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Chapter 2

Measurement of Output: Method and Material

CHANGES in the volume of output are described in this study mainly by means of index numbers, which summarize data collected for the most part by the United States Census of Manufactures. Because indexes of physical output are rather complex measures, and because in any case the indexes that can be computed from the available Census statistics are often only approximations of the desired measures, some discussion of the methods and materials utilized by us is an essential preliminary to a presentation of the indexes themselves. A more detailed treatment of some of the problems considered here is to be found in Appendix A.

IDEAL INDEXES AND PRACTICABLE INDEXES OF PHYSICAL OUTPUT

The meaning of the indexes computed for this study may be understood most readily if we first describe "ideal" indexes of physical output of a single industry and "ideal" indexes of physical output of all manufacturing industries combined. A comparison of the indexes actually computed from the available data with the "ideal" indexes will then show in what respects they differ.

The aggregate money value of an industry's output changes from time to time because of modifications both in prices and in physical quantities. The index of physical output for the industry should measure the changes in this aggregate value that are attributable exclusively to the changes that actually occurred in physical quantities. To this end prices should be kept constant in the computation of the index of physical output.

The particular physical quantities and prices that are relevant to the measurement of physical output depend upon the definition of output chosen. More specifically, the crucial question to be decided is whether we seek to measure gross output or net output. Considered in economic terms, the output of an industry may be taken either as the total value of the goods it sends to market, or as that portion of the value which the industry has itself added in the process of manufacture. The former is gross output, the latter net output. Now there are a number of concepts of gross output. For example, gross output may be defined simply as the gross proceeds from sales of commodities or it may be enlarged to include capital gains. Most commonly, however, the value of gross output is defined as the aggregate value of goods produced in the ordinary course of business, exclusive of capital gains.

Similarly, there are many concepts of net output, each different from the other in the degree to which the product is net. Payments for materials alone may be subtracted from gross sales to yield a net figure. Fuel expenditures also may be subtracted. The number of deductions may be expanded to cover all payments to other business enterprises for commodities and services, excluding capital equipment. Finally, a net figure may be obtained by a further deduction of expenditures on capital equipment, either immediately or in the form of periodic depreciation charges. Here too, fortunately, there is fairly general acceptance of a single concept: [1] the value of net output is usually defined as the aggregate

[1] The most controversial questions revolve chiefly about the treatment of capital gains and losses, and taxes; see Conference on Research in National Income and Wealth, *Studies in Income and Wealth* (National Bureau of Economic Research) Vol. I (1937), Parts 1, 2, 3, 5; Vol. II (1938), Parts 4 and 5.

value of goods produced (i.e., the value of gross output) less the value of all commodities and services purchased from other business enterprises and consumed in the production process, including periodic allowance for depreciation and depletion and provision for losses by accident. This definition does not allow for deduction of losses on "capital account."

An ideal index of the *gross* physical output of an industry would measure the changes in the aggregate value of gross output due only to changes in the physical quantities of final products, with prices of those products kept constant. Thus if prices are kept constant at the level at which they stood in some selected period, called the "weight base,"[2] the index of gross physical output for the year $(_1)$ on the year $(_0)$ as a "comparison base" is $\frac{\Sigma q_1 p_w}{\Sigma q_0 p_w}$, in which quantities of final products are represented by q and prices of final products by p.

The ideal index of the *net* physical output of an industry would measure the changes in the aggregate value of net output attributable exclusively to changes in the physical quantities of the final products and to changes in the physical quantities of the materials and other commodities consumed in the fabrication of the final products, with prices of final products and of commodities consumed kept constant. The index of net physical output corresponding to the above index of gross physical output would be

$$\frac{\Sigma q_1 p_w - \Sigma Q_1 P_w}{\Sigma q_0 p_w - \Sigma Q_0 P_w},$$

in which Q and P stand for the quantities and prices, respectively, of materials and other commodities consumed.

Whether output is to be defined as gross or net depends on

[2] The "weight base" should be distinguished from the "comparison base." The weight base is the period from which the prices or weights are taken. The comparison base is the period used as the point of reference, i.e., that with which other periods are contrasted. The weight base and comparison base periods need not be identical.

the use to be made of the measure of output. For some purposes, gross output is more satisfactory. Thus, if we wish to study the relation between the output of an industry and the input of materials, labor, equipment, etc.—which is indeed one of our ultimate objectives—the appropriate concept is gross output. Again, the degree of correspondence between the output of certain related industries—wood pulp and paper, for instance—may be of concern, as they are here. In this case, also, gross output is the more suitable measure. For these purposes, then, the ideal index of output of an industry is an index of gross output.

