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Productivity, in economics, the ratio of what is produced to what is required to produce it. Usually this ratio is in the form of an average, expressing the total output of some category of goods divided by the total input of, say, labour or raw materials.

In principle, any input can be used in the denominator of the productivity ratio. Thus, one can speak of the productivity of land, labour, capital, or subcategories of any of these factors of production. One may also speak of the productivity of a certain type of fuel or raw material or may combine inputs to determine the productivity of labour and capital together or of all factors combined. The latter type of ratio is called "total factor" or "multifactor" productivity, and changes in it over time reflect the net saving of inputs per unit of output and thus increases in productive efficiency. It is sometimes also called the residual, since it reflects that portion of the growth of output that is not explained by increases in measured inputs. The partial productivity ratios of output to single inputs reflect not only changing productive efficiency but also the substitution of one factor for another—e.g., capital goods or energy for labour.

Labour is by far the most common of the factors used in measuring productivity. One reason for this is, of course, the relatively large share of labour costs in the value of most products. A second reason is that labour inputs are measured more easily than certain others, such as capital. This is especially true if by measurement one means simply counting heads and neglecting differences among workers in levels of skill and intensity of work. In addition, statistics of employment and labour-hours are often readily available, while information on other productive factors may be difficult to obtain. Although ratios of output to persons engaged in production or to labour-hours are referred to as labour productivity, the term does not imply that labour is solely responsible for changes in the ratio. Improvements in output per unit of labour may be due to increased quality and efficiency of the human factor but also to many other variables discussed later. There is special interest in labour productivity measures, however, since human beings are the end as well as a means of production.

The productivity of land, though it receives considerably less attention than the

productivity of labour, has been of historical interest. In ancient and preindustrial times the products of the soil constituted the bulk of total output, and land productivity thus constituted the major ingredient in a people's standard of living. Soil of low productivity could, and over much of the Earth still does, mean poverty for a region's inhabitants. It is, however, no longer generally believed, as it was in past centuries, that a country's economic well-being is inevitably tied to the productive powers of the land, and the productive potential of the land itself has proved to be not fixed but greatly expandable through the use of modern agricultural methods. Moreover, industrialization, where it has taken place, has greatly reduced people's dependence on agriculture. These circumstances, together with expanding opportunities for trade, have enabled some countries to overcome in substantial degree the handicaps of a meagre agricultural endowment.

The productivity of capital—plant, equipment, tools, and other physical aids—is a subject of long-standing interest to economists, though concern with its empirical aspects is of more recent origin. Improved statistical reporting and the availability of data in some industrially advanced countries, notably since World War II, have encouraged systematic efforts to measure the productivity of this factor. Compared with achievements in measuring labour productivity, however, the progress realized has been quite limited. There are considerable theoretical and practical difficulties to be overcome.

Uses of productivity measurement

Index of growth

A nation or an industry advances by using less to make more. Labour productivity is an especially sensitive indicator of this economizing process and is one of the major measures used to chart a nation's or an industry's economic advance. An overall rise in a nation's labour productivity signifies the potential availability of a larger quantity of goods and services per worker than before and, accordingly, a potential for higher real income per worker. Countries with high real wages are usually also those with high labour productivity, while those with low real wages are generally low in productivity. If, for the moment, other productive factors are neglected, one can see that the wage level will then be equal to the total national product divided by the number of workers; that is, it will be equal to the level of labour productivity.

The change in a nation's overall labour productivity during any given interval represents the sum of changes in the major economic sectors and industries. Some

sectors and industries move ahead more rapidly than the overall average while others may gain more slowly or even decline. In the movement of a country from a level of low productivity and low income to one of high productivity and high income a strategic role is played by the industrial, rather than by the agricultural and other, sectors. In the late 18th and early 19th centuries the effect of the Industrial Revolution was felt first in the manufacture of woolen and cotton textiles, power generation, the metal trades, and machine-making industries. Along with the development of new processes came the development of new products and services that formed the basis for new industries. An outstanding feature of these changes was an increased labour productivity that in turn laid the foundations for an enormous expansion of output. Technological change exerted its influence irregularly and unevenly and continues to do so.

