Effects of Relative Price Changes on U.S. Food Sectors, 1967-78

By Gerald Schluter and Gene K. Lee* 

Abstract

For a half-century the parity ratio has served as the most commonly used measure of the effects of relative price changes on the farm economy. The authors present a consistent economic model which measures the price-related income effects of relative price changes in selected sectors of the U.S. economy during the 1967-78 period and use this model to analyse selected sectors within the food system. Their model improves and expands upon the parity ratio. It provides more detailed information within the farm sector, and it provides conceptually consistent measures of the effects of relative price changes in the nonfarm sectors of the food system.

Keywords

Relative price changes, Parity ratio, Input-output analysis, Food system, Farm sector, Inflation

The first step, forming a clear idea of the ultimate use of the result, is most important, since it affords the clue to guide the compiler through the labyrinth of subsequent choices. It is, however, the step most frequently omitted.

Wesley Mitchell, 1915

Introduction

Mr. Mitchell was referring to constructing a price index, but his advice is as true today as it was 65 years ago (5). Equally true, we suggest, is a corollary for choosing a price series. The first step, determining the purpose for which the price index is constructed, is most important, since it affords the clue to guide the user through the labyrinth of subsequent inappropriate uses. A classic example of the failure to follow this corollary is the parity ratio.

The parity ratio has survived 50 years of criticism, and it will likely continue to be used because it is timely (some price data are only about 2 weeks old when published), readily available, and easily understood. In this article, we briefly review its suitability as an indicator of the effect of relative price changes on agriculture and compare it with two alternative price series. Then we present a consistent economic model which measures the effects of relative price changes on selected farm, food-processing, and energy-related sectors of the U.S. economy during the 1967-78 period, which, we propose, provides a better indicator of the effects of relative price changes in the food and agricultural sectors.

At the core of most attempts to support farm income has been the desire to maintain the purchasing power of farmers. Often this effort has taken the route of maintaining relative prices, since makers of agricultural policies have recognized that high or low prices for farm products are not in themselves of major importance. Of far greater importance is the purchasing power of farm products in terms of the items farmers must buy for living and for their businesses. In response to these needs, the U.S. Department of Agriculture (USDA) developed, and first published in 1928, the parity index. The parity index, or the Index of Prices Paid by Farmers for Commodities and Services, Interest, Taxes, and Wage Rates, is expressed on the 1910-14 = 100 base. This parity index was used in conjunction with the Index of Prices Received by Farmers to yield a measure of farmers' purchasing power. One obtains this measure, the parity ratio, by dividing the Index of Prices Received by the parity index. The concept of a parity ratio has been criticized almost from its start (3). Many criticisms have resulted from improper use by data users rather than from problems with the parity ratio series itself. The parity ratio is a price comparison. It is not a measure of cost of production, standard of living, or income parity (9). Nor is it more than one of many indicators of well-being in the farm sector. Many of the criticisms of the parity ratio have resulted from attempts—contrary to Mitchell's advice—to make it serve roles for which it was never intended.

Because the Prices Received Index reflects only farm commodities and the parity index includes farm-household consumption items as well as production expenditures, the

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1 Italicized numbers in parentheses refer to items in the references at the end of this article.
panty ratio most closely mirrors the situation of a farm­
operator household in which the household's income comes
entirely from farm production. Relatively few farm house­
holds today depend solely, or even primarily, on income
from farm sources. Moreover, using the ratio as a broader
indicator to measure relative price changes for agriculture as
an economic sector presents some conceptual problems. The
Prices Paid Index is more inclusive than the Prices Received
Index. In addition to current production items, the parity
index includes consumption items and capital expenditure
items, as well as inflation premiums in interest rates and
possibly in capital inputs. Heady (1, p 142) points out the
parity ratio is faulty in a formal supply sense because the
parity index does not include the implicit cost of resources
already committed and specialized to agriculture. A sector
measure of relative price changes would include only the
prices of current output and current inputs. Considering
only current output and input prices has the additional
advantage of avoiding the measurement problems which
Heady enumerates and the problems of quality adjustment
in capital goods prices and inflation premiums in interest
rates.

