Chapter 3

The Promise and Problems of Technological Change

ONE LESSON of man's history is unmistakable: the crucial element in the rise in our material well-being has been the progressive utilization of our ever-growing store of knowledge of the world in which we live. From the wheel to the electronic computer, new discoveries have been put to work for man's benefit—benefit that has taken the form of shorter hours of work, the elimination of backbreaking toil, a continuing stream of new goods and services, and a total output per capita that has risen 5-fold in the United States since the Civil War.

While technological change is as old as man, its character and pace, and therefore its impact, have changed in recent centuries. The modern economic history of the industrial nations constitutes a decisive break with all of prior history. For thousands of years, a man followed the path of his father and grandfather before him, doing the same things in essentially the same way. Major technological changes came infrequently, and their adoption was spread over many centuries. The whole structure of modern society, however, is geared to innovations—those who initiate or adapt to change are rewarded, those who do not or cannot are penalized. The businessman who refuses to adopt new technology will not merely see his profits stand still; they will surely dwindle and turn into losses as his more adventuresome competitor adopts newer and more efficient production techniques.

Moreover, in a modern society, technological change is self-reinforcing and almost self-generating. Major new breakthroughs in technology soon pave the way for a multitude of other changes. The production of cheap electricity for example, not only replaced gaslights, but made possible the assembly line, modern communications, and the computer.

Even if we wished to, we could not eliminate pervasive and continuous technological and economic change without remaking—on a much inferior basis—the whole fabric of our social and economic institutions. And we would not wish to. Its benefits are essential for continued economic growth, higher standards of living, and the elimination of poverty. Our objective should be to foster and encourage it.

But recognition of the many benefits of technological change must not obscure the human toll often exacted in this process of job transition—the unemployed coal miners of West Virginia, the rural migrants who crowd urban slums, the older workers forced into unwanted retirement, and the middle-aged workers whose earnings power and entitlement to fringe benefits have been eroded by the obsolescence of their skills and the loss of their seniority. We can and should reduce that toll by appropriate public and private policies.

This chapter will explore some issues and policies related to technological change in this country's economy. Some of these issues have recently been the subject of considerable public attention. There has been dispute whether the newest and most dramatic form of technical change, "automation," is a monster that threatens to destroy our whole economic order or an economic and social boon. Others debate whether automation must share the blame for the persistence for six years of an unacceptably high rate of unemployment. President Kennedy proposed—and President Johnson has repeated the proposal—that a high-level Commission on Automation be created to explore carefully these and other questions.

This chapter first points to the benefits of technological change, both those easily measurable and others less so but perhaps equally important. It then turns to a brief review of the sources of such change. It analyzes the extent to which rapid technological change may threaten the maintenance of high over-all employment and the way in which our system adjusts to the unequal impacts of technological change on regions, industries, and skills. Finally, it reviews the policies that Government can use to foster rapid technological change while at the same time helping workers to adapt to the resulting dislocations.

THE FRUITS OF ADVANCING TECHNOLOGY

The state of technological knowledge determines what man can do with his labor, his capital, and the natural resources he finds—what can be produced and how it can be produced. Increases in our standard of living—"economic progress"—come about in considerable part from the application of new technical knowledge to production.

THE NATURE OF TECHNOLOGICAL CHANGE

By technological change we mean the introduction of new arrangements in the process of production and distribution which enable us either to produce new products, or to produce existing products more efficiently and cheaply, employing fewer real resources. The basic characteristic of technological change is that it permits us to use a given set of resources in a way that better satisfies human wants. It includes not only narrowly technical changes but also the application of new organizational and managerial concepts.

It is useful, if imprecise, to distinguish between technological changes that reduce the cost of turning out already existing private and public consumption goods, and those that create completely new or substantially improved products which enlarge the menu of final goods. Television, penicillin, nylon, and the airplane are examples of technological change that produced goods not previously available. Color television, the electric typewriter, and the automobile with automatic transmission represent substantial quality improvements. The Bessemer process for making steel, the catalytic refining of oil, the mechanical picking of cotton, and the automation of bookkeeping are examples of advances enabling industries to produce more cheaply goods or services that were already produced. Yet each of the examples of *new* products might also be said to be merely better or cheaper ways of producing already existing services—television as a substitute for the radio or motion picture in communication, penicillin for sulfa drugs and hospital care in the treatment of pneumonia, nylon for cotton in tires or for silk in blouses, the airplane for the automobile or the ship in transporting persons or goods.

Technological change is only one of several major elements that contribute to economic growth. Others include:

1. Increases in the available quantity of the basic resources used in production—growth of the labor force and accumulation of capital.

2. Improvements in the quality of labor as a result of the better health, education, training, or motivation of members of the labor force.

3. Reductions in cost resulting from expansion in the size of markets—described by economists as economies of scale.

An increased stock of physical capital, embodied in buildings, machinery and equipment, land improvements, mines, stocks in trade, and so on, is one of the more important of these sources. And, since the stock of capital has increased considerably faster than the number of workers, each worker now commands a larger complement of inanimate productive resources. But it has been possible to employ this rising amount of capital per worker primarily through the progress of technology. Equipping a worker with a sturdier or larger shovel does not necessarily raise his output very much. But the invention of a ditch-digging machine or bulldozer allows each worker to use a great deal more capital and thereby to increase his output enormously. Because the added output is the joint product of technological change and an added use of capital, it is impossible fully to separate their contributions.

The same close interrelationship with technological change exists in connection with other sources of expanded output. The improved education and skill of workers often require technical rearrangements of production to make them effective. The availability of a larger supply of trained mathematicians will not significantly improve the productivity of an accounting department based on pencil and paper technology. But a mathematician, developing programs for a computer, may cut the cost of accounting in half. Many of the economies of mass production associated with wider markets have been possible only because technological innovations—for example, the assembly line—opened up new possibilities for organizing the production process on a larger scale.

A fixed quantity of available land, together with a continually depleted stock of fuel and mineral resources might well have inhibited economic growth and rising living standards for an exploding population. Yet in the West, at least, technological change has fully overcome "diminishing returns," as proved by the fact that prices of food and minerals are, in general, no higher relative to other prices today than they were 100 years ago.

THE GROWTH OF OUTPUT AND INCOMES

The most inclusive measure of the gains from technological improvement is the enlargement of total incomes. Technological advance is a major source of higher output; and in the broadest sense higher output and higher incomes are synonomous.

Since the turn of the century, the Nation's real total output—measured as GNP in 1963 prices—has risen by 760 percent, from $68 billion in 1900 to $585 billion in 1963. This represents an annual growth rate averaging 3½ percent for the whole period. With the population rising from 76.1 million to 189.3 million over this period, real output per person climbed from $890 at the start of the century to $3,091 last year. Although many benefits are not captured in GNP measurements, this is perhaps the single best summary index of the increased material well-being of the American people.

An alternative measure of our gains is private consumption per capita, which reflects rising living standards. But it is an incomplete measure, even of living standards, because it omits the growing public services provided by all levels of government. Since 1929, the earliest date for which this measure is available, real private consumption per capita has risen by 66 percent, while total output per capita has risen by 76 percent.

