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CHAPTER 2

The Concepts and Measurement of Output and Input

IN THE first chapter we saw that there are various productivity concepts and that the movements of the corresponding measures differ accordingly. Given the general definition of a particular productivity measure, its movement will again be affected by the precise definitions given to the output and input components of the productivity ratios. This forms the subject matter of the first part of the present chapter. With respect to national output—the real value of the final goods and services produced in the nation's economy—the scope and movement of the measure will depend on the precise operational meaning given to such key words of the definition as "final," "nation," and "economy." These questions have been debated at length by national income experts; but we should like to indicate the significance for productivity analysis of the major issues that are resolved somewhat differently in the several important sets of available real product estimates. Industry output measures are likewise conditioned by industry classifications and output definitions, particularly as regards the distinction between gross and net output. These points also will be discussed.

With respect to input, the labor productivity ratios differ depending on whether the input is defined and measured in terms of employment, or manhours, or manhours weighted by relative average hourly earnings in the various occupations or industries. Thus, output per manhour (unweighted) generally rises more than output per unit of labor input (weighted manhours) since there has been a relative shift of manhours to higher-paying jobs.

Output per unit of capital input will vary in movement depending on whether capital input is assumed to move proportionately with real capital stocks or whether capital stocks are adjusted for changes in rates of utilization. Further, it makes a difference whether reproducible capital stocks are measured gross or net of depreciation allowances—the net measures rise less in periods of growth—and whether stocks in the several industries are separately weighted by the relevant rates of return.

Output per unit of total factor input will, of course, rise less rapidly than the labor productivity measures to the extent that capital input, as measured, rises more rapidly than labor input. The relative movements

of the total and partial productivity measures will also vary depending on the weights accorded each of the major factor classes, a problem which will also be discussed later.

Once the operational concepts of output and input are defined, the reliability of the derived productivity estimates will depend on the quality of the basic data and will also be influenced by methodology. The second part of this chapter describes in brief the sources of the data and the methods used in preparing the economy and industry output and input estimates. This summarizes the material contained in the appendixes. An attempt is also made to appraise roughly the accuracy of the estimates and, thus, to point out the sources of possible weakness. For example, since the output and some of the input estimates are "benchmarked" on occasional comprehensive censuses, with estimates for intervening years interpolated by sample data, it is apparent that the productivity estimates more accurately portray intermediate and long-term trends than annual changes. For benchmark years, we have attempted to reconcile direct estimates of output and of inputs for the private domestic economy with aggregates of industry estimates. The relative closeness of the two sets of partially independent estimates attests to the consistency of the economy and industry figures, although it does not prove the accuracy of either, since they may have errors in common.

Methodology also affects the movement of the variables. Reference has already been made to weighting systems. Weights of more recent periods tend to produce smaller historical increases in aggregates than early-period weights, owing to a tendency of consumers and producers to shift their outlays to goods and services that are becoming relatively cheaper. Fortunately, the effects of alternative weight-bases on outputs and inputs tend to be partially offsetting with respect to the productivity ratios. Other methodological questions arise in connection with coverage adjustments, the choice of physical units, and the direct weighting of physical units as compared with the deflation of values by price indexes to obtain physical volume series. No one rule could be followed, but methods were chosen in particular cases which promised to give better results than alternatives.

The general reader may not wish to read the latter part of this chapter on sources and methods. The main point to remember is that the movement of the productivity measures depends not only on the definitions employed, but also on the data and methodology used to prepare the estimates. Since the basic data leave a good deal to be desired, the productivity estimates are not precision instruments in analytical work. Although they are probably good enough to indicate the general order of magnitude of trend rates of change, significance should not be attached to small changes or differences particularly over short periods. It is nonetheless encouraging that the relationships between the estimates of

productivity and of associated variables, discussed subsequently, seem broadly reasonable.

Operational Concepts of Output or Real Product

In this and the following section we shall describe the concepts of the physical volume of output and of the factor inputs *as measured for this study.* Reference will be made to some ways in which the operational concepts may depart from ideal measures or from possible alternative definitions.

OUTPUT OR REAL PRODUCT

In estimating the physical volume of final output (real product) of the economy or its various sectors and industries, it is important first to define the scope of the measure. This means identifying "final" goods as contrasted with intermediate products, which must be excluded to avoid double counting; delineating the scope of economic activity; and drawing the boundaries of the geographical area covered and its component sectors. Then, there are the problems involved in specifying the dimensions of the physical units of goods and services constituting national or industry outputs and defining the unit values in terms of which the physical units may be aggregated or the total values deflated to eliminate the influence of price change.

Scope of the National or Domestic Product Estimates

Although there are wide areas of agreement, there are also differences of opinion among national income specialists as to the proper concepts and definitions to use to guide empirical work.[1] It is not our purpose intensively to review national income theory. Rather, we shall indicate several of the chief conceptual bases of national product estimates, and the main differences between the product estimates of the Commerce Department and those of Professor Simon Kuznets, both used in this study.[2] Several different versions of these basic sets of estimates are useful for productivity estimates and will be described. A few other alternative treatments of national product will be alluded to in passing, although they have not been implemented statistically. The point will be clear that there is no unique, definitive set of national product estimates. The selection depends on the theoretical predilections of the estimator, the analytical purpose of

[1] For literature on concepts, see *Bibliography on Income and Wealth, 1937–1947,* International Association for Research in Income and Wealth, Cambridge, England: Bowes and Bowes, 1952; recent volumes of *Studies in Income and Wealth,* Princeton University Press (for NBER), particularly Volume 22 (1958); and the several volumes of *Income and Wealth,* International Association for Research in Income and Wealth, London, Bowes and Bowes.

[2] *National Income Supplement, 1954, Survey of Current Business,* Dept. of Commerce; Simon Kuznets, *National Income and Its Composition, 1919–1938,* New York (NBER), 1941.

the user, and the availability of data. Each of the alternatives used here has somewhat different productivity implications, which will be pointed up in the following discussion and quantified in Chapter 3.

"Net" or final output. The most important judgment underlying the measurement of national product has to do with the goals of economic activity, on the basis of which net output is distinguished from gross, or final product from the "intermediate" products consumed in the process of producing final goods and services. Economists are not interested in production without regard to use, and we judge efficiency in terms of the inputs required to produce outputs that are desired for their own sake by the community. Obviously, the definition of the final product affects estimated productivity change, since with a given change in inputs the resulting change in output depends in part on its definition.

Kuznets distinguishes final products on the basis of individualistic, welfare criteria, assuming that "the goal of economic activity is to satisfy wants of individual consumers who are members of the nation, present and future."[3] "If by social welfare we mean a positive contribution to some socially determined set of goals, it is clear that "net product" is an approximation to net additions to social welfare. I don't mean to imply that national income can be an accurate measure of social welfare; but it must be viewed as an approximation to it. . . . Without final goals there is no final or ultimate consumer. . . ."[4]

The Department of Commerce and its spokesmen have not elucidated the conceptual basis of their national product series so explicitly as has Kuznets. They have, rather, relied more heavily on operational rules of measurement defined as follows: "An effective criterion for distinguishing between final and intermediate products can be established by reference to business practices followed in the production of goods and services. There emerges a working definition of final product as a purchase that is not resold, and of intermediate product as one that is resold. . . . A final product is a purchase that is not charged to current cost whereas an intermediate product is one that is so charged."[5]

The practical effect of these approaches is to give quite similar content to private purchases of goods and services, consisting of consumption expenditures and capital formation, as estimated by Kuznets and Commerce; the major difference appears in the composition of government output discussed below. A few minor differences between Kuznets and Commerce on the content of private purchases are noted in Appendix A. It should, nevertheless, be pointed out that a different application of their

[3] Simon Kuznets, "Government Product and National Income," *Income and Wealth, Series I*, p. 180.
[4] *Ibid.*, p. 179.
[5] *National Income Supplement, 1954*, p. 30.

criteria could result in larger differences. Thus, expenditures incurred by individuals primarily on account of their work could be excluded, while expenditures by business concerns designed to promote the welfare of their employees, which are only indirectly a business "cost," might be included in the flow of goods to consumers. Expenditures by individuals necessary to offset industrial nuisances might also be deducted. Further, consumer outlays for durable goods could be classed as capital formation, with an imputed rental (service) value including depreciation counted in consumption expenditures, as is done with owner-occupied dwellings. These alternative treatments have not been adopted, partly for statistical reasons; the movement of existing aggregates would be affected only insofar as the adjustments were not offsetting.

In the area of capital formation, the chief differences relate to the treatment of the consumption of fixed capital. Kuznets presents estimates, both gross and net of capital consumption, in current and in constant dollars, of capital formation and of national product. Commerce presents only gross national product (i.e., gross of capital consumption but net of intermediate products) in constant dollars, while estimates of capital consumption are shown in a mixture of current dollars and original cost.

Theoretically, the most meaningful basis for long-run comparisons is net national product, including only net capital formation. Net additions to capital stock may be measured after provision is made in each period for the decline in the productive powers of existing assets. The net additions alone, and not outlays which offset capital erosion, can be devoted to consumption "without creating an expectation of being worse off at the end of the period than at the beginning of it."[6] We have adjusted the Kuznets estimates of real capital consumption to the Commerce basis, in order to present net as well as gross national product estimates in real terms.

National product and capital formation estimates that are gross of capital consumption continue to be made and used for several reasons. Gross capital formation can be estimated unambiguously, whereas serious theoretical and statistical problems are involved in estimating capital consumption. Moreover, resources devoted to offsetting capital consumption are available for final consumption in the short run in a way that intermediate products are not.[7] We also need gross national product estimates for purposes of comparison with industry output estimates similarly gross of capital consumption. From a welfare standpoint, however, it is clear that net national product estimates are conceptually preferable.

