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Measuring Price Changes

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MEASURING PRICE CHANGES

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INTRODUCTION

The first part of this article, which appeared in last month's issue of this *Review,* discussed recent behavior of the major price indexes—the Consumer Price Index, the Wholesale Price Index, and the Implicit Price Deflator for GNP. These indexes and their components are closely watched by economic analysts, and changes in them are extensively analyzed for evidence of progress or lack of progress in the effort to combat inflation. Increasing attention has been focused on the indexes during the recent highly inflationary period, and, as might be expected, the technical characteristics of the indexes have received added scrutiny. Since much depends upon the indexes in policy making, planning, and forecasting, it is appropriate to ask whether the indexes are accurate, and whether the methods used in constructing them are statistically sound.

This part of this article examines the conceptual and statistical problems encountered in the design and construction of price indexes. Its purpose is expository. Certain criteria for good indexes are discussed as well as certain problems associated with the interpretation of index numbers. The final part of the article, which will appear next month, will review the specific methodologies used by the Departments of Commerce and Labor in the compilation of the major indexes in current use in this country and will evaluate those indexes in the light of the criteria discussed in this part.

THE DESIGN AND CONSTRUCTION OF PRICE INDEXES

An index in the simplest sense is a ratio of one quantity to another. It expresses a given quantity in terms of its relative value in comparison to a base quantity. Thus, a price index designed for the purpose of measuring price changes over time is a ratio of one price (or combination of prices) to the price of the same item (or combination of items) in a different period of time. When properly constructed, index numbers of prices permit the comparison of economic values over time net of the effect of price changes.

Several conceptual and statistical issues involved in the development of meaningful and reliable price indexes to represent the aggregate movement of prices over time are raised in the discussion which follows.

For purposes of illustration of the concepts, a hypothetical example is used throughout the discussion of a consumer whose total budget consists of five items, and whose expenditures on the items are shown for a period of four years. Three of the items are large in relation to his total budget—automobiles and suits, which are purchased infrequently, and rent, which is paid frequently. Two of the items are small, but one, bread, is purchased frequently, and the other, movie tickets, is purchased infrequently. The five items taken together comprise a theoretical "market basket"—a term commonly used to refer to the sample of items upon which an index is based. Usually, the "market basket" is a sample of selected items typical of the consumer's purchases and is used to represent his total budget. In this simplified example, however, it is assumed that the five items comprise this consumer's total budget. Table 1 shows the consumer's situation. This example, though an oversimplification of the problems involved in constructing aggregate price indexes, illustrates a number of the issues.

Conceptual Problems

The Base Period A fundamental problem in the development of index numbers is the selection of a base. If a price index is to serve as a stable basis for comparison of price movements over time, a period of time must be selected and held as the base long enough to generate a series of indexes for subsequent periods that will be useful in comparing those periods not only with the base, but with each other. Price indexes designed for analysis of price changes over time which are also computed for different places, such as the Consumer Price Index, do not automatically provide a valid basis of comparison of one place with another. Since the index relates current prices at a particular location to those in the base period at the same location, without regard to the standardization of base prices among the several locations, the index is useful only for comparisons over time. Current usage of price indexes is generally restricted to temporal comparisons.

Therefore, attention is devoted only to indexes designed for that purpose in the discussion which follows.

Where the object is to devise an aggregate index for general-purpose use, the selection of a base period is necessarily somewhat arbitrary. Under ideal conditions, however, the base period would be one in which extremely erratic movements are not occurring in prices themselves or in underlying economic conditions which would be reflected in prices. Such "normal" periods are difficult to define where prices of hundreds of items must be taken into account. Where the index is more of the special- purpose variety, the selection of an appropriate base is somewhat easier. For example, the earliest concern with index numbers involved an attempt to measure the change in the purchasing power of money (i.e., the reciprocal of the price index) resulting from the importation of silver into Europe after the discovery of America. This first price index, developed by Carli in 1764, covered a 250 year time span with the year 1500 as the base.[1]

Base periods of price indexes are occasionally updated for convenience. As spending patterns change and as technological change occurs, particular selections of goods and services comprising the "market basket" become obsolete as standards for comparison. Items which are commonly purchased in a current period may not have been available in the base period or may have undergone substantial technical or quality changes since the base period. This requires a revision of the sample, and this change may be accompanied by a shift of the base period to a later one for which the revised sample of goods and services is representative.

Though it is sometimes desirable, it is not necessary that both of the above changes be made at the same time. An updating of the sample of goods and services can be accomplished without shifting the base if the revised selection of items is worked into the sample so as not to distort the continuity of the index. This type of adjustment is discussed later in connection with other statistical problems. A straightforward shift of the base period is possible, however, without changing the sample of goods and services if it is known that the original sample selection remains valid, and if all that is desired is a revision of the index base to a more recent date. For example, if the index of 1970 prices for a particular sample of items on a 1960 base is 120.0, and the index on the same base was 105.0 in 1965, then 1970 prices can be expressed on a 1965 base as 114.3, or 120.0/105.0.[2] This kind of linkage, while frequently used, does nothing to improve the quality of the index. The revised number gives the same information that the original index did, but expresses it in terms of a more recent base. The revision in no way allows for changes in quality of goods and services or changes in spending patterns which result from price changes. Thus, the crucial question to which an index must frequently be subjected is whether or not the sample of commodities is currently valid. If it is, no revisions of the base period or the sample are needed. On the other hand, if revisions of the sample are needed, a shift of the base period may be convenient, but not essential.

[1] Mudgett, Bruce D. *Index Numbers.* John Wiley & Sons, Inc., New York, 1951. p. 6.

[2] It is common practice to express index numbers as ratios multiplied by 100 and rounded to one decimal place (e.g., the index 114.3 is the ratio 1.143). It is understood throughout this article that a ratio obtained by any formula is multiplied by 100 to obtain an index. For simplicity that step is not shown in the calculations or formulas.

Table I

HYPOTHETICAL CONSUMER WITH A FIVE-ITEM "MARKET BASKET"
Prices and Quantities Purchased

Item	Years							
	1		2		3		4	
	p_1	q_1	p_2	q_2	p_3	q_3	p_4	q_4
Automobiles, each	$2,000.00	1	$2,200.00	1	$2,500.00	0	$2,500.00	1
Rent, per month	$ 80.00	12	$ 85.00	12	$ 100.00	12	$ 130.00	12
Bread, per loaf	$ .20	250	$ .22	275	$ .25	275	$ .23	300
Movie tickets, each	$ .75	10	$ 1.00	6	$ 1.25	10	$ 1.35	10
Suits, each	$ 85.00	4	$ 95.00	4	$ 115.00	3	$ 135.00	1
Total Expenditures	$3,357.50		$3,666.50		$1,626.25		$4,277.50	

Note: Subscripts represent years, and p and q represent prices and quantities respectively.

