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THE MICROELECTRONICS REVOLUTION, JOB DISPLACEMENT, AND THE FUTURE OF WORK: A POLICY COMMENTARY

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I

We stand at the beginning of the Third Industrial Revolution. In the First Industrial Revolution mankind learned to plant and harvest. Replacing the nomadic hunter-gatherer, who spent most of his time during the year in pursuit of food, was the farmer. By his husbandry, the farmer was able to feed himself and several others. Those freed from the need to feed themselves turned to making other things, to protecting the land from their enemies, and even to framing laws. The key to the Second Industrial Revolution was the invention of steam power which provided engines for industry and power for transportation. At the end of the eighteenth century, machines came to replace hand-held tools as a means of making things, and animals as a means of transportation. The energy in wood replaced the physical energy of men and animals.

The Third Industrial Revolution is dawning. The key element is microelectronics technology which replaces moving parts with integrated circuits and replaces people with chips, robots, and key boards. The microelectronics revolution substitutes energy in a mental form and can be introduced in virtually any workplace, whether an office or factory. The Third Industrial Revolution is destined to have a broad impact.

After surveying the impact of microelectronic technology in production operations and offices, this article focuses on the effect of robots and computers on employment. The introduction of new microelectronic technology could result in the massive technological unemployment of a growing number of workers. Millions of Americans may find that their jobs have been automated and they will not be needed for any job. Microelectronic technology will, therefore, have a general impact in society.

Because of the seemingly limitless potential for the displacement of labor by increasingly efficient machines, the effects of microelectronic technology on the nature of work and the structure of our institutions

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and society in the twenty-first century need to be considered.[1] This essay marks a beginning of the rethinking of the fundamental societal institution of work. We need to consider the fundamental assumptions of a labor-oriented society. Work may be dethroned from its central societal position and income distributed on a basis other than through jobs. In a technologically advanced society, "employment," unlike that which we know today, may exist primarily for self-development and only secondarily for the production of goods and services.

II

Microelectronics technology will impact on both office functions and production operations. The application of computers to office work will vastly reduce the need for human labor in producing and processing information, specifically, in performing tasks such as filing, bookkeeping, and typing. Information processing in the office, in other words, office automation, will transform an office system built around paper, memos, and bulky files. The factory of the future will be totally automated. Three separate types of technology, computer equipment, robots, and computer-numerically controlled machines, will be linked together in an integrated manufacturing process. This section first considers the impact of microelectronics technology on office functions; the impact on production operations is then analyzed.

Advances in microelectronics have already reduced the cost and size of computers and increased their application to office functions. Offices have come to rely on intelligent machines, word processors and optical character readers, which operate in isolation.[2] Microprocessor-based office machines have increased the productivity of secretaries, typists, and other clerical workers.

Currently, microelectronics technology in the office is replacing a paper information system, where paper is an interface medium, with the electronic storage and transmission of information. The aim of office automation is the development of an organization which captures information only once and later processes, transfers, stores, and accesses the

1. For recent scholarly inquiry into the causes and consequences of technological development see *e.g.*, N. ROSENBERG, INSIDE THE BLACK BOX: TECHNOLOGY AND ECONOMICS (1982); P. STONEMAN, THE ECONOMIC ANALYSIS OF TECHNOLOGICAL CHANGE (1983). *See generally* Leontief, *Technological Advance, Economic Growth, and the Distribution of Income*, 9 POPULATION & DEV. REV. 403, 405 (1983).

2. *See, e.g.*, Liebman, *Super-Typewriters: The Word-Processing Industry Has Arrived*, BARRON'S, Mar. 31, 1975, at 11; *The Office of the Future*, BUS. WEEK, June 30, 1975, at 48; Reif, *Word Processing Comes of Age*, N.Y. Times, May 4, 1976, § 3, at 5, col. 1. *See generally* Giuliano, *The Mechanization of Office Work*, SCI. AM., Sept. 1982, at 148.

information with a minimum of human intervention—the hoped for "paperless office."

In the office of the future, microelectronic technology and optics technology[3] will be joined. Separate electronic systems will be integrated by means of high speed communications networks allowing users to share data processing, to share access to central information storage facilities, and to speed the flow of information within the organization.[4] All information generated within a plant or a firm will be available for use by people, machines, and computers quickly, inexpensively, and accurately. These integrated electronic information systems will enable organizations to capture, process, transfer, store, and access information with a minimum of human intervention. As smaller and more flexible systems become available and start-up costs drop, the utilization of integrated systems will spread beyond corporate offices employing large numbers of white collar workers.

As a result of office automation, office productivity has and will continue to increase. Computers increase the amount of work performed by each office worker and enable a firm to expand the volume of its transactions with little or no growth in white collar employment. Administrators, engineers, and managers will be able to do office work themselves, with significantly fewer or even no support personnel. For example, a microcomputer enables staff members to compose reports, transmit them to supervisors and subordinates, receive comments, and make changes—all without paper. Computer software enables managers to perform complex mathematical calculations and to examine alternatives and combinations of numbers.

Machine control in the factory will become increasingly dependent on a variety of computers—from the increasingly familiar desk top micro-computers to the traditional, large mainframe computers. Computer-based equipment on the factory floor will be linked together. Computers will control entire production systems. A plant's computer communications network will monitor the functioning of equipment and schedule the plant for the most efficient operation.

3. For example, fiber optics cables provide greater telephone call handling capabilities than coaxial cables and microwave relays. Semiconductor light sources will provide high speed telecommunications transmission. Riche, *Impact of New Electronic Technology*, MONTHLY LAB. REV., Mar. 1982, at 38. Computers are also used in telephone call switching and signal transmission thereby facilitating telecommunications.

4. *See, e.g.*, *Office Automation Restructures Business*, BUS. WEEK, Oct. 4, 1984, at 118; Tannebaum & Bulkeley, *Device Makers Dream of Electronic Offices, But Obstacles Remain*, Wall St. J., Mar. 13, 1981, at 1, col. 1; *Applications: Voice Mail Arrives in the Office*, BUS. WEEK, June 9, 1980, at 80. *See generally* Drucker, *Managing the Information Explosion*, Wall St. J., Apr. 10, 1980, at 24, col. 4.

A key development in production operations and machinery is the robot. A robot is a reprogrammable manipulator which moves materials, parts, tools, or specialized devices through human-designed programmed motions.[5] Programmed motions are stored in a memory device and may be varied to perform different tasks, such as loading and unloading.[6] Although industrial robots vary in function and complexity, a robot generically consists of four components: 1) the manipulator, which includes the robot frame and mechanical parts; 2) the controller, which determines the sequence of motions by the robot so that an assigned task is performed repeatedly at the same pace and accuracy (in complex robots these motions are programmed with microprocessors); 3) the gripper (or arm), a mechanical, magnetic, or vacuum device which handles parts or other materials; and 4) a motor, which drives or powers the robot.[7]

Businesses use robots in diverse production processes including welding, painting, assembling mechanical and electrical parts, forging, machine loading and unloading, manipulating tools, and machine tending (cutting and drilling). To date, investments in robots have been made primarily to replace unattractive, and often dangerous, jobs in foundries and for welding and painting operations in auto assembly.[8]

Looming on the horizon is the introduction of more sophisticated, more intelligent robots capable of performing machine loading and assembling functions and other more complex tasks.[9] Although welding and painting take place in many industries, assembly of machines and other parts is even more widespread and accounts for the greatest "single share of industrial workers and manufacturing costs."[10] Ultimately, robots will build other robots.

5. In lay terms, a robot reproduces a range of motions for which it has been programmed.

6. Robot Institute of America, *Robotics Today*, RIA NEWS, Spring 1980, at 7, *quoted in* STAFF OF SUBCOMM. ON MONETARY AND FISCAL POLICY OF THE JOINT ECONOMIC COMM., 97TH CONG., 2D SESS., STAFF STUDY: ROBOTICS AND THE ECONOMY 4 (Jt. Comm. Print 1982) [hereinafter STAFF STUDY].

7. *Computerized Manufacturing Automation: Employment, Education, and the Workplace*, 50 (Washington, D.C., U.S. Congress, Office of Technology Assessment, OTA-CIT-235, April 1984) [hereinafter OTA].

8. For example, in the mid 1980's, spot welding accounted for 35 to 45 percent of all robots installed in the United States; handling of materials, arc welding, and paint spraying accounted for, respectively, 25 to 30 percent, 5 to 8 percent, and 8 to 12 percent of all U.S. robots. Draper, *The Golden Arm*, N.Y. REV. OF BOOKS, Oct. 24, 1985, at 46, 47. In 1980, the U.S. auto industry bought 90% of the industrial robots sold in the U.S., mostly for welding. By 1985, 5 out of every 10 robots were sold to customers other than auto plants. Wall St. J., Aug. 8, 1985, at 1, col. 5.

