Productivity
(1960-folder)

[National association of manufacturers.

# PRODUCTIVITY

## *A Measure of Economic Progress*



(*Economic Series* no. 82)

*No. 82*
*November, 1960*

2 EAST 48TH STREET, NEW YORK 17, N. Y.

Price: One Dollar

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### INTRODUCTION

No term has been more misused and misunderstood than the term *Productivity*. Even though the efficiency of inputs in relation to output has always been a subject of study by anyone in business, the present day emphasis and popularity of productivity information is comparatively a new phenomena. Down through the ages men have always searched for ways of producing more with less expenditure of energy, either human or mechanical. However, the measurement of this process for comparative purposes is relatively new. Furthermore the evolution of these measuring techniques from a simple productive operation to the measurement of the efficiency of an entire economy has occurred only in the last few years.

As a result there is much confusion and misunderstanding as to what factors are involved in this new measurement; what the results validly show and don't show, and finally in the application of these results to other economic factors for the purpose of studying interdependent functions in our economic system.

The benefits which may be obtained from a correct understanding and correct application of productivity measurements can do much to further economic progress and understanding. Likewise the harmful consequences which will follow the misuse of productivity measurements can only lead to economic misunderstanding which will deter our economic progress.

In the following pages we will examine the concept of productivity, the sources of increased productivity, the productivity record and the relationship of productivity to our economic well-being. In addition, the reader will find an appendix which outlines the methodologies used to develop productivity measures.

It is our hope that this paper will help foster a broader understanding in this field of economic study and thereby promote a more intelligent approach to the economic problems affecting our national welfare.

*November 1960*

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# I

# PRODUCTIVITY — GENERAL BACKGROUND

Productivity is a measure of the efficiency with which resources are converted into the commodities and services that men want.[1]

To the economist specializing in productivity measurement the above definition adequately describes productivity in general terms. Since economics is not a pure science the interpretation of this definition and the application of these interpretations has led to much confusion in economic thinking.

The primary fact to remember is that productivity is a measure. As a measure it provides a gauge with which we can compare the past with the present or any trend or absence of trend which may have occurred between the past and the present. As a measure of efficiency productivity is expressed in terms of rates per unit of input. Just as the efficiency of an automobile engine is measured in miles per gallon, the efficiency of our economy is judged by the output per unit of input.

The input which changes the efficiency of an automobile engine is not limited to the quality of the gasoline burned by the engine. True, the petroleum industry has developed higher octance gas to produce more power. However, other developments such as new design, better lubricants, better auxiliary parts such as carburetors, etc., and other improvements too numerous to list also contribute to a more efficient engine. Behind all these improvements is brain power and huge investments in laboratories, plants and machinery. All these are inputs which affect the productivity of the automobile engine.

The inputs which result in improved productivity for the economy are just as numerous and each has had a beneficial effect in attaining the goal of more efficient employment of our resources in the production of goods and services which we desire — the output of the economy. There is difficulty, however, in attributing any part or all of a productivity increase to any specific change in one input. It is a combination of all inputs acting interdependently which effects a productivity change. Therefore, while it is possible to measure the productivity change, it is ordinarily impossible to attribute this change to any one specific input.

As already stated, productivity is measured by a ratio of output to input. The output itself may be measured in specific units of the product or in other terms used to express output such as the dollar value of the total product. In any single plant or industry where there is a homogeneous product, output can be expressed in units of outputs such as tons of steel or number of automobiles. However, if we are to consider the output of a broad section of the economy or the entire economy where the output is in heterogeneous units such as tons, units, bushels, etc., it is necessary to use a common denominator to express the entire output. The only possible denominator in this case would be the dollar value of the product.

While it is comparatively simple to evaluate this concept of output with the statistics available the make-up and consideration of inputs is quite difficult. Many input factors are intangible such as general spirit, working conditions, attitudes and other such factors which even though they cannot be quantitatively measured, still can have an important influence on productivity. Each of the more important input factors will be discussed below. As noted, the specific contribution of each input is, in most instances, immeasurable. Nevertheless we cannot ignore the immeasurable contributions of such factors when we are considering the productivity measures.

Recalling our original definition of productivity, we stated that it is a measure of the efficiency with which resources are converted to the goods and services we desire. In the true economic sense our resources can be separated into three categories — land, labor, and capital. As inputs these factors each have a very definite influence on output. Naturally the influence of each as an input factor will vary with the nature of the end product.

Land is a much more influencing factor in agriculture or the extractive industries than it is in manufacturing. However, before a product can be manufactured it must be taken from the land as a raw material. Therefore, we cannot discount the contribution of land as an input factor in our productivity. Even our most industrialized economies were at one time agricultural economies. The fact that the United States rapidly changed from an agricultural country where three out of four persons worked the land, to an industrialized economy where nine out of ten employed people now work in non-agricultural pursuits was due to the quality of the land as well as man-made improvements. Russia still has one out of every two persons

[1] Fabricant, Solomon, *Basic Facts on Productivity Change,* National Bureau of Economic Research, 1959, p. 1.

working in agriculture because her farmers do not attain the outputs that our farmers do. Of course the value of land as an input in the productivity concept in the petroleum, iron and steel, coal, or other natural resource consuming industries is quite obvious.

The second input factor — labor — is the most discussed input factor in productivity measurement. In the first place the amount of labor input from the point of view of time spent working is measurable. There is readily available a numerical denominator to measure the size of the labor input. The most common measure of labor input is man-hours, i.e., the total number of workers times the number of hours they work. However, adjustments have to be made in this simple concept too. One leading man-hour estimate (Bureau of Labor Statistics) embraces a concept termed "man-hours paid." This estimate of man-hours paid includes in addition to the actual time spent working, the time when men do not work but receive regular pay such as paid vacations, paid holidays, etc. The Census Bureau estimate consists only of the actual man-hours worked.

For the sake of convenience, reference to the Bureau of Labor Statistics and the Census Bureau man-hours estimates will be in terms of man-hours paid and man-hours worked respectively. There has been some debate and disagreement about the construction of the two series of estimates. This paper is not an analysis of these estimates but an analysis of productivity measures which employ these estimates.

At this point the reader is undoubtedly concerned about the quality of labor when it is considered as an input. A highly skilled engineer certainly contributes more in one hour's work than a turret lathe operator. At the present time there is only one productivity measure which takes into consideration the different degrees of skill which make up the labor unit. This measure has been developed by John W. Kendrick who weights the man-hours figures with wage rates and thus gives more weight to the labor input of the more highly paid employees who contribute more to production. This type man-hour concept can be readily employed in productivity measures for a specific plant or industry but when it is used in measuring the productivity of the entire economy, the statistical methodology becomes quite a complicated operation.

Capital, one of the most important input factors as far as increased output is concerned is also very difficult to measure. No less important than land or labor, capital differs from these factors because it is created by man. While the earth is endowed with land and human beings who are capable of working, capital is created by men who were willing to deny themselves part of their production and invest this unconsumed production to provide productive facilities. Capital is represented by the buildings, machines, inventories and other assets all of which exist because some people saved the money to finance them. While it is statistically possible to place a dollar value on these assets it is not statistically possible to assign a dollar value to the sacrifice made by the savers who put off consumption to invest their savings. Kendrick has developed a method of assigning a value to the input of capital[1] but this methodology consists of a dollar value assigned to land, plant, equipment and inventories. Here we wish to consider the contribution of capital in a pure economic sense which is statistically immeasurable for it must be thought of in terms of individual sacrifice made by the people who save and invest. All owners of stocks, bonds, savings accounts, pension plans, life insurance, and the many other forms of savings sacrifice current consumption to be able to invest the money necessary to provide capital.

Although we have only briefly reviewed the three major inputs — land, labor, and capital — affecting productivity change, it is hoped that the reader will retain this concept of all three inputs. The difficulty of assigning a statistical value to the relative contribution of these three inputs should not lessen our awareness of the vital contribution each of these inputs, acting independently and interdependently, make to our economic progress. In the Appendix we will analyze two existing productivity measures which are based on labor input, and a labor and capital input. Much work is currently being carried on to include the input of capital and as these new techniques now being developed in this comparatively new field of productivity measurement are perfected, we can look for better understanding of our industrial problems.

The Bureau of Labor Statistics productivity measures are based on labor input for three reasons. First, the input concept is readily understandable. In the second place, labor input is easily measurable, i.e., in terms of man-hours. And finally, the most often quoted productivity indices are based on labor input.

Some general observations will be helpful at this point regarding productivity measures based on labor input. The day of back-breaking work is past except in a few industries such as house painting, window washing, etc. If there is any extraordinary strain on the physical well being of today's average worker, the strain is most apt to be a mental strain rather than a physical strain. Therefore, in considering productivity measures based on labor input, the reader must remember that any increase in efficiency is due more to an effective use of manpower in the productive process and not to any increase in the muscle power applied to the job by any worker or group of workers. Current productivity measurements based on labor input do not include the labor input of government employees or their output. This is due to the fact that the value of the output of these government employees is not measurable in the concepts used to measure the output of the private economy, since the goods and services are not sold in the

[1] *Productivity Trends: Capital and Labor,* John W. Kendrick, Occasional Paper #53, National Bureau of Economic Research, Inc.

market place. Therefore most productivity measures are concerned with the private economy only.[2]

In any analysis of productivity, it is necessary to include the input of all employees. Certain productivity tables limit the labor input to production workers only. Such measures may be of value to people who are examining the efficiency of a particular shop or plant operation, but in the true economic sense the efforts of all the employees enter into production. The researcher or office worker may never be near the production line, but their contribution to production in most instances is greater than the performance of the production worker on the assembly line.

Mr. John W. Kendrick[3] made a conceptual distinction in the types of productivity which will aid the reader in grasping an overall economic idea of productivity. The distinctions made by Kendrick are expressed in terms of "economic efficiency" and "technical efficiency." Changes in economic efficiency are due to a shift in resources among industries to achieve more efficient or economical use of these resources. The classic example of such a shift would be the movement of farm workers into industrial plants. Here the resource of human manpower shifts from the production of a lower unit valued product to the production of a higher unit valued product. Actually there is probably less expenditure of human energy in the industrial plant than on the farm, but the value of the output for the man-hours of input is much higher in the industrial plant.

"Technical efficiency" increases are achieved when the output capacity is increased with the same or less input factors. For example — a new plant layout may achieve the same or higher production with less men. Changes in technical efficiency are the result of research and development work. By its very nature, the contribution of the research and development departments is immeasurable in any given year. However, over a period of years the results of this work have a definite effect on productivity. A research or development department may work for a number of years without producing a tangible product or idea and then suddenly develop a method or a product which improves the entire process of production. In most instances there is a large investment in education and training before people can begin to perform their functions in the research and development fields.

Productivity increases resulting from technical efficiencies are more usually discernible and often more revolutionary than productivity increases resulting from economic efficiencies. This is not necessarily an indication of the relative importance of the two types of productivity improvements. Each is important and has a beneficial effect on the economic welfare of the economy.

In the final analysis productivity increase reflects a more efficient use of all our resources. The standard of living provided by our productive system must also improve the intellectual development of the population as well as satisfy its material needs.

Therefore we must not discount economic efficiencies in favor of technical efficiencies or vice versa in reviewing the productivity records. On the contrary, it is necessary that we remember both these efficiency changes for their contribution to productivity advances. They do work interdependently and in the daily operation of our economic system both are contributing to a more bountiful way of life.

[2] Henry D. Lytton has done some preliminary analysis of the productivity of Federal employees. For a review of his findings see THE NEW YORK TIMES, July 26, 1959, p. 37.

[3] *National Productivity and Its Long-Term Projection*, Kendrick, J. W., National Bureau of Economic Research, 1954, pp. 76-81.

II

# SOURCES OF INCREASED PRODUCTIVITY

It is easy to cite an example of some new invention or technique which resulted in an immediate increase in productivity. The advantages of the cotton gin over the hand separation of seed from the cotton are quite obvious. Between the separation of the seed from the cotton and our purchase of cotton clothing however, there are numerous phases of production which affect the efficient production of the cotton clothing. All along the way the final product was subject to factors which influenced the efficiency with which the final product was produced. Each of these improvement factors of productivity contributed to better and lower priced cotton clothing.