Simple Average of Relatives and Simple Aggregative Price Indexes The simplest form of price index is the ratio of one price to another for a specified commodity. This approach is valid under extremely restricted circumstances. For example, consider the consumer whose expenditures are shown in Table I. Assuming that the loaf of bread listed in the table is the same loaf in size and quality in all four years, a simple index of the price of bread in year 2 is 110.0 (year 1=100). For years 3 and 4, the index is 125.0 and 115.0, respectively. As far as it goes, this index is a valid measure of changes in the price of bread.

If no change in quality could be assumed for the other four items shown, similar price indexes could be constructed for them. But a serious problem arises, even in the absence of any quality changes, if a composite index of this consumer's "market basket" is desired. Consider, for example, only the change between years 1 and 2. The price index for bread, as previously stated, is 110.0; for automobiles, it is also 110.0; for rent, it is 106.3; for movie tickets, it is 133.3; and for suits, it is 111.8. A simple average of the individual indexes yields a composite index of 114.3 for this consumer's total budget in year 2, based upon year 1. This index is questionable since it implicitly gives the highest weight among the five items to that one which rises most in price in percentage terms. That item is movie tickets, one which is of relatively little consequence to this consumer.

The index formula used in the above illustration is known as a simple average of relatives, or

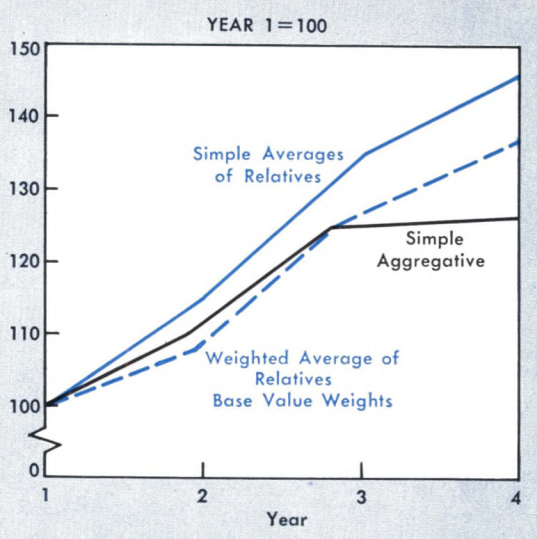
$$I_{1\,2}=\Sigma(p_2/p_1)/n,$$

where $I_{1\,2}$ represents the value of the index for year 2 based upon year 1; p_1 and p_2 represent prices of individual items in years 1 and 2, respectively; Σ is the standard symbol for summation; and n is the number of items comprising the index.[3]

Other means of averaging the price relatives (or ratios) could easily be used. For example, a median of relatives (110.0 in this case) reduces the upward bias resulting from the increase in movie ticket prices. Other methods of averaging price indexes which are frequently employed in order to reduce upward bias resulting from a sharp rise in one item or component are geometric averages and harmonic averages. A comparison of all these procedures for the hypothetical consumer for the four years given is shown in Table II, and selected indexes are graphed in the accompanying chart.

[3] Mills, Frederick C. *Statistical Methods.* Third Edition. Henry Holt & Co., New York, 1955. Ch. 13.

COMPARISON OF SELECTED SIMPLE AND WEIGHTED PRICE INDEXES FOR HYPOTHETICAL CONSUMER



Source: Table 1.

For comparison, another type of index number construction which might be used is the simple aggregative type. For the consumer under discussion, the total of the prices of the items he buys in the base period is $2,165.95. In year 2, the total of these prices is $2,381.22. A simple aggregative index number for year 2 is

$$I_{1\,2}=\Sigma p_2/\Sigma p_1=109.9.$$

Whether this number is any better as a measure of the price changes affecting the consumer is still in question. This procedure implicitly gives the highest weight among the items to the one which has the largest price change in absolute terms. In year 2, that item is automobiles which increased $200. This index is thus highly dependent upon the units for which prices are quoted. Simple aggregative indexes are given for the four years in Table II and in the chart. The chart illustrates that this index has practically no increase in the fourth year when auto prices do not rise while the other indexes shown continue to climb.

Both of these simple index methods raise questions of how to reduce biases in price indexes which arise due to large relative price changes (the movie ticket example) or large absolute price changes which may be small relative to the price of the item (the automobile example). While both of the simple indexes appear to be unweighted, they actually contain implicit weights, due to either actual price changes or

relative price changes. In this illustration, neither of the implicit weights is the desired one. Some procedure for explicitly weighting the items according to their relative importance in the consumer's total budget is needed in order to get a valid indication of the true impact of price changes upon the consumer.

Choice of Weights The kinds of weights needed to correct the bias resulting from the simple index methods are obvious. An indication of the relative importance of individual items in the consumer's budget can be obtained from the quantities he purchases. It is known, of course, that consumers change the mix of their purchases in response to changes in prices, depending upon whether individual items are necessities or luxuries. Business purchasers presumably do the same to the extent that substitution of items is possible. A difficult question to resolve, therefore, is what quantities to use as weights.

For example, in Table I, the consumer's total budget or expenditure in year 1 was $3,357.50 (i.e., $\Sigma p_1 q_1$). His total expenditure in year 2 was $3,666.50 (i.e., $\Sigma p_2 q_2$). A ratio of these expenditures would not result in a valid price index under most circumstances. Since quantities change as well as prices, the resulting ratio is not a pure index of price changes, but simply a ratio of budgets or total expenditures. The consumer's standard of living may have changed at the same time as a result of changes in his income, changes in the quality of items which he purchased, and for numerous other reasons. One type of question which a price index is commonly expected to answer is how much it would cost the consumer in the current period to purchase exactly the same mix of items ("market basket") that he purchased in the base period, assuming no change in the quality and utility of the goods and services he selected. The latter assumption is difficult to allow for in the construction of indexes, but the desired answer to the question is at least approximated if the quantities purchased in the base period are chosen as weights and held constant in computing the index for subsequent periods. If such weights are used, the necessity for periodic updating of the "market basket" is clear. As will be shown in subsequent discussion, however, not all indexes are designed to answer the specific question posed above.

