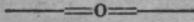# THE REVISION
OF THE
PRICE INDEX NUMBERS

By T. Sheng

Part I.   The Index Numbers of Wholesale Prices
in Shanghai

Part II.   The Index Numbers of Import and Export
Prices in Shanghai

(With Appendices)

FOREWORD

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The course of economic development, maintains Hildebrand, may be exemplified by the steps of evolution in the mechanism of exchange. First comes the barter stage; then the use of money as a medium of exchange; then the period of extensive use of credit which we witness today among the most highly industrialized countries of the world. While it remains to be proved that the present economic world has completely deprived itself of the color of barter system, the absolute pre-dominance of monetary and credit system in the existing economic régime is, indeed, undeniable. Modern economic life, therefore, resolves itself largely into a matter of prices.

Fluctuations in prices are subject to two sets of influences: Changes on the side of commodities affect prices relatively to one another, and those on the side of money affect the general price level. A rise in the general price level means a fall in the purchasing power of money. Conversely, a fall in the general price level is the same as a rise in the purchasing power of money. The essential purpose in the construction of index numbers is to show the relative changes in the value of money in terms of a general aggregation of commodities.

Index numbers were first conceived in the middle of the eighteenth century. It is only during the last thirty years, however, that they begin to receive public interest and recognition. This new development is of course partly due to the advance made in statistical methods within the last few decades, but mostly due to the recognition of the growing importance in the use of index numbers as a result of present-day violent changes in prices with their far-reaching consequences upon our economic system. That this is so may be clearly seen from the fact that many publications on the technique and science of the making of index numbers appear usually after the discovery of gold mines, the issue of inconvertible paper currency, or the breaking out of wars.

The price index numbers compiled by this Commission are the continuation of those originally undertaken by the former

Bureau of Markets of the Ministry of Finance. One is the wholesale price index number dated from September, 1919 and the other is the export and import price index numbers started with May, 1925. Both adopted February, 1913 as the base. While the period since the publication of these index numbers cannot be regarded as long, it has been a period of extreme fluctuations in prices, largely due to the rapid change in the relative value of gold and silver. The ratio of gold to silver was 1 to 34.19 in 1913 and advanced to 1 to 11.10 in February, 1920. But with the rapid fall in the price of silver the ratio dropped to 1 to 25.60 in 1921, then 1 to 29.38 in 1925, and finally 1 to 78.58 in February, 1931. Such rapid changes in the price of silver have never been precedented. China, being now the only important country remaining on a silver basis, has been seriously affected by this violent fluctuation in the form of rapidly advancing prices.

Thus the need for studying index numbers has been gradually realized in this country. Following the publication of our price index numbers, the Bureau of Reconstruction of Kwangtung Province has compiled an index number of whole-sale prices in Canton and the Committee on Social and Economic Research of Nankai University, Tientsin, publishes a similar one for North China. The same endeavour has been undertaken by the Ministry of Industries in Nanking, Hankow and Tsingtao. Aside from these, there are also several indexes on retail prices and on the cost of living. In view of the difference in the choice of base periods, direct comparison between these index numbers is therefore well-nigh impossible. A revision of the index numbers of this Commission, with the primary object to replace the old base by a new, thus becomes imperative. This opportunity is also taken to effect the adoption of more suitable formulae, and certain improvements in the selection of commodities and the methods of classification.

Since the inception of these index numbers, assistance has been received from various eminent economists both in this country and abroad. To Professor Irving Fisher, of Yale University, Dr. L. Ho, Dr. D. K. Liu, Mr. C. Yang, and Dr. K. W. Shaw, a special debt of gratitude is due for their advice and criticism. My appreciation is due also to Mr. T. K. Pan, and Dr. J. C. Chao for their valuable services and constructive suggestions. In connection with the actual work of this revision,

Mr. T. H. Sun is responsible for the investigation and compilation of the wholesale price index numbers in Shanghai and the translation of Part I of this report, and Messrs. T. W. Loh and P. K. Jui, the investigation and compilation of the export and import price index numbers and the translation of Part II of this report.

