Productivity and Food Processing Costs

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Measures of productivity, for agriculture as well as for the private sector of the economy as a whole, have a long and fruitful history in helping to interpret movements in output, prices, and factor costs. To an economist who is familiar with productivity research, and who has watched the continuing rise in marketing charges for farm products, the inevitable question is: What can measures of productivity tell us about the continued rise in the Farm-Food Marketing Bill and the Farm-Food Market Basket (farm-retail spread)?[1] This paper is only a step in that direction (*1*)[2]—it presents some new information, and it brings together our major findings on productivity in factories that process farm food products (*10*). (Similar work on distribution of farm foods is now underway.) Within the last decade, food processing costs in factories have accounted for roughly a third of the Farm-Food Marketing Bill. The eventual product of this area of research should advance our knowledge of supply relations for marketing services for food and, therefore, better our understanding of the relationship between consumer demand for food at retail level and the marketing system's derived demand for agricultural products at the farm level. Briefly summarized, the principal finding in this paper is that, during the post-World War II period, food manufacturing *as a whole* was an average sector with regard to total productivity and price increases—the postwar rise in the price of food processing services was part of the general price rise in the economy as a whole. **The author expresses his appreciation to Jerome Mark, Frank deLeeuw, William Wesson, Forrest Scott, and Allen Paul for their helpful comments.**

[1] As defined by the Economic Research Service, the Farm-Food Marketing Bill is the difference between civilian expenditures for farm foods and the farm value of the raw products. The Farm-Food Market Basket is defined as the difference between the retail cost of the "market basket" and the farm value of the "market basket."

[2] Italic numbers in parenthesis refer to Literature Cited, page 34.

THE MOST commonly used measure of productivity is output per man-hour—that is, "real" output divided by number of man-hours. Changes in output per man-hour reflect substitution between labor, capital, and other production inputs. They also reflect changes in the quality of these productive inputs, technological changes within the industry, and changes in efficiency resulting from economies of scale. Without laboring the point, we can see that output per man-hour is not comprehensive enough to measure changes in technology or efficiency of resources employed in a particular sector. Nevertheless, indexes of output per man-hour are useful. They supplement data on changes in average hourly earnings. When consistently defined, output per man-hour relates average hourly earnings of employees to unit labor costs in production.

A second measure of productivity is output per unit of capital—that is, output divided by some measure of capital inputs.[3] Output per unit of capital inputs obviously suffers from at least the same shortcomings as output per man-hour for measuring changes in technology or efficiency of resources employed in a particular sector. Analogous to the output per man-hour series, output per unit of capital relates returns to capital inputs to unit capital costs in production.

During the last decade, the "total productivity" index has come to the fore. Essentially, it involves dividing an index of net output by an index constructed from a weighted sum of man-hours and capital inputs. Like output per man-hour, total productivity can be a useful descriptive measure.[4]

[3] The reciprocal—the "capital-output ratio"—is more generally used (*4*).

[4] If labor accounts for a large share of combined labor and capital inputs and there has been little or no substitution between labor and capital, output per man-hour can be used to approximate long-term rates of growth of output per unit of labor and capital combined. This has apparently been the case in food manufacturing: From 1919 to 1957, output per man-hour increased 2.3 percent a year compared with 2.1 for output per unit of labor and capital combined. The approximation gets increasingly worse as we shorten the time period.

In order to have stable prices, compensation to labor and capital combined must increase in proportion to total productivity (if the series are consistently defined). That is, if a combined increase in average hourly compensation of labor and returns to capital in food manufacturing exceeds an increase in total productivity in the industry, the price of food processing services will rise. This is a truism obtained from national income accounting.

Total productivity indexes have also come under attack.[5] The major limitation of these indexes results from poor data on inputs, particularly capital inputs. In brief, available measures of factor inputs are not comprehensive enough; for example, the data on capital inputs can, at best, only "allow" for *some* substitution between labor and capital inputs. Total productivity measures, nevertheless, indicate trends and can provide some useful insights for policy—at least by default. They indicate that from the point of view of measuring efficiency of resource use, what we can not measure must be more important than what we can measure.

Technically speaking, the total productivity index can be thought of as derived from a linear production function.[6] What total productivity is really supposed to measure is shifts in the production function—that is, technological changes *within* the industry. What in fact it does reflect is technological changes within the industry, unmeasured changes in quality of both labor and capital inputs, economies of scale, shifts in production between commodities and firms with different levels of productivity, changes in efficiency of resource allocation because of changes in competitive structure of the industry, and so on. Each one of these may involve essentially different policy considerations.

