The future of work: does it belong to us or to the robots?

As the silicon chip helps chip away many factory and office functions, prospects are bright for both robots and microprocessors, but investment and other constraints seem to assure no revolutionary loss of employment

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Today, futurists are discussing the onset of a sweeping technological revolution, one which would rival or surpass the Industrial Revolution of the 19th century in importance. This envisioned social order has been given many names—"postindustrial," "technetronic," or "information" society. At the center of this flurry of interest in technological change is the microprocessor. While computerized automation has been theoretically feasible for more than a decade, large and expensive computer systems could produce cost savings only in the most massive industrial settings, and automated machinery could not be easily adapted to serve various production functions. Now, with the development of the microprocessor, these obstacles have been overcome and the potential uses of computerized machinery at the workplace have dramatically increased.

Microprocessor technology is best symbolized by the silicon chip, a miniaturized system of integrated circuits which can direct electrical current and, thereby, generate vast computational power. A silicon chip the size of one square centimeter can perform millions of multiplications per second, and has the capacity to store the texts of the Declaration of Independence, the Constitution, and a few chapters of the Federalist Papers. Technological advances are expected to result in at least a fourfold expansion of these capabilities within a decade, so that the microprocessors of the future will be extremely powerful computers on a single silicon chip or combination of chips. The reduction in size is astounding—today's hand-held programmable calculators have more computational power than the first full-scale computers built during World War II, computers which could have been "hand held" only by juggling 18,000 different vacuum tubes.

This miniaturization of computer technology is particularly important because it has been accompanied by dramatic cost reductions, making microprocessors economically competitive in a wide range of industrial applications. Once designed, silicon chips can be mass produced at a very low cost, and even further price declines are anticipated as volumes rise. As a result, a calculation which cost 80 cents to perform in the early 1950's costs less than one cent today, after adjusting for inflation. The combined reductions in size and cost of microprocessor technology have triggered renewed interest in prospects for automation and in the broader possibility of a wholesale transformation of modern society driven by these new technological capabilities.

The silicon chip is particularly important to economical automation because it provides the basis for fully integrating computer and machine. In industrial set-

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tings, the microprocessor makes possible the development of manufacturing machinery with unique adaptability. The great majority—at least 75 percent—of all manufactured goods fall into the category of shorter, lower-volume production runs, with only the most basic industries continuing to fit the mass-production stereotype. Technological advances in microelectronics, therefore, were an essential precondition to widespread automation, and the expanding use of reprogrammable machinery has triggered today's intense debate regarding the future of industrialized societies.

The potential impact of microprocessors is heightened by their seemingly endless number of applications. This new technology promises to alter not only the factory, but the office as well. Sophisticated word processors and computerized information storage and retrieval systems are becoming increasingly cost-effective, and because this new technology does not require knowledge of specialized computer languages, their growing use may raise traditionally low productivity among office workers. These office innovations are considered qualitatively different from previous office equipment which "mechanized" or "automated" routine tasks. While memory typewriters made an office worker's tasks easier, emerging computer technologies may change the means by which information is transcribed and made available to others. Again, only with the silicon chip has this decentralized use of computer technology at an affordable cost become possible.

'Robot revolution' coming

The use of the microprocessor to automate production functions is epitomized by the development of the robot. Prior to the last decade, robots were confined to the domain of children's stories and science fiction—their practical and efficient application in work settings was virtually inconceivable given the state of computer technology. The silicon chip has thrust robots from fantasy to reality, and the technology is being pursued with remarkable speed and vigor. A number of top computer companies are now considering entry into the robot market, and several large U.S. corporations have made commitments to purchase robots which are already available. The use of robots in manufacturing has nearly quadrupled between 1979 and 1981, and most analysts expect the sales curve to shoot higher during the next few years.[1] Most importantly, microprocessors seem to be in a prime position for the implementation of "learning curve pricing" strategies in which firms lower prices in anticipation of rising volumes and declining unit costs. The entry of large computer companies into the robot market could ensure this aggressive marketing stance and trigger a sharp rise in robot sales by 1990.

