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Appendix A

Technical Notes on Data and Methods

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Appendix A

Technical Notes on Data and Methods

COVERAGE OF THE CENSUS OF MANUFACTURES

THE United States Census of Manufactures, our basic source, has been taken quinquennially from 1899 to 1919, and biennially since the latter year.[1] Because it has never attempted to include all types and sizes of manufacturing establishments, and because of changes in the particular sizes and types of establishments canvassed, the coverage of the Census has varied from one Census year to another.

General Changes in Coverage: the $500–$5,000 Lower Limit

The Census of Manufactures excludes from its count all establishments with a value of products below a certain minimum.[2] For the Census years 1899–1919 this limit was $500; for the years since 1919 it has been $5,000.[3] The change in the minimum between the years 1919 and 1921 resulted in a decline in the coverage of the Census data. This decline appears to have been

[1] The data collected in the Censuses are tabulated and published by the Bureau of the Census as part of the decennial Censuses, as special reports for the quinquennial periods, and as individual volumes under the title *Biennial Census of Manufactures* for the two-year periods.

[2] In the lumber-mill products industry the minimum is expressed in terms of a physical quantity of product.

[3] For the Census year 1921 data were collected also from establishments with a value of products of $500 to $5,000. The data, published in Table 1,041 in the 1921 Report, are limited to number of establishments, number of wage earners, and value of products. They are not included in any general tables in the reports for 1921 or later years. For the Census years 1923 and 1925 data on products alone were collected in certain industries from establishments with products valued at less than $5,000, but since these were not tabulated they were excluded from the published figures (1925 Report, pp. 5–6). Certain establishments engaged chiefly in nonmanufacturing activities and only secondarily in manufacturing are canvassed only if the value of their products is $20,000 or more. There are many such establishments in such industries as ice cream and confectionery (see 1927 Report, p. 6). Note, also, awnings and other industries listed in Appendix C, below.

of minor importance for the coverage of manufacturing as a whole and for that of most individual industries as well. In any case, the provision by the Bureau of the Census of overlapping figures for the year 1919—one comparable with earlier years and the other comparable with later years—avoids any difficulties that might arise from the change. Only seven industries in 1919 embraced establishments whose value of products was below $5,000 and yet were so relatively numerous that they accounted for more than 5 percent of the value added by the industry as a whole. These were: carpets and rugs, rag; clothing, men's, buttonholes; engraving, other; engraving, wood; charcoal; china firing and decorating; and concrete products. Most of these industries are unimportant in terms of value added.

Apart from the *change* in the minimum from $500 to $5,000, the mere *existence* of the minimum would result in variation in the coverage of the Census, for two reasons:

1. A decline in the relative importance (measured in terms of physical output) of establishments whose value of products falls below the minimum will, of itself, cause an increase in the coverage of the Census. A rise in the relative importance of these establishments will effect a decrease in the Census coverage.
2. A change in the prices of manufactured goods will likewise bring about an increase in the Census coverage (if the change is a rise in prices) or a decrease (if it is a decline).

If there exists no extraordinarily dense concentration of establishments (in terms of the aggregate value of their products) in the size groups under the minimum value of output imposed in each Census, as compared with the corresponding frequency shown by the Census for the size group immediately above the minimum, the incomparabilities introduced by either of these two factors are not at all serious, so far as the total is concerned. That such a dense concentration is unlikely to occur may be observed in the upper half of Table A-1, and even more readily in the lower half of the table, in which the percentages are expressed as ratios to the corresponding class interval (i.e., as average frequencies per unit of class interval) in order to avoid the

obscuring effect of the differing class intervals. In all years but three the unit frequency in the smallest value-of-products or value-added size class shown was equal to or less than the unit frequency in the higher contiguous class. In other words, the

TABLE A-1

ALL MANUFACTURING INDUSTRIES COMBINED
Relative Importance of Small Establishments, 1904–37

Census Year	*As Measured by Value of Products* Establishments with Products Valued at			*As Measured by Value Added* Establishments with Products Valued at		
	$500–$5,000	$5,000–$20,000	$20,000–$100,000	$500–$5,000	$5,000–$20,000	$20,000–$100,000
	PERCENTAGE OF TOTAL[a]					
1904	1.2	5.1	14.4	1.8	6.7	17.3
1909	1.1	4.4	12.3	1.7	6.0	14.8
1914	1.0	3.7	10.5	1.5	5.1	..
1919	0.3	1.5	5.7	0.4	2.2	..
1921	0.3	1.8	7.6	..	..	..
1919	..	1.4	5.2	..	2.0	..
1921	..	1.8	5.7	..	..	..
1923	..	1.2	7.6	..	..	..
1925	..	1.0	5.6	..	..	..
1929	..	1.1	2.1[b]	..	1.5	2.8[b]
1937	..	0.9	2.0[b]	..	1.3	2.6[b]
	PERCENTAGE OF TOTAL, PER 1000 UNITS OF CLASS INTERVAL[c]					
1904	.27	.34	.18	.40	.45	.22
1909	.24	.29	.15	.38	.40	.18
1914	.22	.25	.13	.33	.34	..
1919	.07	.10	.07	.09	.15	..
1921	.07	.12	.10	..	..	..
1919	..	.09	.06	..	.13	..
1921	..	.12	.07	..	..	..
1923	..	.08	.10	..	..	..
1925	..	.07	.07	..	..	..
1929	..	.07	.07[b]	..	.10	.09[b]
1937	..	.06	.07[b]	..	.09	.09[b]

[a] Including $500 and over in 1904–21; including $5,000 and over in 1919–37. No data by size are available for 1899, 1927, and 1931–35.
[b] Class interval: $20,000 to $50,000.
[c] The percentage shown above, divided by the class interval expressed in thousands (e.g., 15 for the class $5,000–$20,000).

maximum frequency point had been passed, and a further decline was to be expected. Even if a rise were to occur it could not be great, since the lowest class includes the low frequencies near the zero point.

The existence of the minimum will have quite a different effect on the figures for those individual industries in which small establishments are relatively important. On the basis of the available Census data we may infer that the figures for only a few individual industries could be affected. Those few would be the seven listed above, in addition to the following: whips, electroplating, hair work, and models and patterns.

General Changes in Coverage: Biennial Canvasses

"Since the canvasses for the biennial years intervening between decennial years are made largely by mail, whereas in making the canvasses for the decennial years it is possible to employ a large field force, it is impossible to make as close an approach to absolute completeness for the biennial years as for the decennial years." [4] The biennial Census of 1935 is an exception, however; in this canvass a large field force of Federal works project employees was used.

The extent to which the biennial Censuses are incomplete has been indicated in only two Census volumes. A special note appears in the 1933 Report [5] concerning the 1933 Census:

> Because of the necessity of making the canvass with a field force considerably smaller than the field forces employed on former censuses of manufactures, the 1933 coverage of some of the industries was not quite complete; but the degree of incompleteness was not sufficient to have any material effect on the comparableness of the 1933 figures with those for earlier years, except in the case of the "Number of establishments" item. That is to say, the establishments that were active in 1933 but were not accounted for in the canvass were of little or no industrial importance.
>
> Of the 175,325 establishments that had reported for 1931, 8,595 failed to supply any information in regard to their status

[4] Letter from LeVerne Beales of the Bureau of the Census, dated February 29, 1932.

[5] Page 3.

(active, idle, out of business, etc.) or their activities in 1933, but these establishments had contributed only nine-tenths of 1 percent of the aggregate number of wage earners employed by all establishments reporting for 1931. For a very few industries the degree of incompleteness, thus measured, exceeded 3 percent, but in the great majority of cases it did not exceed 1.5 percent. Moreover, it is certain that some of the establishments that reported for 1931 but not for 1933 were idle or out of business in the later year, or made products valued at less than $5,000. . . .

Although, as explained above, the field force employed on the 1933 canvass was comparatively small, returns were nevertheless received from approximately 3,000 establishments that had not reported at previous censuses.

The Bureau of the Census estimates that only for seven industries did the reported 1933 totals of value of products or number of wage earners constitute less than 97 percent of the true totals. These seven industries are noted in Appendix C. The Bureau reported no case in which less than 94 percent of an industry was covered in the 1933 Census.

In the 1937 Census a statement similar to the following is to be found in some of the textile industry reports: "Because of the fact that some establishments such as those engaged in making women's, misses', and children's clothing lose their identity during a 2-year period through change of name, ownership, and location and, therefore, may be missed by a canvass made largely by mail, the 1937 statistics for the women's, misses', and children's apparel not elsewhere classified industry are not complete." [6] The Bureau of the Census believes that five of the needle trade industries were affected, mainly because of the inadequacy of trade directories and trade association lists.[7, 8]

[6] *Biennial Census of Manufactures, 1937,* Part I, p. 419, Table 1 (headnote).

[7] Letter from T. J. Fitzgerald, Chief Statistician for Manufactures, January 10, 1939. Notes concerning the inadequacy are appended to the data for these industries in Appendix C.

[8] Brief mention may be made of a third possibility of change in coverage. The Census for any year is taken, of course, in the following year. For example, the 1929 Census schedules were mailed in January 1930 (1929 Report, Vol. I, p. 1). Any establishment that went out of business at any time during 1929 (or even in the first few months of 1930) might not have filled in the schedule at all, despite the efforts of the Bureau of the Census. Be-

Changes in the Coverage of Individual Industries

Changes in the coverage of particular industries are frequently mentioned in the published volumes of the Census of Manufactures for 1899–1937. (Here the expression "change of coverage" refers not to a change resulting from the shift of establishments from one Census manufacturing industry to another consequent upon a change in the definition of the industry, but to a shift of establishments from manufacturing to nonmanufacturing or vice versa.) Such transfers are noted in Appendix C. Many of them result from the fact that the Census of Manufactures has been decreasing its coverage by eliminating operations that are doubtfully included in manufacturing—for example, operations closely related to mining, quarrying, servicing and repairing. We have accepted the definition of manufacturing implied in the 1937 Census,[9] excluding from the data for earlier years figures for industries abandoned in or before 1937.

Absolute Coverage

In discussing changes in the coverage of the Census of Manufactures we have touched only incidentally on the absolute coverage. The absolute coverage of a collection of statistical data can be assessed only by examination of the methods of collection, of the reliability of the personnel utilized, of the experience gained through repetition of the collecting process, etc.; by comparison with other, independently collected, bodies of data; and by tests of the data for internal consistency. It is obvious that a detailed consideration of the absolute coverage is impossible here.[10] We

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cause the number of defunct establishments varies from year to year according to business conditions, changes in the degree of coverage result. However, data collected by the Bureau of the Census for 1929 and 1933 and analyzed by Tracy Thompson and Daniel Creamer indicate that "deaths" during Census years are of minor importance (Tracy Thompson, *Location of Manufactures, 1899–1929* [U.S. Bureau of the Census, 1933], p. 59; and Daniel B. Creamer, "Is Industry Decentralizing?" *Study of Population Redistribution, Bulletin No. 3* [University of Pennsylvania Press, 1935], Chapter 3 and Table 30).

[9] Except that we regard as nonmanufacturing industries two industries covered in the 1937 Census: rectified spirits and poultry killing. These were not consistently covered in the Censuses for years prior to 1937.

[10] Comparisons with the 1930 Census of Occupations, in respect of employment, and with the Treasury compilation of 1937 *Statistics of Income,* in respect of compensation of corporate officers and of inventories, yield rea-

have therefore assumed that the coverage of the Census is practically complete. It must be remembered that the Census of Manufactures has been collected decennially for one hundred years, quinquennially since 1899, and biennially since 1919. In the course of the years there has been brought together a trained personnel that has accumulated experience in phrasing schedules, locating establishments, editing replies [11] and tabulating results. The Bureau of the Census is not only well aware of the likelihood of an undercount but has itself sometimes evaluated such undercounts.[12]

While it is a huge task to assess the coverage of all of the hundreds of manufacturing industries, an investigator interested in one or two particular industries should find it not only possible but desirable to check the Census data for those industries, especially by comparison with other sources and by tests for internal consistency.