Rising total output, as noted earlier, is the joint product of: a rising input of *labor*; a larger input of physical *capital*; and the increased *productive efficiency* of these inputs—as a combined result of improvements in the quality of labor, advances in technology, and economies of scale. A simpler approach divides the total output gain into two parts: a rising input of labor, measured in total man-hours worked; and an increased average output per hour of work—which reflects both the rise in capital input and the increase in productive efficiency. Output in the private economy in 1963 was 720 percent of 1900. This is the product of: (1) total man-hours worked in 1963 equal to 180 percent of 1900; times (2) an output per man-hour in 1963 equal to 400 percent of 1900.

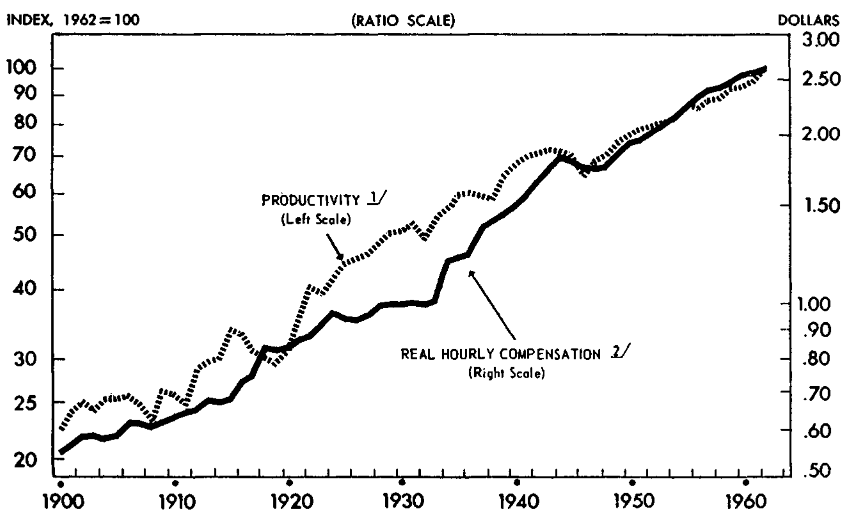
Every technological advance is an opportunity to raise the average standard of living of the whole community. But we are not concerned with the average standard of living alone. Rather, we are interested as well in how the fruits of technological progress are shared by the various sectors of the economy. In particular it is sometimes feared that technological progress may benefit property incomes proportionately more than the incomes of labor.

It is a matter of arithmetic that labor's share in total income will remain unchanged if total hourly labor compensation rises in the same proportion as labor productivity when prices are constant. Although there is no immutable law either of economics or of equity that requires this result, historically the rise in the real earnings of workers has been closely linked with the advance in labor productivity.

Since 1900 real hourly compensation of production workers in manufacturing (average hourly earnings plus fringe benefits deflated by the change in consumer prices) has risen at approximately the same average rate as the average hourly productivity of manufacturing labor, as Chart 10 clearly demonstrates. Despite year-to-year variations, and certain limited periods of apparently nonproportional growth, both productivity and earnings have

Chart 10

Real Hourly Compensation and Productivity in Manufacturing



1/OUTPUT PER MAN-HOUR FOR ALL EMPLOYEES.
2/HOURLY COMPENSATION FOR PRODUCTION WORKERS DEFLATED BY THE CONSUMER PRICE INDEX, 1962=100.
SOURCE: COUNCIL OF ECONOMIC ADVISERS (BASED ON DATA FROM VARIOUS PUBLIC AND PRIVATE SOURCES).

risen strongly and consistently, and their movement has been essentially parallel.

THE OPPORTUNITY FOR LEISURE

One of the most important choices that technological improvement permits is that between increased output, incomes, and consumption, on the one hand, and increased leisure on the other. The growth in output per capita cited earlier underestimates the improvement in the well-being of the population to the extent that workers have voluntarily chosen to take some of the potential rise in their incomes in the form of shorter hours, longer vacations, or later entry into, or earlier retirement from, the labor force. When workers voluntarily choose to reduce their working time—preferring an extra hour of leisure to its equivalent in income—these extra hours of leisure might properly be given a monetary value equal to the incomes foregone.

It is estimated that average annual hours per employee were reduced by about 25 percent between 1909 and 1963. In manufacturing, where measures are best, the average workweek of production workers fell from 51 hours in 1909 to 40.4 hours last year. Moreover, the average number of days worked in a year has declined substantially, through longer vacations and more frequent holidays. Between 1900 and 1960 male life expectancy at birth rose by 19 years. But the expected number of male working years rose by only 9, primarily because of typically earlier retirement from, and later entry into, the work force.

Not only average annual hours *per worker*, but also average annual hours worked *per member of the total population* have declined appreciably since 1900. As a result output per capita rose by 250 percent, a considerably smaller increase than the 350 percent rise in output per man-hour.

On the whole, the discipline of modern production permits neither the individual worker nor, except very crudely, workers as a group to weigh and to choose freely the precise combination of income and leisure that best suits their preferences. Nevertheless, we may expect that over the longer run, some further reduction is likely to occur in hours worked and that this will, in a general way, reflect an increasing preference for leisure over income as further increases in potential income occur at the existing level of hours.

SOME NONMEASURABLE GAINS

Even if we adjust for potential gains taken in the form of leisure, the increase in measured output per capita fails to account for a wide range of real, but unmeasurable benefits of technical progress. We have no satisfactory way of measuring the additional output value incorporated in completely new products, and our methods of measurement probably often undervalue the contribution to real incomes of improvements in the quality of existing products.

For example, can anyone measure how much better off people are as a result of telephone communication? The benefit is surely not measured by comparing the cost of messages delivered by mail and messages spoken along a wire. Nylon is not only cheaper than silk, it is more durable, easier to care for, more resistant to stains. The benefit of transoceanic air travel is not measured solely by the reduction of cost relative to sea travel—the saving of travel time permits many persons to visit Europe or the Far East who would never otherwise be able to do so. Examples abound in the area of medical care. How do we measure the benefit of a vaccine that practically eliminates smallpox or polio—a medicine that conquers tuberculosis or pneumonia—scientific discoveries that permit us to attack mental retardation?

Technological change has permitted everyone to share experiences previously, by their very nature, limited to a few—to attend a World Series game, a class taught by a great teacher, a recital by Pablo Casals.

Moreover, no measure of gross national product attempts to take account of the reduced human costs of producing it. A job on an assembly line may be dull; but it is a vast improvement over the backbreaking drudgery of many jobs a century earlier. And if one complains that our output measures fail to take account of the pollution of urban air and water, it must be noted that they also fail to take account of the fact that inexpensive automobile transportation permits city dwellers to escape to the ocean beaches, the mountains, the areas of forest wilderness.

Thus technological advance and the rising productivity associated with it have many human payoffs: higher incomes and consumption, longer life, reduced suffering and illness, reduced drudgery, greater leisure, and an improved quality of life that cannot be measured in income statistics. Philosophers may debate whether all this contributes to human happiness or the edification of the soul. Ordinary men—those who have not yet enjoyed the fruits of technological advance, those who have tasted them, and those grown accustomed to the diet—all pursue them with fervor undiminished by the philosophers' doubts.

AMERICA'S ROLE IN THE WORLD

America's position of free world leadership carries heavy responsibilities—for our own defense and that of our allies, and for assistance to the newly awakened nations of Latin America, Africa, and Asia. These burdens are not easy. But continued rapid technological advance can permit them to be borne with minimum strain.

The burden of maintaining our defense and aid programs is not only that of producing the value of output that we wish to devote to these purposes. In a world of fixed exchange rates and free convertibility of currencies into each other and of the dollar into gold, it is also a problem of our balance of payments.