The type of index described above is of both the fixed-weight and fixed-base variety. An argument can also be made for the use of current period weights, which necessitates the changing of weights with each successive period, while retaining the fixed base for purposes of price comparisons. If quantities purchased in the current period are used to weight both current and base period prices, the question which the index answers is changed substantially. This type of index tells how much it currently costs

Table II

SELECTED PRICE INDEXES FOR THE HYPOTHETICAL CONSUMER
(Prices and Quantities from Table I)

	Simple Indexes				
Year	Simple Average of Relatives Index	Median of Relatives Index	Geometric Average of Relatives Index	Harmonic Average of Relatives Index	Simple Aggregative Index
1	100.0	100.0	100.0	100.0	100.0
2	114.3	110.0	113.9	113.5	109.9
3	135.4	125.0	134.5	133.7	125.4
4	148.3	158.8	146.2	144.1	127.7

	Weighted and Weighted Chained Indexes						
Year	Weighted Aggregative Index Laspeyres Type	Weighted Aggregative Index Paasche Type	Weighted Average of Relatives Index Base Value Weights	Weighted Average of Relatives Index Current Value Weights	Fisher's "Ideal" Index	Edgeworth's Index	Weighted Aggregative Laspeyres Type Index Chained
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	109.2	109.1	109.2	109.2	109.1	109.1	109.2
3	126.1	127.3	126.1	127.5	126.7	126.5	126.1
4	139.1	137.4	139.1	139.8	138.2	138.3	158.3

the consumer to obtain a given selection of items in relation to how much it *would have* cost him to obtain the same selection in the base period. This is an important question, of course, but period to period comparisons are somewhat more difficult than with the fixed-weight, fixed-base type.

In either case, the indexes compare an actual quantity with a hypothetical quantity. In the first case, the index compares a hypothetical expenditure (base period quantities at current prices) with an actual expenditure (base period quantities at base period prices) made in the base period. The first of these quantities may not be what the consumer really buys if he shifts his purchases due to the price changes. The second type of index compares an actual expenditure (current period quantities at current period prices) with a hypothetical expenditure (current period quantities at base period prices). The latter of these quantities may not represent what the consumer actually would have bought if current period prices had prevailed in the base period.

Weighted Aggregative Indexes—The Laspeyres Type The most commonly accepted weighted price index of the fixed-weight and fixed-base type is that developed by Etienne Laspeyres in 1864. For the consumer represented in Table I, this index results in a value for year 2 of

$$I_{1\ 2}=\Sigma p_2q_1/\Sigma p_1q_1=109.2.$$

The values of this index for the four years are shown in Table II. The index is of the weighted aggregative type since it is the ratio of two expenditures—the numerator being the hypothetical current expenditure, and the denominator being the actual base period expenditure.[4]

A strict interpretation of the value, 109.2, given above for this consumer is that it would cost him 9.2 percent more to purchase the identical "market basket" in year 2—if he desires to purchase it—than it cost him in the base year. Similarly, the same selections would cost him 39.1 percent more in the fourth year than in the base year, as shown in Table II. This index construction reduces the bias introduced into the simple indexes by the large relative increase in the price of movie tickets or by the large absolute change in the price of automobiles in year 2.

Weighted Aggregative Indexes—The Paasche Type A weighted index of the second type described above, which uses current period quantities as weights, is the one developed by H. Paasche in 1874. For the consumer in Table I, for year 2, the index number is

$$I_{1\ 2}=\Sigma p_2q_2/\Sigma p_1q_2=109.1.$$

Other values are shown in Table II. This index, like the Laspeyres, is a ratio of weighted aggregates. But it relates an actual current period expenditure in the numerator to a hypothetical base period expenditure in the denominator.[5]

The interpretation of the Paasche number for this consumer is that it costs him 9.1 percent more to purchase the "market basket" which he bought in the current period than it would have cost him in the base period. Again, this index reduces the upward bias present in the simple indexes for this consumer. In this illustration, a lack of sufficient variation in the quantities purchased between years 1 and 2 results in the Paasche and Laspeyres index numbers being very close together. For example, if this consumer had reacted to the increase in automobile prices by not buying one in year 2, the Paasche index which is affected by current period quantities would have been 107.9. The Laspeyres index for year 2 would not have been affected by the consumer's decision not to purchase an automobile since only base period quantities are relevant. Thus, the Laspeyres number would have remained 109.2.

An important difference in the kinds of interpretations which may be made of these indexes should be noted. Table II shows the Laspeyres index to be 109.2 in year 2 and 126.1 in year 3. It may be concluded, therefore, that the cost of the "market basket" increased 15.5 percent between years 2 and 3 (i.e., (126.1—109.2)/109.2=.155). The "market basket" which the consumer purchased in the base period would cost him 15.5 percent more in year 3 than it would have in year 2. A similar interpretation of the change in the Paasche index between these two years, however, would be incorrect. Each successive Paasche index number compares the current period "market basket" directly to the base year. The selection actually purchased in year 3 cost the consumer 27.3 percent more than it would have cost in the base year, and the selection actually purchased in year 2 cost 9.1 percent more than it would have cost in the base year. Since the particular selection of commodities being priced changes between years 2 and 3, a direct comparison of the index numbers to measure price changes between the two years would be inappropriate. A difficulty of this type in

[4] Fisher, Irving. *The Making of Index Numbers.* Houghton Mifflin Company, New York, 1922. p. 59.

[5] *Ibid.*

the interpretation of the GNP Deflator will be discussed in the final part of this article.

Laspeyres and Paasche Compared Both of the weighted aggregative indexes appear to be superior to any of the previously discussed simple indexes. They reduce the likelihood of misleading movements in the indexes due to large relative changes in prices of items which may be of little importance in the consumer's total budget, or due to large absolute changes which may be small in relation to the price of the item. They are free of the problems associated with the units for which the price is quoted. Aggregation of values or total expenditures is used instead of aggregation of simple prices or price relatives.

There is a considerable body of literature on the Laspeyres and Paasche indexes, and numerous arguments for and against the use of each of them have been advanced. While it is beyond the scope of this article to review all the literature, some of the arguments are particularly pertinent to this discussion, since, as will be shown later, the Laspeyres index is in essence the one used by the Bureau of Labor Statistics in constructing the Consumer Price Index.

