# Two Methods for Estimating Real Structural Change in Agriculture

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*Abstract.* *The regression method of adjustment for price changes produces estimates that are close to those produced by the reclassification method, especially when the results are aggregated into three sales classes The difference between the two methods is greatest for the smallest sales classes Although both methods produced similar results, the regression method is faster, much less expensive, and more flexible than the reclassification method Estimated are census farm numbers and cash receipts by farm sales class from the census of agriculture in terms of constant 1982 farm prices for 1974 and 1978 using a low-cost regression method*

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Structural change in U S agriculture refers to change in the distribution of farms and cash receipts by sales class The rapid concentration of sales on farms in the largest sales classes in recent years is a cause for concern Accurate analysis of structural change in U S agriculture must be achieved before we can understand and address concerns about concentration

A unit of analysis must be chosen from a list of imperfect options Two common choices are acreage classes (farm size based on acres) or sale classes (farm size based on gross sales) Using acreage classes is unwise here because land is a highly heterogeneous resource Different commodities vary greatly in output per acre, and the number of acres on a farm may have little to do with a farm's gross output or value of production Sales classes are better for national analysis of structural change from an economic point of view

A major problem with analyses based on sales classes is that the census data on farms according to sales classes are based on the nominal prices of commodities sold in the census year Changes in prices between census years tend to move large numbers of farms between sales classes whether or not they actually had increases or decreases in sales Price changes, therefore, make nominal-price data unsuitable for accurate structural analysis Other studies adjust farm numbers by sales class to compensate for price changes (*1, 2, 3, 4*)[1] These studies show estimated farm numbers in terms of constant prices for different intervals in different base years

I consider two methods for adjusting farms, sales, income, and acreages for price changes One approach directly reclassifies the individual records from the census of agriculture data tapes (*11*) That approach involves adjusting gross sales of crops and livestock products from individual farms by using the national indices of prices received by farmers Each farm is then placed into the appropriate constant-price sales class This reclassification is useful for detailed analysis because it preserves the relationship between individual farms and their assets and attributes However, the cost to reclassify the Census Summary Table of Farms by Sales Class for a single census year would be $7,500-$10,000 (*5*) Only 1974 and 1978 census data have been reclassified using 1982 price levels The feasibility of processing data tapes for the 1969 census or earlier census years is unknown, and if feasible, the cost would probably be higher than for the 1974 to 1982 censuses

An alternative to direct reclassification is a regression method that adjusts the published data on farms according to the general index of all prices received by farmers The regression method, performed on a personal computer with standard spreadsheet software, is also more flexible than the reclassification method in that updates or changes in the reference year can be made easily, and data from the 1969 census or earlier census years can be adjusted The regression method, however, may be less accurate than the reclassification method because it operates on data aggregated into as few as eight sales classes instead of the individual farm records The regression method does not directly preserve data on the assets and attributes from the records of individual farms

## Method

Lin and others first used the regression method to adjust farm numbers for price changes (*2*) The regression method is applied to a cumulative distribution of farm numbers In the cumulative distribution of farm

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[1]Italicized numbers in parentheses cite sources listed in the References at the end of this article

numbers, the number of farms in each sales class is the sum of the number of farms in that sales class and above Therefore, the smallest sales class in the cumulative distribution has the total number of U S farms while the highest sales class has only the number of farms that actually had sales at that level The cumulative distribution of farm numbers is inversely related to the size of the sales classes and is hypothesized to be well represented by a polynomial regression equation Equation 1 estimates two polynomial regression equations with the same functional form for each census year For example, to compute the amount of adjustment for farm numbers in 1974, the analyst must first regress the cumulative distribution of farm numbers in 1974 on the nominal lower bounds of sales classes (the price change factor, $I_y = 1$) Then, the same distribution of farm numbers must be regressed again on a set of sales class bounds that have been shifted by a price change factor ($I_y$) proportional to the amount of inflation in agricultural prices between 1974 and 1982

The two estimated distributions are then compared with each other to estimate net change due to price changes (equation 2) Subtraction of the distribution of net changes in farm numbers due to price changes from the nominal-price distribution of farms produces an estimate of the constant-price number of farms

Estimates of sales and other attributes of the farms in each sales class are adjusted based on the assumption that these attributes can be shifted in proportion to the shift in farm numbers resulting from the adjustment method

$$FNA_y(L) = \ln\alpha + \sum_{n=1}^{n} \beta_n (\ln L(I_y))^n, \quad (1)$$

$FNA_y(L)$ = Cumulative number of farms that had sales in excess of L in a census year (y)

L = Lower bound of a census sales class in nominal prices

N = Degree of polynomial function

$I_y$ = Deflation (inflation) adjustment factor, the ratio of the index of prices in the base year to the census year (y)

