps not in an adequate way, but they were dealt with. Similarly, the problem we face today can also be dealt with.

During the 1870s an Englishman, Samuel Butler, wrote a novel that he called *Erewhon*, which is an anagram of the word "nowhere." One of his paragraphs reads like this:

> *Take man's vaunted power of calculation. Have we not engines which can do all manner of sums more quickly and correctly than we can? In fact, wherever precision is required, man flies to the machine at once as far preferable to himself. Our sum engines never drop a digit nor our looms a stitch. The machine is brisk and active when the man is weary. It is clear-headed and collected when the man is stupid and dull. It needs no slumber when man must sleep or drop. Ever at its post, ever ready for work, its alacrity never flags, its patience never gives way, its might is stronger than combined hundreds and swifter than the flight of birds.*

He concludes by asking the question, "May not man himself become a sort of parasite upon the machines, an affectionate machine-tickling aphid?" Many of us look at machines in that light, but hopefully engineers do not. Presumably we look at technology as a way to solve problems, not compound them.

WASSILY LEONTIEF

National Perspective: The Definition of Problems and Opportunities

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The great Industrial Revolution triggered by the invention of the steam engine has by now run its course; the age that we are about to enter will be dominated by the sign of the electronic chip. The new wave of technological innovation will carry us forward at least as fast and as far as the last. However, to make full use of these opportunities, our economic, social, and even cultural institutions will probably have to undergo a change as radical as that experienced during the transition from the preindustrial society to the industrial society in which we live today.

The introduction of successive generations of more and more complex machinery made possible by the discovery of new sources and forms of mechanical energy over the last 200 years not only led to an unprecedented rise in the output of various goods and services but at the same time freed working men and women from the toil and trouble associated with physical exertion. The role of labor as the dominant factor of production was not reduced but enhanced. The control and guidance of increasingly powerful and intricate machinery required that each worker exercise mental capabilities of progressively higher and higher order. The competitive market mechanism translated this steadily increasing demand for labor into higher and higher real wage rates.

As the earning power of an average working family increased, it naturally chose to allocate some part of those earnings to acquiring more leisure time. One might speak of this progress as an increase in voluntary technological unemployment. One hundred years ago, the number of hours worked in the average week in the United States was over 70; by the beginning of World War II, hours per week sank to 42.

Computers and robots replace humans in the exercise of mental functions in the same way as mechanical power replaced them in performance of physical tasks. As time goes on, more and more complex mental functions will be performed by machines. Not unlike large bulldozers assigned to earth-moving jobs that could not possibly have been carried out even by the strongest laborers or draft animals, powerful computers are now performing mental operations that could not possibly be accomplished by human minds. Any worker who now performs his task by following specific instructions can, in principle, be replaced by a machine. That means that the role of humans as the most important factor of production is bound to diminish—in the same way that the role of horses in agricultural production was first diminished and then eliminated by the introduction of tractors.

The general theoretical proposition that the worker who loses his job in one industry will necessarily be able to find employment, possibly after appropriate retraining, in some other industry is as invalid as would be the assertion that horses who lost their jobs in transportation and agriculture could necessarily have been put to another economically productive use.

Reduction in the price of labor—that is, in the real wage rates—can and in certain instances did postpone its replacement by machines for the same reason that a reduction of oats rations allocated to horses could delay their replacement by tractors. But this would be only a temporary slowdown in the process; improvements in the efficiency of tractors and other inanimate means of production can be expected to proceed without any limits, while reductions in feed rations or wages have definite limits. In the case of human rations, or real wages, these limits are narrow and are very sensitive indeed.

Assessing the effects of technological change and economic growth on employment, one must take into account "lateral shifts." For instance, with a rise in the per capita income, consumers tend to spend a larger and larger part of income on purchases of various services rather than on food, clothing, or even housing and appliances. Moreover, the increasing division of labor has led to service sectors that specialize in selling services to business that the businesses formerly provided for themselves. This lateral shift would proceed even without any technological change. In fact, computers and other electronic devices replace human mental functions in service industries even faster than in the old smokestack industries. What employment statistics show is the combination of essentially opposite effects of two simultaneous but quite different processes: lateral shifts into the service industries and technological displacement of labor by electronic devices. Without a much more detailed, factual analysis of the second process, systematic numerical interpretation of the employment figures will be impossible. The lateral shift is bound to slow down, however, after 60, 70, or even 90 percent of total output is provided by service industries. As it slows down, the effect of downward pressure on demand for labor in service industries brought about by continued computerization and automation will ultimately prevail.

This brings us to the problem of labor income, which obviously cannot be separated from the problem of employment.

While eliminating the role of labor as a source of physical energy, the first industrial revolution increased the critical importance of labor's mental contributions to such an extent that real wages rose steadily in the United States and other advanced, industrialized countries over the last 200 years. With the spread of computerization and automation, the same competitive forces that brought about a rise not only in the price of labor but also in labor's total share in the national income are likely to begin to operate in the opposite direction.

Before turning to the problem of income distribution, a few words must be said about the ambiguous meaning of numbers commonly used to measure the "productivity" of labor. These numbers are usually obtained by dividing the total output (expressed in physical units or in constant dollars) of a single plant or entire industry by the number of workers (or better, of labor hours) employed in its production. Given this definition, consider the change in productivity of telephone operators in an exchange during a period in which old-fashioned manual switchboards are gradually replaced by automatic switchboards, while the number of telephone calls handled by that exchange remains constant. At the beginning 1,500 operators might be engaged in that operation. As new equipment is installed, the number of operators decreases.

Dividing the same total number of calls

served each year by a smaller and smaller number of operators kept on the job, we find that productivity steadily increases. It becomes very large when only one operator remains. When the last operator is discharged, the productivity of labor in that installation becomes infinitely large. Describing the process in common language, one would say that technological change gradually reduced the role of labor in that particular production process, and after 5 or 10 years the need for labor input was reduced to zero. Using the procedure described above to measure the productivity of the automatic switchboards, we find that as their number increases, their productivity goes down. It reaches its lowest point when all calls are handled automatically.

An employer operating within a competitive market economy can assess the contribution of labor that might be employed along with other inputs; consequently, he can only decide how many workers or labor hours to employ by comparing the combined total cost of all the inputs required to apply each of the alternative technologies to produce the envisaged output. It is in this sense that the introduction of tractors can be said to have reduced the usefulness of horses in agricultural production. In assessing the long-run implications of the introduction of new technology, one has to admit that it might indeed reduce the demand for labor and, unless for demographic or some other reasons the total labor supply adjusts accordingly, bring about what might be called involuntary technological unemployment.

Reducing the growth of labor inputs in production is bound to affect the structure of international trade because the competitive strength of less-developed countries now depends largely on comparatively low wages. Years ago, labor-intensive industries such as simple textiles migrated from the United States, Japan, and Western Europe to India, Brazil, and other less-developed countries. Low wage rates provide advantages to Korea and Taiwan even in the production of simple electronic goods. That advantage inevitably will shrink as these industries become automated and the wage bill becomes a smaller and smaller part of total cost. The expatriate industries will tend to move back to the advanced industrialized countries.

When I spoke about this recently at a meeting of the Confederation of Italian Industry, a textile industry expert connected with Eurocotton confirmed this observation by describing his visit to a recently constructed fully automated mill. Machines stand in tight rows in a completely dark building. Whenever one of them requires attention (which does not happen often), a spotlight automatically identifies the unit that has to be fixed. The total investment is $22 million; the total staff, including the manager, is 10 employees. While the return of expatriate industries would strengthen the balance of payments of the developed countries, it certainly is bound to aggravate the employment situation in the less-developed areas.

As the example of Singapore shows, in order to maintain their competitive positions the less-developed countries also have to adopt the new technology. Since this technology is labor-saving, industrialization will cease to be a cure for chronic unemployment.

The scenario presented above might be correct or it might be faulty. Only a detailed study involving analysis of the present structure of our economy and construction of alternative scenarios based on systematically collected information ("cooking recipes") on the technology available but not yet used in each of the hundreds of different branches of manufacturing, agriculture, transportation, communications, and other service industries can dispel our horrible ignorance on that most important subject.

At the risk of sounding immodest, I venture to suggest that only the input-output approach, in which the structure of the economic system and the flows of various goods and services (including all the various types of labor services) between all its many sectors is described in great detail, can provide a sufficient empirical basis for reasonably anticipating possible future developments and formulating appropriate policies. This would indeed be a massive undertaking, requiring close disciplined cooperation between the engineering community, demographers, labor specialists (especially those concerned with training and retraining), sociologists, and, last but not least, economists.

I know of at least one study of this kind. It was undertaken by the economic institute of the Austrian Academy of Sciences in cooperation with 13 technical research institutes and a large group of outside experts. Several alternative internally consistent scenarios were prepared, each based on a different set of assumptions concerning the rates of introduction of the new technology in all the different branches of the economy. The composition of the labor force, education, and professional training were described in each of these projections in great detail.

As present developments in various service sectors show, even if computerization and automation sooner or later bring about a situation that I have described, the movement in this general direction cannot be expected to be uniform. In dealing with such lateral movements, appropriate training and retraining of the labor force will obviously be required, and the timely anticipation of future structural changes will be of foremost importance. Before beginning to teach 250,000 idle automobile workers how to operate word processors and computers, it would be advisable to estimate how many new job openings of this kind can be expected to appear and in what industries, not only 2 years from now but in 5 or even 10 years when new, greater labor-saving models are introduced. Let us not forget that retraining is essentially an emergency measure to which one should not have to resort if better, more reliable estimates of future structural shifts are available.

Turning to the question of adjusting our economy and our society to a situation in which technological change will progressively reduce the role of physical and mental labor as an indispensable factor of production, it is important to realize that the invisible hand of the competitive system equilibrating the supply and demand of all goods and services by means of appropriate price adjustments would not solve the problem, or rather it would tend to solve it in the same way as it did when it efficiently eliminated the use of horses in agriculture. Had horses had an opportunity to vote and join the Republican or Democratic party, that solution would have been very different from what it actually was. Had we for instance wished to maintain the 20 million unemployed horses by putting them to pasture, we certainly could have done so. To get the necessary appropriation from Congress, it might have been sufficient to declare such action to be necessary for national defense and to include its costs in the military budget.

Speaking seriously, the problem of technological unemployment is likely to be solved by an appropriate combination of labor sharing and income policies. Instead of having one part of the population fully employed and the other totally unemployed, the labor hours might be shortened, the number of workdays in the week reduced, the length of regular vacations increased, the retirement age lowered, and the entry of young people in the labor force delayed through longer schooling. But how about the labor *income*? An increase in wage and salary rates sufficient to compensate for shorter work time would obviously be counterproductive because it would only accelerate the rate at which labor-saving machinery is introduced. To keep the cost of accounting or private business straight, the market price of labor should continue to reflect the competitive advantage of using labor-saving technology.

Accompanying labor sharing, income policy would have to consist of supplementing normal wage earnings with income transfers lying outside the operations of the competitive market mechanism. As a matter of fact, we have been practicing such income policies for many years in the form of social security, unemployment insurance, medicare, and many other methods that are used to supplement the income of those who either earn nothing or do not earn enough. Needless to say, such a policy would require strengthening many of the existing social institutions and creating new ones, a process that cannot be expected to be accomplished easily or smoothly.

But what is more, shortening of labor hours—that is, a gradual increase in leisure or freely disposable time—would mean a change in the way of life of large masses of American people. Such a change can hardly occur without a change in our cultural and personal values. The Puritan work ethic, born in the sixteenth century, served the needs of nineteenth and twentieth century industrial society; now it will have to yield gradually to a somewhat different attitude toward life. Those who ask what the average working man and woman could do with so much free time forget that in Victorian England the "upper classes" did not seem to have been demoralized by their idleness. Some went hunting, others engaged in politics, and still others created some of the greatest poetry, literature, and science the world has known.

While speaking at length of the physical and mental capabilities of men, I have not mentioned creative imagination, the only faculty that seems to be irreplaceable by machines. Without creative imagination, neither art nor science could possibly advance. It is also an indispensable ingredient of any kind of leadership—entrepreneurship in particular. However, only the creative imagination of a relatively few outstanding individuals acquires common currency and is regarded accordingly. In private everyday life an individual's own imagination plays a most important role as the source of a great variety of cultural pursuits. While training for the exercise of productive skills will certainly remain one of the principal objectives of formal education even as computers and robots take over, the other, more general objective of education, the development of taste and of capabilities for nonremunerative cultural activities, will become more and more important.

ROLAND W. SCHMITT

Technological Trends

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When the poet Walt Whitman heard America singing a century ago, he heard the voices of people who worked with their hands—"the shoemaker singing as he sits on his bench, the hatter singing as he stands," the woodcutter's song, the plowboy's, the carpenter's, and the mason's. When a Whitman of a century hence listens for the song of America at work, will he still hear the voices of American workers, "each singing what belongs to him or her and to none else"? Or will he merely hear the clank of robots, the silence of a silicon chip, or a distant, exotic song wafted over the Pacific from Japan?

Imagination has largely failed in the past to envisage future technology. And it has failed even more dramatically to envisage the uses of that technology. No one can be sure today of the long-term technical trends that will most strongly affect tomorrow's work force. But I believe that history, reason, and foresight all support an optimistic view.

The technology revolutions themselves show no signs of slackening. The revolutions in electronics, telecommunications, information, and computer science are now well under way, and others are emerging in medical science and biotechnology. Science and technology are still as much an endless frontier as they were four decades ago or four centuries ago.

The overriding effect of this never-ending source of new economic activity will not be just the rise and fall of already known types of work. We will see the creation of new types, new settings, and new content for work itself. New technology will help society produce goods and services it enjoys today—and even improved versions of these—at less cost and with less effort. With the resources thus released, we will again, as in the past, produce wholly new types of goods and services.

The main trend in the most rapidly emerging of the new technologies is a growing complexity that must be mastered. Modern electronics exemplifies this trend. It is itself complex and is also an essential tool for mastering complexity. The emerging generation of electronics—very large scale integration, or VLSI—will put hundreds of thousands of electronic switches on a silicon chip only a centimeter on a side. But the complexity of those circuits will be even more impressive. Circuits made by today's techniques are equivalent to putting a street map of San Francisco onto a single chip. Within a few years, the equivalent of a street map of the entire state of California will be put on a single chip. And within the next decade, engineers will be putting the equivalent of a street map of the entire United States onto one of those chips.

Only a few years ago, the question was asked, "What will we do with a million transistors on a chip?" The military uses were clear: large, sophisticated communication, command, and control systems in small packages. But today we also know that VLSI will have a tremendous range of commercial applications, too: from robot controls to mobile communications to medical diagnostics.

This new electronics demands a new type of electronics engineer. The individual must work as part of a design team. His pencil, paper, and soldering iron have given way to an interactive computer system. And the role of that computer is evolving from that of a dumb assistant to that of a smart associate of the designer.

This example is a prototype for changes in jobs, even skilled jobs, in the new-technology industries. Obsolescence and displacement are not hazards of blue collar jobs alone. Upgrading of skills will be a lifetime activity in high-technology industries of the future. In many, it already is today.

The advanced materials industries will follow a similar path. Computer-aided design and engineering methods are already revolutionizing the way people use materials. But the next step will involve designing the materials themselves. It may be that the profession of "quantum mechanical materials engineer" will be added to the Department of Labor's *Dictionary of Occupational Titles*. He or she will be a person who uses computerized quantum mechanical calculations and interactive graphics as a sort of electronic test tube to create new materials.

And even the complexities of biology are yielding to new ideas and new tools. The double helix and the central dogma of DNA provided the conceptual foundation. The tools include recombinant DNA (the ability to rewrite the hereditary message of living organisms) and monoclonal antibodies (mass-produced magic bullets for targeting individual cells for detection or treatment). Surprising discoveries continue to be made almost monthly, and the future economic impact is virtually unimaginable. For perspective, think back to a few years after the invention of the transistor. Then, after great effort, the first transistor-based product was offered: a hearing aid! Did anyone in his wildest dreams foresee the eventual impact of that invention on the economy, on employment? I believe that we are similarly situated in biotechnology today. Recombinant DNA is already entering medicine, but it may affect plant biology just as dramatically. The transfer of genetic material from bacteria to plant cells, the asexual generation of new plants, and the fusion of different species are examples of new possibilities for improving crop yields, improving nutritional content, and lowering the cost of food.