The list following contains some of the more important factors which influence productivity. No one is more or less important than the other for all are at work simultaneously in increasing our productivity. In the production of goods and services for our economy each of these factors has played an important part. Although the influence of each item on the list is quite obvious, a few comments on each category will perhaps contribute to a broader understanding and appreciation of the concepts and problems involved in the measurement of productivity change.

## A Partial Outline of the Factors Which Determine Productivity

I TECHNOLOGICAL FACTORS

Ingenuity of engineers and others in devising innovations:

A. In tools and equipment
B. In productive methods
C. In materials

II MANAGEMENT FACTORS

Attitude and behavior of businessmen with respect to:

A. Competitive spirit
B. Willingness to assume risks
C. Willingness to adopt innovations
D. Efficient scheduling of work (including division of labor and plant layout)
E. Efficient purchasing of materials
F. Aggressive expansion of markets
G. Efficient handling of labor relations
H. Active support of search for new and better methods
I. Standardization of products

III FINANCIAL FACTORS

Availability of capital for financing innovations:

A. In existing industries
B. In setting up brand new industries

IV LABOR FACTORS

The characteristics of the labor force with respect to:

A. Degree of skill
B. General Education
C. Health
D. Morale
E. Hours of work
F. Adaptability
G. Geographic mobility
H. Willingness to accept innovations
I. Attitude toward "featherbedding"
J. Manner of compensation

V GOVERNMENT FACTORS

Government policies dealing with:

A. Competition
B. Business size
C. Taxation
D. Subsidization
E. Tariffs

VI ECONOMIC FACTORS

The general background economic climate. In particular:

A. The rate of operations
B. The allocation of population as between farming and industry
C. The availability of transportation
D. Willingness of the public to save and invest
E. Willingness of consumers to accept new products

VII NATURAL FACTORS

The state of such uncontrollable factors as:

A. The weather
B. The presence or absence of mineral deposits
C. The initial condition of the soil

### *Technological Factors*

New and more efficient machines are the primary sources of increased productivity. While we hear of revolutionary inventions in the machine tool field, these newsworthy machines don't crop up very often. The fact that their introduction is an event which receives news space testifies to the scarcity of these inventions. However, improvements of machines and tools are a daily occurrence and it is this day to day, month to month and year to year struggle for better machinery to meet competition that is the real force behind the higher productivity of tools. A few years ago one large auto maker opened what some people called a completely automatic assembly plant. The ideas and equipment that made this plant possible were not conceived just for the erection of this specific plant. Indeed every machine improvement since the installation of the first assembly line was incorporated in this plant. If another new assembly plant were on the drawing boards today, we could expect to see numerous improvements over the so-called "completely automated" plant erected a few years ago. During this time management has been working daily to improve this machine and that machine. The sum total of all these little improvements continuously improves our productivity.

Hand in hand with better machines is the constant search and installation of improved methods of using the better machinery. New layouts in assembly line production have resulted in large productivity increases. This innovation includes such giant moves as relocating plants nearer to raw materials or, dependent upon the nature of the product, nearer to the market. Economies in transportation and the utilization of good labor markets are other examples of improved innovations. It is quite possible for a person who studies different companies in one industry to immediately recognize the fact that one company utilizes its machinery to greater advantage because of its plant layout, even though both companies use the same type of machine.

Finally, the introduction of new materials is another example of technological improvements affecting productivity. Since World War II the substitution of man-made plastics has revolutionized the productive process. Such items are not only easier to work with in the cutting, forming and shaping processes with the resulting increased productivity, but they often possess greater durability which contributes to a better end product.

### *Management Factors*

During 1959, a total of 347,000[1] businesses were discontinued. While some were dissolved voluntarily and others failed, it is not possible to state just how many were discontinued solely because of faulty management. Some of the more important forces which contribute to good management are listed on page 6. Unfortunately, these abilities which are applied to the successful management of the nation's 4,000,000 plus businesses are more or less taken for granted by a large segment of the population. Even worse, there are certain groups which continuously downgrade the motives and the abilities of executive management. When one stops to consider that the jobs of the employees and the availability of the nation's huge supply of goods and services that consumers are able to buy are dependent on decisions of management, it is difficult to understand how these attacks on business executives gain any acceptance. The maligning of executives as greedy profit seekers only points up the ignorance of those who seek to perpetuate this image. Profits are utilized to reward the people whose money is used to create a business and to expand the job creating ability of the business through reinvestment. Businessmen are paid for their ability to successfully run the businesses. The fact that some receive high salaries is not any indication of greed on their part, but testimony to the fact they possess the rare skills and initiative which the average worker does not possess.

In the application of these skills, management utilizes all these factors. The resulting productivity increases, while often not quantitatively measurable, are readily visible. Behind successful management there is a huge investment in education, job training, and business experience.

### *Financial Factors*

Capital is necessary not only to start a business but also to maintain and expand a business. The availability of capital can have much influence on the decisions of management to buy the tools which generate increased productivity. As noted above, new tools and new methods are continuously being developed. If capital is available and can be obtained at a price which will enable business to borrow and improve its profit picture, these more efficient innovations will be put into production. On the bondholder's or stockholder's side of the capital picture, capital must be earning a good enough return or offer the prospect of a good return to encourage the lenders of bond money or the investors in equity capital to invest their savings. Business does not control the money market and must compete not only with other firms in the money market but also with federal, state and local governments and consumers who are also seeking funds to finance their

[1] *Survey of Current Business*, May, 1960, U. S. Department of Commerce.

purchases. The combined demands of all these groups for capital affect its availability and hence affect the pace of investment into facilities which increase productivity.

### *Labor Factors*

The American labor force produces more for its size and effort than the labor force of any other nation. As a body it possesses greater skills, a better educational background, better health, and a better living standard than its counterpart in other sections of the world. All of these assets directly affect its productivity and as each of these assets is improved, the work force will continue to improve its productivity. Just as business must take the necessary steps to adapt to the changes in the productive process, our labor force must be willing to accept and adapt to changed conditions as they affect the labor force, for all these changes have the ultimate purpose of achieving higher productivity. Compared with the labor forces of other countries, American labor has shown a general willingness to cooperate in this productive evolution. However, there are dangerous negative influences which can have a definite deterrent effect on the contribution of the labor force to increased productivity. There are two main categories into which these negative approaches fall. The first concerns the practice on the part of labor to enforce wage demands which are in excess of productivity increases. The second negative action by labor is the practice of resisting labor-saving innovations and/or insisting on make-work practices which not only deter productivity increase, but actually reduce productivity in many instances.

The ability of labor to enforce these demands which are a deterrent to productivity improvement is found in situations where labor possesses monopolistic power in bargaining with management. The insistence that these wasteful and inefficient demands be incorporated in labor contracts is a short-sighted policy which results in serious damage to the overall economy. Wage increases in excess of productivity increases hurt the purchasing power of the entire population including the recipients of the increases. The actual wage earners involved may enjoy a temporary and short-lived purchasing power advantage, but before long they, as well as the entire nation, are hit with the rising price level which must pay for these excessive wage costs. Also the insistence of labor that certain make-work rules be enforced only increase costs and eventually push costs to the point where business cannot compete with similar foreign produced products, or where machinery can take over the job thus eliminating immediately the need for certain employees. In some instances, as soon as labor costs reach the point that machinery can take over, a competitor will enter the field with the equipment that does away with a specific high-cost job. Instead of an orderly transition of employees to new jobs, we have a sudden termination of existing jobs with the accompanying hardships and waste of our labor resources. Some labor leaders recognize the urgency of this situation. Unfortunately in industries where labor monopoly exists, the complacency of labor leaders has lulled them into a position where they are unwilling to face this condition. The enforcement of make-work rules only postpones the orderly re-allocation of manpower resources. This needless postponement will only intensify the problem of retraining and relocation.

### *Government Factors*

The emergence of the Federal Government as the largest single sector of our economy has had an important effect on the productivity of the country. The government's primary job is to govern and when its functions spill over into the business sector to such an extent that it hinders the natural tendency to seek better and cheaper methods of production, it is overstepping the area of its legal functions. It is easy to see the effect that taxation, subsidization and monetary policies can have on business. Well directed and controlled legislation in these fields can do much to enhance the progress of business which is constantly striving to improve its productive efficiency. Punitive, restrictive, and poorly executed legislation in these fields will have the opposite effect. Less obvious, but equally or more effective in influencing the productivity of business, is the government's activities in the anti-trust field, the labor relations field, the price control field and all the other areas where the activities of the Federal Government affect business. Although most of this type legislation is enacted under the guise of achieving "social justice" its effect on business is more destructive than its proponents would like to have us believe, for it kills the incentive which generates higher productivity.

### *Economic Factors*

Any individual decision of an economic nature is usually preceded by a deliberation on a number of important facts, for experience has taught us that rash decisions can be costly. Our deliberations take into account general economic conditions of today and the possibility of the state of economic conditions in the future. Economic conditions can fall into any number of categories, ranging from a depression to a boom, with the degree of distinction between these categories dependent upon the individual outlook of the person making the judgment. In the decisions made by business which are an accumulation of the individual decision made by managements, the economic climate has a powerful effect. As a result, the general economic climate affects our productivity. Experience has shown that there is no set rule linking higher productivity to a good economic climate or lower productivity to bad economic conditions. Indeed many cases can be cited

to show a reverse relationship. While business may be willing to invest in more productive tools and techniques during an era of prosperity, it may also relax its attention on controlling costs in its efforts to satisfy expanded consumer demands. On the other hand, during a recession business may put off investing in newer and more productive tools, but at the same time it will drive for more efficient use of the existing manpower and facilities.

The factors which tend to control the economic climate are too numerous to list. Indeed any daily activity or event will ultimately have an economic effect on some segment of our economy — either in production, consumption, or government. The reactive steps to these daily events by any one or all of these sectors create the economic climate which influences productivity.

### *Natural Factors*

The two most obvious natural factors affecting productivity are the weather and the condition of the soil. Aside from farming these natural factors also influence mining, transportation, communications and all other industrial groups. Climate has an important effect on productivity. The heat of tropic and semi-tropical areas slows down the pace of human actions. Likewise a brisk climate tends to invigorate people in their economic pursuits. In considering the effect that natural factors have on productivity, we cannot disregard the productive work done by man to overcome the drawbacks to increased productivity caused by adverse natural conditions. Heating, air conditioning, deep shaft mining, disease and pest control, and all the other man-made corrective assaults on adverse natural factors add to our productivity.

Now that we have developed a broad concept of productivity and the factors which influence it, we can examine two of the well-known measures of productivity. On the following pages the measures of the Bureau of Labor Statistics and those developed by John W. Kendrick are discussed. The Appendix contains an analysis of the methodologies developed for these measures and should be read to obtain a full understanding of the factors embodied in these measures.

III

## THE PRODUCTIVITY RECORD

As already mentioned, the two best known productivity measures are those developed by the Bureau of Labor Statistics of the Department of Labor and the measures developed by John W. Kendrick. The development of these measures is much more complicated than merely understanding the concept of productivity. Furthermore, it is imperative that the methodologies be fully understood before anyone attempts to use these measures as a tool for economic analysis. To apply validly these measures in reasoning out economic problems, one must be fully aware of the extent of their coverage as well as limitations in their coverage. The Appendix of this booklet contains an analysis of the methodologies employed in the development of the Bureau of Labor Statistics productivity measures and the Kendrick productivity measures. This analysis is far from a complete study of the respective methodologies but merely a description of the principal steps involved. The insertion of this material in the Appendix is for the sole purpose of acquainting the reader with the minimum amount of information necessary in arriving at an understanding of the basic concepts embodied in the measurement of productivity. For a complete comprehension of productivity measurement, it is necessary that the sources used to develop the Appendix be referred to and read. For the present we will consider the productivity records achieved by our economy as evidenced by these two well-known measures.

### *The Bureau of Labor Statistics Estimates*

These estimates which are based on the concept of output per man-hour cover the years 1947 through 1958. Using indices (1947-1949 = 100) the Bureau has developed productivity measures for the agricultural and non-agricultural sectors of the private economy. The Bureau measures are based on inputs of man-hours paid (vacations, holidays, etc.) and man-hours actually worked. The former input is derived from the man-hour statistics of the Department of Labor and the latter from man-hour figures published by the Census Bureau. Both types of inputs are useful depending on how one wished to apply

the measures. For instance output per man-hour paid is useful in cost calculations, while output per man-hour worked would be useful in evaluating the efficiency of the work force during actual working time. In this paper we will consider measures based on both inputs. It is well to keep in mind that these reported measures are estimates and there is no claim to complete accuracy for any one year's measurement.

