Volume Title: Basic Facts on Productivity Change

Volume Author/Editor: Solomon Fabricant

Volume Publisher: NBER

Volume ISBN: 0-87014-377-8

Volume URL: http://www.nber.org/books/fabr59-1

Publication Date: 1959

Chapter Title: The Long-Term Rate of Increase in National Productivity

Chapter Author: Solomon Fabricant

Chapter URL: http://www.nber.org/chapters/c0505

Chapter pages in book: (p. 3 - 10)

the many pages needed to expose to public scrutiny the evidence on which they are based – essential if they are to merit the confidence needed for wide acceptance.

It is useful, in these circumstances, to put together some of the main results of this substantial research effort, state the findings in a minimum of technical language, and make the results available promptly. This is the purpose of the present paper.

Even a summary of facts will have to cover a good deal of territory. Something needs to be said about each of the following matters: the long-term average rate of growth of national productivity; the degree to which growth of productivity has experienced change in pace; productivity increase in relation to the rise in the nation's real output; the extent to which increase of productivity has been the general experience of the various industries of the economy; and the relation between productivity increase and the increase in real wages. To each of these subjects, therefore, a brief section is devoted which lists the main facts and provides such discussion of concepts, data, alternative measurements and findings as is necessary to make the results intelligible. We conclude with a word on recent changes in productivity.

The Long-Term Rate of Increase in National Productivity

Over the sixty-four years between 1889 and 1953 – the period which has been examined most closely and for which presently available statistics are most adequate – the rate of increase in productivity has been as follows:[2]

Physical output per manhour in the private economy has grown at an average rate that appears to be about 2.3 per cent per annum.

Comparing output with a measure of labor input in which a highly paid manhour of work counts for proportionately more than a low-wage manhour yields a measure of productivity for the private economy that grew at a significantly smaller rate – about 2.0 per cent per annum.

A measure of productivity for the private economy that compares output not only with labor input (so determined) but also

[2]Average annual rates for the slightly longer period 1889-1957 (utilizing preliminary estimates for 1954-57) are not significantly different.

with tangible capital, each weighted by the market value of its services, grew still less rapidly – about 1.7 per cent per annum.

All these indexes of productivity in the private economy rose somewhat more rapidly than the corresponding indexes for the economy as a whole, including government, when the usual measurements of government output and input are utilized. For the total including government, productivity rose about 1.5 per cent per annum.

This list presents the main broad measures of long-term productivity increase that John Kendrick has calculated for the American economy. It is by no means complete. Kendrick goes to some trouble to provide still other measures that differ in definition of output or input, in the degree to which they cover the economy, or in details of estimation. However, as Table 1 indicates, these alternative calculations yield results similar to those just given and we may therefore concentrate on the above measures. They differ enough among themselves to raise a serious question about the meaning and measurement of productivity.

Productivity, I have mentioned, is a measure of the efficiency with which the nation's resources are transformed into the consumption, investment, and other goods that satisfy individual or collective wants. Now we can become more (or less) efficient in the use of a particular type of resource, say, plant and equipment, as well as of resources taken as a whole. A given volume of product might be obtained from a smaller amount of plant and equipment, used in conjunction with an unchanged amount of labor, land, inventory, and other resources. This would be a real gain. It would be proper to consider it the result of an increase in efficiency (if fluctuations due to weather and the like were not the cause); and we could measure the increase in efficiency by calculating the ratio of an index of physical output to an index of the volume of plant and equipment. We could also refer to this ratio as a productivity index, as is frequently done. It is necessary to note, however, that we would have to be sure that all resources other than plant and equipment had in fact remained constant (or equivalently, that we had been able to eliminate the effect of changes in them by appropriate statistical techniques), before we could interpret the index as reflecting change in efficiency.

