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Food Manufacturing Productivity and Its Economic Implications

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Abstract

The gross-output multifactor productivity index for U.S. food manufacturing grew 0.19 percent per year between 1975 and 1997. This productivity growth is low when compared with an estimate of 1.25 percent per year for the whole manufacturing sector. Low investment in research and development (R&D) could be one reason. Although productivity has been relatively low, food manufacturing output has grown significantly at 1.88 percent over the last two decades. Indeed, the expansion of combined factor inputs provided significant impetus to food manufacturing output. Food manufacturing is materials-intensive, and declining real producer prices of crude food and feedstuffs fueled the expansion of input utilization and drove down prices of processed foods paid by consumers.

Keywords: Food manufacturing, multifactor productivity, labor productivity.

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Summary

This study measures the productivity of U.S. food manufacturing to explore its input-output relationships during 1975-97. The gross output (the value of shipments net of changes in inventories) of the food manufacturing sector grew 1.88 percent yearly, reaching an annual average of $353 billion in 1995-97. The net output (gross output minus the cost of material inputs and purchased services), which shows the industry's contribution to the Nation's gross domestic product (GDP), increased 3.58 percent yearly. In 1995-97, the annual average net output was $135 billion (about 38 percent of the gross output), with the 62-percent difference accounted for by expenditures on material inputs.

Annual employment growth in the food manufacturing sector averaged just 0.12 percent between 1975 and 1997. However, new capital expenditures, measured at 1982 prices, show a yearly increase from $6.3 billion in 1975-79 to $8.8 billion in 1995-97, a growth rate of 2.39 percent. Similarly, capital services costs increased 1.41 percent annually from $9 billion in 1975-79 to $11.2 billion in 1995-97. Slow growth in employment, coupled with the increase of capital expenditures, is evidence that capital is substituting for labor by providing each employee with more and better capital to work with.

To measure the productivity of the U.S. food manufacturing sector, this study calculates multifactor and labor productivity indexes. The multifactor productivity index measures the rate of output growth in excess of growth due simply to increases in combined factor inputs. The labor productivity index measures the rate of growth in output per labor-hour devoted to the production of that output.

Two approaches are applied to measure the multifactor and labor productivity indexes of U.S. food manufacturing. The gross-output approach specifies gross output as a function of capital, labor, energy, and all intermediate material inputs. Alternatively, the net-output approach specifies net output as a function of labor and capital inputs only. The two approaches produce substantially different productivity measurements, mainly because material costs constitute more than 60 percent of the food manufacturing sector's gross output. The ratios for some food manufacturing industries, like meat products and fats and oils, reached 74 and 79 percent, respectively, in 1995-97. Consequently, including or excluding material inputs as a component in a production function will substantially affect the results of measured productivity indexes.

For interpreting food manufacturing productivity, the gross-output productivity indexes should be used to assess technology changes over time because this model includes as many factor inputs as available data sources allow, and the potential change effects from unmeasured inputs can be avoided. The gross-output multifactor productivity index for food manufacturing grew 0.19 percent per year between 1975 and 1997. This slow growth rate is consistent with the Bureau of Labor Statistics (BLS) estimate of 0.45 percent using different data. Both estimates of productivity indexes are low when compared with the BLS estimate of 1.25 percent per year for the whole manufacturing sector over the same period of time. The reason for the lower productivity growth in food manufacturing is not fully understood, but low investment in research and development (R&D) could be one reason. The economic implications of slow growth in food manufacturing productivity are threefold.

First, instead of productivity growth, the expansion of combined factor inputs provided significant impetus to food manufacturing output. U.S. food manufacturing gross output grew 1.88 percent yearly during 1975-97. During this period, the combined capital, labor, energy, and material inputs grew at an average rate of 1.69 percent yearly, with material inputs growing fastest at 2.25 percent. Food manufacturing is materials-intensive, and a 3.6-percent decline in real producer prices of crude food and feedstuffs fueled the expansion of input utilization.

Second, the productivity growth of food manufacturing contributed little to price declines in recent years. The real producer price of processed foods declined an average 2.13 percent per year over the period 1975-97. Researchers have hypothesized that advances in food manufacturing productivity would explain the decline in real prices of processed foods. According to this study, however, it was a decrease in the prices of crude food and feedstuffs that drove down the prices of processed foods paid by consumers.

Third, heightened merger and acquisition activity in recent years has had little effect on changes in food manufacturing productivity. According to *Mergerstat Review*, which tracked purchases valued at $1 million or higher and transfers of ownership involving at least 10 percent of a company's equity, the pace of merger and acquisition activity in food processing increased steadily from 60 transactions in 1991 to 157 in 1998. On the basis of slow growth in the multifactor productivity index, it appears that recent heightened merger and acquisition activity has had little effect on food manufacturing productivity.

In evaluating the contribution of food manufacturing to the growth of the Nation's GDP, productivity indexes from the net-output approach should be used, because net output is defined the same as gross-product-originating (value-added) GDP. Both the net output and labor productivity indexes exhibit a steady increase, implying that the contribution of food manufacturing to the Nation's GDP has increased over time. This study also evaluates the effects of a 10-percent increase in both capital and labor inputs and finds that food manufacturing's net output would increase by $4.3 billion. In addition, a 10-percent increase in capital input alone would increase the sector's capital intensity, and consequently its labor productivity, by $1.43 per worker-hour. A 10-percent increase in labor input alone would reduce the sector's capital intensity and reduce its labor productivity by $1.58 per worker-hour.

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Introduction

Advances in industrial productivity—measured as the rate of output growth in excess of growth due to increases in factor inputs—are a significant source of increase in national income and improvements in the standard of living and global competitiveness. Most agricultural productivity studies in the United States have focused on productivity changes and the relationship between inputs and outputs at the farm level. Considerably less attention has been devoted to research on productivity beyond the farmgate, such as food manufacturing. Only a few studies (e.g., Ball and Chambers; Heien; MacDonald and Ollinger) addressed the productivity of U.S. food manufacturing industries. This study contributes to the gap in food manufacturing research with a focus on measuring the productivity of U.S. food manufacturing.