And we will also see changes in the field of medical diagnosis. Nuclear magnetic resonance (NMR), for example, is now going to work in medicine. Its imaging capabilities give doctors a view of soft tissues such as the brain that even such previous techniques as computed X-ray tomography (CAT scanning) could not obtain. And NMR spectroscopy techniques may someday enable doctors to determine the physiological condition of tissues and organs in selected parts of the body without cutting it open or sticking needles into it. Other emerging techniques include position emission tomography and brain electrical activity monitoring. Besides providing medicine with new dimensions, they will also extend into other areas, just as CAT scanning is now used for examining turbine blades, measuring steel properties, and analyzing oil well cores.

So in one sense the future belongs to the masters of complexity, to the electronics engineer who can manage design tools, the materials scientist who can apply computerized quantum mechanics, the chemist who masters molecular biology, and the medical diagnostician who understands nuclear magnetic resonance. And it is impossible even to guess the sources much less the effects of future revolutions, whether from neurophysiology, geophysics, developmental biology, or high-energy physics.

These advanced-technology opportunities are not the total answer to the nation's employment problems. The new-technology industries are growing rapidly. Still, the Bureau of Labor Statistics predicts that the number of high-technology jobs created over the next decade will be less than half as great as the number of jobs lost in manufacturing over the next three years. But how do you predict the new jobs to be created in industries and occupations that have not yet emerged? How accurate could predictions made in 1940 have been for the computer industry of 1983?

And the biggest employment impact of advanced technology is not in the new-technology industries themselves. It is in the industries that use the products of advanced technology. It is the users of VLSI chips, microprocessors, and plastics that will have the opportunity to create new jobs in the future. The core industries, the smokestack industries, must become heavy users of these new technologies. Rejecting technology cannot save jobs. It would merely accelerate the rate at which the Japanese, the Germans, the Koreans, the Taiwanese, and others take those jobs away.

The increasing productivity that will save those jobs will come from the technology that is giving us the computer-integrated manufacturing enterprise—a factory that will be a sort of organism with a collective body, brain, and nervous system. The body will be a set of flexible manufacturing tools—robots, numerically controlled machine tools, automated test stands, and the like. The mind will be a distributed data base. It will hold, exchange, and put to work unified three-dimensional representations of products, representations that can serve as graphic images for the designer, as realistic models of the mechanical, electrical, and thermal performance of an object, as sources of programming instructions to robots and numerically controlled machine tools, and as specifications for inspectors and quality controllers. The nervous system linking body and mind will be a high-capacity communications network, perhaps made of fiber optic cables.

As a step toward this future, General Electric is putting some $316 million into turning one of its oldest factories, a locomotive manufacturing plant in Erie, Pennsylvania, into a model of state-of-the-art automation. It features a flexible manufacturing system that has reduced the cycle time of production from 16 days to 16 hours. In one section of the plant where some 60 people used to work on the factory floor, there are now only two, one in overalls who "carries a wrench," the other in a coat and tie sitting in a booth above the floor "pushing buttons" on a console.

The total program at Erie will reduce direct labor by 25 percent, but—and here is the bottom line—when the plant's modernization is completed, it is expected to offer 10 percent more jobs than it did at its prerecession levels. The people running the business expect to do this partly because U.S. markets are getting healthier. But they mainly expect to do it by becoming more competitive on the international scene. They have begun this effort by going out and competing. They have taken on and beaten the Japanese and Germans for a big order in Mexico, and they have gone on to take an order away from those competitors in Indonesia, right in Japan's backyard. They are doing this with many of the same workers from preautomation days. Some 500 production and maintenance workers are going through special training programs to learn about control systems, computer operating systems, communications interfaces, electronics assembly, and the like.

This reshaping of the factory worker's task will save American jobs by making American products more competitive. But we cannot expect it to produce a very large net increase in jobs. For any such increase, we have to look to the service sector where new technology will nurture many, many new ideas and possibilities. The service jobs expected to expand most rapidly in numbers in the 1980s are ones not typically seen as technology intensive: secretaries, nurses and nurses' aides, janitors, sales clerks, cashiers, truck drivers, fast-food workers, clerks, and waiters. But the service jobs that are growing at the fastest percentage rate are more computer oriented, from the programming and operating professions themselves through such jobs as medical technician, information systems specialist, and economist. And we must remember that there are many jobs that will require human hands for a long time to come. As coaxial or fiber optic cables multiply the number of TV channels coming into a person's home, it will still take people to string the cable and hook up the subscribers' sets. Computers may diagnose the problems of automobile engines, but it will still take human hands to change the spark plugs. And, again, there is an element of growth omitted from these forecasts: the growth from the still undreamed of services that will be produced in abundance in the future.

The technologies that will do the most to create wholly new services are artificial intelligence and knowledge engineering. This is partly a hardware revolution. The Japanese have launched their fifth generation computer program on the assumption that it will take a whole new generation of computer architecture to produce a machine that interacts with a person like an intelligent colleague rather than like a literal-minded slave. And that fifth generation of computers will not be the last. The cornucopia of capability being opened up by VLSI is already leading to wholly new types of computers. Computer scientists are exploring such new ideas as data flow computers, interactive graphics programming, reduction architecture, and functional languages. And beyond that, who knows? Perhaps three-dimensional arrays of molecular or even atomic-sized switching elements are not out of the question.

All this is far in the future. But even today's hardware makes possible some initial steps toward knowledge engineering. For example, at the General Electric plant in Erie, Pennsylvania, there is an experiment going on that may prove as important for the future of the service industries as that flexible manufacturing line is for the metal-bending industries. Last year, a couple of our computer scientists started working with a man at Erie who is a genius at diagnosing the ills of sick locomotives. The computer experts lived with him until they felt they could express the way he operated in a detailed computer program consisting of some 350 rules and many, many more items of specific information. They programmed a computer to use those rules, that information, and data read into it by a human operator to perform the locomotive diagnosis job. Now they are testing whether the program does in fact act like an expert. The initial results have been excellent.

This is only one of a large number of expert-system experiments going on all over the world. They are not just new ways of replacing people with computers. They are a kind of intelligence amplifier, a way of getting the most out of the skills of each individual. And an expert system should be an educational tool of tremendous power, too.

It is in areas related to these activities—intelligence amplification and education—that I see the greatest future effects of technology on the service sector. One of the growth industries of the 1980s is physical fitness. It is now a $35 billion a year business, that is, nearly five times the size of the personal computer industry. And it probably accounts for well over half a million jobs. But at the same time, the industry that is in the biggest crisis today is our mental fitness industry, especially education. The next generation of computers, coupled with expert systems, may provide us with the tools we need to launch a mental fitness craze. A nation with a market for a $6000 treadmill for indoor joggers that measures speed and mileage and displays distance on a small screen surely also has a market for equipment to jog the minds of Americans and get them off their mental treadmills.

It is as hard to tell exactly what form this mental fitness technology will take as it was for people in the 1920s to envision the future of television. But surely one key to wholly new mental fitness products is the computer's capability for simulation, interaction, and display. With VLSI and knowledge engineering these capabilities will extend far beyond what we see in today's computer games. Not so far, one hopes, as to lose the playful spirit of those games, but far enough to add an appeal to the creative and inquisitive power of the mind as well. Coupled with advances in telecommunications, this may enable people, for example, to experience nature on a scale previously inaccessible to humans—the submicroscopic world of elementary particles, perhaps, or the supermacroscopic world of galaxies.

This suggests the seeds of some of the service industries of the future: services that enable people to set free the powers of their minds; services that help people interact with information rather than merely absorb it; services that educate or retrain people to fit into the new economy.

That, then, is the song I hear America singing decades from now. I believe that the needs, wants, and imagination of Americans will provide new dimensions of employment opportunity—not just enough jobs, but wholly new types of jobs. In the new-technology industries, I hear the VLSI engineer singing as he sits at his console, shaping systems ideas in silicon, or the quantum mechanical engineer singing as she sits at hers, trying out new ways to put atoms together. In the core industries, I hear the factory worker singing as he walks the plant floor, the master of machines not their slave; the maintenance person singing as she makes the repairs that keep the systems running; and the songs of many, many people who will still work with their hands as well as their brains. And, in the service industries, I hear the person and computer singing together a duet of thought and image, the computer handling the mechanics of logic, graphics, and display, leaving the person free to do the job of creative thought, the job that "belongs to him or her and to none else."

In the new-technology industries, the mastery of complexity; in the core industries, international competitiveness; in the service industries, new ways to enhance the power of the human mind—those are the main impacts, as I see it, of new technology on employment and unemployment in America.

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Work Force Trends

In a 1977 article in *Scientific American*, Eli Ginzberg pointed out that although the American economy had performed well in terms of the number of jobs created since 1950, it had performed poorly in terms of the quality of new jobs.[1] He noted that about two-and-a-half times as many new jobs were added in industries that provided below-average weekly earnings as were added in industries that provide above-average earnings. Yet Daniel Bell, in *The Coming of Post-Industrial Society*, found evidence of a changing economy in which technology was bringing about an upgrading in the quality of work,[2] and this latter view is widely held. Is it possible to reconcile these seemingly conflicting views? Where does the truth lie? In which direction are we moving?

In seeking to shed a little light on these questions, let us first look very quickly at the new technology and then at the major transformation that has occurred in terms of the service economy. We can then examine some trends as reflected in the data, offer some interpretations, and finally suggest some emerging problems.

The more than a quarter-century of computerization of government and business operations has been marked by a continuous evolution toward wider application of technology in terms of both function and size of the user organization. Although there is as yet no accepted division of these years into stages of development, it is clear that the later years have differed sharply from the earlier ones.

The late 1950s and 1960s were characterized largely by batch data processing, with large organizations and service bureaus utilizing large computers to carry out high-volume, routine, repetitive tasks. By the end of the 1970s we had entered an era in which complex distributive processing systems were increasingly used by large organizations, and low-cost microprocessing capability of one sort or another was applicable across a broad spectrum of functions and to a wide range of firms and public sector organizations.

It is probably useful when assessing labor market implications to see the mid-1970s as marking a major change. At least prima facie evidence is found in the National Income Division estimates of investment expenditures.[3] High-technology investment—if we define this as office and store machinery, instruments, and photographic and communications equipment—drifted up from slightly over 0.5 percent of the gross national product (GNP) in 1958 to just over 1.5 percent in 1976.

From 1976 to early 1982, however, these expenditures rose sharply to close to 3.5 percent of the GNP and accounted for increasingly large shares of all durable equipment expenditures. In 1976, high-technology equipment accounted for 26 percent of total equipment expenditures, and in 1982 for 46 percent. This, however, badly understates the level of investment because software expenditures are much larger.

Therefore, what we are seeing is certainly a new era of some sort in terms of the adoption and diffusion of new technology. The increasing role of the computer has been only a part of a much larger picture.

THE RISE OF SERVICES[4]

We cannot understand what has been going on in the labor market without recognizing that there has been a major transformation toward a service-oriented economy, a transformation that is quite complex and in which computers may play a role either as catalyst or accelerator.

The increasing importance of services in our society is not a new development. It goes well back into the nineteenth century, when the rise of the railroads, the telegraph, banking, and wholesaling facilitated opening up new agricultural regions and helped usher in the industrial economy. Services have played a far greater role in the transformation of employment in the post-World War II market, rising from 57 percent of all jobs to just under 70 percent today. This figure is somewhat higher than that given by Leontief (see his remarks), but of course the statistics depend on what you include as services. I include utilities, the distributive services, various producer services, and government along with consumer and nonprofit services. At any rate, employment by the services industries has risen sharply, and these industries provide the lion's share of employment today.

Various sectors are also involved. Government employment has risen until very recently, and the nonprofit sectors have contributed in a major way. To some extent the consumer services are also involved, although the surprising fact is that they have been the least important of the services; much more important are the business and producer services, including finance, insurance, real estate, and consulting.

What has been involved in this movement toward a service economy has been a transformation in both what we produce (the change in composition of our final bill of goods in terms of the shapes accounted for by government, nonprofit services, consumer services, and manufactured goods) and how we produce (the increased importance of services as an input to production, both those performed in-house and such freestanding services as banking, insurance, consulting, accounting, and legal services). This has occurred because we have increasingly gained control over the plant, reducing employment there. At the same time we have found that participating in national and international markets with shorter product lives and a greater need for product differentiation has made it necessary to have a much larger superstructure of business services in order to carry out the development, research, and education required.

CHANGING COMPOSITION OF THE WORK FORCE

Careful analysis of the employment data that are available, cross-classified by industry and occupation for the 1960s and 1970s (see Table 1), provides a number of insights as to how the work force has been changing during the past two decades.

The initial observation is simply that employment growth has largely been in the services and has largely been white collar. Continuous increases in white collar employment with slow growth or decline among blue collar workers sharply altered the nature of work during both decades. Major increases were occurring in professional, technician, clerical, and service worker occupations during both the 1960s and the 1970s.

TABLE 1 Analysis of Employment Change by Occupation for Service and Nonservice Industries, 1960–1967 and 1970–1976

Occupation	1960–1967 Actual Change	1960–1967 Occupational Shift Gain or Loss	1970–1976 Actual Change	1970–1976 Occupational Shift Gain or Loss
Service industries				
Total	7,486,945	0	8,658,605	0
Professional	2,199,072	401,441	1,179,655	−311,234
Technical	780,785	74,176	1,258,142	504,245
Manager	467,817	−354,759	1,444,876	483,923
Office clerical	605,205	86,354	967,857	−87,320
Nonoffice clerical	1,080,542	171,816	828,484	30,868
Sales workers	262,719	−137,059	475,599	−126,106
Craftsmen	457,230	159,925	520,326	153,546
Operatives	436,953	68,527	263,526	−75,433
Service workers	1,094,843	−242,453	1,463,281	−631,501
Laborers	101,779	−55,260	256,859	59,012
Nonservice industries				
Total	1,107,006	0	181,705	0
Professional	225,407	112,772	85,651	82,958
Technical	112,996	29,313	104,123	111,360
Manager	−1,391,991	−143,063	133,470	97,699
Office clerical	163,548	42,415	−23,651	−22,016
Nonoffice clerical	197,501	4,258	−57,978	−47,116
Sales workers	31,398	−37,388	7,316	15,268
Craftsmen	503,773	−510	265,452	73,593
Operatives	1,429,580	379,850	−201,419	−118,849
Service workers	−29,850	−74,419	−68,368	−65,087
Laborers	−135,356	−313,238	−62,891	−127,810

SOURCE: U.S. Bureau of Labor Statistics, *Tomorrow's Manpower Needs, National Industry-Occupational Matrix* (Microdata for 1960, 1967, 1970, and 1976).

A second observation is that there have been significant changes in employment in the various occupations that cannot be accounted for simply by industry change. These shifts—increases or decreases over and beyond those accounted for by rates of change in industry employment—provide indirect evidence of changes in the importance of various types of work within the economy and are shown in summary form in Table 1. In the 1960s both the services and goods sectors showed positive shifts (disproportionate increases) in clerical work and in the employment of professionals and technicians. Laborers and service workers, however, declined in relative importance, as did managers and sales workers. The largest positive shifts were due to increases in employment of professionals, largely the increase of teachers.

During the 1970s the trend toward increasing importance of technicians and managers characterized virtually every service industry (this detail is not shown in Table 1). The negative shift in professionals is largely a reflection of retrenchment in the employment of teachers. Although employment gains elsewhere continued strong, the relative strength of demand for professionals appears to have lessened. Among office clericals, the negative shifts were heavy in the distributive and producer services, especially finance, insurance, and real estate, indicating weakening relative demand in spite of large increases in the employment of office clerical personnel brought on by growth in the service industries. This suggests that new forces—very likely the new office technology—were beginning to be felt. The positive shift in nonoffice clericals was accounted for principally by increased employment of cashiers in self-service outlets.

The substantial negative shift in the service worker classification is largely accounted for by the sharp decline in domestic servants in the consumer services industrial group. It is probable that to some extent it is also due to reduction in the use of service workers through application of labor-saving equipment or changing operation procedures.

In the goods sector there was a substantial trend toward increased importance of professionals, technicians, and managers (executives) with negative shifts for operatives, laborers, and service workers, reflecting a reduction in the demand for production workers and a greater emphasis on administrative and developmental functions. Both office and nonoffice clericals declined slightly in relative importance, reversing the trend of the 1960s toward disproportionate growth and again suggesting the influence of the new office technology.

