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Regional Differences in Per Capita Farm and Nonfarm Income

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Establishment of parity prices by way of the unit of purchasing power approach—the concept on which the parity formula is now based—may not adequately reflect parity of incomes and living standards for farmers. This is true especially if the norm or base period is far back in the past, and if radical changes have occurred in the demand for, and the cost structures of, many farm commodities. Recognition of such limitations has led to a second general approach to the measurement of parity—a formula that involves parity income, with prices derived from this formula. The income approach received Congressional recognition, and resulted in a definition of parity income in the Soil Conservation and Domestic Allotment Act of 1936, revised in the Agricultural Act of 1938. Later, it was replaced with a definition in the Agricultural Act of 1948 that was substantially different. This parity concept centers generally on the relation between the incomes of farm people and those of nonfarm people. In the measurement of such parity two basic approaches have been used. One involves the maintenance of a historical income ratio that would provide farmers with incomes and living standards proportionate to those of nonfarmers; the other would establish the standard of equal incomes or living standards as between farmers and nonfarmers. In the first approach, the ratio of farm to nonfarm income in recent years has been at parity or above, compared with the historical base of 1910–14. The second approach, on the other hand, yields a very substantial differential as between farm and nonfarm incomes, although differences in the purchasing power of the farm dollar versus the nonfarm dollar would probably narrow the gap appreciably. This paper bears on the second of these approaches, that is, the comparison of income differences, especially with respect to the regional variations between the incomes of farm-operator families and those of the nonfarm population.

INCOME COMPARISONS between the total farm population, which includes hired workers, and the nonfarm population, are usually based on U.S. totals regularly published by the Farm Income Branch of the Agricultural Marketing Service in the July issue of the *Farm Income Situation.* Only for 1949 have comparisons been made of the per capita income of persons in farm-operator households only, with income of the nonfarm population. However, the Survey of Farmers' Expenditures in 1955 provided data on which estimates of the per capita income of farm-operator households for a more recent year could be developed, not only for the United States but also for the major geographical regions.

Regional data for 1955 shed considerable light upon the variability in income differences among regions. They permit analysis of the influences of the individual regional differences upon the average difference for the United States as a whole, and they open to question the adequacy of the measurement of the difference between farm and nonfarm per capita incomes when only data for the United States as a whole are employed

TABLE 1.—*Regional distribution of farm-nonfarm income differences, 1955*

Region	Income per capita		Difference	Population of operator households	Total "gap" col. (3) × col. (4)
	Nonfarm	Farm			
	Dollars	*Dollars*	*Dollars*	*Thousands*	*Thousand dollars*
Northeast	2, 175	1, 218	957	1, 420	1, 359
East North Central	2, 182	1, 082	1, 100	3, 003	3, 303
West North Central	1, 861	957	904	3, 301	2, 984
South Atlantic	1, 521	879	642	3, 533	2, 268
East South Central	1, 366	751	615	3, 105	1, 910
West South Central	1, 577	1, 121	456	2, 318	1, 057
Mountain	1, 726	1, 353	373	725	271
Pacific	2, 215	2, 575	−360	840	−302
United States			[1] 704	18, 245	12, 850

[1] Computed by dividing U.S. total gap by total population of farm-operator households.

Sources: Estimates of nonfarm income, per capita, consist of estimated total personal income of the entire population, both farm and nonfarm, as shown in the *Survey of Current Business*, August 1958, U.S. Dept. of Commerce, less estimated farm-operator family income, divided by the Bureau of the Census estimate of total population July 1, 1955 (excluding armed forces overseas) less estimated population in farm-operator households.

Per capita income of farm-operator households consists of (1) the net income of farm operators from farming, as reported in the *Farm Income Situation*, FIS–175, September 1959, plus (2) the off-farm income of farm-operator families, based on data reported in the *Survey of Farmers' Expenditures 1955*, December 1956, U.S. Department of Agriculture, and U.S. Department of Commerce, divided by the estimated population of farm-operators' households, as reported in the *Survey of Farmers' Expenditures, 1955*.

in deriving such a measurement.

The greatest difference between per capita farm and nonfarm incomes in 1955 was in the East North Central Region; farm income per capita in that region fell short of nonfarm income by $1,100 (table 1). In sharp contrast, farm-operator families in the Pacific Region had a per capita income that actually exceeded nonfarm income by $360. For the most part, this reflected the comparatively large-scale farm operations and the relatively small farm population in that region.

The income differential or gap was largest in the North, and smallest in the West; the gap in the South was in between. The fact that the gap was largest in the northern regions reflects for the most part the relatively high degree of industrialization there and the consequent high level of nonfarm income compared with the other regions, with the exception, of course, of the Pacific Region. In that area, not only was per capita income of nonfarm persons highest; the per capita income of farm-operator households was also the highest by far.