U.S. food manufacturing plays an important role in the U.S. food system, stretching from farms and ranches to retail food markets, and has contributed significantly to the Nation's economic growth. According to the *Annual Survey of Manufactures*, the U.S. food manufacturing sector accounted for 10.3 percent of the value of shipments and 9 percent of employment from all U.S. manufacturing sectors in 2000. This study measures the productivity growth of the food manufacturing sector and provides information pertaining to the following questions: What are the productivity trends of food manufacturing? What are the sources of growth in food manufacturing outputs? Does productivity explain a decline in real prices of processed foods in recent years? How does food manufacturing contribute to the Nation's gross domestic product (GDP)?

In addition, the food manufacturing industries have undergone substantial structural changes in recent years because of mergers and acquisitions and a trend toward substituting computers and automated machines for human operations. To better understand the effects of this evolution on the performance of food manufacturing industries, this study analyzes industry production structure and answers the following questions: What are the input-output relationships of food manufacturing? Is there any evidence showing that capital is substituting for labor? Have the recent mergers and acquisitions affected food manufacturing productivity?

Although Bureau of Labor Statistics (BLS) productivity indicators are available for all U.S. manufacturing sectors, this study uses different data and focuses on measuring productivity changes in food manufacturing specifically for the following reasons. First, this study provides net-output (value-added) productivity measures as a linkage to the gross-product-originating GDP to meet the gap caused by the elimination of productivity indexes from BLS news releases of productivity trends for all manufacturing sectors since 1994. Second, the food manufacturing industries are fundamentally different from other manufacturing industries in the sense that food processing is quite materials-intensive. Instead of using the BLS productivity index alone, it is necessary to explore the detailed input-output relationships of food manufacturing. Third, it is useful for this study to compile data and establish a data bank for food manufacturing suitable for online analysis, estimation of productivity changes, and some other productivity-related issues.

This study begins by focusing on the input-output relationships of U.S. food manufacturing with respect to the growth of production and the utilization of labor, capital, and material inputs. Particular attention is given to identify some data sources for factor inputs and outputs that can be used for measuring productivity. The second part of this study discusses the methodology for measuring productivity and its application to U.S. food manufacturing. Since productivity growth is most closely identified with technological gains, the goal of the methodology is to measure these gains as the rate of output growth in excess of growth due simply to increases in combined factor inputs.

Before measuring productivity, it is necessary to understand the input-output relationships of U.S. food manufacturing with respect to the growth of production and the utilization of labor, capital, and material inputs. For easy presentation of a sample period covering 1975-97, each table throughout this study summarizes economic information by dividing the whole sample period into five subperiods with a 5-year interval for most periods and showing the average of annual data in each period. All values are measured at 1982 constant prices.

The data used in this study were compiled mainly from the Bureau of the Census in its *Census of Manufactures* and the *Annual Survey of Manufactures* (ASM), and from the Bureau of Labor Statistics for various producer price indexes including the price of processed foods and feeds. The data refer to an aggregate food manufacturing sector by the Standard Industrial Classification (SIC) System code 20 (Food and Kindred Products) and its nine three-digit coded industries for 1975-97. Those food industries are (201) meat products, (202) dairy products, (203) preserved fruits and vegetables, (204) grain mill products, (205) bakery products, (206) sugar and confectionery products, (207) fats and oils, (208) beverages, and (209) miscellaneous food and kindred products.

The data in the *1997 Census of Manufactures* were published for the first time on the basis of the North American Industry Classification System (NAICS). This system is different from the SIC classification system used in previous censuses. To construct consistent time-series data dating back to 1975, this study compiles the 1997 data into a framework along with the SIC classification system. A comparability of product codes and the compiling procedure used for converting NAICS data into SIC data are listed in Appendix A.

Gross and Net Outputs

According to the *Census of Manufactures*, two commonly used output indicators are the value of shipments and the value added. The value of shipments covers the received or receivable net selling values of all products shipped at the plants excluding freight and taxes. The value added is derived by subtracting the cost of materials, supplies, containers, fuel, and electricity from the value of shipments, but it still contains the cost of purchased services. Thus, the cost of purchased services must be subtracted from the value added to obtain a consistent measurement of the gross-product-originating (value-added) GDP without double-counting the value of sales.

For productivity analysis, gross output is calculated as the adjusted value of shipments by the net change of inventories and then deflated by the producer price index of processed foods and feeds. Similarly, net output is calculated as the “net value added” by subtracting the cost of purchased services from the value added and then deflated by the producer price index of processed foods and feeds. Both gross output and net output are used as output indicators for measuring productivity. In particular, net output may be used as an indicator to show the contribution of an industry to the Nation’s GDP.

The costs of purchased services for each food manufacturing industry are available only in the 1992 and 1997 Censuses but not in the ASM. To determine the cost of purchased services for other years, this study first calculates the average ratios of the cost of purchased services to the value of shipments for each food industry in the two Censuses. Then, these ratios are used to determine the approximate cost of purchased services in each industry for the missing years. The ratios in terms of percentage are food sector (1.35 percent), meats (1.3), dairy (1.17), preserved fruits and vegetables (1.5), grain mill products (1.4), bakery products (1.65), sugar and confections (1.62), fats and oils (1.08), beverages (1.3), and miscellaneous foods (1.3). These ratios are less than 2 percent of the value of shipments across food industries, and the errors of approximation for measuring the net value added should be small.

