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Measurement of Labor Input: Some Questions of Definition and the Adequacy of Data

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THIS paper is mainly concerned with the relative merits of employment and man-hours as measures of labor input in the measurement of productivity, and with the adequacy of the statistical sources for each. However, choice of an input measure cannot be wholly divorced from the measurement of output, nor from one's general approach to the meaning of productivity changes. Hence, this brief introductory section.

Discussion of changes in either economic welfare or the efficiency with which a society satisfies wants and needs is facilitated by distinguishing between changes in the external environment in which the individuals live, and changes in their tastes, likes, and dislikes (even though these may be influenced by the external environment). Insofar as I am aware, no one has attempted to adjust measures of output or productivity for the latter type of change, while efforts have been at least proposed to take account of changes in the external environment.

Conventionally, I shall ignore the fact that, given the same environment, different individuals at different times will not necessarily derive the same satisfactions from any given quantity of goods and services, and also will not be alike in their aversion to work and saving. Unless this is done, quantitative comparisons of the economic performance or economic welfare of a community at different times are not possible. Experience has shown the pragmatic value of such comparisons at least for large groups.

There has been less readiness to make welfare or productivity comparisons that ignore changes in the environment. Unless we do so, a reasonably full appraisal of changes in the performance of an economy and in the economic welfare of individuals requires, in addition to population data, at least four aggregate measures whose general character is as follows:

1. An index of the requirements of the people that would change as needs imposed by the physical or institutional environment or the relations of the society with other peoples change. This index would

move with changes in such things as differences in the costs of urban as against rural living as the population becomes more urbanized, weather changes (such as a shift in the hurricane belt), new diseases, and national defense requirements. It would not take account of changes in the tastes or wants of individuals such as may arise from better education or becoming accustomed to a higher living standard—that is, changes in the individual's own perceptions rather than in his environment. An index of this type has never been attempted. It would have to be subjective to an undesirable and probably prohibitive extent.[1]

2. A measure of the national product, representing the quantity of goods and services produced each year.

3. A measure of the real costs incurred in producing the national product.

4. The ratio of the economic resources actually used to those available to the economy, including involuntarily unemployed resources.

Each of the four measures is informative in itself.[2] In addition, the relationships among them are interesting. The ratio of 2 (national product) to 1 (requirements) would indicate changes in the extent to which wants and needs are satisfied, once the general qualification concerning changes in tastes is accepted. The ratio of 2 to 3 (real costs incurred) would show changes in the efficiency of the economy in using resources actually employed. The product of this ratio and the fourth series would provide a broader measure of efficiency, reflecting both the success of the economy in making full use of resources and its efficiency in utilizing those actually employed.

These four measures, regardless of whether they can be statistically measured, are a minimum that cannot be reduced. The attempt to do so is responsible for much of the debate that has characterized the development of national product measurement, and particularly so in two respects that are crucial for our purpose.

1. Kuznets' recommendation that measures of the national product should omit provision for what he calls "maintenance of the fabric of society," including national defense, police and courts, as well as certain expenditures like travel to and from work that he views as intermediate products, in my opinion amounts to an attempt

[1] Suppose, for instance, that in the base year (1) national product of 100 were divided 60 for consumption, 30 for capital formation, and 10 for national defense and (2) that this represented the public's free choice in full knowledge of the dangers of foreign aggression. Suppose that in a different year, all other things being unchanged, it would cost twice as much to provide the same degree of security from foreign aggression. The index would then rise to 110, regardless of what was actually done about defense expenditures.

[2] Each also has difficult problems of exact definition that I shall ignore here.

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to eliminate the need for the first measure, changes in requirements imposed by the external environment, by adjustment of the second, national product.[3] In effect, he would omit from the measurement of output provision for the satisfaction of all needs that change over time because of changes in individuals' external environment, and count as output only those products that satisfy wants that have not in recent centuries been greatly affected by such changes. His procedure thus attempts to eliminate the necessity for a measure of requirements by narrowing the scope of the output measure. But it fails precisely *because* of the narrowing of scope. No account is taken of provision to satisfy needs that have changed. Hence, it gives the unacceptable result that with the same output of "admissible" consumer and capital goods, and the same population, we are equally well off whether we must walk or can ride to work, or regardless of what we do to forestall thermonuclear destruction by the Communist world. The procedure thus fails as a device to obviate the requirement of a measure of wants and needs for welfare comparisons. It has the positive disadvantage that elimination of part of current output destroys the national product as a measure of the total output that actually is available to satisfy wants and needs.

From the standpoint of productivity measurement, the relation of output to real costs (the ratio of series 2 to series 3), such an omission from output is disastrous. It would destroy the significance of comparisons of output with those of real costs or inputs unless resources devoted to the production of "excluded" output were omitted from the latter series.[4] If they were omitted (which would require very difficult allocations), we would have comparable data, but their coverage would be only a fraction of the economy. In this paper, which is devoted to the labor portion of series 3, we shall assume that labor and other inputs are to be related to an equally comprehensive measure of national product.

2. The frequently advanced proposition that inputs should be measured in units of constant quality, as determined by their ability to contribute to production, is tantamount to making the index of series 3, the economic resources used in production, identical with

[3] See Simon Kuznets' "Discussion of the New Department of Commerce Income Series," *Review of Economics and Statistics*, August 1948; "On the Valuation of Social Income—Reflections on Professor Hicks' Article," *Economica*, February 1948; "Government Product and National Income," *Income and Wealth, Series I* (Cambridge, England, 1951); and "Quantitative Aspects of the Economic Growth of Nations," *Economic Development and Cultural Change*, October 1956.

[4] Kuznets, of course, would not accept this statement. From his standpoint, I think, diversion of resources to protect ourselves, with a consequent reduction in goods contributing directly to consumer welfare, would properly show up as a reduction in the productivity of the economy.

that of series 2, national product. For if a unit of input is defined in terms of its contribution to production, then total input must move in proportion to total output, and the ratio between the two, productivity, can never change.[5] Also, to measure the quantity of input of any one factor, such as labor, it would be necessary to identify the output specifically attributable to it. Since efficiency, or productivity, is the topic of this conference, it seems wise to deal with measures that do not eliminate changes in productivity in the economy as a whole by definition, and to concern ourselves with input measures that are not adjusted for quality change.

Measures of Labor Input

As a practical matter, the units of measurement of labor input that are available for comparisons over time may be reduced to the average number of persons employed and the total number of hours worked. (There are, of course, variants of each, but these need not concern us at this point.) Differences between the movements of the two arise from changes in average hours of work. Intelligent choice, or even discussion, requires information concerning two aspects of working hours about which we unfortunately know too little. First, what is the relationship between hours of work and real costs—"disutility"—of labor? Second, what is the relationship between hours of work and output?

HOURS AND REAL COSTS

Does the movement of total man-hours worked or of employment better approximate changes in the real cost, or disutility, of labour? If we waive the problem of aggregation, we can rephrase the question to ask how disutility varies with hours of work for typical individuals. We concentrate upon the range of hours prevalent in the past and possibly prevalent in the not-completely-remote future—say over thirty hours a week.

[5] Under one scheme, economies of scale might be construed as introducing changing productivity in the economy. Under this scheme, movement *along* a production function represents a productivity change, while movement from one function to another does not, since it can be interpreted as resulting from a change in the quality (and hence in the quantity, adjusted for quality change) of one or more inputs. I agree with Nicholas Kaldor ("A Model of Economic Growth," *The Economic Journal*, December 1957, p. 396) that such a distinction is entirely artificial. Also if, as seems quite arbitrary, the qualities of entrepreneurship and labor are not interpreted to include the knowledge of the entrepreneur or worker (distinguished somehow from the technological state of capital goods), a divergence might appear on that account. This does not seem to me either a valid or workable distinction. For a discussion of the general point that adjustment of inputs for quality change is equivalent to measuring total inputs by output, see my "Theoretical Aspects of Quality Change, Capital Consumption, and Net Capital Formation" in Volume 19 of *Studies in Income and Wealth*.

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If disutility varied proportionately to hours worked, man-hours would provide an appropriate index of the real cost of labor. If disutility did not vary at all with hours of work (above thirty) employment would provide such an index. Only if the percentage increase in the total disutility of work is less than half the percentage increase in working hours as hours increase would employment be the better measure of changes in total disutility. Is this likely?

Usually it is supposed that, after only a few hours' work a week, the marginal disutility of an hour's work increases as hours are increased; certainly it is never assumed that it declines. On the other hand, the disutility of the first hour's work in the week and, possibly to a lesser extent, in each day is certainly high, since the mere necessity of going to work interferes most with one's freedom to do as he will, and also carries with it a heavy overhead in time spent going to and from the work place, changing clothes, etc.[6]

If the disutility of the first hour were sufficiently high relative to subsequent hours, the condition in which employment represents total disutility better than do man-hours would be met; the most important distinction would be between working and not working, rather than in the number of hours worked. If, for example, the disutility of the first hour in the day were twelve times that of every subsequent hour, not until the twelfth hour of the day was reached would the total disutility of work increase by half as large a percentage as working hours, and man-hours therefore move more closely than employment with total disutility of work.

Most people seem to feel intuitively, however, that, within the range experienced in the past or likely to be met in the near future, a reduction in hours does mean something like a proportional reduction in disutility or real cost. I shall assume here that man-hours represent better than employment the real cost, or disutility, of labor input.[7] This assumption is not so firmly based, however, as to

[6] We can, of course, conceive of distributions of working hours over the year, or even a lifetime, in which these initial costs would be minimized; longer vacations, more holidays, and earlier retirement are current examples of a trend in this direction. However, for the past, at least, hours have mainly been reduced by shortening the workweek. Elimination of Saturday work was one general characteristic of the change, and thus eliminated one of the onerous "first hours."