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Part I

The Index Numbers of Wholesale

Prices in Shanghai

I. Base Period

The purpose of the price index numbers is to measure the relative changes in the general price level. It is, therefore, necessary to select the prices of some definite period as the base with which to compare the price changes at different periods. The price quotations thus chosen are called the basic prices; and the period from which the basic prices are selected is termed the base period.

In the previous index numbers of wholesale prices in Shanghai, February, 1913 was adopted as the base period with the object of facilitating direct comparison with many index numbers on the 1913 base in foreign countries. Since its first appearance ten years ago, there have been considerable changes in the field of production and consumption, rendering the original base period too remote to afford accurate comparison with the present-day conditions. An added drawback lies in that, owing also to the difficulty in collecting the back quotations in constructing the previous index numbers, we were obliged to take the prices of one single month as the basic figures. It is obviously necessary, therefore, to change the base to a more recent period in order to be of more practical value and to adopt yearly average quotations as the basic prices in order to mitigate the undue influence of seasonal factors contingent to a short period.

Although 1913 is still used as the base period of many index numbers in foreign countries, the well-known index compiled by the U. S. Bureau of Labor Statistics has in September, 1927 changed its base to 1926. Following this example are the index numbers compiled by Professor Irving Fisher, by the Dominion Bureau of Statistics of Canada, and by the Department of Statistics of Finland. In this country, the 1926 base have been used in the index number of commodity prices at wholesale in

North China compiled by the Committee on Social and Economic Research of Nankai University, Tientsin, and the index number of the cost of living in Shanghai compiled by this Commission. To facilitate comparison, the revised index number of wholesale prices in Shanghai also adopts 1926 as its base and takes the yearly average of prices in 1926 as the basic prices. Just as 1913 is adopted for purpose of comparing the price changes subsequent to the World War, so the year of 1926 which is one year prior to the establishment of the capital of the National Government at Nanking, marks the transition from the old régime to the new.

II. Classification and Commodities

Commodities are generally classified either according to their nature, uses, sources of production, or stage of manufacture to suit the purpose for which the index numbers are intended. The commodities contained in the making of the wholesale price index number in Shanghai are divided into eight groups, some according to their nature, such as Metals and Chemicals, and some according to their uses, such as Cereals, Other Food Products, Textiles, Fuel and Building Materials. Except for some minor changes this classification has been retained in the present revision. However, the original heading, Industrial Materials, has been replaced by Chemicals since the commodities listed therein are practically all chemicals. The four sub-headings, Fuel, Building Materials, Industrial Materials, and Sundries originally included under Miscellaneous Goods now stand as four separate groups so as to avoid averaging of averages.[1]

Many alterations regarding to commodities included in the price table have become necessary in view of the changes in the local consumption habits and production and trade conditions. The revised table consists of 119 commodities and 155 quotations, an increase of 8 quotations over the original 147. Expressed in percentages, Cereals occupy 14.2%, Other Food Products and Provisions 20%, Textile Fibres and Manufactures thereof 24.5%, Metals 7.7%, Fuel and Lighting 8.4%, Building Materials 7.1%, Chemicals and Preparations thereof 6.5% and Miscellaneous Goods 11.6%. Should the quotations be classified

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1. Franklin L. Ho: "Prices and Price Indexes in China," Chinese Economic Journal, Vol. 1, No. 5, May, 1927, pp. 429-463.

| Groups | | No. of Commodities | Commodities and Quotations | | | | | Quotations in the New Index | | | | Quotations in the New Index Classified according to the Stage of Manufacture | | | | Quotations in the New Index Classified according to their Sources | | |
| New Index | Old Index | | New Index | | Old Index | | Those also found in the Old Index | Those not found in the Old Index | Those also found in the Old Index but with different Brand or Grade | Total | Raw Materials | Producers' Goods | Consumers' Goods | Total | Domestic Goods | Imported Goods | Total |
			No. of Quotations	Percentage	No. of Quotations	Percentage											
I. Cereals	I. Cereals	9	22	14.2%	14	9.5%	11	11	—	22	9	—	13	22	17	5	22
II. Other Food Products & Provisions	II. Other Food Products	27	31	20.0%	26	17.7%	17	11	3	31	4	—	27	31	20	11	31
III. Textile Fibres and Manufactures thereof	III. Textiles	24	38	24.5%	27	18.3%	14	18	6	38	8	12	18	38	23	15	38
IV. Metals	IV. Metals	12	12	7.7%	11	7.5%	5	5	2	12	4	7	1	12	2	10	12
V. Fuel and Lighting	V. Miscellaneous Fuels	9	13	8.4%	12	8.2%	4	3	6	13	6	2	5	13	4	9	13
VI. Building Materials	Building Materials	11	11	7.1%	14	9.5%	7	2	2	11	5	6	—	11	6	5	11
VII. Chemicals & Preparations thereof	Industrial Materials	10	10	6.5%	21	14.3%	5	3	2	10	—	10	—	10	1	9	10
VIII. Miscellaneous	Sundries	18	18	11.6%	22	15.0%	13	4	1	18	6	6	6	18	11	7	18
Total		119	155	100.0%	147	100.0%	76	57	22	155	42	43	70	155	84	71	155
Percentage							49.0%	36.8%	14.2%	100.0%	27.1%	27.7%	45.2%	100.0%	54.2%	45.8%	100.0%