In table 1, the yearly value of U.S. food manufacturing gross output measured at 1982 prices increased from $258 billion in 1975-79 to $353 billion in 1995-97, an average annual growth rate of 1.9 percent. Most food industries tended to grow at 2-3 percent except for fats and oils, which showed virtually no growth. In 1995-97, the meat product industry was dominant in gross output valued at $79.8 billion, followed by beverages at $51.5 billion. For net output, food manufacturing as a whole increased from a yearly average of $72 billion

Table 1—Outputs of food manufacturing, 1975-1997

	1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
			Gross output (million $ at 1982 prices)			*Percent*
Food sector	258,325	278,389	302,510	330,374	352,926	1.88
Meat products	65,326	66,045	69,177	76,712	79,799	1.45
Dairy products	34,126	37,919	40,780	42,650	43,904	1.52
Preserved fruits & vegetables	26,703	29,824	34,246	38,495	39,402	2.31
Grain mill products	29,389	31,876	34,718	40,662	44,927	2.13
Bakery products	16,510	17,532	21,021	23,175	25,241	2.11
Sugar and confections	14,688	16,358	17,110	18,409	19,847	1.23
Fats and oils	19,061	17,849	16,356	15,910	17,992	0.49
Beverages	31,185	37,724	43,139	46,242	51,500	2.77
Miscellaneous foods	21,317	23,263	25,962	28,119	30,313	2.77
			Net output (million $ at 1982 prices)			
Food sector	71,653	83,420	105,245	122,668	135,166	3.58
Meat products	9,553	9,891	12,243	14,995	19,045	3.86
Dairy products	7,043	7,973	10,098	11,634	11,838	2.99
Preserved fruits & vegetables	9,817	11,611	15,316	17,979	18,503	3.88
Grain mill products	8,264	10,012	13,502	16,865	17,473	3.78
Bakery products	9,090	10,111	12,878	14,094	15,556	2.98
Sugar and confections	5,056	6,122	7,321	8,327	9,174	3.41
Fats and oils	2,635	2,698	2,860	3,155	3,267	1.90
Beverages	12,621	15,729	19,617	22,463	25,432	3.83
Miscellaneous foods	7,574	9,273	11,411	13,154	14,878	3.98
			Ratio of net output to gross output (percent)			
Food sector	27.74	29.97	34.79	37.13	38.30	
Meat products	14.62	14.98	17.70	19.55	23.87	
Dairy products	20.64	21.03	24.76	27.28	26.96	
Preserved fruits & vegetables	36.76	38.93	44.72	46.70	46.96	
Grain mill products	28.12	31.41	38.89	41.48	38.89	
Bakery products	55.06	57.67	61.26	60.82	61.63	
Sugar and confections	34.42	37.42	42.79	45.24	46.22	
Fats and oils	13.83	15.12	17.48	19.83	18.16	
Beverages	40.47	41.70	45.47	48.58	49.38	
Miscellaneous foods	35.53	39.86	43.95	46.78	49.08	

Note: All values are deflated by the producer price index of processed foods and feeds.

Source: USDA/Economic Research Service.

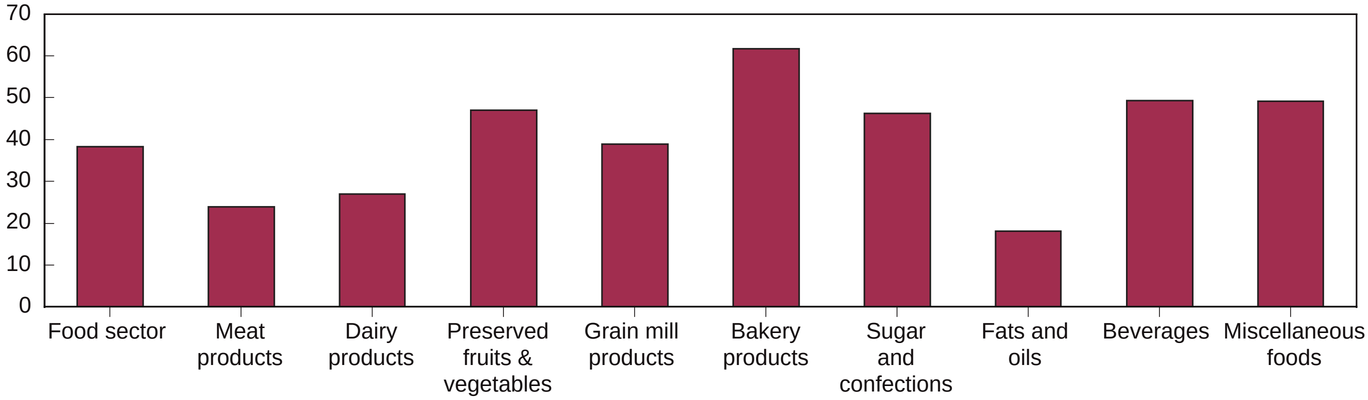
in 1975-79 to $135 billion in 1995-97, with an average annual growth rate of 3.7 percent. For most individual industries, average yearly growth rates ranged from about 3-4 percent. The beverages industry was dominant at $25.4 billion in 1995-97, followed by the meat products industry at $19 billion.

Table 1 shows that the ratio of net output to gross output increased from 27.7 percent in 1975-79 to 38.3 percent in 1995-97 for the food sector as a whole. This increase reflects a decrease in the share of material costs relative to the value of output over time. For individual industries, the meat industry significantly increased this ratio from 14.6 percent in 1975-79 to 23.9 percent in 1995-97, probably because of cheaper meat materials available for processing, especially for sausage and poultry meat products. On the other hand, highly processed, differentiated, and convenient consumer goods are high value-added products. Thus, the ratio increased from 55 percent in 1975-79 to 61.6 percent in 1995-97 for the bakery products industry.

Figure 1 shows the different ratios of net output to gross output across the food manufacturing industries and the whole food sector in 1995-97. In general, the food manufacturing sector is materials-intensive with a

Figure 1

Ratio of net output to gross output, 1995-97 average



Source: USDA/Economic Research Service.

ratio of 38.3 percent, meaning a cost of about $62 on materials consumed for producing $100 of gross output. The ratio for fats and oils was relatively small, only 18 percent. Other low-ratio industries are meats (23.9 percent) and dairy products (27 percent). This is because farm commodities as food materials for processing constitute a major share of processing costs for these products. On the other hand, bakery products are relatively value-intensive products with a ratio of 61.6 percent, because the bakery industry has high labor costs for processing and direct store delivery. Beverages are also value-intensive, with a ratio of 49.4 percent due to low material costs, high advertising expenditures, and the value added to shipments by high-profit soft-drink syrup makers.