$\alpha, \beta_n$ = Parameters of the distribution

$$\text{Net change due to price changes} = [\text{gain due to price changes}] - [\text{loss due to price changes}]$$

$$= (NB_n - NA_n)_y - (NB_{n+1} - NA_{n+1})_y \quad (2)$$

NB = Estimated number of farms in sales class n in year y prices

NA = Estimated number of farms in sales class n in year y, in base year prices

n, n+1 = Sales class, the next higher sales class

## The Two Approaches Compared

The regression method produces results (table 1) for 1974 and 1978 (1982 prices) that are within a few percentage points of the farm numbers from the reclassification method for farms with sales greater than $2,500 (columns 3 and 4) Differences between the two methods probably come from index bias on the part of the regression method and underestimation of small farms by the redistribution method Index bias may occur because cash grain sales are a larger proportion of total sales on medium farms than on small or large farms Using a separate livestock price index and crop price index in the reclassification method may reduce index bias However, the reclassification method probably underestimates the number of farms in the lowest sales class because only farms counted in earlier years are available for reclassification The regression method, in contrast, tends to bring additional farms into the distribution at the lower end (less than $10,000) Yet, the regression method brings too many farms into the distribution in the smallest sales class (less than $2,500)

The regression method most closely matched the reclassification results when farms with sales of less than $2,500 were included in the nominal (input) data for the regression procedure, then truncating the adjusted distribution at $2,500 for purposes of presentation and comparison The variance between the two methods is reduced by aggregating farms into three sales classes (subtotals in table 1), where the two distributions are essentially the same

Sensitivity tests (not shown) demonstrated that the regression method estimation of constant-price large farm numbers was very stable Changes in polynomial regression degree, number of sales classes, and truncation of the nominal distribution had very little effect on the estimated number of large farms

**Table 1—Comparison of constant-price (1982 dollars) farm numbers estimated using the reclassification and the regression method**

| Sales class | Farm numbers produced by the reclassification method | | Farm numbers produced by the regression method | | Regression method results as a percentage of the reclassification results | |
|---|---|---|---|---|---|---|
| | 1974 | 1978 | 1974 | 1978 | 1974 | 1978 |
| | *Thousands* | | | | *Percent* | |
| Less than $2,500 | 534 | 407 | 763 | 406 | 143 | 100 |
| Small, $2,500-$19,999 | 887 | 907 | 876 | 929 | 99 | 102 |
| $2,500 to $4,999 | 282 | 291 | 294 | 315 | 104 | 108 |
| $5,000 to $9,999 | 297 | 314 | 292 | 321 | 98 | 102 |
| $10,000 to $19,999 | 308 | 302 | 290 | 294 | 94 | 97 |
| Medium, $20,000-$99,999 | 680 | 673 | 699 | 679 | 103 | 101 |
| $20,000 to $39,999 | 313 | 297 | 325 | 296 | 104 | 100 |
| $40,000 to $99,999 | 367 | 376 | 375 | 383 | 102 | 102 |
| Large, $100,000 and over | 212 | 269 | 213 | 266 | 100 | 99 |
| $100,000 to $499,999 | 195 | 246 | 197 | 244 | 101 | 99 |
| $500,000 and over | 17 | 23 | 16 | 23 | 96 | 99 |
| All farms with sales greater than $2,500 | 1,779 | 1,849 | 1,788 | 1,874 | 100 | 101 |

## Estimation of Constant-Price Sales by Sales Class

Estimates of constant price farm numbers is only part of structural change Estimates of the constant-price distribution of sales, income, acreage, and other attributes are of interest to researchers and policymakers Constant price sales, income, and acreage by sales class can be obtained directly through the reclassification method I obtained constant-price sales, income, acreage and other attributes using the distribution of constant price farm numbers from the regression method I shifted attributes in proportion to the shifts in estimated farm numbers This results in attributes, such as sales, which sum to a value that usually approaches or equals the nominal sum inflated (deflated) to a constant-price level Additional inflation (deflation) by means of a uniform factor may be necessary to bring the total sales or other attribute to a sum that equals the published estimates of total sales or other attributes

Shifting sales or other attributes in proportion to shifts in estimated farm numbers is mathematically equivalent to an assumption that farms with average sales are the ones that shift between classes The farms that move between classes are not, realistically, the same size as the average farm The shifts in sales due to price changes may be more or less than the correct adjustment In other words, a redistribution bias may occur

I assessed the extent of the potential redistribution bias by comparing two sets of cash receipts that have been shifted in proportion to adjusted farm numbers I shifted one set of cash receipts in proportion to the shifts in farm numbers resulting from the reclassification method I shifted the other set of cash receipts in proportion to the shifts in farm numbers resulting from the regression method (table 2) In comparing the two sets of estimated constant price cash receipts, I uniformly deflated the cash receipts that were shifted by the regression method so that the two totals were the same Not much redistribution bias occurred for farms with sales in excess of $5,000 since the two sets of cash receipts were very close Aggregating the redistributed sales from the seven-class set to a three-class set further reduced redistribution bias, which canceled out the effect of a systematic set of differences between the estimates