according to the stage of manufacture, the raw materials occupy 27.1%, producers' goods 27.7% and consumers' goods 45.2%. Again, should they be grouped according to the sources of production, then domestic products occupy 54.2% while imported goods amount to 45.8%.

It has been our practice in the compilation of index numbers to use the wholesale prices ruling on the 15th of each month as the monthly quotations. The same method is still maintained under the revision. These price quotations are, as usual, obtained through special investigation undertaken by this Commission. The preceding table outlines the contents of the revised series as compared with the original.

III. Formula

The simple arithmetic average was formerly employed in computing the wholesale price index numbers in Shanghai. Under this method, the first process of computation is to express the prices of the given period as percentages of those of the base period: these percentages, known as price relatives, are then summed up and divided by the number of quotations to get the index number. Since no system of weighting based upon either production, consumption, or the trade volumes in apportioning relative importance to the various commodities has been used, this form of average is termed as simple or unweighted. Because of its simplicity and easy understanding this method is extensively used but its accuracy has been doubted by many statisticians. Hence, a more desirable one has to be sought. In measuring the general purchasing power of money, the weighted type is preferable whose computation, however, is not possible at present due to the lack of suitable materials in devising a proper system of weighting. We, therefore, have to be contented with the choice of the simple geometric average as the best for our purpose.

In computing index numbers by simple geometric average, the process for obtaining the price relatives is similar to that of simple arithmetic average, but the price relatives, instead of being added together and divided by the number of quotations, are multiplied together and the product is extracted to the nth root, n being the number of quotations contained in the index. The difference in the results thus obtained by the two methods, be it noted, is directly proportional to the difference in

the original figures. In case of small disparity between the original figures, the difference in the results arrived at by these two methods is negligible, for instance, the arithmetic average of 900 and 1,024 is 962, while their geometric average is 960 which is the square root of their product. But a great disparity obtains in case of figures having wide divergence such as 2 and 32, whose arithmetic average is 17 while their geometric average is only 8. In like manner, the results of index number obtained by the simple arithmetic and the simple geometric averages will not differ much when price changes are normal and moderate; but when prices show great upheaval and wide fluctuation, the index obtained by the simple arithmetic average, being subject to the influence of sharp-advancing prices, tends to be unduly high. The use of the simple geometric average is intended to overcome this drawback. For instance, commodity A advances in price tenfold, (from 100% to 1,000%) and commodity B drops in price to one tenth (from 100% to 10%). The proportional changes of these two commodities, being in opposite directions but to the same extent, remain the same, hence their geometric average is still $100(\sqrt{1,000 \times 10}=100)$, whereas the arithmetic average would show a result of 505 $\left(\frac{1,000+10}{2}=505\right)$.

The purpose in choosing a base is usually to facilitate comparison between prices of some previous period as a standard with those of a subsequent period. Conversely, one can choose the latter period as the base and compare it with the previous one. In other words, the results should show the same relative proportion by the reversal of the base periods. Suppose the price index of 1930 on the 1926 base shows a 100 per cent increase, then the 1926 price index on the 1930 base ought to show a 50 per cent drop. Consequently the index number on the 1926 base should be the reciprocal of that calculated on the 1930 base, while the product of these two indexes based on two different periods should be unity. Any formula which can stand this test is said to conform with the "time reversal test."[2] Unlike the simple geometric, the simple arithmetic average does not, however, meet this test as will be seen from the following.