We would also have to recognize that the importance of the change so calculated depended on the size of the particular input – in this case, the services of plant and equipment – relative to other

TABLE 1

Broad Measures of the Long-Term Rate of Increase in Productivity in the United States

Average annual percentage rates of change, 1889-1953

	Aggregate of Industries for which Individual Productivity Indexes Are Available	*Entire Private Domestic Economy*	*Entire Economy, including Government*		
			"National security" version of output	"Peace-time" version of output	Dept. of Commerce version of output
Gross physical output per unweighted manhour	2.3	2.3	2.2	2.0	2.2
Net physical output per unweighted manhour		2.3	2.2	2.0	2.2
Gross physical output per weighted manhour	1.9	2.0	1.8	1.6	1.8
Net physical output per weighted manhour		2.0	1.8	1.6	1.8
Gross physical output per unweighted unit of tangible capital	1.0	1.2	1.0	0.9	1.0
Net physical output per unweighted unit of tangible capital		1.2	1.0	0.9	1.1
Gross physical output per weighted unit of tangible capital	1.0	1.0	0.8	0.7	0.8
Net physical output per weighted unit of tangible capital		1.1	0.9	0.7	0.9
Gross physical output per weighted unit of labor and tangible capital combined	1.7	1.7	1.5	1.4	1.5
Net physical output per weighted unit of labor and tangible capital combined		1.7	1.6	1.4	1.6

Source: John W. Kendrick, "Productivity Trends in the United States" (a forthcoming report of the National Bureau of Economic Research), especially Chapter 3 and Appendix A. The underlying indexes, reproduced in part in Tables A and B, below, are subject to some revision. Use was made by Kendrick of estimates developed in other National Bureau studies by Kuznets, Goldsmith, Blank, Tostlebe, Ulmer, Creamer, Borenstein, and Barger, among others, as well as of data published by the Departments of Commerce and of Labor.

Gross output differs from net output by the amount of depreciation and other items of capital consumption, in the case of the national indexes; and also by the amount of materials, fuel, and supplies consumed, in the case of the industries covered in the first column of figures (except agriculture). See Kendrick for a fuller explanation of those differences; and also for a detailed explanation of the difference between the weighted and unweighted indexes.

Industries for which individual productivity indexes are available for 1889-1953 include farming, mining, manufacturing, transportation, and communications and public utilities. The detailed list is given in Table B.

The three sets of indexes for the entire economy differ mainly in the treatment of defense outlays in the calculation of national product and of inputs. The "national security" and "peace-time" versions of national product are based largely on concepts developed by Kuznets; the Department of Commerce version is that currently published by its Office of Business Economics.

inputs. If the services of plant and equipment constituted a small fraction of total input, doubling the ratio of product to plant and equipment would have much less significance than if these services constituted a large fraction. In other words, an adequate index of productivity for a single resource requires not only eliminating the effect of changes in other resources, but also somehow taking into account the relative importance of the resource.

When other resources are used in significant volume, and change occurs in the volume of such resources used (which is almost always the case), a measure of productivity based on a single resource might tell us little or nothing of change in the efficiency with which this resource was being utilized. It might not even point in the right direction. For example, output per unit of plant and equipment might have fallen because plant or equipment was being substituted for labor or other resources. Yet the efficiency with which plant and equipment was being used might have risen.

Nor would the index of output per unit of plant and equipment (or any other single resource) provide reliable information on the efficiency with which all resources were being used. Only if all other resources were of small importance, or moved in the same direction (indeed, in virtually identical proportion) as plant and equipment would an index of productivity based on plant and equipment alone provide a reasonably accurate answer to that question. Yet that is the question with which we are primarily concerned.

As a general rule, therefore, it is better not to limit productivity indexes that purport to measure change in efficiency to a comparison of output with a single resource. The broader the coverage of resources, generally, the better is the productivity measure. The best measure is one that compares output with the combined use of all resources.

Information on all resources is not available, however. Until rather recently, economists interested in measuring the rate of increase in national productivity had to make shift with labor input alone – first, in terms of number of workers, then in terms of manhours. This is still true for most individual industries, narrowly defined, even on a historical basis, and for both individual industries and the economy as a whole on a current basis.