Labor Input

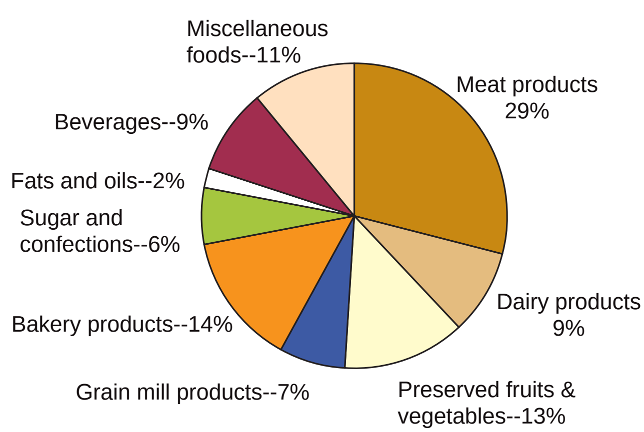
The employment data in the census consist of two categories of workers: production and nonproduction. Production workers, including those engaged in fabricating, processing, assembling, packing, and other services, are closely associated with the production operations at food manufacturing plants. All other employees, such as those engaged in factory supervision above the working foreman level and those in sales, credit, and clerical positions at manufacturing plants, are classified as nonproduction workers.

The U.S. food manufacturing sector employed a yearly average of 1.5 million employees in 1975-79, gradually decreasing to 1.4 million in 1985-89, and then increasing back to 1.5 million employees in 1995-97 (table 2). These total employment numbers are important indicators commonly used to observe whether there is a recession in general economic activities. Meat products and miscellaneous foods were the only industries that increased employment over the sample period, with average yearly growth rates of 1.9 and 1.4 percent, respectively. The number of employees in other industries showed yearly decreases, especially in fats and oils (-1.8 percent) and beverages (-1.4 percent). Figure 2 shows the distribution of employees across different food manufacturing industries using the 1995-97 average. Significant shares are found in the meat products (29 percent), bakery products (14 percent), and preserved fruits and vegetables (13 percent) industries.

For measuring productivity, production worker-hours (hours worked or paid for at the plant, including actual overtime hours) are used as an indicator of labor input

Figure 2

Composition of employment, 1995-97 average



Source: USDA/Economic Research Service.

Table 2—Labor inputs of food manufacturing, 1975-1997

	1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
			All employees number (1,000)			*Percent*
Food sector	1,536	1,484	1,441	1,496	1,533	0.12
Meat products	312	314	336	401	441	1.89
Dairy products	159	143	140	136	132	-1.10
Preserved fruits & vegetables	233	223	214	215	207	-0.34
Grain mill products	114	108	101	105	103	-0.43
Bakery products	232	217	212	214	222	-0.15
Sugar and confections	103	96	90	91	89	-0.56
Fats and oils	42	39	31	28	26	-1.83
Beverages	201	193	165	144	145	-1.37
Miscellaneous foods	141	151	152	162	168	1.36
			Number of nonproduction employees (1,000)			
Food sector	458	438	419	404	405	-0.59
Meat products	56	52	54	58	64	0.92
Dairy products	72	60	54	51	48	-2.23
Preserved fruits & vegetables	35	37	37	36	35	0.46
Grain mill products	34	33	32	33	31	-0.45
Bakery products	94	90	89	83	85	-0.18
Sugar and confections	21	19	18	19	20	-0.15
Fats and oils	12	11	10	9	8	-1.16
Beverages	99	98	85	71	70	-1.59
Miscellaneous foods	35	38	40	44	43	0.60
			Production worker-hours (million)			
Food sector	2,125	2,054	2,007	2,223	2,317	0.57
Meat products	506	515	564	708	774	2.28
Dairy products	180	170	174	179	179	-0.06
Preserved fruits & vegetables	374	354	334	351	347	-0.29
Grain mill products	169	155	145	157	159	-0.37
Bakery products	269	251	241	262	272	-0.05
Sugar and confections	160	151	141	145	145	-0.25
Fats and oils	65	58	43	41	40	-2.02
Beverages	203	190	160	148	152	-0.96
Miscellaneous foods	198	210	206	232	248	1.86

Source: USDA/Economic Research Service.

for production workers. As shown in table 2, the meat products industry increased production worker-hours substantially from 506 million hours in 1975-79 to 774 million hours in 1995-97, an average yearly growth rate of 2.3 percent. Similarly, there is a significant increase of worker-hours in the miscellaneous foods industry from 198 million hours to 248 million hours over the sample period with a yearly growth rate of 1.9 percent. The fats and oils and beverages industries decreased by 2 and 1 percent, respectively. All other food industries showed no significant change in worker-hours.

The number of nonproduction employees, constituting about one-third of total employees, is used to represent the labor input for nonproduction workers. Similar to production workers, the number of nonproduction employees for most industries decreased, especially for the dairy industry, with a 2-percent average annual rate of decrease over the sample period. In 1995-97, the bakery products and beverage industries employed the most nonproduction workers, 85,000 and 70,000 persons, respectively.

Capital Input

In measuring the gross book value of depreciable assets, the assets at the beginning of the year, plus new capital expenditures, less capital retirements, equals assets at the end of the year. Therefore, annual new capital expenditures are a major component in the accumulation of assets over time. In table 3, the new capital expenditures in the food manufacturing sector measured at 1982 prices show an average annual growth rate of 2.4 percent from $6.3 billion in 1975-79 to $8.8 billion in 1995-97. For individual industries, new capital expenditures also increased over the sample period. The growth rates are high for dairy products, bakery products, and miscellaneous foods, each between 3.7-4 percent. Meat products, preserved fruits and vegetables, and grain mill products are next, each about 3 percent. The meat products, preserved fruits and vegetables, grain mill products, and beverages industries had annual capital expenditures of more than $1 billion in 1995-97.

The flow of capital services derived from the stock of capital assets for equipment and structures in an industry is commonly considered as capital input in measuring productivity. In this study, considering the limitation of data, the annual cost of capital services is approximated as the sum of depreciation charges for fixed assets and interest costs on the average value of fixed assets at the beginning and ending of that year. The cost of capital services is then deflated by the producer price index of capital equipment for use as capital input in measuring productivity.