If from 1926 to 1930 the price of flour increases from $4 to $6 per sack, and the price of egg advances from 2 cents to 5 cents per piece, then the index on the 1926 base by the simple

2. Irving Fisher: The Making of Index Numbers, pp. 64-65.

arithmetic average is 200 $\left(\frac{150+250}{2}=200\right)$, that is to say, the index is 100 per cent higher in 1930 than in 1926. By this plain reasoning the index for 1926 would drop by 50 per cent, if the year 1930 is taken as the base. But such is not the case and the index shows an upward bias of $3\frac{1}{3}$ per cent $\left(\frac{66\frac{2}{3}+40}{2}=53\frac{1}{3}\right)$. The product of the indexes with their bases reversed exceeds unity $\left(\frac{200}{100}\times\frac{53\frac{1}{3}}{100}=\frac{106\frac{2}{3}}{100}>1\right)$. This clearly demonstrates the unsuitability of the simple arithmetic with reference to the "time reversal test."

Let us now examine the result by the simple geometric average. If 1926 is taken as the base, the index for 1930 would be $\sqrt{150\times250}=193.65$ and if 1930 is taken as the base, then the index for 1926 would be $\sqrt{66\frac{2}{3}\times40}=51.64$, which is also the reciprocal of the index on the 1926 base $\left(\frac{1}{193.65}\times100=51.64\%\right)$. Furthermore, when the two index numbers secured with the bases reversed are multiplied, their product is unity $\left(\frac{193.65}{100}\times\frac{51.64}{100}=1\right)$. It can be seen that the simple geometric average does conform with the "time reversal test."

Some other points, of course, might be cited as the merits of the simple geometric average. But its labor of computation and unfamiliarity to the public has detracted it from wide use. As we are not confined to the study of averages, the above description goes far enough for the present purpose.[3]

Let the prices of the base period be represented by Po', Po'', Po''',........Po^n and those of any given period, by P$_1$', P$_1$'', P$_1$''',........P$_1^n$, the formulae adopted by the old and revised series are shown as follows:

1. The simple arithmetic method which was adopted by the old series.[4]

$$I = \frac{\dfrac{P_1'}{P_0'}+\dfrac{P_1''}{P_0''}+\dfrac{P_1'''}{P_0'''}+\cdots\dfrac{P_1^n}{P_0^n}}{N} = \frac{\sum\dfrac{P_1}{P_0}}{N}$$

3. Irving Fisher: The Making of Index Numbers, pp. 33-35, 62-72, 206-212.

4. Formula 1, in Fisher's: The Making of Index Numbers, Appendix V, p. 466.

2. The simple geometric method which is adopted by the revised series.[5]

$$I = \sqrt[n]{\frac{P_1'}{P_o'} \times \frac{P_1''}{P_o''} \times \frac{P_1'''}{P_o'''} \times \cdots \cdots \frac{P_1 n}{P_o n}}$$

5. Formula 21 in Fisher's "The Making of Index Numbers," Appendix V, p. 468. In utilizing the logarithms to compute the index, the formula becomes:

$$I = \text{Anti-log} \left(\frac{\text{Log} \frac{P_1'}{P_o'} + \text{Log} \frac{P_1''}{P_o''} + \text{Log} \frac{P_1'''}{P_o'''} + \cdots \cdots \text{Log} \frac{P_1 n}{P_o n}}{N} \right)$$

Part II

The Index Numbers of Import and Export
Prices in Shanghai

I. Base Period

The index numbers of import and export prices in Shanghai were first compiled in May, 1925. Similar to our index number of wholesale prices, February, 1913 was taken as the base period, but instead of the fixed base system, the chain system was adopted. In a fixed base, the prices of the base period are set down as 100. Those of all other periods, antecedent or subsequent thereto, are expressed in precentages to the prices of the base period. These percentages are then summed up and divided by the number of commodities to get the final index number. In the chain system, the prices of a given period are expressed in percentages of those of the one immediately preceding, and the prices of base period are directly taken as 100 only in calculating the index for the first period. To compute the index numbers for the second, third period, etc., the prices of the first, second period, etc., are taken as 100 respectively. The index numbers for different periods thus obtained are called link index numbers. Like links they can be joined together to form a chain by successive multiplication. For instance, if it is desired to join the link index of the third period to the base, it can be done by multiplying it with the link indexes of the second and first period. The product is the so-called chain index number.