Today's robots bear little resemblance to the creations of screenplay writers and science fiction authors. Rather than some form of mechanical humanoid, industrial robots are characterized by mechanical arms linked to reprogrammable computers. An exact definition of a robot, as distinct from other automated machinery, eludes even industry representatives. The Robot Institute of America, an industrial trade group, stresses that it is the "reprogrammable and multifunctional" character of robots which is unique, allowing them to perform a variety of tasks.[2] And the emerging versions of robots are varied—the more extravagant include a "bureaucratic robot" which stamps signatures on letters, a robot "nurse" to assist handicapped persons in wheelchairs, a robot "janitor and guard dog" for the home, and "talking robots" which would advertise products or give job training to illiterates. Microprocessors are revolutionizing design methods for the development of new manufactured goods, and have become an integral part of nearly all modern research equipment so as to expedite lengthy data analysis.[3] Innovations such as voice-sensitive computers which can directly transcribe dictation into written text may be marketable within just a few years. It is this diversity of applications for microprocessor technology which distinguishes it from less significant innovations, and which has led futurists to predict a societal transformation "comparable with the agricultural revolution that began about 10,000 years ago, and with the industrial revolution."[4]

How far . . .

There is little consensus as to where the "robot revolution" is heading and how far it will go. The technology itself may be refined to such an extent that most factory work could be carried out by robots and automated machinery. For example, a study conducted at Carnegie-Mellon University asserts that the current generation of robots has the technical capability to perform nearly 7 million existing factory jobs—one-third of all manufacturing employment—and that sometime after 1990, it will become technically possible to replace all manufacturing operatives in the automotive, electrical-equipment, machinery, and fabricated-metals industries.[5] Yet these theoretical estimates of the potential for automation, which reach as high as 65 to 75 percent of the factory work force, do not reflect the rate at which the new technology will actually be introduced to the workplace. The pace of innovation will depend on the relative costs of labor and computerized technologies, as well as on broader levels of supply and demand for goods and services. Predictions of this nature are infinitely more difficult than abstract assessments of future technological capabilities.

The automobile industry offers an interesting case study, because it is probably the first manufacturing industry to aggressively pursue the use of robots in automated processes. The push toward automation in the auto industry is a response to both rising labor costs and growing concerns for quality control and competitiveness in international markets. Auto manufacturers already find it possible to operate robots for $6 per hour, well below the $20 per hour required for the pay and benefits of a skilled worker in 1981.[6] General Motors, aware of the growing use of robots by Japanese auto makers, predicts that by 1987, 90 percent of all its new capital investments will be in computer-controlled machines.[7] A 1980 survey conducted by the American Society of Manufacturing Engineers predicted that robots will replace 20 percent of existing jobs in the auto industry by 1985, and that 50 percent of automobile assembly will be done by automated machines (including robots) by 1995.[8] Even the United Auto Workers anticipates a 20-percent decline in membership by 1990 and has successfully obtained advance notice and retraining rights from auto manufacturers in a growing effort to gain protection from sweeping automation. Yet, few of these estimates include any consideration of the extent to which capital shortages confronting robot manufacturers and purchasers may limit the speed with which the new technology is adopted.

Projections of the impact of microprocessors on office employment are even more problematic, with analysts more frequently predicting the number of office jobs "affected" rather than eliminated by automation. The Carnegie-Mellon study argued that 38 million of 50 million existing white-collar jobs would eventually be affected by automation, while a vice president for strategic planning for Xerox Corp. offered the more conservative guess of 20 to 30 million jobs affected by 1990.[9] There is general agreement that office technologies will be changing rapidly, but little indication of whether the result will be reduced office employment, shifts in future employment growth, or simply higher levels of productivity in white-collar settings.

A 1982 study prepared for the International Labour Office found that microelectronic technology has not caused widespread displacement of office workers, but perhaps only because of the impact of poor economic conditions on the rate of diffusion of the new technology in office settings. Selected case studies of the banking and insurance industries suggested that new job opportunities were being created, but the skills made redundant by new technologies were generally inappropriate for those emerging opportunities. The report stressed that this trend poses special threats to employment prospects for women, and called for additional education and training efforts to close the "skill gap" caused by the use of microprocessors in office jobs.[10]

Perhaps the greatest fears that automation will lead to widespread unemployment have been voiced, not in the United States, but in Western Europe. For example, two British authors have predicted nothing short of the collapse of work as a social institution in an era of microprocessors:[11]

> It is impossible to overdramatize the forthcoming crisis as it potentially strikes a blow at the very core of industrialized societies—the work ethic. We have based our social structures on this ethic and now it would appear that it is to become redundant along with millions of other people.