9. These complex tasks include leather manufacturing, shoe manufacturing, rubber processing, asbestos processing, plastics processing, and food processing. R. AYRES & S. MILLER, ROBOTICS: APPLICATIONS AND SOCIAL IMPLICATIONS 59-60 (1983).

10. Draper, *supra* note 8, at 48. *See also* OTA, *supra* note 7, at 52, 54-56.

A number of reasons exist for businesses to install robots in factories.[11] Robots reduce labor costs,[12] and eliminate unpleasant, tedious, and dangerous jobs. In addition, automation increases the rate of output[13] and product quality.[14] Finally, robot production results in a savings of materials.[15] However, the rate at which businesses presently install robots depends mainly on the ability of robots to reduce labor costs.[16]

The second major development in microelectronics technology for the factory is computer-numerically controlled machinery. A machine tool is a power drive machine designed to produce parts and cut and form metal.[17] Metal cutting machine tools consist of boring, turning (lathe), drilling and milling machines. Metal forming machine tools include presses, forges, bending, punching and forming machines. In the 1950's, numerically-controlled machine tools were developed. A conventional machine tool depends on a human operator; manual operation is not necessary with a numerically-controlled machine tool which is controlled by programmed instruction on tape and follows a predetermined sequence of steps.[18] By the early 1980's, almost all numerically-controlled machines consisted of computer-numerically controlled machinery, in other words, computer-controlled machine tools. A visual display terminal (cathode ray terminal) and programming capability at the machine replaced taped instruction. The use of computer-numerically controlled machines reduced programming inflexibility and maintenance problems of the tapes.[19]

Finally, computer equipment throughout a firm will be linked together in the future. Computer-numerically controlled machines will be linked to other programmable machines, e.g. robots, on the plant floor of a factory and a computer communications network will monitor produc-

11. R. AYRES & S. MILLER, *supra* note 9, at 70-78.

12. Experts emphasize the substantial hourly robot ($6.00 per hour in 1982)—human costs ($20.00 per hour in 1981 for the auto industry production workers) differential. *Id.* at 70-73.

13. The trade literature frequently mentions output increases of over 100% for specific application. *Id.* at 75-76.

14. *Id.* at 76-77.

15. Significant material savings have been achieved in a few applications, such as spray painting. *Id.* at 77-78.

16. R. AYRES & S. MILLER, *supra* note 9, at 70-71, 73; J. ENGELBERGER, ROBOTICS IN PRACTICE 103 (1980).

17. Unlike a robot, which is programmed to perform a range of motions, microelectronics technology traditionally has not been programmed.

18. D. NOBLE, FORCES OF PRODUCTION: A SOCIAL HISTORY OF INDUSTRIAL AUTOMATION (1984); Pura, *Japanese Electronic "Smart" Tools Are Gaining in Europe and the U.S.*, Wall St. J., Apr. 15, 1981, at 33, col. 5.

19. OTA, *supra* note 7, at 57-60.

tion. Computer-assisted design and engineering will be integrated with manufacturing.[20] Using computer-aided design equipment, engineers will design and redesign any type of large or small product on a computer screen with the system producing the final working drawings. In an automated factory, robots will perform operations which now require human skills. Computers will manage complete systems consisting of multiple operations. There will be automatic inventory, tool management, finishing, assembly, and inspection of goods. Automatic factories will make components for other automatic factories. In a "peopleless factory," machines will interact with each other with little or no human intervention; humans will be relegated to monitoring and repairing the automated machines. Robots and computer-aided machines will work with a speed and precision never before achieved.

In the totally automated, so-called flexible manufactory, all the equipment will be linked in a computerized network tying together planning, design, production, inventory, and quality control.[21] The various functions will make use of extensive computerized data bases which will be shared across all facets of production. Computers will perform the following functions: 1) design products for ease of manufacture; 2) have suppliers deliver all materials in a form that can be handled by machines; 3) control the position of all parts at all times to simplify robot handling and inspection; 4) link robots and machine tools into manufacturing cells; and 5) integrate factory production facilities with office planning and control functions.

A flexible manufacturing system will reduce labor and material costs, aid in developing new products more quickly, promote substantially higher quality and reliability of products, allow small quantities of goods to be produced inexpensively, and permit rapid changeovers in production.[22] These advances will benefit the flexible manufacturing system in the form of reduced costs, a shorter production cycle, and signifi-

20. *Id.* at 43-48; R. AYRES & S. MILLER, *supra* note 9, at 48-57; Gunn, *The Mechanization of Design and Manufacturing*, SCI. AM., Sept. 1982, at 115.

21. OTA, *supra* note 7, at 60, 62, 64-66, 71-74. *See generally* H. SHAIKEN, WORK TRANSFORMED: AUTOMATION AND LABOR IN THE COMPUTER AGE (1985); BUSINESS-HIGHER EDUCATION FORUM, THE NEW MANUFACTURING: AMERICA'S RACE TO AUTOMATE 14-15 (1984). *See also* Holusha, *G.M. 'Factory of the Future' Will Run With Robots*, N.Y. Times, Oct. 20, 1984, at 29, col. 1; Broad, *U.S. Factories Reach Into the Future*, N.Y. Times, Mar. 13, 1984, at C1, col. 3; Lohr, *New in Japan: The Manless Factory*, N.Y. Times, Dec. 13, 1981, § 3, at F1; *The Speedup in Automation: Spreading Through the Factory*, BUS. WEEK, Aug. 3, 1981, at 58; *Finding the Missing Link in Automation*, BUS. WEEK, June 17, 1985, at 39; Holusha, *Standardizing Computer Talk*, N.Y. Times, Sept. 13, 1984, at D2, col. 1; Rowen, *Japan Seizes the Lead in Robotics*, Wash. Post, Apr. 10, 1983, at F1, col. 3; Lehner & Marcom, *Auto Automation*, Wall St. J., July 9, 1984, at 1, col. 6; Salisbury, *The Coming Industrial Revolution*, CHRISTIAN SCI. MONITOR, Nov. 20, 1984, at 37, col. 1.

22. R. AYRES & S. MILLER, *supra* note 9, at 84-90.

cant competitive advantages in the international market. Ultimately, firms will link computers and telecommunications, thereby integrating many separate functions in the factory and the office as well as coordinating functions in ways that are beyond human capability in terms of speed, volume, accuracy, and endurance. Machines, people, and information will be joined into efficient business units. New products and processes will combine the power of computers and communications.

III

The major thrust of this article is on employment, specifically, whether machines will completely replace human labor. As could well be expected, the topic of whether technology creates more jobs than it destroys divides analysts into two camps—the optimists and the pessimists.

Optimistic observers view the microelectronics revolution with little, if any, concern for its effect on employment. As one observer noted, "[t]here is, of course, not a scrap of evidence in either theory or history to suggest that technological development won't increase employment and real incomes today just as it always has."[23] The technological optimists reason along four lines: macroeconomic growth, benefits to individual firms, creation of new jobs, and labor force trends.

First, and most importantly, the optimists reason that employment in other areas of the economy will expand to provide new jobs. Aggregate economic growth will generate sufficient new jobs to absorb those displaced in other economic sectors. The development of new high technology products and services may foster economic growth which will, in turn, create more jobs.

Second, on an individual firm level, technological change can significantly reduce the costs of production, reduce the time needed to produce a given unit of output, and improve the quality of goods. As a result, total demand for a firms' output may increase. The resulting expansion of production may increase employment at the individual firm level.

23. Bartlett, *The Luddite Answer to Unemployment*, Wall St. J., July 18, 1983, at 18, col. 3. *See also* N. GINGRICH, WINDOW OF OPPORTUNITY: A BLUEPRINT FOR THE FUTURE 88 (1984) ("Every major technological breakthrough, from internal-combustion engines to computers, has ultimately created jobs."); STAFF STUDY, *supra* note 6, at 3. Some experts have concluded that planning for massive job displacement resulting from a robot population explosion, at least over the next five to ten years, would be an inappropriate national priority. *Technology and Employment: Joint Hearings Before the Subcomm. on Science, Research and Technology of the House Comm. on Science and Technology and the Task Force on Education and Employment of the House Comm. on the Budget*, 98th Cong., 1st Sess. 330, 338 (1983) (statement of Marc Bendick, Director for the Program on Economic Change and the American Workforce, Urban Institute).

However, the optimists fail to mention that even if the number of jobs increase, the requisite skill levels may significantly change. The automated factory or office needs a different, more sophisticated workforce.

Third, the automation of labor-intensive assembly line work may bring jobs back to the United States that migrated overseas and help keep such jobs in the United States. The decreasing fraction of the product price attributable to labor should reduce the low wage advantage of foreign countries. Automation as found in flexible manufacturing systems[24] will also assist United States industries in fighting foreign competition.

Furthermore, new jobs will be created for those who will design, build, install, program, operate and repair the new technological devices. Additional computer programmers will be needed to program the increasing number of computers and robot technicians will be needed to test, program, install, maintain, and troubleshoot robots.[25] The continued growth of the service sector, especially health care and other personal services, may also provide future job opportunities for displaced workers.