One of the chief merits of the chain system lies in the fact that the link index numbers enable us to make direct and accurate comparisons between two adjacent periods especially as price variations within a short time, month to month, or year to year, are more concentrated. This system, however, is not without its shortcomings. The link index numbers of different periods are accurate and reliable individually, but when they are joined to the base period, any errors which are inherent in the successive multiplication processes are likely to accumulate in the chain

index number. This accumulated error may be insignificant in the first few periods, but after one or two decades, the discrepancy between the chain index and the index directly computed from base period (i.e. the fixed-base index) might be quite considerable. Moreover, the chain index numbers usually rise more than the fixed-base index numbers when prices are rising and fall less when prices are falling. As the trend of prices is more likely to rise than to fall in a sufficiently long period, a chain index number usually gives a higher figure than a fixed-base index, even though the same commodities are included in both index numbers.

The price level in Shanghai, as shown by the old index numbers, advanced incessantly year after year. Since the adverse gold and silver exchange recently became acute, prices of imported goods jumped up by leaps and bounds. In view of the weak points of the chain system, the abnormally high figures might involve a more than ordinary amount of cumulated errors. Therefore, we decide to adopt the fixed base method. The year 1926 is taken as the base period in order to make the figures comparable to our index number of wholesale prices.

II. Classification and Commodities

The commodities in the index number of wholesale prices in Shanghai fall in eight groups as mentioned in Part I. To the readers who are interested in the study of price changes of particular groups (such as Food Products, Textile Fibres and Manufactures thereof, Chemicals and Preparations thereof, Building Materials, Fuel and Lighting, etc.), such a classication, of course, serves as a simple and convenient guide. But it fails to show clearly the causal relations between the price fluctuations of different commodities. Moreover, the purpose of a wholesale price index number measures the price level in the wholesale market of a country, whereas that of import and export index measures the changes of price level in the international market. Some other methods of classification, therefore, must be resorted to in compiling the latter.

According to the conclusions drawn by Professor W. C. Mitchell who made an exhaustive study of the wholesale prices in 1890-1913 in the United States, the commodities in an index number should be definitely grouped to show the peculiarities of their price fluctuations. To quote Professor Mitchell:

"First, the price fluctuations of a raw material are usually reflected in the prices of the manufactured products. Hence to quote in some cases both the raw material and several of its finished products, and to quote in other cases the raw material alone, assigns certain groups of related prices a larger influence upon the results than is assigned the other groups. When the aim is to secure a set of samples which fairly represent price fluctuations as a whole, the existence of these groups must be taken into account.........

"Directly opposing the relations which unite the prices of finished goods with the prices of their raw materials is a second set of influences which make the price fluctuations of manufactured goods considered as a group characteristically different from the price fluctuations of their raw materials considered as a separate group...........These several comparisons established the conclusion that manufactured goods were steadier in price than raw materials..........Further, the manufactured goods had the narrower extreme range of fluctuations, the smaller average change from year to year, and the slighter advance in price from one decade to the next....... ..

"Third, there are characteristic differences among the price fluctuations of groups consisting of mineral products, forest products, animal products, and farm crops..........Here the striking feature is the capricious behavior of the prices of farm crops under the influence of good and bad harvests.......... their advance in the dull year 1904..........their failure to advance in the midst of prosperity of 1906..........are all opposed to the general trend of other prices. The prices of animal products are distinctly less affected by weather than the prices of vegetable crops, but even they behave queerly at times, for example in 1893. Forest-product prices are notable chiefly for maintaining a much higher level of fluctuation........... Finally, the prices of minerals accord better with alternation of prosperity, crisis, and depression than any of the other groups. ....An index number composed largely of quotations for annual crops, then, would be expected at irregular intervals to contradict capriciously the evidence of index numbers in which most of the articles were mineral, forest, or even animal products.

