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PRODUCTIVITY CHANGES IN THE FOOD AND FIBER SYSTEM, 1958-74

By Donald D. Durost and James E. Kirkley*

Measures of output, input, and labor productivity are derived for the food and fiber sector. They are used to analyze changes in output, hours worked, and labor productivity that have occurred in the food and fiber system since 1958. A major result of the analysis is that the reduction in labor at the farm level has apparently not been reflected in either the input or product marketing sectors.
Keywords: Food and fiber sector, output, hours worked, partial productivity.

The U.S. food and fiber system consists of several industries responsible for producing both agricultural goods and the inputs needed in production of these goods. Food and fiber industries are also responsible for maintaining flows of products and necessary inputs from the basic resource stage to the final consumer. To move these goods and inputs requires considerable interaction among the industries within the system's four sectors: inputs, farm, product market, and consumer. The first three sectors produce the products and inputs and move them through to the fourth sector. The consuming sector creates the demand that generates the flow.

In this article, we focus primarily on the three producing sectors and on effects of major changes within these sectors in recent decades. These changes have helped transform U.S. food production into a highly sophisticated, complex operation.

Many of these changes have caused the scale and size of off-farm operations to expand. The input sector has grown as farmers have become more dependent on purchased or nonfarm inputs. In 1947, such inputs made up approximately 44 percent of all inputs used on the farm. Currently, they account for over 60 percent.

In the farm sector, farming activities have become increasingly complex, and many of the jobs performed have been modified. Farmers have had to adapt to the use of modern inputs and comply with changing market requirements. At one time, farmers produced the type, size, and quality of products that they thought best and ran the risk of finding that the market wanted something different. More and more, they are learning the value of paying closer attention to what the market demands. Many agricultural commodities are now produced according to buyers' specifications, for example, formula fed broilers of a specific age and weight, cattle of an exact weight and finish, or wheat with a minimum level of protein. Product specification is a principal feature of production contracts between farmers and buyer-processors.

The product market sector, once comprised of small local markets participated in by nearby producers and processors, and consumers, has changed significantly. The development of new processing technologies and products has promoted large processing and distribution operations. Often, the processing plant is associated with the retail outlet. These large operations have encouraged standardization of products, which, in turn, has forced standardization of commodities produced on the farm.

Increasingly, consumers, the fourth sector in the system, can buy more and more convenience foods. These items have transferred the preparation time, culinary skills, and energy inputs from homemakers' kitchens to the food processor and distributor. In 1973 alone, food companies introduced an estimated 7,200 new products or variations of these for the retail market.

The rapid changes occurring in the food and fiber producing sectors are bound to have some unsettling effects. These have the potential of creating problems for policymakers. Though they have some information, policymakers lack adequate data about changes in output, input, and productivity.

This article attempts to fill the void by presenting measures of output, input, and productivity and possible answers to the following questions:

- What has happened to output?
- Has labor reduction at the farm level been transferred to the other sectors?
- What has happened to labor productivity?

MEASURING OUTPUT

Output may be defined in two ways: (1) gross output minus the value of products produced and used within each sector for further production, and (2) net output, which is the value added by each sector. Both output and input must be measured in constant dollars so that dissimilar items can be combined; for example, corn and cotton, labor and capital.

The net output approach can be used to determine what product or products can be attributed to the inputs within a sector. It differs from the gross output approach in that it excludes intermediate products and results in different measures of input shares. However, the method is useful for measuring the contribution of a subsector to a total sector or system.

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The gross output approach can be used to measure the volume of output of a subsector. However, these volumes cannot be added to get a sector's total as can be done with the net output approach. But because the U.S. Department of Agriculture is primarily interested in the volume of output from all resources committed to food and fiber, the gross output concept is used in this article.

Gross output of the food and fiber system is defined to include the constant dollar value of the following: (1) food expenditures by civilians, (2) value of goods produced on the farm for home consumption, (3) agricultural exports, and (4) manufactured values of tobacco products, beverages, leather tanning, and weaving and finishing of cotton and wool.

The constant dollar values of various items are derived by deflating current values with appropriate price indexes as follows: food expenditures and home consumption values with the consumer food index, exports with the wholesale farm products and processed food index, and manufactured products with individual wholesale prices for census years. However, the constant dollar value for noncensus years had to be interpolated (table 1).