A price series which meets this criterion, measuring only
current economic activity in the farm sector, is the im­

cplicit price deflator for gross national product (GNP)
originating in agriculture, or the gross farm product (GFP).
The implicit GFP deflator includes on the output side not
only prices of commodities sold but also changes in farm­
related income, the value of inventory changes, and selected
Imputed items, and on the input side, purchased current
goods and services and rents paid. Comparing the implicit
GFP deflator to the implicit GNP deflator provides a refer­
ence as to how price changes affect the farm sector relative
to the general economy. Applying this approach, we present
a consistent economic model in which the combined price
effects on 16 farm commodity sectors nearly add to the
implicit GFP deflator and in which the price effects on all
the model's sectors nearly add to the implicit GNP deflator.

Figure 1 presents three alternative measures of the effects of
relative price changes on the farm sector. The “parity ratio”
line (PR/PI) presents the traditional—a albeit inappropriate
for our purpose—measure of the farm-sector relative price

Technically, the parity ratio is defined on a 1910-14 base,
however, we use the same price series with a 1967 base. The
GFP/GNP line is the standard just discussed and also illus­
trates the type of standard used in applying the model. The
PR/CI line presents an unpublished price series constructed
to make the parity ratio approach a more appropriate
concept for our purposes. As in the “parity ratio” line, the
numerator of the ratio is the Prices Received Index (1967 =
100). The denominator, however, is the Index of Prices Paid
by Farmers for Production Items after removing capital
items (autos, trucks, tractors; machinery, and building and
fencing materials). The remaining index and resulting ratio
reflect current production activity.

The three measures follow similar patterns. All three mea­
sures agree that for 1970 and 1971 farm purchasing power
decreased and that for 1973-75 farm purchasing power
increased. The average of the ratios for 1967-78 for all three
measures exceeds 100, suggesting that even though the two
“parity ratio” related measures ended the period below 100,
farm purchasing power increased relative to the general
economy over the entire period.

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In a consistent economic model the output of each
industry is consistent with the demands, both final and from
other industries, for its products. A consistent economic
model assures that estimates for individual sectors and
industries will add up to a total estimate (for example,
GNP).
Purchasing power as reflected here is purchasing power due to relative price changes but not to any change in the volume of economic activity. Our measure of farm-sector purchasing power (implicit GDP deflator) is also conceptually consistent with the general measure of the dollar purchasing power in the general economy (the implicit GNP deflator). Here we present a consistent economic model which provides similar estimates of the effects of relative price changes during the 1967-78 period on selected farm, food-processing, and energy-related sectors of the U.S. economy. We demonstrate changes in the same way that base-period quantities function as weights in a Laspeyres price index, such as the parity index. This similarity to a Laspeyres price index provides a check on the model's performance and shows the vulnerability of the food sector to the relative price changes which have accompanied recent inflation. We used a simplified form of the Lee-Schluter model.

\[
\mathbf{r} = [\mathbf{e} \mathbf{D}_p (\mathbf{I} - \mathbf{A}) - \mathbf{m}] \mathbf{D}_o
\]

where

- \( \mathbf{r} \) = 1 \( \times \) \( n \) vector of values added, \( v_i \)
- \( \mathbf{e} \) = 1 \( \times \) \( n \) vector of 1's
- \( \mathbf{D}_p \) = \( n \times n \) diagonal matrix of price changes relative to a year; \( \mathbf{P}_t / \mathbf{P}_0 \)
- \( \mathbf{I} \) = \( n \times n \) identity matrix
- \( \mathbf{A} \) = \( n \times n \) technical coefficients matrix, \( a_{ij} \)
- \( \mathbf{m} \) = 1 \( \times \) \( n \) vector of import coefficients, \( m_i \)
- \( \mathbf{D}_o \) = \( n \times n \) diagonal matrix of base-period sector output, \( \mathbf{Q}_0 \)

Thus, the value-added series for a particular industry is the 1967 value added to cover profits, rents, interest, taxes, and wages adjusted for changes in that industry's output price and its intermediate input prices. Import prices are held constant at base-period levels.

For our analysis, we used a 42-sector aggregated version of the 1967 national I/O table (13) for the import and the domestic input-output coefficients and, thus, for the base-year income, final demand, and output estimates. Table 1 presents these 42 sectors with the price series selected to represent the annual changes in price level of each sector.