[6] This definition of the net national income has been used by Richard Stone in "Functions and Criteria of a System of Social Accounting," *Income and Wealth, Series I*, p. 3.

[7] Cf. Kuznets, *National Product in Wartime*, New York (NBER), 1945, pp. 20–24.

Apart from the fact that Kuznets lumps public and private capital formation together, whereas Commerce includes the former in government purchases, the two sets of investment estimates are virtually identical. As in the case of consumption outlays, however, alternative treatments are possible. For example, research and development outlays could be classed as capital formation rather than intermediate product since they are designed to increase the future income stream. Here, again, statistical problems would be great.

The chief conceptual difference between the Commerce and the Kuznets series, and the area of greatest controversy generally, arises with respect to government output. In his long-term series, Kuznets counts the cost of government activities as final output only insofar as these conduce directly to the ultimate satisfaction of individuals as consumers, or as they result in durable capital formation (including defense items). The range of government activities designed to promote the productivity of the business economy or maintain the social framework generally (including nondurable national security outlays) are considered to be intermediate products, the costs of which are excluded from final product.

As an analytical tool for use during World War II, Kuznets introduced his "wartime concept" of national product, in which total national security outlays are included. This he justified by placing the goal of national survival during war on a par with the basic goal of satisfaction of consumers wants by the economy. By a simple extension of this reasoning one can maintain that national security is *at all times* a prime objective of economic organization—on these grounds we have seen fit to present a "national security version" of the Kuznets series that includes national security outlays in all years.

National security outlays may also be thought of as representing potential output of consumer goods, since the resources devoted to security could be shifted to consumption if conditions permitted. This is also true of net capital formation, but not of intermediate products proper, of which the production is technically a function of the output of final goods. A great advantage of the national security version is that national product and the derived productivity estimates are not directly affected in significant degree by changes in the proportion of national output devoted to the goal of national security. The national security version thus accords with a basic principle of national income measurement—invariance to institutional changes, if this term be construed to cover changes in international relations and the resulting changes in the relative emphasis on welfare and security objectives within the nation. Actually, the two versions of the Kuznets national product estimates differ but little except in wartime and in the situation of high security outlays that have characterized the recent years of "cold war."

In contrast to Kuznets (either version), the Department of Commerce includes in national product the cost of *all* government purchases as representing the value of public services. This procedure is justified by reference to the "rule," since purchases of goods and services by general government are not resold in a market sense. Thus, the Commerce estimators treat as final those "goods and services provided on behalf of the community as a whole, which it has been found better to secure collectively rather than individually."[8] In practice, the Commerce estimates and the national security version of the Kuznets estimates show much the same broad movements. They differ only to the small degree that the portion of civilian government purchases judged by Kuznets to be intermediate has changed relative to the total national product. The movement of the several aggregate real product and productivity series are compared and interpreted further in Chapter 3.

The economy. In developed countries, national income and product estimates have been closely associated with the relevant purchase and sale transactions of the market place plus the value (at cost) of the services of general government and of private nonprofit institutions. While the market criterion is basic for distinguishing between economic and other activities, certain imputations have traditionally been made in order to value and include in the national product several productive activities that do not involve bilateral transactions but have significant market analogues. The major imputations in both the Commerce and Kuznets estimates are for the food produced and consumed on farms, the rental value of owner-occupied houses, and certain payments in kind. Commerce also imputes a value to the unpaid services of financial intermediaries, which gives rise to a discrepancy between the Commerce and Kuznets consumer service estimates (see Appendix A).

It might be possible to go considerably further in the direction of imputations for nonmarket activity. Thus, a value could be attached to the services of housewives, as well as of domestic employees, and to all the other productive activities adjudged to be economic by some broader criterion than that of appearance on organized markets.

The advantage of a broad measure of economic output is that temporal or spatial comparisons are less affected by institutional changes or differences than is the case with a predominantly market measure. Over the long run, there has been a considerable shift of production from households for own-consumption to business firms for sale in markets.[9] This means that national product has an upward bias as a measure of total production. The bias is less in the case of the productivity measures, however, since the

[8] *National Income Supplement, 1954*, p. 38.

[9] Cf. George J. Stigler, *Trends in Output and Employment*, New York (NBER), 1947, pp. 13–15.

inputs are restricted to the same sectors covered by the output measures. Bias enters the productivity measures only to the extent that productivity in the uncovered area moves differently from that in the covered (largely market) area. It seems reasonable to suppose that productivity in household production has increased less than that in the business sector. So the national productivity estimates as constructed have some upward bias, but to a progressively lesser degree as the uncovered sector shrinks in relative importance. In other words, a total-economy productivity measure, if we had one, would show a lesser rate of increase than the existing measures; but the discrepancy would diminish over time.

The disadvantage of an inclusive measure is the difficulty of defining economic activity apart from market criteria[10] and of estimating the magnitudes involved, which is crucial when the objective is productivity measurement. Aside from the problem of valuing predominantly nonmarket activities, it would be impracticable in most cases to make estimates of the output, as distinct from the inputs, on the basis of existing data. Measures of output tied predominantly to the market criterion thus give us more accurate productivity indexes than would broader measures. The important thing is that the estimates of output and of input cover essentially the same activities.

From the standpoint of accuracy, there are some advantages in taking even narrower measures of output than the existing estimates of national product provide. There is a particular advantage in analyzing the private economy apart from the output originating in general government because of the difficulties in measuring output of the public sector. We therefore estimate real private (domestic) product and productivity, derived from the Commerce series, as the basis for detailed examination of productivity changes.

Perhaps the most meaningful aggregate from the standpoint of relatively reliable productivity estimates would be the real product of the business economy alone. This sector excludes the areas of households and nonprofit institutions, which also present serious problems of definition and measurement of output, as well as government. We have not used such an aggregate; but the possibility is mentioned in order to illustrate further that the "economy" taken for study may be defined in a broader or a narrower way, depending on the objectives at hand and the requirements of accuracy as opposed to those of comprehensiveness. The narrower measures cannot, however, be taken as substitutes for the broader measures.

The nation or domestic geographical area. Both Kuznets and Commerce delimit their product estimates geographically with reference to the income

[10] See Irving B. Kravis, "The Scope of Economic Activity in International Income Comparisons," *Problems in the International Comparison of Economic Accounts*, Studies in Income and Wealth, Volume 20, Princeton University Press (for NBER), 1957.

produced by the factors whose owners reside in the continental United States.[11] Another possibility is to measure product with reference to the location of the factors themselves: income paid on the foreign investments of American residents is excluded, and only the income and product of factors located here counted, regardless of the residence of their owners. We have estimated the latter alternative, "domestic product," by making appropriate adjustments as described in Appendix A to the available national product estimates. This variant is recommended in the United Nations Studies in Method No. 2, *A System of National Accounts and Supporting Tables.*[12] It is more appropriate to productivity analysis as such and to comparisons of economy with industry output and productivity measures.

Scope of the Industry Measures

In theory, we should like to identify industries by meaningful collections of products. In practice, even when data are collected from relatively similar establishments, the range of goods produced is often quite heterogeneous. It is possible to define an industry in terms of certain groups of goods or services which are "primary" to it, in that they are primarily produced in a certain group of establishments. However, these products may also be produced in other groups of establishments which primarily produce other products, and the given industry may also produce "secondary" products which are primarily produced elsewhere. So the industry is a matter of classification, and while the concept aids in arranging establishment data in an orderly way, the operational concept is seldom clean-cut.

Not only is there some heterogeneity in industry output, but the boundaries of an industry may change over time both as the functions of establishments change and as industry definitions change in recognition of changing industrial structure. For example, the farm industry formerly produced much of its capital in the form of horses and mules, but now purchases mechanical tractive equipment from other industries. With this shift has come a corresponding increase in purchases of motor fuel relative to the growing of feed. Similarly, whereas farms used to supply most of their feed and seed directly, they now purchase much of these commercially.

In manufacturing, many industries at one time had to produce their own specialized equipment and intermediate products; but with the growth in scale of output, specialized industries have grown up supplying these goods. This development has increased the efficiency of production,

[11] It would also be possible to define the nation in terms of its customs area, for example, by including the territories and possessions. The resulting product and productivity estimates would be somewhat less reliable than those presently available.

[12] Dept. of Economic Affairs, Statistical Office, New York, 1953.

but not the efficiency of measurement. Also, as new products have been developed, these either have increased the range of products characterizing existing industries, or, if their production warranted it, have given rise to new industry classifications.

Thus, industry product and productivity statistics may relate to a somewhat changing range of activities over time. The analyst can live with this situation so long as inputs and outputs are consistent, recognizing that average productivity movements in the industry are affected when efficiency changes in divested activities differ from those in the industrial "core." Real temporal discontinuities in the productivity measures are introduced, however, if the range of intermediate products produced and consumed in the industry changes, since this affects input requirements but not the amount of gross output. The problem may be serious for certain minor industry classes, but becomes less important as the industry grouping is widened to include more of the intermediate product output. The difficulty disappears in productivity measures for the economy as a whole.

This problem is overcome in principle if industry output is conceived of as real value added or product originating. By this concept, the real value of the purchased intermediate products consumed is deducted from the real value of the final output of an industry. If the production of a particular intermediate product is shifted to a different industry, the real value added in the given industry is reduced by the extent of the additional real purchases. Since factor input would be correspondingly reduced, industry productivity would not appear to increase merely as a result of a shift in the scope of industry activity.

