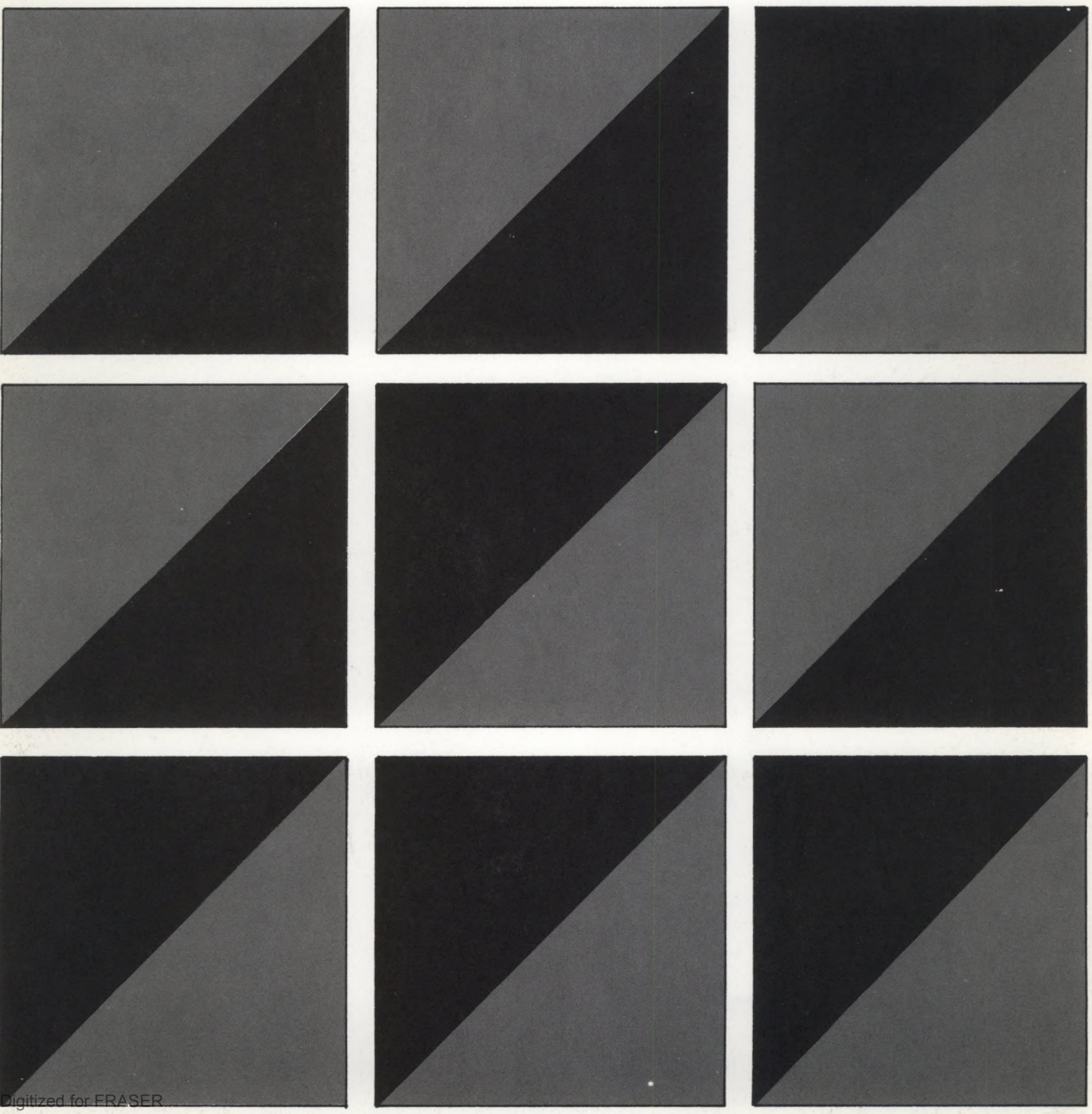
The Meaning and Measurement of Productivity

Bulletin 1714

U. S. DEPARTMENT OF LABOR
Bureau of Labor Statistics



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Prepared for the National Commission on Productivity by the Bureau of Labor Statistics U. S. Department of Labor

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U. S. DEPARTMENT OF LABOR
J. D. Hodgson, Secretary
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Preface

The National Commission on Productivity was established by President Richard Nixon in June 1970 to develop recommendations for programs and policies to improve the productivity of the U.S. economy. The Commission is composed of top-level representatives of business, labor, government, and the public. In order to aid the members in their consideration of various topics, staff papers will be prepared by government or private industry experts in different subject matter fields. These papers serve as background material for the members but do not necessarily represent their views.

The two papers included here were prepared by Herbert Stein, member of the President's Council of Economic Advisers, and Jerome A. Mark, Assistant Commissioner for Productivity and Technology, Bureau of Labor Statistics, U.S. Department of Labor.

Contents

The Meaning of Productivity

by Herbert Stein*

The rate at which productivity grows is central to two of the major issues facing the country. One is the issue of inflation. The other is the speed at which the society's demands on the economy are rising—not only for the traditional purpose of private consumption and investment but also for improving the environment, health, domestic security, and general quality of life.

Recognizing the key role of productivity increase in meeting the Nation's goals, and the potential contribution of all sectors of the community, the President on June 17, 1970, announced his intention to establish a National Commission on Productivity. The Commission when established included six members each from business, labor, and the public at large, and five members from the Federal Government.

Subgroups of the Commission have been established to deal with specific problems. While its work still lies largely ahead of it, some points raised in early discussions by the Commission, with participation by the President, deserve public attention at this time.

THE MEANING AND MEASUREMENT OF PRODUCTIVITY

The most commonly used definition of productivity is real output per hour of work. Productivity in this sense is a rough measure of the effectiveness with which we use our most important productive resource—labor. It has important social implications because it takes account not only of the chief source from which individual and social desires are met—that is, the total output of the economy—but also of a major source of getting that output, namely work. We would surely think that an increase in output achieved by raising the output per hour of work does us more good than an increase in output achieved by working more hours. The definition of productivity as real output per hour of work has economic significance also. If all terms are consistently defined, if labor compensation per hour rises at the same percentage rate as productivity, then unit labor costs will be stable; and if the shares of compensation in the national income remain unchanged, then prices on the average will be stable. In fact, the price level generally moves very closely with the ratio of compensation per hour to productivity per hour except for cyclical or other shortterm interruptions. Finally, estimates of productivity defined in this simple way are available to permit interesting and analytical comparisons of different times and countries, whereas more sophisticated measures are not.

The most commonly used measure of productivity relates the total output of goods and services in the private economy, that is, private Gross National Product (GNP) to the man-hours of all persons engaged in the production of those goods and services. This measure is expressed in the usual GNP constant dollar terms. Other measures, at the firm or industry level, may be constructed in a similar conceptual framework but more often are derived by using some physical concept of output unique to that firm or industry such as tons of steel or kilowatt-hours of electricity.

The most common definition and measure of productivity is sometimes called inadequate or even irrelevant on the ground that it reflects only the "quantity" and not the "quality" of economic performance. It is true that like all measurements, the measurement of productivity relates to a quantity, but it is untrue that the quantity measured is unrelated to the qualities that human beings value. The value of gross national product is a product of the quantities which people buy and the prices which people are willing to pay for them. The quantities people buy, and the amounts they are willing to pay for them, reflect the qualitative values that people find in the different products. Thus, GNP and its components reflect a value or "quality" choice among consumers, subject to limits imposed by income levels and the available supply of goods and services.