### Evaluation

Table 2 summarizes the model's performance. Column 1 gives the model's estimate of the implicit price deflator for farm value added, column 2 gives the U.S. Department of Commerce implicit price deflator for GDP, and column 3 gives the ratio of the two series. As column 3 shows, except for 1974, 1977, and 1978, all the model's estimation errors were 2.8 percent or less. An analysis of the pattern of estimation errors suggests a subtle difference in weights between those implicit in the I/O matrix and those implicit in the price series used by Commerce. The I/O model apparently assigns more weight to the crop sectors. Thus, when livestock prices increase relative to crop prices, our model underestimated the Commerce series. As many crop prices were rising in 1974 while many livestock prices were falling, our model overestimated the implicit price deflator for that year.

Columns 4 through 6 compare total GNP for the 1968-78 period. Our model estimated better for the whole economy than for an individual sector (farm, in this case), with an average error of 1.1 percent and with only one estimation error above 2.5 percent. The model consistently underestimated GNP during the period from 1967 to 1975.

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5 A comparison of columns 2 and 5 shows another difficulty in determining the role of agriculture in general inflation. The volatility of agricultural prices leads to volatile estimates of their role in general inflation. The 1978 implicit GDP deflator of 232.6 represents an 8.79 percent annual rate of increase, well above the 8.1 percent rate in the GNP deflator. Yet the GNP deflator increased in 5 of the 11 years, almost all the increase came in 1969, 1972, 1973, and 1978. Thus, while the GNP deflator increased each year, in only 4 of the 11 years, did the change in the GDP deflator rate exceed the change in the GNP deflator rate. Over the 11-year period, the farm-sector price deflator grew faster than the national deflator rate. Yet, in 5 of those 11 years, the rate of increase in the farm sector was less than one-third that for general price levels.
### Table 1—Sectoring plan and associated price series

<table>
<thead>
<tr>
<th>Sector number</th>
<th>Sector description</th>
<th>Price series²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dairy farm products</td>
<td>Farm income accounts, season average</td>
</tr>
<tr>
<td>2</td>
<td>Poultry and eggs</td>
<td>do</td>
</tr>
<tr>
<td>3</td>
<td>Meat animals</td>
<td>do</td>
</tr>
<tr>
<td>4</td>
<td>Miscellaneous livestock</td>
<td>do</td>
</tr>
<tr>
<td>5</td>
<td>Cotton</td>
<td>do</td>
</tr>
<tr>
<td>6</td>
<td>Food grains</td>
<td>do</td>
</tr>
<tr>
<td>7</td>
<td>Feed grains</td>
<td>do</td>
</tr>
<tr>
<td>8</td>
<td>Grass seed</td>
<td>do</td>
</tr>
<tr>
<td>9</td>
<td>Tobacco</td>
<td>do</td>
</tr>
<tr>
<td>10</td>
<td>Fruits</td>
<td>Prices received</td>
</tr>
<tr>
<td>11</td>
<td>Tree nuts</td>
<td>Farm income accounts, season average</td>
</tr>
<tr>
<td>12</td>
<td>Vegetables</td>
<td>Prices received</td>
</tr>
<tr>
<td>13</td>
<td>Sugar crops</td>
<td>Farm income accounts, season average</td>
</tr>
<tr>
<td>14</td>
<td>Miscellaneous crops</td>
<td>do</td>
</tr>
<tr>
<td>15</td>
<td>Oil-bearing crops</td>
<td>do</td>
</tr>
<tr>
<td>16</td>
<td>Farm-grown forest and nursery products</td>
<td>Prices received</td>
</tr>
<tr>
<td>17</td>
<td>Meat products</td>
<td>Producers Price Index</td>
</tr>
<tr>
<td>18</td>
<td>Dairy plants</td>
<td>do</td>
</tr>
<tr>
<td>19</td>
<td>Canning, freezing, and dehydrating</td>
<td>do</td>
</tr>
<tr>
<td>20</td>
<td>Feed and flour milling</td>
<td>do</td>
</tr>
<tr>
<td>21</td>
<td>Sugar</td>
<td>do</td>
</tr>
<tr>
<td>22</td>
<td>Pate and oils mills</td>
<td>do</td>
</tr>
<tr>
<td>23</td>
<td>Confectioners and bakeries</td>
<td>do</td>
</tr>
<tr>
<td>24</td>
<td>Beverages and flavorings</td>
<td>do</td>
</tr>
<tr>
<td>25</td>
<td>Fertilizers</td>
<td>do</td>
</tr>
<tr>
<td>26</td>
<td>Petroleum refining and related products</td>
<td>do</td>
</tr>
<tr>
<td>27</td>
<td>Miscellaneous food processing</td>
<td>do</td>
</tr>
<tr>
<td>28</td>
<td>Tobacco manufacturing</td>
<td>do</td>
</tr>
<tr>
<td>29</td>
<td>Textiles, apparel, and fabrics</td>
<td>do</td>
</tr>
<tr>
<td>30</td>
<td>Leather and leather products</td>
<td>do</td>
</tr>
<tr>
<td>31</td>
<td>Crude petroleum</td>
<td>do</td>
</tr>
<tr>
<td>32</td>
<td>Coal mining</td>
<td>do</td>
</tr>
<tr>
<td>33</td>
<td>Forestry, fishing, and other mining</td>
<td>do</td>
</tr>
<tr>
<td>34</td>
<td>Other manufacturing</td>
<td>do</td>
</tr>
<tr>
<td>35</td>
<td>Transportation and warehousing</td>
<td>WEFA</td>
</tr>
<tr>
<td>36</td>
<td>Wholesale and retail trade</td>
<td>do</td>
</tr>
<tr>
<td>37</td>
<td>Other noncommodities</td>
<td>do</td>
</tr>
<tr>
<td>38</td>
<td>Electric utilities</td>
<td>Producers Price Index</td>
</tr>
<tr>
<td>39</td>
<td>Gas</td>
<td>do</td>
</tr>
<tr>
<td>40</td>
<td>Real estate</td>
<td>WEFA</td>
</tr>
<tr>
<td>41</td>
<td>Special industries</td>
<td>Assumed unity</td>
</tr>
<tr>
<td>42</td>
<td>Imports</td>
<td>WEFA</td>
</tr>
</tbody>
</table>