Dimensions of Output Units

The physical volume of output may relate to the final goods and services entering national product or to the intermediate products that are the outputs of some industries and the inputs of others. In either case, it is necessary to define the product units in terms of which physical volumes are measured. It is easy to define types of products broadly; but, strictly speaking, each quality of a given type of product should be distinguished if its physical characteristics and price differ at all from those of other members of the product family.

Specification of most goods and services is generally feasible. In some cases it may be difficult to visualize the unit underlying the payments for certain types of services, particularly in the financial area, but close analysis can usually produce working definitions. In other instances, the product may not be standardized if produced to the order or requirements of particular customers, as in residential construction. In this situation, hypothetical bids can be taken on a standard item in order to reveal what

the price would have been had the product been standard and price deflation of the value of production resorted to. Or, if both standard and custom-built goods are produced by an industry, such as the machinery industry, the value of the custom-built product can be deflated by the average price of similar standard items. In these cases, it is apparent that the physical volume of output is of a somewhat conventional character, implying at base that the productivity of resources employed in nonstandardized production shows the same changes as those in related standardized production, or the same productivity changes that producers believe they *could* have effectuated if products *were* standardized.

An even more pervasive problem is posed by the fact that the characteristics of many products change over time. Old models are abandoned and new models are introduced. In measuring production from the viewpoint of productivity analysis, the important question is whether the revised units of a product absorb a different volume of resources than the old units. If so, the real factor-cost weights of the new units should be adjusted by a ratio representing the proportion of factor cost required by the new model to that required by the old in an overlapping time period (or based on producer's estimates if there is no overlap). Fortunately, the Bureau of Labor Statistics, which computes most of the price indexes used in the deflation work underlying the real-product estimates, whenever feasible counts as "pure" price change only that change in market price which does not represent an alteration in the real cost of the materials and services consequent upon a model change.

There have been, of course, significant changes in the quality of many products apart from changes in real costs. This, however, is more of a problem for welfare than for productivity comparisons. There may be some effect on productivity as the proportion of resource inputs devoted to product development changes over time. In some industries, this proportion has tended to increase, a development that would impart some downward bias to the productivity ratio insofar as the associated quality improvements are not counted in output. A relative shift of production towards higher-quality goods within product families does increase real product; but productivity is not affected since the larger output is approximately offset by the larger volume of factor inputs required to produce the higher-valued product mix.

A somewhat different problem is introduced by new products. An advantage of a system of occasionally changing weights is that a new product can be weighted into the aggregate in the subperiod in which it appears in terms of its initial relative importance as measured by unit factor cost. If relative price and cost drop in succeeding subperiods, the relative weight of the product in the aggregate is reduced.

INPUTS

The basic inputs of the economy are the productive services of the factors of production. Input is the time-flow of services of the human and non-human factors available for use in the productive process; the result of the productive services is output, which is distributed as income to the factors. There are thus three dimensions to the various factor inputs: (1) the stocks of the primary factors available for use in production; (2) the time periods (usually hours) in which units of the factor-stocks are available for use in production, in terms of which the flow of services can be measured and their compensation or cost computed; and (3) the output or income resulting from their joint use, of which the shares accruing to each factor for its contribution to production can be used to weight the service-hours.

It would obviously defeat our purpose to measure inputs in terms of their result in the productive process alone, since we would then have a measure of output itself. But the changing efficiency of the inputs is revealed by comparing the available service-time of the real stocks of the factors, in "standard efficiency units" weighted by their unit shares of output (income) in a base period, with their actual output in a given period.[13] An ideal measure of input is thus *net* of any changes in quality over time, as it must be in order to have a basis for getting at efficiency changes through comparisons with output.

By weighting the available service-time of the factors by their base-period compensation, we obtain a measure of what the resources *would* have produced had technological and other conditions of efficiency remained the same as in the base period. By dividing this measure into the *actual* output in successive periods, we obtain a measure of the changes in the efficiency with which factor services are utilized in the processes of production, i.e., of their productivity, as discussed in Chapter 1.

We referred deliberately to the time periods in which the factors were *available* for use in production. This brings out the duality of the factors of production in a free-enterprise economy. Labor usually contracts to sell its services for specified time intervals, comprising a given number of hours per day or week or month. During the period of employment it is available for use in our sense, although it is not always fully utilized in production (as witness "stand-by" time in certain industries, not to mention the varying degrees of utilization of the latent potentials of employees depending on management or labor policies). But when not employed, labor is not available in an immediate sense to firms and is not a direct cost.

[13] Cf. Kenneth E. Boulding, "Some Difficulties in the Concept of Economic Input," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25, Princeton University Press (for NBER), 1961.

In the case of private capital, however, in principle it is wholly available during its lifetime, even if in periods of reduced activity some units are not utilized. It represents a cost which is quite apparent when the capital is leased, or has been financed by debt. Even when it represents equity there is a certain implicit average annual return that must be met if new capital is to be forthcoming. The fullness of utilization of the capital stock is one aspect of the efficiency of private management which is not relevant to the labor force outside employment. It is true that from a social viewpoint the total labor force is available for production and the degree of its utilization is an aspect of the efficiency of the economy; in Chapter 3 we construct one variant of the productivity measure from a social-cost standpoint. But otherwise our measures are constructed from the standpoint of the private-enterprise economy existing in this country, i.e., labor is counted as a cost only when employed, and thus available for use in production, while capital is counted as a cost when owned and thus available. This accords with the general treatment of cost in economic theory.

Another difference between the two major factor-stocks, as measured, is that the "man" provides a rough common denominator of the stock of labor, whereas in the case of capital the "constant dollar" must be used. Actually, the value of the capital represented by human beings differs from one group to another, and this is reflected in the varying rates of compensation. So instead of artificially estimating the real value of human capital in the various industries, adjusting for rates of utilization, and weighting by base-rates of compensation, we can skip a step by directly weighting manhours. In the case of capital, however, we must estimate the value of the stocks and weight by rates of return since there is no unit of capital even superficially uniform. Adjustment for rate of utilization is not necessary, since capital is available 8,760 hours a year, and the movement of "constant dollar capital-hours" would be the same as that of the index numbers of the real capital stock.

Labor Input

In the case of human resources, the "stock" of labor available for productive use is the labor force, of which a varying proportion over time is employed in the various occupations and industries. The majority of persons engaged in productive employment are paid by the hour; and manhours can also be estimated roughly for those not on an hourly rated basis, and their compensation translated to average hourly earnings for weighting purposes. Thus, we use manhours worked as the measure of the flow of available labor services. It is not a direct measure of input, but a measure derived from estimates of the employed stock of human resources and the average hours worked per person per year indicating the rate of utilization. Proprietors and unpaid family workers as well as employees are counted as

labor. When weighted by average hourly compensation in a base period, labor input indicates for a given period what the employed manhours would have contributed to output if productive efficiency had been the same as in the base period. The measure can also be interpreted in terms of the marginal disutility of work.

It is assumed that the inherent average physical and mental capacity of the persons employed in each occupation is constant over time. Insofar as the composition of persons employed in terms of basic aptitudes or capacities in relationship to their occupations changes over time, it cannot be said that the basic units are constant and that manhours would make the same contribution to output if technology and other dynamic factors were held constant between two periods. There are variations among individuals in the same occupations with respect to basic capacity; and there may be variations in the capacities of the same individual in different time periods as a result of aging[14] or of changing states of health. But taking large groups of individuals, the *average* output potential of the manhours worked, with given technical knowledge, should be relatively stable over time.

Perhaps the chief exception to this generalization is provided by the effect on potential labor services per manhour of reductions in the workweek from relatively high levels. In this situation, the energy input and potential output of a manhour may increase somewhat as hours of work are reduced with no change in technology. But as hours of work are progressively reduced, as they have been in this century, the effect on the potential services of a manhour probably becomes progressively smaller.[15] We choose to think of the manhour as the basic input unit, with changes in the length of the workweek or work-year as one of the factors influencing the output-input relationship. Furthermore, it can be maintained that reductions in the workweek have affected productivity less by increasing energy input per manhour than through putting pressure on management to improve its organization or equipment to offset the increase in hourly earnings which frequently accompanies a reduction in average hours.[16]

Since average hourly earnings differ among occupations, roughly reflecting different contributions to product and thus different "quantities" of labor service, manhours should be estimated and weighted separately

[14] A further discussion of changing average age is contained in Chapter 4, in the subsection, "Investment in persons."

[15] See Solomon Fabricant, *Employment in Manufacturing, 1899–1939: An Analysis of Its Relation to the Volume of Production*, New York (NBER), 1942, pp. 12–15. Fabricant cautions: "It is very difficult to determine from the cases described in these and other sources the extent to which changes in factors other than hours affected labor productivity" (*ibid.*, p. 13 n.).

[16] See Edward F. Denison, "Measurement of Labor Input, Some Questions of Definition and the Adequacy of Data," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25.

for each occupation. But estimates of employment and hours are generally available over time only on an industry basis; so industry average hourly compensation estimates are used as weights. The aggregate of industry real labor input so computed will approximate the results obtained by weighting manhours worked by occupation so long as the occupational structures of the various industries are relatively stable.[17]

The labor input index thus holds the services per manhour constant in terms of the real income earned by manhours in each industry in the base period. This is the desired result, since the purpose of the productivity ratio is to compare the outputs actually produced in successive time periods with the outputs that *would* have been produced had the factor services not changed in efficiency. The efficiency changes reflect changes in the skill and degree of utilization of the basic capacities of workers in their jobs, as well as technological progress generally as reflected in improved organization and equipment.