To measure depreciation charges, data are available and reported only for 1977-85. Depreciation charges for the remaining period are projected on the basis of a log-linear regression by fitting the depreciation charges (D) as a function of beginning-of-year structure and equipment assets (K) for 1977-85. A complete listing of fitted depreciation equations for all individual food manufacturing industries is listed in Appendix B. For example, the following is a fitted depreciation equation for the food manufacturing sector:

$$\underset{}{ln}\, D = -3.3203 + \underset{(0.0292)}{1.0630}\, ln\, K \qquad R^2 = 0.99$$

The figure in parenthesis is the standard error. The estimated coefficient is statistically significant with a 1-percent increase in fixed assets causing a 1.06-percent increase in the depreciation charge.

The cost of interest on fixed assets is calculated by multiplying the average yearly value of fixed assets by the interest rates. These interest rates are obtained from the *Survey of Current Business* (SCB) with the Moody's Corporate Industrial Bond Rate from SCB prior to 1994. Yields on new high-grade corporate bonds are used for 1994 and thereafter, because Moody's rates are not available in the latter period.

In table 3, the charges of capital services in the food manufacturing sector increased by 1.41 percent annually from $9 billion in 1975-79 to $11.2 billion in 1995-97. In contrast with a declining employment trend, the increase of capital services is evidence that capital is substituting for labor by providing each employee with more and better capital to work with. The charges of capital services varied across the food manufacturing industries depending on their capital intensity in the production process. Taking 1995-97 as an example, the cost of capital services is highest for the beverage industry, at $2.1 billion, followed by grain mill products at $1.7 billion, and preserved fruits and vegetables at $1.6 billion. In terms of annual growth rate, the grain mill products industry was ranked highest at 2.7 percent, followed by miscellaneous foods at 2.1 percent.

Finally, the ratio of the new capital expenditures to the gross output of an industry can be viewed as an indicator to reflect the rate of investment of the industry. This average annual rate of investment for the food manufacturing sector was 2.6 percent in 1995-97. For individual industries, figure 3 shows that the annual rates of investment in 1995-97 were high (at 3 percent or more) for the sugar and confections, bakery products, grain mill products, preserved fruits and vegetables, and beverages industries. The high investment rate is probably related to new product introduction and rapid technological changes in these industries that require new equipment.

Material and Energy Inputs

In addition to payments for labor input and capital services, the cost of production in food manufacturing includes materials and purchased fuel and electricity. In this study, materials (including raw materials, semifinished goods, and containers) and fuel and electricity are considered as separate inputs in measuring productivity. The quantity of material inputs is determined as the cost of materials adjusted by a net change in inventories and then deflated by the producer price index of

Table 3—Capital inputs of food manufacturing, 1975-1997

	1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
	New capital expenditures (million $ at 1982 prices)					*Percent*
Food sector	6,320	6,298	6,583	7,388	8,837	2.39
Meat products	740	674	799	984	1,240	3.01
Dairy products	561	604	671	726	897	4.00
Preserved fruits & vegetables	774	816	953	1,150	1,157	3.29
Grain mill products	836	828	1,036	1,109	1,365	3.22
Bakery products	526	457	591	704	790	3.72
Sugar and confections	461	456	494	589	626	2.68
Fats and oils	356	329	257	268	335	1.85
Beverages	1,553	1,591	1,185	1,132	1,585	2.63
Miscellaneous foods	513	542	597	726	841	3.67
	Charges of capital services (million $ at 1982 prices)					
Food sector	9,013	11,967	11,354	10,716	11,209	1.41
Meat products	1,075	1,335	1,228	1,260	1,381	1.60
Dairy products	907	1,096	1,061	1,032	1,114	1.18
Preserved fruits & vegetables	1,150	1,547	1,519	1,538	1,550	1.40
Grain mill products	1,121	1,535	1,536	1,545	1,702	2.67
Bakery products	793	962	954	945	1,010	1.26
Sugar and confections	760	945	857	816	846	0.64
Fats and oils	506	686	580	485	467	0.27
Beverages	1,966	2,871	2,659	2,164	2,113	1.04
Miscellaneous foods	735	990	960	931	1,027	2.12
	Ratio of new capital expenditures to gross output (percent)					
Food sector	2.12	2.20	2.24	2.34	2.63	
Meat products	0.99	0.99	1.19	1.34	1.63	
Dairy products	1.43	1.55	1.69	1.78	2.14	
Preserved fruits & vegetables	2.54	2.68	2.86	3.14	3.08	
Grain mill products	2.47	2.52	3.07	2.86	3.19	
Bakery products	2.77	2.53	2.89	3.19	3.28	
Sugar and confections	2.71	2.72	2.99	3.35	3.31	
Fats and oils	1.62	1.79	1.61	1.76	1.94	
Beverages	4.31	4.11	2.83	2.56	3.24	
Miscellaneous foods	2.12	2.26	2.37	2.71	2.92	

Note: All values are deflated by the producer price index of capital equipment.

Source: USDA/Economic Research Service.

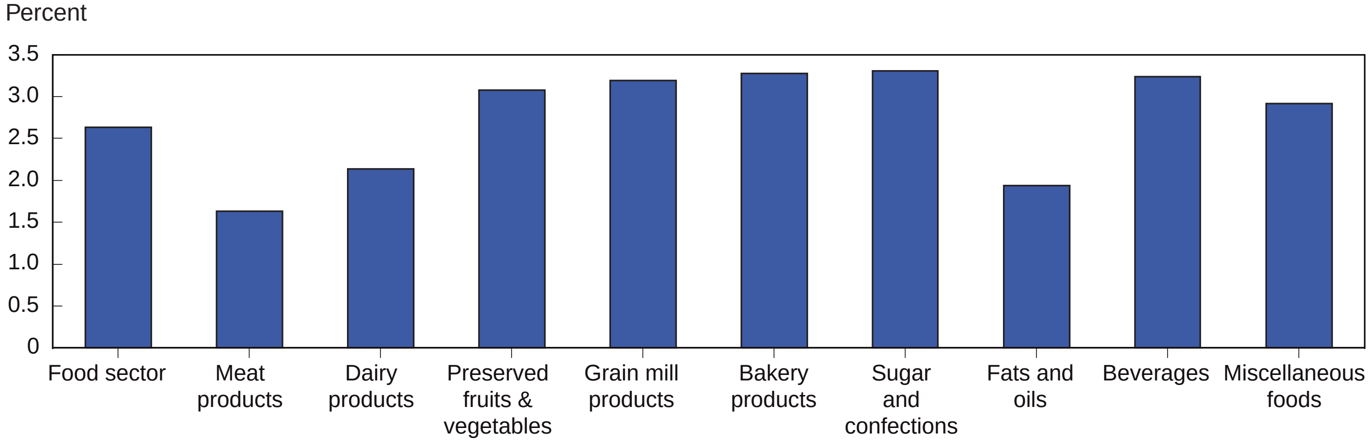
crude foodstuffs and feeds. The energy input is measured as the cost of purchased fuels and electricity deflated by the producer price index of intermediate energy goods.