1 Detail greater than was required for the food-system analysis, reflected in the sectoring plan, is due to the inclusion of alternative-sector, analytical capabilities for the model.

² Farm income accounts = season average price used in cash receipt estimates, Prices received = Index of Prices Received by Farmers, Producers Price Index = U.S. Bureau of Labor Statistics' Producers Price Index, WEFA = (18). The specific variables from these series for each sector are available from the senior author upon request.

Columns 7 through 9 provide a third measure of the performance of our model. Column 8 gives the actual ratio of the GFP deflator over the GNP deflator as graphed in figure 1. Column 7 gives the ratio of our estimates of these statistics, and column 9 gives the ratio of our estimates of the ratio to the actual ratio. Our model predicted the actual ratio within 2 percent for 7 of the 11 years. Although fairly sizable errors occur in 1973, 1974, 1977, and 1978, only in 1977 does the model incorrectly predict the movement of the GFP deflator relative to the GNP deflator.

These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting price relationships that characterize a dynamic economy.

The relative movements provide useful information. One must avoid giving too much weight to the levels as the level of output and input substitution have been fixed at base-year levels. Thus, the income level estimated by the model may differ from the actual income level of the sectors. A
These implicit value-added price series are useful economic data not otherwise available. They show the analysts how the sector has fared in the maze of interacting private relationships that characterize a dynamic economy.

<table>
<thead>
<tr>
<th>Year</th>
<th>GFP deflator</th>
<th>GNP deflator</th>
<th>GFP deflator/GNP deflator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Actual</td>
<td>Estimate/actual</td>
</tr>
<tr>
<td>1968</td>
<td>103.4</td>
<td>102.8</td>
<td>1.006</td>
</tr>
<tr>
<td>1969</td>
<td>109.5</td>
<td>112.4</td>
<td>0.974</td>
</tr>
<tr>
<td>1970</td>
<td>109.3</td>
<td>111.4</td>
<td>0.981</td>
</tr>
<tr>
<td>1971</td>
<td>109.7</td>
<td>112.7</td>
<td>0.973</td>
</tr>
<tr>
<td>1972</td>
<td>131.1</td>
<td>133.7</td>
<td>0.981</td>
</tr>
<tr>
<td>1973</td>
<td>212.2</td>
<td>207.1</td>
<td>1.025</td>
</tr>
<tr>
<td>1974</td>
<td>218.9</td>
<td>199.5</td>
<td>1.097</td>
</tr>
<tr>
<td>1975</td>
<td>193.5</td>
<td>196.2</td>
<td>0.991</td>
</tr>
<tr>
<td>1976</td>
<td>192.4</td>
<td>191.6</td>
<td>1.004</td>
</tr>
<tr>
<td>1977</td>
<td>179.0</td>
<td>191.4</td>
<td>0.935</td>
</tr>
<tr>
<td>1978</td>
<td>221.1</td>
<td>232.6</td>
<td>0.951</td>
</tr>
</tbody>
</table>