There are, of course, consequences of economic activity that are not reflected in existing measures of output per hour and the country has become increasingly conscious of some of these in recent years. On the output side these are generally consequences of activity that does not pass through a market. The outstanding case is the deterioration or improvement of the environment. The deterioration of the environment is not counted as

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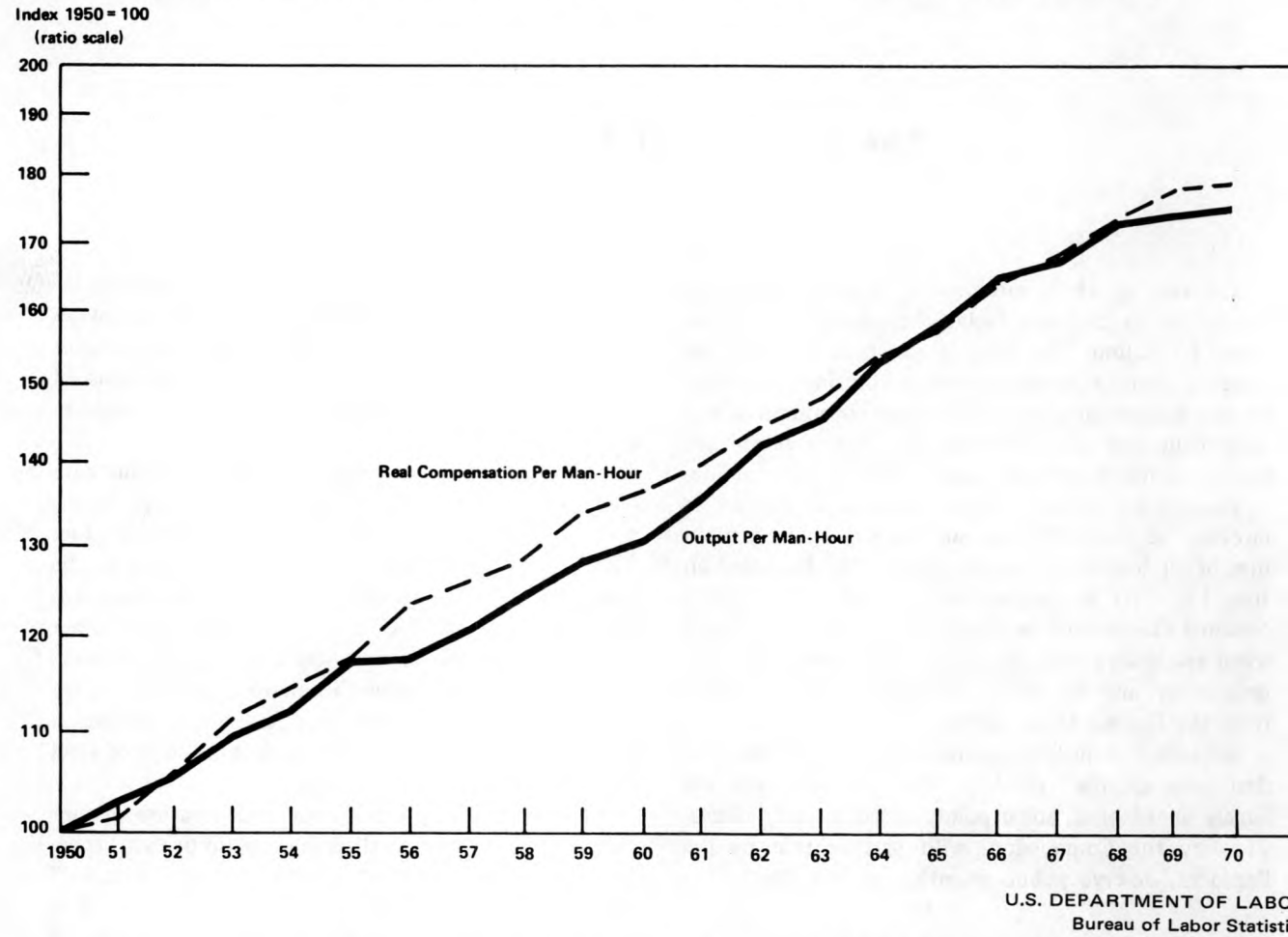
Chart 1. Output Per Man-Hour and Real Compensation Per Man-Hour, Total Private Economy, 1950-70



a cost or a deduction from the product, and an improvement of the environment is not counted as an addition to the product. Thus, as far as this factor alone is concerned, our ordinary figures may have overstated the growth of productivity in the past and may in the future understate the growth if more and more resources are used to improve the environment. However, this is only one among many omissions in the measurement of output and productivity. Going further, it is obvious that productivity statistics do not measure justice, security, happiness, beauty, or the lack of them, and we cannot be sure in what direction our available measurements may be biased. But this obvious fact does not belie the importance of the statistic as an indication of the ability of society as a whole to achieve its goals.

There are other limitations of the statistical measures of productivity which are a consequence of our inability, thus far at least, to perfect our methods of national accounting. In construction, for example, we do not yet know how to measure properly the output of complex and diverse structures such as homes, hotels or hospitals. Nor do we yet know how to assign a correct market value to products which are not sold such as those of education and many government activities.

For many analytical and policy purposes the simple figure of output per hour is inadequate. We would like to know why total output and output per hour are larger in one country, industry or time than another and for this purpose we need additional measures. We need to measure output per unit of all resources, including at least capital as well as labor. And we need to recognize that different kinds of labor, distinguished by skill, in a sense, are different amounts of labor per hour and have different productivities. When we measure output per unit of capital and labor combined and adjusted for quality wer have another measure of the efficiency of resource use. When we break down this measure into its various components we then have a family of measures which permits better estimation of the contribution of different factors to the growth of output and provide insights into the effects of different policies in the future.

Measurements of productivity have been improved substantially in sophistication, variety, and accuracy in the past 20 years. They are still inadequate to answer all the questions that might be asked of them. Further improvement and dissemination of the statistics will contribute to better understanding of our economic problems and to better policy. The Commission hopes to contribute to this.

WHY PRODUCTIVITY IS IMPORTANT NOW

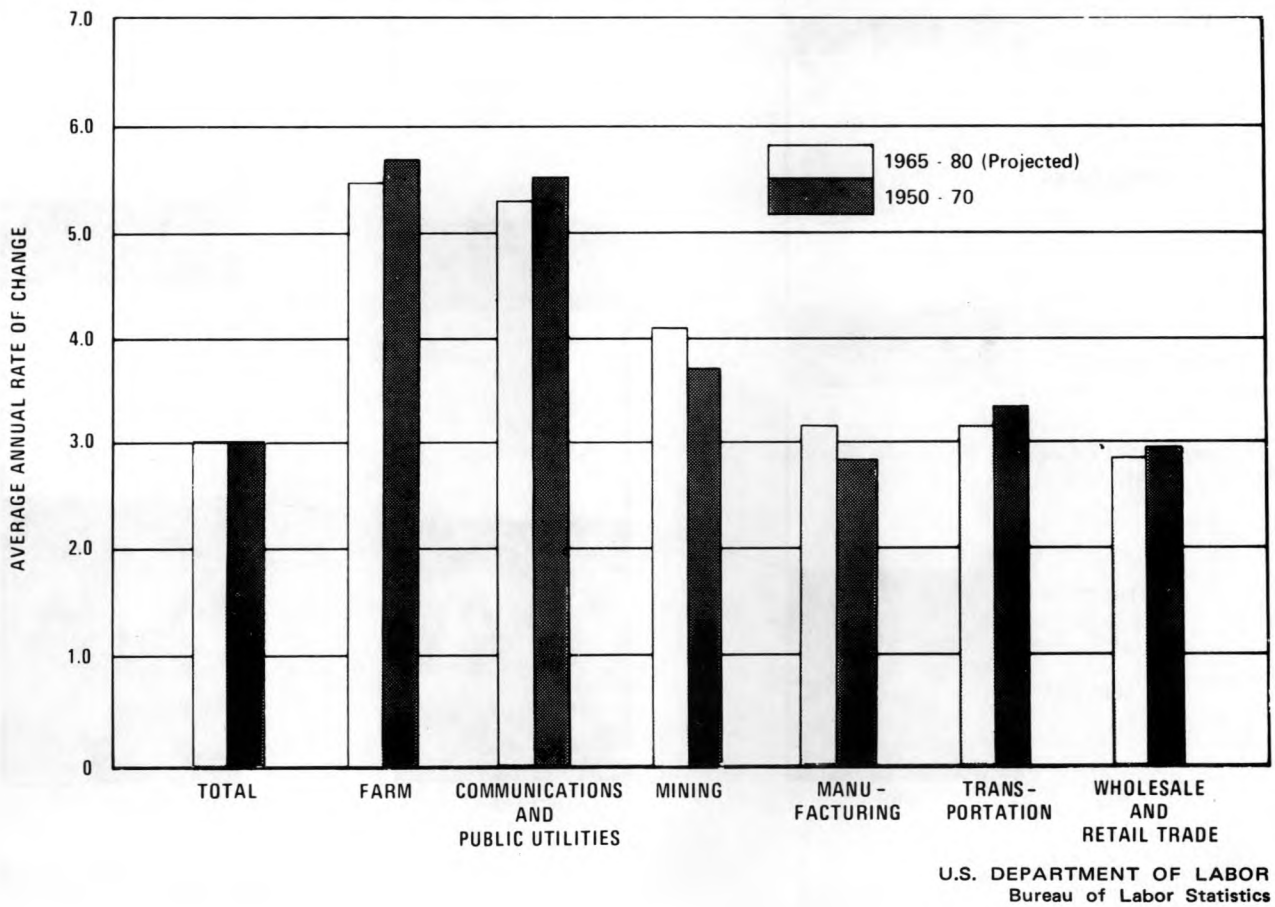
By any available measurement the level of productivity in America has risen persistently over the decades, except for brief cyclical interruptions, and for many years has been the highest in the world. One might think in these circumstances that productivity growth would be a matter of no great concern. Nevertheless, the discussions of the Commission have confirmed the premise which underlay its establishment—namely the great importance of the productivity question today.