In table 4, the cost of materials for the food manufacturing sector measured at 1982 prices grew steadily at 2.3 percent yearly from $167 billion to $243 billion over the sample period. The growth rates of most individual industries were 2-3 percent yearly. For example, the meat products industry spent the most on materials—about $69 billion in 1995-97—more than double that of most other food industries. The cost of purchased fuel and electricity is also shown in table 4. For the food manufacturing sector, the cost of energy utilization measured at 1982 prices was lowest at $5 billion in 1980-84. This is consistent with petroleum-based fuels prices which reached their peak in that period. The ratio of energy costs to gross output (not shown in the table) is 1.3 percent for the general food sector, and the ratios are under 2 percent for the vast majority of the food manufacturing industries.

The ratios of material costs to gross output for the sample period are presented in the lower part of table 4 and in figure 4 for 1995-97. In general, food manu-

Figure 3

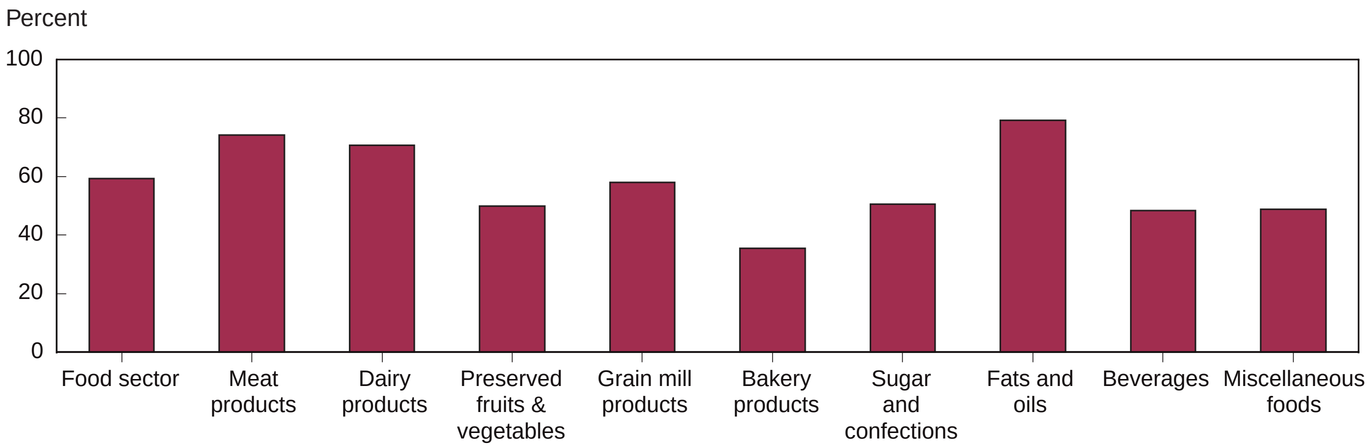
Ratio of new capital expenditures to gross output, 1995-97 average



Source: USDA/Economic Research Service.

Figure 4

Ratio of material cost to gross output, 1995-97 average



Source: USDA/Economic Research Service.

facturing is materials-intensive, with material costs constituting about 60 percent or more of the value of gross output in the food manufacturing sector. The ratios of material costs to gross output vary widely among the food manufacturing industries. Taking 1995-97, for example, the ratio is highest for the fats and oils industry, at 79 percent, reflecting the industry's heavy dependence on materials like soybeans for crushing or semi-refined soybean oil for refining. Also, the ratio is high for the meat and dairy industries—slightly more than 70 percent—because these industries have little value added using relatively expensive meats and milk as raw materials for processing highly standardized products. On the other hand, the ratio for the bakery industry is the lowest (35.4 percent) because the industry uses more production workers and adds more value to flour and other ingredients from other processors.

Table 4—Material and energy inputs of food manufacturing, 1975-97

	1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
	Cost of materials (million $ at 1982 prices)					*Percent*
Food sector	167,032	182,239	206,508	228,299	243,087	2.25
Meat products	50,415	53,307	60,576	68,764	68,841	2.06
Dairy products	24,407	28,299	32,515	34,366	36,114	2.29
Preserved fruits & vegetables	14,976	16,762	19,522	22,170	22,927	2.53
Grain mill products	18,848	20,219	21,815	25,847	30,247	2.57
Bakery products	6,433	6,692	8,208	9,625	10,406	2.22
Sugar and confections	8,355	9,373	10,075	10,916	11,692	1.54
Fats and oils	14,783	13,991	14,037	14,110	16,572	1.55
Beverages	16,570	20,521	24,545	26,147	29,043	3.23
Miscellaneous foods	12,377	13,075	15,216	16,354	17,245	3.52
	Cost of fuels and electricity energy (million $ at 1982 prices)					
Food sector	5,297	5,015	6,372	6,237	6,649	0.20
Meat products	674	688	944	937	1,015	0.41
Dairy products	614	573	762	704	709	0.10
Preserved fruits & vegetables	740	715	879	894	929	0.24
Grain mill products	779	732	1,082	1,116	1,291	0.45
Bakery products	343	319	467	470	495	0.37
Sugar and confections	583	466	478	466	479	-0.12
Fats and oils	572	538	563	482	516	0.14
Beverages	618	598	717	638	684	0.23
Miscellaneous foods	375	386	482	529	533	0.44
	Ratio of material cost to gross output (percent)					
Food sector	70.0	67.2	62.5	60.5	59.2	
Meat products	83.5	82.8	80.1	78.4	74.1	
Dairy products	77.3	76.5	73.0	70.5	70.7	
Preserved fruits & vegetables	60.7	57.7	52.2	50.4	50.0	
Grain mill products	69.4	65.1	57.6	55.6	57.9	
Bakery products	42.1	39.2	35.8	36.3	35.4	
Sugar and confections	61.4	58.9	53.9	51.9	50.6	
Fats and oils	84.0	80.5	78.6	77.6	79.1	
Beverages	57.5	55.8	52.0	49.5	48.4	
Miscellaneous foods	62.6	57.7	53.6	50.9	48.8	