Finally, favorable demographic trends hearten the technological optimists.[26] The American labor force will increase at a smaller rate, enabling the economy to absorb both the new entrants and those displaced by technology.

Pessimists view the microelectronics revolution with alarm. They point to an adverse impact of automation on the work force. The loss of jobs raises ominous prospects for the future, as human labor may be replaced by machines. One estimate places the number of unemployed at thirty to fifty percent of the work force by the end of the twentieth century. Demographic growth and the increasing percentage of women seeking gainful employment may produce a higher figure in certain western nations.[27] This negative view of the impact of microelectronics tech-

24. *See supra* text accompanying note 22; *cf.* Feder, *New Challenge in Automation*, N.Y. Times, Oct. 30, 1986, at D2, col. 1.

25. H. HUNT & T. HUNT, HUMAN RESOURCE IMPLICATIONS OF ROBOTICS 105-63 (1983).

26. For a useful introduction see Drucker, *Demographics and American Economic Policy*, in TOWARD NEW U.S. INDUSTRIAL POLICY (M. Wachter & S. Wachter ed. 1981).

27. A. GORZ, PATHS TO PARADISE: ON THE LIBERATION FROM WORK 31 (1983). In G. SCHWARTZ & W. NEIKIRK, THE WORK REVOLUTION 24 (1983), the authors estimate that after 1990, when current technology has gone through more than half its expected development, it will take perhaps only 75% of the work force to do 100% of the work. The report of one prestigious group states that as a result of the utilization of integrated, computer-controlled production processes, labor requirements per unit of output will be only a fraction of current levels, conservatively being reduced by a factor of one-third, in many cases, much more. BUSINESS-HIGHER EDUCATION FORUM, THE NEW MANUFACTURING; AMERICA'S RACE TO AUTOMATE 15-16 (1984). Estimates point to a significant decline in employment in Western Europe as a result of the introduction of microelectronic technology. *See, e.g.*, *Fears of Higher Unemployment in Europe*, BUS. WEEK,

nology on employment is premised on several arguments.

First, the economy will increasingly be unable to absorb displaced workers[28] because of the simultaneous impact of the new technology on all sectors of the economy. The analogy of the internal-combustion engine to microelectronics technology, offered by technological optimists, is probably fallacious.[29] The internal-combustion engine, a disaster for blacksmiths and buggy manufacturers, proved a source of jobs in the automobile industry. However, displaced blacksmiths and buggy makers could turn to an economy requiring manual workers. Robots and office automation cut the need for labor. The new technologies will likely have a widespread potential impact throughout the economy. Past technological changes eliminated unskilled physical labor in agriculture and some areas of manufacturing and to a lesser extent, skilled labor in some crafts. New microelectronics technologies, which permit computer-based machines to perform higher-order mental tasks, threaten jobs in the factory and the office. New technologies endanger higher level, mental jobs as well as lower level, physical jobs.

Second, the shifting skill requirements create a mismatch between the skills required in the new jobs created and the backgrounds and capabilities of unemployed persons. The ability of the service sector to absorb displaced workers will diminish. The utilization of computer and telecommunications technology will result in a reduced demand for labor in the service sector. Service firms may join the race to automate. The utilization of microelectronics technology, such as computers, electronic mail, and electronic banking, may eliminate service jobs. Computer technology will enable service firms, for instance, banks and insurance companies, to expand operations and still maintain or reduce the number of personnel. Computers will enable service firms to communicate with customers, process sales and claims, and file reports and information. In short, it is not a given that new service jobs will spring into existence to absorb displaced workers. Word processors, electronic scanners, and computer-aided design equipment will transform service industries so that they may also employ fewer workers in the United States even if the service sector of the economy continues to grow.

Third, the capacity to produce goods and services through automation will outstrip the increased demand for goods and services. The pes-

Aug. 3, 1981, at 66 (one study projected that microelectronics would produce a 25% decline by 1995 in wholesale and retail trade employment in England and a 31% decline in insurance, banking, and finance).

28. Those displaced may perform mental or physical tasks.

29. *See generally* I. ASIMOV & K. FRANKEL, ROBOTS: MACHINES IN MAN'S IMAGE (1985).

simists express doubts as to whether the economy will grow at a sufficient rate to generate jobs eliminated by technology. In addition, businesses face increasing costs to create each new job.[30] As the costs of labor increase and the costs of goods, especially computers, decrease, production of the economy's output will require more capital and less labor. The continued substitution of capital for labor in the production of goods and services will require the economy to grow by a greater amount to produce each new job in the future. Whether the economy can achieve and sustain this increased rate of growth is doubtful.

Fourth, the new technologies may not produce an abundance of new jobs. How many robot repair jobs will be created in view of the improved quality of robots? For example, using sensing devices and computer programs which analyze data, computer-aided diagnostic equipment will diagnose machine malfunctions. Mechanics or unskilled personnel will replace a failed part or make a prescribed adjustment obviating the need for a large crew of robot technicians. Thus, the net increase in the number of jobs involving the operation, service, and maintenance of automated technology is likely to be small because most work probably will be handled by a firm's existing production and maintenance labor pool.

Fifth, firms may continue the trend of decentralizing complex manufacturing operations throughout the world. Combining computers with telecommunications allows production to be decentralized globally where costs are lowest and conditions most favorable to the manufacturer. For example, automated inspection machinery reduces the cost of screening-out poor quality components, thereby encouraging businesses to farm out production of standardized parts to developing nations. Thus, the number of new jobs in America may decrease.

This brief survey of the arguments of technological optimists and pessimists quickly bogs down in a number of variables. Neither the optimistic nor pessimistic arguments categorically anticipate the effects of the following:

1) the rate of economic growth in the United States and worldwide;

2) changes in consumer income (personal income growth) and consumer tastes;

3) labor force demographics, including the labor participation rate,[31] and immigration trends;

30. The increased costs consist of direct wage and fringe benefit costs and the capital required to provide new, automated equipment.

31. The labor participation rate focuses on the number of people who want to work relative to the size of the adult population.

4) the decisions of multinational corporations[32] and the competitive position of United States firms in the world economy;
5) the rate of diffusion and installment of new technology;[33] and
6) the impact of United States government trade policies.[34]

In short, predictions with respect to the impact of microelectronics technology on employment are difficult because of widescale political and economic vagaries. We turn next to efforts to quantify the extent of future job displacement.

IV

The first systematic study of the effects of computer automation on the U.S. labor forces uses the dynamic input-output model[35] created by nobel laureate Wassily Leontief. The input-output model constitutes a representation of eighty-nine individual industries and fifty-three different occupations.[36] Because the model is dynamic, it provides employment trends, output levels, and investment pictures over the years 1963 to 2000. The input-output model enables analysts to assess in greater detail the impact of microelectronic advances on changes in the demand for labor. As further developed in this section of the article, the potential for job loss during the remainder of this century resulting from the diffu-

32. Key decisions of multinational corporations include, for example, the location of production facilities.

33. Technological advances may increase the applications of microelectronics technology. The rate of diffusion of the new technology depends on how rapidly technical, financial, and social barriers to automation are overcome. Technical barriers include: lack of technical expertise to design and implement new technologies; problems and costs of developing software to make the systems operate efficiently; absence of the requisite standardizations; shortage of qualified persons to design, operate, and service automated equipment and systems. Financial barriers flow from the need to invest capital in new equipment. The adoption of microelectronics technology is not costless. The financial barriers include: the cost of the new equipment; interest rates; the availability of capital; short-range focus of businesses, which generally wish to recoup the cost of the equipment in three years; capital investment considerations (cash flow position of the company and the risks involved in investing in new equipment); and the rate of capacity utilization. The social barriers are founded on human resistance to change. Union, managerial and institutional inertia slows the adoption of microelectronics technology.

34. United States trade policies are designed to stimulate American exports and stem the trend of plant relocations to overseas locations. In addition, policies which promote research and development of microelectronics technology must also be considered.

35. For background on input-output models, see R. MILLER & P. BLAIR, INPUT-OUTPUT ANALYSIS: FOUNDATIONS AND EXTENSIONS 1-31, 340-51 (1985).

36. W. LEONTIEF & F. DUCHIN, THE IMPACTS OF AUTOMATION ON EMPLOYMENT, 1963-2000 3.5-3.6, 3.30-3.31 (April 1984) (Institute for Economic Analysis, N.Y. Univ.). The 89 individual industries include livestock and livestock products, coal mining, construction, apparel, printing and publishing, petroleum refining construction and mining machinery, electronic computing equipment, household appliances, motor vehicles and equipment, retail trade, insurance, eating and drinking places, hospitals, and robotics manufacturing. *Id.* app. at 16-38.