The claims upon the economy, expressed through the political process or in the market, are very large, even relative to the great capacity of the American economy. The size of these claims results at least in part from past rapid economic growth, which has led to rapidly rising expectations among workers and consumers. We shall come closer to meeting these claims if we can increase the rate of growth of productivity.

During the past 4 years the rates of growth in productivity and GNP slowed down. At the same time the real income gains which workers has come to expect with rising wages also deteriorated. A return to a more normal productivity growth rate can help to restore the rate of gain in average real income. (See chart 1.)

This striving for higher productivity must not be viewed as a whip-cracking exhortation to "work harder" in order to raise some arbitrary abstract measure of economic performance. Increasing productivity is a way of increasing the ability of people to do what they want to do. It can provide the wherewithal for achieving a higher standard of living for families now living at the low end of the income scale. It can provide for a choice of leisure—not idleness—in the form of more holidays and vacations and entrance to an earlier retirement from the world of work, and it can provide the resources for improving the physical quality of the environment.

Chart 2. Productivity Trends, Total Private Economy and Selected Sectors, 1950-70 and 1965-80



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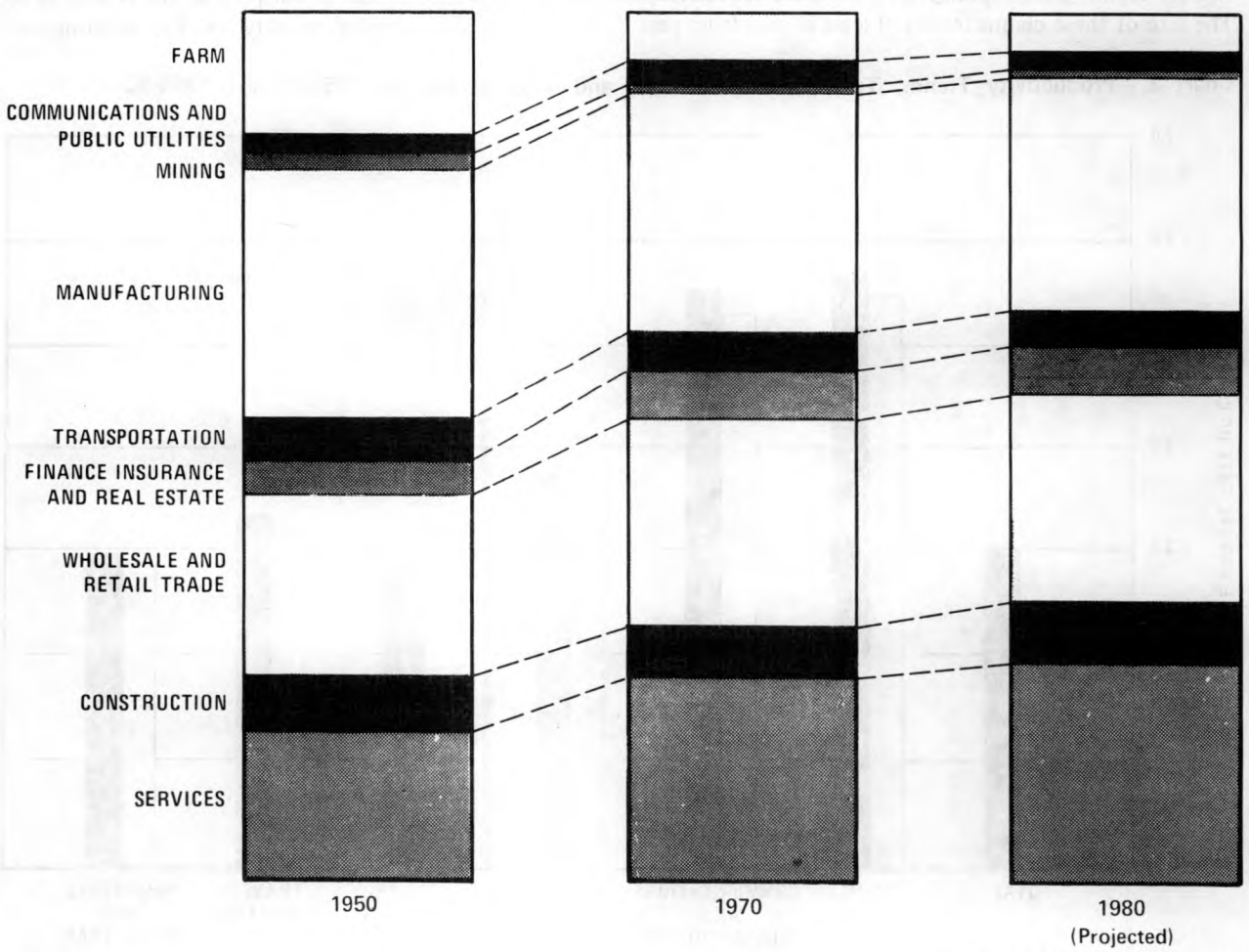
We may be entering a period in which sustaining the rate of growth of productivity will be more difficult. For several decades the shift of workers out of agriculture, where productivity was below the average, contributed substantially to the increase of productivity. The number of workers left in agriculture is so small that this can no longer be significant. On the other hand, there will now be an increase in the proportion of the labor force employed in those industries, loosely called "service industries," where productivity and its rate of growth have been low relative to the national average. (See charts 2 and 3.)

Productivity, in recent years, has been increasing more rapidly in Japan and in several Western European countries than in the United States. The reduction of the gap between our productivity and their's is not a matter of concern; it is to our advantage that their productivity should be high. Neither does it necessarily indicate any superior effectiveness of their economic policies. The fact that they are behind us in productivity by itself helps them to grow more rapidly because it means that they have opportunities to exploit—such as advanced production techniques—which we are already using. In some cases where they have embarked on new product ventures they have built plants embracing the most modern technology. But technology and methods may not be the whole story, and the experience of others requires us to consider carefully whether there are steps that could be taken here to speed up the increase of productivity.