What does the record show? In the period 1947 through 1958 the private economy achieved an average annual improvement rate of 3.1 percent per year based on man-hours paid and 3.5 percent based on the man-hours worked input. In terms of growth a 3.1 percent annual improvement would double output per man-hour paid every twenty-three years and a 3.5 percent annual increase would double output per hour worked every twenty years.

Looking further into the Bureau of Labor Statistics measurements we see that based on man-hours paid, agricultural output increased at an average annual rate of 6.2 percent and non-agricultural output increased at an average annual rate of 2.4 percent. Based on man-hours worked, the agricultural sector recorded an average annual increase of 6.2 percent and the non-agricultural sector 2.9 percent.

It would appear that the productivity in agriculture is far outstripping the productivity of the non-agricultural sector. This is not necessarily true. These measures are measures of change and in no way do they show the level of productivity. The level of productivity is much higher in the non-agricultural sector. Table 1 in the Appendix which records the level of outputs shows the dollar value of the non-agricultural output per man-hour to be double the output per man-hour achieved in the agricultural sector. The spectacular increase registered by agriculture in the post-war period would indicate that this sector is catching up with the non-agricultural gains registered before 1947.

In the non-agricultural sector there is a further division of productivity measures based on man-hours paid. The two categories cover manufacturing and non-manufacturing. For the years 1947 through 1957 (not 1958 as above) the average annual increase in manufacturing (2.9 percent) has been somewhat higher than in non-manufacturing (2.3 percent). This difference is the result of a combination of factors. First, there is a higher investment in manufacturing which has been utilized to increase efficiency. Production records show that more is being produced each year by the manufacturing sector. At the same time employment statistics indicate that employment in manufacturing is actually declining. This combination of more output with less labor input produces the higher productivity increases registered by manufacturing compared to the non-manufacturing sector.

Claims are made that productivity increases have not been large enough and also that they have been exceptionally large in the post-war period. While it is not the purpose of this paper to argue the productivity potential of the economy, it is possible to note the long-term growth rates (1909-1958) which have been developed by the Bureau of Labor Statistics. For the fifty-year period the average annual increases in productivity have been 2.3 percent based on man-hours paid and 2.4 percent based on man-hours worked. Thus the post-war rates of increase of 3.1 percent and 3.5 percent respectively are above all the fifty-year average, but there have been similar periods of accelerated growth in the past half century.

### *The Kendrick Estimates*

Like the Bureau of Labor Statistics estimates, Kendrick's estimates deal with the private economy only. Unlike the Bureau's estimates, Kendrick includes in addition to a labor input an input of tangible capital. Thus this estimate adheres more closely to the original definition of productivity, i.e., a measure of the rate of efficiency with which we use *all* our resources. The addition of a capital input involves many statistical problems. The Appendix of this paper explains some of the more important problems involved and it should be read to have a full appreciation of the significance of Kendrick's estimates and for any use to which the reader may wish to apply these estimates.

Kendrick has drawn up three estimates in all; output per unit of labor input, output per unit of tangible capital input and output per unit of labor and capital combined. Output per unit of labor input is based on a formula somewhat similar to the one used by the Bureau of Labor Statistics. However, some adjustments have been made in the labor input estimate used by the Bureau. In addition all Kendrick's estimates are indices with 1929 as the base year. The Bureau uses 1947-1949 as its base period.

Output per unit of tangible capital is a measure of the efficiency with which business employs its capital. While there has been some question as to Kendrick's methodology in establishing his estimate of capital input, the productivity estimates are informative. Since there has been a greater increase in the amount of capital invested per worker, the index of output per unit of capital input has not risen as fast as the index of the output per unit of labor input.

Output per unit of labor and capital combined as already mentioned is a measure of the efficiency with which we are using all our resources within the limits of Kendrick's methodology. This index does not rise as rapidly as the output per unit of labor input index. On the other hand it does show a greater increase than the index of output per unit of capital. It has been noted that this difference is due to the heavier investment of capital. As already mentioned, some economists have questioned the statistical base of the capital input estimate. We must remember that the measurement of national productivity

is a relatively recent economic innovation and compared to other advances in statistical measurement, we are more or less feeling our way in the field of productivity measurement.

Kendrick's estimate of output per unit of labor input shows an average annual increase of 2.0 percent for the sixty-eight year span between 1889 and 1957. The average annual rate of increase has been subject to varying fluctuations. While there have been single years and specific periods of accelerated increases, there have also been periods of actual reversals. The causes of these variations are numerous. The Appendix contains a partial analysis of these causes, but any analyst could probably cite even more contributing factors. At present we are concerned only with the results which average out to an annual increase of about 2.0 percent.

Growth in output per unit of tangible capital over the 1889-1957 span averaged half of the growth in output per unit of labor input, or about 1.0 percent. Since capital investment is the principal basis for increases in productivity, the record of this input has far-reaching effects. Aside from the ability to pay an incentive return for the investor, the efficiency with which we utilize capital affects present and future employment and the price level as well. Our ability to use capital extends beyond our domestic economy into the international field affecting the flow of investment currency between nations as well as trade balances.

Kendrick's estimate of the productivity of the entire economy, i.e., output per unit of labor and capital combined or total factor output shows an average annual increase of 1.7 percent for the years 1889-1957. At this rate total factor productivity doubles every forty-one years. Of course there are spectacular fluctuations in this average. Any number of periodical breakdowns of the figures is possible over a sixty-eight year span. Considering the years 1889-1957 with three wars, several booms and several serious recessions, and all the intermediate influencing

***Kendrick*[1]**

AVERAGE ANNUAL PERCENTAGE CHANGE IN PRODUCTIVITY FOR THE PRIVATE ECONOMY

| | *1889-1957* | *1889-1919* | *1919-1957* |
|---|---|---|---|
| Output Per Unit of Total Factor Input | 1.7% | 1.3% | 2.1% |
| Output Per Unit of Labor Input | 2.0 | 1.6 | 2.3 |
| Output Per Unit of Weighted Tangible Capital | 1.0 | 0.5 | 1.3 |

[1] Source: See Table 8, page 27.

***Bureau of Labor Statistics*[2]**

AVERAGE ANNUAL PERCENT CHANGE IN REAL PRODUCT PER MAN-HOUR

1909 - 1957

| | *BLS (Man-Hours Paid)* | *Census (Man-Hours Worked)* |
|---|---|---|
| Total Private Economy | 2.3% | 2.4% |
| Agriculture | 2.1 | 2.1 |
| Non-agriculture | 2.0 | 2.1 |

[2] Source: See Table 4, page 22.

factors on our growth, the 1.7 percent average annual increase in total productivity is a fair norm. The big question in everyone's mind is whether this rate is adequate to maintain the rate of improvement in living standards which the economy has thus far achieved and hopes to continue to improve in the future. The answer cannot be found only in the rates of productivity. Numerous other factors affect our economic growth. Furthermore, productivity is a record of past achievements or reversals and while it is inherent in any economic system to endeavor to increase productivity, the desired results are not always forthcoming. Compared to other nations, our economy has grown enormously in the past sixty-eight years. During this period Kendrick estimates that the average annual productivity improvement has been 1.7 percent. To maintain and improve on this productivity record we must promote the conditions that advance productivity and resist the deterrents to increased productivity which are described in Section II of this paper.

### *General Conclusions*

The Bureau of Labor Statistics estimates of an average annual increase of 2.3 percent over the last fifty years and Kendrick's estimate of an average annual increase of 1.7 percent over the last sixty-eight years are amazingly close when we consider the difference in the measuring techniques. The average increase of the two estimates is about 2.0 percent annually.

Both estimates ascertain the fact that the average annual rate of productivity increase in the post World War II period has been greater than the average rate of increase over the last half century. However, it is possible to point out other selected short-term periods in the last half century where the average increase in productivity rates exceeded the norm for the entire period. A closer examination of the post World War II rates of increase for the private economy reveals that the extraordinary gains achieved in the agricultural sector were responsible for the acceleration during this twelve-year period. The non-agricultural sector maintained an average annual increase of about 2.5 percent (based on man-hours paid) in the post World War II period which is only slightly above the average for the past fifty years. Since these estimates are based on an index, it is quite possible to show with selected base periods that there has been an acceleration of growth rates in recent years. An objective analysis of the productivity record does not substantiate these findings. Mr. George Hitchings recently commented on these claims of accelerated productivity growth rates.

> "Over the past fifty years there is no definitely discernible acceleration in growth rate for output per man-hour, exclusive of agriculture. Output for the private non-farm economy has increased at an average of about 3% a year over the period as a whole and total man-hours at about 1%. As a result, output per man-hour has increased about 2%. . . . In recent years, the rate has averaged close to the long run trend."[1]

The fluctuations above and below the average annual productivity growth rate are not yet fully explainable. While it is often possible to cite one or even a few economic factors that might very well have caused these fluctuations, no one has as yet been able to fully explain the absolute cause or causes of these fluctuations. The allocation of resources to the most efficient use is not an exacting science as it is always subject to unknown and/or unexpected economic reactions. However, both measures indicate that our economic advancement thus far has been accompanied by an average annual growth in productivity of about 2.0 percent.

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[1] *Prerequisites for Economic Growth,* National Industrial Conference Board, 1959, p. 43. At the time Mr. Hitchings made this statement (1959) he was Manager of the Economic Analysis Department of the Ford Motor Company. He is presently a Vice-President of American Airlines.

IV

# RECIPIENTS OF PRODUCTIVITY INCREASES

Changes in productivity as reflected in the measures already discussed or the other existing productivity measures are a record of economic progress. Due to the shortcomings already pointed out in the prior analyses, we cannot label existing productivity measures as precise gauges of changes in productivity. Still we can use these existing measures to get a general picture of productivity changes and trends. As the techniques for measuring productivity are refined and expanded we can look forward to more accurate measures of annual productivity changes. For the present we do have a good tool which is reliable in a general analysis of the relationship between productivity and the other factors which affect our economic welfare.

The fruits of increased productivity accrue to the workers, the owners, and the consumers. Actually these gains have been shared by these three groups over the last century *but* they have not been shared equally in any given time period. It is quite possible to select specific periods when the owners received a greater share of productivity increase in the form of a higher return on investment while wages and prices remained constant or actually declined. Again it is possible to point out other eras where consumers benefited from productivity increases through lower prices while the owners and workers failed to receive comparable increases in compensation. In other eras, such as the Post-World War II period, labor received most of the benefits of productivity increases at the expense of the consumers and the owners.[1]

Just as there are numerous input factors which provide for changes in productivity, there are numerous other factors aside from productivity which influence the share of production which accrues to labor, capital, or consumers. It has already been shown that it is impossible to assign the cause of increases in productivity to any one input factor. This being the case, it is impossible to divide up the benefits of productivity among labor, capital, and consumers based on the relative weight of their contribution to the increased productivity. If a measure did exist which could definitely establish the fact that each particular input was directly responsible for a specific productivity increase, natural market factors would probably prevent the assignment of the productivity increase benefits to the responsible input factor. On the positive side, these same market forces are responsible for the distribution of productivity gains to the owners, the workers, and the consumers. The point is that while free market forces tend to allocate these benefits, at the same time they also control the distribution of productivity increase benefits. For example, while most productivity gains can be attributed generally to new technologies and innovations, competitive market forces will force management to share the benefits of the productivity gains. If workers, by an exertion of monopoly power, demand all the benefits of productivity increases and more, with the resulting cost-push on prices and squeeze on profits, corrective action will follow through the forces which operate in the *free* market.

However, there are other factors aside from productivity which influence the operation of the free market. Supply, demand, taxes, inflation, controls, money supply, cost of living, etc., all influence the actions and reactions in the market place. Therefore, while productivity increase is important, it is impossible to isolate for the purpose of allocating the productivity benefits to any particular group which is responsible for the increases. On the other hand, the benefits of productivity increases must go to one or all the sectors for the simple reason that they must go somewhere.