If a choice must be made between the Laspeyres and Paasche index numbers, it would seem that on logical grounds the Laspeyres index provides the answer to the question most commonly asked in index number applications, namely, the change in the cost of the base year "market basket." There are certain other arguments, however, affecting the choice between the two approaches—ignoring for the moment any sampling problems which may be involved. It has been argued that the Laspeyres formula has a tendency to overestimate price changes, while the Paasche formula tends to underestimate price changes. The argument is that the hypothetical expenditure, Σp_2q_1, used in the numerator of the Laspeyres index would probably not be the actual expenditure that the consumer would make in year 2 if he were furnished with that amount of money. The sum, Σp_2q_1, would be sufficient to allow the consumer to obtain the base period "market basket," but in a period of generally rising prices, that sum would be larger than the base period expenditures, Σp_1q_1. Thus, the rational consumer would tend to adjust his purchases, including the substitution of some items for those in the original "market basket" to allow him the same standard of living as before without having to duplicate the base period purchases exactly. To the extent that this is true, the measure of price change applicable to the consumer is somewhat overstated by the Laspeyres index.

The Paasche index, on the other hand, contains the hypothetical expenditure Σp_1q_2, in the denominator for year 2. In a period of generally rising prices this sum is lower than the numerator, Σp_2q_2, which represents the current period's actual expenditure. Thus, the argument is that if the lower sum of money had been given to the consumer in the base period, he probably would have adjusted to a different set of commodities that would have yielded him the highest possible standard of living for that total expenditure rather than necessarily the "market basket" he would choose in year 2 when he has a higher sum available. To the extent that this is true, the measure of price change applicable to the consumer is likely to be understated by the Paasche formula.

These arguments, advanced by Mudgett,[6] do not necessarily mean that in all cases the two indexes are biased, nor do they imply that the Laspeyres number is necessarily greater than the Paasche, since actual quantities purchased respond to economic factors too numerous to evaluate. It is possible that particular economic circumstances may create biases in the opposite direction from those mentioned above. For example, if consumers shift purchases toward goods or services that are advancing rapidly in price, the use of base period quantity weights in the Laspeyres index may cause it to underestimate actual price changes.

To the extent that biases exist, they cannot be quantified because what the consumer might have done cannot be experimentally observed. These potential weaknesses, however, illustrate why it is frequently argued that neither of the indexes provides a valid measure of changes in the cost of living. A cost of living index should measure the change in the cost of obtaining a given standard of living from one period to another. Living standards are determined subjectively by the consumer, and he does in fact shift his purchases in response to changing prices in order to avoid giving up a customary standard or to obtain a higher one. Therefore, an index which cannot take into consideration such adjustments, and thereby hold constant a given standard of living to measure the change in the cost of obtaining it, cannot be a reliable index of the cost of living.[7]

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[6] Mudgett, *Index Numbers*, pp. 34-40.

[7] The problems of constructing cost of living indexes have resulted in extensive research. For detailed discussion, see Ulmer, M. J., *The Economic Theory of Cost of Living Index Numbers*, Columbia University Press, New York, 1949; Frisch, Ragnar, "Some Basic Principles of Price of Living Measurements," *Econometrica*, October, 1954; and Konus, A. A., "The Problem of the True Index of the Cost of Living," *Econometrica*, January, 1939.

Fisher's "Ideal" and Edgeworth's Indexes Concern about potential biases in the Laspeyres and Paasche indexes led Fisher to develop a number of tests for estimating the magnitude of error in various index number formulas.[8] The result of these efforts was Fisher's "Ideal" index which recognized the opposing tendencies toward bias in the Laspeyres and Paasche approaches. The "Ideal" index is the geometric average of the Laspeyres and Paasche indexes. A geometric average is the n-th root of the product of n numbers (i.e., the geometric average of two index numbers is the square root of their product), and it always yields a value somewhat lower than a simple arithmetic average. Thus, the "Ideal" index is closer to the lower of the Laspeyres or Paasche results. The values of this index are given for the hypothetical consumer in Table II.

Due to computational difficulties involved in the practical application of the "Ideal" index to large samples of price data, Edgeworth developed a close approximation which makes use of quantity data for both the base and current periods. Edgeworth's index is defined as

$$I_{1\,2}=\Sigma(q_1+q_2)p_2/\Sigma(q_1+q_2)p_1,$$

where year 1 is the base. For comparison, values of this index for the hypothetical consumer are also shown in Table II.[9]

Weighted Average of Relatives Indexes In terms of conceptual differences, the indexes already discussed essentially cover the field. The weighted average of relatives index number differs not so much in concept as in formula construction—a fact which has important practical value in the calculation of the index. It was noted in the discussion of weighted aggregative indexes that prices are weighted by quantities purchased. By comparison, the weighted average of relatives index weights price relatives (ratios of prices) by total expenditures (values of purchases). A choice must be made again between base period or current period expenditures as the weights. Consider first this type of index using base period expenditures as weights (i.e., base value weights). The index for year 2, where year 1 is the base is

$$I_{1\,2}=\Sigma\left[\frac{p_2}{p_1}\cdot p_1q_1\right]\Big/\Sigma p_1q_1.$$

The price relative is the simple ratio of prices p_2/p_1. The base value weight is the total expenditure in the base period, p_1q_1, for an individual commodity. The weight is multiplied by the price ratio and these quantities are summed for all items in the "market basket." The denominator is the base period expenditure on all items in the "market basket." It can be seen above that p_1's in the numerator cancel so that the formula reduces algebraically and is identical to the Laspeyres type weighted aggregative index. This is not the important distinction, however, because the formula is used as it is shown rather than in its reduced form. As a practical matter, quantities purchased are seldom readily available which makes the direct application of the Laspeyres formula difficult. But prices of items and actual expenditures on individual items are more readily available, which means that the weighted average of relatives index can be applied more easily than any of the other weighted indexes discussed. With minor modification, this index is the one applied by the Bureau of Labor Statistics in deriving the Consumer Price Index, and, therefore, the result is the same as the Laspeyres method.[10]

It is also possible to construct a weighted average of relatives index with current value weights by substituting current period expenditures, p_2q_2, in the numerator and the total of current period expenditures for the given "market basket," Σp_2q_2, in the denominator. This index does *not* reduce to the Paasche weighted aggregative index, but it is easier to apply than the Paasche index for the same reasons as those given above. This construction is known as the Palgrave index formula. It has received little attention by students of index numbers since Fisher,[11] and is discussed here only for completeness. For comparison, the values of the two weighted average of relatives indexes are given in Table II for the hypothetical consumer.