[7] Evidence as to the shape of the real cost curve based on the decisions of individuals facing choices as to how many hours they will work is impossible to obtain. All that can be observed is, at best, the marginal rate of substitution between effort and income, not absolute changes in disutility. Further, individuals are not necessarily in equilibrium because they cannot get the combination of hours and earnings that would suit them best, or do not know the available alternatives. Even for groups of individuals, standard hours have rarely been set by any real comparison of leisure gained with income lost, or even with knowledge of the income actually sacrificed for shorter hours.

warrant the current overwhelming emphasis on output per man-hour to the near exclusion of output per man.

It is obvious that, in this context, the relevant series is that for man-hours actually worked, not man-hours paid for.

HOURS AND OUTPUT

Do man-hours or employment better measure effective labor input, the contribution that labor makes to production? We conclude that, at least where changes in standard hours are under consideration, the evidence favors employment.

We consider first wage and salary workers. It is customary (and I believe correct) to depict the relationship between the length of the workweek of employees and total output as follows. Starting from just over zero hours, as the workweek is lengthened total output rises by a larger percentage than hours (output per man-hour increases) to a point at which output per man-hour is at a maximum; thereafter total output rises less than hours to a point where total output is at a maximum; and thereafter both total output and output per man-hour decline.[8]

Such a theoretical relationship is the same if one moves to left or to right. And it applies to the condition in which skill of management and the quantity of capital are unchanged (although in the long run the form of capital goods may change). Hence the shape of the curve is governed by increasing fatigue of workers as hours are lengthened (which is accompanied by deterioration in the quantity and quality of output, increased losses of work time due to accidents and sickness, etc.) and by other factors (such as opening and closing time, and absenteeism that results from workers' need for time to conduct personal affairs) that are more or less specific to labor.

The historical development, however, has been such that shortening of hours has also had a very decided and immediate impact on the quality of management and, perhaps to a lesser extent, the form and quantity of capital. Shortening of standard hours has come (1) at different times in different establishments and industries; (2) by large discrete amounts (typically from 72 hours to 60, 60 to 48, 48 to 44 or 40, or 84 to 56); and (3) without reduction in the weekly wage. As a consequence, firms faced much higher unit costs unless output per man-hour could be greatly increased, while in many cases other firms producing the same product, and in all cases producers of other products, did not simultaneously face increased costs. Hence firms affected had no assurance that prices could be raised correspondingly

[8] Such a diagram is shown, for example, in Lloyd G. Reynolds, *Labor Economics and Labor Relations*, second edition, p. 254.

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At least to the point where reduction did not bring daily hours below eight, it was typically possible for firms or industries shortening hours to maintain the previous rate of output per man, or at any rate, fully to restore it within a year or two, implying a huge and sudden increase in output per man-hour.[9] The proper apportionment of credit for this result among the reduction of fatigue and similar factors, improved organization and management, and mechanization is not at all certain.

The results of the further shortening of standard hours below 48 a week have not yielded a clear pattern, perhaps because they have not been systematically collected and analyzed.[10]

Lloyd Reynolds, apparently assuming the quality of management and quantity of capital to be constant, has suggested that the maximum total output week in the United States at present is between 40 and 50 hours for most occupations. For purely illustrative purposes, he supposes further that a reduction in hours from 40 to 30 would cause an increase in output per man-hour of 20 per cent and a decline in total weekly output of 10 per cent. With this pattern, it is clear that output per man will vary less than output per man-hour with a change in hours at all points above 30 hours. Others concerned with the subject have often feared the shortening of hours from present standards would reduce output more than this.

The impact of a reduction of standard hours—occuring in different firms at different times, and without reduction of weekly pay—upon the efficiency of operations and mechanization is not obviously related to the length of the workweek from which hours are shortened, but only to the size of the percentage reduction. Hence, it is possible that in the future much, or even all, of the decline in total output that would otherwise result from shorter hours can continue to be offset by better management and mechanization resulting from the shortening. (General hours' shortening throughout industry—as by a change in the wage-hour law—might be expected to provide less stimulus

[9] The widely quoted studies of H. M. Vernon, P. Sargent Florence, and Josephine Goldmark provide much of the basis for this statement.

[10] Bureau of Labor Statistics studies of wartime experience were not concerned with standard hours but with changes in actual hours (mostly overtime) without an offsetting change in wage rates. They showed that, in dealing with actual hours, the results of increasing hours are not simply the opposite of decreasing them. Results also varied according to the physical labor involved, the sex of workers, whether the pace of operations is machine-determined or worker-determined, the weekly pattern of hours, and other factors.

since the chances of passing on increased costs in higher prices would be much greater.) If these effects of hours shortening are considered, in addition to the quality of nonmanagerial labor as such, the case for greater stability in output per man than in output per man-hour is greatly strengthened.

These pressures are not felt when *standard* hours are unchanged but *actual* hours are shortened as a consequence of a cyclical reduction in demand, or increased in periods of rush business, without an offsetting change in hourly wages. Such fluctuations in hours, consequently, are likely to be accompanied by more stability in output per man-hour, and less in output per man, than are changes in standard hours. Standard hours are mainly relevant to long-term trends, while changes in actual hours are chiefly of short-term interest.

This discussion has referred to the relationship between the hours of work of full-time wage and salary workers and their output.[11] For proprietors of unincorporated businesses and unpaid family workers, the considerations are rather different. Generally, wage and salary workers are laid off or put on short time when, to the firm, their output is not worth its cost. Hence it can be assumed that firms are always seeking to maximize employees' output during the time that they are working. Proprietors, on the other hand, remain employed as long as the enterprise is in existence, and their hours are often conventionally set, regardless of the amount of work to be done.

For our purpose, active proprietors fall into three classes. First is a group whose total output is limited by the time available to them. These are the proprietors of the larger establishments and farms, who typically hire workers to do what they cannot perform themselves, and proprietors selling their individual skills—professionals, repairmen, barbers, etc.—when demand keeps them fully occupied. For this group the relationship among employment, hours, and output is much the same as for hired workers, so that, at least when changes are in standard hours, employment is a better measure of effective labor input than man-hours.

Second is a group—notably professionals with offices—whose hours are conventionally set but who could do more within those hours if the volume of business waranted. If the customary hours change, it is likely to have little effect on their total output, so that employment is again the better measure. Also, if hours are unchanged, changes in their output per unit of labor input respond to demand conditions whether input is measured by man-hours or by man-years.

[11] Part-time workers, as discussed later, usually work very few hours and are not affected by changes in standard hours.

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Third is a group that is also under-employed but whose working hours (assuming they are accurately measured) adjust to the amount of work available. This group consists largely of farmers with insufficient land to occupy their time and of construction workers, not in establishments, whose working hours are governed by the work available. Hours may be a better measure of effective labor input than employment, but are still deficient since there is little incentive to maximize output per man-hour.

Unpaid family workers fall into the same categories as proprietors, though with possibly a greater tendency for employment and hours to respond to work requirements in the individual establishment.

If one may judge by the low total output of some millions of farms, and by the predominance of very low incomes among nonfarm proprietors even in prosperous years, the second and third groups, among whom output is mainly demand-determined rather than limited by available labor time, each may easily be as large as the first even under conditions of general business prosperity. There is also some shift from the first group into the others when business declines, although this shift may not be large. (Agricultural production does not typically decline, and proprietors of larger nonfarm establishments may both take over work from paid employees and face more difficult management problems.)

We may also mention the well-known tendency for the number of proprietors and family workers (particularly in agriculture and construction) to respond inversely to sharp changes in employment opportunities for paid workers. Very little output is associated with these marginal proprietors and family workers so that changes in their numbers help to impart a cyclical pattern to series on output per man or output per man-hour.

It is apparent that any meaning attached to either output per man or output per man-hour for proprietors and unpaid family workers must be heavily qualified, but it appears that for long-term comparisons, involving changes in standard hours, the choice again favors employment as the better measure of effective labor input.

From the foregoing discussion of employees and proprietors, I conclude that when we are dealing with reductions in *standard* hours in the economy as a whole (increases have not been and are unlikely to be important), employment, though defective, is a better measure of effective labor input than is man-hours. Changes in standard hours have dominated long-term changes. Whether the same conclusion is applicable to changes in actual hours unaccompanied by changes in standard hours, the situation generally dominant in cyclical swings, there is not sufficient evidence to judge.

The evidence on which I have relied for the crucial wage-and-salary group is based on the experience of individual firms and industries. It might be supposed that comparison of actual changes in output per man-hour and output per man-year in the private economy as a whole as hours have changed in the past would provide additional evidence on these points. It does not because changes in hours, taking place at different times in different industries, have been so gradual that noticeable departures from trend in the economy as a whole invariably appear in both output per man and output per man-hour. A choice between the two based on continuity in years prior to 1929 or subsequent to World War II is impossible for this reason. Between these periods both series show a dip in the depression of the thirties and a bulge during World War II. Each deviation from trend is more pronounced in output per man than in output per man-hour.[12] However, since forces making for deviations were sufficient to affect both series, although their strength is unknown, this is of little assistance in deducing the separate effect of changes in actual hours.

CHOICE OF A MEASURE

The preceding two sections sketched my reasons for assuming (1) that man-hours are a better measure than employment of changes in the disutility or real cost of labor; and (2) that employment is a better measure than man-hours of effective labor input.