Further light on the changing importance of clerical work can be gained from a recent study of Matthew Drennan, a colleague at the Conservation of Human Resources at Columbia University.[5] Drennan analyzed changes in detailed clerical occupational categories for the years 1970 to 1978, with special attention to six service industries characterized by relatively high levels of white collar employment. They included banking, insurance, securities, credit agencies, business services, and miscellaneous services. His analysis, which was supported by interviews in important representative firms in these industries, indicated that by the late 1970s, computer-oriented technology was beginning to alter the nature of clerical work in many organizations, bringing reductions in the more repetitive and routine tasks.

Detailed data are not available for the most recent years, but such evidence as can be tapped (aggregate occupational estimates for 1979-1981) indicates that the trends noted for the earlier years of the 1970s continue. From 1979 to 1981 the share of total employment accounted for by white collar workers rose still further, with the growth rate of professionals and technical workers (combined) and of managerial personnel above that of clerical and sales workers. Among the declining blue collar group, craft worker employment fell relatively less than employment of laborers and operatives. The lower levels in the service worker category continue to expand but at a rate below that of white collar employment.

Taken as a whole, these analyses reflect clearly the impact of transformations in the service category that have been at work, while at the same time they support the generalization that technology has been reshaping the occupational composition of the work force; that routine work, wherever found, is being curtailed; and that nonroutine work is increasing in importance.

WORK FORCE TRENDS—GOOD JOBS OR BAD JOBS?

Although no final analysis can be offered, it is possible to make several observations that help to put recent and current trends in perspective. The first is that there has indeed been an overall increase in the proportion of bad jobs versus good jobs since the 1950s, the position taken by Eli Ginzberg. It has come about through the differentially higher growth of services, which on average pay lower wages and salaries, as well as through the declining importance of production workers, who traditionally have earned what we call good American wages. Our analysis of industry occupational subgroups for the period 1960 to 1975 (see Table 2), which was as far as we could obtain good data, supports this position. Those industry occupation subgroups with

TABLE 2 Distribution of Total U.S. Labor Force Among Earnings Classes, 1960 and 1975, and Distribution of 1960–1975 Job Increases in the Services

	Distribution of Total U.S. Labor Force (percentages)[a]				1960–1975 Job Increases in Services[b]		
Earnings Classes	1960		1975		Numbers of Jobs (1,000)	Percentage	
1.60 and above	10.9	31.6	12.0	34.2	1,947	9.5	35.0
1.59 to 1.20	20.7		22.2		5,224	25.5	
1.19 to 0.80	35.9		27.8		2,311	11.3	
0.79 to 0.40	24.1	32.5	28.4	38.0	9,205	44.9	53.8
0.39 and below	8.4		9.6		1,829	8.9	
Total	100.0		100.0		20,516	100.0	

[a] Excludes agriculture, mining, and public administration.

[b] TCU, wholesale, retail, FIRE, corporate services, consumer services, and nonprofit.

SOURCE: Based on U.S. Bureau of the Census, *Survey of Income and Education* (for 1975), and U.S. Bureau of Labor Statistics, *Tomorrow's Manpower Needs, National Industry-Occupational Matrix* (for 1960).

annual earnings greater than 120 percent of the national average accounted for 35 percent of all the job increases. Those with earnings of less than 80 percent of the average accounted for 54 percent of job increases during that 15-year period. The middle group, with earnings of 80 to 120 percent, was the smallest, accounting for only 11 percent.

Another observation relates to the role of women's work during this period. Between 1950 and 1981 roughly 70 percent of all increases in the total work force can be accounted for by the increase in women's employment. A large share of the rapidly increasing service sector employment has involved work traditionally done by women at low pay, and throughout the period there has been a marked tendency for much of the new white collar work to be defined as women's work, paid for at relatively low rates and performed by women and until recently by young workers from the baby-boom generation.

Still another observation has to do with part-time employment. The increasing importance of the part-time worker has also been, in large measure, concomitant with the rise of the service sector. Whereas blue collar work is disciplined by the machine and typically carried out in full-time shifts, white collar work can often be efficiently organized on a part-time basis.

A fourth observation relates to sheltering. Typically, workers in the service sector have found less security of the sort provided by unions, licensing, or even the work rules and fringe benefits of large organizations than those in the goods-producing sector. To be sure, many professionals and technicians find protection in credentialing, and some service-producing organizations, particularly public utilities and government, are quite large and have well-established arrangements for seniority and fringe benefits. Nevertheless, for the service sector as a whole, the lack of unionization and the prevalence of small firms, coupled with the greater importance of part-time work, have clearly made for less sheltering.

Taken together, these factors go far to explain why the growth of services has been associated with a major expansion of jobs with relatively low earnings.

TECHNOLOGY IN A CHANGING ECONOMIC ENVIRONMENT

When we turn to the effects of technological change, both the data analysis and general observations tell us that a major thrust of the new technology is to root out and eliminate routine repetitive work. Yet there are contradictory tendencies here for the low-level worker and, in many instances, even for the middle-level worker.

On one hand, we see the computerized cash register at McDonald's with its pictures of Big Macs and Chicken McNuggets that permit the inexperienced young employee to serve the customer very quickly and actually make accurate change. On the other, we see the word processor, which creates a need for more skillful and responsible operatives than does a typewriter, as well as the integrated, interactive, computerized office, which is likely to require better-trained and better-paid, if fewer, white collar workers.

It is a puzzle. Where functions are integrated, work often becomes more sophisticated. Where more capital is combined with labor, the worker's responsibility as well as his productivity is increased. Yet one is not necessarily entitled to conclude that this is an upgrading of work. User friendliness makes for simplifications and can make for downgrading. Thus there are ambiguous tendencies regarding whether work is being upgraded or downgraded that we need to understand.

The important point, however, is that for at least two decades we have witnessed two sets of forces at work. On the one hand, the rising importance of service activities coupled with the declining importance of factory work has resulted in increases in white collar jobs in both upper and lower levels but with the lower-level jobs constituting the large majority. But all the while there has been a continuing increase in utilization of a rapidly improving new technology that has tended to eliminate routine tasks and to change the nature of work.

Historically, the first set has been in the ascendency, but the accelerating pace of computerization now promises to give greater scope to the second. This is true not only for the office, the warehouse, and the store but for the factory as well. It includes not simply computers and communications but also other technologies.

My general conclusion is that accelerated adoption of the technology is not likely to bring about any radical improvement in the overall quality of employment. Automation or production through CAM or other technologies may cut costs and permit a reduced blue collar work force to continue to hold jobs in a more internationally competitive manufacturing setting. It may even bring back some manufacturing jobs. It is not likely, however, to be the source of much new employment, nor is it likely to raise industrial wages, given the industrial wage level of other nations. The reality is that we must expect to live in a predominantly white collar society in which the service sector, with its heavy contingent of relatively poorly paying jobs, constitutes the lion's share of employment.

Just how heavily weighted the traditional job distribution of the services is toward low earnings is revealed in the following tabulation for major industry groups of shares (percentages) of employment earning 80 percent or less of the national average in 1975:[6]

Construction	19.1
Manufacturing	17.2
Distributive services	9.7
Retail	60.0
Producer services	45.7
Consumer services	82.2
Nonprofit services	48.4
Public administration	6.4
(excludes health and education)	

Only distributive and public administration among the services have a predominance of jobs that pay at an average or above-average level. Among the remaining service sector groups, poorly paid work makes up a very large share (46 percent or more of all employment).

What we have seen in Drennan's data is displacement of work at the lower rungs of the clerical pay scale and some job expansion at levels not too much higher. Work is being upgraded by the new technology in the sense of being more sophisticated and more responsible. Pay scales may be improving as a result, but they are very likely to remain at fairly low levels.

At the technician, managerial, and professional levels the evidence is not clear. The shift analysis provides tentative evidence that it is in the less well paid technician occupational category that the greatest gains—relative and absolute—are occurring. Moreover, old-fashioned economics should remind us that the user's objective is to decrease, not increase, costs. More and more the sophisticated new technology is likely to be focused on increasing productivity of these higher-level personnel and economizing on their employment.

EMERGING PROBLEM AREAS

At least two major problem areas related to labor markets appear to be emerging as we move into the mid-1980s. The first relates to inequalities in access to career opportunities among various groups of workers. The second relates to inequalities in opportunity among different geographical areas, especially metropolitan areas.

As regards the first, the more widespread application of the new technology may well create new problems for certain groups in gaining satisfactory work careers. A more rapid diffusion of the new technology carries with it the expectation of an increased demand on the part of employers for computer skills, literacy, and, frequently, for a ready familiarity with basic mathematical concepts. Those with superior training or experience in the new technology will enjoy superior employment opportunities. Others will not.

For some time it has become increasingly common for large employers to organize recruitment around a two-track (or more) arrangement. New workers with only high school degrees enter the work force only in certain jobs and cannot advance beyond a certain level. Those with college degrees will usually enter in different jobs and will be given an opportunity to advance to higher managerial or professional echelons. Those with advanced degrees may be allowed to move on even faster tracks. Those with no degrees may be denied any track at all. The problems attendant to these new arrangements are with us now and have not yet been faced.

It is not difficult to see how a further raising of standards of entry is likely to affect the minority youngster who attends a school where these new skills are poorly taught or who is brought up in an environment in which he or she has an inferior motivation or opportunity to learn. The record shows that the poorest gains of minorities have been made by black males in white collar jobs (although they have done relatively well in skilled blue collar jobs). It seems likely that a more rapid adoption in technology in an essentially white collar world raises new barriers to equality of employment opportunity and gives rise to an even more urgent need than previously for a careful reevaluation of our national educational and training policy. The outlook for the factory would not appear to be greatly different. The introduction of highly sophisticated equipment into the manufacturing workplace can hardly be expected to open up job opportunities for the unskilled and untrained.

The emerging problems associated with variations in employment opportunity among different areas, especially among cities, can only be sketched here. Much has been said regarding the rise of the Sun Belt areas and the plight of the old industrial centers, but relatively little attention has been paid to the way in which our metropolitan areas are being affected by the shift to service activities. Employment data clearly show, however, that factory employment has largely shifted away from metropolitan areas and that where older cities have made successful transformations it has been through growth in their service sectors.[7] The new successful cities of the Sun Belt are not importantly specialized in manufactures but in services.

Labor markets tend to differ. They differ among regions and among metropolitan areas and cities. Managerial and professional employment, along with employment of large numbers of clerks and service workers, tends to be concentrated in those places that are being favored by the growth of services, those already established as diversified service centers. Cities specializing in goods production tend to have a large proportion of blue collar workers and a poor service infrastructure. They are, of course, the cities most ravaged by recent waves of industrial unemployment.

One hope for bringing service sector employment to areas of chronic unemployment involves decentralizing back-office-type white collar work via the use of computerized equipment linked through telephone or satellite communication systems. Thus far, however, there is little evidence of an opening up of opportunities among the have-nots of our city system.

To be sure, there has been significant decentralization, but much of it has simply shifted employment to the suburbs. In those instances in which longer-range shifts have occurred, corporations have generally seemed to prefer those urban centers that are already fairly well endowed with services, usually smaller diversified service centers. There has been no trend toward moving such facilities to places where they are really needed, such as the desolated industrial cities of the Middle West.

NOTES

[1] Eli Ginzberg, "The Job Problem," *Scientific American*, November 1977, 237:15.

[2] Daniel Bell, *The Coming of Post-Industrial Society*, New York: Basic Books, 1973.

[3] Goldman Sachs, *The Pocket Chartroom*, New York: Goldman Sachs, February 1983.

[4] The discussion in this section is based largely on T. M. Stanback, Jr., P. J. Bearse, T. J. Noyelle, and R. H. Karasek, *Services/The New Economy*, Totowa, N.J.: Allanheld, Osmun, 1981.

[5] Matthew P. Drennan, "Implications of Computer and Communications Technology for Less Skilled Employment Opportunities," Conservation of Human Resources, Columbia University, unpublished, 1982.

[6] T. M. Stanback, Jr., and T. J. Noyelle, *Cities in Transition*, Totowa, N.J.: Allanheld, Osmun, 1982.

[7] T. J. Noyelle and T. M. Stanback, Jr., *Economic Transformation in American Cities*, Totowa, N.J.: Allanheld, Osmun, 1983.

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Technology and Employment: Effect on the Socioeconomic Structure

Advancing technology raises a host of problems in the arena of employer-employee relations that cover a wide range of issues. Among them are such subjects as wages and salaries, income replacement for employees made redundant by the introduction of new technology, training and retraining, reclassification of functions, relocation of jobs, working conditions, health and safety, and bargaining-unit integrity. Of overriding importance, however, is the issue of employment security at decent levels of income.

The decades-long dispute continues as to whether the work force made redundant or obsolete by initiatives in modern technology will be absorbed as new industries arise or whether structural unemployment will rise as elimination of jobs exceeds job creation. Technology enthusiasts insist that employment opportunities will rise rapidly enough so that more jobs, albeit requiring different skills, will be created than will be destroyed. My personal view of the issue is at odds with this optimistic assessment.

Although employment projections are at best good guesses, they do set the tone for what to anticipate by way of employee displacement. Following, by way of example, are several such predictions, each of which paints an alarming picture of rapid change in employment prospects, with strong inferences concerning the nature and depth of the problem for selected groups.

Item: In fall 1982 Richard Cyert, President of Carnegie-Mellon University, in a report on technological advance noted that by the year 2000 only 3 to 5 percent of the work force in the United States will be employed in manufacturing. The report concludes further that robots alone could replace 1 million workers by 1990 in the automotive, electrical equipment, machinery, and fabricated metals industries and 3 million by the year 2000. "Some time after 1990, robot capabilities will be such as to make all (7.9 million) manufacturing operatives replaceable."[1]

Item: *Business Week*, in its issue of May 23, 1983, cited a finding at Chase Econometrics that "by the 1990's, up to 25,000 robots, plus other computerized equipment, will have reduced by 20 percent the number of workers needed today at the same levels of production." From averages of optimistic and pessimistic scenarios, the UAW concludes that between 1978 and 1985 there will be a 45 percent employment decline in the domestic auto industry, a change so rapid as to be without historical precedent in a basic manufacturing industry.[2]

Item: "The introduction of advanced

technology in the office and service sector will probably accelerate at an even faster pace than in manufacturing. Office work is almost pure information processing, and the art of automated information processing is relatively further advanced than that of automated manufacturing. Thus the automated office is readier than its factory counterpart, and can be implemented more quickly, because there is less capital investment to displace. Furthermore productivity in the service sector is lower than in manufacturing. . . . This adds up to a powerful set of incentives for more speedy office automation. There are several troublesome aspects to this trend; the most serious though is the potential slowdown of (employment) growth in the only major sector of the labor force that has shown healthy increases."[3]

Item: Yamazaki, a Japanese manufacturer of machine tools, has developed a computerized system of machining the beds of lathes, mills, etc., that it distributes under the name Mazak. The system, when it was first installed, reduced the number of machines needed from 68 to 10 and the number of employees from 215 to 12. The entire operation requires five employees on each of two shifts to function as loaders of the massive machine tool bed castings and one employee on the third shift as an occasional watchman. On the third shift the system operates without manpower, with the lights out, with the finished stack ready for delivery to assembly operations when the first shift arrives for work.

Item: *Business Week* devoted a large section of its April 25, 1983, issue to the shrinking of middle management in computer-run offices and factories. It describes in dramatic terms the wholesale elimination of middle-management functions as computers increasingly assume their duties, raising the specter of sharp increases in layoffs and downgrading of functions for this heretofore rather secure sector of the work force.

Thus, the advance of technology, it is widely predicted, will represent a disruptive force of major proportions in the work force, jobs, functions, and overall employment and income security.

A more optimistic macroeconomic view is that nonmanufacturing employment will continue to rise, and the new technology will require vast increases in employment devoted to manufacturing and maintaining the technologically advanced equipment. Therefore, the argument runs, shifts within the work force will limit overall employment disruptions, and redundant employees will be absorbed as growth industries arise.

