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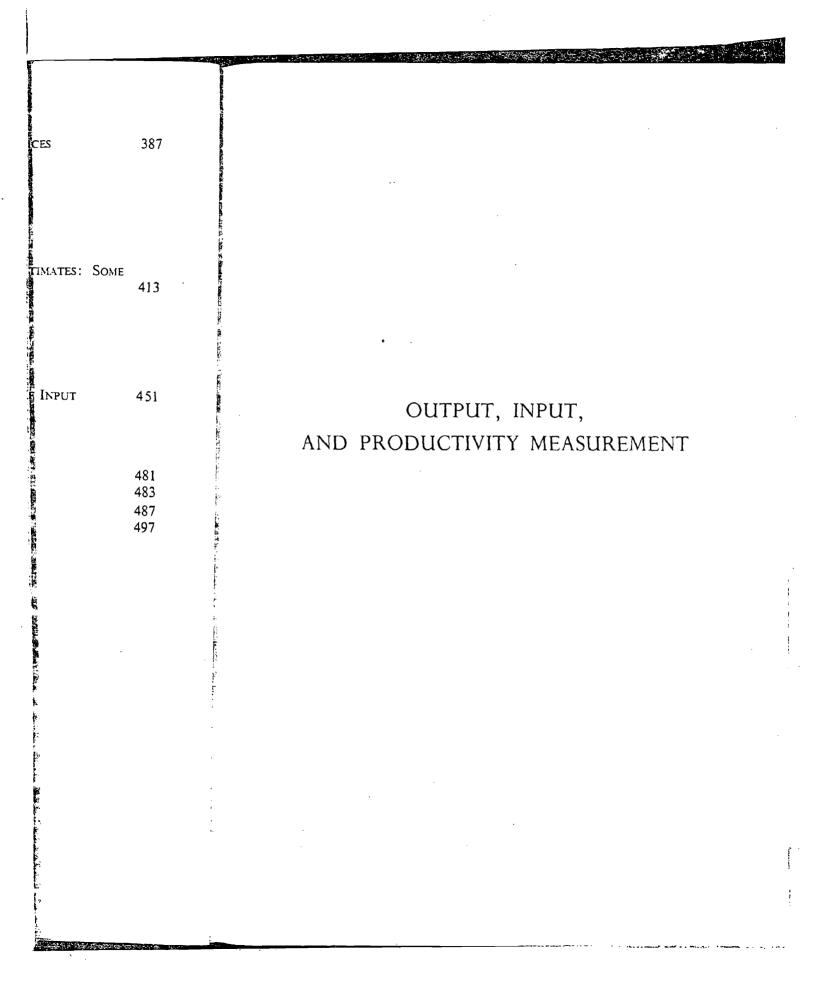Volume URL: http://www.nber.org/books/unkn61-1

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Introduction:
Productivity and National Income Accounting

JOHN W. KENDRICK

ALONG with the upsurge of interest in economic growth during the postwar period have come improvements in the measures of output, input, and productivity. Prior to World War II, most productivity measures were of the simple output-per-man-hour type. Useful though these measures are in showing changes in labor requirements per unit of output, they are obviously inadequate measures of changing productive efficiency as such because not all inputs are included. Since the war, substantial progress in the estimation of gross and net output and real capital stocks, as well as employment, in the economy and various industrial divisions has made possible the preparation of more comprehensive "total factor productivity" estimates.

Despite the care with which such estimates have been made, however, productivity remains one field in which economic statistics have run ahead of economic theory. Unaided by the theoretician with respect to the proper treatment of certain of the more difficult aspects of productivity measurement, especially the problem of measuring real-capital stock and input, the statistician has had to proceed using the most reasonable concepts and conventions he could devise. The results have been useful, but certainly current estimates are amenable to improvement, and both makers and users could profit by devoting more thought to their meaning and interpretation.

The Executive Committee of the conference decided it was time to pause and bring theoretician and statistician together in this important field to try to sharpen our concepts of output, input, and productivity, and to suggest needed improvements in methods of estimation and basic data. Refinement of productivity measures will make possible more meaningful analyses of dynamic economic processes and thus more effective policies in areas affected by productivity change.

The Relation of Productivity Measurement to the Economic Accounts

On first glance, the subject of productivity might appear to be somewhat tangential to the central focus of a Conference on Research in Income and Wealth. Actually, the national income accounts

provide an ideal framework for the measurement of productivity and of related variables on a consistent basis.