Continued rapid technological advance can help in three ways. First, by contributing to a rise in productivity, it can permit us to hold our price level steady in the face of rising wage rates. Combined with some tendency

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for prices to rise in other industrial countries, this will permit us to compete more effectively in world trade. Second, the higher rates of profit that arise from investments exploiting new technological advances will reduce the outflow of capital and attract it from abroad. Third, and perhaps most important, the continued development of new products is one of the surest roads to export expansion. Within a few years after the introduction of almost any new product in today's world, a dozen nations will be able to compete with us in its production. To maintain or expand our share of world exports we must continually be in the vanguard of product development. This requires continuous innovation, increasing technological development, and the most rapid possible exploitation of the new opportunities that emerge from scientific advance.

Thus, rapid technological change needs to be fostered not alone for its effects on the growth of our internal comfort and well-being. It is also an urgent necessity for the solution of our international economic problems. It is the answer to those who say that America must choose between two sets of irreconcilable objectives—domestic prosperity and international payments equilibrium. Combined with the responsible price and wage making discussed in Chapter 4 of this Report, rapid technological gains can permit us to reconcile policies for high employment and growing incomes domestically with our objective of achieving equilibrium in our international payments. It is truly the "great reconciler."

SOURCES OF TECHNOLOGICAL PROGRESS

Technical change occurs in several ways. In its most distinctive and easily identified form, it is a process that begins with an advance in basic scientific knowledge. Such an advance may then lead—often after years or even decades—to the application of the new scientific knowledge to a "practical" problem: the "invention" of a way to produce an existing good or service in a more efficient (i.e., less costly) way or the production of a new good or service.

INVENTION AND INNOVATION

Today the process of invention has been increasingly organized and systematized, and we now identify "R&D" (research and development) as a major activity in our economy. Nonetheless, it must be recognized that significant inventions are often still the product of the individual working alone, sometimes with little formal scientific training. And some of the principal breakthroughs in pure science—particularly, the development of new theoretical concepts—are often still the product of individual scholars.

The final step in the process of technological advance comes after the application has been proved technically feasible and seems to promise economic gain—when it is actually introduced and used. It is at this point that technological change really occurs, a step identified as "innovation." It is important to emphasize that new knowledge and even its application in a *technically* successful way has, by itself, no direct economic significance. Innovation is the key element in the process of technical change from the standpoint of economic progress. The innovator, whether the inventor himself, a small entrepreneur, the manager of a giant firm, or a government official, must make the decision to take the risks of introducing a new and untried process, good, or service. The costs of using a new process or the acceptability of a new product are uncertain until tested on the production line or in the market place. And as cost and demand conditions change, inventions that previously had no chance of successful application may become economically feasible.

Technological change can also come about without any conscious decision to "innovate," but through the many minor changes that occur from day to day as existing processes are used. It may also come about with little or no change in the physical circumstances of production. For example, the discovery that a furnace performs more effectively at a higher or lower temperature than previously supposed may be applied through only the adjustment of a valve.

INVESTMENT AND TECHNOLOGICAL CHANGE

But much technological change requires an alteration of the physical apparatus of production. And where the innovation is of any significance, such an alteration will ordinarly require an act of investment—the modification of existing apparatus, the installation of new machines or equipment, even the construction of new buildings. This fact has several important consequences.

One such consequence is that the rate at which technological progress can be incorporated in production is closely tied to the rate of gross investment. Stepping up the rate of growth of the stock of plant and equipment accelerates the improvement in its quality and productivity.

A second consequence of the tie between technology and physical investment is that normally new technology is not introduced all at once. Particularly where the change represents a new process for accomplishing some productive task, it will often pay business firms to introduce it only as their existing facilities become less efficient with age, thus permitting the differential efficiency of the new equipment to compensate for its additional capital cost. But even if the new equipment is so superior in its productivity that it would pay to scrap the previous equipment immediately, production of new equipment takes time. It would have been impossible to convert all railroads from steam to diesel in one year, simply because the makers of diesel engines could not economically expand their production fast enough.

The physical investment lag—and a perhaps equally important information lag—mean that it often takes years, sometimes decades, for new technology to spread throughout an industry or an economy. The introduction of automation is a case in point. In many applications, automated facilities—which control productive processes through servomechanical ("feed-back") devices—accomplish dramatic savings in direct labor. As with previous major technological changes, one can expect this innovation to be applied to an increasing number of activities. But merely because automation is technically feasible in many applications, it is not necessarily economically feasible, even though it may greatly reduce direct labor costs. Higher capital costs, lack of flexibility, and the necessity for large runs make automation noneconomic in thousands of applications where it is technically feasible. Moreover, even where it is economically advantageous eventually to substitute automated for nonautomated equipment, its introduction may well be delayed until the relative cost of operating the older equipment increases substantially. In a previous generation, electric power did not displace the steam engine overnight, nor did the steam engine in its time take over from the waterwheel overnight. Only a small fraction of the ultimate benefits of automation have yet been realized.

TECHNOLOGICAL CHANGE AND AGGREGATE DEMAND

Like all previous technological change, automation creates the necessity for many workers to change jobs during their lifetimes and for sons to find different work from that of their fathers. The problem created by these labor market adjustments is discussed in a later part of this chapter, together with the policies that can lubricate such adjustments and ease their human toll.

THE EXPANSION OF DEMAND

Quite apart from these adjustment problems many are convinced that recent and current technological change is somehow different in its employment effects from all previous changes. This conviction rests upon one or both of the following propositions: (1) that our productive powers are now outstripping our wants and needs and ability to buy our own output, and thus our economy's ability to create new jobs; and (2) that technological change is now destroying jobs at a much faster rate than ever before.

If the Nation's ability and eagerness to buy output can and does keep pace with its ability to produce, a speeded-up pace of technological advance means that standards of living and economic security can rise more rapidly than ever. In this case, faster progress of productivity is to be sought and welcomed. Only if demand cannot keep pace (or if the required adjustments cannot readily be accommodated) is there a basis for fearing more rapid technological change.

Historically, there is surely no evidence of any inability of demand to rise along with productive capacity, or of any permanent inadequacy of total job opportunities. Rather, our technologically progressive economy has brought higher output and incomes, and more and better consumption and investment, along with the voluntary decision to take some of the fruits of progress in the form of leisure. Since 1929, for instance, output per worker has almost doubled. If total demand had not grown since 1929, and if we were still producing the 1929 level of output, using present methods of production and the present shorter workweek, it would take just 26 million workers to do it. This would leave two-thirds of our present labor force unemployed. Instead, the demand for output is almost three times as high, and employment is 50 percent higher than in 1929. If total demand had grown since 1929 only as fast as population, 46 percent of our labor force would now be unemployed as a result of the higher productivity.

Clearly, the increase in total demand for our potential output is the factor that has reconciled advancing technology with rising employment.

And it should continue to do so far into the future. Despite dramatic increases in average family income, American consumers have continued to spend a remarkably constant proportion of their disposable income on consumer goods and services. And a very large proportion of our families still earn very modest incomes. Millions of families live in actual poverty, as the preceding chapter has shown, and half of American families in 1963 had incomes below $6,200. If median family income increased at the same rate in the next 17 years as it has since 1947, half of American families in 1980 would still have incomes below $9,300 in today's prices. Today, even families at twice that level have no trouble finding ways to spend extra income. There is surely no reason to believe that any plausible rate of technical progress could lead to consumer satiation in the lifetimes of persons now on earth.