The competitive forces of the free market are the best media for allocating these benefits as they take into account all the existing economic conditions including the productivity increases.

[1] "It is equally clear that in the middle years of the period (1947-58) nonlabor factors were getting some benefit from productivity gains, while in recent years real compensation has run ahead of productivity." Ewan Clague, Commissioner of Labor Statistics, Speech before the American Marketing Association — American Farm Economic Association, Dec. 30, 1959.

V

# PRODUCTIVITY AND THE FUTURE

If we recall the original definition of productivity — a measure of the efficiency with which resources are converted to the goods and services we consume — we can see that a correct understanding and use of the existing measures can further labor-management cooperation in fostering economic growth.

As individuals, productivity has a direct bearing on our living standards. As workers, productivity has a direct bearing on the compensation we receive and as citizens, productivity is a factor in our ability to compete internationally and maintain our national strength. While this nation is blessed with an abundance of raw materials which contribute to its economic welfare, we know that other nations, some of which are dedicated to our extinction, have an equal amount or more of natural resources. The difference between our living standards and our ability to defend ourselves is the efficiency with which we use the available resources. The importance of productivity in maintaining and increasing the lead we presently enjoy intensifies each year. This importance is pointedly evident in the following conclusions reached by Solomon Fabricant[1] in his paper on the productivity record since 1889:

"Each year's increase in productivity accounted, on the average, for about half of the year's increase in product. The other half reflected, of course, increase in resources — labor and tangible capital.

"Productivity increase accounted for a larger fraction — about nine-tenths — of each year's increase in per capita product, with the rise in per capita resources contributing the other tenth.

"Prior to World War I, both per capita resources and productivity grew significantly, and thus both contributed to the rise in per capita product. Since World War I, per capita resources have fallen slightly, but productivity has risen even more rapidly than before — rapidly enough, in fact, to keep per capita product growing at an average rate not far below the rate for the earlier period."

Under the free market system we can expect further productivity increases. The size of these increases will be dependent upon the technological advances and innovations which we achieve. The actual rate of achievement is dependent upon the profit motives open to American business. This incentive, to earn a fair profit, is the driving force which compels American business to produce better products more efficiently and cheaper, with the resulting higher living standards for the entire nation.

[1] *Basic Facts on Productivity Change,* Solomon Fabricant, National Bureau of Economic Research, Occasional Paper #63, p. 18.

# APPENDIX

## Bureau of Labor Statistics Estimates

Probably the most widely used of all the productivity estimates is the series developed by the Bureau of Labor Statistics of the U. S. Department of Labor. The BLS computes the productivity performance of the entire private economy, breaking it down between the agricultural and non-agricultural sectors. The non-agricultural sector is further broken down between manufacturing and non-manufacturing industrial divisions.

The BLS measures productivity in terms of output per unit of labor input (man-hours). This is perhaps the most readily understandable method of measuring productivity, i.e., output divided by man-hours of labor input. With only two factors, output and labor input, it is possible to quickly comprehend any change in productivity as a result of a change in either the output factor or the input factor. In essence, the mathematical procedure is simply dividing output by input so any change in the dividend (output) or divisor (input) and its effect on the quotient (in this case productivity) is readily discernible. Here we are not discussing the cause for the changes that may occur in the input or output factors, but merely the effect on productivity that such statistical changes will cause.

If we recall the productivity concept we remember that labor is only one of the resources that is used up in production. In using the BLS estimate of labor productivity there is often a tendency to forget the other inputs and assign the credit for productivity increases solely to the labor input factor. The BLS has pointed out this danger in each of its reports by emphasizing the fact that in restricting the input factor to labor it does not wish to infer that labor is the only contributor to productivity changes. The intent of the BLS in publishing these estimates is to provide a measure of productivity change; not attribute the cause of the change in productivity to any specific input factor.

### *Methodology*

The BLS uses the Gross National Product as a measure of output. Since it is expressed in dollars the GNP represents a homogenization of the total output of the economy. We have already noted that the output of government employees cannot be satisfactorily measured since this output is not valued by the forces which operate in the market place. Therefore, the sector of the GNP representing the output of government — Compensation of Government Employees — is subtracted from the GNP to give us a private GNP or an output value for the private economy.

In order to eliminate the effects of inflation on the value of the GNP, it is converted to constant dollars. The BLS uses the year 1954 to establish the price deflators for conversion to constant dollars. This is the same year used by the Department of Commerce as a base for its price deflators. With the effect of inflation eliminated, the output estimate, private GNP in constant dollars, will more accurately reflect changes in physical volume of production, the optimum measure of output. Since output expressed in physical units of output is statistically impossible to homogenize for the whole economy, the private GNP expressed in constant dollars is the next best measure of total private output.

There are some qualifications which the reader should be aware of when he examines output estimates based on the private GNP, especially if comparisons are made over a period of years. One drawback of this measure is that it does not necessarily represent changes in the quality of output. There is a good possibility that competition will keep the price of the better product in the price range of the inferior product with which it competes. In this GNP estimate it is not statistically possible to compensate for quality changes.

Another limitation of the use of private GNP as a measure of output is that in any given year the real value of research and development projects may not be reflected in the private GNP. Research and development is a continuing process, but the value of output may not be known for a number of years. In the long run, the results are reflected in productivity, but they may show up in one year or a number of years. Meanwhile, the labor input for research and development projects continues over the entire period.

The input factor in the BLS productivity estimates is man-hours of labor and two sets of man-hour measures are employed. One series, developed by the BLS, contains all the man-hours for which workers are paid. In this series the total man-hours consists of all the hours worked plus the hours for which the workers are paid, but actually do not work. The latter includes paid holidays, paid vacations and paid sick leave.

The alternate man-hours worked estimate is prepared by the Bureau of the Census and consist of only the man-hours actually spent on the job. Naturally the total man-hours worked will be a lower figure than the total man-hours paid. Each estimate has certain other refinements and limitations in coverage. However, these differences are not too consequential when we employ these estimates as labor input so they will not be discussed here.

The principal reason for using the two estimates is to provide a check on the labor input. Once the difference between the two estimates is understood, it is possible to check whether the trend indicated by one estimate is in line with the trend of the other estimate. Where one man-hours estimate might be weak in coverage the other might be adequate and vice versa. We are interested in a productivity estimate for the entire economy and the compensating features of each man-hours estimate gives us a good check on the over-all labor input estimate.

Naturally, the two different input estimates gives us different productivity estimates. The productivity formula is output divided by input. If we use the BLS man-hours paid estimate the divisor (labor input) is larger and the quotient (productivity) will be smaller than if we divided by the Census Bureau man-hours worked estimate. Annual estimates of productivity based on man-hours worked (Census) are always higher than productivity estimates based on man-hours paid (BLS). See Table 1.

There are other indexes of labor input which could be employed. The BLS has developed a productivity series which uses a labor input estimate of production workers only. For the present, we are looking at the total economy and the total man-hours estimate is sufficient for our purposes.

Like the private GNP output estimate, the man-hours input estimate lacks refinement where quality is concerned. All man-hour estimates in the BLS productivity consider the contribution of each employee to production as equal. The night watchman is regarded as making the same contribution towards the end-product as the engineer or skilled machinist.

The man-hours paid estimate (BLS) is broken down between the agricultural and the non-agricultural sectors. The non-agricultural sector is further broken down between manufacturing and non-manufacturing industries. On the other hand, the man-hours worked estimate (Census Bureau) is simply broken down between the agricultural and the non-agricultural sectors. See Table 1.

The productivity estimates illustrated in Table 1 are simply the private GNP in constant dollars divided by the total man-hours worked in each year. In this simple application of the productivity formula based on labor input certain facts stand out. Over the twelve-year period the agricultural sector has recorded the largest gains in productivity of any of the industrial sectors. An examination of the statistics used in the compilation of Table 1 shows that while the agricultural sector has steadily increased its output, the principal reason for the large productivity gain is due to a sizeable reduction (almost 40 percent) in the man-hours of input. Another trend par-

**Table 1**

OUTPUT PER MAN-HOUR FOR THE PRIVATE ECONOMY

| | *BLS Man-Hours Paid* | | | | | *CENSUS Man-Hours Worked* | | |
|---|---|---|---|---|---|---|---|---|
| | *Total* | *Agriculture* | *Non-Agriculture* | | | *Total* | *Agriculture* | *Non-Agriculture* |
| | | | *Total* | *Mfg.* | *Non-Mfg.* | | | |
| 1947 | $2.11 | $ .76 | $2.41 | $2.65 | $2.30 | $2.22 | $ .78 | $2.55 |
| 1948 | 2.19 | .90 | 2.46 | 2.72 | 2.34 | 2.29 | .93 | 2.58 |
| 1949 | 2.25 | .86 | 2.55 | 2.79 | 2.45 | 2.34 | .88 | 2.66 |
| 1950 | 2.41 | .97 | 2.69 | 2.97 | 2.56 | 2.52 | 1.00 | 2.82 |
| 1951 | 2.47 | .96 | 2.74 | 3.02 | 2.60 | 2.63 | .99 | 2.93 |
| 1952 | 2.52 | 1.04 | 2.77 | 3.07 | 2.63 | 2.71 | 1.07 | 3.00 |
| 1953 | 2.63 | 1.16 | 2.85 | 3.22 | 2.67 | 2.83 | 1.19 | 3.09 |
| 1954 | 2.67 | 1.24 | 2.89 | 3.19 | 2.76 | 2.90 | 1.28 | 3.16 |
| 1955 | 2.79 | 1.28 | 3.02 | 3.41 | 2.83 | 3.04 | 1.32 | 3.31 |
| 1956 | 2.80 | 1.31 | 3.01 | 3.45 | 2.80 | 3.05 | 1.35 | 3.30 |
| 1957 | 2.90 | 1.40 | 3.09 | 3.47 | 2.92 | 3.15 | 1.44 | 3.38 |
| 1958 | 2.95 | 1.58 | 3.18 | (a) | (a) | 3.18 | 1.64 | 3.38 |

(a) Not available.

SOURCE: *Trends in Output Per Man-Hour For The Private Economy*, 1909-1958, BLS, U. S. Department of Labor, December 1959, Table A-1, p. A-19; Table A-2, p. A-22.

ticular to the agricultural sector is the tendency for productivity to show a continuous increase. Except for the years 1949 and 1951, the agricultural productivity record has been one of uninterrupted steady increases with no indication of a leveling off period. Even so, the latest dollar value of output per man-hour is only about half of the non-agricultural sector. (Table 1)

The non-agricultural sector on the other hand has had a more erratic productivity record. Of course, we must remember that the non-agricultural sector has an output about 17 times as large as agriculture and employs almost 10 times as many man-hours as agriculture. As a result the non-agricultural sector is not subject to the more radical changes which take place in the agricultural sector. The heavier weight of the non-agricultural sector is also evidenced in the more stabilizing effect it has on the total productivity estimates. Between 1947-1958 the total output of the non-agricultural sector has increased almost 42 percent and the total man-hours input has increased almost 10 percent.

In the output per man-hour estimate, which shows a breakdown between manufacturing and non-manufacturing, there is also a divergence between the amount of annual change. The non-manufacturing productivity trend shows a more constant and continuous improval — somewhat similar to the output per man-hour trend experienced in agriculture, although not as spectacular. On the other hand, the manufacturing output per man-hour trend is more dynamic in year-to-year changes.

The statistical explanation behind the trend differentials between manufacturing and non-manufacturing reflect a change in the make-up of our economy. Between 1947 and 1957 non-manufacturing industries increased their output from $156 billion to $231 billion and man-hours of input increased from 68 billion man-hours to 79 billion man-hours. During the same period manufacturing increased its output from $86 billion to $122 billion, but the input of man-hours only increased from 32 billion man-hours to 35 billion man-hours.

The trends are more easily visualized on Charts B and C. These charts are based on indexes which were developed from Table 2. The indexes in Table 2 are based on the output per hour estimates of Table 1, with the years 1947-1949 as the base years. Whenever indexes are used there is an inherent problem connected with the selection of base years. Undoubtedly the selection of the base years 1947-1949 was influenced by the fact that it was more or less a period of normal production. Reconversion was completed and the 1950 Korean War boom had not begun as yet.