Productivity may be defined as a relation, frequently expressed in ratio form, between output and associated inputs in real terms. It is apparent that the current-value national product, "deflated" to eliminate the effects of price changes, provides a comprehensive measure of the physical volume of production of final goods and services for the economy as a whole. What is not as immediately apparent is that the national income, which represents the money costs of units of factor services, may also be deflated by appropriate factor price indexes in order to isolate changes in the physical volume of factor inputs, or "real-factor costs." In practice, it is more convenient to estimate the factor inputs directly, and to obtain the implicit factor price deflator as the quotient of national income and real-factor cost.

Since national income is defined and measured to equal the national product at factor cost, the real outputs and inputs are consistent, and equal in the base period, if the final goods and services are accorded unit-factor-cost weights. The constant dollar input series may be divided into the real product series to obtain productivity ratios through time.

The advantage of relating real product to the sum of associated factor inputs, human and material, is that the ratios indicate the *net* saving of inputs, and thus the change in productive efficiency; ratios of real product to single classes of input, such as labor, reflect the effect of factor substitutions as well. Further, the total factor productivity measures are consistent with the implicit product and factor price indexes. The product price index can be decomposed into unit factor costs of the various types, which, in turn, can be expressed as quotients of the corresponding factor price and partial productivity measures.

The national accounts framework can also be used to obtain industry estimates of real product, factor input, and productivity on a basis consistent with the national estimates. The industry approach is, in fact, a third method of obtaining national aggregates. Real product in the various industries may be estimated as the difference between the deflated values of output and of intermediate product purchases—the so-called "double deflation" method. The inter-industry or "input-output" matrix represents an elaboration of the industry production account, and is helpful in establishing weights for the price deflators of purchased goods.

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income, or real-factor cost, originating by industry represents a direct decomposition of the national aggregate, and is consistent with the industry real-product estimates. Industry productivity estimates, obtained as quotients of real-product and real-factor cost by industry, are thus consistent with the national productivity estimates. The industry unit value added and factor price indexes are likewise consistent with the national measures, and with one another.

Some of the conference papers reveal that substantial progress is being made toward the goal of a comprehensive set of real output, input, productivity, and price estimates for the economy and major sectors and industries in this country and others. A rich analytical harvest awaits the completion of this task; some of the analytical uses of productivity and related measures are illustrated in the papers.

It is interesting to recall that, at the first meetings of the Conference on Research in Income and Wealth, Morris Copeland recognized the potentialities of the national income accounts for productivity measurement.

> "Income derived from an area may be deflated to show changes in the physical volume of services of labor and wealth employed by the economic system from time to time. If we may neglect net income from abroad as relatively small, the deflated distributive shares may be compared with the deflated consumed and saved income to show changes in the efficiency of operation of the economic system."[1]

Recognition of the possibilities of estimation of productivity within the income and product framework is, however, a far cry from the realization of these possibilities; solutions to hundreds of specific conceptual and statistical problems lie in between. Many problems have already been solved in setting up the current value accounts, such as those relating to the scope of the estimates, the definition of "final" as contrasted with "intermediate" products, of consumption and investment, and so on. Even some of these solutions and conventions need re-examination from the viewpoint of requirements for productivity analysis, and alternative definitions, estimating methods, and rearrangements or extensions of the basic current value estimates may be required to give more satisfactory productivity results.

Beyond this, there are the specific problems involved in deflation of product and factor cost to separate price and quantity movements. Several papers given at earlier meetings of the conference have treated certain aspects of these problems, as can be seen from the Indexes to

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[1] Morris A. Copeland, "Concepts of National Income," in *Studies in Income and Wealth*, Volume One, National Bureau of Economic Research, 1937, p. 31.

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the twenty-five volumes of the "Studies in Income and Wealth" series at the end of this volume. There have been several papers on the deflation of the national product; the estimation of employment and the corresponding labor compensation has been touched on; and several sessions have been devoted to wealth estimates, which are a prerequisite to estimating the real services of capital stocks. But the problems of estimating real product and the associated factor inputs have not previously been systematically treated together from the integrating viewpoint of their use in productivity estimation and analysis.

The unifying theme of the meeting—productivity—was the subject of the first of the three conference sessions. The authors consider not only what we might ideally like to measure under this rubric but also the meaning of the actual measures that emerge from the national economic accounts. Both the statistical and theoretical requirements of meaningful measures are set forth, and the adequacy of basic data to implement the concepts is reviewed.