Technological change permits any given level of output to be produced with less labor and, in that sense, destroys jobs. But it also provides a significant spur to investment and consumption and thus creates jobs. Technological change makes existing capital equipment obsolete. New processes and products increase the profitability of investment and stimulate business demand for new machines, new equipment, and new buildings. Technological change both generates high levels of investment and gives consumers new purchasing incentives. Historically periods of rapid technological change have generally been periods of high and rising employment.

There is, of course, no automatic mechanism which guarantees that actual demand will grow each year at exactly the same rate as potential full-employment output. An economy characterized by technological change and growth always faces the challenge of maintaining a growth in demand sufficient for full employment, but not so high as to lead to inflation. Fortunately, growing sophistication in the uses of economic policy, particularly fiscal and monetary policy, make this goal more nearly attainable than ever before.

These tools of economic policy are capable of righting the balance whenever the job-destroying effects of technological progress outweigh its job-creating effects. They will succeed in this task, however, only if they are adjusted to take account of changes in the rate of productivity gains, whether from an altered pace of technological advance or from other sources.

THE TREND OF LABOR PRODUCTIVITY

Some recent developments have been cited frequently to support the belief that technological change is accelerating. In certain instances, automation has greatly lifted output per man-hour and has revolutionized the productive process. These instances are highly dramatic, but they are insufficient for evaluating the over-all impact of technological progress. Such an evaluation must be based on a study of the trend in over-all productivity—output per man-hour—for the private economy.

The main difficulty in assessing the trend of productivity is that current output per man-hour is also affected by numerous transitory factors, most significantly by fluctuations in output and changes in the average age of the machinery in use. For example, during recessions employment falls proportionately less than output as a result of lags in employer reaction, uncertainty about the future, the need to retain the same supervisory and maintenance personnel over wide ranges of output, and hiring and firing costs. Employed manpower is not fully utilized, and the level of output per man-hour is depressed. This is usually followed by rapid rates of increase in labor productivity during the early phases of cyclical expansions (Chart 2).

Moreover, our statistical measures of productivity are far from exact. Productivity is a ratio of recorded output to recorded labor input, and relatively small errors in measuring either the numerator or denominator can distort the pattern of change in productivity. Particularly in measuring productivity for *individual sectors* of the economy, there are statistical problems associated with the measurement of output change; and measures of labor input are also a source of difficulty. (Currently there are two separate official series on employment and man-hours—one based primarily on payroll data reported by business establishments and the other based on a monthly survey of households.) The Department of Commerce is now engaged in major revisions of output data, and the Bureau of Labor Statistics is planning to publish revised productivity indexes during 1964, based on the revised output data. Recorded changes in productivity for individual years and sectors must be viewed as a broad gauge—rather than a precise reading—of economic performance.

With these qualifications, productivity measurements for recent years are presented in Table 17, accompanied by some comparisons with longer-run trends. Labor input data are based on information collected primarily from establishments. The table shows that productivity gains have been healthy but not unprecedentedly large during the past 3 years. While improvement has varied among sectors, the average gain in each case has been greater during the past 3 years than in the preceding decade, but less than the average of 1947–50.

TABLE 17.—*Changes in output per man-hour in the private economy, 1919–63*

Period	Percentage change per year				
	Total private	Agriculture	Nonagriculture		
			Total	Manufacturing [1]	Nonmanufacturing [1]
1919 to 1947	2.2	1.4	2.0	[2] 3.0	(3)
1947 to 1963	3.2	6.1	2.6	2.7	2.5
1947 to 1950	4.5	8.8	3.7	4.3	3.4
1950 to 1960	2.7	5.4	2.1	2.0	2.2
1960 to 1963	3.5	5.5	3.2	3.7	2.9
1960 to 1961	3.3	5.9	2.9	2.6	3.1
1961 to 1962	3.9	3.4	3.8	5.4	2.9
1962 to 1963	3.5	7.4	3.0	3.1	2.8

[1] Department of Labor estimates for 1960–63 are in the course of revision and are not available (see note to Table C–32). Therefore estimates for all years beginning with 1947 have been made by the Council of Economic Advisers on a consistent basis using Department of Commerce net output estimates.
[2] Based on data from private sources.
[3] Not available.

NOTE.—Man-hours are based primarily on establishment data.

Sources: Department of Commerce, Department of Labor, and Council of Economic Advisers.

To determine whether these relatively larger gains of the past 3 years exceed past trends, it is necessary to sort out the cyclical and transitory factors affecting productivity. For this purpose, several alternative statistical analyses were undertaken on the nonfarm productivity gains of 1949–60 to determine the separate influences on productivity of the average age of equipment stocks, variations in the growth of output, and changes in the degree of capacity utilization. These findings were then used to estimate the productivity gains that might have been expected in the years 1961 through 1963 if the past relationships and trends still held.

Depending on which statistical analysis is used (and there is no clear basis for preferring one to another), the recent gains are either about in line with the expectation or exceed it by amounts ranging up to 1 percentage point. These differences are sufficiently tentative that further experience is needed to confirm a positive conclusion.

Recent large gains could reflect no more than a possibly unusually cautious hiring policy on the part of business in the current expansion. Experience with the slack labor market of recent years may have deterred the anticipatory hiring of overhead and skilled personnel, which appears typically to take place during a business expansion as insurance against the possibility of future labor shortages. If so, the recent higher rates of productivity increase may prove to be transitory. Yet optimism may still be warranted. If objective analysis does not support a firm conclusion that the trend of productivity has accelerated, neither can that possibility be dismissed. Technological progress may indeed have accelerated, but its impact on productivity may be only gradually becoming visible because of the time that must elapse before innovations become embodied in new capital equipment and expressed in new organizational forms.

The benefits to society from technological change are not costless. For some individual workers, businesses, and communities technological change brings new opportunity: better jobs, higher profits, greater prosperity. For others it imposes burdens and even hardships. For technical change may reduce the value of—or even make obsolete—particular labor skills, plant and equipment, or natural resources.

By and large our enterprise system works well in producing the shifts of capital and managerial resources from one activity to another that changed circumstances—including technical progress—dictate. But unless the individual worker who is displaced from his job by technological change finds other employment soon, both he and society lose.

Even when over-all employment opportunities are adequate, job security for the individual worker is never certain. Technological change has perhaps been the most perennially disruptive influence on job security; but changes in consumer tastes and business organization, increased competition, and decisions of public policy also frequently and unpredictably disrupt existing job patterns. And even in a strong labor market, it almost always takes time for displaced workers to find new jobs.

The development of new processes directly alters the labor requirements of particular firms and industries and of the whole economy. More indirectly, by raising real incomes and changing relative prices, technological advance induces shifts in the industrial composition of output and employment. A faster-than-average pace of technological change reduces costs of production in the industry where it occurs and is ordinarily reflected either in a decline in the relative price, or in an improvement in the relative quality, of the products of that industry.

Sometimes the technologically induced lowering of price or raising of quality leads to enough expansion of demand actually to increase employment in the industry where the change occurs. Where technological change gives birth to an entire new industry, this is, of course, true. Automobiles in the 1920's and, more recently, airlines, office machinery, and electronic and communications equipment are clear cases of this sort. In other activities, of which farming and coal mining are good examples, spectacular productivity advances have not led to equivalent increases in sales, and employment has declined sharply.