"Fourth, there are characteristic differences between the price fluctuations of manufactured commodities bought by con-

sumers for family use and the price fluctuations of manufactured commodities bought by business men for industrial or commercial use............the consumers' goods are steadier in prices than the producers' goods, because the demand for them is less influenced by changes in business conditions.

. . . .

"Probably the most illuminating way of presenting an index number that aspires to cover the whole field of prices at wholesale would be to publish separate results for the groups that have characteristic differences of price fluctuations, and then to publish also a grand total including all the groups. The groups to be recognised and the distribution of commodities among them is a difficult matter to decide. But, as matters stand, the most significant arrangement seems to be (1) a division of all commodities into raw and manufactured products; (2) the subdivision of raw commodities into farm crops and animal, forest, and mineral products; (3) the subdivision of manufactured products according as they are bought mainly for personal consumption, mainly for business use, or largely for both purposes.

"This classification is based upon differences among the factors affecting the supply of and demand for commodities that belong to the several groups—that is, upon differences among the factors which determine prices."[1]

Professor Mitchell's conclusions concerning the classification of commodities in index number of prices is especially adaptable to index numbers of import and export prices. In studying statistics of external trade of a country, it has been customary to classify goods as Raw Materials, Semi-manufactured Products, and Manufactured Products.[2] As China is still in the

1. Bulletin of the United States Bureau of Labor Statistics No. 284: Index Numbers of Wholesale Prices in the United States and Foreign Countries, pp. 40-51.

2. The Statistics of External Trade may be compiled either for general or for special purpose. Statistics for General Trade may include: (1) as regards imports, all merchandise arriving from all territories external to the country to which the statistics apply, and (2) as regards exports, all merchandise leaving that country for an external destination; while statistics for Special Trade shall include (1) as regards imports, all goods declared for demestic consumption in the territory to which the statistics apply, and all goods declared for transformation, repair or supplementary treatment therein, and, (2) as regards exports, all exported goods

transitional period between the agricultural and the industrial stage, and is at present much affected by the unprecedented adverse gold and silver exchange, the causal relations between her external trade and the price fluctuations of both import and export prices will be more clearly revealed by classifying the commodities in the indexes according to their stage of manufacture.[3]

For the purpose of international comparison the United States Federal Reserve Board has constructed wholesale price indexes for the United States, the United Kingdom, Canada, France and Japan.[4] According to trade movements, three different index numbers are compiled for Goods Produced, Goods Imported, and Goods Exported. The commodities therein are further classified, according to their stage of manufacture as Raw Materials, Producers' Goods and Consumers' Goods; and Raw Materials are subdivided into Farm Crops, Animal,

produced within the territory to which the statistics apply, or nationalized therein. The Chinese Customs Returns contain only the statistics of general trade, but not the special. However, in Appendix B of Part II, both imports and exports are grouped according to the Plan for a Common Nomenclature adopted by the International Conference of Commercial Statistics held at Brussel in 1910. The groups are: (1) Living Animals; (2) Food and Beverages; (3) Materials, Raw or Prepared; (4) Manufactured Products; and (5) Gold and Silver, Unwrought, and Gold and Silver Coins. Such a classification serves, to a certain extent, as an indication of external trade, though some of the commodities are not properly grouped. Following the classification made in the external trade statistics of the United Kingdom, Mr. C. Yang has recently reconstructed our trade statistics into following groups: (1) Food, Drink, and Tobacco; (2) Raw Materials and Semi-manufactured goods; (3) Manufactured goods; and (4) Miscellaneous. See Statistics of China Foreign Trade during the Last Sixty-five Years, published by National Research Institute of Social Sciences, Academia Sinica.

3. The total value of imports to China was Hk. Tls. 570,163,000 in 1913, and Hk. Tls. 1,265,779,000 for 1929, seeming to point to an increase of our import trade by 125% in 16 years. But this is far from being the fact; the depreciation in the price of silver and the appreciation of the price of imported goods should at the same time be taken into consideration. As the import price index for 1929 stood at 178.5 (1913=100), the import value for that year should be Hk. Tls. 709,120,000 in 1913 price (Hk. Tls. 1,265,779,000 ÷178.5%), representing a substantial increase of approximately 25 per cent. over that of 1913.

4. Federal Reserve Bulletin: June, 1921; February, 1922; May, 1922.