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Five such criteria have been computed for each of the price distributions listed above. These are

$$\beta_1 = \frac{\mu^2_3}{\mu^3_2}$$

$$\beta_2 = \frac{\mu_4}{\mu^2_2}$$

$$\kappa_1 = 2\beta_2 - 3\beta_1 - 6$$

$$\kappa_2 = \frac{\beta_1 (\beta_2 + 3)^2}{4 (4\beta_2 - 3\beta_1)(2\beta_2 - 3\beta_1 - 6)}$$

$$r = \frac{6 (\beta_2 - \beta_1 - 1)}{2\beta_2 - 3\beta_1 - 6}$$

where the letters μ_1, μ_2, μ_3 and μ_4 designate the first four moments about the mean, adjusted, where necessary, by the application of Sheppard's corrections.

Differences between Gaussian and non-Gaussian curves are defined by the following measures:

$$\eta \text{ (Kurtosis)} = \beta_2 - 3$$

$$\chi \text{ (Skewness)} = \frac{\sqrt{\beta_1}(\beta_2 + 3)}{2 (5\beta_2 - 6\beta_1 - 9)}$$

$$d \text{ (Modal divergence)} = \chi \cdot \sigma$$

III Changes in the Level of Wholesale Prices

The immediate purpose of the present investigation is not the measurement of changes in the level of prices, a subject which has been discussed extensively elsewhere. But in a study of the behavior of prices in combination some attention must be given to such general price changes, for these constitute one important aspect of group behavior.

1. Comparison of Index Numbers

The column diagrams which are shown in Figure 21 differ from year to year in many ways—in the location of the point of maximum concentration, in the degree of dispersion, in the direction and degree of skewness, and in peakedness. Our present concern is with the shifts in the central tendency from year to year, as measured by the changing values of the annual averages. Prices as a whole drift upward or downward, and the changing position on the x-scale of the point of maximum concentration is an indication of the direction and degree of this drift. It is possible to follow this drift on the charts by noting the varying distances between the central tendencies of the various distributions and the 100 point on the x-scale (the point with a value of 2.00 for the logarithmic distributions). The location of this point is indicated on each of the diagrame. Such inspection provides, of course, only a general impression of the degree of change in the level of prices between given dates. More accurate information concerning these movements is given by the averages of the various distributions, averages which constitute index numbers of the usual type.[1]

[1]In the present study the averages were computed from grouped data. This was done because chief interest attached to measures, other than the mean, describing the various frequency distributions. That a very small error is involved in computing the mean from grouped data, instead of from individual price relatives, is clear from the following table. Measures derived in an earlier study from ungrouped data are here compared with results secured from grouped observations. The comparison is of interest because of its bearing upon practical problems of index number construction.

Weighted geometric means of link relatives computed from ungrouped data, each relative taken to the nearest whole number, are given in column (3) of this table. The weighted geometric means in column (4) were computed from frequency distributions of logarithms of link relatives, the logarithmic class-interval being .03. This is equivalent to a natural class-interval of 3 in the neighborhood of 50 and of 10 in the neighborhood of 150. The weights and the number of price quotations were the same in the two calculations. For purposes of comparison the year-to-year changes in prices recorded by the Bureau of Labor Statistics index of wholesale prices are shown in column (5). The numbers given in column (2) refer, it should be noted, only to the averages in columns (3) and (4).

INDEX NUMBERS OF WHOLESALE PRICES COMPUTED FROM UNGROUPED AND GROUPED LOGARITHMS OF PRICE RELATIVES, WITH INDEX OF UNITED STATES BUREAU OF LABOR STATISTICS

(1) Year	(2) No. of price quotations	(3) Weighted geometric mean of link relatives (computed from ungrouped data)	(4) Weighted geometric mean of link relatives (computed from grouped data)	(5) Link relative computed from U. S. Bureau of Labor Statistics wholesale price index
1891	195	100.0	100.0	99.3
1892	195	94.4	93.8	93.6
1893	195	101.7	101.8	102.4
1894	195	90.0	89.9	89.7
1895	195	101.3	101.3	101.9
1896	195	95.4	95.3	95.3
1897	195	100.7	100.6	100.1
1898	195	103.1	102.6	104.2
1899	195	107.3	107.1	107.6
1900	195	108.8	108.5	107.5
1901	195	99.2	99.2	98.5
1902	195	107.0	107.3	106.4
1903	205	101.1	100.8	101.3
1904	205	99.9	99.6	100.1
1905	205	100.3	100.6	100.7
1906	205	103.5	103.6	102.8
1907	205	106.1	106.4	105.5
1908	205	96.2	96.0	96.4
1909	205	106.3	106.1	107.5
1910	205	103.0	102.9	104.1
1911	205	94.6	94.5	92.8
1912	205	106.5	106.8	105.9
1913	205	100.9	101.1	100.9
1914	391	97.8	97.9	98.1
1915	391	101.1	101.1	102.8
1916	391	125.8	125.8	125.8
1917	391	138.5	138.6	139.7
1918	389	111.7	111.7	109.7
1919	389	107.1	106.8	106.2
1920	391	109.9	110.2	109.6
1921	391	65.3	65.4	64.9
1922	391	101.2	101.0	101.3
1923	390	104.7	105.0	103.3
1924	390	97.1	97.4	97.4
1925	387	105.6	105.8	106.0

(Footnote continued on next page.)

These index numbers are given in simple and chained form in the summary tables of measures relating to the different frequency distributions (Appendix Tables XIX-XXVII). To permit ready comparison of the results secured by different methods of combining price relatives these measures have been brought together in the following tables.[2] The index numbers in Tables 93 and 94 are plotted in Figures 22 and 23.

TABLE 89

INDEX NUMBERS MEASURING CHANGES IN THE LEVEL OF WHOLESALE PRICES IN THE UNITED STATES, 1891-1902

Measures Computed from Fixed Base Relatives (1891=100)

(1) Year	(2) Un-weighted arithmetic mean	(3) Weighted arith-metic mean	(4) Un-weighted median	(5) Weighted median	(6) Un-weighted geometric mean	(7) Weighted geometric mean	(8) U. S. B. of L. S. index
1891	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1892	95.4	95.1	95.9	94.3	94.5	93.8	93.5
1893	95.1	97.4	95.7	97.1	93.9	95.8	95.7
1894	85.7	87.3	87.2	88.3	84.3	85.7	85.9
1895	84.3	89.6	83.5	87.8	82.8	87.3	87.5
1896	81.5	85.1	81.9	84.1	79.6	82.8	83.4
1897	81.0	85.2	81.8	85.4	79.3	83.7	83.5
1898	84.9	88.1	83.9	88.7	83.0	86.4	87.0
1899	92.5	94.8	91.0	93.6	90.2	92.1	93.6
1900	100.1	102.9	99.1	102.4	97.3	100.1	100.6
1901	99.2	102.2	97.6	100.5	96.3	99.6	99.1
1902	102.8	109.7	98.7	104.2	99.6	106.0	105.5

(Continuation of footnote 1, p. 230.)

The greatest discrepancy between the geometric means computed from individual price relatives and those computed from the grouped data is .6, about 6-10 of one per cent of the average in question. This is a negligible difference, for it is less than the probable error of the average. This difference would, of course, tend to be greater with a smaller number of price quotations, but when as many as 200 commodity prices are utilized no material error may be expected from the employment of grouped observations, if appropriate class-intervals be employed.