The second session was devoted to the concepts and problems of measuring real national product. Emphasis is given to the estimation of real product by industry, partly because the deflation of final expenditures by type of goods and services has received more emphasis in the past, but mainly because the alternative industry product approach makes possible the description of national productivity changes and relationships in terms of the component industry movements. It also makes possible international output and productivity comparisons by industry, which are also discussed.

The concepts and problems of measuring the factor inputs were the subject of the third session. Somewhat more attention is devoted to real-capital stocks and services than to labor input, in part because the conceptual and statistical problems of capital measurement seem greater. Problems of factor substitutions are considered, and existing capital estimates are subjected to critical review.

Although the main focus of this conference was on conceptual and methodological problems, a number of the papers are devoted to reviews of data or available estimates, and several sets of estimates are presented for the first time in this volume. While it is obvious from perusal of the papers that we have not wholly deprived future researchers of the joy of solving difficult problems in this area, it is also apparent that much progress has been and can be made toward the goal of an integrated set of total and partial productivity measures within the national accounts. Completion of this work will open new vistas for the analysts who are concerned with causes and effects of productivity change.

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Preview of Conference Papers

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THE CONCEPT AND MEASUREMENT OF PRODUCTIVITY

The opening paper by Irving Siegel is well designed to disabuse the innocents in the field of the notion that there is any general-purpose productivity index, and to warn of the complexities involved in pre-paring appropriate indexes for specific purposes. He finds that many makers and users of index numbers "tend to overlook the strict demands and implications of *literal* algebra while meeting the easy requirements of *verbal* algebra. Both kinds of algebra must be taken into account, however, in the design of consistent output and input measures, the design of productivity measures that are compatible with index numbers of other associated variables (e.g., wages and prices), and the evaluation of indicators that actually are constructed or used." In particular, he would require that output, input, and pro-ductivity estimates have the same coverage, represent an internal average of the component relatives, and that each be derivable from the other two as quotient or product. The national income accounting framework certainly conduces to these objectives.

These requirements necessitate adequate basic data. Siegel is not happy about the progress of productivity measurement since the good old days of the WPA National Research Project, but he is encouraged by the growing tendency of companies to estimate their own produc-tivity changes, which will strengthen the establishment basis of reporting. "Mutually adapted" weighting systems are also necessary. Consistency with related measures would make it possible to express the productivity index as the ratio of input price to output price indexes.

Siegel considers in some detail technical aspects of both the so-called "labor productivity" indexes, and indexes of total, or "multifactor," productivity, and he develops various interesting verbal identities relating to each type of measure. Differing output and input concepts may, of course, enter the productivity formulas. For example, output may be measured gross, net, or in terms of subproducts; labor input in terms of persons engaged, employees, or production workers only, or man-hours worked or paid for; and alternative capital measures

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are also numerous. Siegel does not view pecuniary weights as necessarily superior to or more "economic" than other types of weights, such as man-hours. "Furthermore, since all indexes are artifices, their construction and use must be reckoned as closer to accounting than to economics."

This is one point at which his discussant, Carl Christ, is forced to disagree; Christ feels "that shifts of production functions are what productivity indexes are really about." He also would seem to disagree with Siegel's proposition that labor productivity indexes should be made as weighted means of relatives by use of man-hour weights for output; rather, Christ thinks "that any improvement in social organization which permits the transfer of resources from a less productive to a more productive industry ought to be regarded in one sense as an increase in productivity." Christ later goes further and suggests that one should try to get independent measures of all the forces that may account for increases in total factor productivity. This would give us greater understanding of the dynamics of economic growth, and perhaps enable us "to push forward our production frontier more rapidly or more cheaply than we now know how to do." As a contribution to this objective, he suggests several kinds of empirical studies of the process by which knowledge concerning technical possibilities is diffused.

Professor George Stigler's paper complements Siegel's in that Stigler is concerned with the *economic* problems in measuring and interpreting productivity change. He points out that while the traditional output-per-man-hour measures are partial and unreliable as measures of output per unit of total input, especially over short periods, they nevertheless will "generally rank the commodity-producing industries correctly with respect to true productivity changes." Turning to the total productivity measures, he develops theoretically the major components of productivity change as measured. He would prefer to confine the indexes to the measurement of technological change by segregating the effects of changing scale, rates of utilization of capacity, and changing inherent quality of inputs.