INDUSTRIAL CLASSIFICATION OF THE CENSUS OF MANUFACTURES

Census Definition of Manufacturing

"The Census of Manufactures is confined in general to manufacturing establishments conducted under the so-called factory system as distinguished from the neighborhood, hand, and building industries. No precise definition of a factory, for census purposes, can be given, but the following instructions relative to the

sonably close agreement for total manufacturing, after allowance for differences in scope and classification. Comparisons by industries or industrial groups show less favorable results, perhaps because differences in classification become more pronounced when lesser categories are considered.

[11] Schedules in all the Censuses from which we have taken our data have been edited, with one exception: the 1909 Census. See H. Parker Willis, "The Thirteenth Census," *Journal of Political Economy* (July 1913).

[12] See, for example, the remarks on coverage appended to the 1937 statistics for some of the needle-trade industries. See also footnotes to the table on products of the tobacco industries in the 1935 Census, in which discrepancies between the Census and the Internal Revenue statistics on number of cigarettes produced are explained (1935 Census, p. 1,265, footnote 1). The Bureau of the Census has, of course, enjoyed the cooperation of various business associations. Thus its figures are subjected to the close scrutiny of those who not only have access to other sources of data, but also are willing to share their knowledge with the Bureau.

omission of certain classes of establishments will show the general line of division." [13] Manufacturing carried on in educational, eleemosynary and penal institutions are not included. Other exclusions are:

Custom work on wearing apparel
Establishments, except publishers, having goods made for them, but not furnishing the materials
Hand trades: automobile repairing,[14] multigraph work, jewelry engraving, photography, etc.
Cotton cleaners, rehandlers, compressors, and ginners
Electric light and power stations
Floral designers
Kindling-wood producers
Rectifiers and blenders of liquor [15]
Hide salters
Tobacco stemmers and rehandlers
Manufacturing on farms, except canning and preserving of fruits, vegetables, etc., and where materials are purchased from others
Beneficiating processes applied to minerals
Custom flour and feed mills, if entirely custom work

Certain inclusions are of interest: mining and quarrying operations carried on in conjunction with manufacturing are covered by the Census of Manufactures if they consist of the digging of clay by manufacturers of clay products; the quarrying of cement rock or limestone by manufacturers of cement or lime, respectively; and the quarrying of stone by establishments dressing and finishing stone for monumental, ornamental and construction work. Logging camps also are included in the Census of Manufactures.

In order to follow the latest Census classifications we have excluded several industries listed at various times by the Census; the most important of these are motion pictures, manufactured gas, and railroad repair shops. Certain industries included in the 1937 Census but omitted from some of the earlier Censuses also

[13] Instructions for Preparing Reports, Census of Manufactures: 1929.
[14] Included in the 1909 Census, in combination with automobiles.
[15] Included beginning with the 1935 Census.

have been excluded by us; among these are poultry killing and rectified spirits. A full list appears in the reconciliation of our totals for value added by manufacturing industries with the corresponding Census totals, the last tabulation in Appendix C.

Detail of the Census Classification of Industries

The Bureau of the Census has presented the data on manufactures by industries in varying degree of detail. In the 1929 Census it distinguished 326 separate industries, whereas in the 1919 Census it had listed over 550 (including subindustries). Although the number of industries changed somewhat between every pair of Census years, it dropped sharply in 1925 from the higher level of earlier years. Since 1935 there has been a revival of the subindustry designation and a corresponding increase in detail. In presenting the industrial statistics taken from the Censuses we have accepted the 1929 classification and have combined the subindustries presented in earlier and later Censuses in almost every case.[16] We have used the 1929 breakdown, with its less detailed classification, in order to present continuous data for as long a period as possible.

Overlapping of Industries

Because establishments (with few exceptions) are assigned by the Bureau of the Census as units to one or another industry according to the product or group of products of chief value, and because establishments sometimes turn out a variety of products, overlapping of industries often results. In Table A-2 we present a systematic statement of the overlapping. This tabulation answers two questions. First, to what extent does the given industry make only products described by the name of the industry? That is, what percentage of the total value of products of the industry is represented by its primary (normal) product? Second, of the total production of the commodities described by the name of the industry, what percentage is made within the industry itself?[17] That is, what percentage of a given group of

[16] All industries listed in the 1937 Census are indexed at the end of the present volume; and for subindustries references are given to the industries of which they are components.

[17] The overlapping takes into account only manufacturing industries. We

TABLE A-2

MANUFACTURING INDUSTRIES[a]

Degree of Specialization and Extent of Overlapping of Products, 1929 and 1931

Percentage Class	*Degree of Specialization* Value of Primary Products as Percentage of Total Value of Output of the Industry — Number of Industries or Industrial Groups Reporting		*Extent of Overlapping* Value of Primary Products as Percentage of Value of Total Output of These Products[b] — Number of Industries or Industrial Groups Reporting	
	1929	*1931*	*1929*	*1931*
100.0–95.1	116	113	102	107
95.0–90.1	61	62	46	40
90.0–85.1	35	24	29	25
85.0–80.1	14	21	18	19
80.0–75.1	7	8	12	9
75.0–70.1	5	3	3	7
70.0–65.1	..	..	1	..
65.0–60.1	2	3	2	2
60.0–55.1	..	..	2	1
55.0–50.1	2	1	3	2
50.0– 0.0	..	..	6[c]	6[c]
No data	43	50	61	67
TOTAL	285	285	285	285

[a] Among these 285 industries are included 23 which represent not single industries but groups of industries. For example, "butter," "cheese," and "milk, canned" are counted as one industry; "hosiery," "underwear," "outerwear," and "knit cloth" are counted as one industry; "bags, paper," "boxes, paper," "cardboard," "card-cutting and designing," "envelopes," "labels and tags," "wall paper," and "paper goods, n.e.c." are counted as one industry; "copper," "lead," and "zinc" are counted as one industry; and so forth. The total number of industries included in the 23 combinations is 64.

[b] In some cases where data were lacking we had to take total value of products of the industry as a percentage of value of total production.

[c] The industries in this open-end class, together with the percentages reported by them, are given in detail in Table A-3.

products is produced in the industry specializing in those goods? The two questions are interrelated. If a given industry devotes half its energies to its primary product, the other half will be

disregard such products as butter manufactured on farms. Certain products made and consumed in the same establishment also are disregarded, e.g., cut stock made in the shoe industry and consumed immediately by the plant producing it.

given over to commodities that are primary in another industry. Obviously, then, the sum of all "other" products reported in the Census should equal the sum of all "secondary" products.[18]

In 16 of the 242 industries or groups for which we have data on degree of specialization in 1929, the value of the primary product constituted less than 80 percent of the total output of the industry; in 1931 the number was 15 out of 235. More important was the extent of overlapping. In 1929 out of 224 industries, 29 produced less than 80 percent of the total value of the products in which they specialized; in 1931 the proportion was 27 out of 218. The industries referred to here are listed in detail in Table A-3. Some of the interrelations are obvious. Establishments classified in the cereals industry produce some feeds as well; establishments classified in the feeds industry make some cereal preparations also. Another type of interrelation, where a large industry is surrounded by satellite specialist industries, is illustrated by the meat-packing, oleomargarine, sausage, and shortenings industries.

The percentages are not absolutely consistent in level from year to year, as is revealed by a comparison of the figures for 1929 and 1931. The correlation is rather high, however, and there seems to be no systematic change from the former year to the latter.

It should be remembered that the statistics understate considerably the true amount of overlapping because many of the units relate to groups of industries (see Table A-2, footnote a). Indeed, the combination into particular groups is probably attributable to the large degree of overlapping among these industries.

Changes in Classification

There are two kinds of change in classification. First, establishments may be shifted from one industry-classification to another because of a change from one primary product to another. We consider such cases as analogous to the closing of old plants and

[18] Except where one or the other represents a nonmanufacturing activity, and barring discrepancies in Census coverage and absence of detailed statements of products of certain industries (in 1929 there were more than 50 such cases).

the opening of new ones and therefore disregard them. Second, the Census Bureau has changed the definitions of some industries. Sometimes it has provided an overlap for such cases, and if so, we have reproduced it. Pulp goods, for example, includes molded plastics from 1931 on. In 1931 the industry's value added that is comparable with earlier years is 8.1 million dollars, and in the same year the value added that is comparable with later

TABLE A-3

INDUSTRIES WITH MARKED OVERLAPPING OF PRODUCTS, 1929 AND 1931[a]

A. Indicated by Degree of Specialization

Industry	*Primary Products as a Percentage of Total Output of the Industry*		*Nature of "Other" Products*[b]
	1929	1931	
Cereals	75.0	79.8	Prepared feeds and miscellaneous food products
Oleomargarine	76.3	64.8	Shortenings
Mats and matting	77.9		
Collars, men's		73.6	
Elastic woven goods, other		78.0	
Lumber-mill products	61.0	62.1	Planing-mill products and boxes
Druggists' preparations	75.8	70.8	Patent and proprietary medicines, perfumes, cosmetics, etc.
Grease and tallow	52.9	53.2	
Ink, writing	63.6	53.5	
Liquors, vinous	75.2		
Tanning materials	78.2		
Coke-oven products	62.2	61.6	Illuminating gas
Abrasives		78.8	
Firearms		75.8	
Saws		73.9	
Springs, steel	76.8		
Nonferrous-metal products, not elsewhere classified	79.5		Wire, plumbers' goods, spun and stamped goods, etc.
Machine tools		79.4	
Carriages, wagons and sleighs		77.1	Carriage materials
Locomotives		71.3	Clay machinery, heating equipment, castings, etc.
Miscellaneous articles	79.7		
Paving materials	79.7		
Pencils, lead	70.8		
Pens		75.6	

TABLE A-3 (continued)

B. Indicated by Extent of Overlapping

Industry	*Primary Products as a Percentage of Total Output of These Products*		*Other Industries Contributing to Output of These Products*[b]
	1929	1931	
Cereals	77.9		Feeds
Feeds	74.1	75.2	Cereals
Oleomargarine	58.8	57.6	Meat packing principally
Sausage	29.9	35.1	Meat packing principally
Shortenings	70.8	75.3	Meat packing principally
Vinegar and cider	53.6	50.7	Fruits and vegetables, canned
Horse blankets		75.1	Woolen and worsted goods
Mats and matting	73.8	79.7	
Boxes, wooden	63.3	64.2	Principally lumber products and planing-mill products
Planing-mill products	51.1	56.2	Lumber products principally
Window and door screens	75.3	76.8	
Converted paper products	78.1	77.9	Paper principally
Candles	75.6	78.9	
Cleaning and polishing preparations	76.5		
Compressed gases	72.4	73.1	
Druggists' preparations	75.6	72.2	Patent and proprietary medicines, perfumes and cosmetics
Perfumes and cosmetics		77.7	Druggists' preparations, patent medicines
Grease and tallow	48.1	47.7	Meat packing principally
Ink, writing	62.5	53.4	
Mucilage	70.7	51.6	
Lubricants	16.7	15.9	Petroleum refining
Leather goods, not elsewhere classified	76.1		
Bolts and nuts		77.0	Steel-mill products
Nails and spikes	24.5	24.7	Wire; steel-mill products
Springs, steel	71.3	66.4	Steel-mill products
Wire	34.8	30.2	Steel-mill products; nonferrous-metal products, not elsewhere classified
Wrought pipe	27.4	37.5	Steel-mill products
Machine-tool accessories	73.6		Tools; foundry and machine-shop products; machine tools
Carriages, wagons and sleighs		79.4	
Combs and hairpins	77.8		
Foundry supplies		72.3	
Hand stamps		65.0	
Models and patterns	77.9		
Paving materials		78.8	
Pencils, lead		75.1	

[a] Not including groups, like that combining butter; cheese; and milk, canned. See footnote a to Table A-2.