These numerical results are in accord with general theory concerning errors due to grouping. The standard error due to grouping, for both mean and standard deviation, has been given as $\frac{1}{\sqrt{12N}}$ (in class-interval units). When the sample includes 200 observations and a logarithmic class-interval of .03 is employed, the standard error due to grouping is less than 2-10 of one per cent of the average.

There is one case in which it may be desirable to compute index numbers from individual observations, without grouping, even though the observations be numerous. This is when averages are to be computed from link relatives, these averages to be later chained over a term of years. The chaining involves the cumulation of errors, a process which may magnify a rather slight original error.

[2]The number of price quotations employed each year is shown in the general tables in the Appendix. The names of the different commodities included in the calculations for the different periods, and their weights, are given in Appendix Table I.

TABLE 90

Index Numbers Measuring Changes in the Level of Wholesale Prices in the United States 1891-1902

Measures Computed from Link Relatives
(1891=100 for all chain indexes)

(1) Year	(2) Un-weighted arithmetic mean	(3) Chain index construced from unweighted arithmetic mean	(4) Weighted arithmetic mean	(5) Chain index constructed from weighted arithmetic mean	(6) Un-weighted median	(7) Chain index constructed from unweighted median	(8) Weighted median	(9) Chain index constructed from weighted median	(10) Un-weighted geometric mean	(11) Chain index constructed from unweighted geometric mean	(12) Weighted geometric mean	(13) Chain index constructed from weighted geometric mean
1891	100.3	100.0	101.4	100.0	99.2	100.0	100.7	100.0	99.3	100.0	100.0	100.0
1892	95.4	95.4	95.1	95.1	95.9	95.9	94.3	94.3	94.5	94.5	93.8	93.8
1893	100.1	95.5	102.3	97.3	98.8	94.7	101.1	95.3	99.5	94.0	101.8	95.5
1894	90.6	86.5	90.7	88.3	91.0	86.2	89.8	85.6	90.0	84.5	89.8	85.7
1895	99.1	85.7	102.7	90.7	97.8	84.3	101.0	86.5	98.1	82.9	101.3	86.9
1896	97.1	83.2	96.3	87.3	98.5	83.0	97.3	84.2	96.0	79.6	95.3	82.8
1897	100.9	83.9	101.6	88.7	99.9	82.9	100.8	84.9	99.8	79.4	100.6	83.2
1898	105.1	88.2	103.4	91.7	102.6	85.1	101.9	86.5	104.3	82.8	102.6	85.4
1899	109.8	96.8	108.2	99.2	105.3	89.6	105.9	91.6	108.5	89.9	107.1	91.5
1900	109.0	105.5	109.8	108.9	107.2	96.1	105.6	96.7	108.4	97.5	108.5	99.3
1901	99.7	105.2	100.2	109.1	98.7	94.9	99.4	96.1	98.8	96.4	99.2	98.5
1902	104.8	110.2	107.7	117.5	103.1	97.8	106.1	102.0	104.2	100.3	107.3	105.6

TABLE 91

INDEX NUMBERS MEASURING CHANGES IN THE LEVEL OF WHOLESALE PRICES IN THE UNITED STATES, 1902-1913

Measures Computed from Fixed Base Relatives
(1902=100)

(1) Year	(2) Un-weighted arithmetic mean	(3) Weighted arith-metic mean	(4) Un-weighted median	(5) Weighted median	(6) Un-weighted geometric mean	(7) Weighted geometric mean	(8) U. S. B. of L. S. index
1902	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1903	101.3	102.3	101.6	102.4	100.2	100.8	101.3
1904	101.6	103.8	101.0	102.7	100.0	101.5	101.4
1905	103.0	103.7	102.9	104.9	101.4	102.7	102.1
1906	109.0	106.6	108.0	106.2	106.8	104.7	105.0
1907	115.1	113.5	114.6	113.8	112.8	111.6	110.8
1908	106.8	108.6	109.0	109.7	104.8	106.8	106.7
1909	109.9	116.3	112.3	113.6	107.6	113.9	114.8
1910	115.2	120.3	115.7	117.2	112.1	117.2	119.5
1911	113.1	113.3	110.8	111.0	109.1	110.7	110.2
1912	116.6	119.6	114.6	123.5	113.0	117.2	117.4
1913	116.7	120.9	116.3	123.1	113.5	118.4	118.5

It is not the purpose of the present inquiry to consider in detail the relative merits of different types of index numbers. This has been done in a comprehensive fashion in other investigations. The results in the accompanying tables, which are by-products of the general study, have been presented because of the interest they may possess to students of index numbers. Only a few comments are called for at this point.

The diversity of results is apparent, a diversity that indicates the inherent difficulty of describing by a single measure the complex price movements which take place between given dates. Certain of the averages differ materially from the bulk of the measures secured. One of the results, for which Irving Fisher's conclusions prepare us, is the upward "bias" of the weighted index numbers during the first two periods. We may compare the unweighted and weighted fixed base index numbers (including the chain indexes, but excluding the index of the Bureau of Labor Statistics) at the end of each of the three periods (i. e. in 1902, 1913 and 1926). In each of six comparisons for the year 1902 the weighted index number exceeds the corresponding unweighted measure. The same thing is true of the averages for 1913. At the end of the third period the unweighted measures exceed the corresponding weighted measures in all cases. This upward tendency of the weighted numbers during

TABLE 92

INDEX NUMBERS MEASURING CHANGES IN THE LEVEL OF WHOLESALE PRICES IN THE UNITED STATES, 1902-1913

Measures Computed from Link Relatives
(1902=100 for all chain indexes)

(1) Year	(2) Unweighted arithmetic mean	(3) Chain index constructed from unweighted arithmetic mean	(4) Weighted arithmetic mean	(5) Chain index constructed from weighted arithmetic mean	(6) Unweighted median	(7) Chain index constructed from unweighted median	(8) Weighted median	(9) Chain index constructed from weighted median	(10) Unweighted geometric mean	(11) Chain index constructed from unweighted geometric mean	(12) Weighted geometric mean	(13) Chain index constructed from weighted geometric mean
1902	104.8	100.0	107.7	100.0	103.1	100.0	106.1	100.0	104.2	100.0	107.3	100.0
1903	101.3	101.3	102.3	102.3	101.6	101.6	102.4	102.4	100.2	100.2	100.8	100.8
1904	100.0	101.3	101.0	103.3	99.9	101.5	101.0	103.4	99.2	99.4	99.6	100.4
1905	102.3	103.6	100.8	104.1	101.4	102.9	100.8	104.2	101.9	101.3	100.6	101.0
1906	105.9	109.7	104.1	108.4	105.5	108.6	103.4	107.7	105.4	106.8	103.6	104.6
1907	105.8	116.1	106.5	115.4	104.5	113.5	106.1	114.3	105.5	112.7	106.4	111.3
1908	93.7	108.8	96.5	111.4	94.9	107.7	97.8	111.8	93.0	104.8	96.0	106.8
1909	103.1	112.2	106.5	118.6	101.3	109.1	103.9	116.2	102.6	107.5	106.1	113.3
1910	104.6	117.4	103.8	123.1	102.0	111.3	101.7	118.2	103.9	111.7	102.9	116.6
1911	98.8	116.0	95.4	117.4	98.1	109.2	95.4	112.8	97.7	109.1	94.5	110.2
1912	104.4	121.1	107.4	126.1	102.9	112.4	106.6	120.2	103.8	113.2	106.8	117.7
1913	100.9	122.2	101.9	128.5	101.0	113.5	101.0	121.4	100.1	113.3	101.1	119.0

