Technology and the World of Our Children

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I. INTRODUCTION

I'm delighted to join you at this Aspen Institute Conference on the future world of our children. Many of the forces that will determine that world are already at work. They result from the changing trajectories of technological advance as they interact with the dynamics of the economy and demography. How we prepare our children and ourselves for this changing world and formulate enabling public policies depends on the expectations we have for that future.

We look ahead a quarter of a century to the year 2020 when our children will be in their maturity. While present trends set directions in which the future is evolving, they cannot set the outcomes. Projections a quarter century into the future are hazardous at best. I have spent a good portion of my career in the prediction business, as Chief of the Weather Bureau and Administrator of the National Oceanic and Atmospheric Administration (NOAA). The weather at least is governed by physical laws, the future of society by the interactions of a host of different forces, many of which are inherently unpredictable.

II. THE HISTORY OF TECHNOLOGICAL PREDICTIONS

History is replete with failed predictions. Lord Kelvin, one of the greatest scientists in the United Kingdom in 1885, is quoted as saying, "Heavier than air machines are impossible." Ten years later the Wright brothers proved him wrong. In 1943, Thomas Watson, then Chairman of IBM, said, "I think there is a world market for maybe five computers." Today the number of computers worldwide of all types is in the tens of millions. In more recent times, Ken Olson, President, and Founder of the Digital Equipment Corporation as late as 1977 is quoted as saying, "There is no reason anyone would want a computer in their home." Today personal computers have become common household appliances.

More sobering has been the inability to predict the consequences of new technologies and world-shaking political events. Were we trying in the year 1970 to predict the nature of the world we live in today, we might have missed some of the most important driving events that shape the present. We would have missed the ubiquitous nature of the personal computer and the transformations it has wrought in almost every field of human activity. We would have missed the growth of some of the most dynamic new products and services: software, bio-engineered pharmaceuticals, mobile wireless communications, non-invasive medical diagnostic devices, compact discs and the Internet among others. We would have missed the political upheavals engendered by the collapse of the Soviet Union and the rise of the economic power of Japan and the countries of Southeast Asia. We would have missed the oil embargoes of 1973 and 1979 and detente with China. Not only would we have missed such events, we

would have been wrong about others. We would have misjudged the growth of nuclear power. Remember the promise of almost unlimited and cheap energy?

Technological and economic transformations occur with great rapidity. Twenty five years ago, in 1970, video cassette recorders (VCRs) in U.S. households were too few to be recorded by the Census Bureau. By 1994 there were 74 million U.S. households equipped with video cassette recorders. Cable television tells the same story. In 1970 cable television had penetrated only 4 million households, but by 1994 the penetration had exceeded 59 million. Cellular phones did not exist in 1970, but by 1994 there were 24 million subscribers in the United States. Compact discs were non-existent in 1970, but by 1994 882 million CD's were shipped. The same story is found in the automobile industry. Twenty five years ago the United States imported only 408,000 passenger cars and trucks from Japan annually. By 1994 we were importing 3,250,000 cars and trucks annually. The value of the vehicles imported into the United States had gone from $4 billion to $35 billion in that period. (Source: *Statistical Abstract of the United States*, 1995, pp. 596, 575, 571, 578.)

III. THE ECONOMIC CONSEQUENCES OF TECHNOLOGICAL ADVANCE

While trends are not destiny, the future evolves in a non-linear fashion from present conditions. The functions of society, however, change slowly. In 2020 we will still want and need to conduct elections, to travel, to educate new generations, and to have access to health care, to say nothing of the need for food and shelter. Most importantly, we will need jobs—good paying jobs for our citizens.

One does not need to be a technological determinist to recognize that the principle driving force for economic, demographic and social change is technological advance. Today three enabling technologies are having pervasive effects: information technology, biotechnology and materials technology. These are supplemented by advances in space, energy and environmental technologies. These technologies are at the beginning of their transforming trajectories. No area of human activity is now immune to the changes being wrought by these enabling technologies.

The fundamental consequences of advancement in these technologies is that time and space dimensions of all human activities radically change. In a sense, time delays disappear as we enter a feedback world in which events of all kinds are communicated and in many cases acted upon almost instantaneously. Space dimensions shrink as remote operations become possible, and rapid movement from one part of the world to another is a reality. National borders become permeable, and national sovereignty weakens as the actions of multinational enterprises are superimposed upon nation states. Markets have long been global but access to them becomes central to corporate profitability. Concepts of resources change as intellectual content becomes a dominant input to the production of goods and services.