[b] If specified in the Census reports.

years is 16.4 million dollars. When no overlap is provided, we have at least noted changes in definition whenever they are mentioned or discussed in the Census reports. Further, we have indicated, in footnotes to the basic table in Appendix C, which of the changes in classification appeared to cause a serious disturbance in the continuity of the series for the industries concerned. On this point, unfortunately, the Census usually contains little information.

Major Groups

The 1937 Census classifies manufacturing industries into 15 major groups (excluding railroad repair shops).[19] We have found it convenient to increase this number to 17 by setting up as separate groups both beverages and tobacco products, and to shift a few individual industries from one major group to another to preserve continuity of classification throughout the period 1899–1937.

DATA ON VALUE ADDED

Since value added is the difference between value of products and cost of materials and fuel, the character of value added as reported by the Census is best described by separate discussion of the minuend and the subtrahend.

Value of Products

Items included. Value of products represents not only the value of physical commodities produced in factories but also the value of certain services rendered. Among these services are contract work (important in printing and in the garment industries), custom work (flour mills and slaughtering), repair work (sheet-metal, shipyards, railroad equipment), and advertising (publishing).

Repair work is included only when carried on by plants engaged primarily in the manufacture of physical commodities. Custom work is reported only when accompanied by operations

[19] According to preliminary information there will be 20 major groups in the 1939 Census.

on the plant's own account; when flour mills do custom work even to the extent of more than half of their total business, they are treated as merchant mills and included, whereas custom mills that do not work on their own materials are excluded. In the earlier years of the period 1899–1937, the Census did cover both custom flour mills and shops engaged in auto repairing; since they were dropped many years ago we have excluded them from the figures for the entire period.

Value of products, as reported in the Census, does not include the value of construction, repairs and maintenance undertaken within the manufacturer's plant by his own force.[20]

Method of evaluation. Value of products represents the selling value, f.o.b. factory, of the products manufactured; or, for some industries, receipts for work done. If separate sales departments are maintained, or if transfers are made to other establishments under the same management, the values are the assigned transfer values at which the products are turned over to the other departments or establishments. In the latter case, the Census states, "the transfer value is usually based on market prices or on the cost of manufacture, but sometimes it is purely arbitrary." The differences between transfer values and selling prices do not appear to be great for the few products (pig iron, iron and steel wire, steel ingots, and sheet and tin-plate bars) for which we have computed them.

Period covered. The value of products reported in the Census represents the selling value of the products finished during the year, which may be a fiscal and not a calendar year ending on December 31 of the Census date.[21] Value added to work not

[20] However, maintenance employees and their wages are probably included in the Census data on employment and payrolls.

[21] Fiscal-year reports have been permitted for all industries, and have been requested, for specified fiscal years, for certain industries closely associated with farming, e.g., the beet sugar and cane sugar industries. No information concerning the number of fiscal-year reports is given in the Census of Manufactures, except for the latter industries. Data for corporations, published in *Statistics of Income* by the Statistical Unit of the Bureau of Internal Revenue, indicate that in 1929, 14 percent of all corporate reports on manufactures were on a fiscal year basis, and the "fiscal year" corporations reported 12 percent of the total net income of all manufacturing corporations and 18 percent of all manufacturing deficits. Statisticians at the Bureau of the Census believe that these figures do not apply to the Census reports. "It is definitely the opinion of those who are familiar with the manufacturers' re-

completed by the end of the year is not considered part of the output of the year except in the specific cases of ships and boats and aircraft; in these industries the value of products represents only the value of work done during the year. As a rule, then, the Census value includes some of the value added in the preceding year, and excludes some of the value added in the Census year. For this reason the figures may be somewhat too small during periods of expansion and too large during periods of contraction. It is unlikely, however, that this error will have significant effect upon the figures for more than a few industries.[22]

It is important to note that the increasing tendency of manufacturers to take over distributive functions from wholesalers or retailers has not affected the Census data on value added. The Census figures on value added relate to the value added in the factory proper, since value added is the difference between value of products, f.o.b. factory, and cost of materials delivered to the factory. Value added in manufacturers' sales agencies or warehouses is therefore not represented by the statistics in the present volume.

The value of all goods manufactured is included in the value of products, whether the goods are sold or added to stock. There is one exception to this rule. For the Census year 1929 the value of products for the majority of industries was the selling value, f.o.b. factory, of products shipped or delivered during the year. But for 76 industries, including some of the most important, it represented products manufactured, whether sold or not.[23] The

turns" that the number of fiscal-year reports would amount to "considerably less than 14 percent of all corporate reports." But because no tabulation to determine the exact percentage has been made, "it is impracticable to support this statement with any statistical evidence." (Excerpts from a letter by H. H. McClure, Acting Chief Statistician for Manufactures, November 19, 1938).

The schedules sent out in 1900 requested that the "information returned should cover the business year of the establishment most nearly conforming to and preceding the Census year which ends June 1, 1900." However, as is noted in the Census, "a very large proportion of the reports made in the Twelfth Census actually related to the business of the calendar year 1899."

[22] These are industries in which the manufacturing process is a long one, or in which the fluctuations in output are severe.

If the "natural business year" is used as the fiscal year, then inventories at the end of the year will be rather small, and the carry-over from one year to another will be less important than if the calendar year is used.

[23] These 76 industries were excepted "for special reasons, and in most cases at the request of the associations representing the industries in question, or

Bureau of the Census believes, however, "that the change in question had very little effect on the comparableness of the statistics for 1929 with those for 1931 and those for 1927 and preceding biennial-census years, since it is likely that the excess of sales over production in some establishments and the excess of production over sales in others counter-balanced each other in large measure." [24] In the absence of any empirical support it is difficult to appreciate the basis for this belief. For 52 of the 76 industries mentioned, the Census does present data showing the difference between production and sales, i.e., the net increase or net decrease in inventory of finished goods.[25] In 26 of these industries there was a net increase in inventory during 1929; in 26, a net decrease. Most of these changes constituted small fractions of value of products. However, in nine of the 52 industries the fraction exceeded 5 percent.[26] If we may judge from this meager sample, about one sixth of all industries were affected rather appreciably by the change in the definition of value of products between 1927 and 1929, and between 1929 and 1931.

Cost of Materials

Cost of materials represents the outlay not only for materials but also for containers for goods produced, fuel and purchased

of important manufacturers in the industries" (1929 Report, Vol. I, p. 3). It is not clear whether these industries were excepted because their own inventory changes were especially large.

[24] 1931 Report, p. 5.

[25] *Distribution of Sales of Manufacturing Plants, 15th Census,* Table 3. In the case of the ships and boats industry, the inventory covers unfinished goods also.

[26] These industries are:

	Change in Inventory of Finished Goods, as a Percentage of Total Value of Products
Agricultural implements	+5.5
Aircraft	+7.2
Planing-mill products, not elsewhere made	−6.8
Sand-lime brick	−5.9
Sausage	−8.6
Ships and boats	+9.5
Sugar, beet	+9.1
Sugar, cane	+5.2
Vinegar and cider	−5.4

Since the figures reported for these industries represent output rather than sales, it is unnecessary to correct them for these changes in inventories.

electric energy consumed during the year (including transfers of such items from other plants under the same ownership), and freight and haulage costs (excluding the cost of haulage performed by the plant's own employees and equipment if the latter costs can be segregated).

Treatment of mill and shop supplies. In all years except 1929, 1931 and 1933, cost of materials included mill and shop supplies (such as lubricating oil and minor replacements). The Bureau of the Census holds that the change between 1927 and 1929 was "slight and unimportant. In the reports for the few industries in which the cost of supplies formerly constituted a considerable part of the cost-of-materials item, special attention is called to this fact." [27] The "few industries" number 11, and all of them produce metals and metal products. To these we may add four other industries mentioned in another Census report.[28] The 15 industries are: cast-iron pipe, cutlery, n.e.c., files, firearms, steel-mill products, saws, stoves and ranges, business machines, gas machines and meters, textile machinery, typewriters, automobiles, automobile bodies and parts, foundry and machine-shop products, n.e.c., and hardware, n.e.c.

No evidence is provided in the Census reports on the exact extent to which the figures for these industries were affected by the exclusion of mill and shop supplies between 1927 and 1929 or by the re-inclusion of these supplies in 1935. The sole clue to the quantitative significance of these items is found in the 1904 Census which reports "mill supplies" separately. In 1904 cost of mill supplies, as a percentage of value added (with these supplies excluded), did not exceed 3 percent for any industry, exceeded 2 percent for only one (steel-mill products) and exceeded 1 percent for only five industries. If we may judge by that early Census, none of the figures on value added by the industries listed above would have been seriously affected by the changes between 1927 and 1929, and between 1933 and 1935.

Treatment of contract work and internal revenue taxes. To obtain the value added by manufacturing in the years 1899–1933,

[27] 1929 Report, Vol. I, p. 3.

[28] Tracy Thompson, *Materials Used in Manufacture, 1929* (U.S. Bureau of the Census, 1933), p. 14, footnote 11.

the Bureau of the Census deducted from value of products the cost of materials, excluding payments for contract work. For 1935 the Bureau of the Census computed the value added in some industries by deducting from the value of their products the payments for contract work as well as those for costs of materials. Beginning with 1937 the Bureau of the Census followed this procedure in determining the value added by all industries. We have used this method for all years, wherever possible, for the industries (chiefly textiles and printing and publishing) in which contract work is important, and have made special note of the industries so affected (Appendix C). Moreover, when necessary we adjusted the 1935 and 1937 Census data on the value added by all other industries to render them comparable with the data for earlier years. Such adjustment involved the addition of payments for contract work, if these had been deducted by the Census.

Internal-revenue taxes are similar neither to cost of materials nor to cost of contract work. From the economic standpoint, it might be argued that they should be treated as part of the net output of an industry, rather than as payment for commodities or services purchased from another industry. Subscribing to this view, we have made an effort to include these taxes in the value added data for every year. In order to do so we have had to revise the Census data for 1931–37, since internal-revenue taxes have been included by the Census in value of products in all years and, beginning with 1931, also in cost of materials. We have indicated the industries for which such revision was necessary—chiefly those engaged in tobacco manufacture and liquor production (Appendix C). For one or two of the more recent Census years, however, when it was impossible to obtain the necessary information, we have provided overlaps.

Period covered. For all years except 1929, cost of materials relates to the amount consumed during the year, and not to the amount purchased or paid for.[29] In 1929 manufacturers were given the option of reporting either the amount consumed or the amount purchased, but where amounts reported purchased appeared to be out of line with reports for earlier years in the opin-

[29] Concerning fiscal-year reports, see above, footnote 21.

ion of the Bureau of the Census, data on materials consumed were requested by correspondence. "It is therefore unlikely that the comparableness of the statistics has been affected appreciably by the use of data for materials purchased." [30] The 1931 Census resumed the practice of requiring information on the amount consumed.