On the other hand, if we wish to obtain an aggregate of the output of several industries, another objective of the present study, net output is the preferable measure. For net output is free from all duplication. In principle, at least, the value of net output of different industries can be combined into a meaningful and unambiguous total, which is equal in fact to the national income. Similarly, an index of the aggregate net physical output of all industries measures changes in the real national income. Such an index, represented algebraically by $\frac{\Sigma\,(\Sigma q_1 p_w - \Sigma Q_1 P_w)}{\Sigma\,(\Sigma q_0 p_w - \Sigma Q_0 P_w)}$, is likewise free from all duplication. For example, the gross physical output of the steel industry is included in the first term within the parentheses in the numerator and denominator. Exactly the same item (if exports and imports, transport costs and changes in stocks of steel are ignored, for the sake of simplicity) appears also in the second term in numerator and denominator, as materials consumed by steel-using industries. Unfinished goods are thus canceled out, and only finished goods remain. The quantity of these is equivalent to the real national income.[3] For purposes of combination, then, the ideal index of output of an industry is an index of net output.

[3] Sometimes, all that may be desired is an index of total manufacturing output free only from the duplication that arises from the interchange of semiprocessed goods. For this purpose, the procedure suggested in the text

Having described briefly the computation of ideal indexes of physical output, we may now consider how the nature of available data compels us to modify our procedure when we construct what we call "practicable" indexes. In order to compute the index of gross physical output of an industry we must know the physical quantities and the prices of all the industry's final products. The quantities and prices of substantial samples of final products are readily available for many industries. Because a sample covers incompletely the gross output of an industry, adjustments (described below) must be made for changes in coverage; in this procedure some errors inevitably arise. These errors are slight in most cases, however, since the samples are usually large. Except, then, for the errors that may be introduced because the sample does not cover all the industry's final products, the practicable index of gross output of an industry corresponds to the ideal index described above.

In order to compute the index of net physical output of an industry we must know the physical quantities and the prices not only of the industry's final products but also of the commodities consumed in the making of those final products. As we have already pointed out, data on final products are available. For few industries, however, are there any reliable data on the quantities and prices of commodities consumed in the production process; and for even fewer are these data reasonably complete. The closest possible approximation to the index of net physical output of individual manufacturing industries, therefore, is simply the index of gross physical output.[4] In this case, the practicable index, which covers

is inefficient. A more satisfactory approach is that followed by Simon Kuznets and W. H. Shaw in measuring the output of "finished" processed goods. See Simon Kuznets, *Commodity Flow and Capital Formation* (National Bureau of Economic Research, 1938), and a forthcoming report by Mr. Shaw.

[4] For some industries rough computations of net output were possible. These computations were made for the few scattered industries for which data were available when it appeared that net and gross output had diverged appreciably. The computations are noted below in Part Two. Since indexes of

gross output, and the ideal index of net physical output cannot be expected to correspond very closely. The relation between the two may be expressed algebraically as follows: The index of gross physical output is

$$(1) \qquad \frac{\Sigma q_1 p_w}{\Sigma q_0 p_w};$$

the index of physical input of materials, etc., is

$$(2) \qquad \frac{\Sigma Q_1 P_w}{\Sigma Q_0 P_w};$$

and the index of net physical output [5] is

$$(3) \qquad \frac{\Sigma q_1 p_w - \Sigma Q_1 P_w}{\Sigma q_0 p_w - \Sigma Q_0 P_w}.$$

net output could be computed for a few industries only, and since even for these they were exceedingly rough, no attempt was made to substitute them for the corresponding indexes of gross output.