We focus on two aspects of these technological changes:

1) The effects upon the economy, the characteristics of which will determine the nature of work, the availability of jobs, and standards of living, and
2) The implications for educational and social systems of this new cyber-economy.

IV. THE NEW GLOBAL COMPETITION

The shrinking world in time and space drives the economies of all nations to be integral parts of a dynamic global technological and economic system. We start with the fact that technology has permitted the creation of a global capital pool that is now accessible to qualified enterprises anywhere in the world. A corollary is that management of industrial enterprises located anywhere in the world can oversee production and service components that can be globally dispersed.

The global competitiveness of enterprises now depends on the meshing of new sets of diverse and interacting influences. The factors that determine the costs of production of goods and services now relate to the differences in wage rates throughout the globe, the costs of other inputs that vary from country to country, the costs of compliance with environmental, health and other regulations, intellectual property considerations, the availability of technology, and an educated labor force. The goals of multinational enterprises become independent of

the national goals of the country in which their headquarters is based. The CEO of the Coca Cola Company describes his corporation as an international entity that just happens to be headquartered in the United States. The result is that national sovereignty weakens as control of financial and economic relations with other nations are determined by corporate rather than governmental decisions. Indeed, U.S.-based multinational corporations have been able to maintain their shares of the world market for goods and services; they merely supply those markets from different locations. The share of the world market serviced by U.S.-based corporations has remained at 20-21 percent for decades. The trade deficit in goods and services results from the fact that U.S.-based production has lost world market share.

V. CHANGING CORPORATE STRUCTURES

Technology now permits corporations to evolve into "virtual corporations" that do not own or control all the means of production. These corporations are becoming foci for the assembly of capital deployed to gain strategic advantage using many modes to achieve acceptable returns on investment. Management of enterprises can now oversee the activities of globally dispersed units while operations of the individual units can serve the special market needs of various countries and be located where the combination of all the factors affecting profitability can be taken into account.

We are now witnessing the symptoms of the new nature of global competition. The aerospace industry provides a good example. Because of the need for market access, especially in countries with rapidly developing economies, it is not only wage rate competition that is important in decisions about offshore production, but market access. Technology now makes it possible for a U.S. company like Boeing Aircraft to have the fuselages of some of its aircraft manufactured in Japan, landing gear in Israel, 737 tail sections in China, and nose and wing elements in Korea to gain aircraft sales to national airlines in these countries.

The penalties for the United States are in the transfer of technology and know-how that accompany such manufacture. They are also in the loss of high wage manufacturing jobs to overseas locations. For the Boeing Corporation, such moves are essential to survival as a global supplier of passenger aircraft.

The pharmaceutical industry evidences the cost advantages of global suppliers. Generic drugs now account for 40 percent of prescription drugs sold in the United States. Most of the key ingredients come from foreign suppliers because of cost advantages. So do 60 percent of the components of brand name drugs (*The New York Times,* October 29, 1995).

The implications for defense industries and national security are profound. In a world in which the conception, design, development, production, and distribution of goods and services is an integrated global endeavor, traditional national security concerns such as foreign dependency take on a new meaning. In the past we thought that the nation was at risk whenever there was a possibility that a militarily important technology was available to our adversaries, or only available from overseas sources. The unfolding future will turn this probability into a certainty—global industrial integration portends the same for defense and civil industries. Defense prime contractors may do their system integration in the United States, but their supplier networks will inevitably extend to take advantage of both domestic and foreign core competencies.

The virtual corporation becomes a reality. The future can be seen in the operations of a small biomedical company in the Washington area: Alpha 1 Biomedicals, Inc. has only 6 employees. It literally contracts out everything—its research, its toxicology studies, and production. Universities do its research, commercial laboratories do its toxicology studies and three different drug companies do its manufacturing. (*The Washington Post,* October 29, 1995).

Make or buy decisions for companies have always been a way of life for corporations. There is nothing new in contracting out for parts, retaining in the corporation the key design, systems engineering, product assembly, key technological and marketing functions. But many of these functions now migrate abroad. It is the extent and rationale for outsourcing of functions that is a new phenomenon. A harbinger of the future is in the fact that Nike Inc. does no manufacturing in the United States. The same is true of Mattel Inc. and mostly true of Apple Computer.