Chain Indexes All of the indexes discussed thus far have been fixed-base indexes. That is, it is assumed that the base period upon which the index is computed does not change with each successive period. Chain indexes involve a constantly shifting base period.

The use of a fixed-base index assumes that the span of time between the base period and the current period is sufficiently homogeneous to allow a valid comparison of prices in the current year with those in the base year. It is obvious that this is a difficult assumption to satisfy fully when economic circumstances are rapidly changing and technological

[8] Fisher, *The Making of Index Numbers*, Ch. 11.

[9] Mills, *Statistical Methods*, Ch. 13.

[10] *Ibid.*

[11] Fisher, *The Making of Index Numbers*, Ch. 3.

progress is occurring which affects the quality of items covered by the index. At best it means that frequent updating of the weights and revision of the sample of commodities in the "market basket" are essential. A fixed-base index with base period weights is particularly suspect in this connection, and this is the concept used in constructing most major price indexes in use today. A fixed-base index using current period weights such as the Paasche type is perhaps less subject to criticism on this score although it is questionable whether such an index gives the most useful measure in the first place. Even so, base period prices are still the basis of comparison. Given that an index of the Laspeyres type is the preferred concept, the problem of how to make it consistently valid over any reasonably long period of time becomes significant.

A fixed-base index with base period weights for any given year is independent of price changes that have occurred in any year between the current one and the base year. Intervening price changes, however, may have significantly affected spending patterns. A chain index is an expedient measure for resolving this difficulty. The procedure entails updating the base one period at a time so that the index for any given period uses the previous period as a base. The indexes are then linked together in a multiplicative fashion. Using the Laspeyres formula as an example,

$$I_{1\,2}=\Sigma p_2q_1/\Sigma p_1q_1,$$
$$I_{2\,3}=\Sigma p_3q_2/\Sigma p_2q_2, \text{ and}$$
$$I_{1\,3}=I_{1\,2}\cdot I_{2\,3}, \text{ etc.}$$

The chain index for year 3 uses the quantities purchased in year 2 as weights. The index for any given year can be expressed with any earlier year as the base by multiplying the indexes starting with that earlier year.

Table II shows values of the chained Laspeyres index, for the hypothetical consumer, using year 1 as the base. Table III gives all combinations of the chained Laspeyres index for the four years.

Table III

CHAINED LASPEYRES INDEX FOR HYPOTHETICAL CONSUMER

(Prices and Quantities from Table I)

$I_{1\,2}=109.2$	$I_{1\,3}=126.1$	$I_{1\,4}=158.3$
	$I_{2\,3}=115.5$	$I_{2\,4}=145.1$
		$I_{3\,4}=125.5$

Price increases occurring between years 3 and 4, as measured by the Laspeyres formula, are larger than in any other two successive years in this illustration. The effect of the chaining procedure is evident in the value of $I_{1\,4}$, which shows the compounded result of the price rises of each successive year. It is also possible that any consistent biases present in the index formula will lead to cumulative error by chaining. The chained Laspeyres index indicates price increases to be 13.8 percent greater between years 1 and 4 than the fixed-base Laspeyres index (i.e., 158.3 vs. 139.1). While the divergence between the two indexes is large in the fourth year, the example does not imply that the chain method is invalid as such.

The use of the chain method has been urged by Mudgett as one means of keeping the index close to the market situation.[12] It allows for the shifting of purchases in response to changes in prices more readily than does the fixed-base type. Thus, in a period of rapidly changing prices, such as the current period, the chain method has some attraction, particularly as a supplement to a fixed-base index. The difficulties involved in the interpretation of chain indexes, however, as well as their tendency to magnify successions of sharp price changes pose serious problems. The chain index alone, therefore, is not generally regarded as a satisfactory solution to the problem associated with fixed-base indexes—namely, the need for periodic revisions of the "market basket."

Statistical Problems

There are still a number of statistical problems which remain even after an appropriate index number concept has been selected. This is particularly true of a general-purpose index in which the coverage of items is broad and where the index is used to represent the behavior of prices in general. These are features of the published indexes of wholesale and consumer prices. While there are stated limitations as to the interpretations that may be made from these indexes, their usage has evolved in such a way that they are regarded as broad indicators of price changes.

The remainder of this part of this article serves only to list and explain the nature of the statistical problems involved in the construction of price index numbers. This discussion is not a review of procedures in actual use by those government agencies or others who produce the indexes in current use, but is a more general explanation of the types of problems to be encountered by anyone involved in the construction of price indexes. These problems are

[12] Mudgett, *Index Numbers*, pp. 70-78.

related in more detail to the procedures employed in developing the commonly used indexes of wholesale and consumer prices in the final part.

Sampling of Items It is certainly not feasible to derive a price index for consumers which takes into consideration all goods and services that consumers buy. Nor is it possible to obtain a wholesale index of prices covering all manufactured industrial items, all raw materials, and all farm products. Therefore, an index intended for broad usage must rely on representative samples of items. The design of the sample is thus critically important in determining the quality of the index. Just as there are important differences in spending patterns among urban and rural families, central-city and suburban families, and northern and southern families, there are important differences among individual families within each of these groups. For these reasons there is no single index applicable to all consumers. The Consumer Price Index, for example, which is limited in coverage to those goods and services representative of the budgets of urban wage earners and clerical workers, still covers a diverse group. The selection of the sample of goods and services to be included in the "market basket," therefore, must depend upon a valid survey of spending patterns within the group to which the index is to be applicable.

Sampling Over Time Once the coverage of the index as to groups of consumers or industries is defined and the selection of items in the "market basket" is specified, the question remains of how frequently to observe the prices of the items included. It must be decided whether the index is to be published monthly, quarterly, annually, or by some other period. Under theoretically ideal circumstances, a continuous observation of prices would be desired. For obvious reasons, the cost of such a procedure would exceed the practical benefit. A satisfactory compromise on the problem can be reached if periodic samples of prices are used, and if acceptable means of estimating interim prices can be derived for those periods between benchmark samples. For instance, if it is desired that a price index be published monthly, and samples of prices are obtained every three months, previous experience with the "market basket" may provide sufficient information to allow estimation of prices and therefore of the index for the intervening months. Short-term movements in an index obtained on this basis are, of course, subject to error, particularly as underlying economic circumstances change.