This constancy of quality refers only to the same type of factor service, however. Relative shifts of resources to better-paying industries (in terms of base-period compensation) show up as an increase in labor input rather than as an increase in productivity. This result is also desirable, since from the viewpoint of technological efficiency we are interested in increases of output relative to input within the various industries. Shifts of resources among industries are interpreted as involving a changing quantity of resources, not changing technological efficiency. The proportionate increase in output attributable to a relative shift of resources can be estimated by dividing weighted inputs by undifferentiated inputs. However, this ratio would not reflect the effects of intra-industry shifts of resources, which may also be significant when industries are defined broadly.

Capital Input

The first step in measuring real capital services is to estimate the real net capital stock employed in the various industries; the next is to weight these figures by the base-period rates of return. It is assumed that within each industry relative prices of different types of real capital are proportionate to the present value of the anticipated future absolute returns, since rational management would increase the stock of each type of capital up to the point at which the final unit of each yielded the same rate of return. Different rates of return in the various industries presumably reflect

[17] "Presumably, there are qualitative differences in labor employed by different industries, since rather persistent interindustry wage differentials seem to exist" (Jacob Schmookler, "The Changing Efficiency of the American Economy; 1869–1938," *The Review of Economics and Statistics*, August 1952, p. 216). This accords with our own findings as reported in Chapter 7 and in Appendixes A and D.

different estimates of the degree of risk, different amounts of associated intangible capital resulting from industry investment in technical knowledge, or quasi-rents (positive or negative) resulting from superior (or inferior) adaptation of capital to market potentials. Roughly, we may say that the capital compensation in the several industries reflects the relative contributions to output (real income) of the capital stocks in each except to the extent that monopoly elements are present in differing degree.

Capital stocks (or capital formation data, from which the stock estimates are largely derived) are deflated to eliminate the effect of price changes in such wise that a new unit of a given type of plant or equipment is accorded the same base-period value, or weight, in all periods. Changes in the productive efficiency of new models as compared with the base-period model of a particular item of equipment are not reflected in the real value of the item (unless more resources are used). This is desirable from the viewpoint of productivity analysis, for the increased efficiency should show up in the output-input ratio. Since the units of various types of equipment are given the same weight over time, it is apparent that no allowance is made for changing productivity in the capital goods industries; we are interested in the relationship of outputs to the physical volume of inputs of base-period efficiency—not to the inputs required to replace other inputs in a given period. In the latter case, productivity gains would be double-counted.

Real stocks net of accumulated depreciation allowances are taken as a better measure of a basic capacity to contribute to production and revenue than gross stocks (i.e., the number of items in use, each weighted by base-period price regardless of age). Studies have shown that the gross output capacity of various types of machinery tends to fall with age, and the repair and maintenance charges rise so that the contribution to net revenue falls even more. More significantly, the marginal revenue products of older types of equipment are less than those of new, improved types because of technological advance and resulting obsolescence. This development occurs sporadically as far as a particular type of equipment is concerned, but may be assumed to occur gradually with respect to all the capital goods of an industry. The effect on the real marginal revenue product of groups of items over time is roughly approximated by the gradual decline in the depreciated real value of stock shown by the usual depreciation accounting procedures reflected in the national accounts.[18]

It may be objected that the use of depreciated real stocks seems to violate our basic principle of measuring stocks of resources employed in terms of units representing an equal capacity to contribute to output over

[18] See George Terborgh, *Realistic Depreciation Policy*, Chicago, Machinery and Allied Products Institute, 1954.

time, assuming base-period technical conditions throughout.[19] But in the base period itself, newly produced units of a given type presumably had a larger capacity to contribute to output and net revenue than older units—and the older the unit, the less the capacity. So, in effect, units are broken into age classes, and each is given a different value weight (roughly in proportion to the base-period net revenue produced by the items of varying age). It is assumed that the rate of technological advance and, thus, of obsolescence has been roughly the same throughout the entire period in that the life spans (reflecting both physical and economic factors) used to calculate depreciation are generally taken to be the same over time for given types of capital goods. If obsolescence speeded up, the net capital estimates as computed would have an upward bias, and productivity would be correspondingly understated.

In the case of land, of course, the depreciation problem is not involved since it is assumed that maintenance expenditures preserve the capacity of the various types of land to contribute to output at a constant level in a given technological framework. To the extent that land deteriorates, this would be reflected by a decline in the productivity ratios. The real stocks of land in each industry group are combined with other types of capital before being weighted by the rate of return to capital as a whole in each industry. In agriculture, the acreage of various types of land is estimated separately and combined by the average unit value of each type in order to get aggregate real stock prior to combination with other types of farm capital stocks (see Appendix B).

Inventory estimates represent average beginning- and end-of-year numbers of units of the various types of goods times the average price in the base period. For agriculture, real stocks of crops and livestock are estimated directly as described; in other areas, book value estimates are deflated by price indexes designed to convert to constant, base-year prices.

Sources of Basic Data and Reliability of Estimates

The sources of the basic data and the methods used for the estimates in this study are described in some detail in the appendixes. This material will be summarized here to give the general reader a quick picture of the statistical foundations of the study, and the technician an introduction to the appendixes.

An evaluation of the reliability of the productivity ratios rests primarily upon a qualitative appraisal of the accuracy and consistency of the data underlying the estimates of the outputs and the inputs in the economy

[19] Richard and Nancy Ruggles, "The Conceptual Basis for the Measurement of Real Capital Stock and Services," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25.

and in the major industrial groupings. A considerable degree of interdependence between the output and the input data helps offset possible errors or bias in the sources since these tend to be offsetting in the ratios. We have compared economy estimates with weighted aggregates of industry estimates for output and the two input classes for all or parts of the period since 1889. Since the economy and industry estimates are based to varying degrees on different sources and methods, these comparisons will be summarized here because they will provide a partial test of accuracy. The comparisons also afford a check on the consistency of the two sets of numbers, which is important since in Part III we compare industry with economy trends.

OUTPUT

General Method

If complete basic data were at hand with respect to the physical quantities, prices, and values of all final transactions in the economy, it would be a matter of indifference whether the number of units of each type of commodity or service were weighted by the average final prices prevailing during the base period, or the current value of production were deflated by an index of the relevant prices with variable quantity weights. In terms of a formula, in which Q represents numbers of units of output; P, their average prices; and the subscripts $_0$ and $_1$, the base period and the given period, respectively:

$$\sum Q_1P_0 = \sum Q_1P_1 \div \frac{\sum P_1Q_1}{\sum P_0Q_1}$$

The same result could be obtained adding the real product (net output) originating in the various industrial divisions of the economy. If q stands for the quantities of goods produced by an industry and q' for the quantities purchased from other industries, while p and p' represent their respective average prices in the specified time periods, then

$$\sum Q_1P_0 = \sum_{i=1}^{n} (q_1p_0 - q'_1p'_0)$$

The same result is obtained by deflating the value of output and of intermediate-product inputs for all industries by approximate variable-weighted price indexes and summing the differences.

Actually, although value estimates are generally available for the economy and its industrial divisions, neither quantity nor price data are complete. The choice of method for arriving at aggregate physical-volume estimates depends primarily on the representativeness of the sample of prices as compared with the adequacy of the sample of quantities and of the imputations involved in the coverage adjustments that are usually made

to approximate total physical volume. The deflated-value approach has been used in obtaining the real products of the economy and of several industry divisions. Price-weighted quantity indexes have been used in the other industrial groupings. Both methods have advantages and shortcomings, which will be noted in the following summary and appraisal. It should be mentioned here that only in the farm segment was true net output estimated by deducting real intermediate inputs from real gross output. In the other industry segments, either the component-industry physical output indexes were combined with value-added or national income weights as approximations to net output measures, or the current-value national product estimates were deflated directly. These two methods yield the same results as true net output measures only under special conditions.

Real National Product

The appraisal of the real-product estimates will be treated with respect first to the current-value estimates, and then to the deflators used to eliminate the effect of price changes. The current-dollar series from 1929 forward are based on the estimates of the Commerce Department; and for 1889–1929, on the revised estimates of Kuznets as adjusted. The sources and methods underlying both sets of data are basically the same and have been fully described by the authors;[20] we shall merely highlight some of the possible sources of error and attempt to appraise the general reliability of the over-all estimates.

The basic commodity flow data underlying the estimates for the important consumer and producer commodity segments are benchmarked on the periodic *Census of Manufactures*. They probably portray trends quite accurately, although annual changes interpolated from sample data are less reliable. Kuznets assumed constant distributive margins prior to 1919 because of a lack of readily available data. Later research by Harold Barger indicates a mild increase in margins between 1889 and 1919, so the early current-dollar estimates may have some downward bias, but this should not affect the constant-dollar series based on deflated producer values. Also prior to 1919, direct data are lacking for consumer expenditures for services. Kuznets used ratios of outlays for services to those for commodities, derived from occasional family budget studies. These estimates obviously have larger margins of error than the later estimates benchmarked on the *Census of Business* (first taken in 1929) and other direct information. Information on the "invisible" items of the net foreign balance is also scant before 1919.

Federal government purchase estimates are solidly based throughout. Data on state and local government purchases gradually improved over

[20] See references in Chap. 2, n. 2.

the period, but prior to the 1890 Census the noneducational outlay component is estimated indirectly. Practically no data are available on inventories prior to 1919, and Kuznets estimated net changes from extrapolation backwards of later relationships between stocks and commodity expenditures. Even after 1919, the annual net changes are subject to wide margins of error, although the cumulated net changes give a better indication of trends. The new-construction estimates, based as they are on a spreading of the value of construction permit or contract award data by assumed average monthly patterns of the value of construction put in place, are also less accurate as indicators of annual changes than of movements over longer periods.