VI. TECHNOLOGICAL PRODUCTIVITY AND CORPORATE DOWNSIZING

While globalization and its attendant effects on the economic system are the overriding feature of the new global economy resulting from technological advance, a second pervasive effect is in the downsizing of enterprises. We have already entered the downsized world. Downsizing traditionally has been a characteristic of business downturns. Today downsizing in production, service, and management of corporations in large part results from the increases in productivity brought about by the introduction of new technology. New technologies permit the realization of increased productivity from matters of scale as well as the specialization of products and services associated with small enterprises.

In the past we used to think of firms as vertically or horizontally integrated, or both. Today, the extent of integration has become less important than the ability to rapidly reconfigure the enterprise to take advantage of internal, or external core competencies. New terms have sprung up. We now describe the competitive character of a firm according to whether it is agile or virtual or lean or flexible, or a combination of these traits.

The evidences of gains in technological and management productivity are in the almost continuous announcements of corporate layoffs. The American Management Association, whose members employ 25 percent of U.S. workers, reports that for every new hire another employee is fired. In the first 9 months of 1995, more than 300,000 jobs were eliminated, according to Challenger, Gray and Christmas, Inc. of Chicago, an organization that keeps track of such matters. Salaried workers in middle management were hardest hit. The productivity effect is evidenced in the 1993 merger of the Bank of America with the Security Pacific Corp. In that year, the Bank of America announced record profits of about $1.5 billion while it was simultaneously cutting 7500 jobs (*The Washington Post,* November 5, 1995).

We are in the embrace of truly historic events related to technological productivity and employment. During the past year, AT&T announced that it is offering job buy outs to 77,800 managers, half of its supervisory work force. It expects about 10 percent of these workers to take up the offer. In addition, it has announced, as 1996 arrived, that it plans to lay off 40,000 workers, the majority of whom are in white collar managerial positions. It is information technology that enables the elimination of these jobs. The Bethlehem Steel Co. will stop making steel in its home town in Pennsylvania for the first time since 1873. Some 1800 steel workers will be laid off. Nationwide, the total number of steel workers in the United States has declined from about 550,000 to 171,000 in the 45 year period between 1950 and 1995 as old technology is displaced by new technology that makes modern U.S. mini steel mills competitive in the world marketplace. (*USA Today,* 17 Nov. 1995).

Layoffs in the 4-year period from 1992-1995 on the part of some of the U.S.'s largest corporations tell the same story. IBM has laid off 122,000, AT&T 83,000, General Motors 74,000, U.S. Postal Service 55,000, Sears Roebuck 50,000 and Amoco 12,300 workers. (*The Washington Post,* October 21, 1995). The American Management Association has concluded that the employment predicament is different from anything seen since the invention of the factory 200 years ago. Only 6 percent of its member firms that cut payrolls in 1994 rehired laid off workers. The new workers tend to be in the professional and technical fields. Middle managers make up 5-8 percent of the work force but account for 15–20 percent of the job losses. Very few of the firms gave poor business conditions as their reason for downsizing. Poor business conditions have in the past been the major reason for downsizing. In 1990, 43 percent of firms cited business conditions as the reason for downsizing; by 1992 only 21 percent gave this reason; and in 1994 only 6 percent of firms gave this reason.

An important consequence for the world of work that our children will encounter is the attenuation of firm loyalty by workers. They will no longer be able to count on a lifetime of work for a single corporation. They will need to be comfortable with change, with a life's work for many entities with loyalty to themselves and their careers. The sociological ramifications of this job changing syndrome are only poorly understood.

VII. JOB CREATION, DESTRUCTION AND MIGRATION

The paradox of technological advance is that it creates employment as well as displaces and de-

stroys it. It would be easy to gain the impression from news headlines that technological advance and employment do not mix. The opposite has been true historically. The issue is whether past history is a useful guide to the future. The race between the job creation and destructive power of technology has always been out of balance but from a historical perspective technology has been a net job creator.