TABLE 93

INDEX NUMBERS MEASURING CHANGES IN THE LEVEL OF WHOLESALE PRICES IN THE UNITED STATES, 1913-1926

Measures Computed from Fixed Base Relatives (1913=100)

(1) Year	(2) Unweighted arithmetic mean	(3) Weighted arithmetic mean	(4) Unweighted median	(5) Weighted median	(6) Unweighted geometric mean	(7) Weighted geometric mean	(8) U. S. B. of L. S. index
1913	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1914	100.0	98.3	99.6	99.3	99.2	97.9	98.1
1915	110.1	100.6	100.4	97.9	104.0	98.6	100.8
1916	142.5	127.8	121.0	118.2	130.3	124.6	126.8
1917	190.5	180.1	171.2	174.6	176.3	172.2	177.2
1918	214.7	198.5	192.3	187.7	202.1	192.2	194.3
1919	218.4	211.8	208.9	207.9	210.7	205.2	206.4
1920	245.3	236.7	229.3	223.2	233.0	225.3	226.2
1921	160.2	155.0	154.7	151.9	151.6	146.6	146.9
1922	154.5	155.0	151.5	156.0	147.7	147.8	148.8
1923	164.8	162.8	159.9	160.3	158.1	155.8	153.7
1924	162.8	157.9	156.3	152.5	155.4	152.3	149.7
1925	167.7	164.1	165.1	162.5	161.3	159.4	158.7
1926	161.1	156.4	156.0	152.1	154.7	150.7	151.0

the first and second periods is an inherent characteristic of "given year" weighting (i. e. the use of weights based upon values at the second of two dates for which prices are compared). In the present study weights based upon post-war values are employed. This is not "given year" weighting, but the effect upon the index numbers during the two earlier periods is the same. Those commodities with a pronounced upward trend in price were heavily weighted, relatively, while those for which the trend was downward, or upward at a low rate, were less heavily weighted.

The differences between weighted and unweighted results are perhaps more clearly brought out by a year-to-year comparison of corresponding weighted and unweighted averages. If we include medians and arithmetic and geometric means of fixed base relatives, and chain indexes constructed from medians and arithmetic and geometric means of link relatives, we have 126 pairs of indexes (weighted and unweighted) measuring price changes during the two periods between 1892 and 1913, and 75 pairs covering the years 1914 to 1926. (The base years are 1891, 1902 and 1913. Duplicate measures for the first year after the base year have been omitted in these comparisons.) In 110 out of the 126 comparisons during the

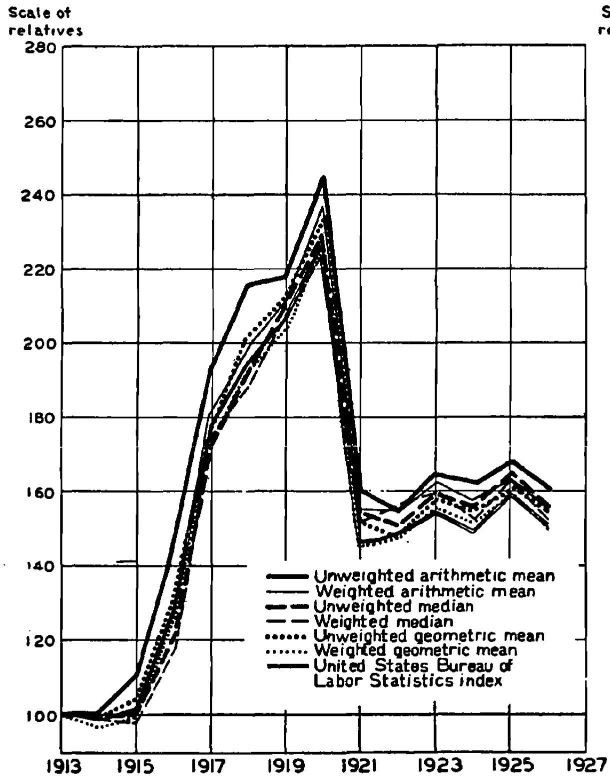
TABLE 94

INDEX NUMBERS MEASURING CHANGES IN THE LEVEL OF WHOLESALE PRICES IN THE UNITED STATES
1913-1926

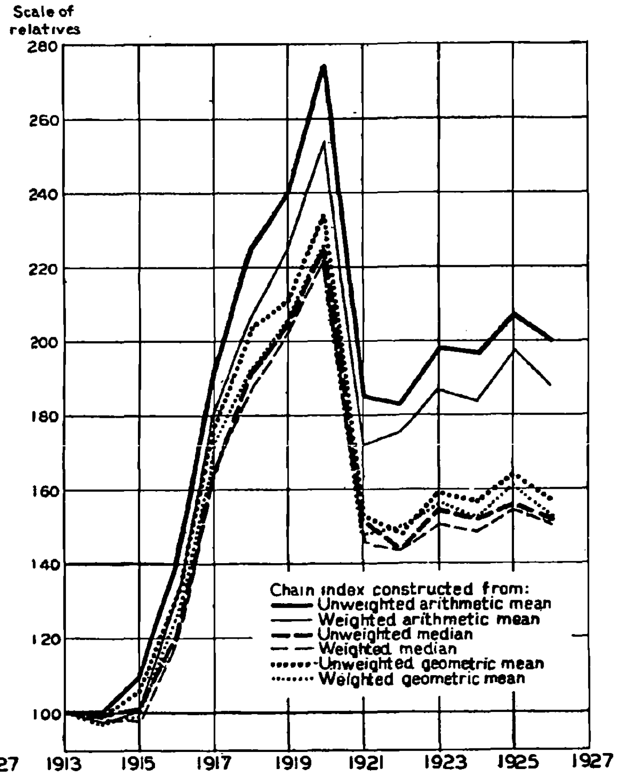
Measures Computed from Link Relatives
(1913=100 for all chain indexes)

(1) Year	(2) Un-weighted arithmetic mean	(3) Chain index constructed from unweighted arithmetic mean	(4) Weighted arithmetic mean	(5) Chain index constructed from weighted arithmetic mean	(6) Un-weighted median	(7) Chain index constructed from unweighted median	(8) Weighted median	(9) Chain index constructed from weighted median	(10) Un-weighted geometric mean	(11) Chain index constructed from unweighted geometric mean	(12) Weighted geometric mean	(13) Chain index constructed from weighted geometric mean
1913	100.9	100.0	101.9	100.0	101.0	100.0	101.0	100.0	100.1	100.0	101.1	100.0
1914	100.0	100.0	98.3	98.3	99.6	99.6	99.3	99.3	99.2	99.2	97.9	97.9
1915	108.7	108.7	102.4	100.6	101.5	101.2	99.2	98.5	105.4	104.5	101.1	98.9
1916	127.6	138.7	128.4	129.2	119.8	121.2	120.4	118.6	124.7	130.2	125.8	124.5
1917	138.0	191.4	140.9	182.1	135.0	163.6	138.9	164.8	135.4	176.3	138.6	172.6
1918	117.0	224.0	113.7	207.0	116.8	191.1	114.9	189.4	114.8	202.5	111.7	192.8
1919	107.3	240.3	108.5	224.7	106.5	203.5	107.3	203.2	104.2	211.0	106.8	205.9
1920	114.1	274.2	113.1	254.1	109.9	223.6	109.2	221.8	111.0	234.3	110.2	226.9
1921	67.4	184.9	67.5	171.5	67.9	151.8	65.9	146.1	65.2	152.8	65.4	148.4
1922	99.2	183.4	102.6	175.9	94.9	144.1	98.5	144.0	97.5	149.0	101.0	149.9
1923	107.9	197.9	106.2	186.9	106.8	153.9	104.9	151.0	107.0	159.4	105.0	157.4
1924	99.5	196.9	98.2	183.5	98.9	152.1	98.0	148.0	98.5	157.0	97.4	153.3
1925	105.2	207.1	107.3	197.0	102.7	156.2	104.1	154.1	104.3	163.8	105.8	162.3
1926	96.4	199.6	95.4	187.9	97.1	151.7	97.0	149.2	95.7	156.8	94.5	153.4