Chart A shows the real product per man-hour for the private economy based on a man-hours-worked concept

**Table 2**

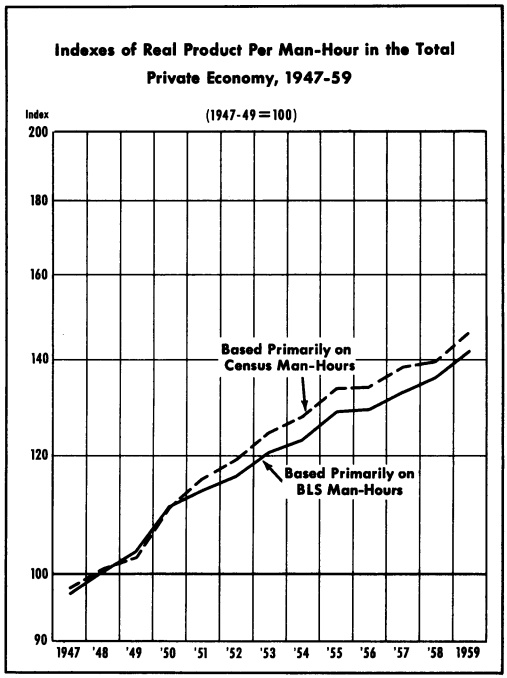
INDEXES OF OUTPUT PER MAN-HOUR FOR THE PRIVATE ECONOMY
(1947-49 = 100)

| | *BLS* *Man-Hours Paid* | | | | | *CENSUS* *Man-Hours Worked* | | |
|---|---|---|---|---|---|---|---|---|
| | *Total* | *Agriculture* | *Non-Agriculture* | | | *Total* | *Agriculture* | *Non-Agriculture* |
| | | | *Total* | *Mfg.* | *Non-Mfg.* | | | |
| 1947 | 96.7 | 90.5 | 97.5 | 97.6 | 97.3 | 97.4 | 90.6 | 98.4 |
| 1948 | 100.2 | 107.1 | 99.4 | 100.1 | 98.9 | 100.3 | 107.5 | 99.4 |
| 1949 | 103.1 | 102.1 | 103.3 | 102.6 | 103.9 | 102.2 | 101.6 | 102.4 |
| 1950 | 110.4 | 116.2 | 108.8 | 109.5 | 108.4 | 110.3 | 116.1 | 108.5 |
| 1951 | 113.2 | 114.5 | 110.6 | 111.2 | 110.0 | 115.2 | 114.1 | 112.8 |
| 1952 | 115.7 | 124.5 | 112.0 | 113.0 | 111.3 | 118.9 | 124.0 | 115.5 |
| 1953 | 120.4 | 138.6 | 115.1 | 118.3 | 112.8 | 123.9 | 138.0 | 119.0 |
| 1954 | 122.6 | 148.3 | 116.9 | 117.4 | 116.7 | 127.0 | 147.9 | 121.8 |
| 1955 | 128.0 | 153.5 | 121.9 | 125.6 | 120.0 | 133.1 | 152.9 | 127.5 |
| 1956 | 128.8 | 156.4 | 121.5 | 127.1 | 118.7 | 133.6 | 155.8 | 127.2 |
| 1957 | 132.8 | 166.7 | 124.9 | 127.7 | 123.8 | 137.9 | 167.0 | 130.1 |
| 1958 | 135.4 | 188.6 | 126.3 | (a) | (a) | 139.1 | 189.2 | 130.1 |
| 1959 | 141.3 | 189.9 | 131.9 | (a) | (a) | 145.0 | 190.2 | 135.6 |

(a) Not available.

SOURCE: *Trends in Output Per Man-Hour For The Private Economy*, 1909-1958, BLS, U. S. Department of Labor, August 10, 1959, Table 1, p. 5 and Table 2, p. 6, and U. S. Dept. of Labor Press Release 4155, dated June 28, 1960.

CHART A



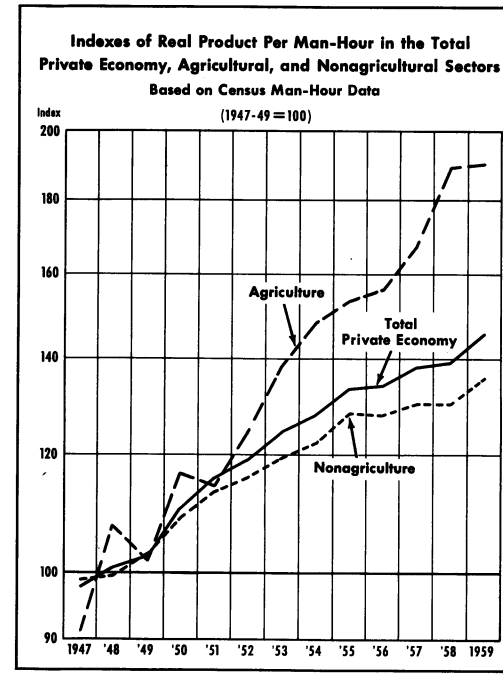

SOURCE: TRENDS IN OUTPUT PER MAN-HOUR IN THE PRIVATE ECONOMY, 1909-1958 PAGE 8, U.S. DEPT. OF LABOR, DEC. 1959

(Census) and man-hours-paid concept (BLS). Both indexes show similar trends although the man-hours-worked trend-line rises somewhat faster. The man-hours-paid productivity trend did not increase as fast because of the increase in the number of days of paid vacations, holidays, and sick leave. The largest single year increase occurred in 1950 and amounted to approximately 9 percent. On the other hand, the increase in 1958 was very modest. Over the entire period 1947-1958, the average annual productivity increase amounted to about 3.1 percent based on the man-hours paid (BLS) labor input and 3.5 percent when calculated on the man-hours worked input (Census). Perhaps the most significant lesson that can be learned from this chart is that year-to-year changes vary and there is no way possible to predict any specific trend from the results of a one to two-year change in trends. Annual changes are sometimes erratic and the variation from the average increase for a long period can be quite substantial in any given year. The year 1950 is an example of a very sudden change which did not materialize into a continuous trend.

Chart B shows the indexes for real product per man-hour in the private economy broken down between agriculture and non-agriculture. The labor input in these indexes is derived from the man-hours-worked concept of the Census Bureau. The first thing that stands out is the productivity record achieved in agriculture which amounted to a phenominal annual average increase of 6.4 percent. Non-agriculture, although its record was not as spectacular as agriculture, showed an improving trend for the period. Its average annual increase amounted to 2.8 percent a year. The heavy weight of the non-agricultural sector in the productivity trend of the total private economy is illustrated by the similarity of the non-agricultural trend-line and the trend-line for the total economy. Between 1947-1958 the average annual increase of the total private economy amounted to 3.5 percent based on man-hours worked.

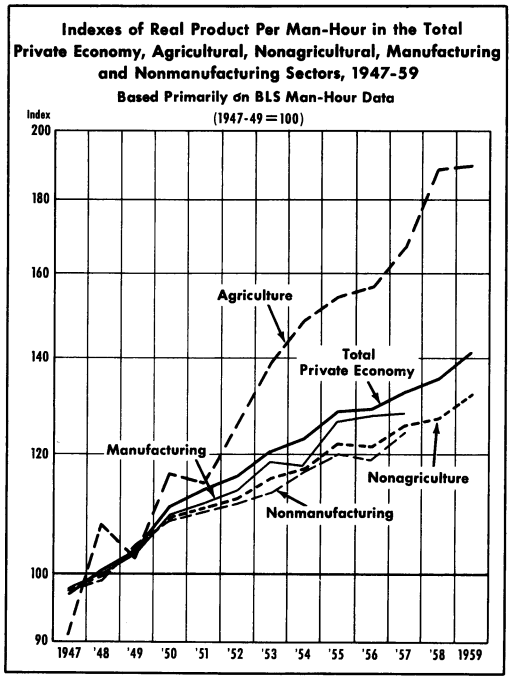
Chart C shows the indexes of real output per man-hour in the private economy broken down between agriculture and non-agriculture for the years 1947 through 1958. The non-agriculture sector is further broken down between manufacturing and non-manufacturing for the years 1947 through 1957 as the 1958 figures are not yet available. The labor input estimates used in these indexes are based on the man-hours-paid tables published by the Bureau of Labor Statistics. As in Chart B, the

CHART B




SOURCE: TRENDS IN OUTPUT PER MAN-HOUR IN THE PRIVATE ECONOMY, 1909-1958 PAGE 11, U.S. DEPT. OF LABOR, DEC. 1959

CHART C




SOURCE: TRENDS IN OUTPUT PER MAN-HOUR IN THE PRIVATE ECONOMY, 1909-1958 PAGE 10, U.S. DEPT. OF LABOR, DEC. 1959

agricultural trend line in Chart C also shows enormous productivity increases. Percentage-wise the average annual increase in agriculture is the same with the BLS or the Census Bureau labor inputs — 6.4 percent. Further examination of Chart C reveals that in the non-agriculture sector breakdown between manufacturing and non-manufacturing, the manufacturing productivity trend ran higher than the non-agricultural trend-line. On the other hand the non-manufacturing productivity trend-line ran slightly below the non-agricultural trend-line, but over the 1947-1957 period it more closely adhered to the non-agricultural trend, while the manufacturing sector's record showed periods of more radical increases and decreases. The average annual percent changes for each sector included in Table 2 are as follows:

| | | |
|---|---|---|
| Total Private Economy | (1947-1959) | 3.2% |
| Agriculture | (1947-1959) | 6.4% |
| Non-agriculture | (1947-1959) | 2.5% |
| Non-agriculture | (1947-1957) | 2.5% |
| Manufacturing | (1947-1957) | 2.9% |
| Non-manufacturing | (1947-1957) | 2.3% |

### *Long-Term Productivity Trends*

As has already been emphasized, it is impossible to read any significance into the year-to-year changes in productivity trends. If we recall the 1947-1958 trends it was quite evident that in certain years, such as 1950, there was an almost 9 percent increase and in other years there was an actual decrease in certain productivity sectors. Manufacturing productivity appears especially subject to annual trend reversals. The year 1950, which experienced unusual gains in productivity was a year of large expansion in all phases of the economy as a result of the Korean War. However, all competent students of productivity measures are very emphatic about the danger of interpreting short-term productivity changes as indications of long-term trends.

The Bureau of Labor Statistics has published productivity statistics for the years 1909-1958 inclusive. They appear in Table 3. In making up this table, the Bureau used unpublished data developed by John W. Kendrick for the years 1909 through 1946. For the years 1947 through 1958, the statistics developed in Tables 1 and 2 were used.

Table 3 contains output per man-hour estimates for the private economy broken down between the agricultural and non-agricultural sectors. Each of the above divisions is calculated on a man-hours paid (BLS) labor input factor and a man-hours worked (Census Bureau) labor input factor.

As it is rather difficult to mentally picture the trends based on figures in Table 3, the information is transposed to graph form in Chart D. For the sake of space only the productivity trends based on man-hours worked (Census Bureau) are charted. As we are concerned with long-term productivity growth the use of one labor input concept in favor of another labor input concept is not significant. There was only one-tenth of 1 percent difference in the average annual rates of increase for the total private economy between the labor input concepts over the 1909-1959 period. The average annual percent increase for the total economy over the entire period 1909-1959 amounted to 2.3 percent based on the man-hours paid (BLS) labor input and 2.4 percent based on the man-hours worked labor input (Census Bureau).