TABLE 2.—*Relationship between income from farming and off-farm sources of farm population, 1955, by regions*

Region	Total net farm income	Income from off-farm sources	Total income	Column (2) ÷ column (3)	Population of farm-operator households	Total net farm income per capita	Off-farm income per capita
	Million dollars	*Million dollars*	*Million dollars*		*Thousands*	*Dollars*	*Dollars*
Northeast	826. 7	902. 7	1, 729. 4	0. 522	1, 419. 9	582	636
East North Central	1, 987. 4	1, 261. 4	3, 248. 8	. 388	3, 003. 0	662	420
West North Central	2, 357. 2	802. 8	3, 160. 0	. 254	3, 300. 6	714	243
South Atlantic	1, 814. 6	1, 290. 2	3, 104. 8	. 416	3, 532. 7	514	365
East South Central	1, 331. 3	999. 3	2, 330. 6	. 429	3, 105. 0	429	322
West South Central	1, 417. 2	1, 182. 0	2, 599. 2	. 455	2, 317. 7	611	510
Mountain	666. 0	315. 9	981. 9	. 322	725. 5	918	435
Pacific	1, 367. 0	796. 3	2, 163. 3	. 368	840. 1	1, 627	948
United States	11, 767. 4	7, 550. 6	19, 318. 0	. 391	18, 244. 5	645	414

Note: See table 1 for sources of data.

Industrialization Provides Off-Farm Income Supplements

Another aspect of the regional differences in the farm-nonfarm income gap is the extent to which farm families in the various regions have been supplementing their incomes from farming with income from off-farm sources (table 2).

Where per capita income from farming is low, dependence upon nonfarm sources of income generally is high, as can be seen in table 2. Per capita income from farming in the Northeast was low and income from off-farm sources accounted for 52 percent of the total per capita income of farm-operator households. In the South Atlantic and East South Central Regions, per capita farm income was also low and income from off-farm sources accounted for 42 and 43 percent, respectively, of total income. In the Pacific, Mountain, and West North Central Regions, on the other hand, per capita farm incomes were relatively high, and in these regions income from off-farm sources was relatively low.

While there appears to be an inverse correlation between the level of farm income and the percentage of total income obtained from off-farm sources, the extent to which farm families in the various regions were able to supplement their incomes from nonfarm sources depended largely upon the availability of job opportunities. In the Pacific and Northeast Regions, for example, industry is heavily concentrated. Farm families' income from nonfarm sources in these regions was greater than farm family income from such sources in any other region. On the other hand, the relatively low level of industrialization in the West North Central, South Atlantic, and East South Central Regions limited the ability of farm families to supplement their incomes from farming.

Use of U.S. Aggregates Biases Gap Measurement

With respect to the influences of regional differences upon the average difference for the United States as a whole, regional data also point up the biases contained in estimates of the farm-nonfarm income gap for the United States as a whole derived from aggregative figures. Because of the lack of detailed geographical estimates of income differences, the farm-nonfarm gap for the United States is usually measured as shown in table 3. This method involves using aggregative figures for the United States. For 1955, the gap is seen to be $908 per capita, indicating that an additional $16.6 billion would have been required in 1955 to provide the 18.2 million persons in farm-operator households the same average income as nonfarm persons.

TABLE 3.—*Comparison of farm and nonfarm income per capita in 1955 using aggregative data for the United States*

Item	Total income	Total population	Income per capita
	Million dollars	*Thousand*	*Dollars*
Nonfarm	287, 280	146, 058	1, 967
Farm	19, 318	18, 245	1, 059
Difference			908

See table 1 for sources of data.

Computation of the average gap for the United States using detailed geographical data, however, points up the upward bias contained in the average derived by use of United States figures—a bias introduced by the variability in the size of the farm population relative to the nonfarm population in each region.

As table 1 shows, the total deficiency for the United States, was (1) $12,850 million when estimated by using regional data, compared with (2) an estimated deficiency of $16,566 million when computed by using United States totals—a difference of about $3.7 billion.

Why the difference? If breakdowns or comparisons by States or counties were available, would the estimated deficiency be reduced even more?

Source of Bias Hidden in Population Weights

In attempting to find some answers let us investigate the makeup of these measurements of gap. The computation of a simple average gap from aggregative figures, whether for a region (an aggregation of States or counties) or for the United States (an aggregation of regions, States, or counties) implies the summation of the nonfarm incomes for each geographical component divided by the summation of the nonfarm population, from which is subtracted the sum of farm

incomes divided by the summation of farm population for each geographical component.