Two problems arise with the gross output measure: use of manufactured values as a proxy for consumer purchases for some products, and omission of certain goods.

The first problem is not too serious because manufactured values should provide a relatively good indication of consumer purchases of the products in category four. However, the use of manufactured values as a proxy for consumer purchases could possibly result in an error in measuring output. Omission of certain goods may be a more severe problem because the omission could result in an understatement of productivity. Several items are excluded from the constant dollar value of output because data are not readily available for the following items: the share of value accounted for by natural fibers as opposed to manmade fibers in blended products,[1] expenditures for imported foods and all fish, domestic military food and fiber purchases, inventory changes, nursery and flower products, and markets for oils (soaps, paints, and so on).

MEASURING INPUTS

Sound measures of inputs are obviously needed to determine what each input contributes to output. However, the U.S. food and fiber system uses several intermediate products as inputs for processing, producing, and marketing final output, which poses a difficulty.

[1] Because these proportions could not be determined, only products made of natural fibers were included.

Table 1.—Value of food and fiber output and percentage distribution, 1958-74
(1967 dollars)

Year	Food (domestic use)[a]		Exported		Other products (domestic use)[b]		Total	
	Value	Share	Value	Share	Value	Share	Value	Share
	Mil. dol.	*Pct.*	*Mil. dol.*	*Pct.*	*Mil. dol.*	*Pct.*	*Mil. dol.*	*Pct.*
1958	70,620	78.4	3,930	4.4	15,488	17.2	90,038	100.0
1959	74,521	78.7	4,230	4.4	15,989	16.9	94,740	100.0
1960	77,370	78.1	5,157	5.2	16,489	16.7	99,016	100.0
1961	78,319	77.8	5,362	5.3	16,989	16.9	100,670	100.0
1962	80,435	77.9	5,316	5.2	17,489	16.9	103,240	100.0
1963	82,198	77.5	5,953	5.6	17,990	16.9	106,141	100.0
1964	84,781	77.0	6,811	6.2	18,529	16.8	110,131	100.0
1965	86,785	77.3	6,415	5.7	19,089	17.0	112,189	100.0
1966	88,544	77.1	6,648	5.8	19,639	17.1	114,831	100.0
1967	89,965	77.2	6,380	5.5	20,190	17.3	116,535	100.0
1968	91,410	77.4	6.082	5.1	20,653	17.5	118,145	100.0
1969	91,444	77.5	5,496	4.6	21,116	17.9	118,056	100.0
1970	92,840	76.8	6,499	5.4	21,579	17.8	120,918	100.0
1971	94,103	76.6	6,760	5.5	22,042	17.9	122,905	100.0
1972	95,086	75.9	7,681	6.1	22,503	18.0	125,270	100.0
1973	94,101	73.3	11,113	8.7	23,105	18.0	128,319	100.0
1974	92,063	71.8	12,398	9.7	23,705	18.5	128,166	100.0

[a]Includes food expenditures and home consumption on farms. [b]Includes manufactured values for census years 1958, 1963, 1967, and 1972, and interpolations for other years. Includes tobacco products (SIC 21), beverages (SIC 208), leather tanning (SIC 311), textiles (SIC 221, 223, 2261).

Unfortunately, for most such inputs, data either are not readily available or are very limited in coverage. Therefore, only labor, in terms of hours worked (man-hours) were used in the study.

Data on hours worked came from the following sources: (1) for farming, from the U.S. Department of Commerce's Bureau of Labor Statistics, (2) for marketing and processing farm foods, from the Economic Research Service, and (3) for tobacco, beverages, leather, and textiles, from the various censuses of manufacturing.

Since data on hours worked were incomplete for the farm input sector, estimates were derived with a method developed by Folke Dovring (*2*).[2] His procedure included farm expenditures for variable inputs plus capital depreciation. He adjusted this sum to exclude the farm value of feed, seed, and livestock purchases. Labor's share of inputs and services was obtained by assuming the same labor ratio as that of total national wages to national income. Hours worked were obtained by dividing the labor share of the value of inputs by the wage rates in the manufacturing subsector (table 2). This method inherently implies that all labor is accounted for, from the raw materials stage to delivery at the farm. But there are some major weaknesses in determining hours worked. First, the share of national income from employee compensation can change from year to year because of fluctuations in general economic conditions. Second, differential rates of inflation among farm input expenditures and the effects of inflation on real wage rates can bias the hours worked. However, the relative changes or trend in hours worked, as derived by this method, probably gives an accurate description of the changes in hours worked (table 3).