Sampling Over Geographic Areas The commonly used aggregate indexes of prices are published on a national basis. Whether the index is of a special-purpose or general-purpose nature, it is known that its applicability is not the same in all parts of the nation in most cases. Just as general economic conditions vary widely among sub-national regions, price changes may vary widely by area. This is particularly true of indexes of consumer prices which include numerous services and highly processed goods. Items which are essentially the same everywhere, for which highly organized national markets exist, and for which there is little variation in costs of production and delivery are less subject to this problem (e.g., some of the items included in the index of basic commodity prices).

If it is desired that a price index (e.g., of consumer items) be generally applicable to a wide geographic area, an appropriate means of sampling among different places must be derived as well as a weighting scheme for assembling the information into a single index. Even so, some error is inevitable in the application of an index derived on this basis to any particular area. The effect of such error is practically impossible to estimate without constructing separate indexes periodically for the specific area in question. Some indexes, such as the Consumer Price Index, are published on a national basis and by narrower regions such as Standard Metropolitan Statistical Areas. While it is clearly not practical to construct price indexes for every city in the nation, it is possible to vary sample cities on a probability sampling basis and thus provide a means of determining the error involved in the estimate of the national figure. Such a procedure possibly has merit in the sense of providing better national indexes, but it does not eliminate the error involved in applying a national index to a particular location.

Quality Changes and Changes In Tastes One of the most difficult problems to resolve in price index construction is the need to adjust the "market basket" to reflect technological change which affects the quality of goods and services purchased, and to reflect changes in tastes and preferences of buyers. These problems, like the geographic area problem, are more serious in an index which measures consumer prices than in one which measures prices of items at a lower stage of processing or basic commodities. Machinery and equipment, construction costs, and numerous other industrial items, however, also undergo technological and quality change which poses similar problems for indexes of industrial or wholesale prices.

It is obvious that a television set purchased in 1970 is quite a different item from one purchased in 1957. It is a higher quality, more sophisticated piece of equipment. The same is true of many consumer goods and services such as automobiles, airplane trips, and refrigerators, as well as machine tools and trucks used by industry. The prices of many of these items have risen in recent years. Part of the price increase, however, is due to the quality improvement and should somehow be eliminated in measuring the price change associated with the original "market basket." Without actually renewing the "market basket," the only generally satisfactory solution to this problem requires gradually splicing in the new or improved item, while at the same time, gradually removing the old item. This prevents disruption of the continuity of the index which would result from an abrupt substitution of the item in the "market basket." As a practical matter, however, the rapidity of technological progress has made this a major problem in constructing indexes of consumer and industrial prices.

Changes in consumer tastes present the same kind of problem. As such things as garters, bed warmers, and washtubs have declined in the preference scales of consumers, the "market basket" has required updating to include entirely new products such as panty hose, electric blankets, and automatic washers. The same problem occurs among industrial items as in the case of textile goods where the gradual substitution of synthetic fibers for cotton has taken place due to changes in the preferences of garment producers. This problem coupled with that of quality changes necessitates continuous review of the current validity of the "market basket."

Transaction Prices vs. List Prices It is a basic requirement of all price indexes that prices used in calculating the index be the actual prices at which transactions are made. Often, however, quoted prices do not change while significant changes occur in prices actually paid. Experience has shown this to be a problem particularly in the measurement of industrial prices. Most prices used in the Wholesale Price Index, for example, are sellers' list prices. Stigler and Kindahl recently contended that these prices bear little resemblance to the prices actually paid on many industrial items with the result that the Wholesale Price Index overstates industrial prices by failing to take cognizance of discounts, special offers, and price shading. Their contention implies that the Wholesale Price Index understates the effect of changing economic conditions upon industrial prices.[13] This is a significant point since the Wholesale Price Index is so closely watched as a barometer of inflation. The Consumer Price Index has not been subject to the same criticism since price observers function like buyers and obtain prices which they know in most instances represent the prices at which the goods and services can be purchased.

Sampling Error In Indexes Even if all statistical problems are satisfactorily dealt with in the construction of price indexes, some error in the estimate of price levels and changes results. This is a phenomenon of sampling which occurs even under the best of circumstances. An important feature of sampling error, however, is that its magnitude can be estimated, and it generally decreases as the sample size increases. This feature makes it possible to state with some degree of confidence (i.e., at some level of probability) how far the calculated value of the index can be expected to vary on either side of its correct value. Estimates of sampling error are frequently published along with the major indexes. It can be a mistake, however, to interpret estimates of sampling error too literally because sampling design considerations and data problems render all major indexes in current use less than perfect on other grounds.

SUMMARY

The issues raised in this part are followed up and related in specific detail to the Bureau of Labor Statistics' Consumer Price Index and Wholesale Price Index and to the Department of Commerce's GNP Deflator in the final part which will appear in next month's issue of this *Review*.

William H. Wallace

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[13] Stigler, George J. and Kindahl, James K. *The Behavior of Industrial Prices.* National Bureau of Economic Research, New York, 1970.

PARITY, SUPPORT PRICES, DIRECT PAYMENTS, AND ALL THAT

Recently, price and income support payments to agricultural producers have been closely scrutinized by politicians, economists, and the general public. As a result Congress has enacted legislation that will limit the amount of money the Government can pay to any one producer. This article briefly reviews Government policy with respect to agriculture and some of the factors leading to payment limitation.

Government involvement in agriculture has a long history. The Homestead Act of 1862, the Morrill Act, the Hatch Act, and the Smith-Lever Act were all landmarks in agricultural legislation. More direct Government involvement with agriculture began in the 1930's when price and income support programs were introduced to raise farm product prices and incomes of farm families.

Terminology To understand the agricultural programs which are the subject of the current debate, it helps to know some of the terminology.

Parity Price The concept of parity was introduced in the 1930's to establish a standard or measuring rod against which farm prices might be compared to determine whether or not they were "fair." Farm prices are said to be at parity if they bear the same relationship to the prices of articles farmers buy as they did in the base period. The years 1910 to 1914 were selected as the base period since they represented a period in which the relationship between prices received and prices paid by farmers was very favorable to farmers.