INDEX NUMBERS OF WHOLESALE PRICES, 1913-1926.
United States Bureau of Labor Statistics Index Number and Six Index Numbers Computed from Fixed Base Relatives.
(1913 = 100)



INDEX NUMBERS OF WHOLESALE PRICES, 1913-1926.
Six Index Numbers Constructed by Chaining Averages of Link Relatives.
(1913 = 100)



years between 1892 and 1913 the weighted indexes are larger than the corresponding unweighted measures. (The comparison in each case is between measures differing only in respect to weight.) During the period 1914-1926 the weighted indexes were greater in only 7 out of 75 cases.

§Price Trends and Bias in Index Numbers

It is clear, from some of the results presented in the first chapter, that over a period of years the prices of different commodities differ materially in their long-term trends. This fact, taken in conjunction with Professor Fisher's arguments concerning the effects of base year and given year weighting, has a distinct bearing upon the choice of weights in the construction of index numbers. If weights are based upon values (i. e. prices times quantities) at the end of a period, there will be an upward tendency not only in the index number for the single "given year" from which the weights were selected, but for every year during which the trends in question continued, unless the differences in price trends are counter-balanced by differences in quantity trends. Thus, if weights based upon values in 1913 were used in constructing index numbers for the period 1896-1913, the weights would cause an upward tendency in the index for every year in the period (assuming no changes in quantities). For, as we have seen, the period 1896-1913 was marked by fairly consistent trends in individual commodity prices, and these trends differed materially from article to article and from group to group. The 1913 weighting would over-value (relatively) the commodities having upward trends in price, and this over-valuing would tend to affect every year in the period. Conversely, weighting based upon values at the beginning of a period will give a downward "bias" to the index throughout the period (again on the assumption that this tendency is not offset by quantity changes). Since such differences in trends may be assumed to exist over any considerable period of years, weights based upon values at any fixed date will lead to bias. (The term *bias* is used in the sense in which it is employed by Irving Fisher in *The Making of Index Numbers*.) This will be upward for index numbers relating to years prior to the date to which the weights relate, and downward for all subsequent years. Cyclical and accidental movements which affect prices prevailing at a single date may possibly conceal the effects of this bias on the index number for that date, but unless quantity changes offset the changes due to differing price trends the long-run tendency would be as indicated.

The conclusion from this accords with that reached by Fisher, that weights should be based upon both base year and given year values. As applied to the measurement of price changes over a period of years, weights should presumably be averages of values at the beginning and end of the period, unless weights are changed from year to year. To employ as weights values prevailing at any single date is to introduce a persistent bias which will distort comparisons both backward and forward in time. The degree of distortion depends upon the degree of difference between the trends of the commodity prices employed and upon the degree of difference in quantity trends. These differences, for the period 1896-1913, doubtless account for the consistently higher values of the weighted measures. It is probable that similar differences in trends will develop during the period of relative stability which began in 1922.

In view of this fact, the practice of basing weights upon the most recent quantity and value figures available provides no solution of the weighting problem, if comparison over a number of years be sought. Comparison of recent years are presumably more accurate, of course, if recent weights be employed.

We may note in the above tables the close agreement between the Bureau of Labor Statistics index number and weighted geometric means of price relatives. In making this comparison it should be remembered that the constituent commodities are the same, with minor exceptions, and that the weights employed in the weighted index numbers constructed in the present study do not differ materially from those employed in constructing the index of the Bureau of Labor Statistics.

The most erratic of the index numbers are the chained arithmetic means of link relatives during the third period. Both weighted and unweighted measures of this type show excessively high values during the years following 1916. In contrast, the chained medians give results for the third period very close to those given by the Bureau of Labor Statistics index and the weighted geometric means.[1]

[1]The various results presented above and in the Appendix make it possible to test a statement made by Edgeworth (Second Memorandum on *Variations in the Value of Money*; reprinted in *Papers Relating to Political Economy*, Vol. I, p. 330) that "the Median seems to keep closer to the Geometric (mean) than to the Arithmetic (mean)." If this were so it would accord with the suggestion made by Edgeworth and endorsed by other economists that price relatives tend to group themselves according to a logarithmic normal law, a subject which will receive some attention in a later section of this volume. In all, we have 136 distributions in which the location of geometric means, arithmetic means and medians may be compared. In 57 of these distributions the median is closer to the arithmetic average, in 79 closer to the geometric. (In making this comparison, the original averages of link relatives, before chaining, have been employed.) This accords with Edgeworth's statement, though it is clear that the relationship is not an invariable one. It does not appear to prevail in the distributions of fixed base relatives, for the median was closer to the arithmetic than to the geometric mean in 38 out of 70 such distributions. In 48 out of 72 distributions of link relatives the median was closer to the geometric than to the arithmetic mean. (Six duplicated distributions have been omitted in arriving at the total of 136, given above.)

A somewhat similar point, dealing with the relations between the arithmetic and geometric means and the mode, has been made by Wesley C. Mitchell. Dr. Mitchell gives as one of the advantages of geometric means that "they are likely to be nearer the modes of the distributions they represent than are arithmetic means." (*The Making and Using of Index Numbers*, Bulletin 284, U. S. Bureau of Labor Statistics, p. 71.) The results now in hand permit this statement to be tested. Using the computed modes

The true story of wholesale price changes from year to year during the period from 1890 to 1926 is told by the frequency distributions to which these various index numbers relate and in terms of which they must be interpreted. The averages which describe the central tendencies of these distributions provide a condensed account of one phase of the price changes which interest us.

The reason for the changes in the price level which are reflected in the shifts in these central tendencies has been a subject of some controversy, but it is not a matter which concerns us at present. We may assume it to be due to a single force or combination of forces. All prices are subject to the action of this force, but all are not equally affected by it. Some prices are rendered relatively inert by contract or custom, while others are peculiarly sensitive to the action of a general price-raising or price-lowering force. It is the failure of prices to change in the same proportion, and the presence of many specific price-making factors affecting individual commodities, that generate the problems of internal instability which are discussed below.

Our immediate problem, the measurement of changes in the general level of prices, is affected by these individual variations. Because of the differences between individual price changes, measures of central tendency are subject to some degree of error when computed from a sample and assumed to apply to the general population of prices. The size of this sampling error is a consideration of some importance in the selection of an index number, for the reliability of a given index number depends in part upon the magnitude of this error.