There are numerous interpretations which could be drawn from Chart D. It is possible to divide the 50-year trend in various cycles, based on specific time periods, war and non-war years, or expansion and recession years. This discussion will be restricted to the general trend over the entire period. As already noted above, the average annual increase in the productivity of the total private economy amounted to 2.4 percent based on man-hours worked (Census). During the last half of the 50-year period, the trend line indicates that the erratic reversals in the trend line which occurred in the period 1909

## Table 3

### REAL PRODUCT PER MAN-HOUR IN THE PRIVATE ECONOMY, AGRICULTURAL AND NON-AGRICULTURAL SECTORS, 1909-1959
(1947-49 = 100)

| | *BLS*[1] | | | *CENSUS*[2] | | |
|---|---|---|---|---|---|---|
| | *Total Private* | *Agriculture* | *Non-Agriculture* | *Total Private* | *Agriculture* | *Non-Agriculture* |
| 1909 | 47.6 | 58.2 | 51.6 | 47.8 | 58.6 | 52.0 |
| 1910 | 47.6 | 59.2 | 51.1 | 47.7 | 59.4 | 51.4 |
| 1911 | 47.9 | 55.9 | 51.8 | 48.0 | 56.2 | 52.2 |
| 1912 | 49.2 | 62.8 | 52.3 | 49.5 | 63.2 | 52.7 |
| 1913 | 49.3 | 57.1 | 53.0 | 49.5 | 57.3 | 53.4 |
| 1914 | 47.7 | 59.8 | 51.4 | 48.0 | 60.2 | 51.8 |
| 1915 | 47.8 | 64.7 | 50.6 | 47.9 | 65.1 | 50.9 |
| 1916 | 48.2 | 59.4 | 50.9 | 48.5 | 59.6 | 51.3 |
| 1917 | 46.7 | 61.6 | 48.9 | 46.9 | 61.9 | 49.2 |
| 1918 | 48.7 | 59.0 | 51.8 | 48.9 | 59.4 | 52.2 |
| 1919 | 52.4 | 60.4 | 56.3 | 52.5 | 60.8 | 56.7 |
| 1920 | 49.9 | 59.0 | 53.6 | 50.2 | 59.4 | 54.0 |
| 1921 | 50.5 | 58.1 | 54.8 | 50.7 | 58.4 | 55.1 |
| 1922 | 55.2 | 60.6 | 59.7 | 55.4 | 61.0 | 60.2 |
| 1923 | 57.8 | 63.5 | 61.3 | 58.1 | 63.9 | 61.8 |
| 1924 | 58.9 | 60.4 | 63.6 | 59.2 | 60.8 | 64.2 |
| 1925 | 61.9 | 63.1 | 66.7 | 62.1 | 63.5 | 67.2 |
| 1926 | 63.3 | 61.4 | 68.1 | 63.5 | 61.7 | 68.5 |
| 1927 | 63.5 | 66.8 | 67.3 | 63.8 | 67.1 | 67.7 |
| 1928 | 63.3 | 63.0 | 67.5 | 63.7 | 63.5 | 68.0 |
| 1929 | 65.8 | 66.9 | 69.8 | 66.2 | 67.4 | 70.2 |
| 1930 | 63.2 | 61.9 | 68.1 | 63.5 | 62.3 | 68.6 |
| 1931 | 63.5 | 70.6 | 69.2 | 63.7 | 70.8 | 69.7 |
| 1932 | 60.1 | 68.9 | 66.7 | 60.3 | 69.5 | 67.2 |
| 1933 | 58.5 | 68.0 | 64.8 | 58.6 | 68.2 | 65.4 |
| 1934 | 64.8 | 62.7 | 72.0 | 65.3 | 63.1 | 72.6 |
| 1935 | 68.3 | 73.7 | 74.5 | 68.6 | 74.2 | 75.0 |
| 1936 | 71.9 | 64.7 | 78.1 | 72.2 | 65.1 | 78.7 |
| 1937 | 72.5 | 75.0 | 77.9 | 72.9 | 75.3 | 78.5 |
| 1938 | 74.7 | 81.3 | 79.9 | 75.0 | 81.6 | 80.5 |
| 1939 | 77.6 | 81.0 | 82.6 | 78.0 | 81.2 | 83.2 |
| 1940 | 81.3 | 80.3 | 86.1 | 81.8 | 80.8 | 86.8 |
| 1941 | 85.9 | 87.9 | 88.9 | 86.5 | 88.6 | 89.5 |
| 1942 | 86.7 | 91.8 | 88.9 | 87.3 | 92.4 | 89.6 |
| 1943 | 88.0 | 85.6 | 90.2 | 88.5 | 85.8 | 90.7 |
| 1944 | 94.0 | 88.1 | 96.7 | 94.7 | 88.7 | 97.4 |
| 1945 | 98.5 | 89.2 | 101.3 | 99.0 | 89.3 | 101.9 |
| 1946 | 96.0 | 93.8 | 97.5 | 96.6 | 94.4 | 98.2 |
| 1947 | 96.7 | 90.5 | 97.5 | 97.4 | 90.6 | 98.4 |
| 1948 | 100.2 | 107.1 | 99.4 | 100.3 | 107.5 | 99.4 |
| 1949 | 103.1 | 102.2 | 103.3 | 102.2 | 101.6 | 102.4 |
| 1950 | 110.4 | 116.2 | 108.8 | 110.3 | 116.1 | 108.5 |
| 1951 | 113.2 | 114.5 | 110.6 | 115.2 | 114.1 | 112.8 |
| 1952 | 115.7 | 124.5 | 112.0 | 118.9 | 124.0 | 115.5 |
| 1953 | 120.4 | 138.6 | 115.1 | 123.9 | 138.0 | 119.0 |
| 1954 | 122.6 | 148.3 | 116.9 | 127.0 | 147.9 | 121.8 |
| 1955 | 128.0 | 153.5 | 121.9 | 133.1 | 152.9 | 127.5 |
| 1956 | 128.3 | 156.4 | 121.5 | 133.6 | 155.8 | 127.2 |
| 1957 | 132.8 | 166.7 | 124.9 | 137.9 | 167.0 | 130.1 |
| 1958 | 135.4 | 188.6 | 126.3 | 139.1 | 189.2 | 130.1 |
| 1959 | 141.3 | 189.9 | 131.9 | 145.0 | 190.2 | 135.6 |

[1] Output per man-hour series based on real product data from Office of Business Economics, Department of Commerce, and unpublished man-hours data prepared by John W. Kendrick linked in 1947 to BLS man-hours.

[2] Output per man-hour series based on real product data from the Office of Business Economics, Department of Commerce, and unpublished man-hours data prepared by John W. Kendrick, linked in 1947 to Census man-hours.

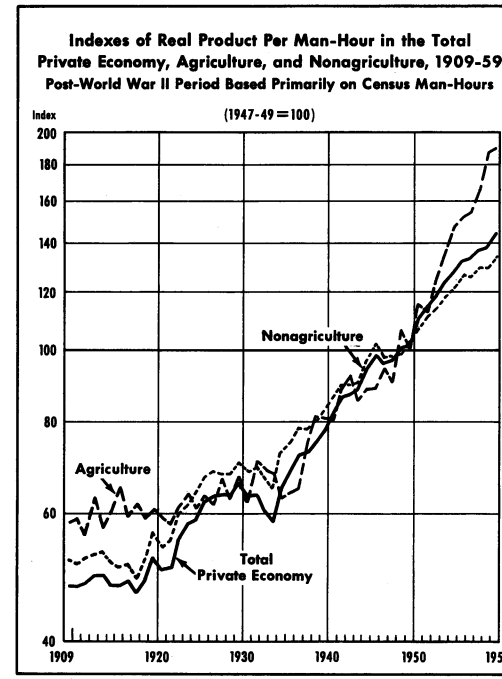
SOURCE: *Trends in Output Per Man-Hour In The Private Economy*, 1909-1958, U. S. Department of Labor, December 1959, p. 17 and U. S. Department of Labor Press Release 4155, June 28, 1960.

to roughly 1933 have been largely eliminated. Since 1933 this trend line climbs at a rather straight rate. At least the deep dips which occurred in 1919 and 1929 have not re-occurred in the last twenty-five years. There was a slight break in the trend after World War II, but it was rather mild and of short duration. The trend line in Chart D representing the total private economy is a reflection of the productivity trends of its component sectors — agriculture and non-agriculture.

Chart D also illustrates the productivity trend of the agricultural sector. As occurred in the 1947-1958 period, agricultural productivity increases far exceeded the productivity increases experienced in the non-agricultural sector for the entire period 1909-1959. Comparing the trend line of Chart D, for the total economy, we can see that the high productivity increase in agriculture had a strong influence on raising the productivity of the total economy. Over the entire period 1909-1959, output per man-hour in agriculture increased at an average annual rate of 2.1 percent. While the productivity trends for the total economy and for the non-agricultural sector more or less remain in a comfortable range of the annual average increase, the agricultural sector productivity trend veers quite a bit below, and quite a bit above, the average annual increase. From 1909 to about 1930 the average annual agricultural productivity increased at about 1.1 percent. Since 1930 the average annual increase in agriculture has been considerably in excess of the 2.1 percent average of the entire 1909-1959 period. In addition, and especially in the post World War II years, each annual increase has exceeded the increase of the previous year by a substantial margin. Just how long this trend will continue is impossible to estimate. In spite of the reduction of the agricultural labor force and the government's efforts to curb production, we continue to pile up huge farm surpluses.

Chart D also shows the indexes of real product per man-hour for the non-agricultural sector for the years 1909-1959. After examining the trend in agriculture, the first thing we notice about the trend in the non-agricultural sector is that the increase in output per man-hour is not as great over the entire 1909-1959 period in the non-agricultural sector as they were in the agricultural sector. Secondly, the non-agriculture trend line adheres to the trend line for the total private economy. Of course the heavy weight of the non-agricultural sector in the total private economy estimates partially explain the similarity of trends. Finally, the non-agricultural trend line does not veer away from the general trend of the total private economy for the entire period either too radically or too often. While the agricultural trend line was subject to almost annual reversals in trends (especially prior to 1933), the non-agricultural trend had experienced only three deep trend reversals over the fifty-year period. Even

CHART D




SOURCE: TRENDS IN OUTPUT PER MAN-HOUR IN THE PRIVATE ECONOMY, 1909-1958 PAGE 20, U.S. DEPT. OF LABOR, DEC. 1959

with these periodical differentials in trend lines, the average annual percent increase in real product per man-hour for the non-agricultural sector was 2.0 percent — about the same as the agricultural sector.

Over a fifty-year period, the effects of shifts in the labor force from lower output per man-hour jobs to higher output per man-hour jobs must be taken into consideration. A shift occurs whenever a man moves from one job to another and produces a higher value of output with the same amount of man-hours labor input or the same value of output with less man-hours of labor input. Shifts in the labor force are going on continuously not only from the agricultural to the non-agricultural sector, but within the non-agricultural sector itself.

To conclude this section on the productivity record for the period 1909-1959, a resume of the average annual percent changes for the entire fifty-year span appears in Table 4. It is also pertinent to repeat the sentiment of authorities in the productivity field that it is the long-term record that counts in helping evaluate our economic progress and that predictions based on short-term trends fail to provide the necessary data for a valid presentation of productivity information.

**Table 4**

AVERAGE ANNUAL PERCENT CHANGE IN REAL PRODUCT PER MAN-HOUR 1909-1959

| | *BLS (Man-Hours Paid)* | *CENSUS (Man-Hours Worked)* |
|---|---|---|
| Total Private Economy | 2.3% | 2.4% |
| Agriculture | 2.1 | 2.1 |
| Non-agriculture | 2.0 | 2.1 |

SOURCE: *Trends in Output per Man-Hour for The Private Economy 1909-1958*, U. S. Department of Labor, December 1959, Table 6, p. 21 and U. S. Department of Labor Press Release 4155, June 28, 1960.

## Kendrick Estimates

John W. Kendrick is one of the leading authorities on productivity measures. Working in collaboration with the National Bureau of Economic Research, Kendrick has prepared a study of productivity trends in the United States covering the years 1889 through 1957. As yet Kendrick's book, *Productivity Trends In The United States,* has not been published. The National Bureau of Economic Research has scheduled its publication later in 1960.

At present some of Kendrick's findings are available in the National Bureau's Occasional Paper Number 63. This treatise on productivity was prepared under the direction of Solomon Fabricant, Research Director of the National Bureau of Economic Research. We are indebted to both Kendrick and Fabricant for the productivity data which follow.

Before any analysis is made of Kendrick's findings, it is necessary that we look into the methodology used in arriving at these productivity estimates. Kendrick employs the same general methods as the Bureau of Labor Statistics, but he refines and expands the input data.

The Bureau of Labor Statistics arrived at its productivity estimates by dividing output (measured in constant dollars of Private Gross National Product) by a man-hours input (measured in both man-hours paid estimates (BLS) and man-hours worked estimates (Census).