Output and Prices of Processing Services

In order to apply the productivity framework or do any macroeconomic analysis of food processing, it is necessary to measure both the "output" and the "price" of total processing services. Our estimates indicate that output in factories processing farm food products rose 32 percent from 1947–49 to 1959, the most recent year for which data are available (table 1). Part of this rise reflects increased consumption of farm foods, but a significant part reflects more factory processing of these products (*11*, pp. 5–7). The price of these food processing services rose 33 percent. During the same period, the general price level for the economy as a whole rose 30 percent, as measured by the implicit price deflator for gross national product. This means that the "real" or deflated price of factory processing services—the price of processing services divided by the general price index—remained about the same between 1947–49 and 1959 while output rose 2½ percent a year. By comparison, the "real" price of processing services for food remained unchanged between 1929 and 1939, but output rose only 1 percent a year.[7]

TABLE 1.—*Output and price of factory processing services for farm food products, selected years, 1929–59*

[1929=100]

Year	Output [1]	Price [2]	"Real" price [3]
1929	100	100	100
1937	105	83	97
1947–49 average	154	153	102
1953	173	181	105
1957	191	199	105
1959	203	204	104

[1] Measures output of manufacturing establishments processing domestically produced farm food products. Output excludes processing of fluid milk, cream, and eggs; it includes food byproducts.

[2] Index of "value added" for manufacturing establishments included in output (column 1) estimated mainly from data reported in Censuses of Manufactures divided by the net output index (column 1).

[3] Index of price of factory processing services (column 2) divided by implicit price deflator for gross national product published by U.S. Dept. Commerce.

[5] For an appraisal of concepts and data used in productivity analysis, see *Output, Input and Productivity Measurement* (*2*).

[6] Instead of an arithmetic aggregate for inputs assuming a linear production function, we could use geometric indexes which would hypothesize a Cobb-Douglas production function; see Zvi Griliches (*6*).

[7] A scatter diagram of "real" prices and output including data for intermittent years indicates that "stable" real prices was the general pattern (that is, there was no upward or downward trend) during the two subperiods, 1929–39 and 1947–59.

We can, therefore, conclude that after "adjusting" for the inflation in the economy as a whole, the postwar rise in the cost of processing farm foods—that is, the rise in "real" costs—was due to an increase in the volume of processing services, not to a rise in the "real" price of these services. Stated another way, inflation in the economy generally, and an increased volume of processing services, accounted for the postwar rise in factory processing costs.

A few definitions are undoubtedly in order at this point. Our measure of output of factory processing services is, *roughly speaking*, "value added" adjusted for changes in prices.[8] "Value added" is essentially the difference between value of industry shipments and costs of materials and supplies as reported in the Census of Manufactures. The "price" of factory processing services is an "implicit" price obtained by dividing the series on value added in current dollars by the series on net output. The obvious statistical pitfall with regard to this indirect method of computing the price series is that both errors of measurement and biases in the output and price series are inversely correlated. Among other things, the output series does not fully reflect quality changes. Hence, it probably understates the increase in output of processing services; consequently, the implicit price series probably overstates the rise in the price of these services. That is, the "real" price of factory processing services may have actually declined over the postwar period 1947 to 1959. Unfortunately, I know of no better way of estimating a series for price of processing services.

Productivity in Food Manufacturing

Changes in the price of processing services can be divided into changes in total productivity and changes in factor prices. Turning now to our measures of productivity in food manufacturing, almost all of the following discussion will be in terms of total productivity—that is, output per unit of labor and capital combined. Data are not available on capital inputs in factory processing of farm food products only. We shall have to base our analysis of total productivity on food manufacturing—that is, Food and kindred products (excluding Beverages). This should serve our purpose because processing of farm food products accounts for about 85 percent of total food manufacturing.

Table 2.—*Total productivity in Food and kindred (excluding Beverages) manufactures, United States, selected years 1929–59*

[1929=100]

Year	Output [1]	Labor-capital inputs [2]	Total productivity [3]
1929	100	100	100
1937	104	91	114
1948	161	104	155
1953	180	104	174
1957	200	109	183
1959 preliminary	212	112	189

[1] Based on Federal Reserve Board Index of Industrial Production for food manufactures after 1948.

[2] Based on the stock of total capital (fixed plus working capital) estimated by Daniel Creamer (*3, 4*) and total number of man-hours worked by *all* employees, estimated mainly from employment and hours data reported in the Censuses and Annual Surveys of Manufactures. Index of inputs computed from a cross-weighted index number formula using weights for 1929 and 1957.

[3] Output divided by labor-capital input index. Computations for total productivity are based on unrounded figures.

Inputs of total man-hours plus total capital employed in food manufacturing rose 8 percent from 1948 to 1959 (table 2), the latest year for which capital data are available. Thus, if there had been no increase in total productivity, output would have increased only 9 percent. Output actually rose 32 percent, which means that total productivity—output divided by inputs of labor and capital combined—rose about 22 percent or about 1.8 percent a year. Roughly three-fourths of the total rise in output resulted from increased productivity; only a fourth came from counted inputs of labor and capital.

