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Input and Output Measures

What are some of the factors that might account for differences in output per man? Previous studies of productivity and growth have called attention to the following: hours worked per man, skill or quality of labor, capital and other nonhuman resources per worker, technological change or advance of knowledge, and economies of scale. We will examine some of these variables in this paper; others must be deferred to a later date. A discussion of the principal concepts and sources used in the analysis follows.

Output

Output is measured by the U. S. Department of Commerce estimates of gross product originating in each industry in 1954 dollars.¹ This is conceptually similar to the gross national product, but the method of obtaining constant-dollar estimates differs from the total and from industry to industry. In principle, the effect of price change is eliminated by the method known as "double deflation." That is, the output of an industry and its purchases are each deflated separately and the difference between the two deflated figures is taken as the gross product in constant dollars. With modifications, this method was used by the Commerce Department for farms, construction, manufacturing, the major portions of finance and insurance, electrical utilities, and railroads. In other industries, real product was estimated by extrapolating the base-year product by an index of the quantity of total output. The

¹Presented for the first time in Martin L. Marimont, "GNP by Major Industries," *Survey of Current Business*, October 1962, and revised in *Survey of Current Business*, September 1963.

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estimates for the period 1929-47 are based on Kendrick's indexes of real output.²

Gross product is not a completely satisfactory measure of real output by industry, but it is probably the best one available for industry productivity analysis. One advantage is that the industry totals do equal the total GNP, and it is therefore possible to calculate industry productivity measures relative to the total economy. Probably the most important defect of the gross product measures is that output in some industries is estimated from employment data. This problem is most serious in government and some of the other service industries. The possible effect of biases in the output measures on trends in productivity is discussed in Section 5.

It should be noted that much of the analysis presented in this paper is concerned with differential changes in various inputs and will be equally relevant if some different and presumably superior output measures become available.

Employment

The Department of Commerce series "Number of Persons Engaged in Production" is used to measure changes in employment. This series includes self-employed as well as employees reduced to full-time equivalents, and is probably reasonably accurate. The exclusion of unpaid family workers may introduce some measurement errors in agriculture and trade, while the method of converting part-time employment into full-time equivalents may introduce some bias in industries such as services, where part-time employment is significant.³

²John W. Kendrick, *Productivity Trends in the United States*, Princeton University Press for National Bureau of Economic Research, 1961. It may be noted that for the years after 1947, where comparison between Kendrick's output indexes and the Office of Business Economics estimates of real gross product are possible, the two methods yield almost identical results for the sector aggregates.

³In converting part-time employment into full-time equivalents, the Office of Business Economics divides the payroll of part-time employees by the average earnings of full-time employees. If, as seems likely, part-time employees earn less per hour than full-time employees, the OBE procedure will understate the true full-time equivalent employment and will overstate the average annual earnings obtained by dividing total payroll by full-time equivalent employment so estimated.

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Man-Hours

Total man-hours for each industry are obtained by multiplying employment by number of hours worked per year per full-time employee. The latter is based on John Kendrick's estimates of average hours worked per week (with interpolations and extrapolations).⁴

Total Labor Input

If one is interested in measuring total labor input, estimates based on man-hours data present a number of difficulties. First, there are possible defects in the employment series. Second, there is the problem of obtaining accurate information concerning the average number of hours actually worked each year by full-time employees. Third, there is the question whether decreases in hours per week, when hours are long, may not result in an offsetting increase in output per man-hour.⁵ Finally, man-hours data tell us nothing about the quality of labor attributable to differences in intelligence, strength, training, and so on. It would be useful to have a measure of labor input which took account of all these factors.

Provided we accept certain assumptions to be discussed, we may be able to approach such a measure through the data on labor compensation. Labor compensation refers to the total payments made to labor, including wages and salaries and supplements to wages and salaries, and the labor income of the self-employed. If we assume that the price of labor (adjusted for quality, effort, and so forth) changes at the same rate in all branches of the economy, then the change in total labor compensation in a particular industry relative to the change in the economy as a whole is equal to the change in labor input in that industry relative to the change in labor input for the economy as a whole.⁶

⁴Kendrick, *Productivity Trends*, p. 310.

⁵See discussion of this point by Edward F. Denison, in *The Sources of Economic Growth in the United States and the Alternatives Before Us*, Supplementary Paper No. 13, New York, Committee for Economic Development, January 1962, p. 40.

⁶See equation (1), Appendix.

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Note that this formulation does not require that a dollar's worth of compensation buy the same amount of labor input in all industries in either the initial or the terminal year. There may be variations based on nonpecuniary factors, monopoly or monopsony power, and so on. The relative change in labor compensation will still be equal to the relative change in labor input provided these other factors do not change from industry to industry over time.

Unfortunately, we do not have data on total labor compensation by industry, but the Office of Business Economics does provide estimates of the compensation of employees (full-time equivalents).⁷ Industry totals have been calculated by assuming that the compensation of the self-employed in each major industry group is equal to the compensation per employee in that group. This procedure may not yield completely accurate estimates of levels, but it still may provide an accurate estimate of changes in labor compensation over time for the following reasons. First, in those industries where the self-employed are a small percentage of the persons engaged, there is no problem. Second, in those industries where the true average compensation of the self-employed is close to the compensation per employee, there is no problem either. Finally, where the proportion of self-employed and the ratio of the true compensation per self-employed to compensation per employee do not change, the estimate will be accurate, regardless of what the true ratio is.

Total Factor Input

The foregoing suggests that relative changes in labor compensation may be used to estimate relative changes in labor input. Similarly, relative changes in total compensation (measured approximately by gross product in current dollars) may be used to estimate relative changes in total factor input. In this case we assume that the price of a composite unit of factor input (land, labor, and capital) has changed at the same

⁷The Office of Business Economics data on compensation per man by industry were compared with industry wage and salary data collected by the Bureau of the Census in its Current Population Survey for 1948 through 1960, as reported in Herman P. Miller, *Trends in the Income of Families and Persons in the United States: 1947-1960*, Bureau of the Census Technical Paper No. 8, Washington, Government Printing Office, 1963, Table 17. The sector differentials were almost identical.

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rate in all branches of the economy.⁸ This assumption is less likely to be true than the same assumption for a single factor because relative factor prices have changed and industry factor proportions differ. Some independent verification is possible through direct estimation of capital input, to be discussed later.

⁸See equation (2), Appendix. See Denison, *Sources of Economic Growth*, pp. 218, 219, for a discussion of this method.