Note: The value of materials is deflated by the producer price index of crude foodstuffs and feedstuffs.
The value of fuels and electricity is deflated by the producer price index of intermediate energy goods.

Source: USDA/Economic Research Service.

In productivity studies, the rates of technological change, which reflect changes in an industrial output for a given input bundle, may be measured by using a production function similar to that developed by Solow. Alternatively, rates of technological change which reflect changes in the cost of obtaining a given output may be measured by using a cost function such as that used in Ball and Chambers. This study applies a production function approach because it provides useful information for a direct explanation about the source of output growth.

The data used in this study are mainly compiled from the Bureau of the Census's *Annual Survey of Manufactures and Census of Manufacturing*. Two common production indicators, the value of shipments and the value added, are available in the data sources. This study uses both indicators as the output of a production function for measuring productivity indexes. The potential difference in productivity measurements from these production indicators is an issue addressed in this study. Following is a brief explanation of the methodology used to measure the multifactor and labor productivity indexes, and a method to modify the model for application to U.S. food manufacturing.

Derivation of Productivity Measures

In productivity studies, multifactor productivity is derived by taking account of various inputs into the productivity measurement. To measure the multifactor productivity index, the underlying production function is assumed to be Hicks' neutral technical change. The general form of the production function with n-factor inputs at time t can be written as:

$$Q_t = A_t f(X_{1t}, X_{2t}, \ldots, X_{nt}), \qquad (1)$$

where variables are Q_t (real output), X_{it} (input of the ith factor, i = 1, 2,..,n), and A_t (index of Hicks' neutral technical change or multifactor productivity). Although the assumption of neutral technical change may be rigid, this production function provides a framework for easy interpretation of the causes of productivity changes.

Differentiating equation (1) with respect to time t, the derived output growth equation becomes

$$(dQ_t/dt) / Q_t = (dA_t/dt) / A_t + \Sigma_i (\partial Q_t/\partial X_{it}) (X_{it} /Q_t) (dX_{it}/dt) / X_{it} \qquad (2)$$

Equation (2) shows the rate of change in output as the sum of the rate of change in multifactor productivity, $(dA_t/dt) / A_t$, and a weighted average of the rates of change in various inputs $(dX_{it}/dt) / X_{it}$. The weight is expressed by $(\partial Q_t/\partial X_{it}) (X_{it} /Q_t)$, which is the elasticity of output with respect to the ith input, showing the percentage change in output per 1-percent change in the ith input.

In addition, under the assumption that a competitive economy is operating at longrun equilibrium, the marginal products of all inputs are equal to their respective real market prices as $\partial Q_t / \partial X_{it} = W_{it} / P_t$, with new variables W_{it} (price of the ith input) and P_t (price of output). Substituting this expression for the elasticity of output in equation (2), and then using S_{it} (cost share of the ith input) to represent $W_{it} X_{it} / P_t Q_t$, the multifactor productivity index can be shown as:

$$(dA_t/dt) / A_t = (dQ_t/dt) / Q_t - \Sigma_i [S_{it} (dX_{it} /dt) / X_{it}] \qquad (3)$$

The competition in output markets indicates that the capital price reflects a competitive rate of return ensuring that all revenues are spent on inputs. In other words, the summation of all input cost shares equals 1 ($\Sigma_i S_{it} = 1$). Thus, the multifactor productivity index, showing the ability to produce more output from the same input, is calculated by subtracting an index series for the combined changes of various inputs from the index series for output changes. Different inputs are aggregated into one input measure by weighting (multiplying) the index series of each input by its share in the total cost of output.

Furthermore, the productivity index of the jth input can be shown as:

$$(dQ_t/dt) / Q_t - (dX_{jt}/dt) / X_{jt} = (dA_t/dt) / At + \Sigma_{i,\, i\neq j}\ S_{it} [(dX_{it}/dt) / X_{it} - (dX_{jt}/dt) / X_{jt}] \qquad (4)$$

In particular, if the jth input is regarded as labor, then this equation represents labor productivity. Accordingly, labor productivity, showing the rate of change in output per worker on the left-hand side of equation, is determined by two components: technological progress and the quantities of capital goods and other inputs available to each worker.

The Törnqvist Index Approximation

The rates of change in equations (3) and (4) are expressed in the Divisia index such as $(dQ_t/dt) / Q_t$ for the change of output and require using continuous data for the presentation. For empirical application, however, the Törnqvist index is commonly used as a discrete approximation of the Divisia index. More specifically, for example, the rate of change of output $(dQ_t/dt) / Q_t = (d\,ln Q_t/dt)$ can be approximated by $ln(Q_t/Q_{t-1})$. Similarly, the rate of change of the ith input $(dX_{it}/dt) / X_{it} = (d\,ln X_{it}/dt)$ can be approximated by $ln(X_{it}/X_{it-1})$. In addition, since the variables are expressed in consecutive change of observed data, an ideal weight S_{it} in the brackets of equations (3) and (4) should be the average shares of S_{it} and S_{it-1}; that is, $1/2(S_{it} + S_{it-1})$.