The creation of jobs depends on the formation and expansion of new industries or new markets, usually both. Technological changes have now moved rapidly to create them. The software industry hardly existed 25 years ago. In 1993 it provided employment for 435,000 employees. By 1993 it was a $32 billion industry. This story is repeated endlessly. In the past decade since 1985 new and growing corporations have been increasing their work force. MCI has grown from 12,445 employees, to 47,500 today. Sprint has increased its work force from 27,415 workers to 51,500. Cable operators and those responsible for conceiving and producing television programs have increased their work force in the past two decades from 23,538 in 1978 to 112,239 today, according to the Federal Communications Commission. The cellular telephone industry since its inception in the 1980's employs 300,000 workers, directly and indirectly, according to the Cellular Telecommunications Industry Association. (*The Washington Post,* January 6, 1996).

Technological advance transformed agricultural practices in the United States. The productivity of U.S. agriculture enabled the 30 percent of the work force on farms at the turn of the century to be reduced to 3 percent of the work force on farms today. That displaced work force, with considerable disruption and pain, became employed in manufacturing and service industries as new technology created new enterprises and services. The process continues today but the circumstances are fundamentally altered because of the globalization of the economy and the fact that technological advance in one country frequently results in job creation in another as advances are quickly exploited.

Market access is one reason for job and technological migration, but wage rate advantages are among the most important driving forces. It is not only wage rates for production workers, but also for highly skilled technical workers that propels jobs overseas. The Council on Competitiveness reports that skilled workers in the United States are facing increased competition from abroad. The jobs at stake are white collar jobs in high tech positions in computer programming, design and financial services. The Council cites advances in computer and communications technology as the basic reason. Much of this kind of work is going to China, India, Singapore and Taiwan as well as to low wage countries in eastern Europe at a fraction of U.S. wages. The cost of hiring an English speaking computer programmer in India is only $15,000–18,000 per year as compared with $150,000-120,000 for an American programmer. Programmers in Bulgaria are paid salaries that range from $10,000–$20,000 per year. This is one fifth of the compensation for programmers in the United States.(*The Next American Nation*, Michael Lind, 1995 The Free Press).

VIII. EVOLVING TECHNOLOGICAL AND COMMERCIAL VISTAS

Other enterprises, in addition to those applying advances in information technology, are emerging from the other dimensions of the technological revolution in mind boggling diversity. One of the most rapidly growing is the biotechnology industry as the private sector rushes to capitalize on the scientific discoveries in molecular biology. The world market for biotechnology products is predicted to grow from $5.7 billion in 1992 to almost $94 billion in the year 2000. (*New Technologies,* Continuum Publishing Co., New York)

The commercial vistas opened by technological developments in information and telecommunications combined with parallel developments in space, energy and materials technology seem almost limitless. Highly automated factories are proliferating in all segments of manufacturing. Computer processing in banking, insurance and retail industries are rendering many routine clerical jobs obsolete. Automated home banking and shopping are already with us. Internet access providers represent an entirely new industry with initial public offerings of their stock at very high multiples of their present earnings.

The technological promise is much more. The Global Positioning System of earth orbiting satellites first developed for military purposes combined

with new wireless communication systems permit wholly new kinds of applications to a wide range of industries. Precision farming becomes possible as satellite linked tilling and sowing machines respond to microchanges in soil characteristics. Transportation systems are rapidly evolving as automated navigation of automobiles and other vehicles opens up the possibility of "smart" highways. Health care is now becoming radically transformed as it becomes possible to diagnose illnesses and provide advice from a distance. The conduct of remote surgery is now a possibility. Monitoring environmental conditions such as ground water contamination becomes possible with the sensor revolution wedded to new information processing systems. And remote sensing from satellites at altitude revolutionizes our ability to predict weather and ocean conditions as well as survey the biosphere and the earth's resources. The possibilities are endless.

IX. THE GROWING INCOME INEQUALITY

Ever new and innovative applications of these technological advances can be anticipated along with the creation of new industries. Will they, however, employ enough workers? The answer is far from clear. Comparisons between employment in low and high tech industries is no cause for comfort. Edward Luttwak points out that Intel, Microsoft, Apple Computer, and Genentech, representing a sampling of firms in the semiconductor, software, computer, and biotechnology industries, employ about 62,500 workers in the United States. This is about the same number of employees as Home Depot, Inc. the hardware company. Most of the Home Depot jobs are low paying by comparison with those in the high tech companies. ("Success in America", *The Washington Post,* November 27, 1994).