For this reason, the most widely used index of productivity – the one I cited first – is simply physical output per manhour. It is a useful index, if its limitations are recognized. Because in the economy at large and, as we shall see, in most – not all – individual industries, labor input is by far the most important type of input

(measured by the fraction of income accruing to it), the index based on manhours alone is not often in serious error. It is a fair approximation to a more comprehensive index of efficiency. But as such it is usually subject to an upward bias, as the figures cited indicate.

The bias in output per manhour results not only from the omission of capital input. The usual index of output per manhour fails also to take into account change in the composition or quality of labor.[3] That is, manhours worked by persons of different skills, levels of education, and lengths of experience are treated as if equivalent, thus ignoring important forms of human capital that aid in production and contribute to wage and salary differentials. The index of output per weighted manhour – the second index cited – catches some of this intangible capital, for the labor in industries with high rates of pay is given a heavier weight than that in low-pay industries. However, the procedure of weighting is only a step in the right direction. All the labor within an industry is still assumed to be homogeneous. Perhaps more important, broad advances in education and the like, which improve the quality of labor in industries generally, are not taken into account. And differences in labor quality are imperfectly measured by pay differentials, since these are influenced by such other factors as the non-economic advantages and disadvantages of particular occupations, differences in the cost of living, and uncompleted adjustments to changes in demand and supply. The figures previously given – the difference between the rate of increase in output per manhour and in output per unit of labor (weighted manhours), which is 0.3 per cent per annum – therefore indicate the direction but not the degree of bias arising from the neglect of change in the quality of labor.

With respect to tangible capital, we are in a better position. In recent years the available information on tangible capital has been broadened, worked over, pieced out, and put into usable form, and this has helped greatly to expand the coverage of inputs for productivity indexes. The data on tangible capital are still far from perfect. In calculating them, difficulties of all sorts are involved – the treat-

[3]If the index relates output to manhours of work done only by "production workers" – which is frequently the case for individual industries – there is a further source of error. In that case, the index will usually rise more rapidly than output per manhour of work done by all workers, for "nonproduction workers" have, over the years, generally increased in relative importance. Our indexes relate output to the work done by all workers, including proprietors, supervisory employees, and clerical workers, as well as wage earners. The only exception is the index in Table 4, which gives output per production worker.

ment of depreciation, the problem of allowing for changes in prices, and the proper valuation of land, among others. These problems have not been entirely solved, but we appear to be sufficiently close to a solution to warrant use of the data. With them, output per unit of tangible capital may be computed (Table 1).[4] This is informative; but, like output per unit of labor, it is an incomplete index of productivity. It tells only part of the story.

Indexes of productivity based on the comparison of output with the input of both labor and tangible capital are better measures of efficiency than those based on labor input or capital input alone.

Indeed, the best currently available approximation to a measure of efficiency is such an index. As we have seen (it is the third index cited initially in the text), it indicates a rate of growth of productivity that is significantly below the rate for output in relation to labor input alone. That it is lower will not be a surprise, since it is well known that tangible capital has increased substantially more than the labor force: tangible capital per weighted manhour has risen at the average annual rate of 0.9 per cent. Because the services of labor have become more and more expensive relative to those of tangible capital, there has been a strong incentive for business firms and other producers to substitute capital for labor. Yet – and this may be surprising – capital increased less rapidly than did output. On net balance, output per unit of tangible capital rose by about 1 per cent per annum. Technological advance and the other means to improved efficiency have led to savings of capital as well as of labor.

Surprising, also, may be the fact that the difference between productivity measured in terms of labor and tangible capital combined and productivity measured in terms of labor alone is no more than the three-tenths of one per cent per annum that we have found. The reason is the relatively high weight given labor in combining it with

[4]The index of output per weighted unit of tangible capital in Table 1 differs from the index of output per unweighted unit of tangible capital for reasons analogous to those accounting for the difference between output per unweighted manhour and output per weighted manhour. (However, the difference between the average annual rates for output per unit of capital – about 0.2 per cent – is somewhat smaller than the difference for output per manhour. In part at least, this is probably because the number of separate industries or divisions to which the weights can be applied is much smaller in the case of capital than in the case of manhours.) More specifically, the weighting allows for interindustry differences, over the base-period, in ratios of total capital (including intangibles) to tangible capital. The base-period weighting cannot take into account such changes in these ratios of total capital to tangible capital as may occur in years after the base-period; and it has other limitations in accounting for forms of capital other than tangible.