The 53 different occupations include various types of engineers, computer programmers, medical personnel, secretaries, cashiers, plumbers, machinists, painters, janitors, and farmers (and farm workers). *Id.* app. at 2-15.

sion of microelectronic technology appears to be much less than pessimists fear.

Relationships between industries are modeled in a dynamic fashion; changes in those relationships are estimated on a yearly basis. The input-output model, being dynamic, allows the impact of computer-related technology to filter through all the industries and occupations included in the model. Output and employment levels in one industry are linked with changes in other industries. Reactions in one industry or occupation can affect other sectors of the economy. As a result of supply, demand, and institutional relationships, this chain of events may impact, via a feedback effect, on the original industry or occupation that commenced the ripple.[37]

The input-output model approximates the dollar value of various inputs needed to produce a given dollar value of various outputs. For any given output, the input-output model provides a percentage distribution of all required inputs. A separate employment requirements table is used to generate employment estimates. The employment requirements table provides the specific labor inputs needed by an industry to produce a given output level. The model accounts for changes in capital requirements, including replacement capital and expansion capital, related to new technologies.[38] The model also uses the projected labor requirements for changing capital to derive occupational employment.

Leontief-Duchin have depicted the capital formation process and the spread of new technology by numerous equations in an attempt to represent what researchers know about the various sectors of the U.S. economy based on actual data.[39] The "guts" of the Leontief-Duchin input-output model are four matrices, denominated A, B, R, and L.[40] The A matrix represents the input requirements of each industry to meet current consumption. The B matrix captures the capital expansion of various industries. The R matrix pictures the capital replacement requirements of each industry.[41] The labor inputs needed by various industries are modeled in the L matrix.[42] A series of columns (so-called vectors) are designed to represent non-investment final demand, includ-

37. *Id.* at 2.1-2.14; R. MILLER & P. BLAIR, *supra* note 35, at 1-31, 340-51. *See generally* W. LEONTIEF, THE STRUCTURE OF AMERICAN ECONOMY 1919-1939 (2d ed. 1951).

38. For example, robots, computer, and office automation equipment.

39. W. LEONTIEF & F. DUCHIN, *supra* note 36, at ch. 3.

40. *Id.* at 1.7, 3.19-3.32.

41. The A, B, and R matrices draw on input-output related studies undertaken by the U.S. Department of Commerce, Bureau of Economic Analysis. *Id.* at 1.7, 3.19-3.32.

42. The L matrix uses input-output related research of the U.S. Department of Labor, Bureau of Labor Statistics. *Id.* at 1.7.

ing household and government consumption, and net exports.[43]

Since the model is dynamic, the matrices and vectors will shift over time. In particular, the introduction and diffusion of microelectronics technology will alter the matrices. Different industries will respond differently to the introduction of new microelectronic technology. The adjustment of each matrix and vector requires separate studies.[44]

Before discussing the Leontief-Duchin findings, several caveats are in order. Historical relationships, even if correctly estimated, may be altered by unpredictable future events. Also, the impact of the introduction and use of new technology on a particular industry may be difficult to capture in a model.

The Leontief-Duchin projections are premised on baseline comparisons. For this type of analysis, Leontief-Duchin created a reference scenario.[45] This reference (or baseline) scenario is premised on the assumption that further technological innovation or automation would not occur after 1980. Although the final demand for goods and services by households, businesses, and governmental units was allowed to grow between 1978 and 2000, these demand forces could only be satisfied by the technology in existence in 1980. After constructing this baseline scenario, the dynamic input-output model generated estimates for a scenario incorporating the rapid adoption and broad use of available technologies during the balance of the twentieth century.[46] Thus, the impact of technology on labor demand, in the aggregate and in various occupations, can be assessed.

Under the "rapid adoption" scenario and the intensive use of automation, 20 million fewer workers would be required to produce the same level and combination of goods and services as in the baseline scenario.[47] Despite the potential problems raised by a shortfall in the demand for labor of this magnitude, Leontief and Duchin offer the following cautionary notes:

43. The final demand vectors use information from the Bureau of Economic Analysis of the U.S. Department of Commerce and the Bureau of Labor Statistics of the U.S. Department of Labor together with private sector studies. *Id.* at 3.3-3.19.

44. Leontief and Duchin investigated the studies undertaken by the Bureau of Economic Analysis and Bureau of Labor Statistics, which cover relationships existing in the mid-1970's, to ascertain how the matrices shifted over a number of years. These investigations were supplemented (and updated) by specific sectorial investigations undertaken by Leontief and Duchin. *Id.* at ch. 3.

45. *Id.* at 1.10-1.11.

46. *Id.* at 1.11.

47. *Id.* at 1.15. The 20 million fewer workers equals 11.4% less labor. *See also* CONG. RESEARCH SERVICE, 99TH CONG., 1ST SESS., THE COMPUTER REVOLUTION AND THE U.S. LABOR FORCE, A STUDY PREPARED FOR THE USE OF THE HOUSE SUBCOMM. ON OVERSIGHT AND INVESTIGATIONS OF THE HOUSE COMM. ON ENERGY AND COMMERCE 10, n.11 (Comm. Print 1985).

> Based on the findings . . . it is not yet possible to pass a final verdict on the question of technological unemployment by the year 2000. Technological changes taken into account . . . have been limited to computer-based automation. To arrive at a verdict, it will be necessary to ascertain by means of equally detailed factual inquiry . . . other types of change that are bound to take place. . . . Moreover, we have explicitly excluded from our scenarios any major breakthroughs in computer technology that might affect significant numbers of workers before the year 2000. While it is likely to be at least twenty years before products embodying future breakthroughs in areas such as automatic programming, speech recognition, or robot vision are actually adopted on a large scale, some surprises are certainly possible.[48]

Other observers draw more optimistic conclusions from these findings. They point out that the more than 11% reduction in the labor required to produce a specified level of goods and services must be balanced against other forces. The rapid adoption of new technology would permit the U.S. economy to produce more goods and services in comparison to the baseline scenario. The rapid adoption scenario would also allow personal and government consumption of goods and services to increase in the 1980's by approximately 2% per year (after adjustment for inflation) more than the baseline scenario and between 1.1 and 0.5% faster in the 1990's.[49] The increased consumption and thus demand for goods and services, even in the context of increasing unemployment, could still increase the demand for U.S. labor. In short, despite the introduction of new microelectronic technology, the American economy may generate sufficient jobs to enable the aggregate demand for labor to be in balance with the quantity of labor supplied in the year 2000.

Microelectronic advances will not uniformly impact on all parts of the U.S. labor force. The relative composition of employment in the United States will experience significant changes from 1978 to 2000. The big winner would be professionals. Under the rapid adoption scenario, professionals, who represented 15.6% of U.S. employment in 1978, could account for approximately 20% of U.S. employment by 2000.[50] In other words, the "rapid adoption" scenario would require 21.5% more professionals.

Production workers will also likely increase their share of the U.S. labor force between 1978 and 2000. The employment share of crafts people, operatives, and laborers represented 33.9% of U.S. employment in 1978. By 2000, their relative employment share could account for 37%

48. W. LEONTIEF & F. DUCHIN, *supra* note 36, at 1.31-1.33.

49. CONG. RESEARCH SERVICE, *supra* note 47, at 1. These consumption estimates result only from the adoption of new microelectronic technology; no other structural changes are assumed.

50. W. LEONTIEF & F. DUCHIN, *supra* note 36, at 1.16.

of U.S. employment.[51] Direct displacement by the utilization of microelectronics technology (for example, robots) will, thus, be offset by increased investment for capital goods, particularly computers, which will probably raise the demand for production workers.

Certain groups in the U.S. labor force may be adversely affected by the microelectronics revolution. Hardest hit by microelectronic automation would be clerical workers and managers who may experience a 40% drop in labor requirements.[52] The relative reduction in the demand for clerical workers and managers could require a massive transfer out of these occupations and into other fields. The likely decline in the number of clerical and managerial jobs may result in a mismatch between people seeking employment and the employment opportunities that will exist. However, service workers may account for a 2.3% increase in U.S. employment by 2000[53] and sales workers and farmers will likely represent the same percentage of U.S. workers in the year 2000, as they did in 1978.[54]

Commenting on the projected decline in demand for clerical workers and managers, Leontief and Duchin note:

> Let us suppose that there is an adequate total number of individuals to fill . . . jobs, but that because of very slow change in the orientation of education, training, guidance, and so on, these individuals' skills and occupational expectations will reflect the mix of jobs that corresponded to the technologies that were in place in 1978. . . . Under these assumptions, 744,000 managers . . . and over five million clerical workers could be potentially unemployed in 1990 while there would be unfilled positions . . . in other aggregate occupational categories. Of course some of those seeking managerial and clerical employment would be able to find jobs of other kinds but with obvious limitations on the degree of job mobility.[55]

Beyond the projected demand for labor in the aggregate and by various occupations, the diffusion of microelectronics technology raises three other issues: 1) the impact on wage levels and income distribution; 2) ge-

51. *Id.* at 1.17. The relative share of U.S. employment of crafts people may increase from 13.3% in 1978 to 15.0% in 2000. *Id.* Operatives and laborers also show relative employment gains from 1978 to 2000 from 15.7 and 4.9%, respectively, to 16.5 and 5.5%. *Id.*

52. In 1978 clerical workers comprised 17.8% of U.S. employment; clerical workers' relative share of U.S. jobs may plummet to 11.4% in 2000. *Id.* During the balance of this century, clerical workers will likely experience the largest percentage decline in employment. Over 30% of the U.S. female work force is employed in clerical occupations. Women could be particularly impacted by the transformation predicted by Leontief and Duchin. Managers could also encounter significant declines in their relative share, from 9.5 to 7.2%, of U.S. employment. *Id.*

53. Service workers who accounted for 12.4% of U.S. employment in 1978, could occupy 14.7% of U.S. jobs by 2000. *Id.*

54. *Id.*

55. *Id.* at 1.33-1.35.

ographical aspects of job displacement; and 3) changes in the character of jobs. Further research must be undertaken to assess the income distribution of individuals and facilities in the United States as a result of the introduction and dissemination of new microelectronics technology.[56] The Leontief-Duchin input-output model presently does not include equations which could be used to make this prediction.