My own view is that work force disruptions and the attendant problems are occurring so rapidly—and will intensify in forthcoming years—and on such a massive scale that society cannot afford to permit the so-called free marketplace to make the necessary adjustments without fostering widespread structural displacement of workers and inflicting enormous hardship upon millions of workers at all levels, their families, and the communities in which they live. Whether this assertion proves out or not, there can be no question that untold numbers of the work force, ranging from nonskilled blue collar workers to the upper reaches of management, will be seriously affected in many ways. Whole sectors of jobs will be eliminated or radically changed. Shifts will occur in the applicable skills as well as in the locations where the skills will be needed. Whole communities will experience disruption as the traditional economic base is altered or relocated.

What then is required?

- A coordinated method of assessing our nation's strengths and weaknesses and envisioning what the future will look like.
- A system of democratic economic planning in which government, management, and labor cooperate in developing appropriate incentives to provide constructive direction for the economy and specific industries, with due regard for "social accounting."
- An enlightened joint labor-management effort in the collective bargaining arena

focusing on the labor relations problems that the rapid initiatives in new technology at the workplace raise and their solutions.

In short, a sound approach to establishing a rational national industrial policy is needed. This would entail

- Providing a cushion through democratic economic planning against disjuncture in the economic and social life of the nation; developing a comprehensive, cohesive industrial policy.
- Establishing vocational training and retraining programs supplemental to private sector efforts to retrain. Having definitive information nationwide as to where job openings exist or will exist and what kinds of jobs they are is an essential element in establishing meaningful training programs.
- Developing a public sector jobs program to refurbish the failing physical infrastructure, improve community services, etc.
- Encouraging research and development strategies directed toward creating new industries and strengthening existing ones.
- Updating educational systems to provide the learning tools needed to enable future employees to cope with a fast-changing, increasingly sophisticated job market.
- Providing an abundance of cultural and recreational opportunities as technology permits increased availability of leisure time resulting from a gradual reduction in work time permitted by increasing productivity.

These suggestions merely scratch the surface of possibilities, but they suffice to indicate the general direction a thoughtful society must take if it is to be sensitive to the needs of its citizens and their communities and concurrently mindful of the importance of technological progress in the face of the competitive global challenge.

Labor-management relations would require a joint problem-solving effort directed toward methods of better ensuring employment and job security, prenotification of incoming technological change, maintaining the integrity of the bargaining unit, training and retraining programs, and revision of economic benefits to cushion against the adverse effects upon income and to enhance job satisfaction and the quality of work life.

Clearly the issue of technology concerns people more than machines. We must state clearly and unequivocally that the fate of a society does not lie just in the technology of its machines but in the vitality of its citizens. Our national policies and programs must be fashioned accordingly.

NOTES

[1] *BNA Daily Report*, November 1, 1982, A-3.

[2] Daniel Luria, "Technology, Employment and the Factory of the Future," SME Autofact III Conference, Detroit, Michigan, November 9, 1982.

[3] Peter Unterweger, "Work Automation and the Economy," paper delivered at AAAS Conference, May 27, 1982.

DENNIS CHAMOT

A Need for Cooperation Among Private and Public Sectors

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American unions do not oppose technological change. They accept the concept that new equipment can lead to greater productivity. What they do object to, and very strongly so, is the misuse of technology. In other words, we are very much interested in how the technology is applied.

In the modern sense of the term, American unions are certainly not Luddites. Indeed, far more opposition to new technologies comes from the ranks of middle managers than from unions. It is interesting at this point, perhaps, to consider for a moment who the original Luddites were and why they acted as they did.

For this we go back to early nineteenth century England, a period of poor economic performance during which labor-saving technologies were introduced in the textile industry. Textile workers were faced with massive unemployment and reduced wages for those who remained employed. In the absence of any willingness on the part of government to help, those workers faced with starvation smashed some of the textile machines. It is important to note, however, that this destruction was not mindless; it was, instead, a response born of frustration and of clear recognition of the immediate threats of the situation coupled with a lack of any obvious alternative.

Moreover, there was a specific goal: to raise wages in the industry. In this the Luddites were successful. They were also successful in another way. To quote Rosalind Williams in a short piece in *Technology Illustrated Magazine*, "Luddism did buy them time. Because of the threat of machine-breaking, employers thought twice before investing in new devices or cutting wages. Nor were the workers' tactics politically futile. Luddism was a significant factor behind the British Government's decision to repeal the continental blockade in June 1812, which resulted in rapid economic improvement."

The point is not that destruction of machinery is a proper tactic. It is not. What is emphasized clearly by the Luddite experience is that the widespread introduction of productivity-enhancing technologies cannot be carried out without due regard for the social consequences.

One can argue that today's technological advances will result in lower costs, better business expansion and, ultimately, job growth. In many cases this was the pattern in the past. But we believe that the past is not a reliable guide today, in great part because of fundamental differences in the technologies themselves. In the past, technological changes were introduced into workplaces in a slow piecemeal fashion. To a great extent the changes were quantitative, making a particular kind of machine more productive or permitting an individual operator to run more than one machine simultaneously. The essential features of the job itself, though, remained recognizable.

Computers and microchips, however, offer the possibility for massive qualitative changes. It is now possible to think seriously of factories without people, as described by Bluestone (see his remarks). The enormous capacity and speed of computers and microchips allow machines to be given flexibility and some decision-making capabilities, characteristics formerly held within the exclusive province of human beings. Indeed, the often unspoken aim of computer-integrated manufacturing is to have computers control all aspects of manufacturing. We can leave people out by design.

This somewhat apocalyptic scene will not occur any time soon. However, it is safe to say that the trend is in the direction of increasing automation and that as real economic growth resumes some time in the future the increased output will be produced with far less rehiring than was the case in the past during periods of recovery.

What makes potential problems even worse is that not only manufacturing facilities are increasing their use of computers and programmable equipment. Precisely the same situation pertains to the services and office work in general. Developments in office automation are in many ways following the manufacturing pattern. At first, improvements are made in individual machines or jobs. For example, stand-alone word processors are replacing typewriters, and individual productivity is increasing. Just as there is discussion of the peopleless factory, so too is there progression toward the paperless office. Although not explicit, the latter term implies fewer people. The key is the extensive use of computers, microchips, and sophisticated electronic communications.

Several firms are already offering systems that allow an individual to create documents from short memos to major reports, including tables and charts. The system can also file or retrieve documents, tap into large data banks, send messages to other people hooked into the system, and receive computer-generated reports without the assistance of secretaries, file clerks, or even middle-level managers.

In general, the service sector of our economy has been relatively labor intensive. Automation is occurring here as well. Banks have automatic teller machines, automatic machines for check processing, and computer terminals for their tellers, eliminating much internal clerical work. The fast-food industry in Japan is reported to be considering the use of robots. The telephone system here has converted to electronic switching, eliminating both telephone operators and maintenance jobs. Even the U.S. Department of Labor uses an automatic cart for the internal delivery of mail.

It can be argued that all of this new technology creates jobs in the manufacture, installation, maintenance, and use of the new equipment. This is true, but the displacement is greater. It is a question of relative rates. If productivity increases faster than the growth and total output, employment will drop. It has been said that automobile industry calculations indicate a net displacement of two to four jobs for each robot installed. In the banking industry the estimates are as high as 30 percent for the net job loss during the decade of the 1980s, even with great economic growth for that industry.

The key points are that (1) modern technologies have incredibly large capacities, and (2) the applications are being found throughout our economy in every kind of organization at every level. We are faced with nothing less than the redefinition of work, and in the process many positions will be eliminated. All of this leaves us with several major issues. In the first place, we may be entering a period of permanent labor surplus. As the economy improves, the unemployment rate may not drop to levels as low as it has in the past. Fewer people will be needed to produce the higher levels of output.

High unemployment is a drain on our economy now. It is estimated that a 1 percent rise in the unemployment rate results in adding about $30 billion to the government's deficit, a combination of lost tax revenues and added spending. Continuing and growing high levels of unemployment are also socially unacceptable. Technology has an impact not only on displaced workers but also on those who are employed. All forms of work are affected. Simultaneously we see jobs being made more flexible and challenging and other jobs being simplified and dissected, requiring far lower levels of skill.

In addition, electronic monitoring and computer pacing are leading to greater levels of job stress. Technological developments sometimes tend to take on a life of their own. Yet engineering designs are not handed down from heaven. They reflect the parameters and constraints within which the designers work. The results may not always be those that are most desirable from a social policy standpoint.

It is also important to remember that just as technology is not the sole cause of our problems, neither is it the solution. Profitability depends on many things. There may be some connection with labor productivity, although labor is no longer the dominant factor in many businesses. Profitability and competitiveness certainly depend on managerial skill and competence, engineering and design ability, marketing skill and vigor, and product attractiveness and dependability; in short, they depend on a host of factors only indirectly related to technology.

Labor cannot be made the scapegoat for all our ills, yet one senses that some business decisions related to automation or related to the specific designs of particular technologies seem to assume that cutting labor costs is the only goal. Japanese wage rates have been rising much faster than our own, and Swedish and German wages and tax burdens are high. These countries have competed very well over the last few years.

There is one other consideration. Some think that our economy does well with a mechanized agricultural sector utilizing only a small work force—in fact less than 3 percent of our work force. Those individuals then extrapolate these ideas to the manufacturing sector, having it automated and using only a fraction of today's work force because we will have an expanded service sector based on growing information-age businesses.

There are some problems with this line of thought. First, business expansion in information technologies does not necessarily translate into job growth because many of these businesses may be less labor intensive than the businesses they replace.

Second, even when there is job growth, it must be remembered that electronic work is very portable. Hence there is no guarantee that the jobs will stay in the United States. Not only office jobs are portable. The recent decision by Atari to close an American manufacturing facility and shift several hundred jobs to the Far East demonstrates that the growth of high-technology industries does not necessarily translate into reduced unemployment in the United States.

Therefore, I am pessimistic to the extent that if nothing is done, the problems associated with technology's effects on employment will be major. There are things that must be done. Our society could not long exist with ever-widening gaps between those who benefit from new technology and those who are cast aside.

The potential benefits of computers, robots, and other modern technologies are very great, but they will not come automatically. The situation will require major changes in social policy, e.g., reductions in the work week and retirement age, which are not technical problems subject to engineering solutions.

The engineering community does, however, bear a special responsibility here. Many of the technologies in routine use today are so complex that the technical details are beyond the understanding of the average worker or politician or even the average corporate manager. Engineers have a special mission to communicate with those who are going to be affected by their decisions. We can no longer afford to design systems with only a technical goal in mind. Social considerations must be incorporated at the design stage.

The full effects of technology on employment will not be easy to unravel, nor will it be easy to anticipate all of the problems that may arise. Only one thing is certain. It is going to take the combined efforts of the business and engineering communities, labor, government, and the public if we are to realize the full benefits of our creative input.

HARLEY SHAIKEN

Short-Term Consequences of Technological Change

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As more and more attention is focused on economic recovery, for 11 million people the grim reality is continued unemployment. Against this backdrop the central issue raised by rampant and pervasive technological change is not simply how many people may be displaced in the coming decade but how many who are currently unemployed will never return to the job. The problem for millions of people is not a long-range one at all. It is all too immediate and all too grim.

The discussion of technological change and unemployment raises three basic questions. First, will enough jobs be generated? Second, who will have access to the jobs that are available? Finally, what will be the quality of those jobs?

Without question, new technology, particularly that based on computers and microelectronics, provides possibilities for more creative work, higher productivity, and important gains to the society as a whole. This same technology, however, developed and deployed without regard to social cost, could result in sustained, technologically induced unemployment. In fact, what we may be looking at is our first high-technology recovery; that is, the economy begins to improve while unemployment remains high.

Much has been said about the role of technology in improving competitiveness. This discussion, however, has been far too narrow. While new technologies based on computers may be vital for competitive success, what happens to those people who are displaced as the price of competitiveness? Microelectronics may sever the link between competitive well-being for the firm and the generation of unemployment. This new reality was illustrated at a meeting of the Business Council in May 1983. The lead to a front-page *New York Times* article covering the meeting reads: "Leaders of major corporations who met here this weekend said they would rehire few of the workers they laid off during the recession, no matter how strongly the economy recovers." In many basic industries this could mean that one-fourth to one-third of the workers during the peak employment in the 1970s will never return to the job.

Automation based on computers and microelectronics is different in some qualitative ways from previous forms of mechanization. Computer-based automation is not a new way of cutting metal or transferring characters to the printed page but rather the automation of the collection, dissemination, and use of information. Not only can the processing of information be automated in occupations as diverse as welding and typing, but computers and microelectronics also make possible the automation of complex engineering jobs in high-technology industries. Many jobs between senior design and engineering occupations and the shop floor—jobs often associated with the routine transfer of information—may go through the most dramatic transformation as a result of computerization.

The extraordinary scope of computer-based automation brings to question some of the more optimistic projections we have seen about job creation in the coming decade. For example, the Bureau of Labor Statistics tells us that in the next 10 years we may need 3 million more secretaries and office clerks, yet it is precisely these occupations that could be significantly affected by technological change.

There is also an important hidden dimension to the use of computers and microelectronics in the workplace: Applications of stand-alone machines in a given work situation (for example, a robot automating what a welder does on the assembly line) are being replaced by automated systems that more fundamentally integrate and reorganize production. The change from stand-alone machines to systems technology has clear implications for employment. The productivity gains of a stand-alone robot versus a welder in the auto industry may be in the range of each robot replacing two or three people, but the productivity gains of systems may be on the order of 5:1 or 6:1 and in some cases as high as 20:1. And integration of individual machines into systems often does not require heavy capital investment.

A further aspect of technological change that makes it quite different from previous forms of automation is that telecommunications and computers facilitate the transfer of production around the world. The global factory is rapidly becoming a reality. A University of Michigan study, for example, pointed out that one-third of the parts used in assembling automobiles in the United States by the 1990s could be imported. The potential impact on employment is obvious.

Even if the economy solves the problems in the aggregate of generating enough jobs for the number of people who want to work, who will have access to those jobs and in what time frame? In order to upgrade from existing jobs, one must have something to upgrade into. Unfortunately, one of the key characteristics of the application of automation in many industries is the creation of two-tiered work forces, with a relatively small number of well-paid, highly skilled, and creative jobs at the top and a much larger number of low-paid, boring, and tightly controlled jobs throughout the rest of the firm. In some cases the gap is widening. In Silicon Valley, for example, the starting wages of engineers grew 33 percent between 1974 and 1978, while the beginning wages of production workers in the same time period grew by only 7 percent. This separation is exacerbated by the lack of career-ladder progressions into better jobs because many intermediate occupations may no longer exist in sufficient numbers.

The application of automation could also exacerbate geographical divisions. Many northern cities such as Detroit, Gary, or Youngstown may be turning into "manufacturing Appalachias," regions that do not share in the economic growth that occurs in the rest of the economy.

Even when a given geographical region does manage to successfully develop a new industry, it is no guarantee that the people employed in the formerly dominant industry or industries will be hired into the new jobs. A study done at the Joint Center for Urban Studies at Harvard and MIT of what happened in Lowell, Massachusetts, is a case in point. Of those people employed in textiles in Massachusetts, only 3 percent found their way into high-technology employment, although this field obviously created a substantial number of jobs in Massachusetts.

Finally, let's consider the quality of the new jobs being created. Obviously, computerization has the potential to improve work, making jobs more creative and skilled in a wide range of areas. While many routine and boring jobs have been eliminated, however, the same technology has been used to convert some very creative jobs into boring and routine occupations, lowering the quality of life for the workers involved. Instead of people commanding the machine, instead of the computer being the tool for those who use it, the person is directed by and subservient to the machine.

This was graphically illustrated by an article in *The Wall Street Journal* about an insurance company in Massachusetts. Quoting a woman who processes claims in a branch office in Plymouth, Massachusetts, the *Journal* stated: "The girls at work call it a sweat shop. Most of them figure they won't last more than two years."

These findings were further corroborated by a recent study of operators of video display terminals (VDTs) in clerical jobs conducted by the National Institute of Safety and Health. These clerical operators exhibited a very high level of stress. The VDT itself was not at fault because another group of professionals and managers using the same technology displayed a much lower level of stress. The real problem was the combination of the technology and the form of work organization that led to a clear erosion of the quality of life on the job.

The real issue is one of choice because the technology provides some very different alternatives. Computer-based automation makes possible more creative work or electronic Taylorism—the fracturing of jobs and their tight control by management. Unfortunately, rather than associating the concept of choice with automation, the word we most normally associate with technological change is *inevitability*. This is a critical mistake. But if we are to take choice seriously, the issues are not only technical in nature; they are political and social.