The higher rates of productivity growth in other countries were accompanied by increases in hourly compensation which, in the past 5 years, tended to exceed those in the United States. The relationship of trends between output per man-hour and compensation per man-hour, however, was closer in those countries than in the United States so their unit labor costs did not go up as much in those years.

Chart 3. Relative Importance of Employment for Major Sectors, 1950, 1970 and Projected 1980



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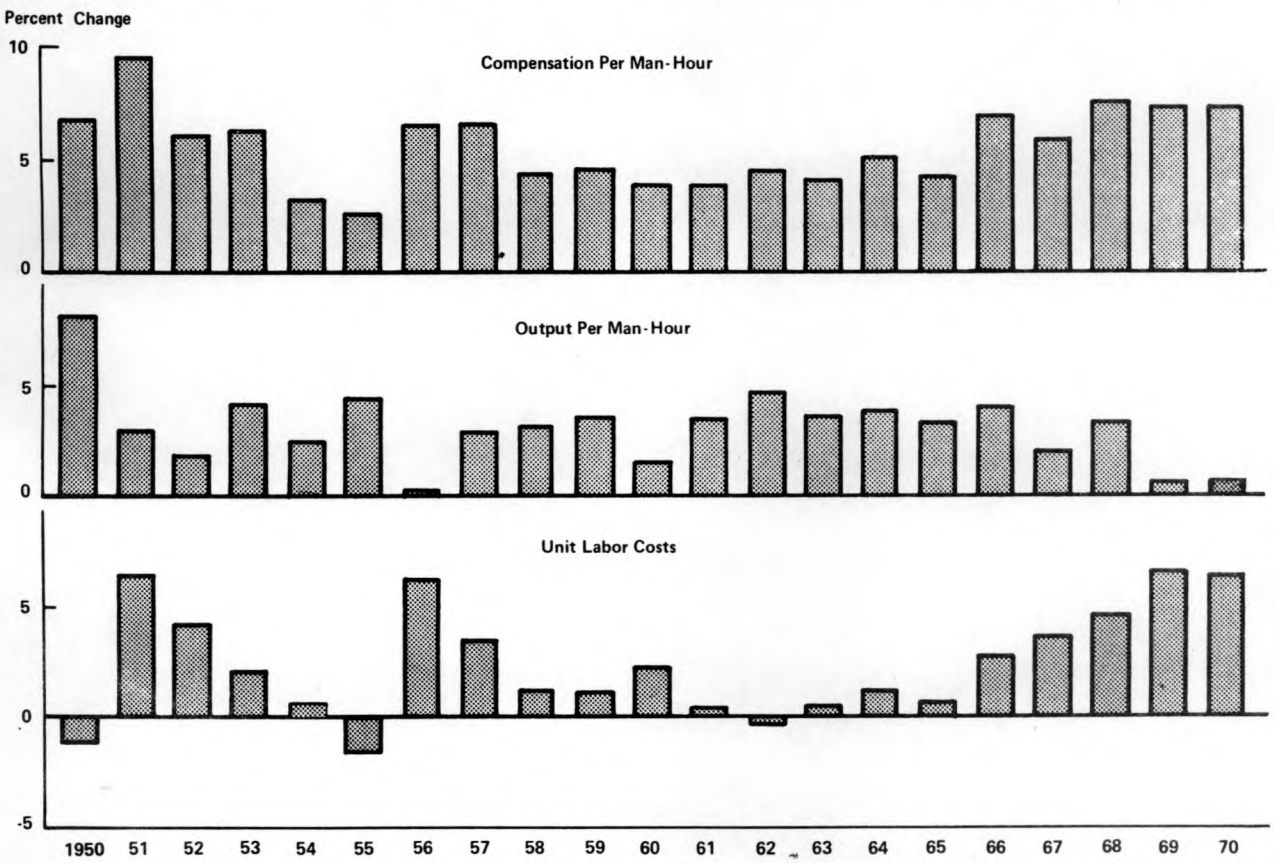
In comparing the trends of productivity and earnings among countries, we must draw a distinction between real income and unit costs. Certainly we must applaud the rising productivity and standard of living of workers in the rest of the world. But the gap between changes in money earnings and changes in productivity which determines unit labor cost trends, is an important element in the difference between a stable or improving or deteriorating position in international trade.

Within the United States, no less than among countries, to recognize the distinction between costs and income is useful. The last 3 years were witness to the highest 3-year increase in average compensation per man-hour (of all persons working in the private economy) since the early 1950's. And yet, when these figures are adjusted for the rise in consumer prices, the resultant real compensation per man-hour showed the smallest 3-year rise over the same period. There was a deterioration in the rate at which higher real income was being achieved.

The important point here is not so much that compensation rose rapidly but rather that there was a large gap between productivity and compensation gains with a resultant large increase in unit labor costs. (See chart 4.) It is a part of the syndrome of inflation in which prices and wage rates each rise—and each, at different points of time, tries to catch up with the other. One way to break into the syndrome is to increase the rate at which productivity grows so that wages can rise without increasing unit costs and the pressure on prices is abated.

Increasing productivity may thus be regarded as the keystone to an improved standard of life and environment for all of society. It is with this broad view in mind that the National Commission on Productivity has set its task of finding ways to continue or accelerate the historical rates of productivity gains in the United States.

Chart 4. Annual Rates of Change in Wages, Productivity, and Unit Labor Costs, Total Private Economy



Compensation includes wages and salaries and supplemental payments for employees and an estimate of the salaries and supplements for the self-employed.

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Concepts and Measures of Productivity

by Jerome A. Mark*

Despite the wide attention paid to productivity over the years, confusion prevails as to its meaning and measurement. This is understandable because the concept does lend itself to ambiguity and a wide range of productivity measures can and have been developed in response to different analytical uses.

Productivity is loosely interpreted to be the efficiency with which output is produced by the resources utilized. A measure of productivity is generally defined as a ratio relating output (goods and services) to one or more of the inputs (labor, capital, energy, etc.) which were associated with that output. More specifically, it is an expression of the physical or real volume of goods and services related to the physical or real quantities of inputs.

A variety of plausible productivity measures can be developed, the particular form depending on the purpose to be served. For example, output per labor input, the most familiar measure, is useful in understanding changes in employment or labor costs. This measure might be based on man-hours paid or man-hours worked, with different results. A more comprehensive measure of input might be more useful in studying how the economy is using labor and capital combined. Also, there are various ways of adding up diverse products into a measure of output. No one measure is the *right* or *best* measure.

Since the interpretation of these statistics depends on the definitions and data used, an understanding of the productivity concepts used in relation to the purpose to be served is always essential.

CONCEPTS OF PRODUCTIVITY

There are two broad classes into which productivity concepts and in turn measures can be grouped. One includes those measures which relate output of a producing enterprise, industry, or economy to one type of input such as labor, capital, energy, etc.; the other includes those which relate output to a combination of inputs extending to a weighted aggregate of all associate inputs.[1]

Although the former measures relate output to one input, they do not measure the specific contribution of that factor to production. Rather, they express the joint effect of a number of interrelated influences on the use of the factor in the production process—such as changes in technology, substitution of one factor for another, utilization of capacity, layout and flow of material, the skill levels and the efforts of the work force, and managerial and organizational skills.

Whether for an individual establishment, an industry, or the entire economy, the most frequently developed and perhaps most useful productivity measure is an output per unit of labor input measure of what is frequently termed a labor productivity measure. There are several reasons for this. Perhaps the most important is that labor is almost universally required for carrying through all types of production. There is a labor element of costs in almost all endeavors; the degree varies but it is always present. In addition, as a practical matter, it is perhaps the most measurable input. Other factors, such as capital, are much more difficult to quantify.

There are, however, various labor productivity measures, depending on the definition of labor input. A measure may refer to output per person or it may take account of changes in hours of work and be based on total hours. It may cover the hours of the entire labor force including proprietors, unpaid family workers, and employers; or it may be limited to selected groups of workers.