[5] The numerator, the denominator, or both numerator and denominator of the index of net output for an industry might conceivably be equal to or less than zero. Such an occurrence might reflect the presence of a zero or negative net value added by the industry in the given year, in the weight-base year, or in both years. The presence of a zero or negative net value is unlikely, though not impossible. A zero or negative numerator or denominator could be the result also of a negative correlation between (1) the change, from the initial year ($_0$) to the given year ($_1$), in the average production coefficient, and (2) the corresponding change in the ratio of (a) the average price of materials and other commodities purchased from outside industries to (b) the average selling price of the goods produced by the industry concerned. There are reasons for believing that such a correlation exists. It seems doubtful, however, that the elasticity of the production coefficient with respect to the price ratio that might be derived from the regression line for the purchased goods could often have such a magnitude as to give rise to zero or negative values in the numerator or denominator of the net output index without the appearance also in the net value added in the two years compared of zero or negative values. The paradoxical result of a negative net physical output that might conceivably be obtained even in the absence of a negative net value added reflects the ambiguity inherent in all index numbers of production and prices—an ambiguity which stems from the assumption that the price and production changes underlying a given change in value are independent and can be measured separately. This ambiguity remains the basic problem to be resolved by the still-inchoate economic theory of index numbers.

(3) is not equal to (1) unless (1) = (2); or, if we transpose terms from one side of this equation to the other, unless

$$\frac{\Sigma Q_1 P_w}{\Sigma q_1 p_w} = \frac{\Sigma Q_0 P_w}{\Sigma q_0 p_w}.$$

That is, the weighted average ratio of input to output (the weighted average "production coefficient") in year ($_1$) must be equal to the weighted average ratio of input to output (the weighted average "production coefficient") in year ($_0$). As a rule, however, the equality is not attained. Changes in the pattern of production—such as shifts in the relative importance of products requiring more or less elaboration of given materials—will render impossible the equalization of the two average ratios. A concrete case would be an increase in the amount of rolled products and a decrease in the amount of ingots in the final output of steel mills. Changes in the pattern of consumption—such as changes in the relative importance of materials requiring more or less elaboration if they are to yield stated quantities of products—operate in the same way. The reduction in the average tenor of the ore used in copper smelting and refining is an example. Presumably for the industries that use ores as raw materials, the index of gross output is a downward-biased index of net output. The direction of bias is downward also for industries whose final products become subject to an increasing degree of fabrication or improvement in quality. On the other hand, for industries whose raw materials have improved in quality, the indexes of gross output are biased upward as estimates of net output. For industries with a single raw material and a single product, both of fairly constant quality (and there are probably many of them), changes in the pattern of output or input could not give rise to a serious discrepancy between the indexes of gross and net output. The same observation must apply also to industries with relatively homogeneous materials and products, although it is difficult to say how many such industries exist.

The possibility of significant discrepancies between changes in gross and in net output is greatest for industries producing a variety of commodities or utilizing a variety of materials. Many of the Census industry classifications fall into this category since they are usually defined rather broadly, as is noted below. It should be emphasized that differences between indexes of gross and net output of these industries are merely *possible*; we do not know how frequently they occur in significant degree.

Even with the patterns of production and consumption remaining constant, a change in the efficiency with which materials are utilized—e.g., a decline in the amount of pig iron required to produce a ton of steel—will prevent equality of the indexes of net and gross output. Apparently in many industries the quantity of materials and of fuel used has tended to decline in relation to gross output. Such a tendency would cause the index of gross physical output to be biased downward as an estimate of the index of net physical output. It seems unlikely, however, that savings in materials and fuel have been great in all industries. The decline in the amount of fuel used, attributable to greater efficiency in the utilization of fuel, has often been counterbalanced in some degree by increased consumption of fuel arising from the displacement of human power by mechanical power. The trends with reference to other costs per unit of gross output, such as supplies, services purchased from other industries, and capital consumption, are less clear.

Because the indexes obtainable for individual industries relate to gross physical output, the indexes for groups of manufacturing industries and for all manufacturing industries combined cannot serve as accurate indexes of net physical output. Fortunately, however, the indexes for groups of related industries and the index for total manufacturing constitute somewhat more satisfactory approximations to indexes of net physical output than do those for individual industries, because in combining the indexes for various industries we have used, as the price to be kept constant, the Census "value added" (value of products minus cost of materials and fuel) per unit, rather than the gross value of products per unit.[6] The value of net output per unit would be even more satisfactory as the p coefficient, but it, too, is lacking for individual industries.