## Fine-Tuning the Regression Method

The regression method helps adjust farm numbers according to prices in the most recent census year or a prior census year Choosing an early year as the base generally results in a deflation of farm numbers in most sales classes and a decrease in the total number of farms Choosing the most recent census year (1982) inflates the number of farms in earlier censuses Mathematical deflation and inflation of total farm numbers resulting from the regression method is directly analogous to what occurs when the census

**Table 2—Comparison of cash receipts redistributed by the reclassification method and the regression method**

| Sales class | Cash receipts redistributed using the reclassification method | | Cash receipts redistributed using results of the regression method | | Columns 1 and 2 as a percentage of columns 3 and 4 | |
|---|---|---|---|---|---|---|
| | 1974 | 1978 | 1974 | 1978 | 1974 | 1978 |
| | *Million dollars* | | | | *Percent* | |
| Less than $2,500 | 569 | 475 | 987 | 635 | 58 | 75 |
| Small, $2,500-$19,999 | 7,033 | 6,996 | 7,036 | 7,277 | 100 | 96 |
| $2,500 to $4,999 | 902 | 968 | 1,161 | 1,134 | 78 | 85 |
| $5,000 to $9,999 | 1,989 | 2,068 | 2,008 | 2,194 | 99 | 94 |
| $10,000 to $19,999 | 4,142 | 3,960 | 3,867 | 3,949 | 107 | 100 |
| Medium, $20,000 $99,999 | 29,493 | 29,907 | 29,355 | 30,179 | 100 | 99 |
| $20,000 to $39,999 | 8,392 | 7,818 | 8,359 | 7,916 | 100 | 99 |
| $40,000 to $99,999 | 21,101 | 22,089 | 20,996 | 22,263 | 100 | 99 |
| Large, $100,000 and over | 55,296 | 75,751 | 55,431 | 75,199 | 100 | 101 |
| $100,000 to $499,999 | 32,025 | 42,145 | 31,946 | 41,587 | 100 | 101 |
| $500,000 and over | 23,271 | 33,606 | 23,485 | 33,611 | 99 | 100 |
| Total receipts for farms with sales greater than $2,500 | 91,822 | 112,654 | 91,822 | 112,655 | 100 | 100 |

[1]For purposes of comparison, the redistributed cash receipts on this table have been uniformly deflated to sum to the total cash receipts estimated by Ahearn (*1*) The nominal cash receipts data used in the regression method are for 1975 published in *Economic Indicators of the Farm Sector* series, deflated to equal the sum of the 1974 cash receipts

farm definition's lower sales limit is changed up or down For example, reducing the sales limit includes a large number of additional places with very small sales or sales potential The census farm definition in fact has been including more farms with lower sales because the official definition is set in terms of sales in nominal prices

Although the application of the regression method is essentially the same regardless of the base year, the effect of the method is not symmetrical Estimation errors are probably more prevalent when the number of farms is inflated relative to the nominal-price distribution For instance, using the current year as the base year tends to bring large numbers of farms into the distribution at the lower bound The adjusted number of farms in the smallest sales class (farms with less than $2,500 in sales) tends, therefore, to be substantially overestimated Inclusion of farms with sales of less than $2,500 is generally problematic regardless of the base year Each census contains large numbers of farms with sales of less than $1,000 that are included in the official totals on the assumption that they could have had sales of more than $1,000

The adjustment process, however, should be inherently more stable and accurate when farm numbers are being deflated The adjustment process tends to push farms into the smallest sales classes and out of the adjusted distribution The uncertainty about farm numbers in the small nominal-price sales classes and the nonmonotonic distribution of farms at and below the definitional boundary therefore becomes much less important Variability in enumeration can be substantially reduced by truncating the nominal-price data set at $2,500 But, estimates of farm numbers from the reclassification method with an earlier base year are unavailable for comparison with the regression method estimates

Both adjustment methods have inherent limits Both methods are only approximate because the indices used are weighted averages of diverse sets of agricultural commodities, while the proportion of sales from different products is not constant across all sales classes, and commodity prices have changed at different rates The decomposition of sales into sales of crops and livestock in the reclassification method eliminates the largest source of index bias The index bias is generally insignificant when the change during 1969-82 is considered because price changes have tended to equalize between commodity groups The largest potential bias exists for the regression method for the 1969-74 interval when cash grain prices increased by about 30 percent more than the index of prices received by farmers Medium farms received about 40 percent of their sales from cash grains compared with 24 percent for large farms

## Conclusions

The regression method of adjustment for price changes produces estimates that are close to those produced by the reclassification method, especially when the results are aggregated into three sales classes The difference between the two methods is greatest for the smallest sales classes although both methods produced similar results However, the regression method is faster, much less expensive, and more flexible than the reclassification method

The accuracy of estimation of farms in the smallest sales classes is probably higher when the regression method deflates farm numbers (for example, when using an earlier base year) rather than inflates farm numbers Results from the reclassification method, however, are not available from earlier base years for comparison purposes

Using the estimated constant price farm numbers as a basis for shifting sales of farms appears to be accurate Similar shifts of other attributes of farms in sales classes may be sufficiently accurate for analytical purposes

## References


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