In symbols, this is

$$I_{U.S.}=\frac{\sum_{i=1}^{n} Yi}{\sum_{i=1}^{n} Pi}-\frac{\sum_{i=1}^{n} Xi}{\sum_{i=1}^{n} bi}, \text{ where}$$

$I_{U.S.}$ = U.S. average gap computed by use of U.S. totals.
Yi = Total nonfarm income of the ith geographical component;
Pi = Total nonfarm population of the ith geographical component;
Xi = Total income of farm-operator households of the ith geographical component; and
bi = Total population of farm-operator households of the ith geographical component.

Assuming three geographical subdivisions this may be written as

$$(2) \qquad I_{U.S.}=\frac{Y_1+Y_2+Y_3}{P_1+P_2+P_3}-\frac{X_1+X_2+X_3}{b_1+b_2+b_3},$$

The right hand member is equivalent to

$$(3) \quad \left[\frac{Y_1}{P_1+P_2+P_3}-\frac{X_1}{b_1+b_2+b_3}\right]+\left[\frac{Y_2}{P_1+P_2+P_3}-\frac{X_2}{b_1+b_2+b_3}\right]+\left[\frac{Y_3}{P_1+P_2+P_3}-\frac{X_3}{b_1+b_2+b_3}\right]$$

Now let us look at the component for any one region, say, the first. This may be written as

$$(4) \quad \left[\frac{Y_1}{P_1}\right]\left[\frac{P_1}{P_1+P_2+P_3}\right]-\left[\frac{X_1}{b_1}\right]\left[\frac{b_1}{b_1+b_2+b_3}\right].$$

This indicates that a region's contribution to a simple average for all regions combined depends on (1) the per capita nonfarm income in that region, (2) the ratio of that region's nonfarm population to the total nonfarm population for all regions combined, (3) the per capita farm family income in that region, and (4) the ratio of that region's farm population to the total farm population for all regions combined.

Turning now to the United States average difference computed by use of the regional data, we have

$$(5) \bar{I}_{U.S.}=\frac{\left[\frac{Y_1}{P_1}-\frac{X_1}{b_1}\right]b_1+\left[\frac{Y_2}{P_2}-\frac{X_2}{b_2}\right]b_2+\left[\frac{Y_3}{P_3}-\frac{X_3}{b_3}\right]b_3}{b_1+b_2+b_3}$$

This in essence is an average of regional differences weighted by the proportion of total farm population residing in each region. Its meaning is straightforward. It is an average per capita difference, which, when multiplied by the total population will yield an estimate of the total dollar deficiency consistent with the existing variations in the gap among regions. In other words, it measures the total amount of *additional income* needed to equalize farm and nonfarm dollar incomes in *each region.*

Again taking a component of this United States average for the first region we get from (5) above.

$$(6) \quad \left[\frac{Y_1}{P_1}-\frac{X_1}{b_1}\right]\frac{b_1}{b_1+b_2+b_3}=\left[\frac{Y_1}{P_1}\right]\left[\frac{b_1}{b_1+b_2+b_3}\right]-\left[\frac{X_1}{b_1}\right]\left[\frac{b_1}{b_1+b_2+b_3}\right]$$

Subtracting this from (4) above, yields

$$(7) \quad \left[\frac{Y_1}{P_1}\right]\left[\frac{P_1}{P_1+P_2+P_3}-\frac{b_1}{b_1+b_2+b_3}\right]$$

Here we have the source of the differences in the measurement of the United States average gap between per capita income of nonfarm persons and that of farmers arising from the use of the aggregative data, on the one hand, and regional data, on the other. It lies in the weighting of the nonfarm per capita income for each region in computing the U.S. average.

In those regions where the proportion of the nonfarm population to the total nonfarm population for all regions is high relative to the proportion of the farm population to the total farm population for all regions, the per capita nonfarm income will receive a heavier weight in the United States average when it is computed by the aggregative method. Where the reverse is true the weight will be lighter. And where they are equal there will be no difference in weight as between the two methods.

As can be seen from (7), these differences will be greater, the higher the absolute level of nonfarm income per capita in a given region.