If rates of technological advance were not too unequal among industries and over-all growth is rapid, employment might still expand in some industries without requiring layoffs in others. Normally, however, transitional problems arise, as the number of jobs in specific firms, industries, occupations, or geographic areas declines more rapidly than the number of workers seeking to fill them, even after account is taken of retirements and voluntary job changes.

THE CHANGING DISTRIBUTION OF JOB REQUIREMENTS

In the past decade, jobs have been destroyed and created at very unequal rates in various regions, occupations, and industries.

Changing *regional requirements* are illustrated by the fact that nonagricultural employment actually declined between 1953 and 1963 in Rhode Island, Pennsylvania, Michigan, and West Virginia, remained essentially unchanged in Maine and Ohio, and rose by 1.5 million (almost 40 percent) in California, 65 percent in Florida, 80 percent in Arizona, and 97 percent in Nevada. Even more striking disparities can be found among metropolitan areas.

Shifts in the *occupational distribution* of jobs have been equally dramatic. The number of farmers and farm workers declined by 2.8 million, or 40 percent, between 1950 and 1960. In more narrowly defined occupations, there were employment declines of 25 percent among locomotive engineers and firemen, 38 percent among textile weavers and spinners, 42 percent among telegraph operators, and 50 percent among fishermen. During this same period, employment rose by 45 percent among professional nurses, 49 percent among teachers, and 60 percent among engineers and draftsmen.

Changes in the *industrial composition* of jobs were highlighted by the continued decline in the importance of goods-producing industries as sources of employment. Total employment in manufacturing, mining, and construction declined by 2 percent between 1953 and 1963. In contrast, employment increased by 65 percent in State and local government, 41 percent in services, 33 percent in finance, and 16 percent in trade.

Automation is often regarded as having a qualitatively different effect on worker displacement than did earlier forms of technological change. Specifically, it is suggested that automation requires a higher average level of education or skills than did earlier forms of technology, and that this complicates the adjustment process for displaced blue-collar workers whose old skills have been rendered obsolete while lack of adequate educational background disqualifies them from filling the new jobs created by automation.

However, the current changes in skill requirements appear to continue a long evolutionary process. Professional and technical workers and craftsmen, for instance, accounted for about 15 percent of the work force in 1900, 23 percent in 1950, and 26 percent in 1960. In contrast, unskilled farm and nonfarm workers accounted for 30 percent of the labor force in 1900, 11 percent in 1950, and only 8 percent in 1960. It is not clear whether automation has caused any acceleration in these trends. Further studies are needed, to which the proposed Commission on Automation should contribute.

Whatever the exact pace and cause, it is clear that the proportion of jobs calling for the exercise of considerable responsibility and for a substantial educational background is rising.

THE ADJUSTMENT PROCESS

With the dramatic changes we have experienced in recent decades in the distribution of available job openings and in the nature of job requirements, it is remarkable that labor market adjustment takes place as efficiently as it does. But American workers are highly mobile.

Although many workers, particularly older ones, are reluctant to sever local ties, even when they become unemployed, there is nevertheless an impressive degree of *geographical mobility.* On the average, during each year of the past decade over 6 percent of the civilian population moved its residence across county lines, and 3 percent across State lines. During prosperous periods, the rates of mobility out of labor surplus areas are considerably higher. Today only 55 percent of all persons aged 25 and over still live in the State of their birth. Rapidly growing areas have managed to attract large numbers of workers from sections of the country where the natural population increase has exceeded the expansion of job opportunities. The net in-migration rate between 1950 and 1960 was over 50 percent in Florida and Nevada, and between 20 and 45 percent in Arizona, Alaska, California, and Delaware. In contrast, the net out-migration rate was 20 percent or higher from such States as Arkansas, West Virginia, and Mississippi.

During 1961 some 8.1 million workers changed jobs, including about 2.6 million who changed voluntarily in order to improve their economic status. Mobility declines rapidly with age; still, almost 6 percent of men 45–64 years old changed jobs in 1961. Fifty-six percent of all job changes involved a shift between major industry groups, and 47 percent between major occupation groups.

The extensive training and retraining programs conducted by many, though not by enough, private employers contribute significantly to the occupational flexibility of the work force. In 1962, establishments accounting for almost 50 percent of private nonfarm employment had some type of training program and were providing training for 15 percent of their employees. The natural turnover in the labor force also contributes to this flexibility. An average of 1,275,000 older persons will die or retire during each year of the current decade, while an average of 425,000 women will leave for family reasons. At the same time an average of 2.6 million young persons will enter the labor market each year, so that by 1970, 30 percent of the labor force will consist of persons who were not in the job market in 1960. This substantial inflow of new workers can provide a supply of relatively well educated and mobile labor for expanding activities.

Indeed, improved education has been the primary factor permitting the rapid adjustment of the labor supply to the demands of changing technology. The average educational attainment of new workers currently entering the labor force is about 40 percent higher than that of those currently retiring. Just since the beginning of World War II the median level of education among the entire adult male labor force aged 18–64 has risen by more than 50 percent. The proportion of the labor force with an 8th grade education or less declined from 36 percent in 1952 to 26 percent in 1962. In contrast, the proportion who were college graduates rose from 8 to 11 percent. And this educational upgrading will certainly continue. More than 1 million persons are expected to graduate from college in 1964 and 1965, and an additional 220,000 persons will receive advanced degrees. The total number of degree recipients will be 70 percent greater than a decade earlier. Unsatisfied as we are, and rightfully so, with our educational accomplishments, it is clear that rising levels of education have been the major force permitting the rapid—and on the whole successful—adjustment of the work force to changing occupational requirements.

DEFECTS OF THE ADJUSTMENT PROCESS

Displaced workers rarely find new jobs instantaneously. Time is required for the flow of job information and for matching the location, education, skill, wage, working conditions, and other preferences of job hunters with the requirements of employers. Personal contacts, employment services, and help-wanted advertisements provide important channels of communication between employers hunting for workers, and workers hunting for jobs. Nonetheless, the flow of labor market information is unnecessarily slow and circumscribed. Because of insufficient staff and, in some instances, because of the failure of employers to provide information, local offices of the Federal-State Employment Service cannot provide complete information on local job opportunities, to say nothing of a full exchange of information among different localities. In the absence of adequate vocational guidance, many young workers are not properly prepared for the activities in which employment is expanding most rapidly. Geographic movement is often restrained by lack of information and by the inability of workers to finance transportation, job search, and change of residence. Occupational mobility is often inhibited by the absence of adequate educational background and the inability to acquire needed skills.

The average displaced worker spends far too long between jobs, even in periods of adequate demand. The average duration of unemployment was 11.6 weeks during the period 1955–57, when the over-all unemployment rate averaged 4.3 percent. And, during the boom years of 1951–53, when the unemployment rate averaged 3.1 percent and the number of unfilled jobs very probably exceeded the number of unemployed workers, the average duration of unemployment was still 8.7 weeks. These statistics do not refer specifically to the average period of joblessness for workers displaced by technological change, but they do indicate the time-consuming nature of the job-hunting process. They also suggest that reduction of the human cost of technological change will require policies—both private and public—for improving and speeding the matching of available jobs and workers.