The point at which the choices should be examined, however, is not after the fact—not how do we adapt to the technological changes that have already taken place, but how do we design and develop new forms of automation to ensure that technology enhances human capabilities and improves the quality of life on the job? In other words, what types of technologies do we want to establish the kinds of workplaces that can most fully use the uniquely human qualities of initiative, creativity, experience, and skills? For these choices to be meaningful, they must take place within the context of full employment and training and upgrading for those people who are displaced. Although even retraining has been inadequate, a preferred and comprehensive approach is pretraining, that is, providing a structure for workers to obtain new skills prior to major change taking place.

Merely speaking about becoming more competitive without creating a mechanism to translate productivity gains into benefits for those who are displaced runs the danger of creating not the Japanese or the West German model for the U.S. economy but a Brazilian model in which high economic growth is associated with high unemployment and with millions of people who do not share in that growth.

The wage remains the key way in which people plug into the distribution of goods in the economy. The extent to which they do not have access to paid livelihoods is the extent to which they are frozen out of whatever gains the technology may bring. Under these circumstances, reduced worktime becomes an important measure to consider in expanding employment.

We must also talk about democratic planning in a way that ensures survival not only of the individuals affected but also of the communities in which they live. It is not enough to seek to transfer everyone who is gainfully employable from one city to another. What we leave are those people who are least employable and an infrastructure that is no longer self-supporting. What we then have is a "manufacturing Appalachia" that may last far longer than the kind of grim realities people in Appalachia faced during the 1950s and 1960s and that many face today.

Finally, we must talk realistically about the participation of those affected by change and the way changes are made. If we are to take choice seriously, those who are affected by change must have some input into the choices available concerning how the changes are made. This involves bold and innovative challenges; but anything less may not be up to what we face in the future.

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Effects of the Confluence of Technologies

We are experiencing a fundamental change, namely, the confluence of three technologies: semiconductors, computers, and communication. These three technologies and their industries are merging and are both the reason for and the cause of what we are experiencing.

Although over the last 30 years we have seen a rapid rate of change brought about by these technologies, the rate of change will be greater in the future; what we have experienced to date was only the start-up period of these new industries and a gestation period for these technologies. To make this point, let me cite the sudden and unexpected proliferation and use of personal and home computers. Even two years ago neither the public, industry itself, nor technical and financial analysts forecast the extent of the demand that we are experiencing today; nor was the breadth of their use foreseen.

Exploiting these technologies in the manufacturing industries, the office and the service industries, and the academic environment transforms the approaches and activities that have been commonplace in the past. In turn this change creates the need for new skills and resources with different training, attitudes, and capabilities than have been required in the past.

What is different about this change? Industry has undergone changes for 200 years. This change is not any more fundamental than that brought about by the Industrial Revolution; neither, however—and herein lies the crux of the matter—is it any less fundamental. This change is the mechanization of information: the access to it, the reduction and analysis of data, the capability to draw inferences from the data, the measurement and acquisition of real-time data fundamental to the control of processes, and the modeling and simulation of problems not just in the sciences and engineering but also in the social sciences, business, and other human activities.

I hesitate somewhat to use this term, but these packages of "mechanical intelligence" in the form of microprocessors, computers, and intelligent terminals are the implementation of the change we are experiencing. I would like to discuss this new environment and its effect on the employees in the industrial sector.

ENVIRONMENT

The question posed here and elsewhere, namely, what the net effect of these changes is with regard to total employment, is difficult to answer. The question, however, needs a quantitative answer: Episodal and anecdotal descriptions are not sufficient to settle the issue between those who are optimistic about the outcome and those who are pessimistic, nor is that approach helpful in arriving at needed programs and new policies. In fact, it might be that no single answer is forthcoming from such an inquiry. But out of a range of plausible scenarios and their analyses it ought to be possible to derive some directionally useful information.

The reason this problem is difficult is that the change caused by the new technologies is occurring at a time when many other changes are impinging on industry and the economy. It is a single equation with many variables, a formidable mathematical problem. Some of the additional environmental changes are:

- Increasing worldwide competition: Today the market is the world; competition can come from any quarter.
- Growth is slowing in the manufacturing industries, while the service and information sector of our economy experiences an increasing rate of growth. This in turn results in dislocations.
- Automation is not just affecting manufacturing through conversion to computer-integrated manufacturing; it also affects the office and the whole of activities in the service industry in a significant way. This results in an increased demand for the "information worker" and a corresponding decrease for the classical skills of the blue collar worker.
- The increasing rate of technological change causes faster obsolescence of the individual's knowledge base.
- As some researchers have pointed out, the U.S. economy can look forward to slowing growth of the work force. In the last decade the growth of the work force was 2.5 percent per year; in the 1990s it will decrease to 1 percent because it has already absorbed people born during the baby boom, and the peak caused by women entering the work force is also behind us.
- For these demographic reasons, our work force is aging. The proportion of workers age 30 and older is increasing by 5 percent, compared to the work force less than 30 years old.
- There are and will continue to be shortages of certain skilled workers, such as computer scientists, electrical engineers, machinists, model makers, and automation technicians, while at the same time there are surpluses in other skill categories.
- The complexity of the tasks (I will come back to this point a number of times) required of every employee is increasing; so is the breadth of the job.
- Last, the social expectations of the work force are increasing at the same time.

IMPLICATIONS FOR MANAGEMENT AND EMPLOYEES

This new environment has implications for management and for employees alike. First, the capability to learn and to relearn many times during the working life is a necessity. Second, compartmentation of an individual's job without regard to content is no longer acceptable. Neither is it efficient or effective. Third, the investment by management in an individual employee in terms of training, education, and support is both mandatory and increasing.

One can best illustrate these points by some actual examples. The first is the activity and the tools of a secretary. In a relatively short time the secretarial workstation has evolved from use of a typewriter to use of a word processor and now to use of a personal computer as a primary tool. And the computer in turn is rapidly becoming part of a sophisticated communications and data network. The secretary is becoming a communications and knowledge expert.

The second example is that of the electronics engineer. Circuit analysis, for instance, has moved from a primarily experimental engineering task to one of modeling and simulation. The circuit laboratory has been replaced by the computer and experimentation by analysis, simulation, and modeling.

The third example is that of a blue collar worker who is no longer tied to a repetitive, single task, but is now part of an automated and integrated manufacturing operation. He is no longer concerned with direct product tasks. His role is now broader; it is the role of an analyst and maintenance technician making changes to tools, modifying software, and changing the process itself.

Management is also affected. Management must rethink its approach to problems; its planning must be more long range because many old and tried approaches are no longer applicable. An example of that change is the behavior of some companies in the U.S. semiconductor industry during the last recession. Some of these companies did not take the approach that they had taken in the past. They did not resort to layoffs of direct workers, technicians, professional people, or managers. The reason was as profoundly simple as it was new: The investment in the employee was too great and rehiring and retraining once the economic upturn occurred was too time consuming and too expensive to make it a reasonable alternative.

After these examples, let me be more general and discuss first the part of the work force of particular interest to this audience: the technical professional, the scientist, the engineer. He leads the change and makes the new wave that I have been discussing; but paradoxically he is the first to face technical obsolescence, namely, the obsolescence of his knowledge base and of the tools he was accustomed to and knew and understood, the obsolescence of what he does and how he does it. Furthermore, the relationships between classical organization lines in which the professional person in industry operates, like research, development, and manufacturing, are also changing. Especially as we move into a process-oriented manufacturing approach, manufacturing and development are becoming more intertwined and can be expected finally to merge. A close working relationship is a necessity, no longer a nicety.

The cost of the professional to the enterprise is increasing, not just in terms of salary but also in terms of the support cost for professional workstations, access to networks, data bases, and sophisticated laboratory equipment and instruments. The focus, therefore, is on productivity of the professional, a difficult parameter to assess or measure but nevertheless one that will become of increasing concern.

There is a mandatory requirement today that the professional person and the employer share: the requirement to counteract obsolescence of the knowledge base by lifelong education. It is no longer a voluntary activity; it is becoming mandatory. More than anything else, this particular area needs new approaches and new emphasis. The new tools that are causing the problem can be part of the solution, as exemplified by graduate-level courses disseminated by TV, videotape, and satellite networks. An early and bold example is the one proposed by the Association for Media-Based Continuing Education for Engineers (AMCEE), which encompasses the activities of 20 universities.

Within a company, more can be done in this area. IBM has three major programs aimed at the scientist and engineer:

- Internal institutes on manufacturing technologies, computer science, software engineering, and quality.
- A work-study program leading to a master's degree that is taught during work and evening hours, with the provision for one semester on campus to accelerate the process.
- A new requirement for 40 hours per year of technical education for the technical staff, including technical managers.

Have I put too much focus on lifelong technical education? I do not think so; it might be the most important activity that industry can undertake.

Universities are faced with the problem of bringing the curriculum of engineering schools up to the requirements of the new environment. Such disciplines as systems analysis, systems engineering, manufacturing engineering, and software engineering all demand urgent attention and focus.

Let me now turn to the other major groups of employees: the production line worker, the clerical worker, the technician. Their problem is analogous to that of the professional employee—the requirement to learn new aspects of the job because the job content itself is changing and so is the environment. As mentioned before, this person is doing a more integrated job; the broader assignment demands increased skills and, therefore, increased training. In fact, training has to become part of the job assignment. It has to be built into the job and reckoned with as a mandatory activity. Therefore the investment in this individual is also increasing. This in turn means that management needs a different attitude vis-à-vis this group of its employees.

The effect on management itself of this new world is equally profound. The shrinking pyramid of management has been discussed in previous papers. This shortening might be helpful in the end because the communication path through that pyramid in the past has not always been as smooth as it should have been. But more important, the need for a wider time horizon in goals, planning, and assessment of risks and rewards is an even bigger change, requiring a new approach to the management of an enterprise. The higher investment in the employee demands that he be valued as any fixed or capital asset, not as the variable in the cost of production that he was in the past. This, in addition to the social concerns and the heightened social expectations, leads one to the conclusion that lifelong employment will become the rule rather than the exception that it is today.

The temptation is to say "Japan revisited"; but it is interesting to note that IBM has had the practice of lifelong employment for over 50 years. To say it was ahead of its time is self-serving. More important, the product and the marketing strategy of IBM probably demanded this farsighted approach. Even before the advent of the electronic computer, IBM was involved with complex machines such as punched card equipment, accounting machines, and time clocks. What it represented at that time was the "mechanical age of computers." The IBM marketing strategy was to lease and not to sell its products and, therefore, IBM was at risk, not the customer. This demanded focus on quality and service, and the combination of complex product, high quality, and high service cannot be accomplished with high turnover among employees. The dependence on a well-motivated and well-trained work force in manufacturing, in the laboratory, and in the field was a prerequisite to success. What better way to achieve it than to provide stability, better-than-average pay, and the respect that the individual deserves?

The acceptance and the application of the new technologies are gated by the changes management is ready to make in philosophy, in its attitudes and its capabilities for learning. It is not gated in most cases by the availability or capability of the technology itself. That, I believe, is often the reason some companies fail and others succeed. In some companies there is the social readiness to accept change and handle change while in others there is not.

SUMMARY

The changes brought about by the new technology affect all people in industry, not just the blue collar worker but the technical professional, the white collar worker, and management alike. In addition to preventing unemployment, preventing obsolescence of the employee is equally important. If we recognize these changes and the new requirements, it might lead to a more responsible and more stable—not static—industry structure and industry environment.

PAT CHOATE

Productivity Growth: The Worker

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In his *Wealth of Nations*, Adam Smith noted that people are the premier resource of a nation and its first responsibility. His observation raises a challenging conundrum: How does a nation in rapidly changing times use its people as its premier resource? The issues discussed in these papers concerning technology and the worker cut to the very core of that conundrum.

In addressing this challenge, it is important to include perspectives that are perhaps different from those we have held in the past. To paraphrase a great philosopher, E.T., "We are not alone." Today the U.S. economy is no longer closed; it is complexly and intricately entwined with the global market. Therefore, any analysis of technology and workers must be approached from the perspective of the United States in a global market. In testimony before the House of Representatives' Committee on Science and Technology in June 1982, for example, the Department of Commerce presented projections that indicated the United States would have approximately 100,000 advanced robots in use by 1990. It was also projected that there will be a million advanced robots in use worldwide. Therefore, in a world of ubiquitous technology, we must consider what 900,000 robots outside the United States will mean to U.S. employment.

Clearly, other nations realize that their economic future depends on being able to produce goods and services that are competitive in price, quality, service, and innovation. The introduction of the new and often comparable technology in other nations may have a greater impact on U.S. employment than technological change within the United States: Foreign technology will create products that compete against viability and employment of an entire firm or industry—not just the part that is automated.

Today, and certainly for the foreseeable future, the United States no longer controls the pace of technological innovation—the most advanced firm in the world economy does. Consequently, the United States faces difficult choices that extend far beyond the issue of what to do with U.S. workers displaced by the introduction of new technology *within* the United States.

The first of these choices is whether it would be wise to attempt to slow the pace of technological innovation and diffusion worldwide. Shall we try to "cartelize" the introduction of technology with all the difficulties that would bring? Shall we take the view that we wish to regulate foreign competition in the United States? Is the United States willing to move away, even in a modified form, from the free-trade principles that have guided our foreign trade activities and erect formal barriers to the introduction in U.S. markets of foreign products made with superior technology—be they formal barriers or, as with the automotive restrictions against Japanese manufacturers, "voluntary."

Do we really wish to attempt to retool our capital plant and our work force and our institutions so they are adequately competitive and adequately flexible to adapt to succeeding waves of change that improved technology always brings?

We will probably do some or all of these things. However, the latter course, helping our work force and businesses to adapt rapidly, is the preferred course and is the action that will bring the most benefits to all—here and abroad.

However, if that is to be done, we must begin with the assumption that our institutions, both public and private, are essentially unprepared to make the changes necessary to help our work force adapt. Basically, we do not have incentives that encourage and facilitate substantial investment in workers beyond the time they are young. Rather, our preferred route to productivity growth is investment in capital and technology over investment in workers—the nation's human capital. Fortunately, this course of the past offers a major opportunity in the future.

Specifically, the absence of policies for retooling the American work force permits us to create institutions and policies appropriate for our times. Such institutions and policies must be based on the assumptions that (1) technology-based change will be a constant for the foreseeable future that is unstoppable; (2) technology will become ubiquitous in the world economy; and (3) change will occur so rapidly and so diffusely that it will be very difficult, if not impossible, to predict what the future will be beyond 5- to 10-year periods.

If change will occur but we cannot accurately predict the ultimate directions of that change, it then is necessary to build into our institutions the flexibility to respond positively to whatever the future might bring. Flexibility becomes the key. The solutions proposed by Professor Bluestone in his paper very much speak to the core of what must be done to create such flexibility.

First, we do need improved labor market information. We need to know, particularly in the short term and by specific geographic regions, the jobs that will be available and the human resources available to take those jobs. Creating such information and making it widely and easily available will be neither a difficult nor an expensive task.

Second, we need to modernize the nation's approximately 4,000 institutions that provide training and retraining for adults. While the buildings in which these institutions operate will be adequate for many years, the equipment in a growing number is already obsolete: It does little good to teach today's workers on 1970s technologies. Equally important, the skills of the faculty must also be modernized.

Third, we must rebalance public policy so firms have as much incentive to invest in worker training as they do in modernized plants and technology. Since the workplace is often the best place to acquire skills, particularly on proprietary equipment, ways must be found to stimulate greater investment by the private sector.

Finally, there is the issue of displaced workers. At least 2 million, and likely more, workers who are unemployed today will never return to their old jobs because these jobs have disappeared. Most of these workers have skills, are competent, and need a job. But they will not be able to secure work until they have new or at least different skills, and in many cases relocation will be necessary. Presently, the only response is a maze of 22 ineffective federal programs that will assist fewer than 200,000 workers in 1983. The time has come to devise some better way to ensure that any worker displaced because of changes in technology or trade will be assisted back into a job with good labor market information, counseling, training and, where necessary, relocation. Moreover, much like the GI bill was after World War II, such a system must be established in a way that will permit great choice and flexibility for the worker, the person who ultimately will bear the consequence of any decisions.

These are difficult questions. But they must be faced. How well and at what pace we do so will determine how well and at what pace we are able to modernize the American economy and meet the competitive challenges we face.