1 Source (14)

Final caveat: it is difficult to establish a base year when all sectors of the economy were "normal," and determining the base year by the scheduling of an economic census may increase the likelihood of choosing a year when a number of sectors were atypical. In our model, these atypical situations have become the norm by which other years are measured. One must remember this difficulty when making intersectoral comparisons.

Relative estimates of the effect of price changes are derived from an economic model which describes the interrelatedness of the U.S. economy. The model is consistent. The model can be validated, and we did validate it, by aggregating individual sector estimates for comparison with published aggregates. However, this is not the chief value of our method. More important, this series is the first systematic, internally consistent set of estimates of the relative vulnerability of parts of the food system to recent relative price changes. These estimates for individual sectors include the price-related income effects on all participants, farm operators, workers, interest recipients, and others who commit factors (labor, capital, land, and others) to the individual sectors.

Model Limitations

The model uses the level and mix of real output in 1967. Thus, the model does not incorporate any changes in income earned by a sector due to changes in level of output or the mix of final demand. It only accounts for changes in income due to changes in relative prices.

Similarly, the weight given each price in calculating this income effect is its weight in the 1967 industry cost function (direct requirements column). Thus, input substitutions due to price changes are ignored, as are input coefficient changes due to changes in production technique. Although these assumptions could lead to potentially serious biases, this problem is common to the use of fixed-weight indexes. Although we do not overlook this potential bias in our model, we accept it as an occupational hazard. Due to the fixed weights, the results can be interpreted as the change in the value added, with all input (primary and intermediate) and output quantities held fixed because of price changes occurring during the 1967-78 period.

Another potential source of error in the model occurs when the series chosen to represent the price effects of a specific sector fails to fulfill this function. The price series chosen may not properly reflect the price changes in that sector, or the collection of price data may differ from commodity marketing patterns.

Finally, these income estimates should not be confused with sector or industry profits, although profits are a component of the income estimates. Rather, our income estimates include wages, interest, depreciation allowances, rents, and indirect business taxes as well as profit-type income. Thus, one dollar of increase in income represents one more dollar of income available for distribution to these factor suppliers.
Results

We discuss our results by groups of sectors. The crop sectors are divided into those more directly influenced by world markets and those more reliant on domestic markets. The food processing sectors are divided into those processing farm livestock products, those processing farm crop products, and those further processing food products. Groups also discussed are farm livestock and energy-related sectors.

Figures 2 through 6 depict graphically our results as percentage variations from the income level in 1967. Thus, a value of zero represents no change, a value of one represents a doubling of base-year income, and a negative number represents an income loss. The implicit GNP deflator is included in each figure to provide a comparison with the overall rate of inflation.

World Market Crop Sectors

Figure 2 presents the estimated income levels of the export-oriented crop sectors relative to the 1967 levels. During the 1968-70 period, relative prices moved to the economic detriment of all these sectors, and their incomes fell below 1967 levels. The oil crops sector first crossed the baseline in 1971 and was 33 percent above it by 1972. Then, with the export boom, the domestic terms of trade shifted dramatically in favor of all four of these crop sectors. The most dramatic shift occurred in the food-grain sector. All four sectors peaked in 1974, income levels fell in 1975 and continued to fall in 1976, except for cotton (for which price and income recovered to above 1974 levels) and for oil crops (which rose slightly from its 1975 income level). In 1977, the oil crops sector continued to rise, but the others dropped. Cotton and food grains rose in 1978, but oil crops stabilized, and feed crops continued to fall.

Because we import a significant share of our domestic sugar, the sugar crop sector is subject to different forces than are other crops. With the expiration of the Sugar Act and a strong world demand for sugar, the income of the sector soared in 1974, dropped (but remained strong) in 1975, and fell again to near 1967-73 trend-line levels in 1976, 1977, and 1978 (fig 2).