A word on our measures of inputs should be mentioned at this point (*10*). Labor inputs are measured by total number of man-hours *worked* by production and nonproduction workers. Capital inputs are based on Creamer's data on the stock of total capital—that is, fixed plus working capital (*3, 4*). Changes in the stock of total capital and in the man-hour series do not reflect changes in the quality (including new technology) of these

[8] The major statistical pitfalls of the output index for purposes of this paper are (1) because of lack of data, the formulas used only approximate the net output concept, and (2) like all physical output indexes, it does not fully reflect changes in quality of production; see Waldorf, (*11*, pp. 27–39).

factor inputs. There is also the difficult accounting problem in measuring depreciation of capital goods realistically. To these statistical and accounting problems must be added the critical assumptions that the flow of capital services used in production is proportional to the stock of total capital and that the flow of labor services is proportional to the number of man-hours worked. Much of the controversy over the usefulness of the total productivity concept centers on the statistical pitfalls in measuring inputs of capital services.

How does the postwar annual productivity rate of 1.8 percent in food manufacturing compare with the rate before World War II, and with postwar rates in other sectors? The annual rate of growth of total productivity in food manufacturing between 1929 and 1937 was 1.7 percent. Thus, the annual rate of growth of total productivity during the post-World War II period was about the same as the rate during the prewar period marked by the Great Depression. During the three decades 1929–59 as a whole, total productivity in food manufacturing rose about 2.2 percent a year, because the annual rate of growth between 1937 and 1948 was sizable. Comparison with Kendrick's (*7*) estimates indicates that, during the postwar period 1948–57, the annual rate of growth in food manufacturing was about the same as in the private nonfarm sector, but only a little more than half as great as in farming.

If total compensation to labor and capital employed in food processing had increased at the same rate as total productivity in food manufacturing during the postwar years—that is, at 1.8 percent a year—the price of factory processing services for food would have remained constant. Prices of productive inputs, however, rose considerably faster than total productivity and, as a result, the *absolute* price of food processing services rose about a third during the period. But available data on hourly earnings and returns to capital indicate that increases in input prices in food processing generally paralleled increases in the nonfarm sector of the economy.

Several notable trends underlying the postwar growth in total productivity in food processing may be enumerated (*10*):

1. Productivity gains in food manufacturing during the postwar period apparently have been as much fixed-capital saving as labor saving. That is, the amount of fixed capital per unit of output declined at about the same rate as the ratio of total man-hours worked per unit of output.

2. Data on output per man-hour indicate that shifts in production from processing industries with higher levels of output per man-hour to those with lower levels have retarded the rate of growth of output per man-hour in all food processing. This is partly due to differences in capital per worker between industries, but future research will indicate if it is also due to differences in levels of total productivity.

3. There has, of course, been an upgrading in the "quality" of man-hour inputs, but as far as can be seen from the data, increased "quality" of labor inputs within individual industries—that is, shifts from production workers to nonproduction employees—have been offset by interindustry shifts.

Summary and Conclusion

We can now summarize our principal findings following a somewhat different outline. During the postwar years 1947–49 to 1959 increased volume of factory processing services for farm foods accounted for about 45 percent of the total rise in processing costs; higher price of these services accounted for the remaining 55 percent. The higher price of processing services resulted from the fact that compensation to factor inputs rose faster than total productivity. However, the rise in total productivity and increases in input prices in food processing paralleled movements in the nonfarm sector of the economy as a whole; and, consequently, the "real" price of factory processing services remained fairly constant.

By the way of outlook, the average price of factory processing services for farm food products may rise, even relative to an overall price index for the economy as a whole—that is, we may be looking forward to a rise in the real price of factory processing services for foods. Differential increases in consumer demands for different food products have resulted in shifts from production of grain-mill products which have a higher level of output per man-hour to production of meat products, which have a lower level of output per man-hour. This change in the product "mix" has retarded the average rate of growth of output per man-hour for all food processing industries. Judging from time series and consumer budget studies of income elasticities for foods, this shift will continue for some time (*5*).

The difference in output per man-hour between the grain-mill products and the meat products industries reflects, in part, differences in capital per worker employed in the industries (*4*, p. 68). To the extent that gains in total productivity arise from new technology which processing firms adopt through purchases of new and modernized plant and equipment (*9*), the shift in production from more to less capital-intensive industries could have a dampening effect on total productivity. Also, and perhaps more important, because of the growth in the total capital stock relative to labor, "real" hourly earnings of workers historically have risen relative to "real" returns on capital in the economy as a whole (*8*). If this trend continues—and it probably will—the shift in production from less to more labor-intensive industries will mean a rise in the average "real" costs per unit of factory processing services for all foods.

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