The Leontief-Duchin model may, however, be used to analyze the United States job hierarchy in terms of occupation structure, status and stratification.[57] This type of analysis is based on dividing the U.S. work force into three groups: upper level occupations (professional and technical workers, managers, officials, and proprietors); middle level occupations (sales workers, clerical workers, and craft workers); and lower level occupations (operatives, service workers, laborers, farmers and farm workers). The projection derived from the Leontief-Duchin model points to shrinkage of the number of people employed in middle level positions and a corresponding expansion of the number of upper and lower level positions.[58] By the year 2000, upper level occupations could increase 1.9% from 1978.[59] The middle level could decline 4.8% from 1978 and the lower level could increase 3.9%.[60] In short, the microelectronics revolution may contribute to the changing income distribution in the United States and the polarizing of the population into low income and high income groups.

The geographical aspects of job displacement must also be considered. For example, the growing use of robots over the next five to ten years will probably have a concentrated impact on highly paid, semi-

56. *See* Leontief, *The Distribution of Work and Income*, SCI. AM., Sept. 1982, at 188; Cyert, *Easing Labor's Transition Trauma*, N.Y. Times, July 22, 1984, § 3, at 3, col. 1.

57. E. GOODE, SOCIOLOGY 433-54 (1984).

58. *See* B. BLUESTONE & B. HARRISON, THE DEINDUSTRIALIZATION OF AMERICA 55-61 (1982). The theory that middle-income jobs are being destroyed thereby threatening the very essence of middle-class society in the United States remains controversial. *See* Samuelson, *Demolishing a Myth*, Wash. Post, June 26, 1985, at D1, col. 1 (distribution of earnings along occupations has remained stable); Lawrence, *Stubborn Demographics: The Middle Class is Alive and Well*, N.Y. Times, June 23, 1985, § 3, at 3 (problem is demographic). *See generally* Kuttner, *A Shrinking Middle Class Is a Call For Action*, BUS. WEEK, Sept. 16, 1985, at 16. Service jobs which do not require much specialized training have traditionally paid less than manufacturing jobs. Will the majority of service sector jobs remain low paying or will increased capital investment in the service sector boost productivity and wages? *See generally* H. BRAVERMAN, LABOR AND MONOPOLY CAPITAL (1974), who argued that as technology advanced in the past, it was used to displace labor selectively, with the most highly skilled, most independent, and best paid workers let go first. In the long run, computer based machines are likely to displace higher order mental jobs (especially high wage jobs).

59. W. LEONTIEF & F. DUCHIN, *supra* note 36, at 1.17. In 1978, approximately 25% of U.S. jobs were upper level occupations, almost 38% of U.S. jobs were in the middle level and 36% were in the lower level. *Id.*

60. *Id.* By the year 2000, projections indicate that 27% of U.S. jobs will be upper level jobs, 32.9% will be in the middle level and 40.1% will be in the lower level.

skilled workers doing routine jobs in metalworking and other traditional industries. One-half of all metal working employment in the United States is located in Michigan, Ohio, Indiana, Illinois, and Wisconsin.[61] The concentration of semi-skilled workers in an economically troubled region increases their economic vulnerability. Displaced workers find it difficult to move elsewhere if they live in cities with a declining economic base and encounter no buyers for their homes where their meager savings are tied up. These states, especially Michigan, will likely experience a greater than proportionate impact of robots on employment over the next decade.

Finally, the result of microelectronics technology could be few "good" jobs[62] and many "bad" jobs.[63] In terms of working conditions, computer-based machines will eliminate the need for individuals to work in hazardous or demanding situations. However, health and safety problems may be associated with the new technology. For example, the use of video display terminals may contribute to visual and musculoskeletal problems, and radiation damage may result from long-term exposure to low levels of radiation.[64]

The levels of skills, autonomy, and authority must also be considered. Will the jobs created by technological advances be more or less skilled than the jobs eliminated? Will the impact of technology on existing jobs raise or lower the requisite work skills? It is unclear whether the general character of computer-based jobs will tend to be more creative, with increased worker autonomy, discretion and decision making. In other words, will the new technology eliminate boring and mundane jobs? Strong work motivations can occur if individuals are given the opportunity to manage, not just monitor, a process.

On the other hand, because the computer has the capacity to handle higher order decision-making normally assigned to an individual, work may become more routinized, with skills removed (or reduced) from a wide range of occupations and new forms of computer monitoring and control widely used.[65] De-skilling of jobs may result in the further frag-

61. R. AYRES & S. MILLER, *supra* note 9, at 212-17. *See also* H. HUNT & T. HUNT, *supra* note 25, at 85, 87, 89-90 (job displacement in Michigan).

62. The term "good" jobs connotes a high level of skills, autonomy and authority.

63. The term "bad" jobs connotes a low level of skills, autonomy and authority.

64. *See, e.g., Joint Hearing Before the Subcomm. on Science, Research and Technology of the Comm. on Science and Technology and the Task Force on Education and Employment of the Comm. on the Budget, U.S. House of Representatives*, 98th Cong., 1st Sess. 634-36 (1983) (testimony of Linda M. Lampkin, Director of Research, American Federation of State, County and Municipal Employees, in Technology and Employment).

65. In part, the literature lacks analytical precision because skill levels are difficult to define and measure. For instance, how do the physical skill requirements of a craft job compare with the

mentation of work if jobs become more routine, interchangeable, and strictly monitored in order to lower costs and better control the production process. This could result in work becoming increasingly repetitious and boring with workers whose skills are under-utilized displaying higher levels of job dissatisfaction and reduced productivity. Little opportunity for advancement may exist. Gaps in skills level progression may occur as mid-level blue-collar jobs (for example, moderately skilled machine operator, welder, or assembler) disappear, resulting in gaps in the promotion process from lower to higher skilled jobs. Organizations may be restructured and characterized by the emergence of the control room executive. Recentralization of decision-making may occur with top management making strategic decisions and plans with a significant increase in delegated authority to first level management. A significant loss of opportunity for worker individuality and judgment could occur in organizations where highly skilled work and better compensated jobs are being transferred to an elite group of employees. In other words, creative decision-making may be centralized at the top of firms. If so, the stratification of the work force will likely generate frustration, anger, and alienation on the part of those who expect upward mobility.

V

The impact of the microelectronics revolution on employment and the nature of work in the twenty-first century will result from technological improvements which increase the application of microelectronic technology. What will happen as quantum leaps occur in the speed and accuracy with which machines perform their tasks? The answer lies in the realm of speculation; hopefully intelligent speculation.

mental skill requirements of a professional job? For discussion of the deskilling problem see *e.g.*, Levin & Rumberger, *High-Tech Requires Fewer Brains*, Wash. Post, Jan. 30, 1983, at C5; *Forecasting: Hearings Before the Subcomm. on Investigations and Oversight of the Comm. on Science and Technology*, 98th Cong., 1st Sess. 76-80 (1983) (statement of Judith Gregory, Research Director, 9 to 5, National Association of Working Women). For robot operators, the incongruency between job activities of monitoring and worker preference may generate boredom and stress. R. AYRES & S. MILLER, *supra* note 9, at 95. *See also* Glenn & Feldberg, *Proletarianizing Clerical Work: Technology and Organizational Control*, in CASE STUDIES IN THE LABOR PROCESS (A. Zimbalist ed. 1979); H. MENZIES, WOMEN AND THE CHIP: CASE STUDIES OF THE EFFECTS OF INFORMATICS ON EMPLOYMENT IN CANADA (1981). The monitoring of each word processing operator's output and instantaneously comparing productivity among workers is examined in Arnold, Birke, & Faulkner, *Women and Microelectronics: The Case of Word Processors*, 4 WOMEN'S STUD. INT'L Q. 321 (Fall 1981). Furthermore, high technology industries provide jobs with little or no knowledge of high technology, i.e., clericals, secretaries, assemblers, and warehouse personnel. In the electronic components industry, for example, 15% of the workers were employed in engineering, science and computer occupations in 1980; the majority were assigned to low-wage assembly work. Riche, Hecker, & Burgan, *High Technology Today and Tomorrow: A Small Slice of the Employment Pie*, 106 MONTHLY LAB. REV. 50, 54 (Nov. 1983).