The use of value added per unit as the p coefficient does not yield an exact index of net output for a group or for all manufacturing combined if the indexes for individual industries are indexes of gross output—as they are in fact. Thus the group or total index we compute is, in simplified form,[7]

$$\frac{\Sigma q_1 \left(p_w - P_w \dfrac{Q_w}{q_w}\right)}{\Sigma q_0 \left(p_w - P_w \dfrac{Q_w}{q_w}\right)}.$$

The parenthetical term is the value added per unit of product. This index will not equal

$$\frac{\Sigma q_1 p_w - \Sigma Q_1 P_w}{\Sigma q_0 p_w - \Sigma Q_0 P_w},$$

the ideal index described earlier, unless

$$\frac{Q_1}{q_1} = \frac{Q_0}{q_0} = \frac{Q_w}{q_w};$$

i.e., unless there have been no changes in the production

[6] Data on value added are available for industries alone, not for individual products. Indeed for an industry in which more than one product is manufactured the value added in the production of any one of the commodities is not theoretically determinable. There are certain materials, like fuel, which are used in the fabrication of all products; the cost of fuel cannot be charged against any particular product except on an arbitrary accounting basis.

[7] The aggregate output of each industry is treated here as a composite quantity, q, and the aggregate input as a composite quantity, Q.

coefficients. It will, however, constitute a closer approximation to the latter than

$$\frac{\Sigma q_1 p_w}{\Sigma q_0 p_w},$$

except in the rare case in which the errors involved in the assumption that the production coefficients are constant happen to be canceled by errors in the opposite direction arising from the use of selling price rather than value added per unit as the p coefficient.

It is impossible to determine accurately the direction, let alone the degree, of bias in our indexes of output for groups and for total manufacturing when these indexes are regarded as estimates of net physical output. For the bias is, so to speak, the net sum of the biases in the component indexes, of which we know little. It is conditioned also by the fact that value added as reported in the Census, which we have used in weighting indexes of individual industries, is not exactly proportionate to the ideal weight, the net value of output as defined above, though this shortcoming is probably not serious. If a guess may be hazarded, the group and total indexes are probably biased downward. It is hardly possible, however, that the various group indexes are all biased in the same degree. To some extent, therefore, group comparisons are distorted.

The import of the preceding discussion may be summarized briefly as follows. For individual industries we should have preferred to present two sets of indexes: one of gross physical output, to be used in a study of the individual industries; and one of net physical output, to be used to obtain composite indexes of net physical output for major industrial groups and for all manufacturing industries combined. However, the nature of our materials permitted us to compute only one comprehensive set of indexes for individual industries, and these only of gross output, although for a small number of industries we have been able to present rough indexes of net output. For major groups and for all manufacturing combined, we should have preferred to present indexes of net physical output. This too was impossible with the available data. Therefore we have followed what appeared to be the next best procedure: we have combined the indexes of gross physical output for individual industries, with value added as the weight, to measure the output of major groups and total manufacturing output. The resulting indexes, despite their shortcomings, are revelatory; although they are not precise measures of net output, they do trace the broad movements of net output for major groups and for manufacturing as a whole.

COMPUTATION OF THE INDEXES OF PHYSICAL OUTPUT

In combining the quantities of output of the different final products of an industry, and in expressing the aggregates as indexes, we used the Edgeworth formula:

$$\frac{\Sigma q_1 (p_0 + p_1)}{\Sigma q_0 (p_0 + p_1)}.$$

The symbol q stands for the quantity of each of the final products of the industry, and p for the corresponding unit value of products. The subscripts identify the year to which these relate.

We employed a mathematically identical formula in combining the indexes of individual industries to obtain the indexes for major manufacturing groups and for total manufacturing. In the construction of the group and total indexes we used the unit value added (value of products minus cost of materials and fuel, per unit of product) rather than the unit value of the products, as the p coefficient.

Our comparison-base periods were 1909 for the 1899 and 1904 indexes, 1919 for the 1909 and 1914 indexes, and 1929 for the remaining indexes. It follows, from the formula chosen, that the weight-base periods were the average of 1909 and 1899 for the 1899 index, the average of 1909 and 1904 for the 1904 index, and so on. We obtained continuous indexes for the entire period 1899–1937 on the 1929 comparison base by splicing the indexes on the 1909 and 1919 bases to those on the 1929 base. In addition, we computed a special set of indexes in which 1899 and 1937 were compared directly. This procedure was designed to check the comparison of these two years made indirectly via the spliced indexes.[8]

The three comparison-base periods, 1909, 1919 and 1929, were selected for two reasons. First, the use of several such periods made it possible for us to utilize the Census data, which tend to become more detailed with each succeeding Census, more effectively than if one period alone had been used. Second, many of our comparisons relate to 1899–1909, 1909–19, 1919–29 and 1929–37. We thought it desirable to construct our indexes in such a manner as to make the average of 1899 and 1909 the weight-base period for the indexes underlying the 1899–1909 comparison, the average of 1909 and 1919 the weight-base period for the indexes underlying the 1909–19 comparison, and so forth.