Such policies can never be completely adequate. The burdens of transitional unemployment may be harsh, but they sometimes represent only part of the cost of change to the displaced worker. The worker made permanently unemployable by technological change is relatively rare, but it is frequent for a displaced worker to find himself required to accept a less challenging and lower paying job. The specialized skill, experience, and seniority which contributed to earning power in the original job frequently do not have transferable market value.

Moreover, the burden of technological displacement often falls most heavily on those least able to bear it. As noted already, the general drift of technological change has tended to be toward increased rather than reduced skill and education requirements and thus in favor of groups already higher up on the income ladder. To be sure, some of the elite of the labor force have suffered—printers and flight engineers, to take two recent examples. But overwhelmingly, the groups displaced have been the less-skilled, less-educated, and therefore poorer members of the labor force. But even if the incidence of technological change were entirely random, the wealthier community, the more prosperous business, the more highly trained and better paid workers have greater adaptability, and greater resources to help them through the period of adaptation.

When technological change displaces considerable numbers of workers in a particular region or occupation, and these workers lack the skills or mobility necessary to find other jobs quickly, their continuing unemployment can well be called "structural." Pockets of such structural unemployment are never absent, and the problems they present for public policy are intensified (and partly concealed) in a generally slack economy with excessive over-all unemployment.

In its testimony before the Senate Subcommittee on Employment and Manpower on October 28, 1963, the Council considered at some length the interrelationships between slack labor markets resulting from insufficient total demand for goods and services and problems of structural unemployment. It dealt in particular with the question whether recent technological change may have increased the incidence of structural unemployment in the American economy and the possible relevance of this for policies to raise demand. The Council explained in detail its reasons for doubting that structural unemployment has increased, but emphasized that such unemployment is both an economic and a human problem of serious proportions and that Government has a responsibility for taking appropriate measures to reduce it. The bulk of this testimony is reprinted as Appendix A to this Report.

PRIVATE POLICIES FACILITATING ADJUSTMENT

Recognition of the human toll that can result from technological change and labor displacement has led to a wide range of private efforts to reduce transitional costs. Human adjustment problems are minimized when needed work force reductions can be accomplished by normal attrition and reassignment. This goal—toward which firms with enlightened personnel policies strive—is often made economically feasible by the limited scope of many innovations or by a sufficiently high rate of voluntary employee turnover. But it requires careful planning. The Bureau of Labor Statistics recently surveyed the work history of 2,800 persons employed in 18 offices doing data processing work which was to be transferred to electronic computers. The firms tried to ensure employment security for their current work force by advance planning and curtailment of hiring. Twelve months after the new installation, more than half of the workers were still in their original positions, and more than 30 percent had been transferred to other positions in the firm. Thirteen percent had quit or retired, and less than 1 percent were laid off.

Collective bargaining agreements have been concerned increasingly with problems of accommodating change while protecting worker security. In recent agreements, increasing stress has been placed on interplant seniority pools, relocation allowances, early retirement provisions, and severance pay plans that provide a lump sum payment or its equivalent as reimbursement for the income losses associated with displacement. The recent Kaiser Steel-United Steelworkers and West Coast Longshoremen's agreements provided employment guarantees or income assurances for workers displaced by technological change. The Railroad Arbitration Board decreed the eventual elimination of 90 percent of diesel locomotive firemen's jobs in freight and yard service, but it provided income guarantees for those with 2 to 10 years of seniority, and lifetime employment protection for those with greater seniority.

Private programs to minimize displacement or to reimburse displaced workers are desirable because the burden of adjustment is prevented from falling exclusively on the displaced worker. Such programs serve a doubly useful purpose when they facilitate the rapid introduction and economical use of new processes. However, they can often be only partial remedies. In many instances of *major* technological change, private programs either are impracticable (for example, if the displacement occurs in industry A as a result of technological change in industry B), or else cannot provide complete worker protection without unduly slowing the pace of technical advance, and preventing the flexible and efficient utilization of the labor force.

PUBLIC POLICY AND TECHNOLOGICAL CHANGE

Two central points emerge from the preceding discussion. First, technological advance is a key element in economic progress; achieving the goals of rapid growth and higher living standards and better international balance depends on maintaining and even increasing its pace. Second, technological change—like other kinds of change—demands adaptations on the part of labor, business, and the community at large; and these adaptations impose real burdens on adversely affected individuals.

Each of these points has significant implications for public policy. They suggest that Government should stimulate and facilitate rapid technological change in order to enlarge its benefits, at the same time attempting to strengthen processes of adaptation and to lighten the burdens of change on affected individuals.

The single most important support the Government can provide for accomplishing each of these purposes is to help the economy achieve and sustain high employment. Without strong markets for their products, businessmen will have inadequate incentives to undertake the risks inherent in innovation. Likewise, the economy's adaptation to technical change—and particularly its ability to transfer the resources released by technical change to other industries and activities—become immeasurably weakened in the absence of strong demand.

TAX STIMULUS FOR INVESTMENT

Enactment of the pending tax bill is thus crucial to the achievement of our dual objectives. First, it helps insure the increase in demand necessary to provide markets for our growing productive potential. But the tax program of the Administration carries a further impact of great importance for the encouragement of rapid technological innovation. This is the specific emphasis on encouraging investment. The investment tax credit and the revised depreciation guidelines of 1962 were designed particularly to reward firms which raised their rate of investment in new plant and equipment. And the pending bill carries this emphasis further, with a large reduction in corporate taxes, a cutback of risk-inhibiting top bracket individual tax rates, and a further broadening of the investment credit.

The stimulus that tax reduction will give to investment both through its effects on markets generally and through its specific improvement in investment incentives is one of the most powerful ways available to encourage the rapid introduction of new and better technology.

GOVERNMENT SUPPORT OF TECHNOLOGICAL ADVANCE

A healthy rate of innovation is encouraged by preserving freedom of entry into markets by new competitors, and by a patent system which provides positive incentives to both invention and innovation.

The Government has also provided more direct encouragement of technological advance, and it can and should do more. Federal support is clearly warranted and appropriate when it encourages innovations that will be used directly to improve performance of a service recognized as a direct responsibility of the Federal Government. National defense is the most important current example of such an activity. But there are many other activities in which government—Federal, State, or local—plays a major role: providing public highways, airways, inland waterways, weather services, and postal services; maintaining an atmosphere free from dangerous pollution and an adequate supply of pure water; and a long list covering such diverse fields as criminology, recreation, and education. In such activities Government has a special responsibility to undertake, or to support, research and development which promise improvements in public services—better quality, greater safety and reliability, and lower cost. In none of these fields can private incentives be expected to provide an adequate research effort.

But there are other situations that justify Federal support of invention and innovation, even in areas that are and should remain the province of private enterprise. This is surely true where the benefits to the community extend far beyond the gains to the individual buyers of the new product or service. The benefits to these buyers may be quite insufficient to cover the private costs and risks of developing the new good or service; yet the benefits to society at large may pay a handsome return to the innovational activity.

Medical research is clearly an example of this kind of activity. Improvements in medical technology are certainly in the public interest; yet the costs of many such improvements could not—and perhaps should not—be borne by the immediate beneficiaries of the new knowledge. Through a political process society has determined that a larger effort should be made, and Government funds primarily support it.