TABLE 4.—*Comparison of regional contributions to computed United States average difference between per capita nonfarm and farm income, using two methods of computation*

Region	Ratio of regional nonfarm population to U.S. nonfarm population	Ratio of regional population of farm households to U.S. population of farm households	Per capita income		Contribution to estimated United States average gap		Estimated bias in aggregative U.S. average
			Nonfarm	Farm	Using aggregative method	Using regional differences	
	Percent	*Percent*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Northeast	0. 3037	0. 0778	2, 175	1, 218	566	74	+492
East North Central	. 2101	. 1646	2, 182	1, 082	280	181	+99
West North Central	. 0792	. 1809	1, 861	957	−26	164	−190
South Atlantic	. 1091	. 1936	1, 521	879	−4	124	−128
East South Central	. 0580	. 1702	1, 366	751	−49	105	−154
West South Central	. 0914	. 1270	1, 577	1, 121	2	58	−56
Mountain	. 0359	. 0398	1, 726	1, 353	8	15	−7
Pacific	. 1126	. 0461	2, 215	2, 575	131	−17	+148
United States	100. 0000	100. 0000	----------	----------	908	704	+204

Regional Distribution of Bias

Table 4 reveals the extent of biases and their distribution by region, when the computation of the United States average differences or gap in per capita nonfarm and farm income is made by use of United States totals only. Some explanation of the data in some of the columns may be in order, at this point, to make the meaning of the table clearer.

Columns (1) and (2) are simply the proportions of total United States nonfarm and farm populations, respectively, in each region. Columns (3) and (4) are the per capita incomes for each region. Columns (5) and (6) under "Contributions to United States average gap," show the estimated dollars per capita contributed by each region to the United States average computed by the aggregative and regional difference methods. Thus, in column (5), we have expression (4) above computed for each region. That is, each entry for a region is (1) the per capita nonfarm income multiplied by the ratio of nonfarm population in that region to total United States nonfarm population, less (2) the per capita income of farm-operator households multiplied by the ratio of the farm population in that region to the total United States farm population. The sum of these computations yields the United States average gap, as computed by use of aggregative United States figures. These are the regional contributions implied by the aggregative method.

In column (6) we have expression (6) above computed for each region. It consists of nonfarm income per capita less the farm income per capita, multiplied by the farm population ratios for each region.

Column (7) which is the difference between columns (5) and (6) shows the estimated "bias" in the United States average gap resulting from the computation of the United States average by use of United States totals. The differences shown in column (7) could also have been obtained by substitution in expression (7) above, which we have found is the difference for each region implied by the two methods. Thus, for the Northeast Region we find that the substantial density of nonfarm population in that area relative to the farm population, combined with the high dollar level of nonfarm income per capita results in an extreme upward bias in that region's contribution to the U.S. average computed by use of aggregative figures. Upward biases are also reflected for the Pacific and East North Central Regions for the same reasons. In all other regions, downward biases are the rule primarily because of the relatively higher density of farm populations in those regions.

Regional Data Would Minimize Bias

One clear implication of these results is the necessity for greater geographical detail in per capita income data in order to properly gage the magnitude of the disparity in income between

farm operators and persons in nonfarm occupations for the country as a whole. As a minimum goal, estimates at a regional level on a current year basis should be aimed at. Of course, biases may be present even in regional measures because such estimates are themselves aggregates of State estimates. However, tests with limited data available for 1955 indicate that if a comparison were made on a State-by-State basis rather than on a regional basis, the U.S. average gap estimated by use of aggregate figures for the U.S. would be reduced by about the same amount as that indicated by the regional data. Considering the additional cost of collecting and analyzing State data, therefore, regional data appear to be quite adequate to measure the average gap between the income of persons on farms and those not on farms for the U.S. as a whole.

A Derivation of Average Cost Curves by Linear Programming

By Randolph Barker

This paper presents a further modification of linear programming technique which provides the basis for the calculation of average cost curves. The procedure followed is similar to variable resource programming. Returns are maximized with respect to the output of a particular product as output is varied over the desired range. This provides information on variable costs which when combined with fixed-cost data permits the plotting of average cost curves. *The author is indebted to Walter R. Butcher and Earl O. Heady for their constructive criticism.*

SEVERAL MODIFICATIONS of linear programming procedure that have been developed have greatly increased the flexibility of programming as a research tool. This paper presents a variation of the simplex solution that permits calculation of average cost curves. Although this method is similar to the variable resource and variable pricing techniques developed earlier, it is based on the continuous variation of a product over the relevant output range.

The procedure for calculating average cost curves is developed in detail. An empirical example is taken from a 1957 investigation of "loose housing" systems on Iowa dairy farms. Synthetic farm models for central Iowa conditions were constructed to permit comparison of the conventional stanchion barn with the following loose-housing milking systems: (1) A 4-abreast stanchion parlor, (2) an elevated side-entry 3-stall parlor, (3) an elevated side-entry 6-stall parlor, and (4) a 6-on-a-side herringbone parlor. Short-run and long-run average cost curves were developed for these systems.