From the first proposition, I conclude directly that man-hours is the better series to use as the labor input component of a series representing the total real cost incurred in producing the national product, and hence in computing output per unit of real input as a measure of the efficiency or productivity of the economy.

From the second proposition, I conclude that the difference between changes in output per man and output per man-hour may be thought of as measuring, though very crudely, that part of the increase in output per man-hour that is the result of shortening hours (whether because of the stimulation it provides to improved management or of its effects on the efficiency of other types of labor). Output per man may accordingly be viewed as a measure of labor input (including management labor) that is adjusted for one type of quality change.

If I am correct in supposing that much of the past increase in output per man-hour is simply the result of shortening hours, it follows that, for long-term projections based on historical experience, projection of output per man will be preferable to that of output per man-hour if the future rate of hours shortening is different from that

[12] I rely here upon John Kendrick's series.

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in the past. It may also be preferable in that it forces explicit consideration of the question whether future hours shortening will have the same effect as in the past. My view about other feasible adjustments for specific types of quality change in labor input is identical. John Kendrick, for example, has weighted man-hours in each industry by base-year average hourly earnings to obtain a measure of what he calls "labour input," which is then combined with "capital input" to obtain "total factor input," the series used to measure overall productivity. I would argue that to *measure* changes in productivity this is not appropriate; the shift of resources from industries in which labor is less productive to industries in which it is more productive is one source of greater productivity in the economy, not something to be eliminated. The calculation is nevertheless valuable. Comparison of output per man-hour with output per unit of "labor input" in Kendrick's sense (or broader input measures of which these are a part) provides a useful measure of the contribution of industry shifts to past increases of productivity, and hence also a useful tool for projections.[13] Other similar calculations, based on such factors as occupation and education, would be useful in the same way (although the results would not, of course, be cumulative except to the extent that available data permitted cross classification).

I do not mean to suggest that one or more such feasible adjustments could really hold the quality of labor input substantially constant. Too many elements enter into the quality of labor to make reasonably complete adjustment for quality change feasible.

Adequacy of Data

This section discusses the adequacy of labor input data for obtaining total output per man-hour worked, and total output per person engaged in production (or some other employment measure). The appraisal would be the same if labor input measures were combined with other imputs to obtain a broader measure of productivity. Two important general points are immediately obvious.

THE SHORTER THE PERIOD, THE GREATER THE NECESSARY ACCURACY

It is customary to express changes in output per man-hour (or per man) in terms of the average annual rate of change between two dates. The farther apart these dates are, the larger is the percentage error in the estimate of man-hours (or employment) that we can tolerate.

[13] If the labor input measure is to be used separately to obtain output per man-hour, the weights should, of course, be value (GNP) added rather than wage rates. It will be evident that I prefer the calculations to be based upon employment, rather than man-hours, so as to facilitate separate treatment of the effects of hours changes.

Suppose, for example, that the true average annual rate of increase in output per man-hour is 2 per cent (approximately the accepted estimate of the long-term rate) and the measures of output at both dates, and of man-hours at the earlier date, are correct. We would then arrive at a rate of increase within one-fourth percentage point (12.5 per cent) of the true (2 per cent) figure if the man-hour estimate for the second date did not deviate from the true figure by more than the percentage shown, for varying periods, in the following table.

Number of Years	*Percentage Deviation from True Figure*
¼	— 0.06 to 0.06
1	— 0.25 to 0.25
2	— 0.49 to 0.49
3	— 0.74 to 0.73
4	— 0.98 to 0.98
5	— 1.23 to 1.22
10	— 2.48 to 2.42
20	— 5.02 to 4.79
30	— 7.62 to 7.10
50	—13.02 to 11.55
100	—27.74 to 21.76

The numbers in the table would be practically the same if a different true rate of increase—say 1 or 6 per cent a year—were assumed, although in that case a quarter percentage point error would appear more, or less, serious.

More generally, the error in the man-hour estimate that we can afford roughly approximates the product of (1) the error, in percentage points, that we are willing to tolerate in the annual rate of increase in output per man-hour and (2) the number of years separating the two dates of comparison. Because of compounding, this is not literally true, and for comparisons over long time periods an underestimate of the later man-hour figures is (by the criterion used) slightly less serious than an overestimate. However, unless we deal with extremely long time periods and large margins of error, this rule of thumb will suffice. It follows that, in computing annual average rates of change, short-period comparisons require far more accuracy in man-hour or employment estimates than do long-period comparisons. The extent to which the data are in fact more accurate for short periods is considered later.

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ADVANTAGE OF STATISTICAL CONSISTENCY BETWEEN INPUT AND OUTPUT ESTIMATES

There is, similarly, no error in the change in output per man-hour (or per employed person) if the indexes of output and of man-hours (or employment) have the same percentage error, or bias. There is an enormous advantage, consequently, in achieving maximum statistical interdependence between the measures of labor input and of output.

For output per man, this advantage can be maximized by use of the Office of Business Economics series for gross national product, measured from the income side, with its series for "persons engaged in production." The former series should be regarded simply as a statistical alternative to the published GNP series, not as something conceptually different. It is not published in constant dollars, but it can readily be obtained by applying to the published constant-dollar series the ratio of current-dollar GNP less statistical discrepancy to current-dollar GNP. Future references to GNP will be to the estimates based on the income side. For short-period comparisons this adjustment often introduces a worth-while improvement.

Data for the employment of wage and salary workers and of payrolls are drawn from the same sources and, to the modest extent that estimation is required, based on similar methods. The same is true of the main components (about 4/5 by value) of employer contributions for social insurance. The opportunity for statistical inconsistency between wage and salary worker employment, on the one hand, and payrolls and employer contributions, on the other, is consequently slight. Since payrolls and employer contributions comprise 56 per cent of the GNP (based on 1956 data), and full-time equivalent employment comprises 85 per cent of "persons engaged in production," the gain from this interdependence of sources and methods is very great.[14] In addition there is some, though much less, interdependence between the estimates of the number of nonfarm proprietors (10 per cent of persons engaged) and nonfarm proprietors' income (7 per cent of GNP), and in the longer run between farm

[14] Data cited throughout this paper are estimates published in July 1958 or the supporting detail published in "U.S. Income and Output," November 1958.

proprietors and their income. For proprietors, interdependence is much greater over longer periods than for year-to-year changes.[15]

Such interdependence of estimates is extremely helpful, but it should not be understood to mean more than it does. In particular, it must be stressed that errors in the deflation of GNP have no counterpart in the employment estimates. Also, the "persons engaged" series measures full-time equivalent employment, while the interdependence refers to average monthly employment. However, I believe there is little likelihood of much error—insofar as movement over time is concerned—in the conversion to full-time equivalence.

Two characteristics of the OBE series on persons engaged in production require brief discussion.

First, in industries where part-time work is important, the figures for wage and salary workers are reduced to full-time equivalence. This seems to me clearly desirable. In most industries the average weekly hours and earnings of part-time workers are only about one-sixth or one-seventh those of full-time workers. Inclusion of part-time workers at full weight in the employment total could consequently badly distort productivity measures if their proportion in the total changed. It is true that the ratio of full-time equivalent to total employment in individual industries seems in fact to be quite stable. Indeed, were this not so, the full-time equivalent employment estimates would be suspect, since in most industries data for an adequate correction are available only when the Census of Business is taken. But such stability need not always prevail, and in addition changes in the relative importance of industries affect the ratio for the all-industry employment totals. A result similar to full-time equivalence in employment is sought for proprietors by the effort to count only those who receive the major fraction of their income, or devote the major portion of their time, to their business or profession.

Second, the OBE series excludes unpaid family workers. The reason is the unsatisfactory state of the data, and particularly the enormously greater figures (roundly in the ratio of 3 to 1) that are reported in establishment censuses than in the Census of Population or the Monthly Report on the Labor Force.[16] Until the reason for this is cleared up, the omission cannot be made good nor its importance even appraised. For estimates running back no farther than

[15] Interdependence carries over to productivity data by industry, if GNP by industry is obtained by adding the necessary adjustment items to national income originating. Because of the problems involved in classification by industry, the advantage of using statistically interdependent employment and output data is, in fact, even much greater in industry than in aggregate productivity measurement.

[16] See my comment on the paper given by Edwin Budd in Volume 24 of *Studies in Income and Wealth*.

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1929, I believe the least objectionable procedure is to follow OBE practice and simply omit unpaid family workers. For earlier periods, when family workers were presumably more important, it may be preferable to follow Kendrick's procedure and to include a series tied to the Census of Population or MRLF level, but it should be recognized that this may be little more than a token inclusion if the establishment censuses are correct.

The general OBE procedure, somewhat oversimplified, for estimating employment in industries covered by social insurance laws is (1) to obtain average monthly employment for establishments covered by state unemployment insurance laws or reporting to the Interstate Commerce Commission; (2) to add employment in firms with fewer employees than are required for unemployment compensation coverage, based on special Old Age and Survivors Insurance tabulations; and, until recently, (3) to adjust the resulting aggregate by the ratio of payrolls based on taxable wages under the Old Age and Survivors Insurance and Railroad Retirement Board programs plus nontaxable wages based on unemployment compensation data, to a preliminary estimate of payrolls based on procedures paralleling those described for employment in steps (1) and (2). The last step was designed to correct for inconsistencies between actual size-of-firm exclusion from unemployment compensation coverage and presumed exclusions, based on BOASI size-of-firm tabulations for a single month, and to pick up firms (chiefly new firms) in covered industries that are omitted from unemployment compensation coverage for reasons other than small size.