Kendrick uses the same measure of output as the Bureau of Labor Statistics, i.e., Private Gross National Product in constant dollars. Kendrick does, however, use a different base year as a deflater in preparing his Private Gross National Product in constant dollars. In constant dollars the Gross National Product becomes "Gross Physical Output" to use a Kendrick term. This concept was explained in our discussion of output in the previous section.

As already noted, Kendrick refines and expands the input data. The refinement occurs in the man-hours input data and the expansion occurs in the addition to the input factor of man-hours, an input factor of tangible capital. If we recall our original definition of productivity it is a measure of the efficiency with which *all* three resources — labor, capital, and land — are used.

Actually the Kendrick measures of productivity are presented in three main categories — output per unit of labor input, output per unit of tangible capital input and output per unit of labor and capital input combined. The last measure is a measure which is more in line with the general definition of productivity since it includes "all" the resources. In this sense "all" means every resource that is capable of being measured in units which can be utilized in the input factor.

If we recall the discussion of labor input in the Bureau of Labor Statistics estimates it was pointed out that no provisions were made for the difference in the quality of work which one man-hour of labor produced. For example, in the BLS estimates the labor input in industries of higher skill and higher rates of pay is given the same weight as the labor input in the lower paying industries. To compensate for the difference in skills contributed by workers in different industries, Kendrick has weighted his man-hours (labor input) figure with the standard industry wage rates that employees received in the base year 1929. If one industry's wage rate is $1.50 per hour in the base year and another industry pays $3.00 per hour, the labor input of higher paid workers would be double that of the lower paid workers for one hour's work. While the purity of a rate of pay measure could be questioned in some specific instances, it is the best measure available to weight the contribution of workers. Some may argue that there are numerous factors which influence pay rates aside from the actual contribution of labor to a specific job. If we recall that we are dealing with the entire labor force in the private economy the pay rate weight is a pretty valid measure of labor's input in the productive process. When dealing with the entire private labor force it is probable that the number of over-paid jobs will wash out the number of under-paid jobs in the national average.

The labor input estimates developed by Kendrick are based on man-hours worked. Before World War II there was little difference between the man-hours worked figures and the man-hours paid figures since paid vacations, sick leave, etc., were not very common. Therefore, Kendrick uses the Bureau of Labor Statistics estimates through the year 1946 for his man-hours estimates. Starting in 1947, Kendrick switched to the man-hours estimate of the Census Bureau (man-hours worked) for consistency. In addition Kendrick also assumes that non-production

workers put in the same number of man-hours as production workers. No estimates are available for the hours of supervisory employees.

In weighting the man-hours by pay rates, all pay is included. Thus, as it is stated, the weight contains all fringe benefits in addition to the basic hourly wage rate.

Table 5 shows the output per weighted man-hour for the private domestic economy for the years 1889 through 1957 as developed by Kendrick. The information contained in Table 5 appears in chart form in Chart E. Over the entire seventy-year span, the average annual rate of increase in the physical output per weighted man-hour came to 2.0 percent. Chart E shows that the increase in productivity per weighted man-hour has been quite steady with no prolonged reversal in the overall trend. Remembering that short period trends are meaningless, we can depict two distinct periods of growth in Chart E. The trend line does show a slightly higher rate of increase after World War I. The higher growth rates achieved after 1919 is evidenced by the average annual rate of increase achieved during the two periods 1889-1919 and 1919-1957. During the former period the annual rate of increase in output per weighted man-hour averaged 1.6 percent,[1] and during the latter period it averaged 2.3 percent.[1] For the entire seventy years the productivity of labor as measured by Kendrick increased in proportion to the expansion of the economy. Another general observation which is evident in Chart E is that the few reversals which occurred in the general increasing labor productivity trend took place during periods of contraction in overall economic activity.

CHART E

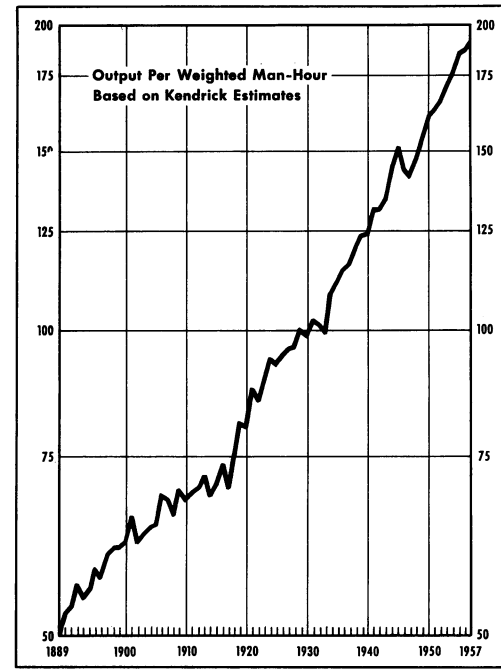



**Table 5**

OUTPUT PER WEIGHTED MAN-HOUR

(1929 = 100)

| | | | |
|---|---|---|---|
| 1889 | 50.0 | 1924 | 92.9 |
| 1890 | 52.4 | 1925 | 92.5 |
| 1891 | 53.2 | 1926 | 94.4 |
| 1892 | 56.0 | 1927 | 95.6 |
| 1893 | 54.1 | 1928 | 95.9 |
| 1894 | 55.3 | 1929 | 100.0 |
| 1895 | 57.7 | 1930 | 98.8 |
| 1896 | 56.3 | 1931 | 102.1 |
| 1897 | 60.0 | 1932 | 100.8 |
| 1898 | 60.9 | 1933 | 99.3 |
| 1899 | 61.0 | 1934 | 108.6 |
| 1900 | 61.7 | 1935 | 111.9 |
| 1901 | 65.2 | 1936 | 114.4 |
| 1902 | 61.9 | 1937 | 115.6 |
| 1903 | 62.9 | 1938 | 120.3 |
| 1904 | 63.5 | 1939 | 123.6 |
| 1905 | 64.2 | 1940 | 124.4 |
| 1906 | 68.5 | 1941 | 131.3 |
| 1907 | 68.0 | 1942 | 131.3 |
| 1908 | 65.6 | 1943 | 134.1 |
| 1909 | 69.6 | 1944 | 144.5 |
| 1910 | 67.7 | 1945 | 150.9 |
| 1911 | 69.0 | 1946 | 143.1 |
| 1912 | 69.7 | 1947 | 142.3 |
| 1913 | 71.8 | 1948 | 146.4 |
| 1914 | 67.9 | 1949 | 152.8 |
| 1915 | 70.2 | 1950 | 162.8 |
| 1916 | 73.7 | 1951 | 164.8 |
| 1917 | 69.5 | 1952 | 167.7 |
| 1918 | 75.0 | 1953 | 173.1 |
| 1919 | 80.4 | 1954 | 178.4 |
| 1920 | 79.6 | 1955 | 186.8 |
| 1921 | 86.8 | 1956 | 188.0 |
| 1922 | 84.9 | 1957 | 192.6 |
| 1923 | 88.2 | | |

SOURCE: *Productivity Trends In The United States,* John W. Kendrick, National Bureau of Economic Research (in preparation).

As already mentioned, Kendrick introduces a new item in productivity measurements by constructing an input factor for the tangible capital employed in production. The stock of tangible capital includes land, plants, equipment and inventories. Real capital input is measured in constant dollars weighted by base period rate of returns. We will examine Kendrick's estimate of real capital stocks and then examine the weighting procedure.

To obtain an estimate of real capital stocks Kendrick used estimates developed by Raymond W. Goldsmith.[2]

[1] *Basic Facts on Productivity Change,* Solomon Fabricant, National Bureau of Economic Research, Occasional Paper #63, 1959, Table 2, p. 11.

[2] *A Study of Saving in the United States,* Vol. I & III, Raymond W. Goldsmith, Princeton University Press, 1956.

The basic method was to take gross annual outlays for plant and equipment and deflate them to 1929 prices. The next step was to depreciate the estimate of real outlays by the straight-line method over the average length of life of the assets. These deflated and depreciated additions of tangible capital were then cumulated beginning with the year 1896. Since part of the existing tangible capital stock of 1896 was purchased prior to 1896 it was necessary to estimate capital outlays for a period prior to 1896 equal to the length of life of the longest lived item which was existing in 1896. By deflating the capital outlays, Goldsmith was able to apply to each new unit of plant and/or equipment the same base-period value in all periods. In this manner it is possible to measure output in terms of the physical volume of capital inputs of base-period efficiency. By depreciating the assets over their useful life, Kendrick makes the assumption that as assets age their contribution to output declines as the toll of age, breakdowns and obsolescence increases.

The result of the above procedure is that the depreciated value of existing stock and the value of new additions to capital stock in any given year represents what it would have cost in the base year to produce the amount of capital stock in the given year. This means the changes in quality of newer equipment are not reflected in the value given to the newer equipment, or in other words the technology of the base period for each item of capital stock prevailed in every other year covered in the estimate. Of course, the results of the increased efficiency will show up in output estimate and in the output-input ratio or measure of productivity.

The land value estimate was derived by applying a constant ratio of .39 to the estimates of real value of structures. This ratio existed in the base year of 1929 according to land-structure ratios developed by Goldsmith.[3] The value of inventories was also taken from Goldsmith's estimates.[3]

The deflation value of capital stock was next converted to an index with 1929 as the base year. The index of capital stock (1929 = 100) was next weighted by various rates of return on capital or capital compensation earned by the different industrial groups. Prior to 1929 the capital compensation rates for the industrial groups for key years were interpolated for the intervening years. Since 1929, capital compensation estimates were derived from the national income estimates of the Department of Commerce. This procedure is similar to the weighting of man-hours by the compensation paid in the various industrial classifications to obtain a labor input estimate.

The record of output per unit of weighted tangible capital as developed by Kendrick appears in Table 6,

**Table 6**

OUTPUT PER UNIT OF WEIGHTED TANGIBLE CAPITAL

(1929 = 100)

| | | | |
|---|---|---|---|
| 1889 | 74.8 | 1924 | 95.3 |
| 1890 | 77.8 | 1925 | 96.4 |
| 1891 | 77.1 | 1926 | 99.2 |
| 1892 | 79.6 | 1927 | 97.5 |
| 1893 | 71.9 | 1928 | 96.1 |
| 1894 | 67.6 | 1929 | 100.0 |
| 1895 | 73.5 | 1930 | 89.0 |
| 1896 | 69.2 | 1931 | 82.3 |
| 1897 | 74.3 | 1932 | 71.9 |
| 1898 | 73.3 | 1933 | 72.5 |
| 1899 | 77.9 | 1934 | 82.0 |
| 1900 | 77.0 | 1935 | 90.6 |
| 1901 | 83.2 | 1936 | 102.2 |
| 1902 | 80.7 | 1937 | 107.7 |
| 1903 | 81.7 | 1938 | 100.8 |
| 1904 | 78.0 | 1939 | 110.4 |
| 1905 | 81.7 | 1940 | 114.9 |
| 1906 | 88.1 | 1941 | 131.7 |
| 1907 | 86.2 | 1942 | 140.2 |
| 1908 | 76.2 | 1943 | 150.4 |
| 1909 | 84.3 | 1944 | 161.3 |
| 1910 | 82.4 | 1945 | 160.7 |
| 1911 | 83.0 | 1946 | 150.3 |
| 1912 | 85.1 | 1947 | 146.7 |
| 1913 | 86.0 | 1948 | 144.6 |
| 1914 | 76.6 | 1949 | 137.9 |
| 1915 | 77.0 | 1950 | 145.5 |
| 1916 | 87.5 | 1951 | 146.0 |
| 1917 | 82.6 | 1952 | 145.6 |
| 1918 | 86.1 | 1953 | 145.3 |
| 1919 | 86.8 | 1954 | 138.9 |
| 1920 | 85.4 | 1955 | 146.8 |
| 1921 | 81.1 | 1956 | 145.1 |
| 1922 | 85.7 | 1957 | 142.4 |
| 1923 | 95.9 | | |

SOURCE: *Productivity Trends In The United States,* John W. Kendrick, National Bureau of Economic Research (in preparation).