§ Reliability of Index Numbers[1]

It has been possible, from the results of the present inquiry, to estimate the standard errors of most of the index numbers represented

in this comparison, we find practical equality between the results for the pre-war years for both fixed base and link relatives, but during the period 1914-1926 the geometric mean is closer to the mode than is the arithmetic mean in five-sixths of the distributions studied. During periods of rapid price rise there appears to be a pronounced tendency of the type suggested by Dr. Mitchell, but no such tendency is apparent at other times.

[1]There has been some debate concerning the application of the calculus of probabilities in the analysis of prices in combination, particularly in reference to the interpretation of index numbers. Recent opinions on this subject are summarized in "The Element of Probability in Index Numbers," by F. Y. Edgeworth (*Journal of the Royal Statistical Society*, Vol. 88, 1925, pp. 557-575). Professor Edgeworth points out that the role of probabilities in the construction of index numbers of prices is implicitly recognized when it is admitted, as all authorities admit, that sampling plays a part in the determination of such index numbers.

above. This has been done, for unweighted arithmetic and logarithmic (geometric) means, by the application of the usual formula:

$$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

It has been recognized in applying this formula that the results secured are only approximations to the measures desired, but the approximation is sufficiently accurate for the purpose in mind, which is the comparison of measures relating to different index numbers computed from the same data. The use of this formula involves, of course, the assumptions that a random sample has been chosen, that the original observations are uncorrelated, and that the number of observations is sufficiently large to justify the use of the observed standard deviation in place of the standard deviation of the entire population. None of these conditions is fully satisfied in dealing with commodity prices. Reference is made below to the question of intercorrelation. In comparing different measures computed from the same original observations it may be ignored.

The standard errors of the weighted means are affected by the weights employed. Bowley has derived the following formula for the computation of such errors:

$$\sigma_{WM} = \frac{\sigma}{\sqrt{N}} \sqrt{1 + \frac{\sigma^2_W}{\bar{w}^2}}$$

(where σ_W represents the standard deviation and $\bar{w}$ represents the mean of the weights). As Professor Bowley points out, this formula must be applied with some reservations, but it probably provides reasonable estimates of the errors involved.[1]

The geometric means have all been computed from frequency distributions of logarithms of price relatives. Their standard errors, which were originally computed in logarithmic terms, have been expressed in natural form as percentages of the corresponding geometric means. To secure comparability the standard errors of arithmetic means have also been expressed as percentages of the averages to which they relate. All these measures of reliability have been summarized in the following table.

[1]Bowley has dealt with this subject in *Elements of Statistics* (4th edition) pp. 316-326, and in "The Measurement of the Accuracy of an Average," *Journal of the Royal Statistical Society*, Vol. 75 (1911) pp. 77-88.

This formula is applied for the purpose of securing approximate measures of the sampling errors to which the various weighted averages are subject. It may be used, says Bowley, when the weights are known and are not subject to error. This condition is not entirely fulfilled in the present instance. The abnormal distribution and wide variation of the weights furnish additional reasons for not accepting the measures of error given by this formula as numerically accurate. These measures may, however, be accepted as estimates sufficiently accurate for the comparisons here to be made.

TABLE 95

MEASURES INDICATING THE SAMPLING RELIABILITY OF VARIOUS INDEX NUMBERS, BY YEARS[1]

(Standard errors of arithmetic and geometric means, expressed as percentages of the corresponding averages.)

(1) Year	(2) No. of price series	(3) Fixed base relatives, Unweighted, arithmetic	(4) Fixed base relatives, Unweighted, geometric	(5) Fixed base relatives, Weighted, arithmetic	(6) Fixed base relatives, Weighted, geometric	(7) Link relatives, Unweighted, arithmetic	(8) Link relatives, Unweighted, geometric	(9) Link relatives, Weighted, arithmetic	(10) Link relatives, Weighted, geometric
1891	195					.94	.94	1.83	2.02
1892	195	.77	.81	1.38	1.39	.77	.81	1.38	1.39
1893	195	1.16	1.13	2.44	2.34	.92	.88	1.65	1.58
1894	195	1.21	1.32	2.41	2.56	.80	.83	1.50	1.52
1895	195	1.36	1.35	3.23	2.80	.98	.96	2.02	1.87
1896	195	1.49	1.63	3.07	3.06	.94	1.03	1.71	1.87
1897	195	1.39	1.54	2.21	2.50	1.14	1.10	1.80	1.86
1898	195	1.50	1.53	2.44	2.57	.86	.83	1.39	1.48
1899	195	1.61	1.67	3.23	3.11	1.26	1.10	2.27	2.01
1900	195	1.67	1.76	3.07	3.06	.89	.87	1.79	1.61
1901	195	1.75	1.78	2.96	2.99	.93	.90	1.48	1.52
1902	195	1.78	1.82	3.45	3.40	.89	.93	1.61	1.64
1903	205	.78	.84	1.71	1.81	.78	.84	1.71	1.81
1904	205	1.20	1.24	2.61	2.66	.85	.89	1.83	1.92
1905	205	1.30	1.30	2.50	2.54	.67	.70	1.32	1.37
1906	205	1.43	1.39	2.36	2.37	.75	.75	1.47	1.44
1907	205	1.46	1.42	2.28	2.96	.73	.76	1.00	1.06
1908	205	1.32	1.42	2.25	2.41	.92	.95	1.54	1.62
1909	205	1.40	1.46	2.54	2.61	.77	.74	1.45	1.42
1910	205	1.77	1.63	2.97	2.91	.78	.76	1.53	1.48
1911	205	2.11	1.82	2.75	2.76	1.02	.97	1.70	1.63
1912	205	2.01	1.72	2.52	2.60	.74	.77	1.36	1.36
1913	205	1.71	1.63	2.59	2.65	.79	.83	1.63	1.57
1914	391	.66	.61	.92	.96	.66	.61	.92	.96
1915	391	3.26	1.34	2.82	1.65	1.94	1.13	1.82	1.38
1916	391	4.66	1.66	2.95	1.91	1.27	1.03	2.12	1.79
1917	391	3.59	1.77	2.99	2.64	.98	1.03	1.60	1.61
1918	389	2.82	1.64	2.50	2.38	1.00	1.04	1.77	1.86
1919	391[2]	1.64	1.38	2.14	2.25	1.23	1.24	1.56	1.55
1920	391	1.68	1.66	2.64	2.84	1.24	1.18	2.10	2.05
1921	391	1.65	1.75	2.76	3.08	1.30	1.37	2.35	2.40
1922	391	1.46	1.56	2.40	2.74	.99	.93	1.67	1.54
1923	390	1.48	1.59	2.45	2.82	.73	.72	1.44	1.44
1924	390	1.52	1.58	2.42	2.74	.73	.66	1.08	1.08
1925	387	1.36	1.41	2.12	2.13	.78	.68	1.82	1.50
1926	385	1.44	1.48	2.35	2.41	.57	.58	1.11	1.17

[1]The bases of the fixed base relatives in the three periods are average prices in 1891, in 1902, and in 1913
[2]389 link relatives were employed.