In the last decade, the source data have improved in one respect and deteriorated in two. The improvement has been the reduction in size-of-firm exclusion in state unemployment compensation laws. The deterioration, which seems to me more important, stems from (1) discontinuance in 1950 of final annual tabulations from the state unemployment compensation agencies that include late-reporting firms, so that the only reports now submitted are quarterly statements including actual data for firms reporting promptly and estimates for those reporting late; and (2) changes in the definition of taxable wages under the BOASI program such that these no longer correspond to taxable wages under the unemployment compensation laws. This has forced substitution of a direct estimate of delinquency in BOASI small-firm tabulations for the third step described in the previous paragraph. Correspondence between the adjustments for employment and payrolls is preserved, however.

Estimates of employment in uncovered industries, and of proprietors, are obtained from a variety of sources we need not describe here.

In general, the annual estimates for 1939 on are of excellent quality, slightly better for 1940 through 1949 or 1950 than in the other years.

HOW GREAT AN ERROR CAN WE AFFORD?

From 1929 to 1957 GNP per person engaged in production, based on OBE data, increased at an average annual rate of 1.6 per cent. Output per man-hour, according to available estimates, has increased at a long-run rate slightly above 2 per cent. In these trend figures, it is apparent that an error of even a fraction of 1 per cent is large relative to the quantity being measured.

We shall also be concerned with year-to-year changes. A distribution of year-to-year changes in output per person engaged since 1929 is shown in the first column of Table 1. It is apparent that the range is

TABLE 1

Distribution of Annual Percentage Changes in Real Gross National Product per Person Engaged in Production (number of cases)

Percentage Change from Previous Year	All Years 1930–57	Years 1948–57
6	3	0
5	5	2
4	0	0
3	3	1
2	2	2
1	7	4
0	2	1
−1	2	0
−2	1	0
−3	0	0
−4	1	0
−5	1	0
−6	0	0
−7	1	0
Total	28	10

Source: Computed from Office of Business Economics data.

very large, and that if an error of no more than, say, 2 or 3 per cent in the data is assumed, we could still distinguish twelve to fourteen of the twenty-eight annual changes as being distinctly above or below the trend average of 1.6 per cent. The period is decidedly abnormal, however, in that it is distorted by the great depression and World War II. Of the ten years from 1948 to 1957, a more normal period, for only two could we conclude that they differed from the trend level

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if we admitted an error of as much as 2 per cent, and assuming accuracy within 1 per cent would add only two more to the list. More refined analysis would require very accurate estimates.

It is against this background that we must appraise the accuracy of employment and man-hour estimates.

APPRAISAL OF EMPLOYMENT ESTIMATES

We come now to an appraisal, which can represent only my own judgment, of the adequacy of data for "persons engaged" for use in productivity measurements. I make no allowance for the omission of unpaid family workers since I do not know how to judge its importance.[17]

My judgment is that, for the period since 1939, the error introduced, by errors in the persons engaged series, into the year-to-year percentage change in GNP per person engaged in production is not likely to exceed 0.2 percentage points. I have in mind a range corresponding to one standard deviation, which means that two changes out of three would be less, and one out of three would exceed (usually slightly) 0.2 percentage points, while errors of as much as 0.4 percentage points would be rare.

This is not an estimate of the error in the persons engaged series itself, which would be larger. It is reduced by the interdependence between employment and income figures. Moreover, a similar reduction is allowable in the error for GNP. Indeed, the meaning of the 0.2 estimate (or guess) may most easily be made clear by indicating the types of error in GNP that would have to be allowed for, in addition, to obtain a complete appraisal of the reliability of year-to-year changes in output per person engaged. These are: (1) the errors in the sum of current-dollar estimates of rental income, corporate profits, net interest, farm proprietors' income, "other labor income," indirect business taxes, business transfer payments, capital consumption allowances, subsidies, and the current surplus of government enterprises; (2) errors in employee compensation and in nonfarm proprietors' income that have no counterpart in the employment series (for employee compensation, I believe this would be a minor fraction of the total error, but for nonfarm proprietors' income it would comprise the bulk of the total error); (3) all errors in deflation, except for

[17] In Table 5, MRLF estimates of unpaid family workers (which may be far too low) are shown in absolute numbers and as a percentage of OBE "persons engaged" in private industries as far back as 1940. The reader may judge the difference that their addition to the OBE series would make to productivity estimation, but this says nothing about their reliability. In addition to the question of level, the earlier years can scarcely be considered comparable with those for the later period in view of a change in questioning procedure in 1945.

deflation of the compensation of government employees and of domestic servants.[18]

The errors in employment that concern me tend to be random rather than cumulative. In addition, the interdependence between proprietors and proprietors' income is greater over longer time periods than short. Hence, for the period since 1939, I would not increase by much the error margin introduced by the employment estimates in comparing estimates that are not adjacent. This means that, in computing an average annual increase in output per person engaged over a two-year period, the error from this source drops to about 0.1 percentage point and for longer periods becomes negligible.

Were no errors introduced by output measurement, the employment estimates since 1939 would suffice for measurement of year-to-year changes in productivity. The estimates from 1929 to 1938 are less reliable, but given the large productivity changes of that period, probably are good enough for meaningful year-to-year measurement, and should certainly be adequate for average changes over three or four years. Also, an average rate of change from 1929 to, say, 1957 should be as good as from 1939 or a later year if the advantage of a longer time period is considered.

Table 2 indicates my approach to the appraisal of reliability of year-to-year comparisons since 1939. The "persons engaged" total is divided into the four groups shown.

Since the deflation of GNP expenditures for general government employees and domestic servants assumes no changes in productivity, employment there may be considered a "wash" item introducing no error into the productivity estimate (provided, of course, that the deflation convention is accepted).

Estimates of farm employment (proprietors and employees) are statistically independent of year-to-year changes in the income measure (for proprietors and employees combined). Hence the error margin of 1.5 per cent (within which two-thirds of the changes are assumed to fall) carries over entirely into the error in output per person engaged.

For other employees I have put the error in the annual change at 0.3 per cent, but this has almost no effect on the error in productivity since I have taken only 2 per cent of this amount as the portion that

[18] It is not my assignment to appraise the output measures. However, if we admit an error of as much as 2 per cent in the items covered in (1) and (2)—and this does not seem exorbitant at least for preliminary estimates prepared prior to the availability of Internal Revenue Service data—this is equivalent to 0.9 per cent of GNP. The error margin in deflation can scarcely be supposed less than 0.5 per cent. It would be hard luck if the errors (0.2, 0.9, and 0.5 per cent) should be cumulative, but should this happen they would total 1.6 per cent, which is the same as the average annual increase in output per person engaged since 1929.

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Categories of Persons Engaged

General govt. and private households
Farms (proprietors and employees)
All other employees
Nonfarm proprietors

Total of above

Allowance for errors in conversion to full-time equivalence and in weighting

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TABLE 2

Categories of Persons Engaged	1956 Number of Persons Engaged (000)	Assumed Margin of Error (per cent)	Assumed Degree of Independence of Corresponding Employee Compensation or Proprietors' Income (per cent)	Independent Error in Persons Engaged Series (per cent)	(000)
General govt. and private households	10,545	[a]	0	0	0
Farms (proprietors and employees)	5,269	1.5	100	1.5	79
All other employees	43,830	0.3	2	0.006	3
Nonfarm proprietors	6,538	1.5	85	1.28	84
Total of above	66,182				166
Allowance for errors in conversion to full-time equivalence and in weighting	66,182			0.1	66
Total	66,182			0.35[b]	232

[a] Not estimated.
[b] Computed from first and last columns.

would not affect employee compensation proportionately. Either figure could be changed considerably without much effect on the end result.

For nonfarm proprietors I have used the same error margin, 1.5 per cent, as for farm proprietors, but have assumed that 15 per cent of such an error would carry over into the estimate of proprietors' income.

Finally, I have allowed 0.1 per cent for errors in the conversion to full-time equivalence, and to cover errors that might arise because errors in the levels of any of the series affect the weights, and hence the movement, of the aggregate.

Summed up, this would give an error margin of 232,000, or 0.35 per cent, in year-to-year movement of "persons engaged" at the 1956 level. However, given the probability that errors of the various types will not be in the same direction, this must be reduced to, roundly, 0.2 per cent.

Again, I must stress that the values in the table represent no more than moderately informed guesses. Different guesses for farm employment and for proprietors, particularly, would change the result appreciably.

Preliminary estimates of full-time equivalent employment, prepared without benefit of annual unemployment compensation statistics, have been published in the February issues of the *Survey of*

Current Business since February 1953. A comparison for private industries of changes shown in February with those shown the following July and with the latest estimates is given for six years in Table 3. At best, these advance estimates, although rather good by ordinary standards, have been accurate enough to warrant their use (supplemented by preliminary estimates of proprietors) only in the early discovery of years in which productivity change departs sharply from trend.

TABLE 3

Comparison of Preliminary and Revised Estimates of Full-Time Equivalent Employment in Private Industries
(preceding year = 100)

Year	Revised July 1958	Published in Following July	Published in Following February
1952	101.1	101.3	100.0
1953	102.5	102.8	103.2
1954	96.6	96.5	96.5
1955	103.4	103.7	102.5
1956	102.9	103.4	102.7
1957	100.4	100.4	100.8

Source: Computed from Office of Business Economics data.