and is pictured on Chart F, for the years 1889 to 1957 inclusive. The trend line representing the productivity of capital (Chart F) is much more erratic than the general trend line representing the productivity of labor. The most noticeable reversal in the improvement trend in the capital productivity record occurred in the 1929-33 depression era. Other reversals in the trend, with the exception of the 1945 break, can be found in years where there was a drop in total output. This is readily understandable when we recall the concept of productivity. Tangible capital stock does not contract in a recession period. The man-hours input will drop as workers are laid off. Actually, capital stock will usually increase even in recession years, although not at the same rate as in expansion years. As a result, during a recession the economy experiences a drop in output with no drop (often a slight increase) in tangible capital input. The quotient (output per unit of capital), i.e., output divided by input, will naturally decrease. The reader should remember that the tangible capital stock input estimate is a measure of existing capital and the rate of capacity at which this stock of capital is used is not considered in this measure of produc-

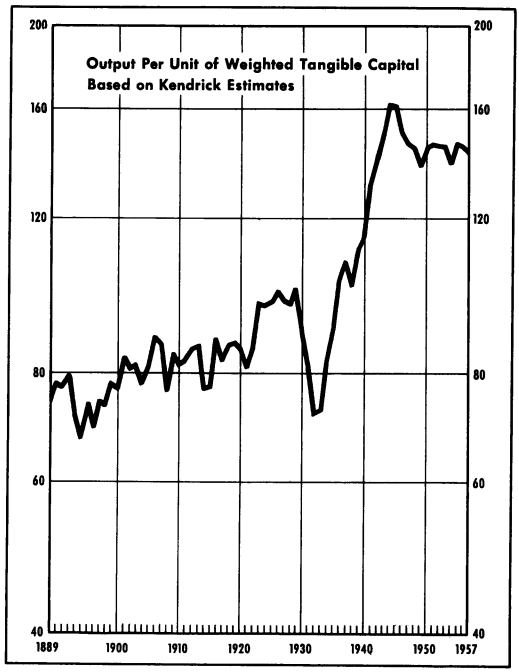
[3] *A Study of Saving in the United States,* Vol. III, Raymond W. Goldsmith, Princeton University Press, 1956.

tivity. The effect or lack of effect on productivity measures which changes in the capacity rate have is evident in the explanation made in the following paragraph for the post World War II period.

During World War II we expanded our output at a very fast rate. Due to material shortages it was not possible to increase our stock of tangible capital as much as the output justified. Even obsolete equipment was brought into production to obtain maximum output. As a result, the economy experienced a tremendous output increase without a corresponding increase in the stock of capital. This accounts for the sharp rise in the output per unit of weighted capital input from 1939-1945. At the war's end our stock of capital was pretty well depreciated and amortized as it was obsolete for the production of peacetime consumption items. The reconversion and expansion which began in 1946 represented a huge increase in our stock of tangible capital. Although output increased, our stock of capital increased at a faster rate with the resulting decrease in the output per unit of weighted capital input.

For the entire period 1889 to 1957 the annual rate of increase per weighted unit of tangible capital averaged 1.0 percent.[4] If the seventy-year span is divided into two periods, 1889-1919 and 1919-1957, as we did with the labor productivity, the latter period experienced a higher rate of average annual increase. For the period 1889 to 1919 the annual rate of increase averaged 0.5 percent.[1] The average rate of increase in physical output per weighted unit of tangible capital amounted to 1.3 percent[5] for the 1919-1957 period.

CHART F




The output per unit of total input (both labor input and capital input combined) is described as total factor productivity. In a sense this means all the input factors are included in the measure. Actually it is only the measurable input factors that are utilized. We must remember that there are numerous intangible capital inputs such as improvements in machines, methods, training, education, etc., which can't be translated into statistics. However, total factor productivity does measure the output per unit of all inputs (land, labor, and capital) which are subject to measure.

In combining weighted labor input and weighted capital input into a total input factor Kendrick adjusted for the relative weight of each input factor. The common denominator in this procedure is the earnings received by each input factor. For example, if labor earns $2.00 per hour and capital returns 4% ($4.00 per $100 invested) per year, then each $100 of tangible capital stock is equal to two hours of work. Because of increasing wages and a more or less constant rate of return on capital, labor naturally receives a much greater weight than capital.

Table 7 shows the output per unit of total input for the private economy from 1889 to 1957. This information is also graphed on Chart G. Over the entire period 1889-1957 total factor productivity increased at an average annual rate of 1.7 percent.[6] If we divide the time span into pre-1919 period and post-1919 period as we did with productivity per unit of labor input and productivity per unit of tangible capital input, we find that the years after 1919 showed a greater average annual increase in total factor productivity than the pre-1919 era. From 1889 to 1919 total factor productivity averaged a 1.3 percent[6] annual increase. After 1919 and up through 1957 the average annual increase in total factor productivity was 2.1 percent.[6]

During the same period 1889-1957, the real private domestic product increased at an average annual rate of 3.5 percent. Therefore almost half (1.7 percent) of this 3.5 percent average increase was the result of increased efficiency in the utilization of labor and capital. The other half of this increase is the result of additions to real labor and capital inputs. A 3.5 percent annual increase, when

[4] *Productivity Trends in the United States,* John W. Kendrick, National Bureau of Economic Research (in preparation).
[5] *Basic Facts on Productivity Change,* Solomon Fabricant, National Bureau of Economic Research, Occasional Paper No. 63, 1959, Table 2, page 11.
[6] *Basic Facts on Productivity Change,* Solomon Fabricant, National Bureau of Economic Research, 1959, Table 2, page 11.

**Table 7**

## OUTPUT PER UNIT OF TOTAL INPUT

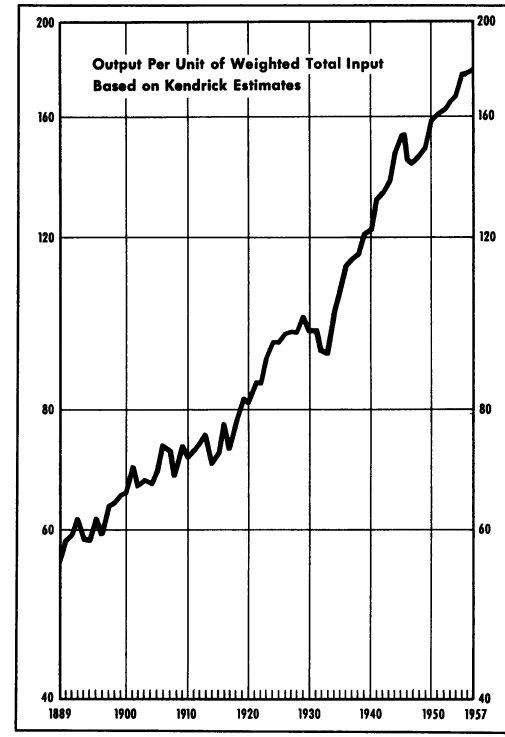
(1929 = 100)

(Total Input = Weighted Man-Hours and Weighted Tangible Capital)

| | | | |
|---|---|---|---|
| 1889 | 56.0 | 1924 | 93.6 |
| 1890 | 58.6 | 1925 | 93.6 |
| 1891 | 59.1 | 1926 | 95.7 |
| 1892 | 61.8 | 1927 | 96.1 |
| 1893 | 58.7 | 1928 | 96.0 |
| 1894 | 58.5 | 1929 | 100.0 |
| 1895 | 61.7 | 1930 | 96.3 |
| 1896 | 59.5 | 1931 | 96.4 |
| 1897 | 63.7 | 1932 | 91.9 |
| 1898 | 64.1 | 1933 | 91.3 |
| 1899 | 65.4 | 1934 | 100.8 |
| 1900 | 65.7 | 1935 | 105.9 |
| 1901 | 69.8 | 1936 | 111.2 |
| 1902 | 66.7 | 1937 | 113.6 |
| 1903 | 67.7 | 1938 | 115.2 |
| 1904 | 67.2 | 1939 | 120.2 |
| 1905 | 68.8 | 1940 | 122.0 |
| 1906 | 73.5 | 1941 | 131.3 |
| 1907 | 72.7 | 1942 | 133.1 |
| 1908 | 68.2 | 1943 | 137.3 |
| 1909 | 73.4 | 1944 | 147.9 |
| 1910 | 71.6 | 1945 | 152.9 |
| 1911 | 72.7 | 1946 | 144.5 |
| 1912 | 73.7 | 1947 | 143.1 |
| 1913 | 75.6 | 1948 | 145.9 |
| 1914 | 70.3 | 1949 | 149.3 |
| 1915 | 72.0 | 1950 | 158.7 |
| 1916 | 77.4 | 1951 | 160.4 |
| 1917 | 73.0 | 1952 | 162.5 |
| 1918 | 78.0 | 1953 | 166.4 |
| 1919 | 82.1 | 1954 | 168.4 |
| 1920 | 81.2 | 1955 | 176.8 |
| 1921 | 85.1 | 1956 | 177.1 |
| 1922 | 85.1 | 1957 | 179.4 |
| 1923 | 90.2 | | |

SOURCE: *Productivity Trends In The United States,* John W. Kendrick, National Bureau of Economic Research (in preparation).

CHART G




compounded, would double the real private product in twenty years. At an annual increase at the rate of 1.7 percent, the total factor productivity increase when compounded would double the total factor productivity every forty years.

### *Review of Kendrick Estimates*

Kendrick estimates on productivity in the private domestic economy are presented in three separate indexes. They are:

1. Output per weighted man-hour (labor input).
2. Output per unit of weighted tangible capital.
3. Output per weighted unit of labor and tangible capital combined.

Chart H graphically illustrates the trend lines of these three indexes. The relative position of each trend line on the chart is meaningless for the purpose of this chart is to depict the course of the trend lines. Over the entire period 1889-1957, the gain in output per weighted man-hour proceeds at a rather steady pace. The trend line for output per unit of weighted tangible capital, on the other hand, is somewhat more erratic. When both labor and capital inputs are combined into total factor input, the productivity trend line (output per weighted unit of labor and tangible capital) tends to follow the productivity trend line for output per unit of labor input. At least it follows a more similar trend which tends to eliminate (although not entirely) the deep reversals experienced in the trend line based on input of tangible capital. The reason for this is the heavier weight given to labor input when labor input and capital input are combined into total factor input.

The annual average increases experienced in Kendrick's three sectors appear on the following page broken down into the two periods used in our previous discussion. In addition, Table 4, showing average annual rate of productivity increase based on BLS estimates, is reprinted on following page for comparison of the two estimates.

CHART H

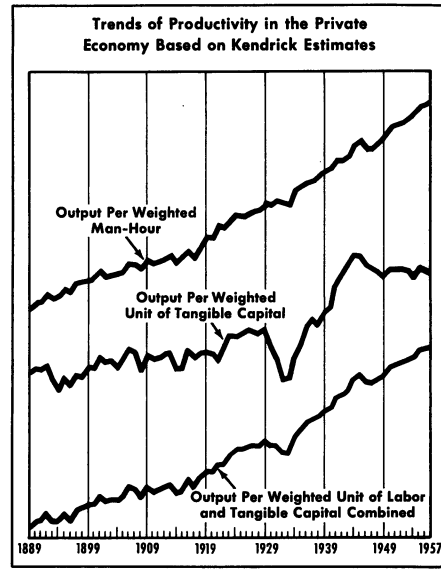



**Table 8**

***Kendrick***

AVERAGE ANNUAL PERCENTAGE CHANGE IN PRODUCTIVITY FOR THE PRIVATE ECONOMY

| | *1889-1957* | *1889-1919* | *1919-1957* |
|---|---|---|---|
| Output Per Unit of Total Factor Input | 1.7% | 1.3% | 2.1% |
| Output Per Unit of Labor Input | 2.0 | 1.6 | 2.3 |
| Output Per Unit of Weighted Tangible Capital | 1.0 | 0.5 | 1.3 |

SOURCE: *Basic Facts on Productivity Change,* Solomon Fabricant, National Bureau of Economic Research Occasional Paper #63, Table 2, p. 11.

**Table 4**

***Bureau of Labor Statistics***

AVERAGE ANNUAL PERCENT CHANGE IN REAL PRODUCT PER MAN-HOUR

1909 - 1957

| | *BLS (Man-Hours Paid)* | *CENSUS (Man-Hours Worked)* |
|---|---|---|
| Total Private Economy | 2.3% | 2.4% |
| Agriculture | 2.1 | 2.1 |
| Non-agriculture | 2.0 | 2.1 |

SOURCE: See Table 4, page 22.

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