Several features of future advances in microelectronic technology are presently apparent. First, robots will be developed with a vision system and touch sensitive arms. They will thus become more capable of identifying and selecting parts and maintaining a high degree of repeatability. As a result, robots will be even more widely used on the assembly line.[66]

In addition to technological advances, the cost of robots will decline relative to the cost of labor they replace. The volume of robots being produced will rise. Robots will be programmed to make a variety of products and, therefore, be useful through a number of product transformations. Changing a disk will prepare a robot to make a new product. With increased robot flexibility, corporate financial officers will accept a longer payback period and corporate accounting departments will present less of a barrier to the spread of robotics.

Increased robot functions and flexibility may increase the number of workers displaced by a single robot. Instead of each robot replacing three workers, based on the average displacement per robot of 1.5 workers per shift and a two shift operation,[67] each robot may replace at least five or ten people.[68] For instance, based on second-generation robots which can be used in assembly operations, West Germany's Commerzbank estimates that half of the jobs held by that country's 1,200,000 production line workers may be at risk.[69] In short, increased functions and lower costs of future robots will likely result in more usage and greater worker displacement.

Second, with the development of artificial intelligence, i.e., computer simulation of human intelligence, computers will rival, and perhaps surpass their human progenitors.[70] Today's computers can handle 10,000 to 100,000 logical inferences per second; the next-generation of computers will be capable of 100 million to 1 billion logical inferences per second. These computers will be capable of intelligent reasoning (including draw-

66. OTA, *supra* note 7, at 89-92; R. AYRES & S. MILLER, *supra* note 9, at 60-63, 319-33; Holusha, *Robots That 'See' and 'Feel'*, N.Y. Times, June 6, 1985, at D2, col. 1.

67. W. LEONTIEF & F. DUCHIN, *supra* note 36, at 4.41. *See also* R. AYRES & S. MILLER, *supra* note 9, at 72-73; Buss, *High-Tech Track*, Wall St. J., Apr. 13, 1983, at 1, col. 6. Offsetting this worker displacement is the need for robot technicians. One robot technician may be required for each six robots per shift. W. LEONTIEF & F. DUCHIN, *supra* note 36, at 4.41. *See also* Freedman, *Behind Every Successful Robot Is A Technician*, N.Y. Times, Oct. 17, 1982, § 12, at 34, col. 3. In two shift operations, two robot technicians are required for every six robots.

68. Draper, *supra* note 8, at 46, 50. The greater displacement rate results from the increased productivity and flexibility of future robots.

69. *Id.*

70. E. FEIGENBAUM & P. MCCORDUCK, THE FIFTH GENERATION: ARTIFICIAL INTELLIGENCE AND JAPAN'S COMPUTER CHALLENGE TO THE WORLD (1983). *See also* OTA, *supra* note 7, at 83-87.

ing inferences and offering conclusions) and will be able to interact with people using natural language and pictures. Compared to today's computers, the next-generation computers will be what automobiles are to bicycles. Once computers surpass humans, they will be capable of their own design and will be reproductive. To a large extent, microelectronics will replace human minds in the Third Industrial Revolution, just as steam replaced human muscle in the Second Industrial Revolution.

The advances in and the diffusion of microelectronics technology in the twenty-first century point to ever increasing job displacement. As robots become more advanced and offices become more automated the labor force displacement impact could be enormous. The number of factory and office workers needed for the production of most goods and services will become insignificant. Automation of the factory and office will reduce the necessary work time. A worker who loses his or her job in one industry will not necessarily find employment in another industry. The long-term technological unemployment will be characterized by a bigger proportion of the labor force being incapable of fitting into the economic process because it lacks the literacy and math skills to work with the new technology. Low wage scales abroad, cheap communications, and the rapid diffusion of technology may render U.S. labor-intensive industry unable to grow fast enough to absorb the unemployed.

In Western society, work has traditionally been the basis of status, and the measure of an individual's worth. What will happen as work becomes less available? A society with excess productive capacity and plentiful labor is unable to attain its goal of full employment. Studies have indicated the adverse impact of unemployment on an individual is manifested in terms of negative feelings of self-worth and a loss of self-esteem, destruction of an individual's concept of his social and economic roles in society, and an increase in boredom, social strife and political and economic alienation.[71]

If the concept of work becomes meaningless in several generations, one of three scenarios may unfold: (1) free market; (2) Keynesian; or (3) human needs.[72] In the free market approach, there is no change in societal values and no government intervention in the market, resulting in a decrease in the overall quality of life. The Keynesian approach ad-

71. Much evidence links unemployment to emotional problems, alcoholism, drug use, and crime. *See, e.g.*, M. AIKEN, L.A. FERMAN, & H.L. SHEPART, ECONOMIC FAILURE, ALIENATION, AND EXTREMISM (1968); L.A. FERMAN & J. GARDNER, ECONOMIC DEPRIVATION, SOCIAL MOBILITY AND MENTAL HEALTH (1979).

72. Various scenarios are developed by A. GORZ, PATHS TO PARADISE: ON THE LIBERATION FROM WORK (1983); J. ROBERTSON, THE SANE ALTERNATIVE: A CHOICE OF FUTURES (rev. ed. 1983).

vocates governmental intervention in the market to preserve the status quo of the quality of life. The human needs approach advocates a change in societal values which improves the quality of life. However, this approach is the most difficult to implement because both individual and group social values must change. Of these three approaches, the human needs model best accomplishes an overall benefit to society.

In the free market scenario, automated factories and offices will not only reduce the number of workers but also abolish potential buyers of goods and services. A vast number of unemployed workers, in excess of the unemployment in the depths of the Great Depression, may coexist with an ever smaller strata of more-or-less permanently employed individuals. A growing gap may unfold between the elite who work at interesting jobs and the rejected who lack a permanent job.[73] The elite will likely regard the unemployed as social inferiors, increasingly unworthy of participation in social institutions. As social outcasts, the unemployed may survive precariously on grudgingly given charity, crime, the underground economy, and a desperate effort to sell domestic or sexual services to well-paid workers, corporate executives, professionals, and the self-employed. Poverty and opulence may go hand in hand. Feelings of social inferiority and inadequacy coupled with contempt displayed by the employed toward the unemployed may result in the physical separation of workers and non-workers, a sort of employment apartheid.

The Social Welfare-Keynesian approach may take one of two paths to deal with the ever mounting levels of unemployment and the underclass of individuals who never will have a permanent job at a living wage rate. On one hand, the government could institute mandatory regulations, which either require or prohibit certain citizen behaviors. On the other hand, the government could encourage and promote the desired behaviors through rewards and incentives. Either approach rests on the assumption that government intervention is necessary to resolve the problems caused by massive unemployment.

Faced with mounting job displacement, the government could pursue a number of mechanisms to mandate the distribution and sharing of available jobs. For example, substantial unemployment benefits could be cast in the form of early retirement[74] or a limitation on work by people within certain age limits.[75] In addition, compulsory education could be extended to delay entry into the work force, and military service and

73. K. VONNEGUT, PLAYER PIANO (1952).
74. The government could mandate early retirement at age 50 or 55.
75. The government could, for example, proscribe work by individuals under age 21 or over age 50.

youth service could be imposed on all citizens. Furthermore, available jobs could be shared. Two or three people may share one job, since the more automated a task, the easier it is for different people to perform it. Alternatively, the work week could be reduced. For example, thirty, twenty and then ten hour work weeks may become the norm. The government could subsidize work sharing and reduced work weeks by allowing individuals working partial shifts or partial work weeks to collect unemployment benefits for the part of the work week they are not actually on the job. Finally, only one person per "household" could be allowed to work.[76] In short, the government could intervene to distribute the available work and the accompanying income by deciding who will work and on what basis.

Another alternative, government promotion of consumption, would follow the more directly Keynesian model.[77] The Keynesian system is based on several principles: 1) mass consumption is necessary not only to enable all members of society to enjoy a high standard of living, but also to support mass production in an industrial society; 2) mass consumption requires the mass distribution of purchasing power; 3) full employment creates the mass distribution of purchasing power and therefore general prosperity; and finally, 4) it is a function of government to promote full employment through promoting mass consumption and economic growth. Thus, the traditional Keynesian model seeks to promote, rather than dictate, economic growth and prosperity as a means of preserving the status quo of the quality of life.