In West Germany, studies of the impact of automation on future employment levels commissioned by the Bonn government projected that the number of jobs in 1990 will at best be marginally above 1977 levels—a pessimistic view in light of anticipated population growth. The issue of technologically induced unemployment increasingly is capturing the attention of West European leaders, and unions in Italy, Germany, and elsewhere are responding with demands for shorter workweeks to protect employment levels. Perennial fears that machines would replace workers have never been fulfilled, but European futurists insist that it will be different this time.

. . . and how fast?

While the impact of automation in the past has been offset by the emergence of new industries and by growth in the service sector of the economy, these avenues for employment growth may indeed be less open in an era of microprocessors. The electronics industry, which supports this computerized technology, certainly will experience rapid growth in the coming decade, but a 1979 survey of the world electronics industry prepared for the Organization for Economic Cooperation and Development revealed that the internal use of its own technology will keep employment growth in this sector to a minimum.[12] It is this "reproductive" potential of computerized technology—the prospect of robots building robots—which challenges traditional patterns of employment growth through new industries. And to the extent that the microprocessor will affect service as well as manufacturing industries, even the recent trend of expanding service employment may fail to provide jobs.

In spite of these relatively unique characteristics of microprocessor applications, predictions of immediate and massive job losses tend to ignore the market forces which slow the pace of technological change. As stressed in recent research by the Bureau of Labor Statistics, many factors limit the speed of diffusion of technological change and thereby mitigate possible employment implications. The size of required investment, the rate of capacity utilization and the institutional arrangements within industries all can act as "economic governors" which slow the adoption of automated technologies.[13]

Virtually all capital-intensive industries have a massive investment in existing plant facilities, and they cannot afford to squander these resources through the wholesale replacement of working machinery. More importantly, the financial constraints on capital formation necessarily limit the rate at which new technologies are introduced. In this context, Joseph Engleberger, president of Unimation, Inc. (the Nation's largest robot manufacturer), has dismissed predictions of galloping automation, noting that even the replacement of 5 percent of all blue-collar workers in Western industrialized nations would require investments totaling $3 billion in each of the next 40 years.[14] While microprocessor technology may be promising in its flexibility and potential efficiency, industries must be able to afford the new acquisitions in order to use them.

A less tangible but perhaps equally important force limiting the expansion of computer technology lies in the attitudes of both workers and consumers. While a computer may be able to diagnose medical problems, its bedside manner may be less than comforting. Similarly, word processors and telephone answering systems may alter clerical roles, but most executives will not want to forgo the convenience offered by their personal secretaries. People can hear the best music in the comfort of their homes, but flock to concert halls to hear lesser performances. Even on the assembly line, where robots may be perfectly suited for production processes, the aversion of managers and workers to such unfamiliar companions may hamper their smooth and rapid assimilation at the workplace. These psychological barriers cannot be factored into equations of economic efficiency, but they are likely to slow the pace of technological change nonetheless.

Will workers become obsolete?

The picture which emerges when the functioning of capital markets and work organizations are considered is one of evolutionary rather than revolutionary change. With annual sales of robots well below 10,000 in a labor force of more than 100 million, it will be some time before computerized technologies make a major dent in aggregate employment levels. This perspective is emphasized by Robotics International, a professional group which polled 100 users and manufacturers of robots. Based on the responses, the group concluded that robots are likely to replace 440,000 rather than a million workers by 1990, and that all but 5 percent of the displaced workers would be retrained rather than dismissed.[15] The relative lack of union concern in the United States over aggregate job losses through automation also stems from this belief that the pace of innovation has been exaggerated. William Winpisinger, president of the International Association of Machinists, has argued that the replacement of human skills with computerized machinery will occur slowly and that a shortage of skilled workers will remain our most pressing manpower problem.[16] No doubt, unions will continue to seek guarantees of job security in some industries, and collective bargaining may gradually extend to include management investment decisions.

In the more distant future, no one can be sure where new employment growth will occur. Expectations of a workless society still linger; as described in one forecast:[17]

> Earning a living may no longer be a necessity but a privilege; services may have to be protected from automation, and given certain social status; leisure time activities may have to be invented in order to give new meaning to a mode of life that may have become economically useless for a majority of the populace.