Domestic Crops

In contrast to the world-market crop sectors, the income of the domestic crop sectors (vegetables, fruits, and tree nuts) did not shift dramatically due to relative price movements.

Livestock Sectors

The livestock sectors, especially poultry and eggs, were more vulnerable to price changes (fig 3). Some of the variability in poultry and egg income was due to a relatively low income level in the base year, which accentuated the degree of income fluctuations as relative prices changed. Furthermore, the output price for this sector tends to vary more than the input prices, which introduces income variability. Thus, in 1968 and 1969, poultry and egg prices were 7 and 21 percent, respectively, above 1967 levels, leading to income 80 and 180 percent, respectively, above the base period. Conversely, in 1971 and 1972, when price levels were only 3 and 5 percent, respectively, above 1967, income levels were 73 and 89 percent, respectively, below 1967. A subsequent price rise in 1973, to 79 percent above 1967 levels, sent incomes soaring, to 250 percent above base level. When the
poultry and egg price index dropped 17 index points in 1974, while the feed crop price index increased 72 index points and the grain mills (manufactured feeds) PPI increased 22 index points, the poultry and egg sector income plunged to negative levels. Subsequent strength in poultry and egg prices, together with weaker feed prices, allowed 1975 and 1976 estimated income levels to recover to levels 38 and 15 percent, respectively, above base period before falling again below base level in 1977 and recovering to 28 percent above base level in 1978.

The meat animal sector was less volatile than the poultry and egg sector because of a larger base-year income and more stable output prices. The sharp drop in the meat animal index in 1974 does not appear in other economic indicators, such as the Index of Prices Received by Farmers for Meat Animals. Figure 4 dramatically illustrates the superiority of the proposed index of relative income over ordinary price indexes. The relative income index allows explicitly for higher feed costs, whereas the Index of Prices Received by Farmers for Meat Animals does not. The meat animal sector experienced 2 strong years (1972-73) before price weaknesses and higher feed costs took their toll. From 1974 to 1977, the Index of Prices Received by Farmers for Meat Animals was fairly constant (165, 169, 170, and 168), thus, any increase in strength of sector income resulted from slightly lower input prices. Price strength in 1978 improved the income position of this sector to 175 percent above base level. Relying solely on the Index of Prices Received by Farmers for Meat Animals would have been misleading because of changes in input prices.

The income pattern in the dairy sector (fig 3) was rather stable for most of this period, with exceptional strength since 1976. From 1975 to 1978, the dairy product price index rose 20 percent above 1975 levels, whereas the feed-crop price index fell 20 percent. As a result, sector income rose from 39 percent above base level in 1975 to 143 percent above base level in 1978.

Livestock Processing

The stable price and income pattern that we observed for the farm dairy sector is even more pronounced for the manufactured dairy products sector (fig 5). From 1967 through 1975, the estimated income levels stayed within 10 percent.
of base year levels, not until 1976 did they exceed 10 percent. Nonetheless, the sector was losing ground relative to the implicit GNP price deflator. Apparently, this sector is able to pass on increases in the farm price of milk, but the demand for milk prevents larger increases.

The meat- and poultry-processing sector faces a different demand situation (fig 5). As the farm price of meat animals and poultry rose in 1971-73, the meat- and poultry-processing sector apparently did not pass on higher raw product costs, and income levels fell almost 40 percent below base level. After 1973, the PPI for processed meats showed more resilience than farm prices, and the income position of this sector rose during the 1974-75 period, it later dropped to more modest levels.

Farm Crop Processing

Figure 6 shows the variety of income responses of food manufacturing sectors to explicit changes in prices of their respective farm raw materials. The feed and flour-milling sector exhibits tendencies similar to those in the meat-processing sector. Millers apparently did not pass on all costs of higher priced grain inputs during 1974 and 1975, and incomes dropped to near 1967 levels. But their 1976 and 1977 output prices rose 4 and 2 index points, respectively, over 1975 levels, while the food-grains price index fell 37 and 80 index points, respectively, from 1975 levels, resulting in income jumps of 43 and 54 percent, respectively, above base levels.

The fats and oils refining sector exhibited a different pattern. Its income pattern roughly parallels that of the oil crop sector, which suggests that the sector is able to pass through increased raw material costs and a proportional margin to its customers, but the nature of the sector's supply and demand conditions does not allow it to maintain its output price when associated farm prices decline. An exception to this parallel pattern occurred in 1976 when the refining sector's income fell, while oil crops income rose slightly.