Method of evaluation. Both cost of materials consumed and cost of materials purchased are evaluated in terms of the prices paid. If they were to be expressed in terms of the prices prevailing at the time of use rather than at the time of purchase, the data on value added would be different from the Census figures. In a period of rising prices value added would be smaller, and in a period of falling prices, larger; consequently, the cyclical amplitude of fluctuation would be reduced. In Table A-4 are presented estimates of value added by all manufacturing industries combined, computed on the basis of current rather than original cost of materials, and comparisons with the value added as reported in the Census of Manufactures. The adjustments are large for 1921, 1931 and 1933, when there were substantial changes in prices.

Value Added

Because it is computed as the difference between two items, value added is subject to all the qualifications attaching to the minuend and subtrahend, except to the extent that these cancel one another. Some of the qualifications do cancel out in a certain sense. For example, if assigned transfer values are too high or too low, they influence cost of materials in the same manner as value of products affects such costs (unless the transfers are to nonmanufacturing industries), and thus leave the aggregate value added by all manufacturing industries untouched; on the other hand, the value added by particular industries is necessarily affected by assigned transfer values.

Data on value added are free from the defects in aggregates of value of products and cost of materials that tend to arise from the integration of industrial plants. For example, the Bureau of the

[30] 1929 Report, Vol. I, p. 3.

TABLE A-4

VALUE ADDED BY MANUFACTURING, 1919–33

Census Totals, Before and After Adjustment for Inventory Revaluation[a]

Year	*Unadjusted Total ($1,000,000)* (1)	*Inventory Revaluation ($1,000,000)* (2)	*Adjusted Total ($1,000,000)* (3)	*Unadjusted Total as a Percentage of Adjusted Total* (1÷3)
1919	23,313	+902	22,411	104
1921	16,879	−2,813	19,692	86
1923	24,031	+129	23,902	101
1925	25,162	+51	25,111	100
1927	25,769	−383	26,152	99
1929	30,062	−362	30,424	99
1931	18,597	−1,517	20,114	92
1933	14,119	+1,111	13,008	109

[a] The inventory revaluation data, available for 1919–33 alone, are derived from estimates by Simon Kuznets, some of which were published in his *Commodity Flow and Capital Formation* (National Bureau of Economic Research, 1938), Vol. I, Part VII.

Census draws attention to the duplication in the latter two items which is attributable to the fact that smelters, classified in the smelting and refining industry, sell crude metals to independent refiners, also classified in this industry. More serious than the degree of duplication is the possibility of a change in its relative importance. An increase in the proportion of smelting and refining plants that are integrated will affect not only the aggregate amounts of the industry's value of products and cost of materials but also their movements in time.

Value added is not free from all duplication, however. It includes many items which should be deducted if a truly net value added is to be obtained. These are mainly overhead items, such as depreciation, taxes, rent, interest on short-term debt, maintenance and repairs, and other purchased supplies and services (advertising, light, office supplies, professional services).[31] The ratio of

[31] For manufacturing as a whole the magnitudes of these items in 1929 may be estimated roughly as follows:

the net value added to the Census value added is .63 for 1929.[32] For the six major divisions of manufacturing for which we have figures, the 1929 ratios vary from .49 to .69, five being between .60 and .70 (Table A-5).

Not all the overhead items included in value added are inflexible in the short run, but a comparison of the Census value added and estimates of net value added [33] by major manufacturing divisions in the Census years 1919–37, and by all manufacturing combined in 1909–37, shows that the total of these overhead items is relatively inflexible (Table A-5). As a consequence net value added falls more rapidly during business recessions than does the Census value added, and rises more sharply during advances in business. Further, the amplitude of cyclical changes in the ratio of net value added to the Census value added varies from major group to major group: the greater the cyclical amplitude of changes in value added, the greater seems to be the cyclical amplitude of the ratio. Reference to the table shows that value added is a poor approximation to net value added so far as short-term changes are concerned.

The two values are somewhat closer in respect of movements

	Billion dollars	
Value of products		67.9
Cost of materials and fuel		37.8
Value added		30.1
Other deductions		
Depreciation	1.9	
Depletion	.3	
Provision for fire losses	.1	
Maintenance and repairs	3.0	
Interest on short-term debt	.5	
Taxes	1.3	
Bad debts	.3	
Rent (net)	.3	
Advertising	.5	
Other deductions, and errors of estimate	3.0	11.2
NET VALUE ADDED		18.9

These estimates are derived from data in *Statistics of Income*, an annual publication of the Bureau of Internal Revenue; from Solomon Fabricant, *Capital Consumption and Adjustment* (National Bureau of Economic Research, 1938); and from the Census of Manufactures.

[32] If taxes, interest and rent are considered as income originating in manufacturing, the ratio becomes .70.

[33] The net value added in an industry, as defined here, is of course identical with the portion of the national income produced in the industry.

TABLE A-5

COMBINATIONS OF MAJOR GROUPS

Net Value Added as a Percentage of Census Value Added,[a] 1919–37

Combined Group	*1919*	*1921*	*1923*	*1925*	*1927*	*1929*	*1931*	*1933*	*1935*	*1937*
Foods, beverages and tobacco products	58	47	58	52	51	49	41	41 43	46 49	52
Textile and leather products	75	61	69	66	66	61	50	65	66	64
Forest, stone, clay and glass products	77	67	79	76	72	69	52	48	61	64
Paper products and printing and publishing	68	62	66	65	64	62	56	55	59	62
Metal products	72	54	68	67	64	65	46	48	62	68
Chemical and petroleum products	61	45	56	61	54	64	32	39	55	58
TOTAL[b]	72	57	69	66	64	63	48	51	60 61	65

[a] The Census data on value added are to be found in Appendix C. The figures on net value added are those computed by Simon Kuznets for the National Bureau (1919–35), by R. R. Nathan for the Department of Commerce (1935–37), and by W. I. King for the National Bureau (1909–19). The figures for 1919–37 relate to "national income," while those for 1909–19 refer to "payments to individuals."

[b] Includes a miscellaneous group. For earlier years the corresponding percentages for total manufacturing are: 68 for 1909; 75 for 1914; and 68 for 1919. These are not available by groups.

from peak to peak. For all manufacturing the ratio of net value added to the Census value added changed but slightly from 1909 to 1919 and from 1919 to 1923, about 10 percent from 1923 to 1929, and 2 percent from 1929 to 1937. The shift ranged from zero to 15 percent for the major groups from 1919 to 1923, 1923 to 1929, and 1929 to 1937. Over longer periods, the discrepancies in trend between net value added and the Census value added often cumulate. From 1919 to 1937 the relation of these two series changed about 11 percent for all manufacturing, 20 percent for foods, 15 percent for textiles and leather, 17 percent for forest, stone, clay and glass products, 9 percent for paper and printing, 6 percent for metal products, and 5 percent for chemical and petroleum products. In all groups value added rose in relation to net value added, a fact which indicates the growing im-

portance of the overhead items. It should be noted that these conclusions based on major groups cannot be applied without reservation to the interpretation of the data on value added by individual industries.

DATA ON PHYSICAL OUTPUT

The figures on physical volume are subject to almost all the qualifications outlined above, and in addition, to certain other reservations.

"Primary" and "Secondary" Products

The first difficulty encountered in any attempt to use the Census data on physical output arises from the fact that the Census tables seldom give the quantities of individual products made in an industry.[34] Instead, the Census usually publishes the amounts of each individual product wherever made. That is, it lumps together primary and secondary output, as these are defined above (pp. 336–37). Thus the amount of butter produced in factories in 1929 was reported in the Census as 1.6 billion pounds. But this quantity includes not only butter made in the "butter" industry proper, but that made as a secondary product in the "cheese" and other industries. Because this sort of combination is frequently encountered we have had to treat all of the product reported (e.g., the 1.6 billion pounds of butter) as if it were made in the industry of which it is a primary product (in this instance the "butter" industry). Usually secondary output accounts in fact for only a small proportion of the total made (see Table A-2 above), though for a few industries secondary output is rather important. In the case of the latter industries the method of treatment just described may sometimes lead to the result that the sum of the values of the specified individual products (including secondary production outside the industry) exceeds the total value of products of the industry proper.[35] Such a result

[34] The tables supply this information for only a few products, among which are wire and oleomargarine. It is possible that in the earlier years the data in the Census tables were restricted to primary products; but whether this is true cannot be ascertained.

[35] Another possible result is overstatement of the "coverage ratio" (see below).

is not necessarily a grave matter, since changes in the ratio of these two values, whatever the cause, are taken into account by means of the "coverage ratio adjustment" discussed below.

Also of concern is the fact that it is often impossible to tell exactly to what the Census data refer. Occasionally they relate to different products in different years. For example, in the canned fish industry the product data prior to 1925 include clam chowder manufactured by canners of vegetables and fruits, whereas the figures for the later years do not. Difficulties of this sort also are most commonly resolved by the coverage ratio adjustment.

Degree of Coverage

Another defect of the Census data on physical quantities arises from incomplete coverage of products. For many industries no data on physical quantities are reported at all, and consequently no index of physical output can be computed for them. When we come to compute indexes for major groups and for "total" manufacturing, we have prominent gaps in our list. Our efforts to overcome this handicap are described in a later section. In the case of many other industries, data on physical output are reported, but these do not cover all the products of the industry. It then becomes necessary to try to answer two important questions: First, for what industries is adequate coverage of output provided? Second, what is the effect of a change in the percentage of coverage?

The answer to the first question depends primarily on the relation between the products for which we have quantity data and those for which we do not have quantity data. In other words, it depends on the character and size of the sample. There is little that we can say concerning the character of the sample because an adequate opinion requires an intimate knowledge of the particular industry under discussion. The size of a sample, however, can readily be measured. We have had to form our judgments, therefore, on the basis of the second criterion alone; for this reason our calculations for particular industries are subject to revision by experts familiar with them. In this study we have regarded a coverage of 40 percent as sufficient to warrant the

computation of an index of physical output for an industry.[36] A coverage of 40 percent is not very high, especially since the percentages at hand usually overstate the true coverage because "secondary" products are counted in as if they were primary products.[37] However, the indexes of but a few industries cover as little as 40 percent of the products.

The coverage ratios are given in detail in the tables in Appendix B. If the reader chooses he may raise the standards and refuse to accept as reliable the indexes based on less than 60, 70 or even 80 percent coverage. It is apparent from the summary of the coverage ratios that appears in Table A-6 that for most of the indexes the coverage is high. Thus, out of 129 indexes available for 1937, 82 are based on a coverage of 80 percent or more. Only 11 are based on less than 60 percent coverage.

Another problem arises from changes in the degree of coverage. If an industry consistently reported the physical quantities of 60 percent of its products, we could confidently assume that the index of physical volume of output that could be computed would

[36] For a few industries (for example, chemicals, not elsewhere classified), we computed indexes of physical output even when the coverage fell slightly below 40 percent for a few years, provided that we could build up fairly long series of index numbers for the industries concerned.

[37] The computed coverage ratio equals the total value of products of the industry (most often excluding "other products" of the industry but usually including "secondary products" of other industries) that are covered by quantity statistics, divided by the total value of products of the industry. The "true" coverage ratio excludes from its numerator the secondary products. In symbols, let V = the total value of products of a given industry, as reported in the Census; O = value of "other products not normally belonging to the industry"; S = value of secondary products of other industries; and let the subscript q indicate coverage by quantity statistics. Then the computed coverage ratio is commonly equal to

$$\frac{(V-O)_q + S_q}{V}$$

and the true coverage ratio is equal to

$$\frac{(V-O)_q}{V}.$$

Thus, the computed coverage ratio is equal to or greater than the true ratio, most frequently the latter. It follows that a 40 percent coverage ratio is normally somewhat less conservative than it would appear to be. It may also happen occasionally that the coverage ratio will exceed 100 percent.

More important than the relation between the computed and true coverage ratios is the relation between the changes in the prices of the "secondary products" and the corresponding changes in the prices of the "other products." But this also is a question concerning the *character* of the sample, about which we can say nothing here.