JOHN S. REED

Vice Chairman
Citicorp

Employment and Unemployment in the Service Sector

The topic of the long-term impact of employment and unemployment in the service sector can be seen from many perspectives and embraces a number of different problems and, of course, some opportunities. It is probably important to begin by saying that if we are really to look at this topic, we should recognize at the outset that the impact is not at all clear. If we look at the data, we find that persuasive comments can be posited on all sides of this issue. The subject is clearly important, and it lends itself to a much more detailed study, both at the mechanical level and at the policy level. There are very significant social and policy issues that must at least be put within a framework, and there is need to get good hard data to provide a better sense of what is happening.

The service sector already has been substantially affected by the electronic communication/processing revolution. The future impact will be even greater.

As a baseline assumption the communication/processing revolution is likely to have very much the same employment effects as the technical revolutions in manufacturing between 1800 and 1950. In the United States, for example, output generally expanded in those industries with the fastest improvements in labor productivity. Consumers ultimately expanded their purchases most rapidly for products whose real price declined most. The result is that over the decades there has been little relationship on an industry-by-industry basis between growth of productivity and growth of employment.

At the same time, retraining, on-the-job education in new skills, and geographic mobility of labor as people individually sought to maximize their lifetime earnings meant that the supply of human capital kept pace with shifting demand for human capital. The skill composition of the labor force has changed radically over time, but unemployment in the United States has generally averaged close to a normal frictional level, currently estimated at around 6 to 7 percent of the labor force.

The Industrial Revolution had a multiple effect on skill requirements. It created huge needs for highly trained engineers and technicians. It generated even larger requirements for semiskilled operatives. And, in the process, many skilled handcraftsmen became obsolete. Even in the long run, job displacement constituted a real, though modest, social cost. And on an individual basis, the cost often was overwhelming.

We can already see that the electronic communication/processing revolution is exerting a similar impact on the service sector. Growth of service employment in the past 10 to 15 years has been most rapid in "business services"—including engineering and technical services, business-security services, and management consulting—and in health services and the entertainment business. Employment has grown moderately in finance, education, trade, and a variety of nonprofit activities. Employment growth has been slowest in old-fashioned personal services, such as laundries and beauty shops.

Some of the forces at work are demographic and social—declining growth of the school-age population, for example, and burgeoning publicly financed health and welfare programs in the 1960s and the 1970s. But the explosive growth of business services is most instructive and potentially the most important factor. Most business-service industries have been growing at a pace of 5 to 7 percent per year because the effective real cost of people transactions, financial transactions, and information transactions has been declining. In turn, because the demand for business services is responsive to cost reductions and to improved performance, the output of business services has increased. Employment in business-sector industries can be expected to continue to grow by at least 4 to 5 percent per year, 2 to 3 times as fast as employment growth in the nation, and 5 to 10 times as fast as industrial employment.

Speaking on behalf of Citicorp as a representative service industry, I can say that on a worldwide basis we have been attempting to bring information technologies into our own activities as rapidly as we possibly can. We probably have more work in front of than behind us, which undoubtedly implies that our work will continue.

About one-third of our new hires at Citicorp now are managerial and professional, a far cry from 5 to 10 years ago. At the same time, the increasing efficiency and sophistication of electronic/processing equipment have enabled us to eliminate many low-skill jobs. In

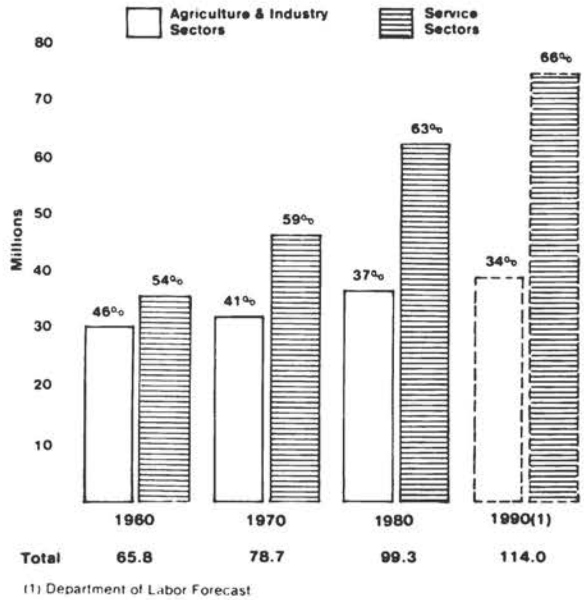

FIGURE 1 U.S. civilian employment, by sector.

the total service sector, the number of clerical jobs probably will continue to swell faster than total employment in the country as a whole, but at Citicorp we envision a declining proportion of our jobs in purely clerical capacities.

We are continuing to increase our aggregate employment, and while there are lots of problems in the company and there is a great deal of training going on, we have found on a worldwide basis that we are increasing both the number and quality of jobs. So, at least on a sort of front-end basis, we have found that while technology is relevant and brings with it many challenges, it has not been, at least within our own particular situation, the disruptive force that some would suggest.

On the other hand, speaking for the service industry at large, we are looking at the leading edge of a fundamental change. There is no question that the advent of electronics and the so-called information society is going to have a very dramatic impact on the service sector of this economy—what it looks like, what its prospects look like, what opportunities it represents, what impact it has on the country.

The figures that follow are presented by way

	Employment (Millions)		Employment (Millions)
AGRICULTURE	3	SERVICES:	
INDUSTRY:		Communications	1
Manufacturing	21	Trade	22
Utilities	1	Health	8
Transportation	3	Education	8
Construction	6	General government	5
Mining	1	Finance	4
	35	Religion, private welfare services	2
		Laundries, beauty shops & other personal services	1 2
		Entertainment	1
		Repair services	1
		Real Estate firms	1
		Protective services building services & other infrastructure	1
		Legal services	1
		Engineering & technical firms	1
		Other	9
			68

TOTAL CIVILIAN EMPLOYMENT:
103 million

at "normal" 6-7% unemployment rates

Employment estimated - number who would be employed if the economy were at full employment in 1983

FIGURE 2 U.S. employment, by sector, and composition of service sector employment.

of background to illustrate what I mean when I say that we really do not know exactly what we are getting into.

Figure 1 simply confirms what everyone has said; the service sector is growing. It is growing very rapidly, and it is extremely large within our economy. Second, and I think very important, the service sector is not homogenous. Figure 2 shows the service sector in terms of millions of people employed, using an arbitrary base of 103 million. There are in fact lots of different sectors, each of which has its own patterns and each of which will be in its own way affected by technology. Trade, which obviously is extremely important, refers to retail trade and is a major employer. The distribution of both services and goods is one of the major components of the service economy and is undoubtedly going to be one of the areas most affected by some of the changes being talked about. The principal point here is simply that we cannot be simplistic and talk about the service sector; we must look within the sector itself.

Figure 3 simply illustrates that some occupations are going through very high growth. These six occupations are popularly reported as experiencing very high growth rates in

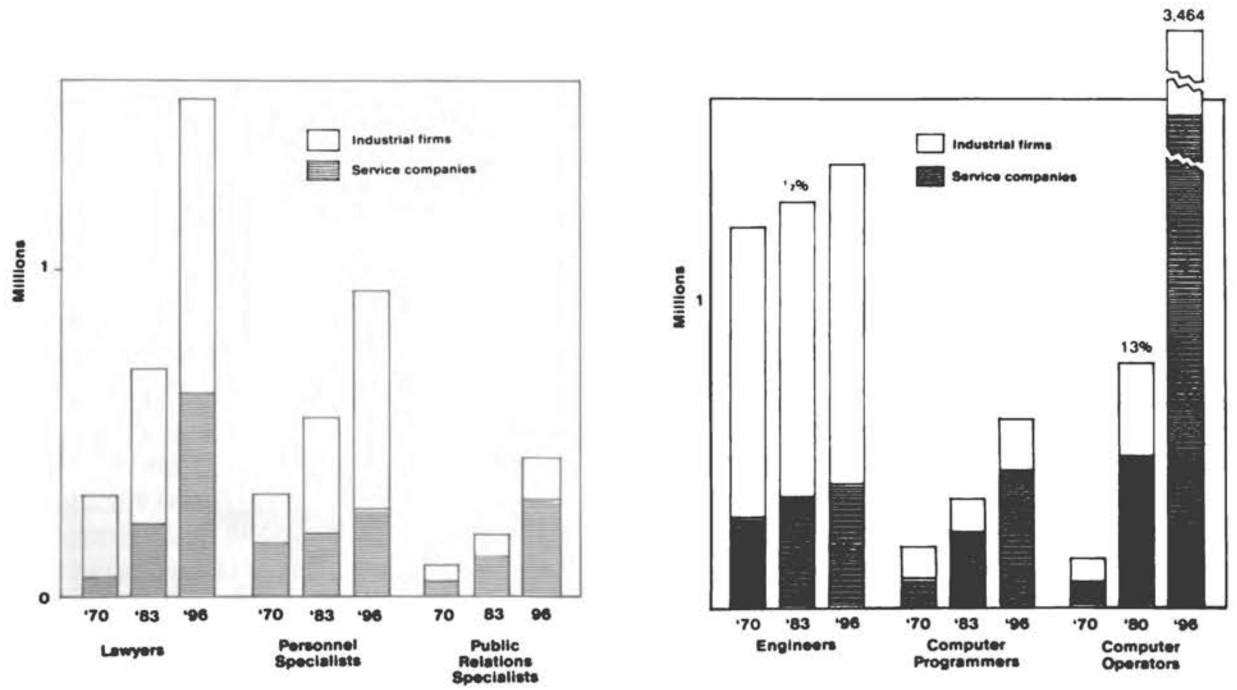

FIGURE 3 High-growth occupations. Employment estimates for 1983 and 1996 are extrapolated from employment levels and growth rates for the 1970s.

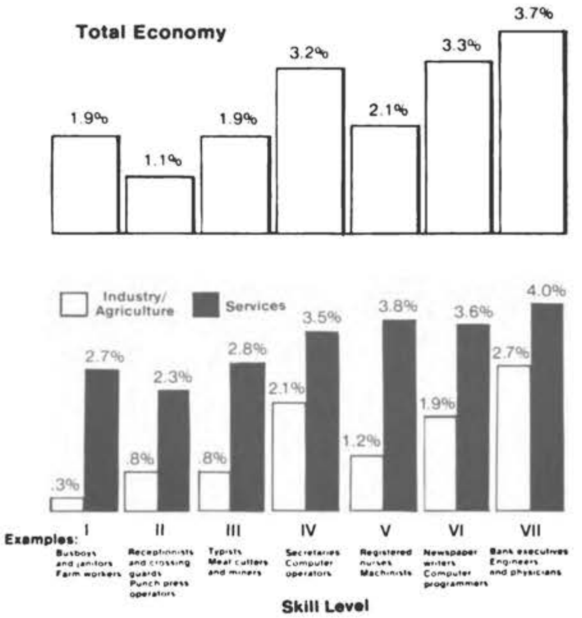

FIGURE 4 Annual employment growth rate by skill level and sector, 1970–1978.

terms of the number of new jobs created, and the data suggest that is indeed an accurate assessment.

The growth rate by skill level as illustrated in Figure 4 is not concentrated at the lower levels of skill. The lower half of the figure shows the service sector and the upper half the rest of the economy. As can be seen by comparing the two, the growth in terms of jobs has taken place across all the skill levels and is not, in fact, concentrated solely at the bottom, or service area—an impression that tends to prevail when we think of the service sector.

Figure 5 shows the nonservice sector and service sectors of the economy, respectively. The X axis represents the number of jobs, and the Y axis is income. Each is an income-job profile of that sector of the economy in 1971.

It is true that the service sector has some low-income jobs; however, I do not believe that it is a solely low-income profile. In Figure 6 the two income-job profiles are superimposed on one another. While the service sector is somewhat broader down at the bottom, it is not a bad fit in terms of the number of jobs and the income distribution as of 1971.

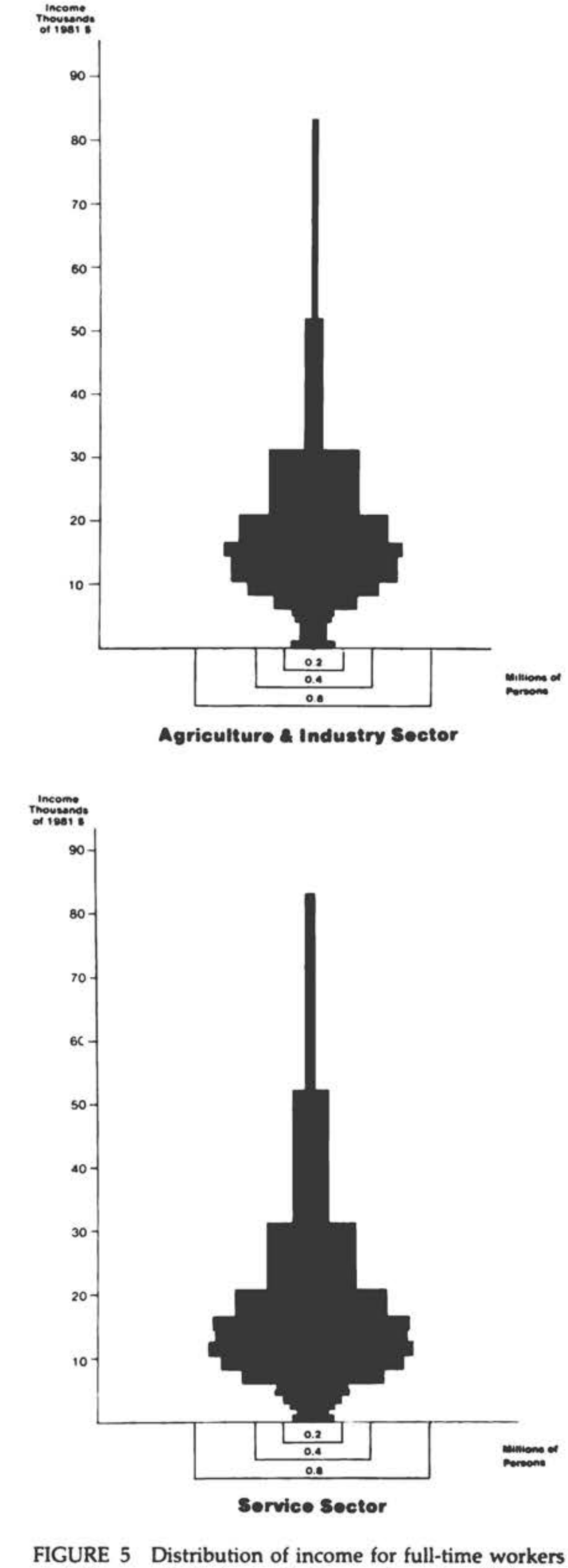

FIGURE 5 Distribution of income for full-time workers in agriculture and industry and in the service sector, 1971.

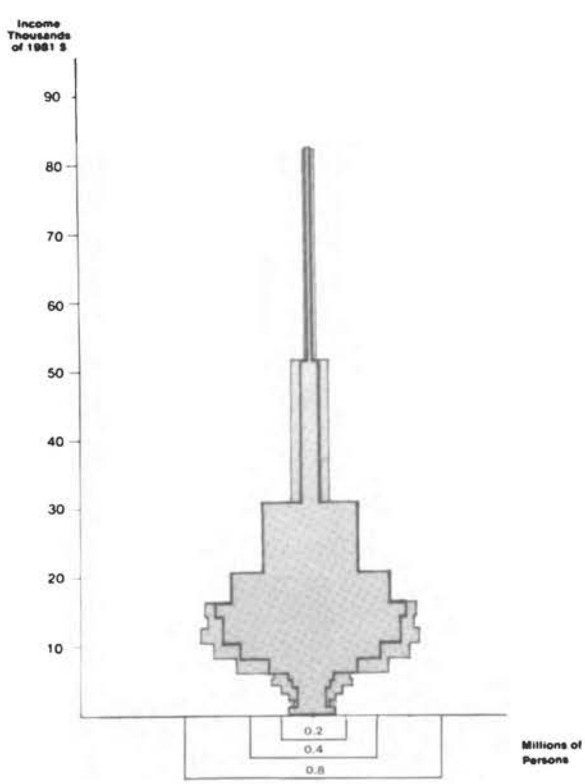

FIGURE 6 Superimposition of income distribution of agricultural and industrial workers on income distribution of service workers, 1971.