Attention could be focused on structuring the political economy to further encourage the consumption of goods and services. To prevent a future economic collapse, the state could force a significant redistribution of business profits. For example, the income tax system could be used as a redistribution mechanism to enable individuals to continue to purchase goods and services.

The state may also use the consumption of goods and services as a sophisticated system of social control.[78] In the state-promoted consumption model, the semblance of capitalism may remain, but its capitalistic substance would be lost. Goods and services would not be produced according to market signals to maximize profits. Instead, individuals

76. The government would, however, face the need to define the term "household" and then police this limitation.

77. *See generally* J.M. KEYNES, THE GENERAL THEORY OF EMPLOYMENT, INTEREST, AND MONEY (1936).

78. A. GORZ, *supra* note 72, at 32. *See generally* H. MARCUSE, ONE DIMENSIONAL MAN (1964).

would be paid to consume to perpetuate social order and control. An elite technocracy would run society, perhaps only with the aim of maintaining social order and strengthening its control, while condemning most people to dependency and an existence at the margin of society. Under either Keynesian approach, mandate or promotion, the government intervenes to stabilize the economy and preserve the status quo.

The human needs approach advocates a change in societal values in order to improve the quality of life. The human needs approach centers on the writings of Abraham Maslow who developed a hierarchical theory of motivation based on mankind's biological propensities.[79] A hierarchy of needs is postulated: physiological (the lowest), safety, social esteem (which encompasses belonging, self-respect and the respect of others), and self-actualization (the higher need) which is regarded as the fulfillment of one's potential in life. The strongest (prepotent) needs must be satisfied first. The lower needs (e.g., physiological) are inherently more important than the higher needs and have a stronger influence on motivating an individual's behavior. When one level of need is satisfied, at least to some extent, the next level in the hierarchy emerges and becomes the dominant influence on the individual. The pattern of increased satisfaction and decreased importance repeats itself causing a greater importance of needs at the next higher level until the self-actualization level is reached. Stated differently, greater satisfaction at one level leads to increased need strength at the next higher level. Self-actualization, which is perceived as attained late in life, encompasses a person's desire to achieve his full potential. Self-actualization is characterized by a superior perception of reality, an increased acceptance of self, others and nature, spontaneity, increased problem centering outside the individual, autonomy, freshness of appreciation, richness of emotional reaction, improved interpersonal relations, and increased creativity.

A dynamic self-generating system is envisaged in which individuals become conscious of higher needs. A network of growing and developing

79. A. MASLOW, MOTIVATION AND PERSONALITY (2d ed. 1970) [hereinafter MOTIVATION]; A. MASLOW, TOWARD A PSYCHOLOGY OF BEING 30 (1968) [hereinafter PSYCHOLOGY]. Maslow divided the hierarchy into deficiency motivated needs (physiological, safety, belonging, love, respect and self-esteem) and growth motivated needs. Maslow notes, "[i]t is these [deficiency motivated] needs which are essentially deficits in the organism, empty holes, so to speak, which must be filled up for health's sake, and furthermore, must be filled up from without by human beings other than the subject, that I shall call deficits or deficiency needs." PSYCHOLOGY, *supra*, at 22-23. The deficiency needs are best known to psychologists because their frustration produces psychopathology. MOTIVATION, *supra*, at 2. The self-actualizers, motivated by growth needs, search for what Maslow called "being" values and may encounter peak (transcendent, mystical) experiences in which, they reported, larger meanings subsumed the self and its boundaries and limitations. MOTIVATION, *supra*, at 149-80.

personalities interacting in a variety of experiences constitutes society. The good society thus provides the means for human growth. The unfolding self-realization produces creative and beneficial results for both the individual and humanity. Maslow notes, "self-actualizing people are, without one single exception, involved in a cause outside their own skin, in something outside themselves, and they are devoted, working at something which is very precious to them—some calling or vocation in the old sense . . . so that the work-joy dichotomy in them disappears."[80]

The underlying principle of human growth implies a desire for innovation and experimentation and a trust in the individual. The accent is on developing new social structures and institutions which foster individual awareness and personal fulfillment. "Third" force psychologists and neo-Freudian psychoanalysts perceive the world as an open-ended system in which mankind has almost infinite potential. The humanistic ideal sees humanity moving in a forward direction and seeking to maximize individual self-development and self-realization. The focus is on the realization of capabilities and the attainment of "happiness."

In the next century, the full impact of the microelectronics revolution may force a reconsideration of work as the central activity of peoples' lives. In the twenty-first century there likely will not be full-time employment for a significant portion of the U.S. work force. Wages will not depend on the amount of work performed; income will not be related to work (or will be related to work in a different way). Few will be able to survive on the wages received for the hours actually worked.

The diminution of work as a significant factor in human lives and a high degree of individual idleness may lead to a reconsideration of values and a reconceptualization of the concept of a life worth living. As the crisis gets deep enough and the reduction of employment and work time becomes even more general, the will to transform society may arise as a result of a massive increase in the number of unemployed persons. As a corollary, mechanisms will be developed to provide income independent of any labor required for the production of goods and services, thereby replacing a key social structure of the industrial era—individual dependency on work and employer as the central organizing life force. The present system of distributing income based on work may undergo revision. In short, the possibility exists that social institutions may be restructured to serve the entire hierarchy of human needs.

Within the context of the human needs approach, life may come to be viewed not in terms of money or work time but time made productive

80. A. MASLOW, THE FARTHER REACHES OF HUMAN NATURE 43 (1971).

and creative. Disposable time enables individuals to enjoy life, to seek recreation, and to improve their minds. Individuals may devote themselves to endeavors for the pleasure of creating, giving, and learning. The quality of human relations and the values of cooperation, creativity, and self-actualization may come to the fore. The abolition of the work ethic may lead to human liberation, personal skill development[81] and increased social activity.[82]

Since basic needs must be provided for before higher needs can be fulfilled, existence for most people may come to depend on some form of government-provided guaranteed income for life, such as a personal allowance system. The guaranteed income concept raises three major issues: (1) how to fund a guaranteed income; (2) whether the guaranteed income will enable individual social development or foster passive consumption; and (3) whether the new social order will collapse as people will not want to work at all.

A tax on automated factories and offices could provide one means to finance a guaranteed income for life.[83] A tax on robots and other types of microelectronic equipment could be based on a unit of the output of goods or services. The level of taxation could be geared to the type of goods or services produced, depending on whether society wishes to promote or retard the consumption of this type of good or service.

A robot tax raises, in turn, three problems. First, the imposition of this tax would decrease the cost differential between labor and robots, thereby slowing the automation process. Stated differently, the robot tax may make sense from the viewpoint of organized labor, but not from a societal standpoint. Second, the imposition of a robot tax to fund a guaranteed income for life would increase the cost of production and slow the automation process thereby retarding the international competitive position of U.S. firms in driving production overseas. Third, who will make the determination of what is socially useful or desirable consumption? How will the determination be made? What criteria will be used?[84] The

81. Personal skill development could occur in a variety of areas, including arts, sports, and continuing education.

82. Social activity could include greater participation in society's economic and political spheres.

83. INTERNATIONAL ASSOCIATION OF MACHINISTS AND AEROSPACE WORKERS, THE ORIGINAL REBUILDING AMERICA ACT 202-04 (1984) (proposing the imposition of a tax on machinery, equipment, robots and production systems that displace workers and cause unemployment).

84. Perhaps society could arrive at a consensus with respect to basic human needs. A necessary minimum might include "food sufficient in quantity and kind for health, palatable but without variety, uniform clothing adequate for all seasons, shelter on an individual, family and group basis, with adequate conveniences for different environments; medical services and transportation." P. & P. GOODMAN, COMMUNITAS 200-01 (2d ed. 1960). *See also infra* note 86.

answers to these questions may turn on the widescale acceptance of a human needs orientation.

A lifetime guaranteed income independent of a job could be a social wage based on consumption and passivity, a means to enable individual and social development, or both a social wage and a means to enable individual and social development. Below a certain income level, an individual would receive a specified payment from the state. The unemployed, who have been marginalized by the microelectronic revolution, would be made socially acceptable and be maintained at the least cost to society. A lifetime guaranteed income in the form of a negative income tax would permit the abolition of a variety of governmental benefits and allowances and their attendant separate administrative systems, thereby releasing funds to finance the lifetime guaranteed income system.[85] However, the individuals receiving the guaranteed income would remain dependent on the state and would be expected to orient their lives around the continued consumption of goods and services. This could result in merely passive consumption. Alternatively, a guaranteed income for life may be viewed as the product of a specified minimum amount of socially useful labor which an individual provides throughout his or her lifetime. Estimates place the lifetime amount of work to produce basic necessities[86] at 20,000 hours[87] or substantially less in a society characterized by less competition and a more relaxed lifestyle. The 20,000 hours may represent ten years of full-time employment (at 2,000 hours per year), twenty years of part-time work, or forty years of intermittent work combining full-time and part-time employment, as well as periods for individual development and community activities.