There is now no quarterly series for "persons engaged." One could be constructed, but the error introduced into current quarterly productivity changes by errors in the employment (and GNP) estimates could not be reduced nearly as much as we have reduced that in annual changes to take account of statistical interdependence, and the actual quarter-to-quarter error in employment might well approach that in the preliminary annual estimates. Given the extreme accuracy required to say anything about quarterly changes in productivity (as indicated in the table on page 358), I see little prospect of obtaining a meaningful quarterly measure. Nor do I see any great need for it. Such estimates would have value only in constructing an advance estimate for the year.

Estimates of employment prior to 1929 have been prepared by several investigators. I have not reviewed these in detail. I judge, however, that at least back to 1880 their quality does not deteriorate much faster than is offset by the statistical advantage of a longer time period for computing an annual rate of change in output per man for periods ending with the present. They are probably good enough to establish, over periods of two or three decades, any sharp changes in productivity trends (if the same can be said for the deflated GNP figures). They are clearly inappropriate for short-term productivity comparisons.

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measure seems clearly to indicate the desirability of using OBE employment statistics with OBE national product data, employment estimates of BLS or Census are sometimes used in practice, so it is of some interest to compare them. The comparison will also prove useful when we turn to the man-hours data.

Office of Business Economics employment estimates are compared with those of the Bureau of Labor Statistics in Table 4. The comparisons here exclude government employment since productivity calculations have generally been confined to private industries, and since the government comparison has certain difficulties.

TABLE 4

Comparison of OBE and BLS Estimates of Private Wage and Salary Worker Employment
(full-time and part-time)

Year	OBE (excluding government, farms, and private households) (000)	BLS (excluding government) (000)	BLS as a Percentage of OBE
1929	28,066	27,975	99.7
1930	26,175	25,944	99.1
1931	23,299	23,119	99.2
1932	20,303	20,152	99.3
1933	20,397	20,299	99.5
1934	22,551	22,401	99.3
1935	23,453	23,315	99.4
1936	25,327	25,140	99.3
1937	27,210	26,969	99.1
1938	25,151	25,026	99.5
1939	26,570	26,316	99.0
1940	28,385	27,856	98.1
1941	32,246	31,560	97.9
1942	34,804	34,296	98.5
1943	36,303	36,026	99.2
1944	35,614	35,491	99.7
1945	34,172	34,093	99.8
1946	36,368	35,692	98.1
1947	38,260	37,988	99.3
1948	39,077	38,798	99.3
1949	37,531	37,459	99.8
1950	38,931	38,712	99.4
1951	41,480	40,958	98.7
1952	42,216	41,694	98.8
1953	43,370	43,036	99.2
1954	41,946	41,680	99.4
1955	43,301	43,142	99.6
1956	44,663	44,489	99.6
1957	44,861	44,536	99.3

Agreement of the OBE data for average monthly employment of private wage and salary workers, excluding farms and private households, with BLS data is sufficiently close that if the average annual change in output per man between each of the twenty-eight prior years shown and 1957 were computed on the basis of both employment series, the result would differ by more than 0.1 percentage point only in the two comparisons involving the two immediately preceding years. Differences in year-to-year changes are larger. Of twenty-eight cases, twenty differ by more than 0.1 per cent, fourteen by more than 0.2 per cent, seven by more than 0.5 per cent, and two (both including 1946) by more than 1.0 per cent.

Since 1939 a principal difference in methodology between OBE and BLS has been the handling of social insurance statistics in estimating employment. In the BLS procedure the third step noted in the description of OBE procedures is omitted, and the first two steps are utilized only for the first quarter of each year, the other quarters being estimated by interpolating these benchmark figures by employment in the BLS sample of firms.

Census Bureau estimates of employment of private wage and salary workers and proprietors and own-account workers are compared with OBE estimates of persons engaged in production in private industries in Table 5.

The series, which have largely independent statistical sources, also differ in definition. Probably the most important differences are (1) that the Census series counts part-time workers holding a single job at full value but does not account for second jobs, while the OBE series (in industries in which part-time work is common) counts all part-time jobs at a fractional value; and (2) that the Census series shown here, based on definitions prior to the 1957 revision, includes workers with a job but not at work, who are omitted from the OBE series.

From 1947 to 1956 general agreement of the two series is nonetheless fairly good, but year-to-year movements frequently differ enough to affect seriously short-term productivity comparisons. There is some suggestion of greater cyclical stability in the Census series. Prior to 1947 agreement is poor, although for the annual rate of productivity change from, say, 1940 to 1956 the difference is less than 0.1 percentage point.

APPRAISAL OF MAN-HOURS ESTIMATES

Output per man-hour cannot be estimated as accurately as output per "person engaged." For short-period comparisons the difference in accuracy is likely to be substantial. The error introduced into

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Comparison of Census
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Year	*Census Labor Force* (000)
1940	45,520[a]
1941	48,110[a]
1942	51,100[a]
1942	46,050
1943	45,820
1944	45,410
1945	44,620
1946	47,640
1947	50,944
1948	52,134
1949	51,311
1950	52,308
1951	53,131
1952	53,026
1953	53,944
1954	52,884
1955	54,533
1956	56,141

[a] Includes governmen
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Source: Bureau of th

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TABLE 5

Comparison of Census Estimates of Private Wage and Salary Workers and Self-Employed with OBE Estimates of Persons Engaged in Private Industries

Year	*Census Labor Force* (000)	*OBE Persons Engaged* (000)	*Census as Per Cent of OBE* (%)	*Addendum*	
				Census Unpaid Family Workers (000)	Unpaid Family Workers as Per Cent of Persons Engaged (private) (%)
1940	45,520[a]	46,137[a]	98.7[a]	2,000	4.7
1941	48,110[a]	50,066[a]	96.1[a]	2,240	4.9
1942	51,100[a]	53,235[a]	96.0[a]	2,650	5.5
1942	46,050	48,141	95.7	2,650	5.5
1943	45,820	48,684	94.1	2,840	5.8
1944	45,410	47,552	95.5	2,770	5.8
1945	44,620	46,045	96.9	2,660	5.8
1946	47,640	48,583	98.1	2,300	4.7
1947	50,944	50,915	100.1	2,043	4.0
1948	52,134	51,776	100.7	1,957	3.8
1949	51,311	50,043	102.5	1,959	3.9
1950	52,308	51,346	101.9	1,831	3.6
1951	53,131	53,515	99.3	1,786	3.4
1952	53,026	54,054	98.1	1,773	3.3
1953	53,944	55,078	98.0	1,696	3.1
1954	52,884	53,529	98.8	1,675	3.2
1955	54,533	55,098	99.0	1,823	3.3
1956	56,141	56,398	99.5	1,904	3.4

[a] Includes government civilian employees (except work relief) since Census data for 1940 and 1941 are not available without them.

Source: Bureau of the Census and Office of Business Economics.

year-to-year comparisons of output per man-hour by errors in the man-hour estimates could hardly be put at less than several times the error that is introduced into output per "person engaged" estimates by errors in the estimates for the number of "persons engaged." For long-term trends the difference in accuracy may not be important because if the time period is long enough, even the error in man-hours may be quite acceptable. Were it not for the wide divergence between alternative estimates of the long-term trend of average hours in agriculture, we could be fairly certain that this is so.

We have been referring to output per man-hour worked, not output per man-hour paid for. This clearly is the concept appropriate for measuring the performance of the economy. Even for analysis of inflation I believe it is the more useful concept, since it shows the amount by which employee compensation could be increased in any form without giving impetus to inflationary pressures.

For the period since 1940 three general approaches can be used in estimating total man-hours worked in the economy as a whole, or in such broad branches as government, agriculture, and private nonagricultural industries.[19] For the period prior to 1940, only the third is available.

1. Total man-hours worked can be computed directly from the Census Bureau's Monthly Report on the Labor Force.

2. "Persons engaged," as estimated by the Office of Business Economics, can be multipled by average hours worked, as reported by the MRLF.

3. The various industrial components of average monthly employment and the number of active proprietors, as estimated by OBE,[20] can be multiplied by estimates from establishment sources of average hours of work paid for (or, in the case of agriculture, "required" for the work done); corrections to an "hours worked" concept can be attempted on the basis of scattered information; and the components can then be summed to obtain the desired aggregates. Data are collected on a sample basis for a number of large groups by the BLS, by the Census Bureau in certain industrial census and census surveys, by regulatory commissions, and by the Department of Agriculture. For others, average hours must be estimated from fragmentary sources, by imputing hours of groups for which data are available, or by use of MRLF data for them. These include salaried employees generally, all nonfarm proprietors, and employees in agricultural services, forestry, and fisheries; finance, insurance, and real estate; services (except year-round hotels, laundries, and cleaning and dyeing plants); transportation (except railroads and local transit lines) and government.

Some considerations that should influence the choice of method and appraisal of the error introduced into output per man-hour follow:

1. Regardless of which method is used, the error in the estimate of average hours worked, unlike that in "persons engaged," has no statistical counterpart in the production estimate, and hence creates directly a corresponding error in output per man-hour.

2. The second and third methods preserve for the man-hour series, while the first does not, the advantage of interdependence between employment and output data.

[19] None of these cover military employment, for which the whole concept of hours worked is vague.

[20] Different estimates of employment, particularly those of the Bureau of Labor Statistics, for the groups covered might also, of course, be used.

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3. Even aside from this interdependence, the absence of a comprehensive establishment reporting system like that provided for employment by the social security system means that hours statistics are much less reliable. Hours reporting from establishment sources is less complete than employment reporting prior to 1939.