The component of total productivity change which he considers potentially largest, and the most difficult to separate from technical change as such, is the net effect of external scale economies. Here, Stigler presents the results of some econometric studies, based on fitting a production function to Creamer's estimates for domestic manufacturing, and on an international cross-section analysis. His results lead him to conclude that "economies of scale are potentially of the same order of magnitude as technical progress."

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scale in time series, since the effects of increasing return to scale and of technical advance are mixed together. He questions the meaningfulness of the international cross-section study and demonstrates that "universal constant returns to scale might lead to just such an appearance of increasing returns" as Stigler finds, but for different reasons. Morris Copeland also criticizes Stigler's cross-section analysis, and produces an alternative statistical analysis of the same data which results in the appearance of decreasing returns. Copeland regrets that Stigler did not find it possible to attempt to quantify the other components of productivity change as measured.

Stigler's remarks need not be interpreted as detracting from the value of total productivity measures; they do underscore the caution that users must be aware that the present measures reflect more than pure technical advance. It would undoubtedly be useful for the study of economic growth to know how important the scale factor has been, although the broad productivity measures are still indispensable. One suspects that we may in the end have to rely more on the hunches of a Stigler than on neat econometric solutions to the puzzle of distinguishing the effects of scale economies from those of technical progress

In passing, Stigler mentions the tendency toward diminishing return in extractive industry, but does not consider its potential magnitude as an offset to increasing return. Harold Barnett of Wayne State University and Resources for the Future devotes his paper to this problem. Looking at it first from a theoretical standpoint, he maintains that the premise of a dynamized law of diminishing return— *economic* scarcity of natural resources—must be viewed as a hypothesis and not a fact. He attempts a partial test of the hypothesis by comparing the extractive and nonextractive sectors of the economy with respect to trend in both average prices and output per man-hour.

The productivity comparisons are based on estimates presented in a separate conference paper by Neal Potter and Francis T. Christy, Jr. The price and productivity comparisons either do not support or are adverse to the hypothesis of resource scarcity with respect to agriculture and mineral industries, but do support the hypothesis in the timber industry. Barnett hastens to add that his tentative conclusions would be modified if there had been differential change in the two sectors with respect to other parameters such as technology.

William Vickrey develops other theoretical qualifications to the tests; also the very practical empirical point that output units are quite standard over time in extractive industry, while in many other sectors there has been a gradual net quality improvement which imparts a persistent bias to the relative price and productivity movements.

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INTRODUCTION

It is also apparent, as Barnett notes, that the productivity comparisons would have been even more convincing if they had taken account of capital and intermediate product inputs as well as the labor inputs. Nonetheless, the Potter-Christy paper adds considerably to our knowledge of the extractive sector. It is also useful, as pointed up by the comments of Vivian Spencer, in illustrating the difficulties encountered in estimating output and labor input over a long time span in a major industry segment.

The availability of data for the measurement of output and man-hours for all segments of the United States economy is reviewed in a final paper by Leon Greenberg, who directs the program of productivity measurement in the Labor Department. He covers methodological problems of estimation, and also pinpoints weaknesses and gaps in the underlying data. Particularly valuable is the compilation he presents for all industries showing availability of data on output quantities, values, prices, employment, and hours. The paper's discussant, Raymond T. Bowman, comments: "In the years ahead, it should be possible to use the information to strengthen the basic sources of productivity data and fill in the more important gaps." This comment has added significance, coming from the Assistant Director for Statistical Standards of the Bureau of the Budget, under whose aegis the Greenberg survey was instigated.

ESTIMATES OF REAL PRODUCT

The second portion of the conference was devoted to the concepts and measurement of output, with particular emphasis on the estimation of industry real products. The industry approach, as noted earlier, makes possible estimates of productivity by industry which are consistent with national productivity measures.

It was appropriate that the session was opened with a paper by V. R. Berlinguette and F. H. Leacy of the Dominion Bureau of Statistics, since Canada has probably gone further with implementing the industry product approach than has the United States. The authors point out that the Dominion Bureau has found the industry real-product (net output) estimates to be useful (a) as a check on the results of deflating the gross national expenditure, (b) for current analysis of the industrial composition of changes in the volume of total real product and productivity, (c) for analysis of price-volume components of value changes, and (d) as a basis for economic projections incorporating component industry detail.