These technological and economic forces have now given rise to growing income inequality in the United States. There is perhaps no more important feature of the U.S. economic system than the emerging two tier compensation system. One tier provides high paying career tracks for technologically adept workers, the other relatively low paying ones. The conventional wisdom is that the answer to the problem is better education for our children, enabling them to ride the first tier track to the "good" life. The problem with the conventional wisdom is not that it demands better educational opportunities, but that it assumes that the jobs will be there to employ all who are well educated and trained. A good education to meet the demanding needs of the new high tech industries is a *sine qua non.* It is however a necessary but not a sufficient condition to enable our young to compete for good jobs.

The Organization for Economic Cooperation and Development (OECD) reports that the difference between the best paid 10 percentof American workers and the worst is wider than for any large industrial nation.(*The New York Times,* Oct 29, 1995). Lester Thurow, the MIT economist, has expressed grave concern about this phenomenon. He points out that since 1968, economic inequality has been on the rise in the United States. In the twenty year period from 1968 to 1988, the earnings difference between the top 20 percent of wage earners and the bottom 20 percent doubled. The share of the total net worth of the top 1 percent of the population rose from 26 percent to 31 percent. By the early 1990s, more than 40 percent of the wealth was held by the top 1 percent of the population. This is double what it was in 1970. Since 1979 all of the income growth in the United States has gone to the top 40 percent of households and nearly all of that to the top 20 percent. Gains in productivity are not being translated into rising incomes for the great majority of workers. According to Claudia Goldin, a Harvard historian of science and technology, we are in a period of great fortune building based on new technology much like the fortune building in the late 1800s, which was also based on new technology. ("Winner Take All", by Steven Pearlstein, *The Washington Post*, November 19, 1995)

X. THE AMERICAN DILEMMA

The dilemma now being faced by the American economy is that there is a growing conflict between the need to provide high skills to compete in the international marketplace through productivity gains while at the same time low wage rates in other countries prevent higher salaries in the United States. The facts seem to bear this dilemma out. Productivity has been going up in the United States without resulting wage gains. The average produc-

tivity of American workers has increased 30 percent between 1987 and 1992 while average real wages fell by 13 percent. Productivity is increasing because of technological innovation and not education. The problem is that wages fall or at least do not increase if there is an abundance of workers competing for these jobs. This Marxian assessment seems borne out by the realities of the global job market. This abundance is created by the globalization of industry as well as large scale immigration. In turn globalization and increased immigration can be traced directly back to technological changes. (*The Next American Nation,* Michael Lind, Free Press, 1995.)

What does all this imply for the future of our children? The outlines are clear even now. It is a law of nature that water flows down hill. And it is a law of nature that intellectual knowledge diffuses and leaks. Laws may slow the diffusion, but cannot stop it. In modern economic terms, technological know-how migrates from countries with high know-how to countries with low know-how. Japan and the other Asian countries demonstrate that technological comparability can be achieved in less than half of a century. We are witnessing this process at work today. At present rates of economic growth and technological prowess we can expect China and other nations that place a high value on education and the harnessing of technology for economic growth to be significant economic powers. The competition, however, will not only be in the efficient production and marketing of goods and services, it will be a new kind of competition for intellectual advantage.

XI. THE KNOWLEDGE ECONOMY AND THE U.S. WORK FORCE

In the currently unfolding economic system the intellectual content of goods and services becomes ever more important. Our children will be competing not only with other U.S. workers but with the coming generations of workers in other countries. They will truly live and work in a global multicultural world. We will measure the abilities of the U.S. multicultural work force against the global one. Not only will wage rates and work ethics be compared, but most importantly education and technological adaptability.

International comparisons portray student educational achievement as a competitive race for intellectual excellence, which we are losing. The implications are that the United States will be unable to compete in the new technological world. While acknowledging the importance of strengthening the U.S. educational system, especially in the K-12 grades, great care must be taken in the interpretation of these international comparisons.

A very thoughtful article in a recent volume of the journal *Science* by Iris Rotberg questions the myths raised by these international comparisons. She points out that the evaluations are based on the comparison of groups selected in different ways. She points out that highly selected groups in other countries are compared with the achievement of the total body of students in the United States, thus leading inevitably to test scores that are unfavorable to U.S. students. When comparable selected groups of students are tested, U.S. students are competitive. ("Myths about Test Score Comparisons", Iris Rotberg, *Science*, December 1995.)