4. Strictly, the conceptual differences between "persons engaged" and MRLF "employment" make use of MRLF hours with OBE "persons engaged" inappropriate. The choice between using MRLF data directly for total man-hours (the first method) and using them only to obtain average hours (the second method) rests on the reason for the divergences shown in Table 5 between the movement of "persons engaged" and the most nearly corresponding employment data from the MRLF. If they result mainly from the conceptual differences in definition, use of MRLF aggregate hours is preferable. If, as seems much more likely, the greater part of the difference is statistical rather than conceptual, the second method is preferable. (Even so, some error resulting from inconsistent definitions must be allowed for.)

5. The MRLF data for "hours worked," dependent as they are on the respondents' knowledge and memory, subject to certain biases (such as the reported tendency to overlook hours worked on a secondary job), and based on a small sample, are inferior statistically to the available establishment data for "hours paid for." But there are huge gaps in the latter. Even if these are filled by use of MRLF data for the missing sectors, the presence of secondary job holders and probable inconsistencies in classification introduces a hybrid element into the resulting aggregate. An additional limitation on the third method is the need to convert "hours paid for" into "hours worked," an adjustment for which information is scanty. Fortunately, in the pre-1940 period, for which this is the only approach available, the distinction was much less important. For the later period, the choice between the second and third methods is a close one.

6. The trend of farm hours is in dispute. Department of Agriculture estimates imply no significant trend, but substantial fluctuations, in farm hours since 1910. John Kendrick, in measuring productivity, has used this series and continued the assumption of no trend in hours since 1869. MRLF data, on the other hand, show a reduction of farm hours since 1940, and the Twentieth Century Fund has assumed a reduction comparable to that in nonfarm occupations during the entire period since 1870. The difference is large and, because of the importance of agriculture in the earlier decades, of

some importance even in the long-run trend of output per man-hour in the economy as a whole. I am not in a position to resolve this question.

7. The accuracy of employment data is limited by the fact that reports are available only for one payroll period a month (or less), so that they represent a sampling of the year. Hours data are subject to a similar limitation, but for hours it is more serious because there is less continuity in hours than in employment. Indeed, estimation of annual averages of hours worked weekly requires careful examination to see that holidays and vacations are properly represented. Omission of a single holiday in a 260-work-day year represents a 0.4 per cent error in the annual hours figure. Use of a week including a holiday to represent a full month would involve a 1.1 per cent error. These are large amounts in the measurement of annual productivity changes.

8. Even rounding, a cause of error practically absent from employment reporting, cannot be ignored in hours estimation for productivity measurement. In MRLF data, average hours are computed from the nearest reported whole hour, and rounding on the part of respondents must also be assumed. An error in the resulting average of as much as 0.1 hours, or six minutes, on a forty-hour average is an error of 0.25 per cent, greater than the whole error we allowed in year-to-year movements in "output per person engaged" arising from errors in the employment estimates.

My estimate of that error margin at 0.2 per cent was cut markedly because employment and output data are statistically interdependent. The same statistical interdependence reduces the error that must be allowed for in the product measure. Estimates of changes in average hours, even when prepared as carefully as possible, must be assigned a much larger error margin than those for employment, and allow no reduction for statistical interdependence. The error likely to be introduced into year-to-year changes in output per man-hour by errors in the man-hour series, even if estimated so as to preserve the interdependence between employment and output, could hardly be put at much less than 1 per cent, at the two out of three probability level. The errors in output measurement that must be combined with this are the same as in the case of employment. If the methodology does not preserve the interdependence between employment and output, a much larger allowance for error must be made in both employment and output.

As with employment, but with an important possible exception for agriculture, errors are not likely to cumulate much over time, so that the error becomes unimportant in comparisons spanning long periods.

COMMENT

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COMMENT

G. S. TOLLEY, North Carolina State College

I

Denison's judgments on employment series, in the form of subjective standard errors, probably are the best available on their reliability. It is made clear that the man-hours series are less reliable than employment estimates, but no similar numerical judgments on accuracy of man-hours is given. This lack is perhaps the main criticism to be made of this part of Denison's work. Those who prefer man-hours to employment as a labor input concept will particularly feel the lack.

Judgments like Denison's provide a beginning toward more rigorous data accuracy procedures. The paper concerns labor input for the U.S. economy as a whole, an area in which we are relatively well off. Percentage errors may be larger for inputs on a disaggregated basis. His footnote 17 emphasizes that output measures appear less accurate than those of labor input. The most serious errors of all may arise in measures of capital input.

A conjecture is that, unlike labor, capital introduces its most serious errors in productivity comparisons over an intermediate length such as five to twenty years. For a longer period, as Denison points out, there can be a great deal of error before estimated rate of productivity change is affected much. This is particularly true for capital, because its weight as an input for most industries is on the order of only a third to a quarter. For closely adjacent years of relative economic stability, errors introduced by capital measurement may be small enough to be neglected also. This is because errors due to conceptual and estimating problems may be of substantially the same bias over short stable periods. However, suppose that the estimate of capital were correct at the beginning of the period with a 10 per cent error coming in over five years. If true productivity growth was around 2 per cent per year, we could have the illusion that it was as low as about 1.5 per cent or as high as about 2.5 per cent.

II

In the other part of Denison's paper, which deals with conceptual issues in measuring labor input, he concludes that employment is a better measure than man-hours of effective labor input. The contrary view can be supported.

His contention that better management and mechanization result

from shortening of hours seems to me to support use of hours rather than employment. What is being said is that capital and output per unit of input may have changed when hours shortened. Do we want productivity measures to obscure these effects?

For man-hours to be superior to employment as a measure of input would seem to me to require that the output of a worker be the same no matter how many hours he works. This would be a kind of Parkinson's law in economics surely not valid for the United States. Rather, qualitative considerations cited for any diminishing returns at all to hours strike me as having limited importance. Cited were increasing fatigue of workers as hours are lengthened, opening and closing time, and absenteeism that results from workers' need for time to conduct personal affairs. These may be minor enough to warrant being neglected altogether. That is, as a first approximation, we might safely assume the quality of a man-hour does not change with hours worked.

The choice between man-hours and employment in part depends on a conception of what productivity indexes should try to measure. No formulation is going to be perfect from every point of view, but my feeling is that we should be trying to get at shifts in firm production functions within the context of a market-oriented economy. Man-hours seem more consistent than employment with a firm approach.

If quality changes are in fact associated with hour shortening or if hour shortening induces productivity and capital changes, these adjustments can be made explicitly.

The use of man-hours is a straightforward measure of input. It is easy to understand, whereas the idea that employment is a measure of labor input "adjusted for one type of quality change" could be confusing to a wider audience.

III

In generally not allowing for changes in input quality, Denison is at one extreme of positions on how to construct productivity measures. He is against measures that eliminate changes in productivity in the economy as a whole by definition. At the other extreme is the view that measures should try to do just what Denison fears. According to this view, the total change in output cannot be understood unless inputs of some kind or other add up to total output. This again raises the question of what productivity indexes should try to measure. The no-quality-change approach and the explain-everything approach do not comfortably fit into a scheme for interpreting relative price movements and factor remuneration. The production function approach

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favored in the preceding section does fit into that scheme. My feeling is that such a scheme has the best chance of furthering our understanding of economic growth.

If productivity indexes try to get at shifts in production functions, adjustments will be made for some input quality changes, but the adjustments are unlikely to account for all the growth in output. For instance, changes in quality of labor that are the result of investments in education would be allowed for inasmuch as these may be expected to affect the return to that labor. But such things as economies of scale and easily copiable innovations, e.g., inventions and reorganizations of production such as the assembly line or automation, would not be adjusted for. The effects of the latter would show up as productivity increases.

Let us try to illustrate how this approach fits into an understanding of growth relations between agriculture and the rest of the economy. We will be concerned with the relative price of agricultural products and will bring in the role of inputs purchased by farms. A value added productivity measure is used, and the analysis suggests how this type of measure can fit into a total interpretation of growth.[1]

The demand for agricultural products is related to the total sales value of output, but on the production side we find this breaks down into value added and purchased inputs. Value added may be viewed as the agricultural output that is "produced" in the farm sector of the economy, whereas the purchased inputs are agricultural output "produced" in the nonfarm sector. Let k be the proportion of total agricultural output "produced" in the nonfarm sector, i.e., the ratio of intermediate products consumed to total agricultural output. Over the quarter century from 1929 to 1954, the proportion rose from 11 per cent to 23 per cent. A main reason is that more power is produced off the farm than previously in connection with widespread shift from horses to tractors. It can also be said that more soil is produced off the farm, as fertilizer has increased dramatically as a source of nutrients.

The following identity concerns the price of agricultural products relative to the price of nonagricultural products:[2]

[1] The ensuing is related to a study in progress by Seymour Smidt and myself on agriculture's role in economic growth.

[2] This is derived from the relation that total value of agricultural output = value of intermediate products consumed + value added on farms. Divide both sides of the relation by a constant dollar measure of total agricultural output. We then have: Implicit price deflator for total agricultural output = (Implicit price deflator for intermediate products consumed on farms) (k) + (Implicit price deflator for farm value added) $(1-k)$. To get the text expression, we then divide by the implicit price deflator for private nonfarm gross product. The numbers in the text are in terms of 1929 dollars and are derived from figures given in the *Survey of Current Business*.

$$\begin{bmatrix}\text{Relative price of agri-}\\ \text{cultural products}\end{bmatrix} = \begin{bmatrix}\text{Relative price of}\\ \text{purchased inputs}\end{bmatrix}\begin{bmatrix}k\end{bmatrix} + \begin{bmatrix}\text{Relative price of out-}\\ \text{put added by farms}\end{bmatrix}\begin{bmatrix}1-k\end{bmatrix}$$

For the 1929 base this identity is

$$[100] = [100]\ [.11] + [100]\ [.89].$$

For 1954 it is

$$[95] = [86]\ [.23] + [98]\ [.77].$$

The slight decline in relative price of agricultural products, from 100 to 95, is probably best viewed as essential constancy.