Figure 7 shows the 1981 figures for service and nonservice sectors. Although there are some clear changes in the 10-year period that is covered in Figures 5 and 7, the basic profile itself looks very similar, and the nonservice sector portion of the economy does have a fair number of jobs that are well below the $15,000-per-year level. As Figure 7 shows, the service sector is much expanded between 1971 and 1981, illustrating the growth during that 10-year period. Based on this, I would once again suggest that not all of the job creation is, indeed, at the bottom of the scale.

Figure 8 superimposes the sectors shown in Figure 7. Growth in the service sector need not imply that all the jobs created are of a particular low-income category or that they are bunched at the bottom of the scale.

Figure 9 comments on the educational demands of different occupations, showing the education of the workers that were in the

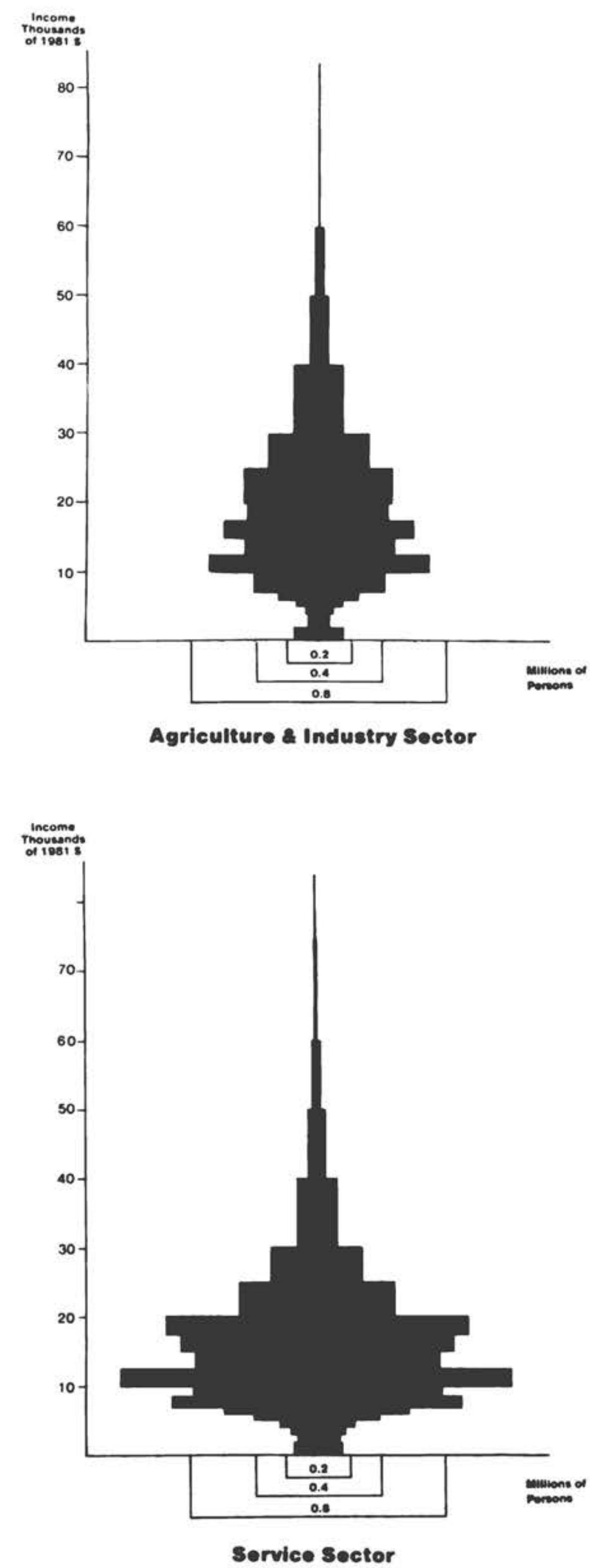

FIGURE 7 Distribution of income for full-time workers in agriculture and industry and in the service sector, 1981.

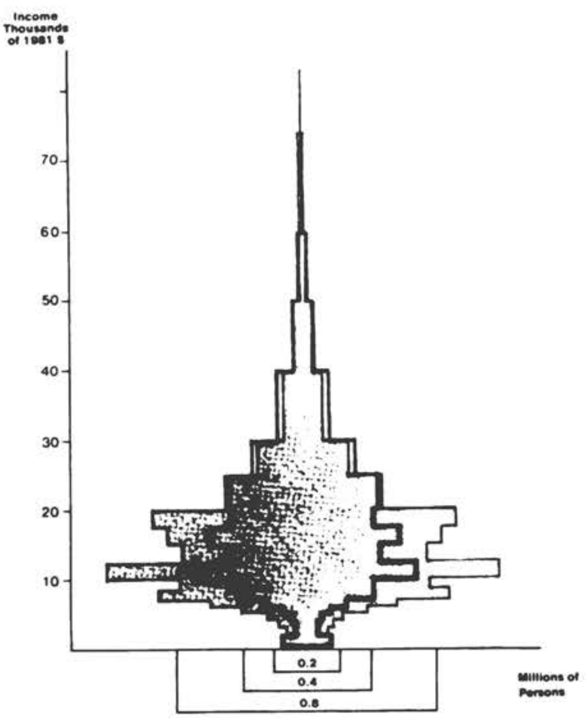

FIGURE 8 Superimposition of income distribution of agricultural and industrial workers on income distribution of service workers, 1981.

nonservice sector of the economy in 1970. Superimposing the agriculture and industry sector on the service sector (Figure 10) shows, at the top end of this scale, some additional breadth, which indicates that the service sector does create a number of jobs requiring high qualifications—recall, of course, the medical services are very much part of this—so some jobs do require high training. I would also comment that if the service sector is going to grow in our economy, we had better get our education system organized or we will not be able to fill those jobs that require reasonable levels of education.

The impact of technology on employment and unemployment, however, is not clear. Figure 11 shows growth in output in terms of percentage in gross employment. Obviously, as industries grow in their output, they also grow in their employment. Figure 12 shows the productivity growth and the output growth. As productivity grows, output

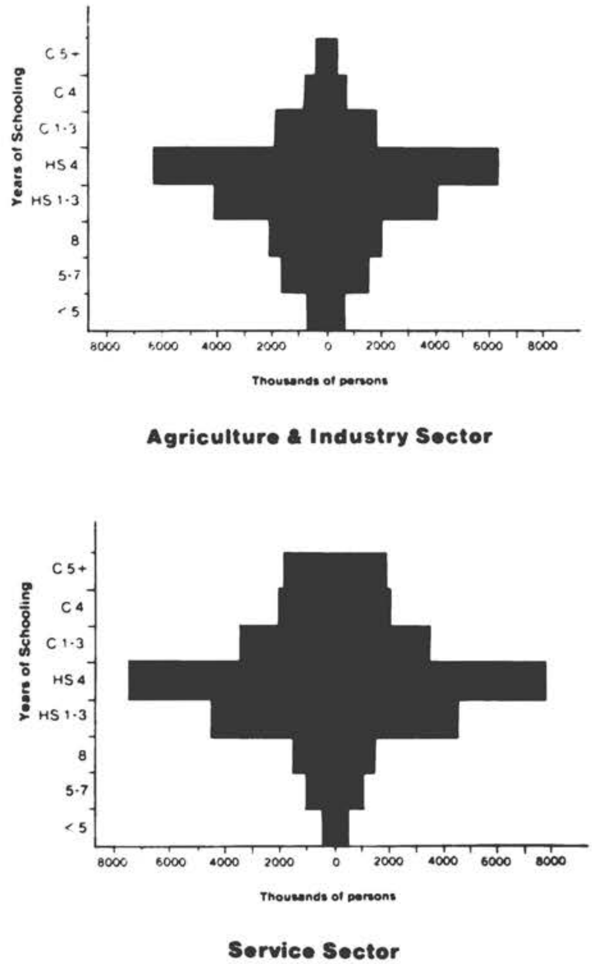

FIGURE 9 Educational attainment of workers in agriculture and industry and in the service sector, 1970.

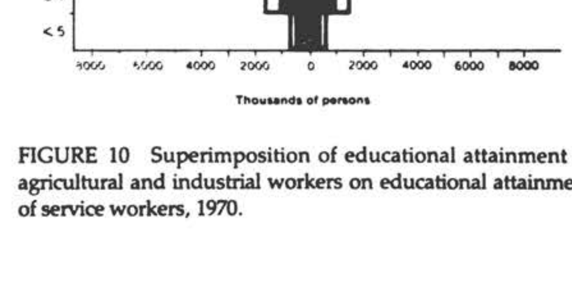

FIGURE 10 Superimposition of educational attainment of agricultural and industrial workers on educational attainment of service workers, 1970.

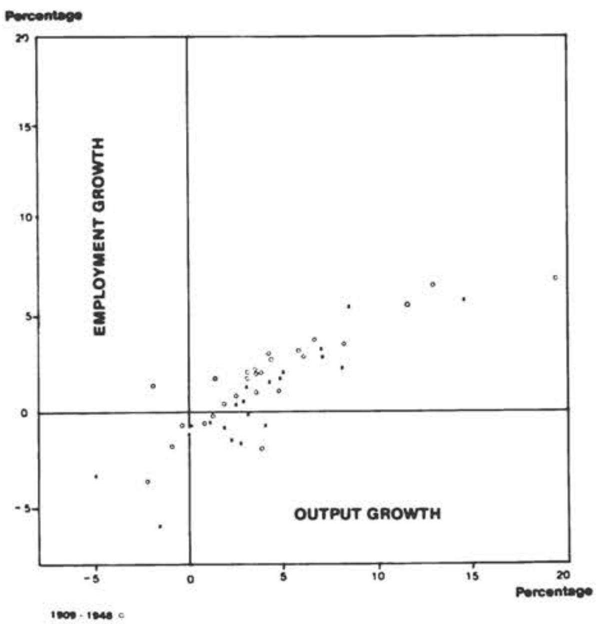

FIGURE 11 Growth of industrial employment and output, annual rates of change, 1909–1948 and 1948–1966.

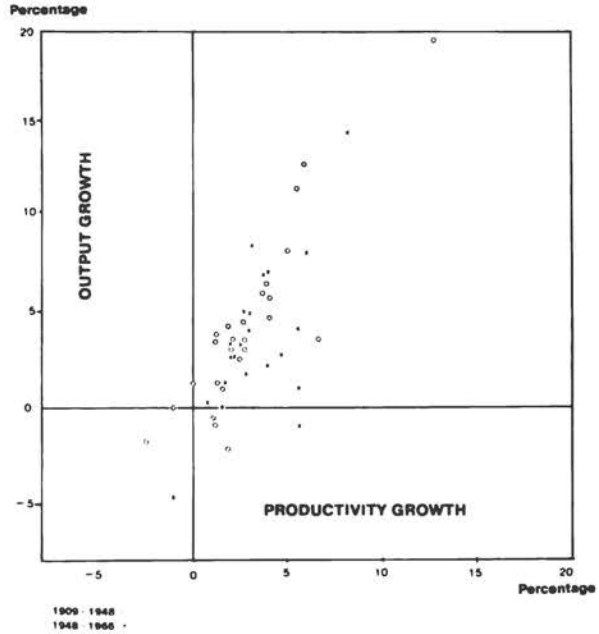

FIGURE 12 Growth of industrial output and productivity, annual rates of change, 1909–1948 and 1948–1966.

grows—again, not surprising. Figure 13 is the crucial one. It asks the question: "As you get productivity growth, do you get employment growth?" And the answer is yes, sometimes, and no, sometimes. Each of the data points is an SIC code. The items at the bottom of the figure have productivity growth with loss of jobs; the items up at the top have productivity growth with employment growth. If you are an economist and try to understand what is involved here, obviously what you have to understand (and this is something I would suggest the study group worry about) is that there must be some feeling for the price elasticity of the service itself. In other words, if there is tremendous price elasticity and productivity growth, it implies at a given price level that there will be a reduction of that price level. Given a sufficient increase in demand so as to more than offset the inherent lowering of costs associated with the productivity growth, more jobs will be generated. If the price elasticity is not of that variety, then there will be no offsetting effect because the productivity growth will not, in fact, generate a

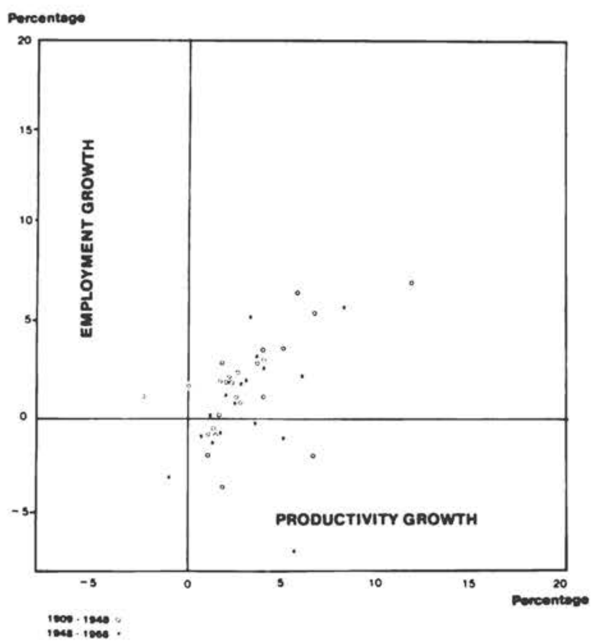

FIGURE 13 Interaction of employment and productivity growth, annual rates of change, 1909–1948 and 1948–1966.

demand for the particular service or the particular product.

Obviously, the work that must be done with respect to the service sector is to have some sense of the price elasticity of the service, something that we know very little about, at least in those services with which I am familiar. I think there are probably some data in the medical area on this.

We must also have some assumptions with regard to the impact of productivity growth. We need to quantify just what it is going to mean to have all of the electronic capability that will be available, what it is going to do to our production function. What kind of productivity growth is that going to represent, and can we translate it into price and, hence, new demand for the particular product?

Finally, obviously, we need some sense of the secondary effects; that is, if a teller position is replaced by a cash machine, we may think we have some productivity growth. We have also created some job opportunities in the nonservice sector of the economy. Recent studies suggest that for every 100 new jobs in the service sector, there are 50 jobs created in the nonservice sectors. This reduces the negative impact on employment of the growth of the service sector.

The net message, then, is that the service sector is growing, it is of increasing importance to the economy, and it is heterogeneous. Those of us involved in it are reaching out and seeking to bring technology to bear on our day-to-day activities. To date we do not have any reason to believe that we are going to be dealing with unmanageable employment and training problems. Our experience—and this is true not only in the United States but around the world—is only that bringing technology to bear on our business has had the effect of causing change.

We have tended to create great educational burdens, but we have not seen a reduction in employment. That does not mean that we will not experience that in the future. Looking at the data, all I would say is that there is good reason to believe this is an important issue and there is good reason to believe it is deserving of more study, but I think it is premature to reach policy conclusions or to try to set in concrete institutional arrangements that presume some kind of fact base that we do not yet have.

NARCISO CANO

Urban Response to Technological Change

Director
Department of Economic and Employment Development
San Antonio

We have heard opinions on megatrends and possible impacts of technological change on the macrolevel. I wish to relate those trends to my area of expertise: trying to improve the economy of a city. After all is said and done, the cities are the first level of government that must contend with the impact of technological change on employment. But even in this area our city is an anomaly in that we seem to be benefiting from both technological and population trends.

My city, San Antonio, is in the Southwest—an area that Peter Drucker in his new book, *Managing in Turbulent Times*, says may be "the only region in the developed world to show sizable growth in traditional manufacturing industry over the next 20 to 25 years." I found his thesis particularly interesting because it is partially based on his beliefs that the labor markets in developed countries will tighten over that period and that the United States will continue to have steady immigration from Mexico. In fact he predicts Hispanics in the United States will total 50 million by 2000, up from the 12 million counted in 1980. Drucker is independently supported on both points by Clark Reynolds of Stanford University, who predicts an excess demand for labor in the United States perhaps exceeding 10 million workers and an excess supply of labor in Mexico reaching 5 million.

So if we are to believe Drucker and Reynolds and if we are to rely on our recent progress, it seems San Antonio is doing well and can expect to do better. But let me tell you what it is really like for our city as the world shifts into fast forward—another phrase I have for it is trying to ease into the fast lane.