REASONS FOR UNDERINVESTMENT IN RESEARCH AND INNOVATION

Aside from medicine, the other principal field in which significant Federal support has been given to technological change in an essentially private, civilian industry is agriculture. This type of support has a long history, going back at least to 1887, when the Hatch Act established the national system of agricultural experiment stations, and to 1914, when the Agricultural Extension Service was founded. The basic justification for supporting agricultural research differs from that applicable to national defense or medicine. And it is a justification which would seem to extend to other industries as well. In a number of industries the amount of organized private research undertaken is insignificant, and the technology of many of these low-research industries has notably failed to keep pace with advances elsewhere in the economy.

Several factors can be identified to account for the underinvestment in research and development on the part of private firms in such industries. The primary one is an inability of the individual firm to recover the costs of research in its prices, even though the additional value to the direct consumers of the product would greatly exceed those costs. Particularly in the case of basic research, the "product" is new knowledge; but scientific knowledge cannot be appropriated by an individual firm. Other firms and even other industries—which have not incurred the research costs—share the benefits. As a new development moves further along the research and development spectrum toward actual production, an individual firm may be able, through the patent system, to appropriate to itself rewards sufficient to justify the costs and risks of developing and introducing the new process or new product. The clearest case for public support thus applies to the more basic forms of research. This case is reinforced by greater riskiness at this early end of the R&D spectrum. Ordinarily, at least, uncertainty decreases as a new process or product approaches specific economic application. Indeed, the research cycle can usefully be viewed as a process of progressive reduction of uncertainty as more knowledge is acquired.

Another reason for the virtual absence of organized research in many industries is the high cost of research in the relevant technologies in relation to the typical size of firms in those industries. Research plant and equipment costs are very high in nuclear physics, for example. In other cases, effective research may require large staffs of scientists and engineers since advances may depend on contributions from many scientific specialties. Furthermore, the small establishment is unable to take advantage of the spreading of risks among a number of R&D projects under way at the same time. The larger firm, able to support a number of projects, can safely take the risk of many "failures" (i.e., projects that do not produce economically applicable results), since a few successes will ordinarily more than compensate for the entire investment. The large firm has the additional advantage of being in a better position to market successfully the new products of its research laboratory because of its broader market coverage. For example, in the chemicals industry—which is relatively active in research—many firms typically participate in a broad range of product markets. In this field, at least, where new R&D results are often profitably applicable in more than one market, the large firm is better able to recognize and take advantage of possible payoffs in several applications.

However, some industries characterized by large firms undertake relatively little R&D. Part of the explanation seems to lie in the age of the industry. Industries which were already mature before sophisticated scientific and engineering techniques began to be applied to industry lack a research tradition. Many important newer industries, such as electronics, grew directly out of modern organized research and development, and their managements find it natural and profitable to continue this emphasis on R&D as they mature.

The fact that some industries spend little on research does not in itself prove that there would be high payoffs to additional research. It may be that research effort is slight because it is clear that it would not pay. Nor does it automatically follow that productivity gains in these fields are low. They may, and often do, show rapid gains based on innovations by the capital goods industries which supply their equipment.

Nevertheless, the above analysis has suggested some reasons, quite unrelated to the potential gains from accelerated R&D, that account for an underinvestment in research in many fields—particularly where firms are small. The data at the bottom of Table 18 clearly show that manufacturing firms with R&D programs, and with 5,000 or more employees, did—on the average—more than twice as much research as a percentage of sales as did smaller firms.

TABLE 18.—*Research and development performed by industry, 1961*

Industry and size	Millions of dollars		Percent of sales [1]	
	Total	Company financed	Total	Company financed
By industry:				
Total	10,872	4,631	4.4	1.9
Aircraft and missiles	3,957	392	24.2	2.4
Electrical equipment and communication	2,404	871	10.4	3.8
Chemicals and allied products	1,073	877	4.6	3.6
Machinery	896	610	4.4	3.0
Motor vehicles and other transportation equipment	802	628	2.9	2.3
Professional and scientific instruments	384	212	7.3	4.0
Petroleum refining and extraction	294	286	1.0	1.0
Primary metals	160	151	.8	.8
Rubber products	126	88	2.2	1.5
Fabricated metal products	118	90	1.3	1.0
Food and kindred products	105	106	.3	.3
Stone, clay, and glass products	103	95	1.8	1.7
Paper and allied products	60	63	.7	.8
Textiles and apparel	33	(2)	.6	(2)
Lumber, wood products, and furniture	9	(2)	.5	(2)
Other industries	[3] 348	[3] 127	1.4	.5
By size of company:				
Less than 1,000 employees	596	(2)	2.0	(2)
1,000 to 4,999 employees	935	591	2.2	1.5
5,000 employees or more	9,341	3,728	5.2	2.0

[1] Data for manufacturing companies with R&D programs.
[2] Not separately available but included in total.
[3] Includes dollar amounts for other manufacturing and nonmanufacturing companies not elsewhere classified.

NOTE.—Detail will not necessarily add to totals because of rounding.

Source: National Science Foundation.

THE EXTENT AND DISTRIBUTION OF R&D

Table 18 shows the heavy concentration of R&D performance in 3 industry groups: aircraft and missiles, electrical equipment and communications, and chemicals and allied products. These 3 fields account for 68 percent of the total. Together with machinery and motor vehicles and other transportation equipment, they account for 84 percent. Professional and scientific instruments is a smaller industry in which research and development expenditures are high relative to sales. Federal support for research is important in several of these cases. Yet it is striking that these 6 high-research industries all show an important volume of *company-financed* R&D.

The data in Table 19 show that the Federal Government is already a heavy contributor to research and development in America, although its support is now heavily concentrated in areas related to defense and space exploration. Its contribution grew from $2.7 billion in 1953–54 to an estimated $11.0 billion in 1962–63 and expanded from a little over half of the total R&D spending in 1953–54 to more than two-thirds in 1962–63. What is now at issue is whether a relatively small fraction of that support

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should be directed in the future to civilian fields in which technological development has been lagging.

TABLE 19.—*Research and development expenditures, 1953–54 to 1962–63*

[Billions of dollars]

Year [1]	Total expenditures	By sources of funds [2]			By performance		
		Federal Government	Industry	Universities and other nonprofit institutions	Federal Government	Industry [3]	Universities and other nonprofit institutions [3]
1953–54	5.15	2.74	2.24	0.17	0.97	3.63	0.55
1954–55	5.62	3.07	2.37	.18	.95	4.07	.60
1955–56	6.39	3.67	2.51	.21	1.09	4.64	.66
1956–57	8.67	5.10	3.32	.25	1.28	6.60	.79
1957–58	10.10	6.39	3.45	.26	1.44	7.73	.93
1958–59	11.13	7.17	3.68	.28	1.73	8.36	1.04
1959–60	12.68	8.32	4.06	.30	1.83	9.61	1.24
1960–61	13.89	9.01	4.55	.33	1.90	10.51	1.48
1961–62	14.74	9.65	4.71	.38	2.09	10.87	1.78
1962–63 [4]	16.42	11.00	5.00	.43	2.71	11.56	2.15

[1] Federal Government performance on fiscal year basis; data for industry are calendar year basis and other data are primarily on fiscal year basis. Fiscal years are as indicated; calendar years refer to year beginning with half of indicated fiscal year.
[2] Based on reports by performers.
[3] Includes research centers administered by organizations in this sector under contract with Federal agencies.
[4] Preliminary.

Note.—Detail will not necessarily add to totals because of rounding.