TABLE A-6

COVERAGE OF INDEXES OF PHYSICAL OUTPUT

Frequency Distribution of Manufacturing Industries by Percentage of Coverage, Selected Years[a]

Percentage of Coverage	*Number of Industries*				
	1899	1909	1919	1929	1937
Below 40.0	1	..	..	1	2
40.0–49.9	2	3	2	5	4
50.0–59.9	1	3	3	4	5
60.0–69.9	2	1	6	10	10
70.0–79.9	7	8	8	24	26
80.0–89.9	6	8	12	28	28
90.0–99.9	17	24	25	46	39
100.0 and above[b]	2	6	8	15	15
TOTAL NUMBER OF INDUSTRIES	38	53	64	133	129

[a] Not including industries for which the exact percentage of coverage is not known. For most of these the coverage is undoubtedly close to 100 percent.

Two or more coverage ratios are available for most industries for most of the years listed. For example, for 1919 there is a 1919 coverage ratio for the 1919 index relative to 1909, and one for the 1919 index relative to 1929. The ratios in this table apply to the indexes relative to the latest year (e.g., 1919 relative to 1929).

[b] See footnote 37, above.

represent adequately the total output of the industry. But often the products not covered in the index of production increase or decrease in importance. We are then less justified in considering our index of output as representative. Obviously an adjustment is called for. This adjustment, as made in the present study, is described at a later point in this section. When no adjustment could be made, the unadjusted index was used. When adjustment was possible only for part of the index, the adjusted index was interpolated or extrapolated by the unadjusted index.

Homogeneity of Product Classes

The detail in which products have been covered in the Census of Manufactures has varied from time to time. On the whole, there has been a secular trend toward an increase in detail: the classes of products shown in the Census have become more homogeneous. For this reason our indexes for the more recent years are superior to those for the earlier years of the period 1899–1937. For ex-

ample, the 1899–1927 index for cheese is based on one output series ("all varieties"), and is therefore somewhat inferior to the 1929–37 index which is based on 4 or 5 series.

The difference between an index derived from detailed data and one derived from less detailed data may be very great. It will depend upon the relative magnitudes of the prices and quantities of the several products and the relative magnitude of the changes in the prices and quantities. If, for example, the output of the more expensive products of an industry is increasing in relation to the output of the less expensive products, an index based on the more detailed data will rise more rapidly than an index based on the less detailed data. The degree of disparity between the two indexes will be determined by the relation between the values of the two groups of products. Some of the differences that may be found when indexes based on detailed data are compared with indexes based on broad groups of data are illustrated by figures on carpet and rug production computed by Dr. Mills.[38] Additional empirical tests made in the present study yield the results shown in Table A-7. Here it is apparent that the differences are rather pronounced for some of the industries. On the basis of this limited evidence, and of a consideration of the assumptions implicit in the acceptance of indexes based on inadequate detail, we decided to use fairly detailed data in computing our indexes whenever it was possible to do so.[39]

For some industries for all years, and for some industries for certain years, no indexes were computed at all because it was felt that the available Census data were insufficiently detailed. Thus it is impossible to compute satisfactory indexes of physical output for most of the machinery industries because of the extremely heterogeneous classifications of their products. In the 1929 report for the electrical machinery industry, for example, alternating-current generators "under 2,000 kv-a" are combined with alternating-current generators "2,000 kv-a and over." According to detailed data available in the 1935 Census, these two

[38] F. C. Mills, *Economic Tendencies* (National Bureau of Economic Research, 1932), p. 32, footnote.

[39] The most detailed data were not used if, after inspection of the Census reports, homogeneous combinations could be constructed or had been published by the Census. Severity of judgment as to what constituted homogeneity varied, perhaps, as the work proceeded. The combinations we have used appear in the basic tables in Appendix B.

TABLE A-7

Ratios Of Indexes Constructed From More Detailed Data To Indexes Constructed From Less Detailed Data, 1919–37

Year	*Baking Powder*	*Cheese*	*Linoleum*	*Boxes, Wooden, Cigar*	*Blast-Furnace Products*	*Pianos*	*Tin and Other Foils*	*Hosiery, Knit*	*Carpets and Rugs, Wool*
1919	..	..	..	..	1.01	..	..	..	0.78
1921	..	..	..	..	..	..	..	..	0.80
1923	..	..	1.12	..	..	..	..	0.67	0.88
1925	..	..	1.09	..	1.01	..	..	0.77	0.97
1927	1.02	..	1.08	1.01	1.00	0.98	1.13	0.87	0.97
1929	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1931	1.00	1.01	0.94	1.01	0.99	1.08	..	1.03	1.07
1933	1.06	1.00	..	..	0.99	..	..	1.08	1.02
1935	1.05	1.00	0.94	1.01	0.99	0.97	..	1.08	1.01
1937	1.04	1.00	0.92	1.00	1.00	..	..	1.09	0.99

types were valued at $660 each and $151,025 each, respectively, in the later year. Another example of heterogeneity is found in the organs industry. In 1937 only one series was given for this industry—a combination of pipe, reed, and electronic organs—to avoid disclosure of output by individual establishments. According to the more detailed data available for 1931, such a combination involved a lumping together of pipe organs valued in that year at $5,761 each, and reed organs valued at $131 each.

Continuity of Series

Difficulties related to changes in degree of detail are encountered also when one tries to secure chronological comparability in the series for individual products. From time to time the Census changes its definition of a series so that the data for the given year are not strictly comparable with those for the base year. When this sort of change in a series appeared to be slight, we used the series in constructing our index; when large, we did not use the series. Sometimes, when revisions of data for earlier years were made by the Census, we found that the series could be broken into segments, each of which was usable.

Another type of difficulty arises from changes in titles. Occasionally the Census alters the title of a series but fails to give

definite information as to whether a real change in the composition of the series has taken place. We had to assume in such cases that the change was confined to the title alone.

In the data for the washing and ironing machines industry we find an example of the sort of incomparability described above. Figures on electric washing machines for household use (standard size) include apartment-size washing machines for 1927 and 1929 but not for other years. Changes in title are encountered in the data on the steel-mill products industry: the series listed in 1904 as "splice bars, including all patent splices and rail joints" was called in 1919 "rail joints, fastenings, etc." and in 1929 "rail joints and fastenings, tie plates, etc."

Incomparabilities in old series may be suspected when "new" series appear. A separate series was listed for automobile chassis in 1919 for the first time, but there was no statement concerning the classification of chassis in earlier years. It is likely, however, that they were combined with some of the other products presented in earlier Census reports. In the pulp industry a new series, "screenings," is listed in 1914. Here, however, there is a statement that prior to 1914 "screenings" were included in "sulphite-fiber, soda-fiber, and mechanical pulp." We sought to resolve the attendant difficulties in accordance with the following policy: where there was no statement regarding the classification in earlier years of products included in a new series, the series from which the products might have been taken were considered comparable as between the years in question. Where a definite statement was made, the resulting incomparabilities were, of course, taken into account. Fortunately, the incomparability from this source is not likely to be serious, because a product is usually segregated by the Census before it has acquired any great importance. In 1914, the value of screenings, for example, was less than one-half of one percent of the total value of the products among which it had previously been included.

Non-Census Data

While we have made no effort to compute index numbers for non-Census years, we have tried to secure index numbers for all

the Census years for each industry. To this end we have sometimes had to seek data from sources outside the Census.

When Census data were not available for a particular industry for all the Census years, related series taken from other sources were spliced to the index based on Census data. Two criteria were applied in an attempt to determine whether a series was related closely enough for this purpose: (1) theoretical grounds for expecting conformity of movement; (2) statistical conformity over the period for which both sets of data were available. When a series which met these requirements was found, the incomplete index based on Census data was extrapolated backward or forward on the basis of the related series. For instance, the Willett and Gray series for sugar meltings which appears in the *Statistical Sugar Trade Journal* moves very similarly to our cane-sugar refining index for the period 1914–37. An index based on the Willett and Gray series was therefore constructed for the period 1899–1914 and spliced to our index for 1914. While it was often possible to obtain statistical series which might be expected to conform closely to our corresponding indexes, series which did in fact conform were seldom found.

Non-Census data were used mainly for the construction of indexes for industries for which no Census data at all were available. Bureau of Internal Revenue figures published in *The Annual Report of the Commissioner of Internal Revenue* were employed for the tobacco industries and for most of the beverage industries. In a few of these, as in the case of cigarettes, Census data also could be obtained for one or two years. In such instances index numbers based on data from both sources were constructed and compared. Data collected by the Bureau of Mines and published in the *Minerals Yearbook* were employed likewise. Sometimes the Census itself reproduced these data, as in the case of cement, but usually they were to be found only in the *Yearbook,* as was true for copper, lead and zinc. Whenever no source is mentioned in Appendix B, it may be assumed that the figures were collected in the Census of Manufactures; otherwise the source is specifically indicated in footnotes to the tables in that Appendix.

METHOD OF CONSTRUCTION OF THE INDEXES OF PHYSICAL OUTPUT

Formula and Bases

The aggregate physical volume of output in a given year may be defined as the output of that year evaluated at weight-base prices. Thus we multiply the number of tons of steel ingots produced for sale or shipment by steel mills in a given year (designated by q_1) by the price of steel ingots per ton in the weight-base period (p_w); do the same for steel sheets and for other products of steel mills; then add these computed values to obtain the physical output of steel mills. In algebraic language, this is $\Sigma q_1 p_w$. We secure these values for each year and, to compute the index of output, express them as relatives on a comparison-base period: $\Sigma q_1 p_w / \Sigma q_o p_w$. When the comparison base and weight base are identical, we have $\Sigma q_1 p_o / \Sigma q_o p_o$. When the weight base is the "given" year, we have $\Sigma q_1 p_1 / \Sigma q_o p_1$. A combination of both years as the weight base yields the Edgeworth formula, which we have used:

$$\frac{\Sigma q_1 (p_o + p_1)}{\Sigma q_o (p_o + p_1)}.$$

In short, to determine the change in physical output between any two years we use price coefficients taken from both years. The formula we employ gives results that fall between those yielded by the other two formulas cited.

According to the theory underlying the Edgeworth formula, a separate index number must be computed for each pair of years compared. Thus, if we wish to determine the changes in output between any two of the 14 Census years, 1899–1937, we require 91 separate index numbers. It is common experience, however, that only a minor degree of inaccuracy is likely to be introduced if the number of separate index numbers is reduced, and several comparisons are made indirectly. If only 13 index numbers were computed, say those comparing output in 1899 with output in each of the years 1904–37, comparisons of indexes for any other

two years, e.g., 1904 and 1937, would be made by division of the 1937 index number (relative to 1899) by the 1904 index number (relative to 1899). Such a procedure would yield, in algebraic symbols,

$$\frac{\Sigma q_{37}(p_{99}+p_{37})}{\Sigma q_{99}(p_{99}+p_{37})} \div \frac{\Sigma q_{04}(p_{99}+p_{04})}{\Sigma q_{99}(p_{99}+p_{04})},$$

as an approximation to the desired index number,

$$\frac{\Sigma q_{37}(p_{04}+p_{37})}{\Sigma q_{04}(p_{04}+p_{37})}.$$

In this study we computed the following index numbers: 1899 and 1904 on a 1909 base; 1909 and 1914 on a 1919 base; and 1919 through 1937 on a 1929 base.[40] This selection proved helpful on two counts. First, it provided us with direct comparisons of 1899 with 1909, of 1909 with 1919, of 1919 with 1929, and of 1929 with 1937; we have used these comparisons in Parts One and Two of the text. Second, since the Census data usually increased progressively in detail, the use of 1909, 1919 and 1929 as successive bases enabled us to take advantage of the available detail. For the major groups of industries and for total manufacturing we com-

[40] Exceptions, made necessary by the character of the data in certain industries, are noted in Appendix B. The most common exception is the use of 1931 as a base for the 1933 index. For many industries the quantity data for 1933 are incomplete. Because of a smaller appropriation in that year the Bureau of the Census found it necessary to use an abridged schedule in canvassing the smaller establishments in many industries. The Bureau writes: "With a very few exceptions, the establishments in any industry for which this [the abridged] schedule was used did not contribute more than 10 percent of the total value of products for the industry, and in most cases the percentage was considerably smaller. So far as practicable, the data returned on the abridged schedule were distributed among the proper items in the tables giving detailed production statistics. . . . Where this could not be done, two sets of detailed production figures are given for 1931, one comparable with 1929 and the other adjusted for comparison with the 1933 figures derived from the standard schedules; or—especially in the cases of the less important industries—the total value of products reported on the abridged schedule for 1933 is carried as a single item at the end of the table and only one set of figures is given for 1931." (Census of Manufactures, 1933, p. 4.)