In his book, Drucker goes on to say that the action for the next 20 years is likely to be in the "almost developing" countries of the world. When I read his definition of the term, I thought it could just as easily be applied to cities. Using his definition, we can do a few things well but as yet not many things at the same time. We are still trying to reach the labor-intensive stages of production. We are starting to produce an adequate number of well-trained people but do not yet generate the technology required to sustain long-term economic momentum. We can become "developed" or slip back to being "lesser developed." We aspire to be a developed city. But being a successful city is like trying to be a successful individual or a successful company: It is 95 percent hard work and 5 percent luck.

Thirteen years ago, we were in the same

shape as many other Sun Belt cities, perhaps worse. We lacked a public university, a modern-day prerequisite for big-city survival. But we had a few people who had a vision of what we could be, and we set out to build on our strengths and to shore up our weaknesses:

- We got a four-year state-funded university.
- We grew our own computer company, Datapoint.
- We started advertising heavily.
- We resolved our ethnic differences and united on the need to develop our economy.
- We negotiated a delicate truce between pro-growth and no-growth adherents that has allowed us to seek development while maintaining a good quality of life.

And then we did something really wise. We were given a leader for our times. Henry Cisneros, now in his second two-year term as mayor, is a politician who should have been an actor. He is smart, good-looking, and has all the right credentials. If he did not exist, James Michener would have had to make him up for his upcoming novel on Texas. He is the hometown boy who goes off to the East for the union cards of Harvard and White House service and returns to live in the same inner-city neighborhood where he grew up and becomes mayor.

But what really makes it interesting and something perhaps uniquely Texan is that the trait is shared by the office of the governor. The office of the mayor has little official authority. Remember I am from a part of the country where an engrained attitude is "the less government the better." For example, our mayor cannot technically hire his own secretary. All administrative power in our city, including hiring the mayor's secretary, is vested with the city manager. But official or unofficial, Mayor Cisneros knows how to capture the public eye. He is a communicator's communicator who is also adroit at defining issues, mobilizing resources, pushing for consensus, and tapping the spirit of civic duty latent in everyman. Single handedly he recently wrote his famous orange book, *San Antonio's Place in the Technology Economy*, wherein he reviewed emerging technologies that may result in new industries of interest to us. He analyzed San Antonio's possible role, and he suggested specific actions needed to move the city along the technological road. In the spring of 1983 he followed that up by proposing 154 goals for the city for 1990 in his *San Antonio: Target '90*. Technological development is emphasized. He has made assignments to everyone in town, which is not unusual. What is unusual is that he is periodically checking progress and making everyone accountable.

But he demands no less than he gives. Because of our system of government, he is able to spend a lot of time on the road selling the city. In the spring of 1983 the city hosted a large lunch for foreign ambassadors and economic attaches here in Washington. Later, in New York he assembled American executives of major overseas banks and managers of pension funds to sell them on investing in our city. He also visited Silicon Valley for a three-day session of sales calls.

Besides selling for all we are worth, we are also trying to shore up our infrastructure:

- to start magnet schools initially for math and science, despite our balkanized system of 13 school districts that span the spectrum from rich to very poor.
- to build our recently sanctioned engineering school at the now 10-year-old state-funded university. Approval for the school of engineering was obtained over the objection of the state bureaucrats by a massive lobbying effort. Our next goal is to obtain decent funding out of the state's oil trust fund. And then we hope to offer advanced degrees.
- to improve the climate for emerging companies by starting major venture-capital activities, with a distinct private sector emphasis.
- to target bioresearch as our possible niche

in the spectrum of opportunity and aggressively seek the money to move to the front ranks in this field.

• to do our part to attract the MCC Corporation headed by former Admiral Inman to our friendly rival city, Austin, because we hope to benefit from the spillover.

• to attempt to develop plans should we miss our goal of achieving a critical mass for our economy and help San Antonio become the place it used to be. As an example, Bill Norris, chief executive officer of Control Data Corporation, before he located a plant in our area, specifically wanted us to plan for the day when eventually their plant would close.

To sum up, Joel Garreau, author of *Nine Nations of North America*, has said, "The triangle bounded by Dallas, Houston, and San Antonio with Austin at its center today may be the most exciting piece of real estate on the North American Continent." But brother, speaking as historically the possessor of the fewest natural assets of that threesome, and as a native Texan, it has not been easy.

AUDREY FREEDMAN

Labor Economist
The Conference Board

Employment-Unemployment: Another Look

At the end of each of the recessions of the past decade, unemployment has come in at a higher level. Unemployment was 3.5 percent in 1969. Then there was a recession and a recovery with an unemployment rate of 4.5 percent, followed again by a recession and a recovery with the rate rising to 6 percent. There are suggestions that we will have a minimum unemployment of 7 or 7.5 percent after the present recession.

The terms "structural unemployment" and "cyclical unemployment" are not well defined. We do know that when a cycle has been completed and we have reached recovery, cyclical unemployment disappears and structural unemployment is left. The question then arises: Are we having higher unreducible unemployment levels or structural unemployment? Let us for a moment examine some of the components of structural unemployment and perhaps determine which ones might have contributed to what clearly is an increase.

There are four major component parts of structural unemployment. The first is the mobility or immobility of the labor force or, more simply, the location of the workers in one place and the location of capital in another (geographical immobility). There is no reason for a decline in mobility to have taken place during the past decade and for it to have contributed to the rise in structural unemployment. In fact, the labor force now is at a very young age, mostly in their thirties. Mobility is very much associated with age. Young people are very mobile, and as they grow older they become much less so. Thus, at the moment there is high mobility among the labor force.

The second component is discrimination of all kinds: against blacks, women, older people. However, discrimination did not increase during the 1970s. It did not decline either, but an increase in structural unemployment probably cannot be attributed to discrimination.

A third element is institutional barriers to full employment. The minimum wage is one of these, as are the Davis-Bacon Act (which produces some minimums in some kinds of work) and union patterns, firmly entrenched patterns that in effect set a minimum for an industry. Although these institutional barriers may have increased during the early 1970s, certainly during the last part of the decade they have faded in importance. The minimum wage, for example, has not been changed for some years, so it has not been an increasing barrier; it has faded into the background. Union power to set industrywide wage rates has clearly decreased during the past three to four years. Because institutional barriers did not increase during the 1970s, I class them as not contributing to an increased structural unemployment level.

There is a fourth element in structural unemployment wherein may lie the explanation for the increase. This is the skill mismatch, actually the basic training mismatch, between workers and jobs. In other words the labor force that is available does not fit the job demands made. If this is true, the issue here, in my opinion, is how much involvement of the federal government is necessary or required in the training and adaptation of the work force. What is our current system? Where do we start?

Basically, in the United States there is an employer-paid training system that builds on a basic education funded by local taxes and controlled by local bureaucracies. The education system is not integrated with work. Thus, we actually have two systems: the basic education system and the essentially employer-paid training system for all workers.

We have advanced technical training paid for primarily by the recipient, with some federal and state subsidies that are very undifferentiated as to kinds of training that are subsidized. In other words, these subsidies are not focused. Essentially, though, the advanced technical training that our society provides is paid for by the recipient.

The third element is supplemental training. There are two categories here: (1) upgrading, which implies employer-designed and -paid systems, and (2) retraining. Retraining has no concerted programming, primarily because of a lack of job offers or connections. We seem to demand that the retraining be focused on job connection, and lacking that job connection we do not have a system. There are in this area some small local subsidies, minor federal subsidies, and recipient-paid activities.

The skill mismatch involved in the gap between our educational and employment institutions seems to be the only element of structural unemployment that could increase. It is clear that our training system is not doing the job and that perhaps all of the structures that we have created for both education and work training are at fault. That is where we might focus our attention during the coming decade.

Speaking as a very apolitical observer, I would have expected a conservative administration such as the one we have to press for increased investment to conserve and enhance a productive resource—our work force. We are resource-rich as a nation, and one of the resources is our people.

During the Kennedy era there was a short period in which the federal government's responsibility to invest in human resources was stressed. Legislation such as the Manpower Development and Training Act was passed. There was an investment in training by the federal government and by local governments, and there was an investment in the mobility of the work force. There were mobility programs, some of which I was associated with. And there was also an effort to reduce discrimination. Thus three of the four elements of structural unemployment were addressed. However, there was no effort to deal with the institutional barriers to employment, that is, the minimum wage, the Davis-Bacon Act, etc.

During the late 1960s the same programs (training, antidiscrimination, and mobility) became essentially a pacification effort because of two factors: race riots and tremendous domestic unrest over the Vietnam War. By the early 1970s they had become political payments to local governments—"revenue sharing"—no longer with any human resource investment purpose. It is no wonder they became discredited. No one had much faith any longer in these investment programs.

There is an opportunity now for reevaluating the federal government's role in this vital area. I suggest that the federal government should take a leading role in guiding and emphasizing increased investment in our human resource.

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Primary Policy Issues in Question

There have been no significant long-term impacts of work technology on the level of employment and unemployment. During the years after World War II, the dominant trends in aggregate employment conditions, adjusted for cyclical conditions, were the following: (1) a substantial increase in the employment rate (the proportion of the adult population in paid employment), (2) a substantial increase in the unemployment rate (a near doubling of the unemployment rate at cyclical peaks), and (3) a continued but rather small reduction of hours worked per person, except in the distribution sector.

Changes in workplace technology have had almost no effect on these conditions, except as they increased wealth and income. The primary long-term effects of changes in workplace technology have been on the nature of the work environment, the composition of employment by sector, the composition of employment by region, and total wealth.

Other types of technology that have had an important effect on both the level and the sectoral composition of employment include changes in household technology and more effective contraception. These two factors have substantially increased female participation in the paid labor force.

Changes in medical technology have improved health and extended life. Air-conditioning has contributed to the relative growth of the South. Changes in transportation and communications technology, by reducing the economics of agglomeration, have contributed to the relative growth of the suburbs and, more recently, rural areas. The personal computer offers the potential for increasing both full- and part-time paid employment in the home. Finally, history suggests that there is no basis for the Luddite fear that prospective changes in workplace technology will reduce total employment, although these changes will alter the composition of the demands for different skills. Radical perspectives are created to serve radical ends.

The major policy issues that are relevant are as follows. First, the perspective that U.S. society must make adjustments to changes in technology is either empty or misleading. These adjustments will be made for the most part in ways that we cannot now anticipate. The adjustments will be made by individuals and, for the most part, through decentralized institutions. There should be no presumption that the adjustments either require or should involve collective decisions or direction.

Second, the primary policy issues concern the problems of short-term, not long-term, adjustment. Government forecasts of long-term skill demand have been notoriously misleading, and there is no reason to believe that this will improve. The nature of our political process also leads government to be notoriously shortsighted. In Washington, the "long run" means after the next election, and it is very difficult to focus the attention of political officials on long-term issues and conditions.

Third, there are two important sets of government policies that may either facilitate or impede the process of adjustment by individuals and institutions. First, a wide range of government policies involves the protection of concentrated interests or a more general socialization of risks. Such policies include, but not exclusively, the Wagner Act, agricultural price supports, restraints on international trade, regulation of price and entry in many industries, unemployment insurance, and trade adjustment assistance. This is an incomplete list by far. Such policies almost uniformly impede adjustment to changing conditions, and in some sense that is their purpose. By itself, this *does not* necessarily mean that these policies are wrong. Most of us buy private insurance, which indicates that we prefer some reduction in our expected wealth in exchange for a reduction in the variance of our wealth.

Public policies, in part, are motivated by the same considerations, but we should recognize the trade-off we are making. In these areas the primary challenge is to develop alternative policies that facilitate adjustment or at least inhibit adjustment less than the present policies, while providing a similar level of insurance or at least a level of insurance that is acceptable to our political system.

The proposed Employment Act of 1983 includes several such policies that to date have received almost no attention. One proposal would permit those eligible for extended-term unemployment benefits to transform their unused benefits into a wage voucher for roughly the same amount of government outlays. This would then transform the program at the option of each individual from a subsidy for continued unemployment into a subsidy for reemployment.

Other components of this proposed Employment Act would permit states to use part of their unemployment funds for retraining and relocation assistance and would permit part-time reemployment without losing all unemployment benefits, a practice that is now the case in three western states.

The second major set of government policies involves a wide range of services that are complementary to the market economy. The most important of these are research and development, education, and some components of the transportation system. There is ample reason to continue the important federal role in promoting research and some development. At the same time, however, there is reason to question the relative magnitude of the continuing investments in such programs as the space shuttle, nuclear energy, and synthetic fuels.

The National Commission on Excellence in Education has recently and appropriately focused our attention on the wide range of problems in our education system. The commission, however, avoided the most important issue. The primary problem of the public school system is its monopoly status. Most of the problems identified by the commission proceed from this condition. Except in the smallest communities, there are no economies of scale in the provision of primary and secondary schooling and thus no reason to accept the consequences of the public school monopoly.

The most powerful instrument to improve the quality of our education system would be to make public money for education available to students who attend either public or private schools. The recent Supreme Court decision and the President's proposal for tuition tax credits should focus increased attention on this approach. The most dangerous potential outcome of this renewed debate on education policy would be an increased centralization of the decisions on the program and the management of individual schools and school systems.

In conclusion, I am a cautious optimist that the market will adjust to the new technology, as it has in the past—not without costs but without major mistakes. I am less sure whether government will be part of the problem or part of the solution.

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Should Government Become Actively Involved?

Agriculture had one set of time constraints. Anthropologists have taught that agriculture grappled with time that was measured in seasons and days. When manufacturing became important, its world was broken up into eight-hour shifts. Workers had to be there when the piece came down the line. With the new technology, time is considered very differently. Very few people in the total population will be structured by time. What this means for work sharing among families or among people or unionization is an important question.

What is our will with regard to these problems? Is there a problem? The Bureau of Labor Statistics (BLS) projects that the fastest growing occupations in percentage terms will not be the fastest growing in quantitative terms. Hospital workers over the last four years occupied 458,000 more jobs, at a growth rate of 18 percent. Computer and data processing services grew 52 percent, but that entailed only 134,000 new jobs. BLS, which is very competent, projects the future on the basis of the past.

There are many more janitor jobs coming up than computer jobs. Is that a concern of government or of the public, or do we let the free market determine if we have the right number of janitors? The other way to look at it is that perhaps we have different preferences and that we can influence the job market.

Twenty years ago there were very few computer programmers. Had IBM done its work the same way the BLS does its work, they would say the growth was restricted because the base was very small. Everyone knows things can grow only so fast. Moreover, the stock market would not have sold IBM shares at the price-earnings ratio it did. IBM recognized that 70 percent or more of the computers that were going to be sold would be manufactured by IBM and that what would restrict the sales of computers was the number of people who could use the complicated machines. Therefore they trained a large number of computer programmers, and they created a cadre of people who could use their computers. They did not sit passively back and say, "Let the labor market take care of itself."

Indeed, the reason IBM could afford to make the investment is because they had so much of the market. It would have been very difficult for a truly atomized industry to make that kind of investment. IBM had the will, they had the foresight, and they went out and made their own advantage.

Economists talk about comparative advantage and that is what you sell—what you have a comparative advantage in. Japan has shown over the last 40 years that you create your own comparative advantage. With no physical resources, but by investing in their human resources, they created a comparative advantage in the same way that an individual creates his comparative advantage by education, training, and life experiences. It is interesting that the countries with the fewest physical resources, such as Japan and Singapore, seem to do much better than those countries that have an abundance of physical resources.

Thus, there is a single policy question about the impact of technology on employment and unemployment: Do we believe that it is a problem we should do something about, and do we have the will to do something?

Let me provide a simple example of what government could do. The government is not a good forecaster of future job needs, and you cannot have effective training programs without knowing what jobs you are training for. It is true that the current situation is the best information of any forecast. Unfortunately we do not know what the job openings are today or yesterday. Many economists would agree that that kind of information would serve the public well. There are a number of reasons why we do not have it. For example, we do not want mandatory registration of employment opportunities. Perhaps we should ask associations of industry, for example, the insurance industry, about their openings today, in six months, and next year. This information might help us build better training systems.

Therefore, perhaps the most important of the policy questions we have to address is whether the issue that the National Academy of Engineering is going to look at is an issue with which the government should be involved or whether we can live with whatever the free market deals us.