In the compilation of overall averages this diversity is concealed because high rates in some industries offset low rates in others. Thus, the rate of increase of productivity for the economy as a whole varies within narrower limits than the spread of rates among individual industries would suggest. Aside from erratic short-term movements, the rate of growth of productivity may appear to be fairly stable over extended periods. A surge of labour-saving innovations would cause the overall average rate to move higher, while a technological lull would depress the average rate. History suggests that the surges tend to be associated with basic technological changes such as, for example, the steam engine, the gasoline engine, the electric motor, and the concept of the standardization of parts. Once introduced, such inventions or developments are used in many different industries. These surges tend also to be associated with such developments as, for instance, employment of the open-hearth furnace in steel manufacture or the introduction of the steam railroad.

Productivity is valuable also as an indicator of comparative rates of change among industries and products. Growth in general can be better understood if the relative contributions of individual industries and the circumstances underlying productivity changes in each of these industries are understood.

Measure of efficiency

Productivity is also used to measure efficiency, as an aid in economic planning and forecasting, and as a means of assessing the uses to which resources are being put. As to the first of these, the efficiency of industrial operations, for instance, may be evaluated by the yardstick of output per worker or machine, and such a yardstick may also provide the basis for supplemental or premium payments for workers.

When pay is based on piecework alone, labour productivity becomes the sole determinant. Productivity may also serve as a standard for grading and evaluating any group of workers performing common tasks, distinguishing the more from the less productive. And applied to equipment, productivity standards can indicate when a machine is performing poorly and is in need of service. In forecasting, productivity estimates are useful when it is necessary to be able to project the performance of the economy at some future date, given the probable size of the working force. A variant of this is common in planning for developing countries that want to increase their productivity; information about target levels of productivity, together with expectations as to the growth of the labour force and some understanding of the relation between capital per worker and output per worker, helps in estimating the amount of capital investment needed to reach the target. Again, estimates of the probable annual gain in labour productivity together with estimates of the probable annual increase in output allow one to estimate how many jobs will become available at some time in the future. Finally, productivity is a helpful analytical tool in studying the possible allocation of resources among different uses. The extent to which resources flow to various uses depends, among other things, on their productivity in each of those uses. Changes in productivity in the course of time alter the pattern of use and cause the quantities of resources required in particular uses to change. The resulting trends depend on several things. On the one hand, an increase in the productivity of, for instance, labour, since it means a decrease in labour requirements per unit of output, will tend to reduce the demand for labour. But it will also imply a cheapening of labour relative to the cost of other competing factors of production. Hence there will be a tendency to substitute labour for other factors. When labour cost represents a large fraction of total cost, a productivity increase will contribute toward a reduction in the price of the product, thereby expanding sales and with them the demand for labour. The net result will depend upon the sum total of all of these separate effects. It is by no means uncommon to find that the expansionary effects predominate, and many economists consider this to be the normal outcome. In any event, the productivity concept and data on productivity trends can contribute to an understanding of resource and output flows.

Wage and price analysis

Real average labour compensation has increased over the long run at about the same pace as labour productivity. The association of these two variables must be close so long as the labour share of total cost does not change much. If nominal average earnings were to increase more than labour productivity, labour cost per unit of

output would rise and so would prices unless profit margins were reduced to compensate. In general, prices rise by less than wage rates and other input prices to the extent that total productivity rises. Productivity growth is thus an anti-inflationary factor, although inflation is basically a monetary phenomenon.