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The paper by Jack Alterman and Eva Jacobs presents exploratory estimates of real product originating in all major industry divisions of the U.S. economy annually since 1947, a description of methodology, and some analysis of the results. This project was undertaken at the request and with cooperation of an Interagency Committee on Production and Productivity Statistics sponsored by the Office of Statistical Standards in the Bureau of the Budget. It is gratifying that the real gross national product derived as the sum of the real product of fourteen industry divisions, for which estimates are presented, is quite close in all years to the real GNP estimates derived by deflating final expenditures by type, as published by the Department of Commerce. Encouraged by the results of this exploratory study, in which its representatives also participated, the National Income Division of the Commerce Department in fiscal year 1960 has begun to devote resources to the estimation of national product by industry grouping, which it is hoped will eventually become part of the official national accounts.

National product estimates by industry not only provide an additional approach to and check on the aggregate but they also permit new and useful lines of analysis, two examples of which are provided by Alterman and Jacobs. The new estimates make possible analysis of the changing industrial structure of production and, when related to associated inputs, the analysis of relative productivity change by industry. Thus, the reader who consults Table 1 of the paper will see that business and personal services show average increases in real product per man-hour well below average, while farming and public utilities have been on the high end of the scale in the postwar period. The estimates also make possible the calculation of the effect on productivity of interindustry manpower shifts. Between 1947 and 1955, only 4 per cent of the over-all increase in real product per man-hour

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is traced to this cause—a significantly smaller proportion than has been revealed by studies covering longer time spans.

The notes on sources, methods, and techniques provide a relatively solid point of departure in most sectors for further work along these lines. It should be noted that the estimates described by Alterman and Jacobs were based on then-available data. New tabulations from the 1958 censuses, the interindustry chart for that year also being undertaken by the National Income Division, and expansion of the BLS price-collection program will help substantially in preparation of yet more reliable industry product figures.

Prior to the estimates presented by Alterman and Jacobs, only three major sets of industry real-product estimates had been published—those by Kendrick and Jones for the farm sector (which have been continued by the Commerce Department), the net output series for manufacturing developed by the Labor Department, and an earlier set of estimates for various industries prepared by Simon Kuznets. The methodology underlying these series is carefully reviewed by Almarin Phillips. Except for agriculture, Kuznets' industry output estimates were obtained by extrapolating base-period national income by gross output measures. Their validity depends on the generally untested assumption that the ratio of net to gross constant dollar output remains unchanged. This comment applies as well to the industries treated likewise in the estimates presented in the papers just discussed. With respect to the true net output series, Phillips finds them "virtually devoid of serious conceptual error," but points out specific needs for better data. He makes a real contribution to further work by calling attention to and developing one variant of Kuznets' deflation technique that has gone largely unnoticed. By this method, current dollar value added or industry product can be deflated by "a weighted average of the difference between the gross output and the input price indexes." This technique is most useful when industry product estimates are available, but not the necessary data on sales and purchased intermediate products. Phillips tests this method applied to manufacturing value added against the results obtained by BLS using "double deflation."

Since the Phillips paper is, in a sense, a commentary on the Alterman-Jacobs work, Charles Schultze, who was scheduled as a discussant of the latter paper, was free to give the conference a bonus by illustrating applications of the industry real-product series in price-change analysis. He demonstrates that in conjunction with current dollar industry-product estimates (which Schultze built up from the Commerce Department's industry income figures), the consistent real-product series can be used to obtain industry unit value-added

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The OEEC has· recently been experimenting with international comparisons of real product by industry. This work is not to be confused with the reports issued in 1954 and 1958 which compared national product by expenditure class for several member countries and the United States.

Milton Gilbert and Wilfred Beckerman, in their discussion of this recent work, devote much of their paper to the theoretical problems involved in international product comparisons—treatment of net income from abroad, the effect of differences in tastes and income distribution among nations, quality differences and unique products, and differences in relative price weights. With respect to tastes, for example, they argue that international differences are less than differences over long time spans in the same country. They support this position by reference to their statistical studies: "It was remarkable how greatly the observed international differences in consumption patterns appeared to be explained by differences in incomes and relative prices." This conclusion was concurred in by their discussant, Tibor Scitovsky.

In general, Gilbert and Beckerman feel that conceptual limitations on intercountry comparisons are no greater than those which apply to intertemporal comparisons, and are not great enough seriously to affect the order of magnitude of the results.