Only rarely does the Census provide information on the physical quantities of all the products of an industry. The indexes, even for individual industries, were therefore based on samples. When these samples equaled or exceeded 40 percent (in terms of value) of the total output, the index built

[8] In algebraic language, we sought to determine how

$$\frac{\Sigma q_{37}(p_{37}+p_{29})}{\Sigma q_{29}(p_{37}+p_{29})} \times \frac{\Sigma q_{29}(p_{29}+p_{19})}{\Sigma q_{19}(p_{29}+p_{19})} \times \frac{\Sigma q_{19}(p_{19}+p_{09})}{\Sigma q_{09}(p_{19}+p_{09})} \times \frac{\Sigma q_{09}(p_{09}+p_{99})}{\Sigma q_{99}(p_{09}+p_{99})}$$

differs from

$$\frac{\Sigma q_{37}(p_{37}+p_{99})}{\Sigma q_{99}(p_{37}+p_{99})}.$$

(The number and character of the industries whose output is summated are identical for numerator and denominator of each fraction, but vary from one fraction to another.) These special indexes are referred to briefly in the chapters following. For a more extended discussion, see Appendix A.

up from them was considered representative, within a reasonable margin of error, of the output of the industry. Whenever possible we took a further step before accepting an index based on a 40 percent or even greater coverage: we applied the Mills "adequacy adjustment," [9] whereby a correction is attempted for any change that may have occurred in the sample's coverage of the products of the industry. This procedure is based upon the assumption that the average price of all the goods produced in an industry has moved in the same manner as the average price of the goods represented in the index. In the absence of detailed knowledge concerning the reasons for the change in coverage in each industry, such an adjustment seemed preferable to acceptance of the index as it stood. The adjustment has been justified empirically in tests made by us and described in Appendix A. A similar adjustment for changes in coverage was made in the construction of the indexes for groups of manufacturing industries and of the index for all manufacturing industries combined, since these also are based on samples.

SOME DEFICIENCIES OF THE DATA

The most serious deficiency of the data in the Census of Manufactures, the basic source of information on manufacturing production, arises from the fact that its records are available for Census years only: 1899, 1904, 1909, 1914, 1919, and then biennially through 1937. These years cover different phases of business cycles. Some coincide with peaks in general business, some with troughs; some are in expanding phases, some in contracting. The movements from one Census year to another therefore tend to lack consistency with respect to the cyclical phases they bridge, and to that extent are inadequate descriptions of the short-term movements in manufacturing

[9] F. C. Mills, *Economic Tendencies* (National Bureau of Economic Research, 1932), pp. 90, 92–93; and Appendix A, below.

production. Even if it is known that one Census year includes a peak in general business, and that another includes a trough, such knowledge cannot be applied to all individual industries; for this reason it is unjustifiable to draw inferences from the decline in output between these two years concerning the decline from the peak to the trough of a particular industry. For similar reasons, and also because annual data are much less satisfactory than monthly data as indicators of short-term changes,[10] this volume contains no conclusions drawn from these data in respect of cyclical movements in production. We devote our attention almost entirely to the longer-term trends in production, except for a brief discussion of the fluctuations in the annual index for all manufacturing industries combined. The latter index we obtained by interpolating our index for Census years by available annual indexes, which are based on much less comprehensive data. The trends are measured simply by comparisons of good or fairly good years in business activity, mostly ten years apart (1899 with 1909, 1909 with 1919, 1919 with 1929, and 1929 with 1937).[11] The decade trends may be checked by observation of the extent to which the changes between quinquennial and biennial dates confirm or render doubtful the conclusions based on the decade changes. Very long-term movements are more safely traced with the Census data. A good deal of our attention, therefore, is devoted to the net change between 1899 and 1937, a span of 38 years.