A positive view of student educational achievement is taken by Gerald W. Bracey, a research psychologist who marshals education statistics that illustrates that U.S. students compare favorably with their international counterparts. He cites a record of almost continuous improvement, pointing out that in the past century the United States has gone from a 3 percent high school graduation rate to an 83 percent rate. The proportion of students scoring about 650 on the SAT mathematics is at an all time high. American students had the second highest average score among 31 nations in an international competition of reading skills. We must not be misled by invidious educational international comparisons of U.S. student achievement. Nor can we be complacent about the U.S. educational system.

XII. THE CHANGING WORK FORCE DEMOGRAPHICS

By the year 2020, the work force in the United States will have a significantly different composition than that of today. We have reasonably reliable projections of the composition of the population and what it is likely to be in 2020. Out of the total present population of 260 million, about 73 percent

is white, 12 percent is African American, 10 percent is Hispanic and 3.5 percent is Asian. By 2020 we can expect a shift to 64 percent white, 13 percent African American, 16.5 percent Hispanic and 6.5 percent Asian out of a population that will have grown to 325 million. Our children will live in a nation much different from the one we have today. ("Bureau of Census Current Population Reports", *Statistical Abstract of the United States,* 115th edition,).

If present trends in income and education persist into the future, our children will live in a socially differentiated society, riven by great social tensions driven by income inequalities. African Americans and Hispanics by and large work in the low wage tier of the economy. Every indicator confirms this unfortunate truth. Per capita income of African Americans in 1993 hovered between 50 and 60 percent of that of whites and Asians. Median family income reveals the same phenomenon.

If education is essential to participation in the high wage tier, indicators of educational levels and achievement among African Americans and Hispanics suggest the nation has a formidable problem. Baccalaureate and professional degrees are measures of the educational attainment that will be in demand in a technology and knowledge based world. From 1981 to 1992 whites, who comprised 80 percent of the total U.S. population in 1980 of 226 million, acquired 86 percent of bachelors degrees and 90 percent of professional degrees. While the percentage of such degrees acquired by whites decreased to 83 percent for both professional and bachelors degrees by 1992, their numbers also decreased to 74 percent of the total U.S. population. The relative educational position of whites changed little in the intervening years. African Americans showed no improvement over this period of time in their position relative to their percentage of the total population although the absolute number of degrees in each class awarded to African Americans increased. At roughly 11 percent of the population, only 6.5 percent and 4 percent of baccalaureate and professional degrees were acquired by African Americans. Hispanics made small gains in their relative position. The big gainer was the Asian population which saw its numbers in the total population more than double between 1980-94 to about 8.5 million while the number of bachelors degrees more than doubled from about 19,000 to 47,000 and the number of professional degrees about doubled, from 2700 to 4500. ("Digest of Educational Statistics", U.S. National Center for Educational Statistics, *Statistical Abstract of the United States*, 115th Edition.)

While it is impolitic to dwell on the different skills and achievements of the different ethnic groups in the United States, the implications for the U.S. society are worrisome. Quite apart from the availability of jobs, high paying jobs and rewarding careers will require high levels of educational achievement. Managerial and technical jobs, professional and highly skilled support jobs will be open only to those who have had the requisite education. Today, Caucasians and Asians are heavily represented among the students seeking higher education. African Americans and Hispanics are heavily represented among the students who do not pursue higher education. In one group many members are trained to exploit the opportunities of the new economy, in the other fewer are trained and able to prosper. This unfortunate ethnic correlation with economic opportunity could become a flash point in U.S. society. The remedy is nowhere in sight.

XII. IMPLICATIONS FOR OUR CHILDREN'S FUTURE

Presumably we are interested in the shape of the future at this conference because of the implications for the education and training of children and because we may be able to take actions now that can either enhance the attractive aspects of the future or perhaps more importantly because action in the near future can forestall some of the more ominous directions in which technology appears to be driving society. We have recognized the impossibility of predicting the future 25 years from now, but we do have a good sense of the directions that present trends are taking us. We have noted the power of technology to shape the economy and its corollary implications for the demographic problems that the country is likely to encounter.