The results of a comparison of real product by major industry division for the United States and United Kingdom in the year 1950, together with employment comparisons, are given in tables. The aggregate industry product estimates are compared with the real-expenditure totals for the same year. The effect of the alternative country weights are somewhat different in the two sets of estimates, and the authors discuss the relative reliability of the statistical underpinnings of each. The implied net output per worker comparisons by industry are very interesting, and one hopes that the corresponding

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capital coefficients will some day be available to help in the explanation of international productivity differences by industry.

Tibor Scitovsky opens his comments on the Gilbert-Beckerman paper by reference to the "tug of war between the more imaginative statisticians and the more rigorous—or should I say more pedantic—theorists." Although cast in the role of the pedant, Scitovsky declared himself as quite sympathetic to the OEEC attempts at international real-income comparisons. He goes on to discuss further the economic meaning of the comparisons in both their welfare and productivity aspects, and argues that the estimates are more ambiguous in meaning from the productivity viewpoint.

THE MEASUREMENT OF INPUT

The third and final session of the conference was devoted to problems in the concepts and measures of economic input. In planning the program the Committee placed particular emphasis on capital, the estimation of which is peculiarly elusive.

In his introductory paper, Kenneth Boulding points out that definitions of input vary with the context. Whereas, in studies of income distribution and resource allocation, inputs must be defined as equal to output, in productivity studies it is essential that input be defined in such a way that its changes will *not* equal output changes. This leads to the problem of differentiating between significant and nonsignificant inputs. In a later discussion, Zvi Griliches suggests trying to measure *all* input in an attempt fully to explain output change. But in any case, it is apparent that the change in "efficiency" indicated by a productivity index depends on the scope and definitions of the inputs.

Like Stigler, Boulding is interested in identifying productivity change in terms of shifts in production function. He discusses theoretically various types of "factor-saving" shifts, and his discussant, Murray Kemp, pushes the analysis somewhat further. Unfortunately, statistical measures cannot precisely reveal the shifts except under an unholy alliance of assumptions of linear, homogeneous production functions, competitive markets, and constant input proportions.

The first part of Boulding's discussion is based on the assumption that labor and capital inputs can be measured in homogeneous units over time. He then raises questions as to how "labor" use of time may be separated from nonlabor use, and how the intensity of labor may be measured. Dangers in measuring capital-output ratios are noted: "The composition and physical nature of capital changes all the time, and any measure of its aggregate becomes increasingly arbitrary as time goes on." Despite his avowed failure to find solutions, Boulding pleads that "accurate" input measures should not be

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substituted for "significant" ones, and he concludes by warning against "the danger of our information system controlling the questions instead of the questions the information system."

The problems of measuring labor input were assigned to Edward Denison and his two scheduled discussants, George Tolley and Murray Wernick. Before settling down to the main issue, Denison could not resist the temptation briefly to renew the discussion concerning the proper scope of national product estimates. He argues that "social overhead" outlays must be included in product; their exclusion as advocated by Kuznets would, in effect, "omit from the measurement of output provision for the satisfaction of all needs that change over time because of changes in individuals' external environment." Denison thinks this "destroys the national product as a measure of the total output that actually is available to satisfy wants and needs." The narrower treatment would also produce changes in productivity due solely to external environmental changes, unless the resources devoted to the excluded output were omitted from the input measures, which would involve difficult allocations.

Turning to labor input as such, Denison argues that man-hours worked are a better measure than employment of real cost in terms of disutility. Thus, he considers man-hours to be the appropriate gauge of labor input to combine with other input measures to derive measures of productivity, "or the efficiency with which an economy maximizes output to satisfy its members' wants while minimizing real costs." Denison enters more controversial territory, however, when he claims that employment is a better measure than man-hours of effective labor input in terms of the contribution labor makes to production. He argues that output per man will vary less than output per man-hour with changes in hours at all points above thirty or so per week, and thus employment is a labor input measure "that is crudely adjusted for one form of quality change—the quality of an hour's work that is due to shortening of hours." The effect of a shorter week on hourly production is seen to work through several channels: reduction of worker fatigue and, more important, stimulation of management efficiency and substitution of capital for labor. With regard to the latter, Tolley asks: "Do we want productivity measures to obscure these effects?" Wernick also favors man-hours measures, and makes some cogent criticisms of the estimates of full-time equivalent employment as prepared by the Office of Business Economics.