Another set of productivity measures relating output to a single input is output per unit of capital. These measures are particularly useful in understanding movements in unit nonlabor costs by relating the measures to corresponding measures of returns to capital. As in the case of other single factor productivity measures they indicate the changes in the use of capital per unit of output not the contribution of capital alone. The measures

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[1] Even at the level of an individual craftsman where the output-input relationships are limited, these two concepts are present. Productivity can refer to the volume of work the individual is able to accomplish within a given time span—i.e., output per man-hour. It can also refer to the volume of work completed per unit of his time, his tools, and his materials—i.e., an output per total factor input.

have been limited to reproduction of what has been termed "tangible" capital.

Other single factor measures such as output per energy input or output per material input are relevant for plant and industry study where these inputs are of considerable importance in the production process or represent relatively scarce resources. For example, in the aluminum industry where electrical power is an important element in processing bauxite, output per KWH is very useful as an indication of the efficiency with which electricity is being utilized.

As mentioned earlier, all single factor productivity measures reflect the joint effect of a variety of factors including the substitution of one factor for another. For some purposes, to develop a measure which eliminates the effect of that substitution is useful. This type of measure relates output to a combination of inputs. Thus, a productivity index of output per labor and capital combined elininates the effects of changes in amounts of capital per workers These measures have been termed multifactor or "total factor" or simply "total" productivity measures. For both conceptual and statistical reasons they have generally been limited to labor and "tangible" capital inputs and have not included as inputs activities such as research and education which can be viewed as intangible capital.[2]

Output

For all productivity measures, output is measured in physical or real terms. The concept is one of work done or the amount of product added in the various enterprises, industries, sectors, or economy. It refers not to activity as such but to the results of activity.

In this sense, at the plant level, production and hence productivity measurement differs from work measurement. Work measurement generally refers to the analysis of the stages of activity and the requirements at each of these stages. Productivity refers to the finished product (the result of activity) and its relationship to input.

In the case of a producing unit making one homogeneous commodity, production in physical terms would merely be a count of units produced. For a commodity to be regarded as homogeneous, certain conditions should be fulfilled. The product should be of a specified quality (e.g., carbon steel) and it must conform to precise standards of size, volume, unit, etc. Even though the measure of production in this case is a single count, the way of defining the unit of product can have different implications for productivity measurement. For example, carpeting can be measured in pounds or square yards. A change in the density of the carpeting would affect the weight per yard and, therefore, have a different impact on man-hour requirements depending on whether output is measured by the yard or by the pound.

For the more usual case of a plant or an industry producing many heterogeneous products, the different units must be expressed on some common basis. They can also be combined in terms of their man-hour requirements. The advantage of the latter method for measures of output per man-hour is that the change in the productivity of the entire plant or industry is then a simple arithmetic average of the changes in the productivity of the individual components.

When the components are combined with value or price weights, that is, on the basis of their dollar value, then the output per man-hour measure for the total reflects not only changes in the productivity of the components but shifts in the importance of the components.

Physical quantity data are often not readily available, so deflation of dollar value is used. That is, total value of production is adjusted for change in price by use of a price index. This type of index is usually referred to as constant dollar output or deflated value of output. Such indexes are conceptually equivalent to indexes which use physical quantities combined with price weights.

The contribution of a producing unit lies in the value added, by its own labor and capital, to the materials and services purchased from other producing units—i.e., its net addition. Net output, therefore, is the constant dollar value of production minus the constant dollar value of purchased goods and services. In measuring productivity, the net measure would then be related to the particular input or all associated inputs except the material inputs. Relating a net output measure to a single input, when the various commodities produced and purchased are combined with value or price weights, will result in a single factor productivity measure that reflects not only the changes in productivity of the components and shifts in the importance of these components but also savings in material consumption.

Labor input

For all productivity measures where labor is relevant, labor input is measured in physical terms. The measure can refer either to the total number of individuals engaged in production or to only part of the work force, or it can refer to the man-hours of workers.

It is usually preferable to include the entire employed work force in the labor input measure—blue-collar and

[2] Denison in his work on the sources of economic growth has made estimates of the contributions of intangible factor input such as research, education, organization, etc., to total output. See Edward Denison, *The Sources of Economic Growth in the United States and the Alternatives Before Us* (New York, 1962) and *Why Growth Rates Differ* (Washington, D.C., The Brookings Institution, 1967).

white-collar workers, corporate officers, and the self-employed. The assessment of manpower needs must take all labor input requirements into account. But of course, there are times when analysis of labor requirements and the analysis of cost components suggests the use of measures which include only a component of the work force.

To analyze the productive capacity of labor and the effects of changes in working hours, or in use for projections of manpower needs, an output per man-hour measure is most relevant. The most suitable unit of measure is man-hours worked. There are some ambiguities or differences of opinion on what to include, for example, standby time, coffee breaks, etc. In general, "hours worked" refers to the time spent at the place of employment, and therefore excludes hours paid for but used on leave for vacation, holiday, illness, accident, etc. In some cases, total hours paid are utilized in the productivity measures because data on hours worked are not available.

In developing a labor input measure, in many cases man-hours are treated as homogeneous and additive. These measures are particularly relevant to problems of estimating total man-hour requirements. But merely adding up the number of hours ignores the qualitative aspect of an hour worked by different individuals. Therefore, a productivity measure which is based on the sum of undifferentiated man-hours will reflect changes in the composition of the work force with different qualitative characteristics.

For some purposes, it may be desirable to develop a productivity measure which takes into account the differences in the "quality" of an hour of labor. That is, an hour of high quality labor is counted as proportionately more than an hour of low quality labor. To do this some methods have to be introduced to differentiate these hours. One way which has been utilized is to combine the man-hours of various employees in terms of pay differentials. The man-hours of higher paid workers are given more weight than lower paid. This assumes that differences in earnings reflect differences in education, experience, skill, and their contribution to output.[3] Another method is to adjust the data to take into account changes in vocational training, length of schooling, or type of education, etc., of the work force, assuming there is a close relationship between qualifications and quality. When adjustments are made for changes in the quality of labor input the resultant productivity measure will not reflect changes in the composition of the work force as a productivity change but rather as a change in factor input.

[3] Except to the extent that regional or similar wage differentials affect average hourly earnings.

Capital input

Capital stock estimates include the constant dollar value of structures, plants, and equipment current available for production. These estimates may also take into account the value of land, inventories, and working capital.

Generally capital stock measures are derived by adjusting the value of existing plant and equipment for new investment and the retirement of old assets. There are different ways of measuring the stock of capital; for example, they may be gross or net. Net stock estimates are derived by depreciating assets (and there are various methods of depreciation). Gross stock estimates are derived by retaining assets at their full value until they are retired from use. Since these are physical measures, the value of capital stock must be adjusted for price changes.

For productivity analysis, however, the flow of capital services rather than the stock is the preferred measure. A capital stock measure does not account for differences in the intensity of use over time. Equipment, for example, may be used for several shifts during a business expansion or may be idle during a contraction. Then, too, a large part of existing capital capacity may be standby and employed only during periods when the economy is operating at very high rates. There is also a loss of efficiency of assets as they grow older. A flow measure reflects differences in usage and efficiency and how they affect varying levels of output, which is the basis of productivity estimation. Ideally flow measures should indicate the amount of capital employed to produce current output.

To derive this capital flow measure, an aggregate of the capital hours used weighted by the rental value of each type of structure and piece of equipment is needed. The data for this measure are often not available in the detail necessary for a capital flow measure.

A commonly used flow of capital service measure is depreciation. However, this is based on accounting principles which often reflect current income tax regulations rather than the actual amount of capital used for current production. Because of the difficulty of estimating a capital flow measure, however, most analyses of capital and production use capital stock estimates.