For purchased inputs there was a fall of relative price from 100 to 86, and we have already mentioned the dramatic swing to these inputs. This swing had implications for farm adjustment problems, because it displaced farm resources. But the purchased inputs did not become important enough to be overriding in the explanation of the essential constancy of relative price of agricultural products.

The main reason for the essential constancy is the fact that the relative price for output added by farms changed very little. The change was from 100 to 98. In trying to relate this result to farm productivity, consider the assertion that movements in capital and labor rates of pay were nearly the same in agriculture as in the rest of the economy over the twenty-five year period. We will not take space to support the assertion except to say that real returns to labor appear to have risen secularly in similar fashion in the farm and nonfarm sectors, and relative returns to capital probably remained roughly the same also. If this is true, the relative price for output added by farms must primarily reflect efficiency in use of the factors.

Preliminary calculations of productivity change for the value added concepts, farm gross product and private nonfarm gross product, have been carried out on a comparable basis. They indicate an increase in output per unit of input in both sectors at an average annual rate of perhaps 1.5 per cent per year over this period. Thus the expectation of equal productivity change from the relative price analysis is fulfilled.

This illustrates how productivity measures can contribute to an understanding of changes in the economy. This ought to guide construction of the indexes. We can be even more explicit by emphasizing aims in productivity measurement that would be ruled out if this aim were accepted.

The ruling out of no-quality-change and explain-everything approaches has already been discussed. Another idea that sometimes

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gets into discussions of productivity measurement is that indexes should measure changes in welfare. We come back to an old question: If our concept of utility is ordinal, what is the meaning of trying to measure it cardinally? Productivity indexes among other things throw light on welfare changes, but we need to avoid the pitfall of thinking that the indexes themselves can directly measure welfare changes.

This gives us a criterion for not trying to take account of such things as time spent going to and from work. While this unremunerated time is assuredly relevant to worker welfare its inclusion does not give a measure of *firms'* efficiency. How much disutility is involved in going to and from work is a question that productivity indexes cannot measure.

Still another idea is that productivity indexes should reflect projectable uniformities in the data. This idea seemed partly to motivate Denison's preference for employment over man-hours as a labor input measure. While projection is one of many uses of an understanding of economic growth, the projectionist may naturally also wish to find smooth trends that look extrapolatable—sometimes regardless of theoretical justification. To my mind, the latter type of trend should not have the name of productivity index.

IV

One source of changes in quality of labor input is changing skill associated with occupational structure. Denison mentions that it would be useful to have calculations showing this effect. Let me synopsize some calculations carried out in a broader study.

The calculations are made possible by the volume giving historical data on occupation by detailed groups published in connection with the 1940 census.[3] Suppose we take income differentials among the occupations in 1949 as a measure of relative quality.[4] A quality index can then be constructed, showing for each census year, what income per worker would have been in 1949 if the occupation mix of the given year had prevailed.

A report follows on quality indexes for the nonfarm and farm labor forces going back to 1910.[5] These are used to conjecture what has happened to quality of labor input for the economy as a whole.

[3] Bureau of the Census, *Sixteenth Census of Population: 1940, Population. Comparative Occupation Statistics for the United States, 1870–1940* (Washington: Government Printing Office, 1943).

[4] Bureau of the Census, *1950 Population Census, Characteristics of the Population, U.S. Summary* (Washington: Government Printing Office, 1953), Table 129.

[5] As part of the study by Seymour Smidt and myself on agriculture's role in economic growth the details of these and other related calculations will be described.

QUALITY OF THE NONFARM LABOR FORCE

Numbers of persons are available by census year for the major socioeconomic groups: professional; proprietors, managers and officials; clerks and kindred; skilled workers and foremen; semiskilled workers; and unskilled workers. About 150 detailed occupations form subgroups of these. Comparable data on numbers for each census year and income for 1949 are not available for all of the 150 subgroups. Subgroups for which comparable data were not available were put into an "other" category for each of the major socioeconomic groups. The quality indexes are based on the resulting fifty-five occupational groups, including the "other" groups.

Put on a 1910 base, the quality index for the nonfarm occupations is as follows.

1910	100
1920	102
1930	103
1940	102
1950	105

This lack of much quality increase between 1910 and 1950 is especially surprising if one looks at the relative decline in unskilled workers.

While there were large increases in the highly paid groups of professional persons, these still did not make up a large percentage of the labor force. Meanwhile there were numerically more important increases among groups of clerks and kindred workers with below-average incomes. Semiskilled workers also became more prevalent. These are the kinds of change that account for the apparent lack of quality increase, even though there were substantial changes in occupational composition of the labor force.

QUALITY OF THE FARM LABOR FORCE

Within agriculture there was a relative shift away from farm laborers to the managerial groups of owners and tenants. This made for a rise in quality.

The farm labor force may be incorporated into the analysis under two alternate assumptions. First is a low-quality assumption that uses the 1949 unadjusted income figures for farmers. The second, a high-quality assumption, uses nonfarm incomes within the same major socioeconomic classification as the measure of farmer quality. This second assumption is motivated by thoughts on why farmer money income may understate the desired measure of income. Low price levels may prevail for farmers due both to rurality and to concentration in the South. Moreover, income in kind is undoubtedly more important for farmers.

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Under the low-quality assumption, the actual 1949 average income for farm laborers is $1,080 and for owners and tenants is $2,073. Under the high-quality assumption, the income for farm laborers is $2,002 and for owners and tenants is $4,621; these are average incomes for nonfarm laborers and nonfarm proprietors respectively.

The farm labor force quality indexes are as follows.

	Low-Quality Assumption	*High-Quality Assumption*
1910	100	100
1920	106	107
1930	104	104
1940	103	104
1950	105	107

The alternate assumptions do not much affect general movement of farm quality, but they are of importance in combining farm and nonfarm labor forces.

LABOR FORCE QUALITY FOR THE ECONOMY AS A WHOLE

For farm and nonfarm separately, the above indexes show hypothetical average income per worker, using a 1949 income measure in conjunction with occupation mix. An index of quality for the economy as a whole is obtained if we add the hypothetical farm and nonfarm total income and divide by total labor force to get hypothetical average income per worker.

	Low-Farm-Quality Assumption	*High-Farm-Quality Assumption*
1910	100	100
1920	106	102
1930	107	100
1940	108	99
1950	114	100

The alternate assumptions underlying these indexes are the same as described previously for the farm labor force.

The 14 per cent rise from 1910 to 1950 under the low-farm-quality assumption is principally due to the relative decline of agriculture and to the fact that farm quality is substantially less than nonfarm quality under this assumption.

The marked stability under the high-farm-quality assumption is due to the fact that farm quality here turns out to be somewhat higher than nonfarm. The farm decline then makes for a fall in quality that offsets the slight rise in nonfarm quality.

The indexes are hardly exact measures of quality. Too many questions can be raised as to the underlying classifications and the choices made in the index construction.

Yet the measures support several important conclusions. Changing quality of labor inputs associated with occupational mix seems to have been a minor source of U.S. growth from 1910 to date. While a positive increase in quality may be indicated, it is almost certainly very small on an average annual basis as compared with changes, say, in output per unit of input. If there has been a significant increase in quality at all, it is associated with the relative decline of agriculture. Possible lack of comparability of farm and nonfarm money income is a chief hindrance to accuracy in our estimation of changing quality.

Data exist for extending the calculations back to 1870. Preliminarily, it looks as if labor quality change was greater in the four decades prior to 1910 than it has been since.

MURRAY WERNICK, Board of Governors of the Federal Reserve System

Edward Denison has presented a useful discussion of over-all productivity measurements, relying primarily on OBE employment data to compute labor input. However, productivity statistics using manpower inputs have many uses and users and the fundamental question is, as Boulding has stated, "What questions can be answered better as a result of the measure we devise?"

From earlier concern over the labor-displacing effects of mechanization, interest has increasingly shifted to the relationships of labor productivity to wages and inflation, to expanding national industrial strength, to future manpower needs, to cyclical relationships, and to the distribution of the increments in real income among the factors of production.

Much has been said at this conference about the need to determine the effect of quality changes of inputs on productivity measurements. The impact of recent technological innovations, shifts in demands, and the increasing importance of research and development are accelerating shifts in the composition of employment. However, disaggregating the effect of such changes in specific quality variables as industry, occupation, and sex is difficult. Not only is there a question of adequacy of manpower input data, but even the presumption that we can ever obtain the necessary comparable real output data is suspect. Research, however, is indispensable if we are to obtain insight into periodic deviations from long-term trends in productivity or to analyze actual changes in the slope of the trend line for important industries and occupations, as well as the economy as a whole.

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Denison is primarily concerned with a long-run measure of productivity which tends to incorporate all qualitative changes in manpower input into a single homogeneous quantity, either total employment or total man-hours. His series, he indicates, measures the efficiency with which an economy maximizes output while minimizing real costs. Other uses of productivity series are mentioned but it is clear that the over-all series he has constructed is not sufficiently versatile to meet the broader needs mentioned above. This leads to two problems: the validity of his suggested measures of manpower inputs in aggregate productivity series and the additional measures of input which are necessary to evaluate and answer questions, especially operational questions often imposed by public policy needs.