Source: National Science Foundation.

A FEDERAL CIVILIAN TECHNOLOGY PROGRAM

Primary responsibility for Federal programs fostering industrial technology is assigned to the Department of Commerce, which has embarked on several broad programs to stimulate technological advance in all sectors of the economy. The fundamental role of government is to help industry help itself by catalyzing and supporting the efforts of firms and communities to promote economic progress through technical change.

In order to disseminate the results of federally sponsored research and development more efficiently, the Departments of Commerce and Defense have agreed to assign to the Office of Technical Services in Commerce the handling of all unclassified and unlimited Department of Defense documents.

The National Bureau of Standards is administering contracts for research useful to the textile industry, under a new Civilian Technology program approved by Congress in 1963. The objective of this program is to sponsor technical investigations of problems faced by the industry at large—problems that no single firm could afford to solve on its own behalf, but that are especially suited to combined investigation.

Industry associations can be an important vehicle for undertaking research of broad significance to an entire industry. The Commerce Department is accordingly considering a legislative proposal authorizing government assistance to such groups in order to stimulate their sponsorship of non-proprietary technical investigations.

A further legislative proposal is under consideration to provide for Federal cooperation with States, universities, and industry groups to aid in the development and dissemination of new technological information. The purpose of this program would be to bring the reservoir of technical information available at scientific centers to bear on the problems of firms that are not able to support large research organizations. Such a technical service program should be tailored to the needs of the local area and conducted under local direction.

FEDERAL SUPPORT FOR BASIC RESEARCH

"Basic research" has sometimes been defined as research undertaken with no specific practical goal in mind—beyond a general conviction that extending man's knowledge of his environment and of himself is bound to serve the purposes of human life and human society. Most basic research is conducted in universities, sometimes supported by the Federal Government. A relatively small number of large business organizations support basic research in areas of their general interests.

Merely to agree that basic research is a "good thing" does not necessarily justify Federal support for it and, in particular, gives no basis for determining how much support should be provided for what kinds of basic research.

It is inevitable that primary support should be given to those fields of natural science where potential payoffs in national security, health, and economic growth are obviously high even if uncertain in location and character. The fact that many of our most dramatically "practical" technological achievements have grown quite directly—and often quite promptly—from new discoveries in these fields builds a solid case for their support.

Recognizing this relationship between basic research in the natural sciences and practical achievements benefiting society in many diverse ways, the Congress has provided generous support for research in the natural sciences, particularly through the Department of Defense, the Atomic Energy Commission, the National Aeronautics and Space Administration, the Department of Health, Education, and Welfare, and the National Science Foundation. The breadth of Federal support of basic research is reflected in the work of the NSF, which supports and encourages research over a spectrum including atmospheric sciences, high energy physics, oceanography, and metabolic biology—in each of which research costs are often high and the potential payoff to society may be very great.

Yet basic research in other fields may also have "practical" payoffs even if not in industrial technology or national security. Thus Federal support is given to investigations in psychology, where potential payoffs in more efficient organizations or better mental health can be large. The social sciences, where expanding knowledge of economic and social relationships may improve the efficiency and effectiveness of government and private organizations, also merit support even on "practical" grounds, and some modest beginnings in these fields are now being undertaken.

A strong system of university and technical education must underlie progress in basic research. Institutions of higher education not only conduct much of our national research effort, but they also train most of the scientific research workers on whom future progress depends. The National Science Foundation's program simultaneously supports both university research and higher education, reflecting their close interrelationship. Higher education is also supported through programs under the National Defense Education Act and the new Higher Education Facilities Act.

GOVERNMENT'S ROLE IN AIDING ADJUSTMENT

Federal responsibility for fostering more rapid technical advance clearly could not be successfully—or even appropriately—undertaken in an economy in which total demand perennially failed to rise enough to reemploy the workers initially displaced as well as new additions to the labor force. But maintaining high demand and satisfactory over-all employment is not enough. There are other important policies which the Federal Government must pursue if adjustments to change are to be successful, and if the effects on labor, business, and local communities are to be acceptable. Many of the programs needed for this purpose also form one cornerstone of the attack on poverty.

The labor market programs of the Federal Government have made striking progress in recent years, and this progress must continue. Since 1961 the Federal-State Employment Service has increased its nonfarm job placements by almost 25 percent. But its guidance and placement facilities must be further strengthened in order to improve the matching of workers and jobs. The vocational retraining program of the Department of Labor and the Area Redevelopment Administration has reduced transition costs and improved future earning potential for a significant number of displaced workers. Some 148,000 workers will be in training or retraining during fiscal year 1964 in skills as diverse as drafting, stenography, nursing, auto repairing, and metalworking; and the program will be expanded to provide training and retraining for 288,000 workers in fiscal year 1965. The recent broadening of the Manpower, Development and Training Act will increase its effectiveness in coping with unemployment among low-skilled workers and youths. An important element included as part of this program will be the provision of adult education courses in fiscal year 1965 for 60,000 persons who are unable to acquire industrial skills because of a lack of basic literacy, and vocational training will be provided for 85,000 unemployed youths.

In this connection the recent passage by the Congress of a broad new program of aid to vocational education is of great significance. It should lead not only to a large expansion of existing programs but also to a considerable broadening and redirection, including new emphasis on business and office occupations. The work-study program and provision in the new legislation for residential vocational schools will greatly improve opportunities for young people previously unable to acquire vocational training. In addition, passage of the Youth Employment Act will provide work and training through conservation work camps and work projects in local communities for 60,000 youths during 1964 and over 100,000 the following year. The prevalence of discriminatory hiring practices has been significantly reduced by the vigorous efforts of the President's Committee on Equal Employment Opportunities.

The unemployment insurance system—first line of defense against the costs of unemployment—must be modernized in order to deal better with the unemployment that results from shifts of jobs from one occupation, industry, or area to another. The additional labor market programs that are being recommended will be discussed at greater length in the forthcoming Manpower Report of the President.

In our concern with the problems of today's unemployed, it should not be forgotten that a strengthened system of basic education will be the best guarantee against significant problems of displacement and dislocation in tomorrow's full-employment economy.

Technical education and vocational guidance programs can be kept more current by the creation of any early warning system on new technological advances. But the possibility of accurately predicting occupational requirements even 10 years into the future is highly limited. And the average male's working life now extends over 45 years. We can best prepare for the occupational requirements of the labor market of 1970 through an educational system that produces well-educated and technically versatile graduates, able rapidly to acquire new skills. Such versatility will accelerate the process of matching jobs and workers and greatly reduce the loss of potential earning power resulting from the obsolescence of specific skills.

CONCLUSION

Fears of technological advance are understandable on the part of those who feel its threat to their livelihoods. In the absence of wise and effective private and public action such fears are justified. But any comprehensive appraisal can lead only to the conclusion that the benefits of technical change—in the future as in the past—are such that public policy should foster rather than shun it. To yield to apprehension that the machine will become our master, that we are unable to absorb and adjust to rapid change, that we must deny ourselves the continued rise in material well-being that ever-growing knowledge and understanding place within our grasp and the increased freedom it brings to pursue higher goals—such a defeatist view is both unworthy of our heritage and unjustified. For as scientific and technical knowledge has grown over the years, so, too, has understanding of our social and economic system and institutions—including the proper role of government in a free society. Applying this knowledge, all citizens can enjoy the fruits of rapid change.