PROBLEMS OF MEASUREMENT OF PRODUCTIVITY

The measurement of productivity trends involves two fundamental problems which are applicable to both output and input data. First, because of difficulties in obtaining direct quantity measures of output and input, substitute measures or approximations must be used in many cases. Second, since most data are collected for

purposes other than productivity measurement, definitions already established and procedures for reporting information on production and factor inputs must be used; these may or may not be consistent with concepts appropriate for productivity measurement.

Output

Economy and sector level. The problems of using the gross national product data for productivity measurement involve primarily the inadequacies of the measures of real output for some components and the lack of comparability of coverage between output and labor input measures.

Limitations in measuring output affect the reliability of productivity statistics in some sectors more than others. Since the implications for productivity movements can be offsetting among the sectors, the effect on measures for the overall economy is not as large as it is in each of the sectors.

The three areas where the real product measures as derived from the national accounts are particularly weak for productivity measurement are government, construction, and services (including business and personal services, and finance, insurance, and real estate).

In the absence of market valuation of the services of general government agencies, the practice in national income accounting is to value government output in terms of the wages and salaries of government employees. The deflated, or constant dollar, measure is derived from changes in employment. Such an output measure, when related to a labor input measure, results in no statistical change in productivity. This measure of government output may be increasingly difficult to continue in view of the reported increases in output per man-hour in certain government operations which are subject to measurement. [4] Based on these data the trend of output per man-hour for the national economy would be biased downward. As a consequence, the available measures of productivity are limited to the private economy.

Measuring output in the service activities is difficult because of the absence of a directly quantifiable entity which describes a unit of service. Consequently, various substitute indicators are utilized in the national accounts. These usually involve the use of some "price" index for deflating the value of the service activities or the use of an employment index to develop trends in producers of services.

As in the case of government, the use of the employment movements as an indicator of the change in real output implies a constant labor productivity. This approach is utilized for such activities as security and commodity brokers, [5] insurance agents, and miscellaneous business and repair services.

For the bulk of service activities, however, the deflation approach is used and its validity for the resultant output measure rests on the adequacy of the price indexes. Most of the price indexes used are components of the Consumer Price Index, which in turn have different degrees of reliability. The indexes for medical services, for example, do not adequately take into account changes in the quality of medical services performed.

As mentioned earlier, the real product measure is conceptually a net output measure but in many of the service activities data are not available on the real value of the material inputs. In such cases estimates of real product are made on the basis of changes in the total volume of output. This does not present a serious problem, however, since in most service industries intermediate purchases constitute a relatively small proportion of total value.

The other major activity in the national accounts where the output measure has severe limitations for productivity measurement is the construction industry. The constant dollar output measure is obtained by deflation, but the price index used is really a cost index. For the most part, these are measures of the change in costs of materials and labor weighted in terms of their base period importance. These indexes do not take into account any savings in the utilization of materials or labor, and, as a result, there is an overstatement of price increases. Consequently, there is an understatement of gains in real output and hence productivity.

Productivity indexes based on real product for construction show an average annual decline of 0.2 percent. This is somewhat inconsistent with studies which the Bureau of Labor Statistics has conducted of labor requirements for various specific types of construction during this period. These studies indicate for schools there was approximately a 2¾ percent per year gain over much of this period, for highways a 3-percent increase per year, and for hospitals not much change.

With regard to lack of comparability of coverage between output and labor, perhaps the largest evidence of this occurs in the real estate activity. For national income accounting purposes, an inputed rent for home ownership is added to the output of the real estate industry. There is, however, no corresponding labor in-

[4] Nestor E. Terleckyj "Recent Trends in Output and Input of the Federal Government," in Proceedings of the Business and Economics Section, American Statistical Association, 1964, pp. 76-94.

[5] In view of the rapid spread in recent years of electronic data processing in this industry this measure must be very much understated since the productivity gains undoubtedly were large, John Kendrick has suggested that data on shares of stocks and bonds sold appropriately weighted would be a better measure. See "Production and Productivity in the Service Industries," Victor Fuchs, Educational Studies in Income and Wealth No. 39, National Bureau of Economic Research, 1969.

put associated with that output. Rough estimates indicate that the removal of this activity from the output account would reduce the productivity trend for the private economy about two-tenths of a percent per year over the last two decades.

Industry level. The effects of certain measurement problems are greater at the individual industry level than at the national level where there is a tendency for errors and biases to offset each other. On the other hand, at the industry level, more flexibility is possible because the output measures are not part of an overall framework (such as the national income and product accounts) which requires certain definitions and measures not necessarily consistent with the desired productivity measures.

Three major problems are encountered in developing measures of output from available data for industry productivity indexes. First, for many industries, the appropriate detailed product data are not available. Second, there is the well known quality change problem which results from the development of new products and the changing specifications of existing products. Third, appropriate weights are often not available for deriving the desired industry measure.

Some of the presently available industry indexes are based on unit man-hour weights; others are based on unit value or price. The use of unit value or price weights is not a serious problem among commodities where labor consts or inputs are a high proportion of price.

Labor input

With regard to labor input measures there are several data gaps in presently available measures. They relate to changes in the composition of labor (the quality), groups of the work force for which data are lacking or incomplete, the relationship of output to the time of research development and other workers whose activities are not directed to current production, and finally, the absence of adequate hours worked data on a comprehensive basis.

1. *Quality.* As mentioned earlier, changes in the composition of labor input are adjusted in some measures by weighting industry man-hours with the average hourly earnings of workers in the industry. Insofar as earnings differentials reflect productivity differences among workers, this measure captures changes in the quality of workers of different industries. However, this approach has severe limitations. Pay differentials between industries reflect many factors unrelated to productivity differences, such as the degree of unionization or regional and geographical differentials. Moreover, the industry hourly earnings differential does not take into account occupational changes which occur within an industry.

Estimates of the effects of shifts among major sectors—farming, manufacturing, mining, etc., show that shifts contributed about 0.3 percent per year of the output per man-hour growth over the last two decades. The shift in composition of the work force within manufacturing between production and nonproduction workers contributed 0.1 percent per year to the rate of increase in private output per man-hour over the last two decades. In recent years this has been reduced considerably to less than 0.05 percentage points.

In view of the limited information on occupational detail, another approach (followed by Denison) to ascertain the impact of shifts and changes in the work force has been to utilize information on changes in age, sex, and education. He estimates, for example, that the increase in education of the work force contributed 0.7 percentage points to the trend rate in output per man-hour from 1950-62. For a longer period, 1929-57, he estimates the effect to be 0.9 percentage points per year. Another estimate of the contribution of education to the growth rate by Schwartzman [6] provides a much lower figure—three-tenths of a percent per year for a roughly comparable period, 1929-63. The magnitude of these differences in this critical area suggests that there is need for further exploration of the interrelationship between education skills, training, earnings, and productivity.

2. *Gaps in coverage.* Payroll data on employment and average weekly hours, which are the primary source of man-hours estimates, do not include the entire economy, but are limited to nonfarm wage and salary workers. These data do not cover farm workers, proprietors, unpaid family workers, and domestics. Estimates for these sectors, for the most part, are taken from the labor force series (based on household surveys) which is not strictly comparable to the payroll series. Employment is a count of persons rather than jobs as in the payroll data, so that appropriate adjustments must be made.

Average hours for supervisory workers in nonmanufacturing industries are not available. The assumption is made that the average workweek for these workers is the same as for the nonsupervisory workers in each industry. Since 85 percent of all employees in nonmanufacturing industries are nonsupervisory workers, however, the effect of this imputation may be minimal.

Sampling procedures also affect the man-hours estimates. One week of each month is used to represent the entire month. If anything unusual, such as an unpaid holiday, strike, or bad weather, occurs during this period, the estimates will reflect these aberrations for the entire

[6] David Schwartzman, "Education and the Quality of Labor, 1929-63," *American Economic Review,* June 1968.

month. On the other hand, fluctuations in employment between survey periods may not be reflected in the sample estimates. For example, short-term layoffs and plant shutdowns of 1 to 2 weeks between survey periods would not be reflected in the man-hour estimates for the month—leading to an overestimate of man-hours and an underestimate of productivity.