A lesser defect in data derived from the Census of Manufactures is attributable to changes in the number of industries covered. On the whole, this number has tended to decline. With the passing of time, the Bureau of the Census has dropped from its list of manufacturing industries several formerly included in it and still in existence. Thus, automo-

[10] See the forthcoming National Bureau report by W. C. Mitchell and A. F. Burns, *Methods of Measuring Cyclical Behavior,* Chapter 11.

[11] The years 1909, 1919 and 1929 were used as bases in the computation of the indexes partly in order to facilitate such comparison.

bile repairing, motion pictures, manufactured gas, and railroad repair shops are no longer considered manufacturing industries. On the other hand, some smaller industries were added to the Census of Manufactures after 1899, e.g., ice cream in 1914. Because of such changes we excluded all industries not covered in 1937,[12] the latest Census year for which data are available, a procedure which enhanced the comparability but not the coverage of the data. The more important doubts concerning the comprehensiveness of the measures presented here arise in connection with the omission of manufactured gas and railroad repair shops, motion pictures, illegal liquor production, and the farm production of processed foods.[13]

Another shortcoming of our indexes of physical output is attributable to lack of detail in the Census quantity data. Sometimes the quantities presented are for relatively heterogenous groups of products—"women's dresses," for example. With such heterogeneous groups, variation in the proportion of complex to simple or of expensive to cheap products within the group are perforce ignored. Since indexes constructed from these statistical materials would be subject to a bias of unknown magnitude, we have sought to avoid the use of excessively heterogeneous groups. The indexes computed for the more recent years are more satisfactory in this respect, because the later Census data are usually more detailed.

Our measures of physical output are subject to still another limitation—changes in the quality of products. The quantity units in the Census reports are the ordinary commercial units. Because of changes in the quality of products these units are not always stable in an economic sense. In some degree, therefore, statements concerning changes in the output of a given commodity are incomplete. Thus an index showing the

[12] Exceptions to this statement are poultry killing and rectified spirits.

[13] Some of these industries will be covered in a later volume dealing with nonmanufacturing output.

increase in the number of radios produced measures the change in only one physical characteristic of radio production: other relevant physical characteristics that remain unmeasured are size of cabinet, type of speaker, range of reception and ease of tuning. Even so-called standardized commodities are likely to change in quality. In our discussion of the indexes of physical output we note relevant quality changes that have come to our attention, although we are unable to take statistical account of them.

DIFFERENTIATION OF INDUSTRIES

Census Classification. The principle basic to the industrial classification used in the Census of Manufactures is formulated by the Bureau of the Census as follows:

> The production of each specific class of finished commodities, however small, might be looked upon as a separate industry; and in some cases certain of the distinct processes in the manufacture of a single commodity might be treated as distinct industries, as, indeed, is sometimes actually done in the Census reports. Manifestly, however, there must be some grouping of commodities and processes, not only in order to bring the number of industries within reasonable compass, but also in order to avoid the extensive overlapping which would result from an attempt to distinguish so large a number of industries. Each establishment must as a rule be treated as a unit and the data reported by it assigned in toto to some one industry. In many cases an establishment manufactures several related articles or commodities, or performs several related operations. The classification should, therefore, if practicable, be broad enough to cover the entire activities of such establishments.
>
> The effort has been made to distinguish, so far as practicable, each well-defined or well-recognized industry. The classification has been based on prevailing conditions as to the actual organization of industry and the distribution of the various

> branches of production among individual establishments. It has been necessary, however, in some cases to combine the data for two or more industries which are usually considered fairly distinct from one another, because of the considerable amount of overlapping among them. . . .[14]

The number of industries distinguished in the Census of Manufactures varies from one Census to another, giving rise to certain complications in the presentation of the data and disturbing the continuity of the industrial series. In order to skirt these difficulties we have followed, as far as possible, the 1929 classification in which 326 industries are differentiated. The classification of that year is one of the least detailed, so that the classifications in other years can readily be adapted to it through combination of subindustries.

Overlapping of Industries. Even after combining what are ordinarily considered to be two or more distinct industries, the Bureau of the Census has not been able to avoid overlapping. Many an establishment produces diverse commodities, some of which constitute the major products of one Census industry while others are classed as the major products of a different Census industry. Yet the firm may keep only one set of books, may transfer workers frequently from one task to another, may use its power plant to feed all machines in the establishment, and so forth. Such considerations make it difficult, if not impossible, to divide the output of an establishment into two categories; invariably the result is overlapping.