Unfortunately, it is not possible to estimate the probable margins of error of the over-all national product estimates. As Milton Gilbert has put it: "The reason is that in the complex of factors that might lead to inaccuracy of the statistics, there are no measures of the errors arising out of most of them, and hence no way to assign them weights so as to arrive at a combined margin of error."[21] For some components, knowledge about the size and characteristics of the universe is lacking, while error due to faulty reporting, willful misstatements by respondents, or negligent enumeration is outside the scope of sampling error measurement. The Commerce Department experts have concluded: "A study of the statistical methodology underlying the national income estimates, supplemented by analysis of the statistical discrepancy and of the revisions, will remain the major avenue for obtaining an evaluation of their reliability."[22] Based on its own appraisal, the Commerce report concluded that "the foregoing survey may provide a sufficiently definitive basis for the general conclusion that the estimated annual totals of gross national product, national income, and personal income are subject to only a small percentage of error. . . ."[23]

Our brief review suggests that estimates for more recent years are probably better than those for earlier years owing to the existence of a somewhat larger body of census data since 1929, improved sample data for interpolations, and expanded administrative statistics. If Gilbert is correct in asserting that for the United States "the probability is all towards under-estimates . . . ,"[24] the improvement in the quality of the estimates might result in some upward bias over time. A review of sources does not suggest a major bias, and to the extent that it also affected the input estimates, it would not affect the productivity ratios. There can be no doubt that long-term changes in the national product estimates are

[21] Milton Gilbert, "Statistical Sources and Methods in National Accounts Estimates and the Problem of Reliability," *Income and Wealth, Series III*, p. 6.
[22] *National Income Supplement, 1954*, pp. 66–67.
[23] *Ibid.*, p. 66.
[24] Gilbert, *op. cit.*, p. 7.

subject to a smaller margin of error than are annual changes, which are based to a large extent on sample data. This conclusion is borne out by an examination of the effect of successive revisions on the estimates and by the movement of the statistical discrepancy between gross product and national income plus other charges against product.

The accuracy of the price deflators and the real national product estimates has not been evaluated by Kuznets or the Commerce Department, but the margins of error are almost certainly greater than those for the current values. In the first place, price indexes are not available to represent all products, even in the market area of the economy. The indexes are reasonably good for food, clothing, and many of the major categories of final product; but they are weak for certain types of consumer services (other than rents), particularly prior to 1935, and for many types of producer durable equipment before 1939, when the Bureau of Labor Statistics greatly expanded its price data collection program. At best, the price indexes used for deflation involve a considerable degree of imputation of price movements with respect to grades or "qualities" of a commodity, to various types of commodities in a given "family," and to commodity families within broader product classes. Sampling is also necessary with respect to types of distributive outlets, localities, and time periods. In recent years the Bureau of Labor Statistics, the chief source of price index numbers, has conducted periodic tests of the representativeness of its samples. It is not clear that price indexes from other sources are as representative of the product classes to which they are applied or that the imputations involved in the deflation procedure itself are reasonable. But in view of the large number of price series used, it is probable that the margins of error in the deflators for the standardized product groupings in the market area of the economy do not seriously distort trends in real product. Greater difficulties are encountered in the nonstandardized and in the nonmarket areas of the economy.

The price deflators for the value of output of nonstandard products such as ships and aircraft are unit cost indexes (weighted averages of materials prices and wage rates), and the construction cost deflators are partially of this character. The deflators for the estimated value (cost) of output of households (mainly domestic service) and of nonprofit institutions are of the same type (primarily average earnings series) as are the deflators for some types of professional services that are not standardized to any extent. The Commerce method of deflating the product of general government explicitly makes no allowance for possible changes in productivity, and Kuznets' estimates imply the same result.

Even assuming that productivity has not advanced as rapidly in these as in other areas of the economy, the relative magnitude of the value of output deflated by unit cost indexes suggests that the rate of growth of the

resulting real private product estimates is subject to a downward bias approaching 10 per cent; while the bias in the growth rate of total product, including general government, is somewhat greater.

There is also some cyclical bias in the real-product estimates. The price indexes are usually based on quoted prices and do not take full account of changes in subsidiary terms of sale—special discounts, trade-in allowances, credit terms, prices of collateral equipment, and services or extras. "Net realized" prices tend to fluctuate more than quoted prices over the business cycle and thus the real-product estimates have a downward bias in depressed periods and an upward bias in recoveries. Comparisons of periods characterized by similar degrees of business activity should not be significantly affected.

Industry Output Measures

For our five basic segments and thirty-three industry groups, except for farming, output measures were obtained by weighting physical units and adjusting for incomplete coverage when necessary. In farming, although deflated value estimates are used, the results are virtually the same as those obtained by weighting quantities owing to the relative completeness and consistency of the value, price, and quantity data. For trade, we follow Barger in estimating the deflated value of goods passing through the various types of distributive outlets and weighting by the base-period distributive margins in each.[25] In the residual segments (construction, finance, and services), we have deflated the industry gross-product estimates since 1929 by the implicit deflators for the final products of those industries that enter the gross national product.

Data sources. With respect to the five basic segments, periodic industry censuses are available for agriculture, mining, manufacturing, water transportation, telephone and telegraph, and electric industries.[26] Inter-

[25] Harold Barger, *Distribution's Place in the American Economy since 1869*, Princeton University Press (for NBER), 1955, pp. 20ff.

[26] Census data are available as follows:

Agriculture: Decennial to 1920, quinquennial thereafter. Comprehensive annual data from sample surveys begin in 1910.

Mining: Decennial to 1939, except that a census was taken in 1902 instead of 1899; since 1939 censuses have been taken in 1954 and 1958. In addition, the Bureau of Mines publishes almost comprehensive annual production estimates by type of mineral in the *Minerals Yearbook*.

Manufacturing: Decennial to 1899; quinquennial, 1899–1919; biennial, 1919–39; and 1947, 1954, and 1958. Annual surveys of manufactures, conducted by the Census Bureau, are available beginning 1949 for noncensus years. Additional annual commodity data are contained in the Census *Facts for Industry* reports.

Water transportation: 1880, 1889, 1906, 1916, and 1926; estimates brought forward by relatively good data from the Maritime Commission and other agencies described in Appendix G.

Telephone and telegraph: 1880, 1890, and quinquennial, 1902–37.

Electric industries: 1882–1937 quinquennially, including electric railways.

state Commerce Commission annual statistics begin in 1890 for the railroads, 1936 for pipe lines, and 1939 for intercity buses and motor trucking.[27] Civil Aeronautics Authority (and predecessor agency) data are available for airlines beginning in 1929. American Transit Association reports contain annual data for electric railways (used to interpolate and extrapolate census data) and local bus lines. Annual data on production of manufactured and natural gas since 1929 come from the American Gas Association; before 1929, data on manufactured gas production are contained in the *Census of Manufactures*, and on natural gas production, in the *Minerals Yearbook*. When complete annual data are not available, we either show estimates for benchmark years only, or interpolate annually on the basis of sample surveys or fragmentary data. In the latter cases, the annual estimates are obviously less reliable than the benchmark estimates.

The commodity flow estimates involved in the trade output figures are based on the *Census of Manufactures* as processed by William Shaw for 1869–1929,[28] and by the Commerce Department thereafter. Distributive margins were first reported in censuses beginning in 1929; Barger used a variety of sources to estimate margins in earlier years. The gross product estimates for construction, finance, and services are based on the estimates of the Commerce Department that tie into census data first collected in 1929. The price deflators are those implicit in the real gross national product estimates, and are subject to the biases discussed earlier, particularly as regards construction and services orginating in households and nonprofit institutions. Our chief purpose in estimating real product and productivity in these segments was to make explicit the implications of the over-all estimates.

If the reliability of the benchmark census data is accepted, the accuracy of the derived estimates will depend largely on the nature of the output units and the adequacy of coverage adjustments or price imputations. It is to these matters that we now turn.

Nature of output units. In some instances, there is a choice as to the units in which production may be expressed, and judgment is required to determine the unit which would be most meaningful for productivity comparisons. For example, in the minerals industries, metallic content of ore was considered a preferable unit to the volume of ore; and in transportation of freight, ton-miles carried, rather than freight-car miles or tons of freight, was used.

A more serious problem arises because the available or preferable units are usually not entirely homogeneous, but comprise a number of qualities

[27] Harold Barger's estimates of pipe lines and intercity motor transport were pushed back roughly to 1919 on the basis of trade data as described in Appendix G.

[28] Simon Kuznets, *Commodity Flow and Capital Formation*, New York (NBER), 1938, Vol. 1; and William H. Shaw, *The Value of Commodity Output since 1869*, New York (NBER), 1947.

or types of goods that are lumped together for reporting purposes. For example, although numbers of pairs of leather shoes produced may be reported under the categories of men's, women's, and children's, there are many price lines within each of these classes. Shifts of demand and production among price lines would not affect production indexes based on gross units, but they would affect an ideal index based on a weighted aggregate of homogeneous units. Insofar as there has been a shift of demand towards higher qualities of goods over the long run or in cyclical expansions as real income advances, the gross-unit measures understate the increase in production. The reverse bias could affect the measures in contraction periods. In this regard, deflation of values by indexes of the prices of strictly specified representative goods is a preferable procedure, since shifts among qualities would show up as changes in the real values.