3. *Hours paid versus hours worked.* Because of lack of data, productivity measures for the most part refer to hours paid rather than the more desirable measure of hours worked.

Surveys now are being conducted biannually for the nonfarm economy where information on leave hours and hours worked will soon provide a body of data which will fill some gaps in this area. Estimates of the effects of the difference between hours paid for but not worked on output per man-hour measures developed by the Bureau of Labor Statistics indicate that the effect over the last 15 years has been about 0.1 percent per year for the nonfarm economy.

The effects of course can vary substantially by sector and at the industry level. Within manufacturing, the annual surveys and censuses of manufactures do provide measures of what could be termed plant man-hours, and these are used in many industry productivity measures.

Total factor measures

Total factor productivity measures relate output to the weighted sum of labor and capital and are therefore subject to the limitations of each of these data series. The problems of measuring output and labor input have been discussed. Capital measures, however, are probably the most difficult and complex measures to derive. They contain highly differentiated elements, and to express this differentiated stock in physical terms requires adjusting dollar values of assets for price change.

For the most part, available data for prices of structures are based primarily on cost information. As mentioned earlier, they do not take into account savings in utilization of materials and other inputs. Furthermore, the problems of obtaining representative prices for equipment which is highly differentiated severely affects the adequacy of the price measures used in capital measurement.

In addition, technical advances are often built into capital so that a piece of equipment produced in an earlier period may not be as efficient as one currently produced. In constructing price indexes, some of these technical improvements may be incorporated as quality changes, but adjusting for quality is often difficult. There is some question as to whether improvements in the quality of new capital should be incorporated in the capital stock measures or treated as a productivity increase. Both interpretations have been used in productivity analysis.

Total factor measures as currently presented are not consistent with their treatment of capital and labor. In general, labor refers to actual man-hours whereas capital refers to available stock not taking into account varying levels of utilization.

AVAILABLE MEASURES OF PRODUCTIVITY

Labor productivity

National measures. Each quarter, the BLS prepares and publishes indexes of output per man-hour for the private economy and for the farm, nonfarm, and manufacturing sectors. [7] For these measures, output per man-hour refers to the constant dollar value of goods and services produced in relation to the man-hours of all persons employed (including proprietors and unpaid family workers). Corresponding and comparable indexes of hourly compensation and unit labor costs are also developed.

The output measure for these productivity indexes is real gross national product originating in the private economy or the individual sectors. It comprises the purchase of goods and services by consumers, gross private domestic investment (including the change in business inventors), net foreign investment, and government all deflated separately for changes in prices.

Final goods and services are differentiated from intermediate products in that they are usually not purchased for further fabrication or resale. In addition to purchases in the market, final goods and services also include some items provided but not actually purchased such as food furnished to employees, food produced and consumed on farms, and the rental value of owner occupied homes.

Measures for the farm, nonfarm and manufacturing sectors are derived by subtracting the value of goods and services purchased by the sector from the constant dollar value of products and services leaving the sector. [8]

The labor input measures for these series are based largely on a monthly survey of establishment payroll records. Since this survey does not cover total employment in the private economy and because there are gaps in the hours information, it is necessary to use some supplementary data to derive man-hours estimates for all persons engaged in producing the output of the private

[7] Productivity, Wages and Prices, quarterly release issued by the Bureau of Labor Statistics, U.S. Department of Labor.

[8] The actual measures are developed according to a variety of approaches because of data limitations. However, all are attempts to approximate this concept.

economy. Various sources are utilized and data from them are adjusted for consistency with the establishment man-hours.

The establishment man-hours are based on an hours paid rather than an hours worked concept. That is, the estimates include paid holidays, vacations, sick leave and other time off paid for by the employer in addition to actual hours worked.

Another set of labor productivity indexes is developed based on man-hours obtained from a monthly survey of the noninstitutional civilian population. This survey of households provides information on the labor force, employment, unemployment as well as man-hours. The man-hours estimates for the labor force series are based on an hours worked concept, i.e., hours spent at the establishment, thus excluding vacation and sick leave but including such things as rest periods and standby time.

Since compensation data are derived primarily from establishment payroll records, when relating labor productivity measures to hourly compensation, the appropriate series is the one based on establishment man-hours. On the other hand, when examining the relationship between productivity changes and displacement of workers, since the employment and unemployment measures are based on the household survey, the more consistent output per man-hour measure is the one based on labor force data.

In addition to the current indexes of output per man-hour published by the BLS, John Kendrick of the National Bureau of Economic Research has published indexes of output per man-hour for the private economy and major sectors (as well as total factor productivity) which include a series that makes adjustments for changes in the composition of man-hours.[9] Using average hourly earnings for weighting man-hours at the industry level he derives an index of output per weighted man-hour. The basic man-hour data for this series are generally the same as those for the establishment series and the weights are also derived from BLS average hourly earnings data. These indexes presently cover the period 1887 to 1966.

Edward Denison of the Brookings Institution has published measures of output per labor input in the form of growth rates for selected periods, the most recent being 1950-62.[10] These measures also take into account changes in the quality of labor; however, the procedure differs from Kendrick's. Adjustment based on age, sex, education, and other changes in the labor force are applied to basic employment and man-hours measures to derive labor input reflecting changes in quality. These measures are available only at the national level.

Industry measures. In addition to the indexes for the private economy and major sectors, the BLS publishes annually indexes of output per man-hour for selected industries.[11] At the present time, measures for about 40 manufacturing and nonmanufacturing industries such as steel, motor vehicles, railroad transportation, coal, etc., are prepared.

The output measures for these indexes are developed by combining the data on quantities of commodities or services within the industry with fixed period weights. As mentioned earlier, man-hour weights would be preferred for developing these measures and insofar as possible these are used. However, where such information is not available, other weights such as unit labor costs, or unit value (price) are used. These substitutions are introduced on the assumption that unit values are good commodities in an industry.

In addition, for some industries where it is not possible to obtain any quantity information, indexes of deflated value of output are developed. For these industry measures current dollar value estimates are divided by indexes of price change for the industry to derive a real output measuer. The adequacy of these measures is dependent on the quality of the price measure.

The labor input data for these measures are establishment man-hours. As in the aggregate measures, they are derived from payroll records and for the most part are based on an hours paid concept. For manufacturing industries, however, additional man-hours information is available in terms of hours at the plant. These data which theoretically exclude vacation, holdiays, and such leave hours are closer in concept to an hours worked measure. Unfortunately, the information on plant man-hours is usually not as current as that from other sources on establishment man-hours.

Capital productivity

Measures of output per unit of capital are not available on a current basis. Historical measures have been developed by a number of researchers.

Separate estimates of capital stock and hence measures of capital productivity are available for the private economy from sources such as the National Industrial Conference Board, National Bureau of Economic Research, and many economists doing research in production analysis. In addition, the Office of Business Economics prepares 12 different capital series depending on alternative options for service lives, depreciation, and

[9] John W. Kendrick, *Productivity Trends in the United States*, Princeton University Press, 1961.
[10] Edward F. Denison, op. cit.
[11] *Indexes of Output per Man-Hour, Selected Industries, 1939 and 1947-70* (BLS Bulletin 1692).

adjustment for price change. These estimates are constructed within the framework of the national accounts and are consistent with output measures used for labor productivity in the private economy. However, the variation among these series gives different results for the growth of capital productivity.

The OBE estimates are prepared annually for the private economy, farm, manufacturing, nonfarm, and nonmanufacturing. They include equipment and nonresidential structures, but exclude such items as housing, motels, and hotels.