In comparing these results for the different classes of index numbers an essential difference between the weighted and the unweighted measures should be borne in mind. The standard errors of the weighted means tend, in general, to be larger than the standard errors of the unweighted means. The difference between the errors of weighted and unweighted means is likely to be material when the dispersion of the weights is great, as it is in the present case. While a recognition of this difference is important in comparing the weighted and unweighted index numbers, the fact that the error of the weighted index is greater in a given case does not necessarily mean that the unweighted measure is preferable. The ultimate standard for the weighted mean, the standard in terms of which sampling fluctuations are judged, is the *weighted* mean of the entire population from which the sample is drawn. The ultimate standard for the unweighted mean is the *unweighted* average of the entire population. If the former standard is the one we wish to approach, the weighted average of a sample may do it better than the unweighted, though the standard error of the weighted mean be greater than that of the unweighted. This same point holds in respect to the other averages compared. The question as to which average we would use if we were computing it from the entire population of price relatives is thus not answered by a comparison of standard errors. Sampling stability is, however, one important criterion of excellence in an index number, and measures of sampling reliability possess considerable practical and theoretical importance.

The figures in Table 95 may be used in comparing, in respect to sampling stability, unweighted and weighted averages, averages computed from fixed base and link relatives, and averages computed from relatives in logarithmic and in natural form.

The preceding discussion touched upon the first of these comparisons. We should expect the unweighted average to be less subject to sampling fluctuations than the weighted, and this is borne out by the results. When 136 different pairs of index numbers, each pair differing only in the matter of weighting, are compared, the unweighted average is found to have the smaller standard error in 131 cases. The only exceptions are arithmetic averages of link relatives for the year 1915, and arithmetic averages of fixed base relatives for the years 1915-1918. In these years the weighted average, in spite of its being subject to special sampling errors because of the use of widely dispersed weights, was liable to smaller sampling fluctuations than the unweighted. In years of exceptional price movements the simple arithmetic average of price relatives is particularly subject to sampling errors, because of the very wide dispersion of the unweighted relatives.

As we should expect, averages of link relatives are marked by smaller sampling errors than are averages of fixed base relatives. This is true in all of the 128 cases in which direct comparison is possible. This merely confirms the well-established principle that measures of year-to-year price changes are more accurate than measures of price changes between more widely removed dates.

The comparison of logarithmic and natural measures, after they have been reduced to comparable terms, gives a net result slightly in favor of the arithmetic figures. It is possible to make 136 direct comparisons between measures of reliability for averages which differ only in the form of the relative employed in their computation (i. e. logarithmic or natural). In 72 cases the standard error of the arithmetic measure is less than that of the logarithmic measure, in 58 cases the logarithmic mean is the more reliable, while in 6 cases the two are equal. This enumeration takes no account of the magnitude of the differences between the measures of reliability. If this be done, the odds swing somewhat in favor of the logarithmic measures, even though they be slightly behind on the above count. In years of extreme price disturbance the arithmetic measures are subject to wide sampling fluctuations, while the logarithmic measures are much more stable. In 1916 the standard error of the unweighted arithmetic mean of fixed base relatives was equal to 4.66 per cent of the average; the standard error of the unweighted geometric mean was only 1.66 per cent of the average. In no case is there any difference of this magnitude in favor of the arithmetic mean. Over the six year period from 1915 to 1920, which was marked by great price increases, the logarithmic measures were more reliable 17 times out of 24. The conclusion to which these comparisons lead is that during normal times there is little to choose between the arithmetic and logarithmic measures of price change in the matter of sampling reliability, but that the arithmetic measures are much less reliable during periods of extreme disturbance.

Averages of the standard errors of the different index numbers for the periods 1891-1913 and 1914-1926 are shown in the following table. These are expressed as percentages of the averages to which they refer.

TABLE 96

AVERAGE STANDARD ERRORS OF VARIOUS INDEX NUMBERS

(1) Type of index number	(2) Average standard error, 1891-1913 (1892-1913 for fixed base index numbers), as percentage of mean (based on 195-205 price quotations)	(3) Average standard error, 1914-1926, as percentage of mean (based on 385-391 price quotations)
Unwtd. arithmetic, fixed base relatives	1.46	2.09
Unwtd. geometric, fixed base relatives	1.46	1.49
Wtd. arithmetic, fixed base relatives	2.59	2.42
Wtd. geometric, fixed base relatives	2.64	2.35
Unwtd. arithmetic, link relatives	.87	1.03
Unwtd. geometric, link relatives	.87	.94
Wtd. arithmetic, link relatives	1.61	1.64
Wtd. geometric, link relatives	1.61	1.56

These figures give a fairly accurate indication of the sampling reliability of these different index numbers. In comparing these averages it must be remembered that the standard errors of the fixed base measures tend to increase somewhat as the base becomes farther removed, because of the secular increase in dispersion. This does not invalidate the comparison of the various measures relating to fixed base relatives over a given period. Fixed base measures relating to different periods are not directly comparable, however, nor are link and fixed base measures. Again, we must note in interpreting these figures that the number of quotations included is one of the factors upon which the standard error of the mean depends. The figures in column (3) above are based upon samples each consisting of 385 to 391 observations; the figures in column (2) relate to samples of from 195 to 205 observations. If the dispersion were constant and the degree of intercorrelation were the same in the two groups,[1] the errors of averages based upon 390 measures would be about two-thirds as great as the errors of averages based upon 200 observations. Since no account of intercorrelation has been taken in these calculations, the larger errors of the later averages are due to the wider dispersion of prices during the war years.

The identity of the results for arithmetic and geometric measures during the years from 1891 to 1913 is noteworthy. The standard errors of arithmetic and geometric averages of unweighted link relatives during this period averaged .87 of 1 per cent. For unweighted fixed base relatives the standard errors averaged 1.46 per cent in both cases. The standard errors are greater for weighted averages, but again there is no marked difference between the measures relating to arithmetic and geometric averages.

The results for the years 1914-1926 indicate that under the price conditions of this period the standard errors of unweighted averages of link relatives computed from about 390 cases amounted to about 1 per cent of the means to which they related, while the standard errors of weighted averages of link relatives slightly exceeded 1.5 per cent. In each case geometric averages had somewhat lower standard errors than arithmetic averages. Standard errors of averages of fixed base relatives, which ran from 1.49 per cent for unweighted geometric measures to 2.42 per cent for weighted arithmetic averages, were abnormally high for the period covered, because of the exceptionally wide dispersion of prices.

[1]In the present case it is not true that the degree of intercorrelation is the same in the two groups. Many of the series added by the Bureau of Labor Statistics for the period beginning in 1913 represent duplications of series previously used. Thus four series of wholesale prices of wheat were added to the one series employed before 1913, and two series of cattle prices were added to the two series entering into the earlier calculations. The correlation between these different series relating to the same commodity is not perfect, hence the addition of the new series adds something to the reliability of the index number. But the additions do not have the same effect, in reducing the sampling error, as would an equal number of price series which were quite independent of those previously used.

It will, in general, be true of index numbers of prices that the reduction in the sampling error with an increase in the number of commodities included will be less than that which the theory of sampling would lead one to expect. No general rule can be laid down, since the effect of an increase in the number of commodities in a given case will depend upon the degree to which these duplicate quotations previously included. Professor Fisher has suggested that if account be taken of weights, instead of number of commodities, a closer approach to results consistent with probability theory will be secured. (*The Making of Index Numbers*, pp. 336-340.)