The probable downward bias in the physical-unit measures has decreased over time, however, since in manufacturing there has been a marked increase in the detail in which quantity data have been collected in the censuses (see Appendix D, subsection on "Physical units and weights"). A decreasing downward bias means that the estimates tend to increase relative to the true figures.

The problem of changes in quality of the same commodity, as distinguished from a change in quality-mix, was mentioned in the earlier conceptual discussion. Here, it should be noted that quality change will be greater in some industries than in others. Thus, manufactured goods are more susceptible to quality improvements than are farm products; and within manufacturing the quality of automobiles and machinery, for example, has probably improved more than that of lumber and lumber products. This should be kept in mind in interpreting relative changes in output and productivity by industry.

Coverage adjustments. A major problem in estimating the physical volume of production is posed by the fact that in many industry groups, particularly in the manufacturing segment, the physical-unit data do not relate to all of the production of the component industries, whereas the input data are comprehensive. Since it would be highly questionable to assume that uncovered output moved with the covered portion of output, F. C. Mills and Solomon Fabricant developed the technique of adjusting the partial quantity indexes to full coverage by an index of the ratio of the value of covered output to the total value of industry production. This involves the assumption that the average prices of the products for which quantity data are unavailable move with the average prices of the covered products. To obtain full coverage of industry groups or of the whole segment, the coverage adjustment was based on value-added ratios, a procedure which involves the assumption that unit values added in the covered and uncovered industries have parallel movements.

Since changes in relative price and unit value added reflect primarily relative changes in productivity over longer periods, the adequacy of the Mills-Fabricant coverage adjustment indirectly hinges on the assumption that productivity in the covered and uncovered areas moves similarly. In adjusting the manufacturing output indexes for 1947 relative to 1939, the Census Bureau and the Federal Reserve Board moved closer to this assumption by basing their adjustment factors on the ratios of employment in the covered area to total employment (see Appendix D). We have, likewise, used coverage adjustments based on employment ratios in the transportation and communications and public utility segments.

Tests using only part of the available data indicate that adjusted output indexes are better than unadjusted indexes. The degree of reliability depends on the validity of the underlying assumption and the relative size of the uncovered segment. As to the implicit assumption, it seems reasonable to suppose that productivity movements of parts of the same industry or industry group are more similar than productivity (or price) movements in less closely related areas. It has been suggested that the coverage adjustment leads to some downward bias since the uncovered area often includes relatively new products in the production of which prices tend to fall and productivity tends to rise in relation to the older products. This would be offset in some industries by the custom-built products for which unit data are not given since it might be expected that productivity increase would be less rapid in the case of these items. This same problem is, of course, present in the deflation of values. The imputation of price movements of covered to those of uncovered products has very similar limitations unless the imputations are periodically checked and adjusted.

With respect to the magnitude of the area uncovered by physical-volume or direct price information, a run-down by segment suggests that it comprises about one-fifth of the value of output in the private domestic economy in 1929. In farming and mining (except for nonmetallic mining and quarrying) coverage is virtually complete, whereas in manufacturing we estimate that about 53 per cent of the total value of production in the segment was not covered by quantity data in 1899, and 38 per cent in 1947—although these percentages were reduced somewhat by the use of deflated value estimates for some industries or groups.

In general, the uncovered area has declined over the decades as more quantity and price information has become available, so whatever bias is involved in coverage adjustments has tended to grow smaller. In addition, note that the real capital stock and input series also involve imputation of price deflators to uncovered items and have similar biases.

A different coverage problem is posed by the fact that certain types of output are included neither in the physical-unit nor the value measures,

while the associated inputs enter the input measures. Force account construction activity, research and development, and in-plant training are included neither in the industry nor national output measures. Force account construction is significant in the extractive industries,[29] manufacturing, and the regulated industries, but its importance is declining. Research, development, and training are of increasing importance, and a significant factor in certain industry groups. Some downward bias is present in output and productivity indexes for these groups.

In some other cases, certain activities were not included in the physical-volume composites, nor did a basis for coverage adjustment exist—for example, in the transmission of television programs and in the rental of private wires by the telephone industry. Usually these outputs are minor relative to total output, but their omission impairs accuracy if their movement differs from that of covered output. It is likely that the bulk of uncovered activities are comparatively new and are growing relatively; so their omission results in an understatement of production and productivity increase.

Gross and net industry output. Only the farm real-product estimates are true net output measures, obtained by subtracting the deflated value of intermediate-product purchases from the real value of gross output. In the construction, finance, and service segments since 1929, we deflated gross product directly. This procedure yields true net output measures to the degree that output and intermediate input prices show parallel movements. This appears to have been the case in construction (see Appendix E). In finance and services the importance of intermediate products is relatively small, so the probable bias is slight. In the other segments, since we relate the gross output measures to factor inputs, we are assuming that the movement of gross measures approximates the movement of net measures. Based on scattered evidence for the United States, net output in nonfarm industries may have risen somewhat more than gross output as a result of materials savings and a shift towards more highly processed goods. Canadian estimates for recent decades, however, do not show much difference between the movements of nonfarm net and gross output measures, on balance.[30]

Comparison of Real Private Domestic Product and the Industry Output Aggregate

A comparison of aggregates of real final expenditures and of industry outputs in the private domestic economy since 1929 is contained in Table A-3. To some extent similar sources and methods were used; so the

[29] The crude petroleum production index was adjusted to include the construction of oil wells.

[30] V. R. Berlinguette and F. H. Leacy, "The Estimation of Real Domestic Product by Final Expenditure Categories and by Industry of Origin, Canada," *Output, Input, and Productivity Measurement,* Studies in Income and Wealth, Volume 25.

comparison is but a partial check on accuracy; it is more meaningful as a check on the consistency of the economy and the industry measures. Since consistent value estimates and the same deflators were used in the construction, finance, and service areas, both the economy and the segment estimates are subject to a downward bias on account of inadequate deflators. The implications of the real-product estimates with respect to the output of the trade segment are similar to those made explicit in the segment estimates. But in the other segments, the economy estimates are derived as deflated final expenditures while the industry estimates are generally weighted physical units with coverage adjustment.

It is, therefore, gratifying that relative to 1929, the two sets of estimates were only 2.2 per cent apart in 1953.[31] The higher level of the real-product estimate supports our surmise that weighted physical units, because of heterogeneity may have a secular downward bias relative to deflated values, or that net output estimates outside the extractive industries may tend to rise more than gross estimates due to reductions in intermediate materials consumption per unit of output, or that perhaps both explanations may apply. But the discrepancy is small enough to justify the comparison of industry and economy output and productivity estimates made in Part III.

The comparison prior to 1929 is less direct. Since output estimates for the finance and service segments are not available, an industry output aggregate for the other segments was used in conjunction with the real private domestic product estimates to derive output in the uncovered area as a residual. Between 1889 and 1929, the residual estimates of real product originating in the finance and service segments, when divided by the corresponding manhours, show virtually the same trend in output per manhour as do the estimates since 1929 (see Appendix A, end of section "Comparison of Real Product with an Aggregate of Industry Output"). This result is sufficiently plausible to suggest that the economy and the industry output estimates are reasonably consistent in the earlier period.[32]

LABOR INPUT

Estimates of labor input in the economy as a whole were built up from industry estimates and are, therefore, consistent. There are decennial external checks on the economy employment aggregates, and annual

[31] There was also close correspondence in a similar comparison for 1947–55, reported by Jack Alterman and Eva Jacobs, "Estimates of Real Product in the United States, 1947–55," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25.

[32] Between 1869 and 1889, however, the estimates for finance and services show an absurdly large increase in output and productivity. This confirms the judgment that the 1869 estimate of national product is seriously understated, a judgment which led to the decision not to extend the economy analysis back of 1889.

checks on average hours and total manhours as well as on employment estimates since 1940. Further, there is throughout a close statistical interrelation between the output and employment estimates for the economy and some of the major industry segments.

The total-employment estimates appear to be quite good indicators of trends throughout the entire period, judging not only from the quality of the sources but also from their consistency with estimates of the labor force or the number of "gainful workers," adjusted for unemployment. The latter are largely independent of the employment estimates since 1929 and are partially so in earlier decades. Annual employment estimates are of a high degree of reliability only since 1939 when the Social Security reporting system began.

The estimates of average hours worked, which enter the manhour figures, are generally less reliable than the employment estimates. Correspondence between our industry-composite average hours estimates and those provided by the annual population surveys since 1940 is fairly good. The source data, while less abundant prior to the mid-1930's than after, provide broad benchmarks back to 1920. Before that date chief reliance had to be placed on available data relating to standard hours, which can be roughly adjusted to actual hours worked, and on estimates based on state data. Margins of error are probably high for the early decades. Despite its inadequacy, however, the statistical base is still broad enough to make unlikely any serious bias in the trend of the hours estimates, although estimates of annual changes prior to the mid-1930's may be subject to high margins of error. The industry labor compensation estimates used for weights are good and generally consistent with the employment data.

Employment

From 1929 forward, the Commerce Department estimates of numbers of employees and proprietors engaged in the various industries were used with only minor adjustment. From 1939 on, these are solidly based on comprehensive annual data provided by Social Security, Railroad Retirement, and federal civil service collections that cover over 95 per cent of employees, while collateral sources provide relatively good data for the remainder. Back to 1929, benchmarks are available from censuses covering almost all industries. The number of unpaid family workers was estimated back to 1940 on the basis of the Current Population Surveys, and prior to that date by applying the 1940 ratios to the number of proprietors in the several industry segments in earlier years. These estimates are weak, but the component is small. The Department of Agriculture estimates of farm employment were substituted for those of Commerce since the former include unpaid family workers.