[2] Italicized numbers in parentheses refer to items in References at the end of this article.

MEASURING PRODUCTIVITY

Productivity represents the quantity of output obtainable from a given set of inputs during a given period of time. There are, in general, two types of productivity measurements: an average or gross measure where all inputs are considered, and a measure

Table 2.—Computation of hours worked in farm input sector, 1958-74

Year	National income[a]	Compensation to labor[b]	Labor share of national income[c]	Farm input expenditures		Manufacturing wage rate[f]	Hours worked[g]
				Total value[d]	Labor share[e]		
	Bil. dol.		*Pct.*	*Bil. dol.*		*Dol.*	*Mil. h.*
1958	361.2	255.4	70.71	13,776	9,741	2.11	4,617
1959	394.2	276.7	70.19	14,800	10,388	2.19	4,743
1960	409.5	291.8	71.26	14,797	10,544	2.26	4,665
1961	421.0	300.4	71.35	15,146	10.807	2.32	4,658
1962	454.1	321.8	70.87	15,791	11,191	1.39	4,682
1963	479.4	339.5	70.82	16,441	11,644	2.46	4,733
1964	515.7	364.5	70.68	16,823	11,890	2.53	4,700
1965	562.4	392.9	69.86	17,431	12,177	2.61	4,666
1966	618.5	435.6	70.43	18,681	13,157	2.72	4,837
1967	652.1	468.2	71.80	19,976	14,343	2.83	5,068
1968	710.5	515.9	72.61	20,528	14,905	3.01	4,952
1969	763.7	567.2	74.27	21,429	15,915	3.19	4,989
1970	794.1	604.9	76.17	23,363	17,796	3.36	5,296
1971	853.7	654.9	75.66	24,015	18.120	3.57	5,090
1972	947.4	710.5	75.00	25,359	19,019	3.81	4,992
1973	1,062.1	792.5	74.62	30,389	22,676	4.08	5,558
1974	1,135.1	867.0	76.38	37,185	28,402	4.41	6,440

[a]Excludes farm wages. National income from 1976 *Economic Report of the President*, Table B-12. [b]Excludes farm wages. Data from the sources in footnote a. [c]Compensation to labor divided by national income. [d]Expenditures include: fertilizer and lime; repair and operations; feed, seed, and livestock purchases (excluding farm value); depreciation and capital consumption; and miscellaneous. Farm operator's dwellings and non-real estate interest excluded. Data from various tables from *Farm Income Statistics*, Stat. Bul. 547, Econ. Res. Serv., USDA. [e]Value of farm input expenditures times labor's share of national income. [f]Manufacturing wage rates from the 1976 *Economic Report of the President*, Table B-18. [g]Wage rates divided into labor's share of farm input expenditures.

Table 3.—Hours worked in the food and fiber system, 1958-74

Year	Farm input market		Farm production		Product market		Total	
	Mil. h.[a]	*Pct.*	*Mil. h.*[b]	*Pct.*	*Mil. h.*[c]	*Pct.*	*Mil. h.*	*Pct.*
1958	4,617	16.0	12,906	44.6	11,375	39.4	28,898	100.0
1959	4,343	15.1	12,919	45.0	11,481	39.9	28,743	100.0
1960	4,665	16.4	12,463	43.7	11,385	39.9	28,513	100.0
1961	4,658	17.0	11,796	43.0	10,981	40.0	27,435	100.0
1962	4,682	17.4	11,434	42.3	10,889	40.3	37,005	100.0
1963	4,733	17.9	10,955	41.4	10,745	40.7	26,433	100.0
1964	4,700	18.2	10,359	40.0	10,823	41.8	25,882	100.0
1965	4,666	18.1	10,091	39.2	11,009	42.7	25,766	100.0
1966	4,837	19.3	9,141	36.5	11,071	44.2	25,049	100.0
1967	5,068	20.3	8,815	35.3	11,096	44.4	24,979	100.0
1968	4,962	19.8	8,624	34.5	11,167	44.7	24,753	100.0
1969	4,989	20.4	8,152	33.3	11,307	46.3	24,448	100.0
1970	5,296	22.0	7,645	31.7	11,169	46.3	24,110	100.0
1971	5,090	21.4	7,423	31.2	11,258	47.4	23,771	100.0
1972	4,992	20.9	7,475	31.3	11,444	47.8	23,911	100.0
1973	5,558	22.8	7,342	30.1	11,491	47.1	24,391	100.0
1974	6,440	25.1	7,352	28.7	11,859	46.2	25,651	100.0