tangible capital. Obviously, manhours cannot be combined with dollars of tangible capital without translating each of them into comparable units. The appropriate unit is a dollar's worth of services in a reference base period. If a manhour of labor commands two dollars in the base period and a hundred dollars of capital equipment commands six dollars of net revenue per year (whether in rent, profits, or otherwise is immaterial), we count the hundred dollars of equipment as equivalent to three manhours. Because, in production, use is made of many more manhours than of even hundreds of dollars of capital, labor as a whole gets a much greater weight than does capital. The weights for the private economy are currently as 8 to 2. The index of output per unit of labor and capital combined – which rose at the rate of 1.7 per cent per annum in the private economy – is thus, in effect, a weighted average of the index of output per unit of labor – 2.0 per cent per annum – and of the index of output per unit of capital – 1.0 per cent.[5]

I have called this weighted index the best available approximation to the measure of efficiency that we seek. It is approximate for more reasons than those already given. One is the problem of measuring output, which involves combining into a meaningful aggregate a changing variety of old and new goods. A special difficulty arises in putting a figure on the quantity of services produced by government to meet collective wants. This accounts for the greater confidence most statisticians have in the estimate of productivity for the private economy, exclusive of government, and explains the plurality of estimates given in Table 1 for the economy inclusive of government.

A general deficiency of all the measures of output – and thus of productivity – is their failure to take adequate account of change in the quality of output. This, it is likely, subjects them to a downward bias. And, to repeat, the indexes of output per unit of labor and tangible capital combined, though broader than any other indexes now available, fail to cover adequately the investment in education, science, technology, and social organization that serves to increase production – a point to which we shall have to return.

The technical questions raised above (which I have selected from

[5]Output may be compared also with a *weighted* combination of *unweighted* manhours and of *unweighted* tangible capital. This is one of the possible alternative calculations not given in Table 1. So measured (see Table A, in the appendix), the rate of increase in productivity turns out to be 2.0 per cent per annum between 1889 and 1953. This is, in effect, the weighted average of the 2.3 per cent for output per unweighted manhour and the 1.2 per cent for output per unweighted unit of capital shown in Table 1.

a host) are, of course, matters primarily for the producer rather than the user of productivity statistics. But for the user it is important to be aware of the sharp differences made in the rate of growth of productivity by technical choices not always specified: whether output or input is defined in one way rather than another, or weights of components of output and input are determined by this rather than that method, or data are selected or estimated from one or another source.

Measured in any of the ways listed above, however, productivity in the United States has grown at a remarkable average rate over the past two-thirds of a century. The more comprehensive indexes, in which output is compared with both labor and capital input, indicate a doubling of efficiency every forty years. The index of output per (unweighted) manhour indicates a doubling even more frequently – every thirty years. Not many of the countries for which corresponding records might be constructed would show average rates as high or higher over so long a period. Over shorter periods, it is very likely, our long-term rate has been exceeded in various countries. This has happened here, as well as elsewhere, as we shall see in a moment. But it is safe to say that the United States' long-term rate is not low in relation to the experience of other countries over comparable periods. It may appear low only in comparison with aspirations – the long-term rates dreamt of by countries embarked on ambitious programs of economic development, or the rates some of our own citizens believe we need to reach and maintain if we are to meet some of the urgent problems that confront us.

Fluctuations in the Rate of Productivity Increase

Productivity did not grow at an even rate. Its rate of growth was subject to a variety of changes, which may be characterized as follows:

A distinct change in trend appeared sometime after World War I. By each of our measures, productivity rose on the average more rapidly after World War I than before.

Over the whole period since 1889, productivity fluctuated with the state of business. Year-to-year rises in productivity were greater than the long-term rate when business was generally expanding, and less (or often, falling), when business was generally contracting.