The literature in recent decades has been replete with speculations on how people would cope with the loss of meaningful work roles, or how society would allocate and distribute wealth in the absence of strong ties between work and income.[18] Even for those who reject such forebodings, the belief in continued employment growth admittedly contains as much faith as foresight.

Still, there seems little likelihood that the worker will become obsolete in the foreseeable future. In one sense, past waves of automation have created dislocations, but it has been distributed throughout the labor force in the form of benefits and social progress—shorter workweeks, more vacation time, longer training and education, earlier retirement, child labor laws, and welfare and unemployment payments. We can expect this trend to continue, particularly as labor seeks assurances of job security. Assuming a healthy rate of economic growth during a period of innovation and increasing automation, it is also likely that levels of aggregate demand will support the emergence of new goods and services. Rising expectations alone will cause Americans to translate productivity gains into higher standards of living instead of less work, a pattern which has held for centuries. The period of adjustment which lies ahead may not be painless, but it seems that work is here to stay. □

——— *FOOTNOTES* ———

[1] "Robots Join the Labor Force," *Business Week*, June 9, 1980, p. 62; and Joann S. Lublin, "As Robot Age Arrives . . . ," *The Wall Street Journal*, Oct. 26, 1981, p. 1.

[2] Otto Friedrich, "The Robot Revolution," *Time*, Dec. 8, 1980, p. 75.

[3] Gene Bylinsky, "A New Industrial Revolution is on the Way," *Fortune*, Oct. 5, 1981, pp. 106–14; and Barnaby J. Feder, "The Automated Research Lab," *The New York Times*, Oct. 27, 1981, p. D1.

[4] Herman Kahn, William Brown, and Leon Martel, *The Next 200 Years* (New York, Morrow, 1976), pp. 8; 20–24.

[5] Lublin, "As Robot Age Arrives . . . ,"; and "The Speedup in Automation," *Business Week*, Aug. 3, 1981, p. 62.

[6] *Congressional Record* (daily edition), Dec. 10, 1981, p. S14908.

[7] Harley Shaiken, "Detroit Downsizes U.S. Jobs," *The Nation*, Oct. 11, 1980.

[8] Fred Reed, "The Robots Are Coming, The Robots Are Coming," *Next*, May/June 1980, p. 32.

[9] "The Speedup in Automation."

[10] Diane Werneke, "Microelectronics and Office Jobs: The Impact of the Chip on Women's Employment," report prepared for the International Labour Office, 1982, pp. 115–24.

[11] Clive Jenkins and Barrie Sherman, *The Collapse of Work* (London, Eyre Methuen, 1979), p. 182.

[12] Mich McLean, "Sector Report: The Electronics Industry," background study prepared for the Organization for Economic Cooperation and Development, in *Technical Change and Economic Policy* (Paris, OECD, 1980).

[13] Richard W. Riche, "Impact of new electronic technology," *Monthly Labor Review*, March 1982, p. 39.

[14] Reed, "The Robots Are Coming."

[15] Lublin, "As Robot Age Arrives. . . ."

[16] William W. Winpisinger, "Correcting the Shortage of Skilled Workers," *The AFL–CIO American Federationist*, June 1980, p. 21.

[17] Theodore J. Gordon and Olaf Helmer, "Report on a Long-Range Forecasting Study," in *Social Technology* (New York, Basic Books, 1966), pp. 81–82.

[18] James S. Albus, *People's Capitalism: The Economics of the Robot Revolution* (Md., New World Books, 1976); and Colin Hines and Graham Searle, *Automatic Unemployment* (London, Earth Resources Research Ltd., 1979).

Smoothing the transition

Union resistance to labor-saving technical change within an industry can often be moderated by careful management of change, which will minimize its effect in creating unemployment. This is much more difficult in the case of interindustry effects, since an enterprise in one industry is unlikely to be concerned with the effects of its decisions on employment in another industry. Technical change often produces losses for investors who have invested in equipment and skills that are made obsolete. Where the investment is embodied in people rather than in machines, the human problems it causes are more severe and less tractable. Those outside the union movement cannot condone a position that blocks technical progress, but they can approve one that uses some of the fruits of progress to give reasonable compensation to workers for the loss of their livelihood.

—ALBERT REES
The Economics of Work and Pay
(New York, Harper & Row, Publishers, Inc., 1973), p. 137.