The sugar refining sector benefitted from large increases in world sugar prices in 1974, and it increased its income position slightly in 1975 when the sugar crop sector declined.
1978, however, incomes in this sector had returned to a level about 145 percent above base level.

After a fairly stable, but increasing, income level during the 1967-73 period, the canning, freezing, and dehydrating sector income grew considerably during 1974 and 1975, weakened somewhat in 1976, and ended the period 111 percent above base level.

Highly Processed Foods

The three highly processed food sectors were relatively stable, exhibiting no abrupt annual fluctuations. For example, the confectioners and bakeries sector retained its 1967 income level throughout 1968, its income increased to 30 percent over base in 1969, then reached a 40-50 percent plateau where it stayed through 1973. After 1973, the sector income rose steadily for 2 years to a new plateau of 85-90 percent above base level in spite of high sugar prices. By 1978, its price-related income position was 103 percent above base level.

The income level of the flavoring and beverages sector was nearly constant from 1969 through 1973, rose sharply from 1974 to 1977, then dipped in 1978.

The miscellaneous food processing sector did not show strong income growth during the 1968-78 period.

Energy-Related Sectors

The plot of income due to relative price changes for energy-related sectors illustrates a pattern characteristic of the US energy price situation. From 1967 to 1973, the real price of energy declined annually. After 1973, it rose to allocate tight supplies of oil and gas. The plot for the energy-related sectors (Fig. 7) contrasts with plots for the farm sectors. Whereas the farm sectors did not retain any income peaks resulting from relative price shifts in their favor brought about by supply or demand shocks, the energy-related sectors have been able to retain income levels resulting from relative price changes.

Conclusion

Our model is useful because it shows which sectors of the food system have gained from the relative price changes accompanying the recent inflation and which sectors have lost.

We have proposed, as a rough measure of the relative position of a sector with respect to inflation, its sector value-added price deflator relative to the GNP implicit price deflator. This comparison is available from the sector's value-added deflator lines and the GNP implicit price deflator in each figure.

Since 1973, except for feed crops in 1978 and food grains in 1977 and 1978, all export-oriented crops have exceeded the national norm (the implicit GNP deflator) and have benefitted from the relative price changes accompanying inflation by an amount likely to offset their less favorable position from 1967 to 1973.

Sugar has benefitted from the recent relative price changes accompanying inflation. Domestic-oriented crops have been relative losers. On balance, fruits, tree nuts, and vegetables have been relative losers. Since 1973, all the livestock sectors, except dairy in 1976 and 1977 and dairies and meat animals in 1978, have been below the national norm. From 1967 to 1973, the meat animal sector was a relative winner, as were dairy in 1967-72 and poultry and eggs in 1967-70. The livestock sectors gained in the years when the general farm price...
levels were rising slowly, but lost during the big farm price surge. Among livestock-product processing firms, the dairy food manufacturing sector has consistently been below the national trend. Meat and poultry processing was not only below the national trend but also below the base year during the 1967-73 period, it caught up with the national trend in 1974, was above it in 1975-1976, and below it in 1977-78.

Among the sectors processing crude farm crops, fats and oils mills have exceeded the national trend since 1970. Sugar refiners reached trend levels in 1970, and canning, freezing, and dehydrating reached trend levels in 1974. On balance, fats and oils mills and sugar refiners were gainers, grain mills were losers, and canners were unchanged.

Among the more highly refined food-processing sectors, confectioners and bakers benefitted from relative price changes accompanying inflation, as have beverages and flavorings in recent years. The miscellaneous food processing sector has not benefitted.

Implications

Our results, which illustrate sector vulnerabilities to the relative price changes characterizing an economy adjusting to inflation, are not without lessons.

We have seen that if one uses the standard of the GFP implicit price deflator relative to the GNP price deflator, the farm sector has benefitted from relative price changes on agriculture during the inflationary periods have not gone beyond the farm sector. Tweeten and Quance (11) found that farmers were disadvantaged by input price inflation. They concluded that a 10-percent increase in the Prices Paid by Farmers Index reduces nominal net farm income by 4 percent in the short run and by 2 percent in the long run. Tweeten and Griffin (10), updating this model, estimated that a 10-percent increase in farm input prices would reduce nominal net farm income 9 percent in short run, but would raise net farm income as much as 17 percent in the long run.