Primary reliance on the Commerce estimates of persons engaged has the great advantage of providing a high degree of statistical interdependence with the real-product estimates. The estimates of employee compensation and proprietors' net income, derived from the same sources as the estimates of employees and proprietors, comprise almost three-fourths of the value of the national product. It is true that we use real-product estimates built up from expenditures rather than national income plus other charges; but over the period since 1929 there has been no noticeable trend in the statistical discrepancy between the two sets of estimates. For analysis of annual productivity changes, however, there would be some advantage in adjusting the real-product estimates by the statistical discrepancy. On the product side there is also interdependence, especially before 1939, when both output and employment estimates were drawn from the same censuses. This also applies to the industry output and employment estimates.

Prior to 1929, the employment estimates for manufacturing, mining, transportation, and public utilities were extrapolated by series, presented in National Bureau monographs, based on periodic industry censuses or agency reports. In some cases we pushed the monograph estimates back further by use of the same sources. For most of the remaining industry segments, for which censuses were not taken prior to 1929, it was necessary to rely on industrial distributions of gainful workers based on occupational data from the decennial population censuses, as prepared by Daniel Carson (see Appendix A) and roughly adjusted to an employment basis. Government employment estimates were based on Civil Service records and data from the Governments Division of the Census Bureau and from the Office of Education.

Annual estimates for many industry segments prior to 1929 could be interpolated between benchmarks on the basis of sample surveys or state data. For a few segments, interpolation was done on the basis of output series. For obvious reasons, such estimates are not presented in the industry productivity tables, but were merely used to build up the economy employment and manhour totals. Although the annual economy totals before 1929 are therefore not entirely independent of output series for intercensal years, they are dominated by independent data.

To combine the employment estimates with average hours estimates for a number of the segments, full- and part-time averages were appropriate. For purposes of showing industrial distributions, as in Table A-VII, however, it is more meaningful to express employment in terms of full-time equivalents. On this basis, the industry aggregates are quite close to the population census totals for the labor force or for the number of gainful workers after adjustment to exclude the estimated number of persons unemployed. More significantly, the trends of the two aggregates between

1870 and 1950 are not far apart. The industry aggregate rose from 99 per cent of the adjusted labor force estimate in 1870 (or 100 per cent in 1890) to 103 per cent in 1950 (see Table A-VIII). Even though about half of estimated employment prior to 1929 was based on the labor force estimates, the correspondence between the totals is evidence that the economy trends are reasonable. The industry trends based on population census data are probably less accurate since allocation by industry of persons in occupations common to several industries cannot be precise. It is also evident that annual changes in the estimates up to 1939 are subject to wider margins of error than are the trends.

Edward Denison concluded a review of the employment estimates as follows:

> 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 gross national product per person engaged in production is not likely to exceed 0.2 percentage points. . . . 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 . . . 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 average rate of change in output per man for periods ending with the present.[33]

Average Hours and Manhours

From 1940 forward, estimates of average hours worked per week are available for all segments. The majority of the private-industry estimates are from the Bureau of Labor Statistics establishment surveys, although average hours worked in manufacturing groups since 1947 are taken from the Census annual surveys. For finance and services the chief source is the *Census of Population, 1940* and unpublished data from the Current Population Surveys. The weighted average of the industry estimates shows virtually the same trend and movements as the average hours estimates for the total civilian economy reported in the Census *Monthly Report on the Labor Force* (see Table A-XII). The manhours estimates based on the two sources also showed like trends, but year-to-year correspondence was less close, primarily because of divergences in annual changes in the employment estimates. Of the two sets of estimates, those based on establishment reports were chosen not only because they are statistically consistent with the output estimates, but also because the estimates based on Current

[33] Denison, *op. cit.*

Population Surveys rely on a small sample and are subject to wider margins of error.

In the conceptual discussion, it was noted that manhours worked, rather than manhours paid for, is the appropriate measure. The difference between the two concepts is not operationally significant prior to 1939,[34] but with the trend toward paid vacations, holidays, and sick leave during and after the war, the divergence has been increasing. Actually, our estimates are mixed, although comprising mainly hours worked. The BLS-based average hours are on a paid-for basis, while the census estimates (adjusted to exclude "0-hours") are hours worked. The farming and federal government manhour estimates are also on an hours worked basis.

The establishment-based estimates of average hours worked extend back to the mid- or early 1930's, and in the case of manufacturing to 1909. But estimates for most segments are available for 1920–22 from a survey by W. I. King for the National Bureau of Economic Research. For earlier years, standard weekly or daily hours estimates are available for manufacturing, mining, construction, railroads, and manufactured gas utilities. These are good trend indicators, although adjustments to an actual hours worked basis were made by correlations derived from estimates for periods when both types of estimates are available (see Appendixes A, C, D, E, and G).

For farming, Department of Agriculture estimates of manhours are available since 1910, based on technological studies of manhour requirements for various types of farm output. Prior to 1910, we accepted Barger's judgment that average hours in farming did not change significantly (see Appendix B). Estimates for most of the other private-industry segments are based on reports covering a number of states. Since the state data are fragmentary, the average hours estimates are weak for these segments. Civil Service Commission reports provide the basis for average hours worked per year by federal civilian employees. For the economy as a whole, the basis of the data for the average hours estimates is fairly broad, even in the latter part of the nineteenth century; but, unfortunately, there is no good method of subjecting the average hours and manhours estimates before 1940 to an external check.

Average hours data for some industries, notably manufacturing, relate to production workers. We imputed the same movements of average hours to nonproduction workers. Although nonproduction workers comprise a minor portion of total persons engaged, this assumption introduces additional possible sources of error, but more so in the annual fluctuations than in the trends. A similar imputation was made for average hours

[34] See Albert Rees, *New Measures of Wage-Earner Compensation in Manufacturing, 1914–57*, Occasional Paper 75, New York (NBR), 1960.

worked by proprietors and unpaid family workers, but an allowance was made for the higher level of average hours for this group relative to average hours for employees revealed by unpublished data from recent Current Population Surveys.

The labor compensation estimates used for weighting purposes are of the same order of reliability as the employment estimates and are generally consistent with them. That is, the Commerce Department estimates were used since 1929 and were extrapolated to 1919 by the Kuznets estimates after the latter were adjusted for consistency with our employment figures. The adjustment consisted of multiplying Kuznets' labor income estimates by the ratio of our employment estimates to his. In general, the 1919–29 weights were used for earlier subperiods. In any case, relative average hourly earnings in the various industries did not change very much over the decades (see Table A-5).

It should be noted that labor compensation includes supplements as well as wages and salaries. When this value is divided by manhours worked, the resultant average hourly earnings reflect the effect of changes in paid leave as well as in other supplements, which is consistent with our preferred treatment of manhours in the productivity ratios.

REAL CAPITAL STOCKS AND SERVICES

Since capital stock, unlike the labor force, is immediately available for use at all times, we have not adjusted for rate of utilization, counting this as an aspect of the efficiency with which the capital is used. Rather, weighting the real stock by its base-period rate of return, we measure the input of capital in constant dollars in successive years, assuming base-year efficiency in use of the instruments. Weighting is discussed in the next section; here we describe, in summary fashion, the real-stock estimates.[35]

For the major portion of the private nonfarm, nonresidential economy estimates, we used the reproducible real-wealth estimates prepared by Raymond Goldsmith for the period since 1896.[36] Goldsmith's basic method was to estimate annual gross outlays for plant and equipment by major types, deflate to 1929 prices, depreciate the real outlays by the straight-line method over average lengths of life as prescribed by *Bulletin "F"* of the Treasury Department,[37] and then cumulate the net additions to stock.

[35] A more detailed summary and discussion of the industry capital estimates is to be found in Daniel Creamer, "An Appraisal of Long-Term Capital Estimates: Some Reference Notes," *Output, Input, and Productivity Measurement*, Studies in Income and Wealth, Volume 25.

[36] *A Study of Saving in the United States*, Princeton, N.J., Princeton University Press, 1956, Volume III.

[37] *Income Tax Depreciation and Obsolescence, Estimated Useful Lives and Depreciation Rates*, Rev. Ed. (July 1942), Bureau of Internal Revenue (now Internal Revenue Service), 1942.

Site land was allowed for by applying the 1929 ratio of land value to value of structures to the constant-dollar value of the latter throughout. Inventories were estimated separately on a basis consistent with the national product component. To carry the reproducible stock estimates back of 1896, we successively deducted the corresponding annual net capital formation estimates contained in Kuznets' real national product estimates.

Goldsmith compared his "perpetual inventory" estimates with deflated census-type asset-value estimates, and found a good correspondence of trend.[38] Kuznets likewise compared cumulative totals of his net capital formation estimates with the deflated Census reproducible wealth estimates and found much the same net change over long periods, although there was considerable divergence over shorter periods.[39] It is his conclusion that the cumulative real net investment estimates provide a more reliable series than the deflated wealth estimates.

For this study, we made a somewhat different type of comparison. We subtracted the sum of the real fixed capital stock estimates for the private nonfarm industry segments that were available from the Goldsmith estimates (excluding residential real estate from both estimates), and compared the trends of the covered and residual sectors in relation to manhours worked in each. The estimates for the various groups in mining and manufacturing are based on deflated Census and Internal Revenue Service estimates of the value of assets (presumed to be at original cost), adjusted to exclude financial items.[40] Estimates for the groups included in the transportation, communications, and public utility segments were obtained chiefly by the method of cumulating real net investment, but this was done independently of the Goldsmith estimates.[41] It is these capital estimates that we use in the productivity estimates for the nonfarm industry groups.