Just as we cannot see the future clearly we need to be prepared with various action scenarios that could address the multiple issues that confront the country. We can, however, point to some important principles that should guide us whatever scenario unfolds.

a) The overriding principle is the need to appreciate the formidable power of science and technology. The country must remain at the forefront internationally in scientific and technological research. To do this it must take whatever steps are necessary to see that the education of our young can produce the world class scientists and engineers that industry and government need. Science and technology literacy for the population as a whole will be necessary if the United States is to remain globally competitive. Recently the National Academy of Sciences and Engineering and the Institute of Medicine completed a multi-year study at the request of the Secretary of Education culminating in the publication of National Science Standards. It is a fine publication and for the first time sets out what students should know about science and technology and when they should know it. These standards, or variants of them tailored to various school districts, must be adopted everywhere in this country's school systems. (National Research Council, *National Science Education Standards,* National Academy Press, December 1995.)

b) We will need to adopt policies that are incentives to investment in science and technology—both in the public and private sectors. This issue confronts us directly with the role of the federal government in the support of basic and applied research. Whether such incentives are incorporated in the tax code or provided through direct government investment, or in the reformulation of present disincentives to investment in science and technology, are political decisions for the Congress. We need to remember that throughout the history of the United States we have oscillated between strong and weak roles for the federal government. We have seen many successes and failures. The preeminence of our agricultural, aeronautic, and biotechnology industries' has been largely attributable to strong government roles. On the other hand, we have had our share of failures such as in supersonic transport, nuclear breeder reactors and in the Synthetic Fuels Corporation.

c) The migration of jobs must take place on a two way street with traffic both ways being roughly equal. On the one hand we do not wish to restrict U.S. multinational corporations from taking advantage of the global labor, economic or capital markets if that is what is required for their viability. On the other hand we will need to adopt policies that will assure that the United States retains a fair share of the attractive jobs in the world. It may be that the free market will naturally achieve this result. It will take several years before we can conclude whether it can or not. The evidence is mixed at the present time. Set against the migration of jobs overseas there has been a counter flow of jobs as foreign based corporations employ U.S. workers at all levels from production to design and research in the United States. Automobile transplants of foreign automobile companies now employ tens of thousands of U.S. workers. Ten percent of all industrial research and development in the United States today takes place in U.S. subsidiaries of foreign corporations.

d) We must make the United States an attractive country in which to do business of all kinds—from routine production and services to the most esoteric research and development. The public policies that will encourage this at both the federal and state levels will consist of a complex mix of actions. Certainly we will need to have an attractive and well trained work force and associated educational institutions. But we will need much more. We will need to consider local content policies and tax incentives. Not unimportant will be the maintenance and improvement of the complex infrastructure of roads, airports, communication systems which in the United States are already among the best in the world.

e) The emerging two-tier compensation system for workers must be addressed. The problem is several fold. It is clear that educational opportunities for economically depressed citizens must be increased. But this will not suffice. We have a problem in the distribution of the benefits of the technological pro-

ductivity explosion. We have traditionally used the tax code to make a more equitable distribution of the wealth generated by productivity gains and we will have to continuously keep this approach under consideration. How we do this will be a politically charged issue, but the alternative of a socially explosive income inequity situation is even less attractive.

f) It will be necessary to keep a close eye on general unemployment levels in the United States. Technological productivity gains historically have resulted in the shortening of the work week. Our fathers and grandfathers worked a normal 60 hours per week. Today the average work week is 40 hours or somewhat less. Shortening work weeks is possible in a globally competitive world only if gains in productivity can compensate. Already in Europe 4-day work weeks have been adopted, for example in the automotive industry in Germany. The fact is that over the past 40 years unemployment in the United States has ranged from a low of 4 percent to a high of 8 percent. While economic ups and downs have principally been responsible for the fluctuations in unemployment, there has been a systematic trend upward that economists refer to as the natural level of unemployment. This natural level has risen from 4 percent to 6 percent in the intervening half century—about 1/2 percent per decade.

We do not pretend to have the answers to the very difficult issues we have raised. We do know that willy nilly they will need to be addressed. The task will not be easy but the future well being of our children will directly depend on how we address these issues.

NOTES

1. Richard H. White, Research Economist, Institute of Defense Analyses contributed information for this speech.