There is a significant negative correlation between relative industry changes in productivity and in prices—when productivity rises, price tends to fall. In the industrial sector of an economy in which there is a significant price elasticity of demand (i.e., where price is relatively responsive to changes in demand), there is also a significant positive correlation between relative industry changes in productivity and in output—when productivity rises, output tends to rise as well. This is an interactive relationship, since the tendency of price to fall as productivity increases is reinforced by the tendency of economies of scale made possible by increased output to further enhance productivity.

In dynamic economies the supply of capital has risen faster than the size of the labour force, and wage rates have risen faster than the price of capital. As a result there has been a marked tendency to substitute capital for labour in almost all industries. Yet there has been no long-term trend toward increased unemployment because real aggregate demand has tended to rise enough to absorb the growth of the labour force. Cyclical fluctuations in output and employment in capitalist countries are not the result of technological displacements of labour but rather reflect macroeconomic variables, such as growth of the money supply, that affect aggregate demand.

Factors that determine productivity levels

The level of productivity in a country, industry, or enterprise is determined by a number of factors. These include the available supplies of labour, land, raw materials, capital facilities, and mechanical aids of various kinds. Included also are the education and skills of the labour force; the level of technology; methods of organizing production; the energy and enterprise of managers and workers; and a range of social, psychological, and cultural factors that underlie and condition economic attitudes and behaviour.

These variables interact and mutually condition one another in determining productivity levels and their changes. Thus, in any country one expects the level of technology, the skills of the work force, the quantity of capital, and the capacity for rational economic organization to be positively correlated. A country with low

productivity is likely to have deficiencies on all counts; a country with high productivity is likely to score high on all. To put it differently, the numerous productivity-determining factors behave as variables in a system of simultaneous equations, with all acting concurrently to shape the outcome. Within this system, there are no grounds for assigning causal priority to one or a few variables. All interact mutually to determine the outcome. Within certain problem frameworks, however, it may be entirely appropriate and indeed essential for explanatory purposes to emphasize certain variables over others.

Two broad problem frameworks may be distinguished, both of them of concern to students of productivity and growth. One of these involves changes in productivity over time; the other involves differences in productivity levels among enterprises, industries, and countries at a given time. Within these frameworks are many problems and subproblems, each of which may lead to a different selection and emphasis of variables.

Explanations of long-term productivity changes in a country, region, or industry usually stress technological change and, as an adjunct, changes in the quality and quantity of capital. Other variables are regarded as playing a passive role and are subordinate. The justification for this is that change in technological knowledge and the capital embodying it is both essential to substantial gains in productivity and the factor most immediately associated with those gains. It ordinarily is perceived as the leading and moving force in the process. When technological change occurs, the quality of capital improves and the amount available to aid each worker usually increases. The kinds of raw materials used may change, with better grades being required or the use of lower grades becoming possible. Changes occur in the way productive factors are organized and production is carried on. Although in some periods and in some circumstances work may have become harder and more tedious following technological advance and although the transition from land to factory has often entailed special hardships, the dominant trend has been toward shorter hours and a diminution of the arduousness of labour.

Emphasis on technological change and capital accumulation as primary forces arises also from a recognition that they are essential and unique to large and systematic advances in productivity. Those gains that can be obtained solely through a reorganization of work or the use of better raw materials or the breakdown of restraining attitudes or practices may occasionally be dramatic, but they are always limited. By contrast, very substantial gains can follow in the wake of growing technological knowledge and increasing supplies of capital. If allowance is made

simply for adaptive changes in other factors, the prospects for advance become almost unlimited. Only these two factors can fairly be singled out as constituting the engines of productivity growth.

It has been noted that both the quantity of capital and its quality change as productivity increases, and it is not possible adequately to separate the two in terms of their effects. Increases in capital per worker through the accumulation of more and more of the same kinds of equipment and tools would not lead continuously to proportionate or more than proportionate increases in output per worker. They would, after a point, lead to diminishing increases and eventually even to a decline in output per worker. The onset of a decline would be far distant in an industry or economy possessed of a high level of technical knowledge but starting near the bottom of the accumulation ladder and affected by an acute scarcity of capital instruments. But an ultimate decline would be expected.