The results of the comparison for key years beginning with 1899 are shown in Table A-6. The level of capital and particularly of capital per manhour in the uncovered sector is considerably lower than in the covered sector, but the trend of capital per manhour in the uncovered sector from 1909 on is moderately greater than in the covered sector. These results do not seem unreasonable (see Appendix A, section "Nonfarm Nonresidential Capital"), and confirmation of the 1939 level is provided

[38] Raymond W. Goldsmith, "A Perpetual Inventory of National Wealth," *Studies in Income and Wealth, Volume 14*, New York (NBER), 1952, pp. 46–57.

[39] Simon Kuznets, *National Product since 1869*, New York (NBER), 1946, pp. 193–199; see also *Capital in the American Economy: Its Formation and Financing*, in preparation.

[40] Israel Borenstein, *Capital and Output Trends in Mining Industries, 1870–1948*, Occasional Paper 45, New York (NBER), 1954; Daniel Creamer, *Capital and Output Trends in Manufacturing Industries, 1880–1948*, Occasional Paper 41, New York (NBER), 1954.

[41] Melville J. Ulmer, *Capital in Transportation, Communications, and Public Utilities: Its Formation and Financing*, Princeton University Press (for NBER), 1960.

by the results of the Harvard interindustry study group.[42] The increase of capital in the uncovered sector between 1899 and 1909 seems quite high, however, suggesting that the economy estimate for 1899 may be on the low side or that the covered-industry aggregate may be high. In general, the comparison does not indicate that the two sets of estimates are inconsistent. A similar comparison by Kuznets of the sum of his net investment estimates with the difference in the sum of industry capital stock between 1880 and 1922 showed only a 4 per cent discrepancy, although the correspondence in subperiods was not as close.[43]

Estimates of the stock of nonfarm residential structures in 1929 prices are those prepared by Leo Grebler, David M. Blank, and Louis Winnick.[44] The latter also cumulated real net additions to stock. Depreciation was computed by the declining balance method, using a rate of 2 per cent a year. A base in 1890 was provided by the product of the number of units in the stock and the deflated average value per unit given by the mortgage census of 1890.[45] The base agrees closely with the Kuznets independent estimate for this component of wealth. The estimates were carried back by subtracting Kuznets' estimates of real outlays for new nonfarm residential structures. The Grebler-Blank-Winnick estimates for 1950 relative to 1890 are about 5 per cent lower than independent census-type real-wealth estimates and about 10 per cent lower than Goldsmith's estimates. We used the Goldsmith method of applying a fixed percentage markup to obtain the real value of site land.

The estimates of farm capital other than machinery are those prepared by Alvin S. Tostlebe for census years 1870–1950,[46] interpolated annually and extrapolated forward by Goldsmith's estimates. Tostlebe used acres of farm land in the various states, by type, multiplied by the average value per acre in the base period. His weighted aggregate increases significantly less than a simple measure of acreage, reflecting the greater relative increase in unimproved compared to higher-value improved land. Tostlebe's estimates of inventories were obtained by multiplying numbers by average value per unit in the base period, by state. The changes in the real farm inventory values as estimated by Tostlebe accord closely with the corresponding gross national product (GNP) component.

Goldsmith's estimates were also used for the stock of net foreign assets,

[42] Research Project on the Structure of the American Economy, "The Capital Structure of the American Economy," *Studies in the Structure of the American Economy*, New York, Oxford University Press, 1953.

[43] Kuznets, *Capital in the American Economy*, Vol. II, Part D.

[44] *Capital Formation in Residential Real Estate: Trends and Prospects*, Princeton University Press (for NBER), 1956.

[45] *Census of the United States, 1890*, Vol. XII, *Report on Real Estate Mortgages*.

[46] *The Growth of Physical Capital in Agriculture, 1870–1950*, Occasional Paper 44, New York (NBER), 1954.

mentioned earlier, and as a basis for government-owned capital stock. In the latter category, we modified his land estimates somewhat; and for the sake of consistency with national product sectoring, we roughly estimated the capital stocks held by government enterprises to include them with the business sector rather than with general government.

It is not easy to appraise the accuracy of the real-stock estimates, given their conceptual basis.[47] The correspondence between long-run movements of the deflated book value estimates and the cumulated real net investment series is reassuring as to the basic value data, but these estimates are subject to common error on two scores. In the first place, the deflators for capital goods are not entirely satisfactory. This is true of construction throughout and of equipment particularly in the earlier decades. The probable downward bias in the plant physical-volume estimates is, of course, matched by a similar bias in the new-construction component of GNP. Secondly, the lengths of life of plant and equipment, according to which the gross capital outlays are depreciated by the perpetual inventory method, are also implicit in the book value estimates. Insofar as these are unrealistic, they affect the estimates of stock and associated capital services; or (more importantly), insofar as actual lengths of life have changed over the period, the estimates of real capital stock and associated capital inputs have somewhat distorted movements.

Comparisons of estimates based on the different approaches indicate that margins of error are probably greater in shorter-term movements than in the long-run trends. The statistical base of the capital outlay estimates is generally more solid for recent decades; so it is reasonable to suppose that the derived real capital stock estimates are more accurate in recent periods than in earlier years.

THE WEIGHTING SYSTEM

In many American industries, and in the economy, there tends to be a negative correlation between relative changes in outputs and in prices. This means that a late-period weight-base results in a smaller increase in the aggregate industry or economy output than an early-period weight-base. There is a similar, but less pronounced, tendency characterizing input aggregates, since capital per unit of labor input has increased, while unit capital compensation has declined, relative to wage rates. So, as we shall see, the weighting system makes less difference in the movement of total factor productivity than it does in the movement of real product. But the choice of a weighting system is still of consequence.

Ideally, in comparisons of an aggregate between two periods, one should use the relative weights of each period in order to bracket the difference

[47] See Creamer, "An Appraisal of Long-Term Capital Estimates: Some Reference Notes."

in change. This is hardly practical in presenting a long time series, and certainly not so for the many time series in this study. Accordingly, we have resorted to the weighting convention used in most of the other National Bureau studies of output. That is, in comparing movements between key years we have used arithmetic averages of the unit values in the two years to weight component units (the Marshall-Edgeworth formula), and then linked the resulting index numbers for the several subperiods in order to form a continuous series, with 1929 as the reference base.

Although there is no unique solution to the index number problem, the chain index with occasionally changing weights seems to be a reasonable convention. The relative unit values for each time-segment of the index are consistent with the contemporaneous structure of production. Usually, structural changes are gradual enough to warrant only occasional changes in weights, but the changes cumulate so that over as long a period as we are studying frequent weight changes seem desirable. In comparing changes between the key years of the long period (1889–1957), it might be argued that cross-weights for these two years should be used. But differences in the nature of product are so great over as long a period as is considered here that this procedure would be impractical.

We have quantified the difference in movement of the output and input aggregates and of total factor productivity in the private domestic economy as a whole by using changing weights as compared with a fixed (1929) weight-base. With respect to real product, weighting by both systems was carried out in terms of about 200 product classes from 1929 on, and several dozen classes in the earlier years. Between 1889 and 1929, the chain index rose about 5 per cent more than the fixed-weight aggregate in line with the tendency for relative changes in prices and quantities to be inversely correlated. There is, however, very little difference between the two indexes between 1929 and 1953. One would have expected the fixed-weight (1929) aggregate to show a greater increase over this period, and its failure to do so seems to be connected with peculiarities of the post-World War II period (see Appendix A and Table A-XVIII). The input indexes were alternatively weighted in terms of 47 industrial groupings in the case of labor, and 25 in the case of capital, and the two broad input groups were also weighted together using both schemes. The fixed-weight aggregate rose about 2 per cent less than the chain index up to 1929 and then by about 1 per cent more between 1929 and 1953.

As a result of the relative movements described above, the productivity ratio showed less divergence of movement between 1889 and 1929 using the alternative weighting systems than was the case with real product, because the divergence of the input indexes was in the same direction as that of the output indexes up to 1929. Since 1929, however, the divergence was slightly greater, because whereas the fixed-weight input

aggregate fell a bit relative to the chain index (in line with expectations), the divergence of the two real-product series was to a slight extent in the opposite direction (see Tables A-XVII and A-XVIII).

Some other comparisons of the effect of alternative weight-bases are made in the industry appendixes. In general, it appears that the effect of alternative weight-bases in groupings as broad as those used in this study is not great in relation to the large changes in the output and input aggregates and their ratios. But it is likewise clear that the changes vary somewhat depending on the particular weighting convention employed. The differences are minor, however, compared with differences in movement between weighted and unweighted input aggregates.

Finally, two deficiencies of the factor-cost estimates should be noted which affect their use for the analysis in Chapter 5 as well as for weighting purposes. They do not relate to the quality of the basic data, which is relatively good since 1919, but rather to methods of estimation. First, whereas the labor compensation estimates are based on plant data, in line with the principle of industry classification, the data on corporate profits relate to firms. Insofar as firms have establishments in several industries, there is some distortion since all profits are thrown into the industry in which the firm's major activities lie. We have transferred some of the profits reported for the petroleum refining industry (manufacturing) to the crude oil and natural gas producing industry (mining); but in several other cases distortions are probably significant enough to warrant adjustments, which, however, were not made because of lack of a firm statistical base. Second, whereas profits have been adjusted for the effect of inventory revaluation to current prices in the national accounts, a similar adjustment for depreciation revaluation has not been made. This is not so important in the relative weights assigned to the real capital stocks in the various sectors, but it is of somewhat greater importance in the relative weights accorded to labor and capital. In periods of rising prices, profits and the relative weight of capital tend to be overstated.