Denison next considers the adequacy of employment and man-hour data. He points out the "enormous advantage in statistical interdependence between the measures of output and labor input" in the national accounts. Use of the gross national product estimates

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calculated from the income side in conjunction with persons-engaged series consistent with the labor compensation component maximizes this advantage in short-run comparisons, although over the long run the statistical discrepancy is not important. Based on his long experience in income work at the Commerce Department, Denison guesses the average error in the annual rate of change in real national product per person resulting from errors in the "persons-engaged" series to be roughly 0.2 percentage points for year-to-year comparisons, and to be negligible for periods longer than two or three years. Since data for average hours of work are less reliable and complete than employment data, Denison puts the error in the man-hour series at several times that in the persons-engaged estimates. He doubts whether the error is serious in long-term comparisons of output per man-hour, although it may be for short-term changes. "However, year-to-year variations in productivity change are so great that even rather crude measures may be useful in distinguishing years of large from those of small or negative productivity increase."

Denison prefers to use unweighted man-hours in productivity ratios, rather than weight by average hourly earnings in the various occupations or industries, so that the effects of shifts will show up in the productivity measures. He believes, nevertheless, that "comparison of output per man-hour with output per unit of 'labor input' in Kendrick's sense [weighted man-hours] . . . provides a useful measure of the contribution of industry shifts to past increases of productivity, and hence also a useful tool for projections." Tolley presents some new statistical evidence on this point, based on labor force estimates weighted in terms of fifty-five occupational groups for the period 1910–50. He concludes that "Changing quality of labor inputs associated with occupational mix seems to have been a minor source of U.S. growth from 1910 to date." Wernick urges further investigation of this factor, as well as of changing composition of the work force with reference to sex, industry, and·production as compared with nonproduction workers.

In their paper on concepts of real-capital stocks and services for productivity measurement purposes, Richard and Nancy Ruggles make no attempt to gloss over the inherent difficulties. They are critical of the conventional measures of real capital based on what it would cost in the base year to produce a given year's stock. Such measures attempt to treat capital in terms of standard units, adjusting to exclude changing efficiency of the capital goods but not for the changing efficiency with which they are produced. This attempt runs into difficulties because, for one thing, the designs of products interact with their costs of production. More broadly: "The basic fact is

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that capital in general has no physical units, and any arbitrary solution will predetermine the answers we get." With changes in quality and new kinds of capital goods, it is not possible to know what they would have cost in an earlier, base period. Further, the Ruggleses see an incongruity in not adjusting capital goods for improved efficiency, but yet adjusting net capital stocks downward for the effects of obsolescence. The usual problem of aggregation is posed by changing relative prices, which in the case of capital items are affected by changes in the relative quantities of cooperating inputs as well as by changing technology and other supply and demand forces.

The alternatives of measuring capital in terms of real input, or of capacity, are discussed, but their limitations from a productivity standpoint preclude much support.

Despite the conceptual problems, the Ruggleses find the studies of the National Bureau of Economic Research in the areas of capital-output ratios to be illuminating. This usefulness they trace to the fact that price deflators for capital and for output do not diverge widely, so the ratios in terms of physical volumes move similarly to those based on current dollars, which the authors consider to have significance.

In addition to their treatment of capital stocks and services, the Ruggleses also seek to clarify the treatment of capital formation in the national accounts. They propose adjustment for efficiency change parallel with that extended to consumer goods, and inclusion of certain types of intangible investment and governmental capital formation.

Evsey Domar's first reaction to the Ruggleses' paper was a feeling of relief for having been spared the job himself! He points to attributes of capital which complicate measurement: longevity, impermanence, technological change, source of future income, and a limited second-hand market. Yet, as he notes, most of these attributes also attach to labor, but they "do not prevent our labor friends from merrily aggregating man-hours among industries and over time."

Milton Gilbert, who also contributes a commentary on the Ruggleses' paper, is much more sanguine than they about the possibilities of constructing meaningful capital measures. He thinks that there are enough capital goods that retain their basic characteristics over long enough periods of time to permit the construction of estimates without much more resort to convention than is necessary in the national product estimates as a whole.