These capital stock series are developed using the perpetual inventory method. That is, each new piece of equipment or structure is added into the stock estimates and remains there until retired from use. Retirements of assets are based on mean useful service lives published in the Internal Revenue Services Bulletin of Service Lives of Assets. Because the latter are believed to overstate asset lives, OBE prepares estimates of capital series either based on Bulletin F or 85 percent of Bulletin F service lives.

Net capital measures are derived using either straight line or double declining balance depreciation.

Most other capital series are developed in a manner similar to the OBE measures with other variations on mean service lives and methods of depreciating assets.

Combined factor input productivity

The second group of productivity measures—those which relate output to several factors—involve the weighting together of the quantities of the separate factors. For the most part, these measures have been limited to output per unit of capital and labor combined.

Just as the separate components of an output index must be combined with appropriate weights, the separate components of the input measure also must be appropriately weighted together. Capital and labor can be aggregated using their unit costs (e.g., wages, rate of returns of capital) in a base year as weights. These weights can also be viewed as the proportion of current dollar output earned by each input (factor share) in a base period.

Two sources of combined factor input or total factor productivity measures exist—the work done by John Kendrick for the National Bureau of Economic Research and that by Edward Denison in his work on sources of growth.

Kendrick provided annual measures for the period 1889 to 1957, and more recent measures, 1957-69, will be available early in 1972. Estimates cover the private economy and are based on GNP output measures. Separate measures were made for farm, manufacturing, trade, finance, transportation, public utilities, and services and for selected industries within these major groups.

Labor input is measured in man-hours and adjusted for quality change using industrial hourly earnings. Capital includes the net stock of structure, plant equipment, inventories, working capital and land. The capital measures do not include quality inprovements which can occur because of technical advance. The capital and labor input are added together with factor prices as weights. The base period for the weights was changed periodically to reflect economic conditions of the various subperiods under analysis.

The combined factor measure developed by Edward Denison relates net domestic product (excluding depreciation) to weighted sum of capital and labor. The weights are the base period share of dollar output of each of these inputs. He also periodically shifted the base period for the factor shares to reflect current economic conditions. Denison's analysis covers the total economy for the 1919-62 period, and he is currently updating his work.

His labor input is employment adjusted for quality change using relative earnings for selected age-sex-education groups. He also adjusts the labor input for intensity of effort as reflected in varying lengths of the workweek. His assumption is that as the workweek declines productivity improves because the worker is less fatigued and can work more diligently.

RECOMMENDATIONS

Within the general constraints imposed on all users of economic data, productivity measures for the total private and private nonfarm economics and for selected major sectors (manufacturing, mining, trade, transportation, communication, and public utilities) are reliable and useful for economic analysis. Conversely, productivity measures for construction and service-type industries are not reliable measures for identifying either the magnitude or direction of change in productivity for the reasons outlined above. To improve these measures, additional information must be developed in two areas—the data base from which output, input, and price statistics are compiled, and the conceptual base upon which the output and price data are developed.

Additional price information

More and better price information in the service and construction industries is of prime urgency. In construction, work is currently underway by the Census Bureau to develop price measures in order to improve the measures of the real volume of residential construction put in place. Additional research is also necessary for nonresidential construction. In the service sector, more adequate

and extensive price information on personal services is needed as well as the expansion of wholesale prices to include business services. The BLS at the present time is trying to develop an index of the general price level. The development of this index will materially assist productivity measurement because it will require the collection of a wider range of service prices.

More work is also needed in collecting data on durable equipment (such as heavy machinery and aircraft) which is highly differentiated and often custom-made.

Another recommendation is to have timely (quarterly and annually) estimates on the imputed rental value of owner occupied housing so that it may be excluded from the output estimate and not bias productivity measurement.

Better man-hour and capital data

Input data also need to be improved. Most important to productivity measurement would be better estimates for certain components of labor input. This would entail estimating supervisory hours in nonmanufacturing and expanding employment sampling coverage so that resultant data refer to the entire month rather than 1 week. Adjustment for changes in labor quality calls for more detailed information on occupational wages and man-hours. Some research is being carried out using occupational and wage data to account for some changes in labor quality, but it is necessary to develop a more integrated system for collection than in currently in effect.

Capital information is also needed to make a more complete analysis of factors affecting productivity growth. Of paramount importance are better data on changes in the quality of capital equipment and the length of service lives.

The concepts used to define output need to be changed to conform to a productivity framework. This is particularly true of government and households and institutions where actual output definitions are needed rather than merely relying on an employment measure.

Financial intermediaries also present definitional problems. For example, banking output is currently measured as liquidity. If the output reflected changes in the number of transactions weighted by some value measures, it would be more compatible with the inputs and provide a means for making a better productivity measure.

These recommendations will not solve all of the problems of productivity measurement. However, they will certainly improve the output and related input measures and thereby make productivity a more viable tool for economic analysis.

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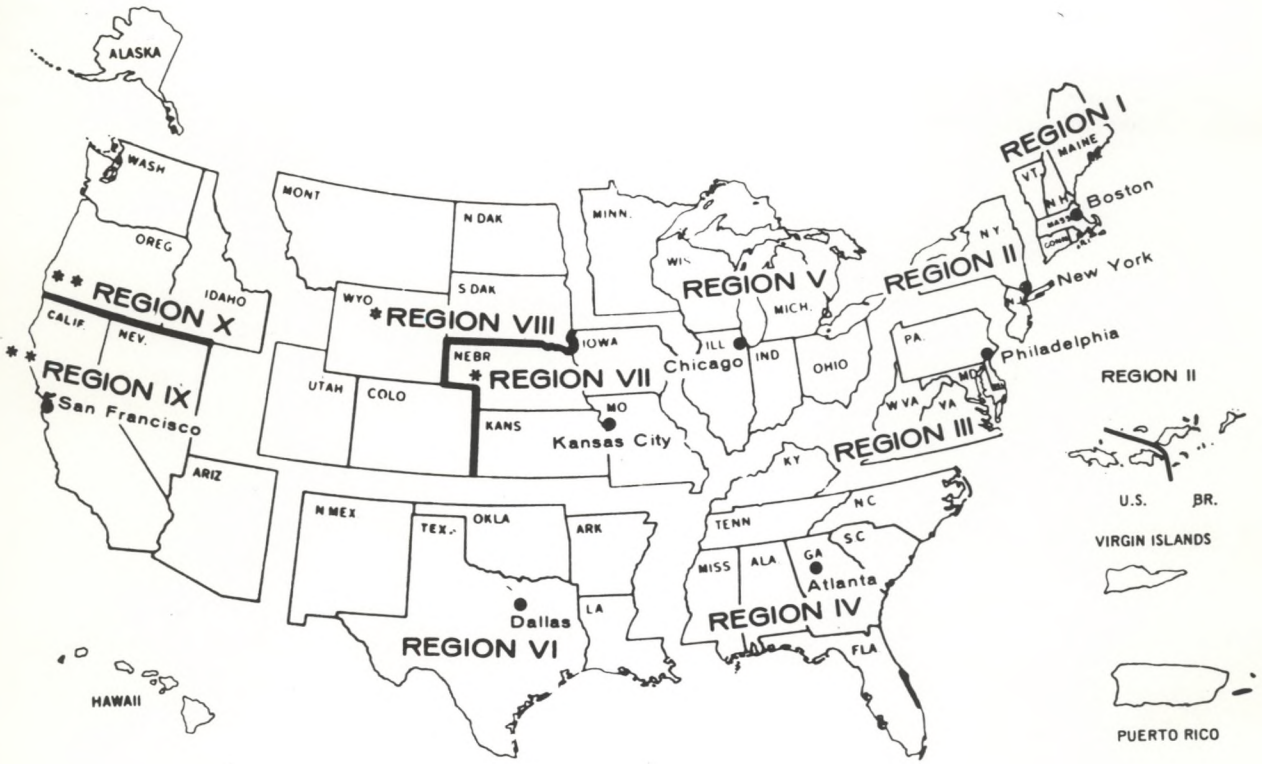

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