Under conditions of normal dispersion, over a corresponding period, these would be about two-thirds as large.[1]

In computing the various measures of reliability given above use has been made of the customary formula for the standard error of a mean. One of the conditions necessary to the application of this formula is that the various observations shall be independent of each other. This condition is not fulfilled perfectly in combining prices. It is obvious, for example, that the quotations on the various grades of wheat are correlated, and that the price of steel billets is not independent of the price of pig iron. Professor A. L. Bowley has recently completed a comprehensive study in which he has sought to determine the precise degree of intercorrelation prevailing between wholesale commodity price series. He has found that the degree of intercorrelation is not as great as is commonly assumed. He is able to reach quite definite conclusions as to the number of independent observations to which the recorded quotations employed in the Sauerbeck-Statist index are equivalent. The 45 commodity price series actually employed in constructing the index are equivalent to 39.5 independent price series, each with the standard deviation typical of the 45. But since 10 of these 45 series are themselves averages of 10 pairs of original quotations, allowance is made, in another calculation, for the presence of these additional series. The 55 series of price quotations are the equivalent, according to Bowley's calculations, of 43.5 uncorrelated commodity price series, each with the standard deviation typical of the 55.

These conclusions are based upon the hypothesis that the secular movements of the various price series are independent. The adjustments noted above are intended as corrections for correlation between short period variations of these price series.

In tracing relations among the 45 primary price series studied, Bowley found only 52 cases (out of 990 possible combinations) in which the correlation was as great as .30. The quantities correlated were derived by expressing the price relative of a given commodity in a given year as a percentage of the general price index for that year. When the effects of rectilinear trends upon the individual commodity price series were eliminated, only 35 correlations reached or exceeded a value of .30. (Although the full 990 coefficients were not computed, the procedure employed probably resulted in the finding of most, if not all, of the significant correlations.)[2]

[1]There is a sharp distinction, of course, between the "sampling error" to which the above measures apply and the "instrumental error" with which Professor Irving Fisher deals in *The Making of Index Numbers* (pp. 225-229). Professor Fisher is concerned with the degree of mathematical accuracy which may be secured in handling certain price and quantity data. He concludes, after comparing the results secured by the application of the thirteen most accurate formulas to the same data, that the "probable error" involved seldom reaches one-tenth of one per cent, and is generally very much smaller than this figure. This measure of Fisher's does not relate to the error involved in generalizing the results obtained from a sample, and does not stand in any simple relation to the sampling errors given in Tables 95 and 96.

[2]This study is described in "The Influence on the Precision of Index Numbers of Correlation between the Prices of Commodities" in the *Journal of the Royal Statistical Society*, Vol. 89, Part II (1926) pp. 300-319. The investigation covered the period

Without making a study similar to that of Bowley it is impossible to state precisely the degree of intercorrelation between the price series utilized in the present investigation. It seems reasonable, upon an inspection of the figures, to assume that approximately the same degree of intercorrelation found in the Sauerbeck series prevailed among the price series entering into our pre-war calculations. There seems, however, to be considerably more intercorrelation and duplication in the 390 series used in calculations for the years since 1913. It may be estimated that the price series covering the years 1890-1913 (varying from 195 to 205 in number) are the equivalent of about 160 uncorrelated series, and that the series available for the years 1914-1926 (varying from 385 to 391) are the equivalent of about 270 uncorrelated series. (Some account has been taken, in arriving at these estimates, of the differences in the markets from which quotations are drawn.) Upon the basis of these estimates the standard errors of the various index numbers relating to the pre-war years should be increased by about 12 per cent, and the standard errors for the years from 1914 to 1926 should be increased by about 20 per cent.

It is possible to compare one of the present results with a similar figure derived by Bowley. Bowley finds that the probable error of an unweighted geometric mean of relatives computed from the Sauerbeck-Statist list of wholesale prices for the year 1913 (1901 being the base) was 2.25 per cent. (The probable error is here expressed as a percentage of the mean.) The probable error of the corresponding index for the United States for the year 1913 (on the 1902 base) was 1.22 per cent. Bowley's measure is derived, in this case, on the assumption that the price series employed are equivalent to 40 independent series, while the American figure is derived on the assumption that the 205 relatives are equivalent to 160 independent observations. Under these conditions, and assuming approximately the same degree of price dispersion in the two countries, the probable error of the American figure would be about half that of the British average. The actual measures are very close to this relation. (The difference of one year between the base periods would have no material influence upon the degree of dispersion.)

2. A Monthly Price Index: Changes in the Price Level Over Twelve-Month Intervals

In later sections dealing with the dispersion and displacement of prices use is made of monthly link relatives, each link covering a twelve-month period. That is, the price of a commodity in January, 1926, is expressed as a percentage of the price in January, 1925; the price in February, 1926, is expressed as a percentage of the price in February, 1925, and so on. These relatives may be

1867-1913. The results of an earlier study by Bowley, touching upon the same subject, are given in a memorandum of the London Cambridge Economic Service (*Special Memorandum No. 5*, February, 1924) "Relative Changes in Price and other Index Numbers."

used in constructing index numbers of prices. The indexes thus secured differ materially from those of the usual type, which measure changes in reference to a constant base. This method of measuring price changes was first suggested by A. W. Flux,[1] but has not been widely employed. It possesses certain distinct advantages, particularly in connection with the measurement of internal shifts in price relations.

Weighted geometric means of such relatives, computed from the prices of 100 commodities,[2] are plotted in Figure 24. This index covers the years 1920-1926. The wholesale price index of the United States Bureau of Labor Statistics has been put in the same form (i. e. each monthly value has been expressed as a percentage of the value for the same month during the preceding year) and carried back, by months, to 1901. It will be noted that there is a very close correspondence between the two sets of index numbers during the period covered by both. The index of the Bureau of Labor Statistics is shown in its original form (1913 = 100) as well as on the twelve-month link basis, to permit comparison.

The movements of the twelve-month link index differ from those of the fixed base index and require, of course, a different interpretation. The points at which plotted values of the link index lie upon the 100 line mark the dates when the price level was precisely the same as at dates twelve months preceding. A high point on this curve marks the date when the price level was at its maximum, in comparison with the level twelve months preceding. Thus a high value was reached in April, 1920. Until October, 1920, the index was above the values recorded twelve months earlier, but by smaller amounts than in April. The lowest point of the price index was reached in June, 1921. Not until May, 1922, was the price level back to that prevailing twelve months earlier. The index rose after June, 1921, because after that date the index was not as far below the figure for the twelfth month preceding as it was in June. Viewed in this light, the low point of that price cycle came in June, 1921, instead of in January, 1922, when the lowest value in reference to a fixed base was recorded.

This price level index traces out the major cyclical movements very clearly. The turning points precede, in general, those in the

[1] "The Measurement of Price Changes," *Journal of the Royal Statistical Society*, Vol. 84 (1921), pp. 167-190.