[a]See table 2. [b]Data from Bureau of Labor Statistics, U.S. Dept. Commerce. [c]Data for processing and marketing of farm food products from *Marketing and Transportation Situation*, MTS-198, Econ. Res. Serv., USDA, table 11. Data for nonfood manufactured products are from Industrial Censuses for 1958, 1963, 1967, and 1972, and they are interpolated for other years.

which considers only individual or subsets of inputs.

The gross measure of productivity is difficult to construct because data are not adequate for many of the inputs.[3] Thus, the study involved only a measure of productivity of a single input; namely, labor. With other input changes held constant, this measure credits all changes in output for the system as a whole to labor (table 4). However, as will be shown later, different rates of change in labor productivity are implied for the three sectors by differences in the way each of them has apparently combined other inputs with labor.

CHANGES IN OUTPUT AND LABOR SINCE 1958

In the overview section, three questions were asked:

- What has happened to output?
- Has the reduction in labor at the farm level been transferred to the other sectors?
- What has happened to labor productivity?

Food and fiber output has changed considerably since 1958 (table 1). Total output (constant dollars) increased from $90,038,000 that year to $128,166,000 in 1974, a

Table 4.—Food and fiber labor productivity indexes, 1958-74
(1967 = 100)

Year	Output[a]	Hours worked[b]	Labor productivity[c]
1958	77.3	115.7	66.8
1959	81.3	115.1	70.6
1960	85.0	114.2	74.4
1961	86.4	109.8	78.7
1962	88.6	108.1	82.0
1963	91.1	105.8	86.1
1964	94.5	103.6	91.2
1965	96.4	103.2	93.4
1966	98.5	100.3	98.2
1967	100.0	100.0	100.0
1968	101.4	99.1	102.3
1969	101.3	97.9	103.5
1970	103.8	96.5	107.6
1971	105.5	95.2	110.8
1972	107.5	95.7	112.3
1973	110.1	97.7	112.7
1974	110.0	102.3	107.5

[a]Index based on constant values shown in table 1. [b]Index based on hours worked shown in table 3. [c]Derived by dividing index of output by index of hours worked.

[3] The only regularly available measure of gross productivity is for the farm production sector. This measure is prepared by the National Economic Analysis Division, Economic Research Service.

42-percent rise. Output went up every year except 1974, when no change occurred from the 1973 level.

Food has accounted for the greatest share of total food and fiber output, ranging from 78.7 percent in 1959 to 71.8 percent in 1974. But this share has declined slightly and persistently. Further, estimates of food's share may be on the high side because of certain omissions from total output previously mentioned.

Thus, food's share of total output decreased during the period although total volume of food has increased. It has gone from $70,620,000 in 1958 to $92,063,000 in 1974—a steady increase in all years except 1973 and 1974. Possibly, the slight decrease between 1973 and 1974 occurred because of rising food prices and declining per capita consumption in those years.

Exports have more than tripled since 1958; however, most of this increase occurred between 1972 and 1974. Exports' share of total food and fiber output has remained relatively constant except for the last 3 years. In that period, the share rose to almost 10 percent (1974).