Qualitative changes in capital, reflecting advances in knowledge and skill and leading to the design and construction of improved capital instruments, offer an escape from this principle. If capital can be steadily improved over time, its expansion need not entail diminishing returns. In countries for which data from broad sectors and many individual industries are available, there is a rough correlation between growth in the quantity of capital per worker and increases in labour productivity.

Measurement of productivity

As a prelude to an examination of productivity trends over time, this section considers various methods of measuring the output and input components of productivity ratios and some of the difficulties and limitations of the resulting estimates.

Output

With respect to output, ideally the numbers of units of each category of tangible commodity or service should be counted in successive time periods and aggregated for the firm, industry, or total economy in terms of some indicator of relative importance, usually price or cost per unit as of a particular period. The unit value “weights”—price, cost, or other—must be held constant for two or more periods being compared so that changes in aggregate output reflect changes in physical volumes rather than in prices. An alternative procedure that produces the same results with ideal data is to “deflate” current values of the various items produced by index

numbers that reflect relative price changes in order to eliminate the effects of price changes. Price deflation is usually employed to obtain estimates of real gross product by sector and industry to be used as numerators of productivity ratios. For tangible industrial production measures, quantities of the various commodities are generally weighted together by constant unit values.

Unfortunately, in most countries data on quantities and prices for many outputs of the finance and service industries are deficient. In the broader real gross product estimates, changes in outputs of a portion of such services are approximated by estimating changes in inputs. Estimates so derived are not suitable for productivity measurement, however. They impart a downward bias to estimates of real product and productivity for the services sector and its affected components and hence for the economy as a whole.

Other problems in estimating output arise in adjusting estimates of outputs to take account of quality change, measuring quantities or prices of nonstandard custom-made products, and estimating outputs of nonmarket goods and services. Partial adjustments for quality changes may be made when increases in real costs per unit are associated with the improvements. But it is generally agreed that physical-volume or real-product measures fail to capture at least part of the improvements in product quality, as distinguished from relative shifts among alternative qualities (price-lines) of a given product. Methods of estimating changes in the physical volume of custom-built products, such as buildings or other major structures, have improved in recent years. But changes in the output of nonmarket goods and services, such as those of governments, households, and nonprofit institutions, must generally be measured by changes in inputs. In consequence, productivity estimates are usually confined to the predominant business (enterprise) sector of an economy.

Inputs

Labour input is relatively easy to measure if one is content to count heads of persons engaged in production or, preferably, hours worked. But in fact, the available hours data often relate to hours paid for, rather than hours worked, and these tend to rise in relation to hours at the workplace as the number of paid holidays and leaves are increased. Official estimates generally do not differentiate among various categories of labour. But some academic economists measure labour inputs by occupation and/or industry and possibly other categories and weight the aggregate in each category by a measure of the average compensation in some designated base period. As the average levels of education, training, skills, and experience of workers

increase, the weighted measures rise relative to unweighted measures of labour input. Change in the ratio of the two indicates change in the quality of labour input, which is an important part of the explanation of change in productivity.

Capital input is usually assumed to change in the same direction as and proportionally to changes in the real stocks of structures, equipment, inventories, and natural resources. The rates of return on those capital goods in some base period are taken to be indicative of their productivity for the purpose of weighting them together with other factor inputs. Some analysts adjust the capital estimates to take into account changing rates of utilization of capacity; otherwise, changes in utilization rates are reflected in the productivity estimates.

Interindustry purchases and sales of intermediate products—those materials, energy, and other services that are consumed in the production process—are accounted for on a value-added basis and cancel out in the national income and product estimates by industry (one industry's output being the next one's input). But if intermediate purchases are counted as an input for comparisons with gross output estimates, they are measured in the same manner as described for outputs.