Over the years the formula for calculating parity prices has changed. The present method of calculating parity uses an adjusted base period. The adjusted base period for a commodity is obtained by dividing the average market price received by farmers for the commodity during the most recent ten-year period by the average index of all prices received by farmers for the same period. To obtain the 1970 adjusted base price of corn, for example, the average price received by farmers for corn, adjusted to allow for unredeemed loans and other supplemental payments resulting from price support operations, in the period 1960-69 ($1.17 per bushel) is divided by the average index of price received by farmers, adjusted to include an allowance for unredeemed loans, etc., for the same ten-year period (257 on a 1910-14 base). The current parity price is obtained by multiplying the adjusted base price by the current index of prices paid by farmers, including interest, taxes and wage rates. In August 1970, the index of prices paid (on a 1910-14 base) was 389. Thus, the August 1970 parity price for corn was $1.77 per bushel ($0.45 x 389/100).

The parity concept simply expresses arithmetically one idea of what is equitable or fair. Equity is a subjective concept; however, and there is no objective way to measure it. Shifting the base to a period other than 1910-14, for example, may have a substantial impact on current parity prices. Nevertheless, parity often figures prominently in farm policy discussion.

Support Prices The nature of supply and demand for farm products causes their prices to be notoriously unstable. Because farm prices were unstable and because of the general economic depression at that time, price support programs for farm products were initiated in 1933, with the goal of raising farm prices to a parity level. Parity level support prices were sought through loan, purchase, and storage operations as well as through production control programs that authorized the Secretary of Agriculture to support different commodities at different percentages of parity. Originally, production control was voluntary but this failed and production control was made mandatory. Control of agricultural production, started at a time when many people were unemployed and without enough food to feed their families, brought forth a great deal of derision in its early years. One critic wrote the following letter to a newspaper:

> "Mr. B. has a friend who received a Government check this year for not raising hogs. So B now proposes to get a farm and go into the business of not raising hogs; says in fact not raising hogs appeals to him very strongly. Of course he will need a hired man and that is where I come in. I write you as to your opinion of the best kind of farm not to raise hogs on, the best strain of hogs not to raise, and how best to keep an inventory of hogs you are not raising. His friend who got the $1,000 got it for not raising 500 hogs; now we figure we might easily not raise 1,500 or even 2,000 hogs, so you see the

possible profits are only limited by the number of hogs we do not raise."[1]

The new programs were supposed to raise prices by reducing crop production and by removing surpluses from the market. They were not successful in raising prices during the 1930's, but where production control and support programs had failed the war succeeded and farm prices rose to new highs. For some time after the war, the Farm Bloc in Congress succeeded in maintaining high wartime support prices. Meanwhile, world farm prices came under heavy downward pressure as Europe recovered. The results were predictable. By the end of the 1950's high support prices and ineffective production control were creating large surpluses despite substantial diversion of acreage from 1956 to 1959 under the acreage reserve and conservation reserve programs authorized by the Soil Bank Act. By the early 1960's practically every grain and butter storage facility in the United States was filled. In 1961, the annual cost of owning and storing the $9 billion farm surplus was $1 billion.

Direct Payments High support prices combined with attempts of the United States Government to sell farm products at above world prices stimulated production abroad. This policy led to a loss in the United States' share of the world market, particularly in cotton, one of our major farm exports. Consequently, support prices were reduced to bring them in line with world prices and reduce Treasury costs. To maintain farm income, high level support prices were replaced with direct cash payments to producers participating in the programs. Direct payments are used (1) to supplement income and (2) to control production by paying producers to restrict the acreage of certain crops.

Increasing Costs Since their introduction in the early 1960's, direct payments (primarily for the major field crops—cotton, wheat, and feed grains) have increased from $702 million to approximately $3.7 billion. Direct payments as a percent of realized net farm income in the United States increased from 6% in 1960 to 23% in 1968 (Table I). The same pattern was evident in the Fifth District. Producers in West Virginia and South Carolina received respectively 20.7% and 35.7% of their realized net farm income from direct Government payments.

Distribution of Benefits Most of the direct benefits from the price support and direct payments programs go to a relatively few producers operating large farms. Program benefits are concentrated on these larger farms which earn comparatively good incomes (Table II). Measured by size of payment, the top one-fifth of the cotton, wheat, and feed grain producers received respectively 69%, 62%, and 56% of the program benefits, whereas the one-fifth with the smallest payments received 2%, 3%, and 1%. The 5% of the producers receiving the largest payments accounted for 41%, 39%, and 24% respectively of the total benefits. Farm income received by the top 20% of the recipients was more than one-half of the total farm income of all producers receiving benefits.

Additional evidence which shows that payments

[1] Clair Wilcox, *Public Policies Toward Business* (Homewood, Illinois: Richard D. Irvin, Inc., 1960), p. 462.

TABLE I

Government Payments as a Percentage of Realized Net Farm Income
United States and Fifth District States, 1960-1968

Year	Maryland	Virginia	West Virginia	North Carolina	South Carolina	United States
1960	3.6	3.8	6.4	2.2	9.5	6.0
1961	6.8	6.2	8.7	5.2	10.4	11.8
1962	6.9	7.8	9.4	6.2	11.4	13.8
1963	6.7	7.9	11.3	5.2	10.5	13.5
1964	7.2	7.5	12.3	5.6	12.2	16.7
1965	6.1	8.3	11.6	8.2	15.5	17.6
1966	5.5	9.5	13.2	9.9	27.7	20.1
1967	5.9	10.1	24.2	10.0	30.2	21.6
1968	6.4	10.4	20.7	11.1	35.7	23.0

Source: United States Department of Agriculture.

TABLE II

Distribution of Farm and Benefits of Selected Programs—Proportion of Income or Benefits Received by Selected Groups of Recipients United States, Selected Years

Item		Percent of Benefits Received by Lower 20% of Recipients	Upper 20% of Recipients	Upper 5% of Recipients
Sugarcane	1965	1.0	83.1	63.2
Cotton	1964	1.8	69.2	41.2
Rice	1963	1.0	65.3	34.6
Wheat	1964	3.3	62.4	38.5
Feed grains	1964	1.0	56.1	23.9
Peanuts	1964	3.8	57.2	28.5
Tobacco	1965	3.9	52.3	24.9
Farmer and farm manager total income	1963	3.2	50.5	20.8

Source: James T. Bonnen, "The Absence of Knowledge of Distributional Impacts: An Obstacle to Effective Public Program Analysis and Decisions," **Economic Analysis of Public Expenditure Decisions, The PPB System,** (Joint Economic Committee, U. S. Congress, May 1969) p. 440.

go to a relatively few large scale producers is available. For example, 12,921 producers received payments of $20,000 or more in 1969. This figure was approximately one-half of 1% of all producers receiving payments, but these producers received 13.7% of the total payments (Table III).