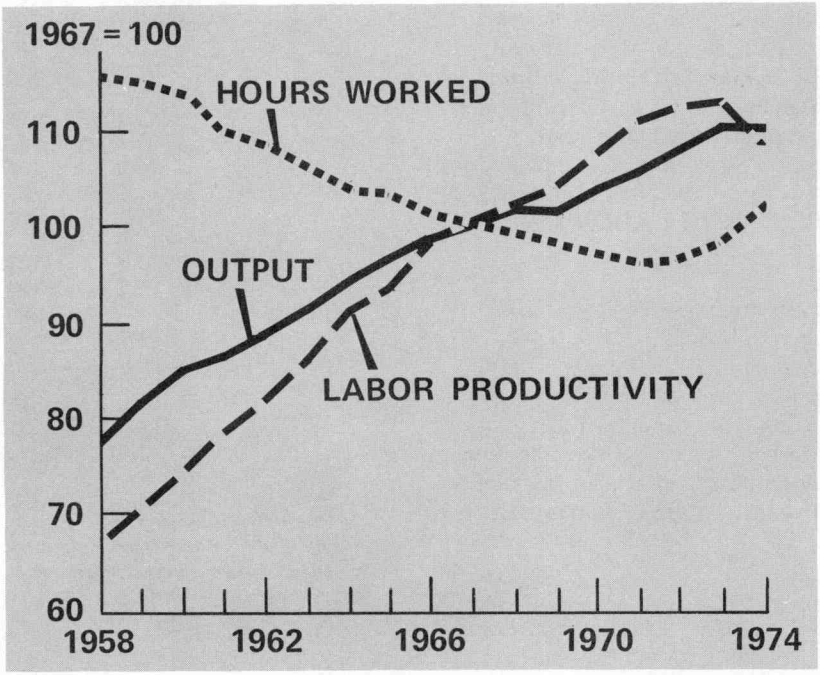
For labor's input though, the story is quite different. Since 1958, total number of hours worked fell continuously until 1972, with all of the decrease accounted for by the farm production sector (table 3). The recent modest decline for farm labor, however, has been more than offset by increases in the other two sectors.

In fact, the upward swing in total hours worked in 1973 and 1974 came largely because of the sharp increase in farm input labor. Part of this increase is real because farmers have purchased record levels of inputs. However, part of the rise results from the method used to calculate the hours. The inflation rate for farm inputs appears to have outstripped the real wage rates for manufacturing. Up until 1973, however, hours worked in the farm input sector moved up very slowly.

The product market sector has shown remarkable stability in the use of labor over the entire 17-year period. Use has remained at just over 11 billion hours, except for a slight drop in the early 1960's and a slight increase in 1974. For farm production, hours worked have fallen each year since 1959 except in 1972 and 1974.

These different trends indicate that labor-saving inputs and technologies increased output per hour worked in farming, but reduced the number of hours needed. In the other two sectors, input substitution in-

FOOD AND FIBER OUTPUT, HOURS WORKED, AND PRODUCTIVITY, 1958-74



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creased the productivity of labor but failed to reduce the number of hours.

In 1958, agriculture accounted for 45 percent of the hours worked in the food and fiber system. This share has declined each succeeding year. In 1974, slightly less than 30 percent of the hours worked were devoted to farming. It has been theorized that the reduction in labor required for farming has been picked up in other nonfarming occupations, including the input and product market sectors. The evidence suggests that this shift has occurred only for occupations outside the food and fiber system.

Although hours of labor required decreased 14 percent in the food and fiber system between 1958 and 1974, the volume of food and fiber output increased 42 percent. Thus, labor productivity has risen 61 percent, or at an annual rate of 3.2 percent, since 1958 (table 4).

The greatest increase in labor productivity—47 percent—occurred during the first half of the period (figure). After 1966, it went up 15 percent. During the entire period, labor productivity decreased only once, a 5-percent drop which occurred between 1973 and 1974. Output had a similar trend but it experienced decreases in two periods—1968-69 and 1973-74. The hours worked, however, had a reverse trend. They consistently decreased until 1972, when they began to increase.

Although output has been increasing, not all of this rise can actually be attributed to labor. As suggested before, new technology directed at reducing labor and increasing productivity has been adopted by all three sectors. But its impact has been the most significant in farming.

CONCLUSIONS

All of the desired data are not available, but the measures of output, input, and productivity do provide information about the general direction of change in the U.S. food and fiber system. It does appear that labor productivity has been increasing. Furthermore, the technologies adopted by the farming sector have reduced the quantity of labor used and increased its productivity. Technologies adopted in the other two sectors, though, seem to have done more to increase productivity than to reduce labor requirements.

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