Daniel Creamer's paper is devoted to a review and appraisal of the capital, or "wealth," estimates for the major sectors of the U.S. economy, prepared for the National Bureau of Economic Research in

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connection with its study of "Trends in Capital Formation and Financing." All possible methods were employed in these estimates: censuses or balance sheet data were used for agriculture, mining, and manufactures; cumulation of annual net expenditures for nonfarm residential construction; and a combination of these methods for the regulated industries. Creamer describes in some detail the sources of basic data, methodology used, and other characteristics of each of the sets of estimates. For all sectors except mining, he finds it possible to test the estimates by comparison with other more or less independent estimates.

He also aggregates the real net fixed capital estimates for the five sectors and compares them with Kuznets' estimates obtained by cumulating net fixed capital formation in constant (1929) dollars for all private, profit-making sectors of the national economy by decade intervals, 1880–1948. The relative movement of the two series over the period as a whole appears reasonable, although large differences in rates of change in certain decades are disturbing.

Raymond Goldsmith concludes from Creamer's materials that "our best hope for the future is the systematic development of the perpetual inventory method of measuring the stock of capital, i.e., the cumulation of price-adjusted and properly depreciated figures for gross capital expenditures, sectorally classified and broken down by main types . . . ." The indispensable gross capital expenditure figures are available, but Goldsmith sees three chief obstacles to their transformation into stock estimates: (1) better capital goods price indexes are needed, (2) considerable effort is needed to develop realistic depreciation rates, and (3) at least one postwar benchmark estimate of capital stock is required. To supply the last need, Goldsmith proposes a census of national wealth. He thinks we are in far better position to take a meaningful census now than we were at the time of the last one in 1922. Addressing himself to this point, Robert W. Burgess notes various unsolved problems of wealth estimation. He suggests that "the Census Bureau can make the greatest feasible contribution toward an ultimate 'census of wealth' by contributing the results now provided by the various censuses and making some relatively modest changes and supplementary studies that will make these results more useful in the field of wealth. After more material of this general type has been accumulated, and more helpful conceptual analyses have been made, the Bureau might be in a position to cooperate effectively in conducting a single, comprehensive census of wealth."

Whether it is possible to measure capital at all precisely, much precise thought has been devoted to the analysis of conditions of factor substitutions. This problem was of concern to the conference if only

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because relative changes in input quantities and prices create the same index number problem in measuring inputs that beset the estimator of output. More broadly, there is the question of the forces behind factor substitution, and their possible relation to advances in technology and productivity.

Against this background, Eric Schiff first takes up the question whether upward pressure on wage rates, as by labor unions, stimulates research and invention in industry "by making the search for new labor-saving procedures even more imperative than it would otherwise be." On admittedly scanty evidence, he concludes that there is little or no relation. Vernon Ruttan points out that there is even some question whether unions have been able to raise wages generally above equilibrium levels in the first place. Schiff then asks whether wage boosts accelerate the rate at which managements adopt known labor-saving devices. In most nonfarm industry, he argues, "process variation by merely changing 'doses' of individual input elements is precluded by fairly strict technological complementarity constraints." After an interesting review of considerable empirical evidence, he suggests that redesigns of industrial processes are largely independent of changes in labor costs. Ruttan would qualify this viewpoint: "In the longer run, where the production function may resemble something closer to its classical form . . . the possibilities for factor substitution may be considerably greater" than in the short run.

Schiff succeeds in eliciting agreement from Ruttan on his proposition regarding the effect of relative factor price changes: "If capital is substituted for labor in response to rising labor costs rather than to declining costs of capital equipment, then the effect on *total* productivity (output per unit of total input) is negative, despite the rise in *labor* productivity."

The other major section of Schiff's paper has to do with the impact of the corporate income tax on factor substitution. His model leads to the conclusion that increases in corporate income tax rates encourage the substitution of processes that are more labor intensive for ones that require more capital and are more efficient at the lower tax rates. Schiff suggests that the increased tax rates of the 1930's may have been one of the causes of the decline in the capital coefficient during that period.

Ruttan points out that Schiff's conclusion hinges on his assumptions, which are not wholly realistic. He offers several alternative hypotheses to explain the thirty-year decline in the capital coefficient following World War I.

Whatever the impression created by the printed conference record,

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the discussions at the day and a half of meetings were lively, at times heated, and often humorous. In short, a good time was had by the participants. This was a welcome by-product of the presentation of a set of papers which contribute substantially to our growing understanding of the concepts, measures, and meaning of productivity change.

Productivity

Real (