The concentration of program benefits to the producers of a relatively few commodities and to a few large-scale producers has led many people to question the equity of the agricultural programs of the 1960's.

Proposals to Limit Payments Recently, efforts have been made to limit the size of direct cash payments to producers. The House of Representatives passed legislation in 1968 and 1969 to limit payments to $20,000 per producer but the Senate did not support payment limitation. In 1970, the Senate voted to limit payments to $20,000 per producer and the House passed a $55,000 per program limitation to producers of wheat, feed grains, and cotton. After reconsideration the Senate also approved a payment limitation of $55,000 per program.

Supporters of payment limitation question the equity of current agricultural programs. They argue that it is hard to justify large payments to a few producers especially when public funds are needed for other problems such as education, job training, health, pollution control, and food aid programs.

Impact of Payment Limitations Until Congress voted for a $55,000 per program limitation in the 1970 session, the most discussed level of limitation was $20,000 per individual and the idea of a $20,000 limit will likely be reintroduced when the 1970 farm legislation expires. Thus the remainder of this paper compares the impact of these two payment limits.

Producers of cotton, feed grains, and wheat will be most affected by payment limitations. In 1969, the number of cotton, feed grain, and wheat producers receiving payments of $20,000 or more totaled 8,799 (Table IV). This number relates only to those producers who would be affected by a payment limitation on a *single* commodity. A total of 11,733 producers would have been affected in 1969 if the limitation applied to a *combination* of the three major commodity programs. In 1969, only 1,100 cotton, feed grain, and wheat producers received payments of $55,000 or more. Thus, a $55,000 per program limitation will affect only 1,100 producers. A $55,000 per program limitation on wheat, feed grains, and cotton amounts to a $165,000 limitation per producer. Very few farms, however, are large enough to collect $55,000 from more than one program. United States Department of Agriculture figures show that in 1969 only two producers received in excess of $50,000 from each of the three programs and 37 received $50,000 payments from two of these programs.

John Schnittker, former Under Secretary of Agriculture, estimated that a $20,000 limitation per producer would have saved the Treasury $206 million in 1967.[2] Using 1969 data, the United States Department of Agriculture estimated that a $55,000 per program limitation would have saved $58.3 million.

Payment limitations will clearly have the greatest impact on cotton producers (Table IV). In 1969, the 6,194 cotton payees who received payments of

[2] John A. Schnittker, "The Distribution of Benefits From Existing and Prospective Farm Programs," reproduced in *The Congressional Record*, Vol. 115, June 1969, No. 98, p. H4836.

TABLE III

Frequency Distribution of Producer Payments Under Agricultural Stabilization and Conservation Service Programs United States, 1969

Payment Range	Number	Percent	Million Dollars	Percent
Less than $20,000	2,504,383	99.48	3,188.5	86.29
$20,000 - $49,999	10,970	.44	315.0	8.52
More than $50,000	1,951	.08	191.7	5.19
Total	2,517,304	100.00	3,695.2	100.00

Source: **The Congressional Record,** Volume 116, July 8, 1970, No. 114, p. S10806.

$20,000 or more were paid $262.6 million and the 949 payees receiving payments of $55,000 or more were paid $103.8 million.

Impact on the Fifth District In the Fifth District very few producers will be affected by either a $20,000 per producer or a $55,000 per program limitation (Table V). A few producers in North and South Carolina will be directly affected. In 1969 a payment limitation of $55,000 per program would have affected three cotton and three feed grain producers in North Carolina, and 13 cotton producers in South Carolina. Total payment reductions to these two states would have been $600,000 and $400,000 respectively.

Effect of Payment Limitations on Production Direct payments are made to supplement farm income and to encourage producers to restrict acreages of certain crops. The Department of Agriculture estimates that approximately 65% of all direct payments are for resource adjustment purposes. In other words this is the price that farmers are paid to divert part of their cropland acreage from production. The amount diverted varies from year to year. Opponents of payment limitation argue that a limitation may cause large-scale producers not to participate in production control programs and thus destroy the effectiveness of such programs. However, both Schnittker[3] and Mangum[4] present persuasive arguments that payment limitations as low as $20,000 per producer will not seriously affect program participation.

TABLE IV

Producers Receiving Agricultural Stabilization and Conservation Service Program Payments Greater Than The Indicated Amount United States, 1969

Program	Total Recipients	Payments of $20,000 or more	Payments of $55,000 or more
Cotton	445,155	6,194	949
Feed Grain	1,641,863	1,482	98
Wheat	995,371	1,123	53
Cotton, Feed Grain and Wheat[1]	2,125,491	11,733	1,100

[1] Does not equal total for cotton, feed grain and wheat because some producers receive payments from more than one program.

Source: **The Congressional Record,** Volume 116, July 8, 1970, No. 114, p. S10806 and House of Representatives Report No. 91-13129, 91st Congress, 2d session, July 23, 1970, p. 17.

TABLE V

Producers Receiving Payments of More Than The Indicated Amount Fifth District, 1969

State	Producers Receiving Payments of $20,000 or more: Cotton	Feed Grain	Wheat	Producers Receiving Payments of $55,000 or more: Cotton	Feed Grain	Wheat
Maryland	....	3	....	....	....	....
Virginia	....	2	....	....	....	....
West Virginia	....	....	....	....	....	....
North Carolina	38	14	....	3	3	....
South Carolina	201	6	....	13	....	....

Source: **The Congressional Record,** Volume 116, July 8, 1970, No. 114, p. S10806 and House of Representatives, Report No. 91-1329, 91st Congress, 2d session, July 23, 1970, p. 17.

Summary Congress recently voted to limit direct payments to producers of wheat, feed grains, and cotton. This action was the result of public concern about the cost of the programs and the distribution of benefits. The impact of the limitation will be mostly on cotton producers. Among producers in the Fifth District, it would appear that only 19 producers in North Carolina and South Carolina will be affected.

Thomas E. Snider

[3] John A. Schnittker, *op. cit.*, p. H4836.

[4] Fred A. Mangum, "The Case for Payment Limitations," talk presented at Southern Region Extension Public Affairs Committee Meeting, New Orleans, March 25, 1969.