I believe that in the construction of labor productivity series, the preferable labor input measure is usually some man-hour measure. The number of persons employed is not satisfactory because of the wide diversity of hours experience and the sharp relative growth in recent years of part-time employment, particularly in service and trade industries. Denison implicitly acknowledges this and attempts to compensate for variation in the workweek and in the number of weeks worked per year by converting part-time employment into full-time equivalent employment in some major industry groups. This is accomplished by dividing total wages and salaries by average annual salaries of full-time workers. This conversion is, however, not performed for manufacturing, mining, construction, farming, or public utilities because of the estimating procedure used by Denison, although the Bureau of the Census' Current Population Survey reports a small but increasing number of part-time workers in these industries. Inclusion of full-time equivalents for the excluded industries would reduce the denominator and increase output per man.

Other objections can be raised to the full-time equivalent employment series. Annual data used by the Office of Business Economics to estimate full- and part-time employment and payrolls are available for selected industries only for years in which a Census of Business is conducted. Estimates of full-time equivalent employment are accurate only if the ratio of part-time workers to full-time workers and the ratio of average hours worked by part-time workers to average hours worked by full-time workers has remained constant since the last benchmark. During recent years, these ratios have shown sharp changes which are not reflected in the "persons engaged" series. Thus, for example, between 1950 and 1957, the number of part-time workers, primarily women engaged in service and trade occupations, rose by 40 per cent, while the number of year-round full-time workers increased by only 10 per cent. This shift in workforce composition has

probably had some adverse influence on measures of output per unit of labor input which are not fully reflected in the "full-time" equivalent series.

Since average hourly earnings of full-time employees are substantially higher than earnings of part-time employees, the OBE series in effect implicitly makes a partial adjustment of employment for quality changes by weighting hours paid for by earnings. While it is at times desirable to adjust input factors for specific quality changes, such adjustments are most useful when done on a more systematic and comprehensive basis.

Denison buttresses his preference for employment rather than man-hour inputs by stating that reductions in standard hours worked have been a prime cause of increases in output per man-hour. He states that hours reduction has exerted an influence on productivity through two channels: reduction of worker fatigue and, more important, encouragement of greater managerial effort and of the substitution of capital for labor. These factors undoubtedly have played some role in past advances in output per man-hour, but probably were of less significance than Denison implies.

A real reduction in fatigue undoubtedly accompanied the shortening of the workweek, so long as average hours were considerably over forty. There is considerable evidence that since the end of World War II, fatigue is no longer a compelling reason for reducing the workweek. In many industries workers have willingly traded some leisure for additional income. In the Akron rubber industry, a standard workweek below forty hours led to a sharp growth in the number of persons holding two jobs and apparently to an actual increase in average hours worked per worker. When labor demands are strong multiple job holding tends to become more prevalent. Twice as many employees in 1957 held dual jobs than in 1950.

The more important aspect of Denison's position, however, rests on the fact that historically reductions in standard hours have usually been accompanied by a rise in hourly earnings. Denison argues that this rise in labor cost has been an incentive to more effective organization of the labor force and to mechanization of operations. However, it is well known that improvement in management practices and in the substitution of capital for labor have occurred during our entire industrial history. The high relative price of labor and the belief that hourly labor compensation would continue to increase relative to capital cost (irrespective of whether hours declined or remained constant) has, of course, provided an incentive for investment. Other related developments should not be overlooked: the constant advance of technology, the growing skill and education of the labor force, the

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growth of scientific management, and the increasing use of engineers and other professional employees. It is true that in the past, hours reduction sometimes involved sufficiently large increases in cost to have some shock effect on managerial efficiency. Nevertheless, it seems more fruitful to view reductions in standard hours as one of the methods by which productivity gains are shared rather than as a specific cause of productivity advance.

The postwar trend has been toward more leisure. Longer paid vacation periods and more holidays, rather than reductions in the standard workweek, have become the major forms in which leisure has been extended. These developments make it increasingly important to use man-hours worked rather than man-hours paid as a measure of labor input. The older age of entrance into and earlier retirement from the labor force may also be conceived as adding to the leisure of persons in the working age population and a benefit of increasing productivity. This form of welfare gain is only implied in current productivity measures and to measure its significance probably requires an approach which relates man-hours worked to potential manpower resources available.

I now turn to current needs for more refined labor productivity data. I would urge in this connection the extension of manpower input measures in the following areas.

1. Disaggregation of over-all input data by industry. Substantial progress is being made, as indicated in Alterman's and other papers delivered at this conference. Output per man-hour series for individual industries should eventually permit us to compare rates of change between manufacturing and other sectors, and to determine the influence on economy-wide productivity change of the shift in manpower resources from commodity-producing industries to noncommodity-producing activities, such as government and private services, and distribution. It should also shed important light on wage-cost-productivity relationships among the industries. "Should" is used advisedly instead of "would" because the meaning of productivity measures outside the commodity-producing sectors remains unclear conceptually.

One of the major advantages of disaggregation may be a negative one. Industry detail tends to highlight the inadequacies of measures of real output for the noncommodity sectors. For instance, productivity gains have probably been substantial in domestic service, but if real output is measured by deflated payrolls then output per man-hour is shown as a constant over time. Constant dollars of personal consumption expenditure for medical services divided by the number of medical personnel may measure growth in overhead medical staffs

and change in the number of patients a doctor manages to see in a day, but has little relevance to the real productivity factors, such as number of visits required for a cure, average length of illness, or proportion of patients surviving a particular disorder. Likewise, the validity of deflated personal consumption for educational services as a measure of output is questionable.

Generally, industry manpower input series are more inclusive than output data. Producers of productivity indexes have handled these problems in various ways. General government employment and output are excluded from most productivity measures, although the manpower input of this sector has become increasingly important. Professional workers are included in input series, although their product is only partly measured in current output data. Domestic servants are included, though under the asumption of constant productivity. These inconsistencies affect the validity of productivity measures as these sectors change in importance or as their rate of productivity change differs from that of the economy.

2. Further analysis is urgently required of the impact on output of shifts in the composition by occupation and sex of the employed labor force. In the past decade the number of salaried employees has risen sharply. At the same time the number of semi-skilled mechanical or hourly rated employees has shown no increase or possibly even a decline, despite a very large increase in total real output.

In manufacturing industries the rapid increase in employment of non-production workers relative to the increase in output in recent years has been reflected in at least a temporary retardation of the rate of growth in measures of output per man-hour of all employees and has been an important element accounting for a continuous rise in unit wage and salary costs between 1952 and 1957. However, if the man-hours input measure is limited to production workers, the rate of increase in productivity has been more in line with historical patterns, and unit wage costs show relatively small changes since 1952.

The sharp growth in the number of nonproduction workers in manufacturing reflects primarily expanded employment of professional workers, many of whom are engaged in research and development activities. Research and development, however, is not fully reflected in current measures of output either in the physical volume series or in GNP-based measures. A more realistic approach probably requires the capitalization of at least part of current research expenditures, rather than their present treatment as a current labor cost.

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at a record level. Female employment tends to be concentrated in certain occupations—salesworkers, clerks, nurses, and school teachers—and a high proportion is in part-time work. Their entrance into employment probably has some dampening effect on over-all productivity measures. The rapid and sustained rise in the participation rate of women in the work force is possibly due in large degree to the substantial reduction in labor input required in homemaking, but no present measure takes account of this factor. It is thus likely that the social output per woman worker has risen, a fact excluded from current productivity measurements.

3. Large variations in year-to-year changes in productivity pose important problems for current economic analysis, especially when public and government attention is focused on inflation. A case in point is the experience of 1956 and 1957, which in most computations show up as years of relatively small productivity increases. The 1956 Economic Report of the President states that "the smallness of the 1956 gain in productivity contributed to the rise in unit labor costs and, in turn, to the increase in prices."

Nowhere have I been able to find an adequate analysis of why productivity failed to make normal gains in these two years. On the manpower input side of the equation a rapid shift in the composition of the employed labor force can be shown to be one possible important short-run factor. The rather consistent pattern of change in productivity growth during the business cycle is also worthy of analysis.

Some interesting work on changes in productivity during the cycle has been done with existing data. Thor Hultgren of the National Bureau, using monthly BLS man-hours data and some of the monthly industry series of FRB Index of Manufacturing Production for which quantity data are available, has shown a definite relationship for the industry series between the stage of cycle and the rate of productivity change. Our own studies generally confirm the findings of an acceleration of productivity gains and a consequent decline in unit labor costs during recovery periods with the reverse development taking place in expansion periods.

Are the available data adequate for such detailed analysis of manpower inputs? The answer must be equivocal. A vast expansion has taken place in both the quantity and quality of available manpower statistics in the postwar period and such data are a basic part of our statistical area economic intelligence. A wide variety of cross-classified information relating to industry, occupation, sex, part-time work, and dual job holding are being produced from sample establishment reports, sample household reports, and from expanded social security programs. While progress is being made, much of this information

lies dormant and has not been exploited for experimentation in input-output measures and related problems of labor requirements and unit labor costs. In large part this is due to lack of appropriate comparable real output quantities. However, our preliminary studies using Bureau of Census data for the manufacturing industries leads to the conclusion that occupational and other data relating to quality factors can be meaningfully used as inputs when a real output series exists for an industry.

The rather stringent criteria which Denison has established for permissible error in manpower input measures, the need for interdependency between input and output data, and the greater reliability of long-term measures cannot be ignored. But, if current interests and frequently legitimate policy questions pertaining to labor productivity are to be taken seriously, then compromises with less precise measures—a not unusual operational practice—may have to be made.

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