Where two sets of detailed production statistics were given for 1931, we treated that year as an additional base year. The 1933 index number we constructed on 1931, using the two sets of comparable figures; the 1931 index number we constructed on 1929, using the 1931 figures comparable with those of 1929; we then spliced the two segments together.

puted, in addition, index numbers comparing output in 1899 directly with output in 1937 (see below).

Computation of the Indexes for Individual Industries

The computation of the indexes for individual industries may be illustrated by reference to the 1929–31 index for cane-sugar refining.

The first step was the transcription in full detail of the quantities and values of individual products made in this industry in the most recent year, 1937 (taken from the Census of Manufactures, 1937), and the computation of average prices:

		1937
Refined sugar, hard		
Quantity	th. tons	4,251.3
Value	th. $	395,142
Price	$ per ton	92.946
Refined sugar, soft or brown		
Quantity	th. tons	264.30
Value	th. $	22,603
Price	$ per ton	85.520
Refiners' sirup, edible		
Quantity	th. gal.	2,735.5
Value	th. $	546.83
Price	¢ per gal.	19.990
Refiners' blackstrap and nonedible sirup		
Quantity	th. gal.	23,380
Value	th. $	1,399.0
Price	¢ per gal.	5.9837

On the basis of a study of this table, we could determine the amount of detail to be used in our computations. Because the prices of both types of refined sugar were close to each other, and because the two products appeared to be similar in character, we decided to combine their output into a single series for our index; and because the prices of the next two items were rather dissimilar, we decided not to combine them.[41]

A subsequent step was the assembly of products data in the degree of detail thus decided upon, for all available Census years.

[41] If one were making a detailed study of the output of the sugar industry he might, of course, find it more rewarding to distinguish between the two types of sugar—because of their importance—than between the two types of by-products—which are relatively unimportant. In the present study, however, it was necessary to combine similar products whenever possible (similarity being judged by character of product and by average price) in order to lessen the labor of calculation.

These are given in the basic table for cane-sugar refining in Appendix B, p. 387. We took the data from the latest Census volumes, working backwards: the 1937 volume for 1937–31 data; the 1931 report for 1931–27 data; and so on. The quantity and value data were given in the Census; we derived the per-unit values (indicated by p)[42] by dividing the values by the corresponding quantities.

Next, we combined the basic data into the unadjusted index, in accordance with the following form (showing 1929 and 1931 only):

		1931/1929	
		$q_{31}(p_{29}+p_{31})$	$q_{29}(p_{29}+p_{31})$
1	Refined sugar	827,270	955,306
2	Refiners' sirup, edible	1,444	1,835
3	Refiners' blackstrap and nonedible sirup	3,066	4,723
4	$\Sigma(1+2+3)$	831,780	961,864
5	Index, unadjusted	86.476	100.000
6	Coverage ratio	.99673	.99799
7	Coverage adjustment factor	.99874	1.00000
8	Index, adjusted (5÷7)	86.585	100.00

We computed the ratios of coverage by adding up the values of the three products shown and dividing their sum by the industry's total value of products. These ratios we then transformed into coverage adjustment factors by dividing by the base year ratio ($.99673 \div .99799 = .99874$). Next we divided the unadjusted index for 1931 (86.476) by the coverage adjustment factor, to derive the adjusted index (86.585). Finally we linked together the unadjusted and adjusted indexes on the various bases (1909, 1919 and 1929) and arrived at the indexes given in Appendix B.

The procedure illustrated above was followed whenever possible, but not invariably. Sometimes quantity data were reported for only part of the total output of a particular product, whereas value was reported both for this part and for the total. In such a case an additional step was introduced: we estimated the total quantity of the product by deriving a price obtained from the in-

[42] Although we use the symbol p and the term "price" for the per-unit value, it does not represent a price in a strict sense. It is the average realized price for the entire country's output, f.o.b. many different factories, of a class of goods which is sometimes rather heterogeneous.

complete figures and dividing this price into the total value. This, as well as other deviations from the procedure outlined, are noted in footnotes to the tables in Appendix B.

Adjustment for Changes in Coverage

The coverage adjustment requires further examination, particularly since there are three possible assumptions concerning the cause of a variation in coverage.

(1) It might be assumed that the prices of the goods not represented by physical quantity data have fluctuated in the same manner as the prices of the goods represented. If this were so, a decline or rise in the coverage of the index of output would be entirely the result of a decline or rise in the physical quantity of output of the represented goods in relation to the physical quantity of output of the unrepresented goods. Thus, a decline in coverage means that the index of output overstates the actual decline in the industry or understates the actual rise; and a rise in coverage means that the index understates the actual decline or overstates the actual rise. If the assumption concerning the identical price movements is valid, we can correct for the overstatement by deflating the unrepresented portion of the value of products of the industry by an index of the prices of the represented portion, and by then combining this physical output with the physical output of the represented portion; or we can follow an equivalent procedure and deflate the entire value of products of the industry by this price index. (The price index is obtained by division of the value relatives of the represented goods by the corresponding quantity indexes.) This adjustment, identical with Frederick C. Mills' adequacy adjustment,[48] may be accomplished easily by way of an algebraic short cut. The procedure is illustrated in the following hypothetical example, in which we assume that there has been no change in the true total output:

	1929	*1933*
1 Index of output based on selected products	100	70
2 Coverage ratio	.80	.56
3 Index of output adjusted for change in relation between the value of the selected products and the total value of products of the industry	100	100

[48] *Op. cit.*, pp. 90, 92–93.

The index of output based on partial coverage in 1929 and 1933 declined from 100 to 70. This drop represents merely a decline in the importance of certain of the products of the industry in relation to the other products. Such a movement must be eliminated. Knowing the change in the coverage, we can apply a correction factor to obtain an adjusted index. In the present example, this adjustment involves multiplication of the uncorrected index, 70, by the coverage adjustment factor, .80/.56.[44]

(2) A second assumption concerning the reason for changes in coverage is that the quantity of output of the unrepresented goods has changed in the same degree as the quantity of the represented goods. This would mean that the decline in the coverage of the index of output is a result entirely of a decline in the prices of the represented commodities relative to the prices of the unrepresented goods. It follows then that the computed index of output correctly reflects the movements of physical output of the entire industry. We need make no adjustment.

[44] The equivalence of this simplified procedure to the deflation process mentioned can be demonstrated algebraically. If the symbols p_1, p_0, q_1, q_0, are used in the usual sense, the simplified procedure involves the following operations. (The unprimed quantities relate to the represented commodities, the primed to the unrepresented commodities.)

(1) Index of output based on partial coverage, $\frac{\Sigma p_0 q_1}{\Sigma p_0 q_0}$.

(2) Coverage of index of output in current year, $\frac{\Sigma p_1 q_1}{\Sigma (p_1 q_1 + p'_1 q'_1)}$.

(3) Index of total output adjusted for change in coverage,

$$\frac{\Sigma p_0 q_1}{\Sigma p_0 q_0} \div \frac{\dfrac{\Sigma p_1 q_1}{\Sigma (p_1 q_1 + p'_1 q'_1)}}{\dfrac{\Sigma p_0 q_0}{\Sigma (p_0 q_0 + p'_0 q'_0)}}.$$

The deflation procedure involves the following operations:

(4) Index of output based on partial coverage, $\frac{\Sigma p_0 q_1}{\Sigma p_0 q_0}$.

(5) Index of prices of the covered items, $\frac{\Sigma p_1 q_1}{\Sigma p_0 q_0} \div \frac{\Sigma p_0 q_1}{\Sigma p_0 q_0}$.

(6) Index of total output adjusted for change in coverage,

$$\frac{\Sigma (p_1 q_1 + p'_1 q'_1)}{\Sigma (p_0 q_0 + p'_0 q'_0)} \div \left[\frac{\Sigma p_1 q_1}{\Sigma p_0 q_0} \div \frac{\Sigma p_0 q_1}{\Sigma p_0 q_0} \right].$$

It is clear that both procedures yield the same results: (3) and (6) are identical. This equality stands also if the Edgeworth or the Fisher ideal index formula is used.

This assumption is implicit when changes in the coverage ratio are ignored.

(3) Third, it might be assumed that both the quantity and the price of the group of unrepresented goods have behaved differently from the quantity and price of the represented goods. Any adjustment, therefore, must be adapted to the particular case and based on the widest possible survey of the facts. Thus, the value of products of an industry, say copper smelting and refining, may involve duplication, in the sense that the products (e.g., blister copper) made by establishments within that industry are sold for further processing (refining) to other establishments within that industry. The duplication, furthermore, may change in relative importance. Now if our index of physical volume of output is measured at one or the other stage of the process—blister copper or refined copper—then the coverage ratio will change merely because of a modification in the degree of duplication. In this case, no correction for the change in coverage is desirable; indeed, a complete coverage of *both* stages of production, with a coverage ratio of 1.00, will yield an incorrect index of physical volume which will have to be adjusted for the changing amount of duplication.

After considering the three possible assumptions outlined above, we decided that in the absence of specific and detailed knowledge the first was the least objectionable and we therefore adopted it for this study.[45] Its use is justified by the fact that prices probably move together within closer limits than do quantities, which may rise one-hundredfold or fall to zero. With but a few exceptions, we make the adjustment only when the coverage ratio in both years compared is at least .40, and in this way limit the possibility of error. For most industries the adjustment has only a slight effect upon the index. It scarcely needs to be repeated that expert knowledge of each industry might suggest other, less mechanical, methods of adjustment.