Prices Received Index and Prices Paid by Farmers Index on the implicit GNP deflator and the lag of each variable for 1920-69. They observed a positive and significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator, but no significant relationship for the Prices Received Index. On this basis, they concluded, "national inflation exerts a real price effect on the farming industry, reducing the parity ratio" (10, p. 10).

Because the Tweeten-Griffin results are based on price data similar to ours, yet arrive at the opposite conclusion, a further comparison of these two findings is in order. Some of the difference is explained by the different time periods. Tweeten and Griffin studied the 1920-69 period, whereas our study used the 1967-78 period. We suggest as an unproven hypothesis that the 1972-73 period, with its rapid expansion of agricultural exports and changes in the pricing policies of oil exporting countries, may have caused such fundamental shifts in relative price relationships as to invalidate many economic judgments for the post-1973 period, based on studies of time periods prior to 1972.

A second explanation is suggested by Figure 8—that is, the Prices Received and Prices Paid by Farmers Indexes plotted.

Figure 8

Farmers’ Prices Received and Prices Paid Index Compared to the Implicit GNP Deflator

% of 1967

220

Prices received

180

Prices paid

140

GNP deflator

100

120 140 160 180 200

Implicit price deflator, % of 1967

10
against the implicit GNP deflator. The prices paid line increases throughout the period and often nearly parallels the GNP deflator (45°) line. One would expect the Tweeten-Griffin result of a significant relationship between the Prices Paid by Farmers Index and the implicit GNP deflator. However, the Prices Received Index line both rises sharply and falls during the 1967-78 period and is hardly parallel. Again, one would expect the Tweeten-Griffin result of no significant relationship between the Prices Received Index and the implicit GNP deflator. But one would be misled by drawing a conclusion like Tweeten and Griffin's from these results that is, general inflation reduces the parity ratio, because during this period, although the Prices Received Index varied too much to be significantly related to the GNP deflator, most of the variance was at a level above the GNP deflator.

Thus, during the 1967 period, while the general price level as measured by the GNP deflator rose each year and the rise totaled 92 percent, the parity ratio (1967 = 100) did not fall in 4 of the 11 years and fell only 4 percent over the 11-year period. The Tweeten-Griffin equations would have predicted an 8-percent drop, if one uses their insignificant coefficient in the Prices Received equation, and would have predicted a somewhat larger drop, assuming no relationship between the Prices Received Index and the GNP deflator. In 3 of the 4 years, the parity ratio did not fall, it rose 5 percent or more. The Tweeten-Griffin analysis does not consider the fact that, in recent times, supply and demand shocks on farm output prices have enhanced rather than depressed prices.

The first implication of our study, therefore, is to question the conventional wisdom about general price inflation having a negative real price effect on agriculture.

The proposed relative income index adds an analytical tool which measures the effect of relative price changes in greater detail than can the parity ratio. Our model allows the analyst to consider relative price effects on nonfarm sectors of the economy by keeping the individual sector measures consistent with national aggregate measures.

Ordinary price indexes are likely to mislead because they reflect only prices received or paid, but not both. The relative income index reflects net income after adjusting for prices received and paid by an individual sector.

Our model also demonstrates the effects of relative price changes on different sectors of the food system. Considering inflationary effects on either the food system or the farm sector masks the diversity in relative prices at the commodity and industry level.

Because inflation distorts investment decisions, capital values, and other time-related economic variables, the relative price effects presented here provide the policymaker with unique economic data. These effects are derived only from current flows from current production, thus, the relative measures of effects of relative price changes are not distorted by investment, cash flow, tax effects, and other time-related distortions.

References

Statistical demand analysis is a synthesis of several disciplines—economic theory, probability theory, and mathematical statistics—applied to concrete data. Each application requires special knowledge of the commodities involved and the adequacy of the statistical series which purport to measure their prices and quantities.

No one of these specialties prepares [one] to give well-rounded advice to commodity experts concerning the statistical measurement of economic relationships. The verbal economist is too verbal, the mathematical economist too mathematical, and the statistician too disdainful of non-experimental data. In ignorance or desperation the commodity economist turns to empiricism, and it is too empirical.

Karl A. Fox
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