Because income would be received and necessities would be provided for, each person could receive the same amount according to a theory of equality. However, if each receives the same amount, those with special or additional needs would suffer. Special needs could be accommodated on the basis of general categories of people (e.g., the

85. *See generally* ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT, NEGATIVE INCOME TAX: AN APPROACH TO THE COORDINATION OF TAXATION AND SOCIAL WELFARE POLICIES (1974). Advocates' thoughts of a guaranteed lifetime income in the form of a negative income tax may be based on a desire to simplify and reduce government activity. M. FRIEDMAN, CAPITALISM AND FREEDOM 190-95 (1962).

The guaranteed lifetime income system may also provide the basis for positive receptivity to technological change. When it becomes apparent that the new technologies will affect more workers, a general resistance to change may occur; the power of the resisters may increase. Human resistance may take the form of stalling the process of change or imposing unreasonable penalties on it. Resistance will prove self-defeating because firms will become noncompetitive and go out of business.

86. Basic necessities include durable, repairable goods and services which are functional and economical in terms of the inputs of labor and natural resources. *See also supra* note 84.

87. A. GORZ, *supra* note 72, at 41.

aged) or payments could be based on individual need in accordance with a theory of equity. However, individualized need payments raise the spectre of expensive and complicated need determination tests.

The obligatory full-time or part-time lifetime work would be devoted to producing necessities. A guaranteed lifetime income would provide sufficient time for numerous activities and different ways of life without economic objectives. Free time activities could be devoted to fulfilling needs beyond economic necessities, partaking of interests and skills[88] or engaging in unnecessary superfluous activities which are not anti-social.[89] Leisure could replace work in terms of prestige, identification, the structure of time and as a means of attaining self-realization.[90]

Disposable time may take the form of a prosumer society.[91] Individuals, families, and small groups may produce goods and services they want to consume or exchange outside the market through barter and trade, or even gifts. Individuals may reassert the sovereignty of their needs and the means of satisfying them. Production of goods and services may become more decentralized, with a significant proportion of production centered in the household and the community. There may be a merging of work and leisure as more people take a greater control of all aspects of their lives. A trend to greater self-reliance may occur through the growing use of small-scale technologies which people control for themselves.

The path of leisure and spontaneous activity may not provide the best alternative to self-realization. Segments of the population, such as the children of autocrats or super rich, who have approached conditions of "liberation" constitute some of the most frustrated and alienated citizens. They fill their boredom and loneliness with alcohol and drugs. If a majority of the population responds in this manner to increased leisure

88. The development of interests and skills could include, for example, sports, arts, music, or volunteer activities.

89. *See* H. MARCUSE, EROS AND CIVILIZATION (1955) for the development of the view of an effortless utopia in which technology replaces all necessary activity. For Marcuse, by eliminating the "surplus repression" resulting from the social organization of labor imposed in the interest of domination, the entire body could again become a source of pleasure (polymorphous perversity). In the new order, life becomes a spontaneous endeavor, where human bodies become organs of pleasure with greater intensity and a variety of erotic experience. *See also* R. RICTA, CIVILIZATION AT THE CROSSROADS (1969); D. RIESMAN, THE LONELY CROWD ch. XV (rev. ed. 1961) (autonomy in the post-industrial world could be found in leisure, not work).

90. *See, e.g.*, Dubin, *Industrial Workers' Worlds: A Study of the 'Central Life Interest' of Industrial Workers*, 3 SOC. PROBS. 140 (1958) (study of workers' central life interest in terms of expressed preference for a given locale or situation in carrying out an activity. Although the workers evidenced a sense of attachment to their work and workplace, they were not committed to it. For three out of four industrial workers surveyed, their self-actualization came in institutional settings outside their work organization).

91. A. TOFFLER, THE THIRD WAVE ch. 20 (1980).

time, we may be back to the free market scenario, sketched earlier. This scenario is characterized by the development of a technical elite which controls and understands the new automated factories and offices. The elite may keep the remainder of the population in a state of submissive ignorance, thus impeding the realization of individual self-fufillment.

Based on the present use of leisure (that is, non-work) time, the promise of considerably more free time appears less than encouraging as a means for human growth and development. Today, many workers crave leisure as a means of relaxation and regeneration—through the elimination of mental and physical fatigue—from the uniformity and fragmentation of jobs. As a mode of compensation for the nature of work, it appears insufficient for individuals to be employed and to be linked to life through leisure-time consumership. The pursuit of leisure through passive activities dominated by consumption and the machinery of amusement illustrates the illusory possession of non-work time. Leisure has become organized, administered, institutionalized and commercialized, spurring, in conjunction with the mass media and advertising, the consumption that business so assiduously cultivates.[92] Rather than achieving self-realization, many individuals kill time through monotonous diversions. Intellectual capacity or excitement atrophies as gadgets fill the emptiness of time. Education can, however, alter leisure patterns.[93] Lifelong learning may come to be the form of education that makes the most sense. Implicit in the human needs approach is the vision of people leading more educationally-oriented and less gadget-ridden lives.

Change may come voluntarily. As material goods are available to more people, consumption may be satiated and items may lose their positions as status symbols.[94] However, new items may become future status

92. *See* Seligman, *On Work, Alienation, and Leisure*, 24 AM. J. ECON. & SOC., 337, 356-60 (1965); DE GRAZIA, OF WORK, TIME AND LEISURE (1964). C.W. MILLS, WHITE COLLAR 238 (1958) notes that work is made completely subservient to leisure for "leisure is the way to spend money, [while] work is the way to make it. When the two compete, leisure wins hands down." A. KORNHAUSER, MENTAL HEALTH OF THE INDUSTRIAL WORKER: A DETROIT STUDY 199-203, 266-67, 271 (1965) portrays the barrenness of leisure. One-half of the workers surveyed had no hobby or special interest to occupy their spare time. Active and meaningful leisure was reported by less than 15% of the workers surveyed. The workers, in groping for meaningful ways to fill spare time without a conception of the possibilities, emphasize consumption, not self-development.

93. *See* Wilensky, *Mass Society and Mass Culture: Interdependence or Independence*, 29 AM. SOC. REV. 173 (1964) (leisure styles of men with a short-hourwork day consists of compulsive absorption of large amounts of shoddy television as a time filler through a retreat to escapist violent programs, but the great majority of men with a high quality college education display high leisure competence).

94. Blumberg, *The Decline and Fall of the Status Symbol: Some Thoughts on Status in a Post-Industrial Society*, 21 SOC. PROBS. 480, 486, 496-97 (1974).

symbols or a variety of means may be created to satisfy basic needs. If this change is not voluntarily achieved, the government might take the lead in restricting consumption.[95] For example, taxes could be imposed on goods thought socially undesirable. The aim of voluntary or government regulation of consumption would be the development of a subsistence standard for all people.[96] This raises the problems of whether the American people would be content with minimum levels of food, clothing, housing, and health care. As Fromm comments, "[i]f consumption were to be reduced, a good deal of anxiety would become manifest. The resistance against possible arousal of anxiety would result in the unwillingness to reduce consumption."[97] Together with a reduction of consumption, society could promote or require lifelong continuing education as a social palliative and a means of furthering a human needs orientation.

People guaranteed an income for life may not want to work at all if not forced to do so. If so, the new social order may collapse. With the abolition of compulsion to work full-time for forty or fifty years, an individual may want to work because it makes him or her feel useful to society. Work also provides a means of escape from conformity and narrowness of a family or other domestic unit or a community. For example, it provides a way to meet other people and form relationships not based on a regulated world in which everyone is limited to his or her allocated place. Finally, in an automated society, the issue of work incentives would not arise at all. In sum, automation opens the possibility of a society filled with promises and pitfalls.

CONCLUSION

The workless society of the twenty-first century is not to be feared. The workless society of ancient Greece, in which citizens were neither expected nor encouraged to work, gave rise to the beginning of modern arts and sciences. Freeing citizens from the need to make a living enabled creativity to flourish in widely different fields. Learning, fulfillment, and all social institutions were "directed to this end. This is what the Athenians did . . . . They made their society one designed to bring all the members to the fullest development of their highest powers. . . . In Athens, education was not a segregated activity, conducted for certain hours,

95. Society must, of course, reach a consensus as to whether the government should promote or restrict consumption.

96. P. & P. GOODMAN, *supra* note 84, at 200-01.

97. E. FROMM, THE REVOLUTION OF HOPE 124 (1968). *See also* P. & P. GOODMAN, *supra* note 84, at 212-13.

in certain places, at a certain time of life. It was the aim of society."[98] In short, lifelong learning may take place in all of society's institutions.

Future generations may enjoy a similar experience. The workless society of the future may give rise to an unparalleled period of creativity and originality, and enable people to fulfill a broad range of their needs.

98. R. HUTCHINS, THE LEARNING SOCIETY 134-35 (1968).

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COMMENTS