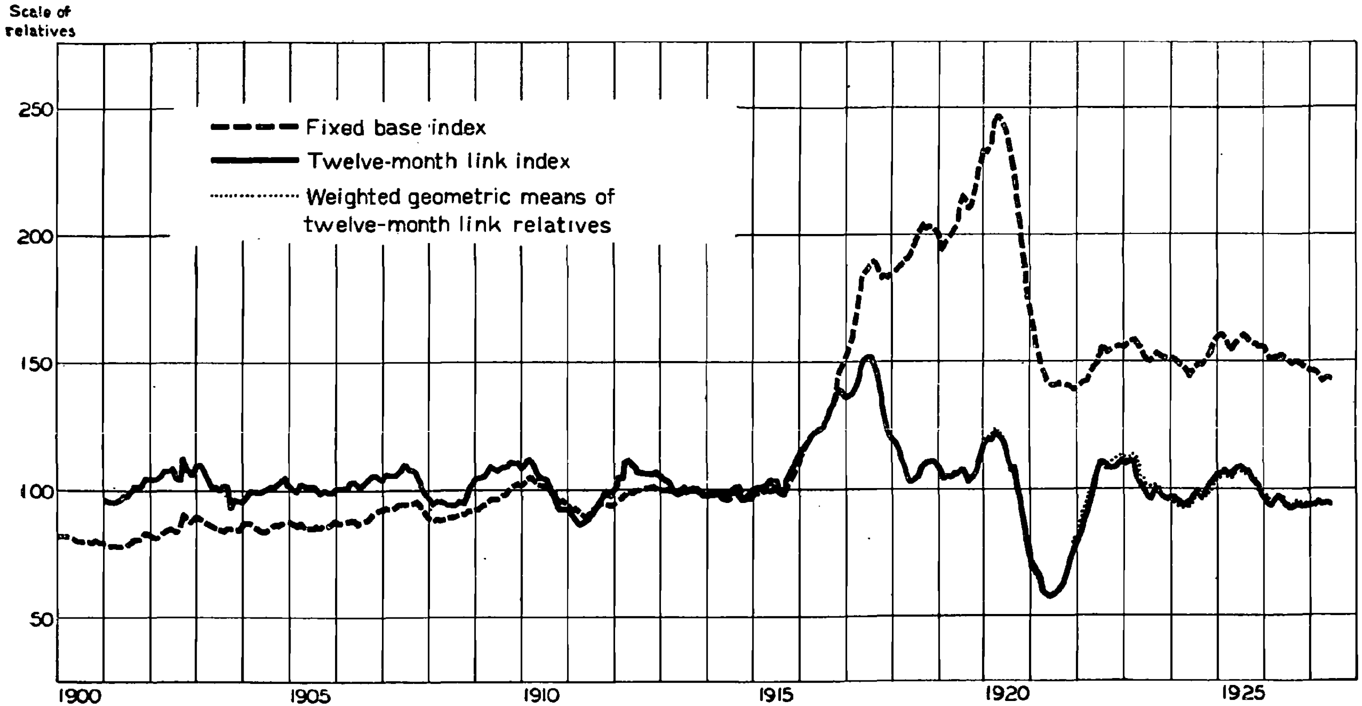
[2] For the list of these commodities, see p. 271. The monthly values of the index are given in Table 103.

FIGURE 24

FLUCTUATIONS IN WHOLESALE PRICES, BY MONTHS, 1900-1927.

Comparison of a Fixed Base Index and a Twelve-Month Link Index.

(The fixed base index is that of the United States Bureau of Labor Statistics. The base is 1913. The twelve-month link index covering the entire period is derived from the index of the Bureau of Labor Statistics. Weighted geometric means of twelve-month link relatives are plotted for the period 1920-1926.)



fixed base index of the usual type. This is clear from the following summary.

TABLE 97

COMPARISON OF TURNING POINTS, UNITED STATES BUREAU OF LABOR STATISTICS INDEX (1913=100) AND TWELVE-MONTH LINK INDEX

(1) Period number[1]	(2) Turning points: Fixed base index	(3) Turning points: Twelve-month link index	(4) Number of months by which link index precedes (—) or lags behind (+) fixed base index
7 (low)	July, 1901	April, 1901	— 3
8 (high)	Oct., 1902	Oct., 1902	0
9 (low)	July, 1904	Oct., 1903	— 9
10 (high)	Oct., 1907	July, 1907	— 3
11 (low)	Feb., 1908	Feb., 1908	0
12 (high)	April, 1910	March, 1910	— 1
13 (low)	June, 1911	April, 1911	— 2
14 (high)	Sept., 1913	May, 1912	—16
15 (low)	Nov., 1914	Nov., 1914	0
16 (high)	Sept., 1918	July, 1917	—14
17 (low)	Feb., 1919	Sept., 1919	+ 7
18 (high)	May, 1920	April, 1920	— 1
19 (low)	Jan., 1922	June, 1921	— 7
20 (high)	April, 1923	Jan., 1923	— 3
21 (low)	June, 1924	April, 1924	— 2
22 (high)	March, 1925[2]	June, 1925	+ 3

[1]The numbers refer to the periods defined on p. 81.
[2]This value was 161.0. The real turning point came, however, in August, when a second high of 160.4 was recorded. The turn in the link index came two months before the latter date.

There is no necessary relationship which would cause the turns in the twelve-month link index always to precede the turns in a fixed base index, but this will generally be so. This is because the rate of advance (or of fall) in the fixed base index of prices is retarded before the maximum (or minimum) value is reached. Only under rather exceptional conditions will the twelve-month index lag behind the fixed base index in its major turns.[1]

The reference of price changes to a date twelve months before has certain advantages. If there were seasonal changes in the price index (of which there is no clear evidence) they would be eliminated. Again, the values of such an index fluctuate about the base line (i. e. the 100 line). The effect of a consistent trend is not, of course, eliminated, but it appears in a form somewhat different from that to which we are accustomed. The effect of an upward trend on a

[1]This will happen when a minor movement (upward or downward) in the fixed base index has occurred during the twelve months preceding the major turn, this earlier movement being in the same direction as the ensuing major movement, and at a higher rate than that which follows the major turn.

twelve-month index of this sort would be to increase the number of entries above 100, intensifying and lengthening the swings of the index above the base line. A downward trend would have the reverse effect.

An index of this type cannot, of course, replace those of the familiar fixed base type, but it is useful in presenting price fluctuations in a somewhat different light. In its construction it accords with the current practice of comparing prices at a given date with prices prevailing at a date twelve months earlier. And, as will appear later, it is a useful companion measure to certain measures of dispersion and displacement which appear to be most significant on a twelve-month basis.

The measures discussed in the preceding pages relate to a first and extremely important aspect of price instability—instability of the general level of prices. There have been presented different types of index numbers which measure, with varying degrees of accuracy, the changes through which the level of wholesale prices has passed since 1890. Certain points of some technical interest, relating to weighting and to the reliability of different types of index numbers, have been noted in passing. It has not been the purpose of this section, however, to discuss the technique of index number construction, and no attempt has been made to deal with the various "crossed" formulas derived by Professor Irving Fisher.

But it is an inadequate survey of the price problem which contents itself with the information concerning price changes which is yielded by index numbers of the type given above. These are merely averages of diverse distributions of price relatives, and they relate only to one aspect of price behavior. Other important aspects are still to be described. When this has been done, and appropriate measures have been computed, the relation of instability in the price level to other types of price instability may be considered.

IV Price Dispersion[1]

Of those aspects of price behavior which are not reflected in the movements of an index number of the orthodox type, probably

[1] I regret that I was not able to include in this section the results secured by Dr. Maurice Olivier in his study of price dispersion (*Les Nombres Indices de la Variation des Prix*, Paris, Giard, 1927, pp. 90-98.) His book came into my hands after the text of this volume had gone to the printer. This study of price dispersion, based upon the movements of the price series used in the construction of the Federal Reserve Board's index of wholesale prices for France, covers the years 1920-1924, by months. Arithmetic and logarithmic measures of dispersion are employed. Dr. Olivier finds, during this period, a tendency toward a positive relationship between changes in the price level in France and the dispersion of price relatives in natural form.