It is well to explore the implications of our use of the 40 percent minimum coverage. These implications can be brought out

[45] For a few industries, such as copper and automobiles, no adjustment for coverage was made, chiefly because of changes in the degree of duplication within the industries. These exceptions are noted in Appendix B.

if we make certain simplifying assumptions. Let us suppose that the ratio of coverage, c, remains constant between the two years compared, and let us use Laspeyres' formula, $\Sigma q_1 p_o / \Sigma q_o p_o$, to compute the output index. We define k as the ratio of the price index of the products for which we have quantity data (derived by division of the index of value by the index of output) to the price index of the products for which we do not have quantity data (similarly derived). Then the ratio, r, of the correct total to the estimated total (adjusted) quantity index, is $r = c + (1 - c)k$. The ratio, r, varies with c or k. If we limit c, then r depends only on k; i.e., the accuracy of the index is determined by the validity of the assumptions we make about k. This is the logical basis of the 40 percent minimum. Suppose we define a correct quantity index as one falling within 5 percent of the true index. Then to obtain at least the accuracy implied by this definition, values of k and c must satisfy the following inequality:

$$1.05 > c + (1 - c)\,k > .95.$$

Let us consider the .95 and 1.05 and the .90 and 1.10 lines; that is, the lines described by

$$c + (1 - c)\,k = .95 \text{ or } 1.05, \text{ and } c + (1 - c)k = .90 \text{ or } 1.10.$$

For these lines, we have:

c	k (r=.90)	k (r=.95)	k (r=1.05)	k (r=1.10)
.0	.90	.95	1.05	1.10
.1	.89	.94	1.06	1.11
.2	.88	.94	1.06	1.12
.3	.86	.93	1.07	1.14
.4	.83	.92	1.08	1.17
.5	.80	.90	1.10	1.20
.6	.75	.88	1.12	1.25
.7	.67	.83	1.17	1.33
.8	.50	.75	1.25	1.50
.9	0	.50	1.50	2.00
1.0	$-\infty$	$-\infty$	$+\infty$	$+\infty$

If the ratio of coverage is only .3, then the derived quantity index can be within 5 percent of the true index only if the value of k is not less than .93 or more than 1.07; i.e., the ratio of the price index of the covered products to the price index of the other

products must not be less than .93 or more than 1.07. If the derived index is to come within 10 percent of the true indexes, the value of k must be between .86 and 1.14. For $c = .4$, so long as k lies between .92 and 1.08 our derived index will be correct within 5 percent, and if k lies between .83 and 1.17 it will be correct within 10 percent. It is clear that sometimes we shall be in error when we assume that an index based only on a 40 percent coverage reflects correctly the change in the total output of an industry.[46] We may point out in this connection some comforting considerations. First, only a few of the industries considered here are characterized by low coverage, as we have seen in Table A–6. Second, the indexes for industries with low coverage ratios are merely *subject* to error. The evidence at hand suggests that the dispersion of prices in general is not very large; and within industries we may expect even less dispersion.[47] The probability that values of k may differ widely from unity is therefore relatively slight,[48] though it is likely that as the period between the years compared increases, k also moves farther from unity.

The validity of the coverage adjustment was tested empirically (Table A–8, pp. 368–69). We sought to determine whether adjusted indexes based on low coverage tend to be more accurate than unadjusted indexes based on the same coverage. We took industries for which we had indexes (1937 relative to 1929) based on at least 80 percent coverage. These are listed in Table A–8, together with the percentage coverage (column 2). In lieu

[46] As was noted earlier (footnote 37, above), sometimes c exceeds unity because the secondary products of other industries cannot be separated from the primary products of the industry for which c is computed. Consequently, there should be imposed also an upper limit on c, which will lessen the probability of an incorrect index. However, because the number of industries for which c exceeds unity is small, we have ignored this possibility of error.

[47] Dr. Mills' measures of price dispersion (the approximate percentage limits, measured from the mean, within which 50 percent of the price relatives would fall if the distribution of price relatives were normal) range from 7.1 to 23.0 for fixed-base relatives, and from 5.4 to 18.0 for link relatives. (These are measured about the weighted arithmetic means in both cases.) The modal values of the measures are about 12 to 15 and 9 to 12, respectively. See F. C. Mills, *The Behavior of Prices* (National Bureau of Economic Research, 1927), pp. 257–59.

[48] It is difficult to be precise in this context because weights are used in the actual computation of our indexes, and because k is not entirely a matter of chance.

of other information we regarded the adjusted indexes (column 4) as the "correct" indexes for the industry in one set of our computations, and the unadjusted indexes (column 6) as the "correct" ones in a second set of computations. For these same industries we then computed new indexes based on low coverage, discarding sufficient data to reduce the coverage by at least 15 percent but not to fall below a coverage of 45 percent.[40] The "new" coverage is given in column 3 and the new indexes, adjusted and unadjusted, are shown in columns 5 and 7. We then computed our measures of accuracy of these new indexes: these appear in columns 8–11. The final comparisons between the degree of accuracy of the new adjusted indexes and the new unadjusted indexes are presented in the last two columns. In 37 of the 47 industries, the adjusted indexes based on low coverage are more accurate than the unadjusted indexes based on identically low coverage, if the adjusted index based on high coverage is taken to be the "correct" one. The proportion is 30 out of 47 if the unadjusted index based on high coverage is regarded as "correct." The evidence is clear that in most cases, although not in all, the adjusted indexes are more accurate than the unadjusted. Inspection of columns 8–11 reveals that the unadjusted indexes tend to be higher than the correct indexes (30 out of 47 are higher in one case and 32 out of 47 in the other), while the adjusted indexes are almost evenly divided (23 out of 47 being higher in one case and 22 out of 47 in the other). The magnitudes of the percentage differences given in columns 8–11 are large for some industries, but no frequency distribution for all the industries may be worked out since the original percentage coverages vary, as do also the new percentage coverages (columns 2 and 3). For the 5 industries with an original coverage of 90–94.9 percent and a reduced coverage of 55–59.9 percent, the percentage differences between the new adjusted and the old adjusted indexes are +4.7, +3.2, −2.9, −1.9, and −1.8. The percentage differences between the new unadjusted and the old adjusted indexes are −4.2, +23.6, +5.9, +32.3 and −8.3.

[49] We discarded the less important items, such as by-products, because when coverage is small the quantity of the chief products is usually reported by the Census.

TABLE A–8

SELECTED MANUFACTURING INDUSTRIES

Comparison of Accuracy of Adjusted and Unadjusted Indexes of Physical Output

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry	*Percentage Coverage in 1937*		*Index, Adjusted (1937 on 1929 as 100)*		*Index, Unadjusted (1937 on 1929 as 100)*	
	Old	New	Old	New	Old	New
Meat packing	89.7	50.9	93.8	103.0	89.2	101.1
Shortenings	91.9	58.2	147.8	154.8	141.8	141.6
Milk, canned	103.8	65.1	128.1	128.1	126.9	137.7
Cheese	102.4	69.4	128.8	128.0	131.0	127.9
Fish, canned	86.8	51.6	103.7	102.9	99.6	107.7
Flour	96.7	72.1	85.8	84.6	84.6	87.7
Macaroni	99.6	78.5	122.7	118.4	122.8	113.2
Chocolate	99.6	78.3	123.5	123.6	124.0	119.1
Ice cream	101.8	85.1	109.0	108.4	109.7	96.1
Cotton goods	87.4	58.9	98.9	97.6	102.9	103.4
Hats, fur-felt	97.4	66.2	100.0	101.6	104.3	96.9
Carpets and rugs, wool	86.5	57.8	92.4	82.2	87.1	119.3
Linoleum	83.0	56.3	82.7	85.6	80.6	95.3
Asphalted-felt-base floor covering	105.8	54.7	144.1	161.1	131.5	126.1
Clothing, women's, n.e.c.	81.8	58.3	124.7	130.6	117.0	105.7
Corsets	98.9	50.8	129.4	131.2	134.8	156.0
Hats, wool-felt	86.6	62.5	256.0	310.4	249.9	485.0
Linen goods	93.9	55.4	77.2	79.7	89.6	95.4
Artificial leather	81.5	47.1	118.1	123.2	104.2	86.5
Handkerchiefs	95.2	54.1	85.6	78.3	84.4	85.2
Hosiery, knit	97.3	63.1	114.6	118.2	113.5	128.6
Boxes, wooden, cigar	90.7	67.2	82.9	85.0	79.9	89.6
Turpentine and rosin	99.6	76.6	80.6	70.0	85.4	86.5
Caskets and coffins	85.6	60.7	104.1	98.2	108.0	94.3
Wood-distillation products	84.1	63.4	101.3	77.4	99.1	119.7
Paper	92.7	56.8	115.2	111.9	114.3	122.0
Pulp	90.3	56.1	141.0	138.3	137.3	186.6
Soap	82.8	63.9	109.0	108.8	109.2	115.0
Linseed products	89.9	66.2	86.0	77.9	83.5	86.1
Glue and gelatin	91.7	61.9	138.7	130.4	128.6	115.6
Gases, compressed	107.4	64.7	138.1	139.4	143.3	154.2
Explosives	83.8	60.3	92.8	93.9	89.6	93.4
Fertilizers	88.6	65.8	105.9	104.7	98.0	94.8
Paints and varnishes	98.6	58.6	109.0	102.1	109.5	120.7
Clocks, watches and materials	81.8	52.3	139.2	180.6	152.0	212.0
Roofing	83.5	62.7	110.4	100.5	100.9	83.2
Tin cans and tinware, n.e.c.	89.5	51.6	160.2	152.8	153.0	163.9
Shoes, leather	89.1	56.5	112.3	118.3	109.5	113.0
Shoes, rubber	90.4	56.5	95.1	93.4	79.2	87.2
Petroleum refining	97.4	57.7	119.2	131.8	117.6	124.7
Coke-oven products	96.3	62.6	87.3	81.7	89.1	91.1
Clay products, n.e.c.	83.7	61.8	65.7	62.2	60.6	58.0
Cast-iron pipe	108.3	58.6	68.5	78.1	69.3	94.3
Scales and balances	90.0	63.3	86.9	108.2	106.3	127.3
Carriages and sleds, children's	82.3	62.3	88.7	92.9	98.2	108.3
Pianos	90.2	48.3	66.0	67.3	73.1	110.9
Brooms	105.2	77.8	81.4	82.6	87.4	78.9

(8)	(9)	(10)	(11)	(12)	(13)
Percentage Difference from Old Adjusted Index		*Percentage Difference from Old Unadjusted Index*		*Comparison between New Adjusted and New Unadjusted Indexes: Difference between Absolute Percentage Differences*	
New Adjusted	New Unadjusted	New Adjusted	New Unadjusted	|(8)| − |(9)|	|(10)| − |(11)|
+9.8	+7.8	+15.5	+13.3	+2.0	+2.2
+4.7	−4.2	+9.2	−0.1	+0.5	+9.1
0	+7.5	+0.9	+8.5	−7.5	−7.6
−0.6	−0.7	−2.3	−2.4	−0.1	−0.1
−0.8	+3.9	+3.3	+8.1	−3.1	−4.8
−1.4	+2.2	0	+3.7	−0.8	−3.7
−3.5	−7.7	−3.6	−7.8	−4.2	−4.2
+0.1	−3.6	−0.3	−4.0	−3.5	−3.7
−0.6	−11.8	−1.2	−12.4	−11.2	−11.2
−1.3	+4.6	−5.2	+0.5	−3.3	+4.7
+1.6	−3.1	−2.6	−7.1	−1.5	−4.5
−11.0	+29.1	−5.6	+37.0	−18.1	−31.4
+3.5	+15.2	+6.2	+18.2	−11.7	−12.0
+11.8	−12.5	+22.5	−4.1	−0.7	+18.4
+4.7	−15.2	+11.6	−9.7	−10.5	+1.9
+1.4	+20.6	−2.7	+15.7	−19.2	−13.0
+21.2	+89.5	+24.2	+94.1	−68.3	−69.9
+3.2	+23.6	−11.0	+6.5	−20.4	+4.5
+4.3	−26.8	+18.2	−17.0	−22.5	+1.2
−8.5	−0.5	−7.2	+0.9	+8.0	+6.3
+3.1	+12.2	+4.1	+13.3	−9.1	−9.2
+2.5	+8.1	+6.4	+12.1	−5.6	−5.7
−13.2	+7.3	−18.0	+1.3	−5.9	+16.7
−5.7	−9.4	−9.1	−12.7	−3.7	−3.6
−23.6	+18.2	−21.9	+20.8	+5.4	+1.1
−2.9	+5.9	−2.1	+6.7	−3.0	−4.6
−1.9	+32.3	+0.7	+35.9	−30.4	−35.2
−0.2	+5.5	−0.4	+5.3	−5.3	−4.9
−9.4	+0.1	−6.7	+3.1	+9.3	+3.6
−6.0	−16.7	+1.4	−10.1	−10.7	−8.7
+0.9	+11.7	−2.7	+7.6	−10.8	−4.9
+1.2	+0.6	+4.8	+4.2	+0.6	+0.6
−1.1	−10.5	+6.8	−3.3	−9.4	+3.5
−6.3	+10.7	−6.8	+10.2	−4.4	−3.4
+29.7	+52.3	+18.8	+39.5	−22.6	−20.7
−9.0	−24.6	−0.4	−17.5	−15.6	−17.1
−4.6	+2.3	−0.1	+7.1	+2.3	−7.0
+5.3	+0.6	+8.0	+3.2	+4.7	+4.8
−1.8	−8.3	+17.9	+10.1	−6.5	+7.8
+10.6	+4.6	+12.1	+6.0	+6.0	+6.1
−6.4	+4.4	−8.3	+2.2	+2.0	+6.1
−5.3	−11.7	+2.6	−4.3	−6.4	−1.7
+14.0	+37.7	+12.7	+36.1	−23.7	−23.4
+24.5	+46.5	+1.8	+19.8	−22.0	−18.0
+4.7	+22.1	−5.4	+10.3	−17.4	−4.9
+2.0	+68.0	−7.9	+51.7	−66.0	−43.8
+1.5	−3.1	−5.5	−9.7	−1.6	−4.2