Examination of the detailed Census reports reveals that among the 242 industries for which data on degree of specialization were available for 1929, there were at least 16 in which the value of the primary product constituted less than 80 percent of the value of the industry's total output.[15] For example,

[14] U. S. Bureau of the Census, Fifteenth Census of the United States, *Manufactures: 1929* (Washington, 1933), Vol. I, pp. 3–4.

[15] See Appendix A, Table A–2. Because in many cases the Census gives information only for groups of related industries rather than for the individual

in 1929 the lumber-mill products industry devoted only about 61 percent of its energies (measured by value of output) to commodities classified as primary products of that industry: rough lumber, shingles and lath. It produced in addition such items as boxes, flooring, doors and molding, all of which are treated by the Census as primary products of other industries.

Again, the Census reports indicate that of a total of 224 industries, 29 produced in 1929 less than 80 percent of the country's output of the products in which they specialized. For example, the oleomargarine industry as defined by the Bureau of the Census produced in 1929 only 56 percent of all the oleomargarine made in the United States. Most of the remainder was made as a secondary product by establishments classified in the meat-packing industry.

Overlapping of this sort creates an obstacle to the differentiation of industries, especially if a fair degree of detail is desired in the classification. Thus we find in the Census classification several large industries, each with a number of satellites. Meat packing, for example, is closely associated with a group of specialist industries whose primary products are sausage, oleomargarine and shortenings. The relation among these industries may change; there may be a trend toward specialization, so that output in satellite industries will rise at the expense of the major industry. For this reason we cannot safely infer from the movements of output in a specialist industry what has happened to the total output of the product in which the industry specializes. This conclusion is a special and rather extreme development of the general rule that changes in the output of an industry do not measure precisely the changes in the total output of the product to which it is mainly, or even entirely, devoted.

Changes in the Classification. As we have already noted, the number of industries differentiated by the Bureau of the Cen-

industries themselves, the statistics quoted in the text understate the amount of overlapping among Census industries.

sus has varied from time to time. One reason for the variation is the growth of new industries. When a branch within an existing industry becomes large enough, the Census promotes it to independent status as a new industry. In consequence, parent industries appear to grow less rapidly than industries that do not propagate themselves in this way. Examples of new offshoot industries are rayon and gases, the former included in "chemicals, not elsewhere classified" prior to 1923, and the latter in the same category prior to 1927; radios, classified with electrical machinery prior to 1931; and mechanical refrigerators, classed with foundry and machine-shop products prior to 1927.

The decisions involved in an attempt to bring "the number of industries within reasonable compass"—and such decisions are necessarily arbitrary—affected not only the number of industries to be differentiated but also the size of each industry. Thus the knit goods industry was divided into four separate branches beginning with 1923; [16] instead of one large industry four relatively small industries were reported thereafter. The effect on size is important because in a sense a large industry is a group of industries and the behavior of its output may be an average behavior and consequently less extreme than the behavior of the output of any of its component branches.

Because of overlapping of industrial functions, the setting of an exact boundary between two industries likewise involves a more or less arbitrary decision. Reconsideration of, and changes in, these decisions by the Bureau of the Census lead to changes in the definition of the Census industries. Establishments devoted to a given product may be classified in a certain industry in one Census year and in another industry in the next Census year, and the continuity of the indexes of output of both industries may be disturbed thereby. Some-

[16] Prior to 1921, also, the group was subdivided into several branches, but these were not exactly comparable with the later divisions.

times this sort of discontinuity is minimized through the provision, by the Census, of two figures for each industry affected, one based on the old definition and one on the new. Often, however, such separate data are not given. The possible effects of these changes should not be disregarded altogether, although their importance is not always susceptible of exact measurement.

Despite the deficiencies inherent in the data, the statistical material assembled by the Census of Manufactures provides the basis for a reasonably trustworthy account of the course of manufacturing output during the period 1899–1937. Many of the difficulties encountered in the differentiation of individual industries do not arise at all when we confine our attention to major groups of industries. Still fewer appear when—as in the following chapter—we deal with the aggregate of all manufacturing industries.