Computation of the Indexes for Major Groups and for the Total

The method of computation of the major group indexes is identical, in principle, with that for individual industries. The component series used were the adjusted indexes for the industries comprising the group, or the unadjusted indexes, if adjusted indexes were not available. Instead of value of products per unit of product, the price coefficient was value added per unit. To avoid unnecessary computation we employed the following formula, in which Q is the given year index (on the base year as 100) for each individual industry, V_1 is the value added in the given year, and V_0 is the value added in the base year: $\frac{\Sigma (V_1 + QV_0)}{\Sigma (V_0 + \frac{V_1}{Q})}$. This formula yields results identical with those obtained by the usual form of the Edgeworth formula. The index derived by such combination of the adjusted individual industry indexes is the *unadjusted* index for the group. This index, of course, is based on a sample only: its coverage is incomplete and changing in amount, as the coverage ratios collected in Appendix B will show.[50] Adjustment identical in principle with that used for the individual industry indexes yields the adjusted indexes.

For two groups, machinery and miscellaneous products, no index was computed for any year; and for a few other groups, no index was computed for certain years. The reason in all instances was inadequacy of coverage (under 40 percent).

We computed an unadjusted index for total manufacturing by using the available adjusted group indexes and the adjusted industry indexes for the few industries (machinery and others) for which no group indexes were available. This index was then adjusted for changes in coverage. For checking purposes we computed an additional set of indexes for all industries combined. In this supplementary computation we used the adjusted individual industry indexes (rather than the group indexes) to obtain the unadjusted index for total manufacturing, and then

[50] In a few groups of industries the coverage is complete.

made an adjustment for changing coverage to obtain the adjusted index for total manufacturing. The two sets of indexes are presented in Appendix B.

In these adjustments of the total indexes for changes in coverage of the underlying samples there is implied a relationship between changes in value added and in physical output. In Chapter 5 we noted that the relationship in our sample was both close and significant.[51] We must assume, of course, a corresponding relationship for industries not in the sample; i.e., we must take the sample to be representative of the entire population of industries in respect of the relation between changes in value added and in physical output. Such an assumption appears reasonable. Examination of the sample does not suggest that those included industries which may be considered similar in character to the industries not in the sample are different, in this particular respect, from the other industries included. For major industrial divisions the adjustment is less easily justified; too few series are available for individual groups to invest the empirical test with appreciable significance.[52] We must simply assume that for each industrial division changes in value added are closely related to changes in physical output. We have made this assumption reluctantly and offer the results without claiming great accuracy for them. We believe, however, that the adjusted group indexes are probably better estimates than the unadjusted group indexes.[53]

[51] The correlation noted in Chapter 5 relates to the indexes for 1937 on the 1899 base. Similar correlations were calculated for other periods: 1909 relative to 1899, 1919 relative to 1909, 1929 relative to 1919, and 1937 relative to 1929. In all, the coefficients were fairly high: none fell below .6.

[52] A related difficulty lies in the fact that the empirical test ignores the importance of the industries covered. This is not a serious matter when we test our entire sample, but it is important for a test of group samples, in which the number of items is small.

[53] The adjustment does more than correct for the bias of a limited sample. It tends to avoid another common fault of indexes, which may be illustrated by reference to the data on forest products. For 1923 we have indexes for only two of the industries in the group—lumber-mill products and turpentine and rosin. The weighted average of these two indexes, on 1929 as 100, is 98.4. For 1925, we have indexes for four industries, the two mentioned plus planing-mill products and excelsior. The average of these four indexes, on 1929 as 100, is 108.5. If we compare 1923 and 1925 by means of these unadjusted indexes we find a change of 10 percent between the two years. The question arises whether this result does not reflect mainly the fact that the 1925 index for planing-mill products was on a relatively high level (ex-

Our adjustment is derived from that employed by F. C. Mills [54] for the adjustment of his index of total manufacturing output. We have extended its use to individual groups as well as to the total; and have adopted as its basis value added alone, whereas Mills uses number of wage earners as well. An alternative method of passing from indexes based on a sample of manufacturing industries to an index representative of total manufacturing involves the use of imputed weights.[55] According to such a procedure the unadjusted index for a given group is not corrected for changing coverage, but when it is combined with other indexes into a grand average it is given the weight of the entire group to which it refers, including the industries it fails to cover. Here too are involved several assumptions; in this particular procedure the assumptions relate to the ratio of materials consumed per unit of gross output, imports and exports of semimanufactured goods, and changes in inventories of semimanufactured goods. These assumptions seem less valid than those underlying our own adjustment.

Still another method of covering the output of industries for which data on physical volume cannot be obtained is to deflate their value of products by suitable price indexes. However, very few indexes of prices of homogeneous products of these industries are available. It is true that the adjustment we have used is similar in principle to the deflation process mentioned, but there is a fundamental difference also: we do not present indexes for the individual industries not included in our sample. Our objective has been to estimate the aggregate, including the indexes for the industries not covered, rather than the individual indexes themselves. In view of the nature of the available data this approach seems the more defensible of the two.

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celsior may be disregarded because of its slight importance). The indexes of the two industries for which we have data for both 1923 and 1925 rose only 7 and 3 percent respectively. This ambiguity in the 1923–25 comparison of the *unadjusted* indexes cannot be avoided except by construction of a new index that compares the two years directly. The ambiguity is obviated, however, by the *adjusted* indexes, which are designed to represent the movements of the *entire* forest products group and therefore do not suffer from incomparabilities arising from changes in the size of the sample.

[54] *Economic Tendencies*, pp. 39–43.

[55] See E. E. Day and Woodlief Thomas, *Growth of Manufactures, 1899 to 1923*, pp. 101–02. This index is described below, in Appendix D.

Since our indexes are relatively short links, which must be chained together for long-period comparisons, a question arises concerning the results that might have been obtained if we had constructed indexes comparing directly years that are far apart.

TABLE A–9

INDEX NUMBERS OF PHYSICAL OUTPUT, 1937 RELATIVE TO 1899

Direct Comparisons and Chains of Three Series of Indexes on Different Bases

Group	*Direct Indexes*		*Chained Indexes*		*Ratio of Chained to Direct Indexes*	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Foods	257	354	256	344	1.00	0.97
Beverages	200	243	189	232	0.95	0.95
Tobacco products	375	375	393	393	1.05	1.05
Textile products	245	273	253	280	1.03	1.03
Leather products	176	171	175	169	0.99	0.99
Paper products	618	667	616	667	1.00	1.00
Printing and publishing[a]	594	594	594	594	1.00	1.00
Chemical products	830	643	796	666	0.96	1.04
Petroleum and coal products	1,365	1,183	1,508	1,306	1.10	1.10
Forest products	68	94	67	93	0.99	0.99
Iron and steel products	388	419	394	427	1.02	1.02
Transportation equipment	959	849	1,286	1,242	1.34	1.46
Total manufacturing	338	363	339	376	1.00	1.04

[a] The index for this group is based on a single series which represents the entire group output.

In order to answer this question we constructed special indexes, unadjusted and adjusted, for groups as well as for total manufacturing, comparing 1899 and 1937 directly with each other.[56] These are shown in Table A–9, where they are also compared with the chained indexes. The differences found are relatively

[56] In computing these direct indexes we assumed that the indexes of individual industries were fully comparable for any pair of years covered; in fact, however, the indexes for individual industries are also chains of links for the various periods.

slight except for the transportation equipment group. Here the differences between the direct and indirect unadjusted and adjusted indexes are 34 and 46 percent, respectively. For all manufacturing industries combined, the two unadjusted indexes are close to each other, and the two adjusted indexes are less than 5 percent apart.

The indexes for total manufacturing given in Table A–9 are those obtained by a combination of the adjusted group indexes. The indexes derived by combination of the adjusted indexes of individual industries are as follows:

Indexes	*Direct*	*Chained*	*Ratio of Chained to Direct Indexes*
Unadjusted	371	354	0.95
Adjusted	418	416	1.00

Here also we find substantial correspondence between the direct and indirect indexes.

BUSINESS-CYCLE PHASES COVERED BY THE CENSUS YEARS

The detailed data we have assembled on production relate to quinquennial and biennial Census years. The picture they draw of the entire 1899–1937 period is necessarily incomplete, because they fail to depict the developments in the years for which we have no data and to show the relation of the years covered to those for which no information is available. They cannot be interpreted intelligently, therefore, without some description of the setting from which they are taken. That background is sketched in broad outline in Table A–10, which shows the relative position of the several Census years in the business cycles of the period.

The period 1899–1937 is characterized by two severe business cycles, 1920–23 and 1929–37; and by eight comparatively mild cycles, with troughs in 1900, 1904, 1908, 1911, 1914, 1919, 1924 and 1927. Five of the Census years contain cyclical troughs, four contain peaks, four are years of expansion and one is a year of contraction.

TABLE A–10

CYCLICAL POSITION OF GENERAL BUSINESS IN THE UNITED STATES

Calendar Years 1899–1938 [a]

Stage of Cycle	*Calendar Year*
Peak	1899
Mid-contraction	1899–1900
Trough	1900
Mid-expansion	1901–1902
Peak	1903
Mid-contraction	1903–1904
Trough	1904
Mid-expansion	1905–1906
Peak	1907
Mid-contraction	1907–1908
Trough	1908
Mid-expansion	1909
Peak	1910
Mid-contraction	1910–1911
Trough	1911
Mid-expansion	1912
Peak	1913
Mid-contraction	1913–1914
Trough	1914
Mid-expansion	1915–1916–1917
Peak	1918
Mid-contraction	1918–1919
Trough	1919
Mid-expansion	1919–1920
Peak	1920
Mid-contraction	1920–1921
Trough	1921
Mid-expansion	1922
Peak	1923
Mid-contraction	1923–1924
Trough	1924
Mid-expansion	1925
Peak	1926
Mid-contraction	1926–1927
Trough	1927
Mid-expansion	1928
Peak	1929
Mid-contraction	1930–1931
Trough	1932
Mid-expansion	1934–1935
Peak	1937
Mid-contraction	1937–1938
Trough	1938

[a] Taken from unpublished data compiled at the National Bureau of Economic Research by W. C. Mitchell and A. F. Burns.