Therefore, by applying the Törnqvist index as a discrete approximation of the Divisia index, the multifactor productivity in equation (3) can be expressed as:

$$ln(A_t/A_{t-1}) = ln(Q_t/Q_{t-1}) - \Sigma_i \, [1/2(S_{it} + S_{it-1}) \, ln(X_{it}/X_{it-1})] \qquad (5)$$

This expression shows that the rate of change of multifactor productivity $ln(A_t/A_{t-1})$ is the difference between the rate of change in output $ln(Q_t/Q_{t-1})$ and a weighted average of the rates of change of all factor inputs in the bracket. This methodology was used by the Bureau of Labor Statistics, and a discussion of the model for two factors (labor and capital) in a production function was documented in Mark and Waldorf.

Similarly, the Törnqvist index approximation of the productivity index of the jth input in equation (4) becomes:

$$ln(Q_t/Q_{t-1}) - ln(X_{jt}/X_{jt-1}) = ln(A_t/A_{t-1}) + \Sigma_{i,\, i\neq j} \, 1/2(S_{it} + S_{it-1}) \, [ln(X_{it}/X_{it-1}) - ln(X_{jt}/X_{jt-1})] \qquad (6)$$

Again, if the jth input is regarded as labor, then this equation represents labor productivity. The above expression in natural logarithmic form shows that the rate of change of labor productivity is equal to the sum of the rate of change of multifactor productivity and the contribution of the changes in all other inputs per unit of labor to output.

While the above procedures for measuring productivity can be easily implemented, one might question that the underlying assumption of perfect competition may not be appropriate to the food manufacturing sector, which may be characterized by oligopoly. Ideally, we need to perform some tests on the potential oligopoly structure of the food manufacturing sector, but these tests are beyond the scope of this study. A noted paper by Azzam et al. incorporated information about markups, demand, and cost parameters into the measurement of productivity. This set of extraneous information, however, is obtained from different sources, and may introduce errors in the productivity measurement because the extraneous information is not obtained within the same framework as the measurement of productivity changes.

Empirical Modeling

In applying the methodology of measuring productivity for the U.S. food manufacturing industries, two commonly used output indicators (the value of shipments and the value added) are available in the *Census of Manufactures* and *Annual Survey of Manufactures*. By using these output indicators, this study applies two approaches to specify a production function for measuring the multifactor and labor productivity indexes.

One is the gross-output approach, such that the adjusted value of shipments is a function of capital, labor, energy, and material inputs as follows:

$$Q_t = A_t \, f(K_t, La_t, Lb_t, E_t, M_t), \qquad (7)$$

where Q_t is the gross output defined as the value of shipments adjusted by the net change in inventories measured at 1982 prices, with the producer price index of processed foods and feeds as a deflator. K_t represents capital services charges measured at 1982 prices, with the producer price index of capital equipment as a deflator. Capital services charges are approximated as the sum of depreciation charges for fixed assets and interest costs on the average value of fixed assets at the beginning and ending of that year. The labor inputs are divided into two components: production and nonproduction workers. La_t represents production worker-hours, and Lb_t is the number of nonproduction employees. E_t represents purchased fuels and electricity at 1982 prices, with the producer price index for intermediate energy goods as a deflator. M_t is the cost of materials at 1982 prices, with the producer price index of crude foodstuffs and feedstuffs as a deflator. A_t is the index of multifactor productivity for the value of shipments. This gross-output production function represents a production structure that includes the contribution of all factor inputs that are available in the data sources.

The net-output approach uses net output or the net value added as an output in a production function. Net output is calculated by subtracting the cost of materials, supplies, containers, fuel, electricity, and purchased services from the value of shipments and then deflating by the producer price index of processed foods and feeds. The net output represents the value that is added, by the application of capital and labor, to intermediate inputs in converting those inputs to finished products. Therefore, capital and labor are the relevant inputs in generating the net output of an industry, and a production function for the net output is specified as follows:

$$Q_t^* = A_t^* f(K_t, La_t, Lb_t), \qquad (8)$$

where Q_t^* is the quantity of net output or net value added, and K_t, La_t, and Lb_t are defined the same as in equation 7. A_t^* is the index of multifactor productivity for the net value added.

The existence of this net-output production function, as discussed in Gullickson, requires that the production of gross output (as shown in equation 7) be characterized by value-added separability, in which intermediate inputs cannot be the source of productivity growth. In other words, intermediate inputs are excluded from consideration in the net-output model on the assumption that they are insignificant to the analysis of productivity growth. With this restrictive assumption, the purpose of measuring net-output productivity from equation 8 is to calculate an industry's contribution to the Nation's GDP in a simple and straightforward way. For interpreting industry productivity, however, the gross-output model specification is generally preferred.

Empirical Productivity Measures

Both the gross-output and net-output approaches are applied to measure the multifactor and labor productivity indexes of the food manufacturing sector and its associated nine industries. The gross-output approach relates the adjusted value of shipments as a function of capital, labor, energy, and all intermediate materials as shown in equation 7, while the net-output approach relates the net value added as a function of labor and capital as shown in equation 8. The detailed empirical results of yearly productivity indexes and related measures obtained from both approaches are reported in Appendix C. This section focuses mainly on the productivity results compiled in tables 5-10, in which average figures for each of 5 subperiods (four 5-year periods and one final 3-year period) are presented.

Gross-Output Productivity Measures

Table 5 presents the gross-output productivity results of the food manufacturing sector. As indicated in the table, the annual rate of change in multifactor productivity (4) is obtained by subtracting the combined inputs (2) from the gross output (1). The annual rate of change in labor productivity (5) is a summation of the capital and other input intensity per unit of labor (3) and multifactor productivity (4).

In table 5, the gross-output multifactor productivity index for food manufacturing grew 0.19 percent a year between 1975 and 1997. The productivity growth of food manufacturing shows a gain of 1.7 percent in 1975-79, then a loss of 1.38 percent in 1980-84, rebounding to 1.08 percent in 1985-89, before decreasing to a negative rate of -0.63 percent in 1995-97. The slow growth rate found in this study is consistent with the Bureau of Labor Statistics (BLS) estimate of 0.45 percent using different data. As shown in figure 5a, both the study's and BLS' productivity indexes show a trend of slow growth, moving up and down within 10 percent along a level slightly above the base year 1975.

Both the study's and BLS' estimates of productivity indexes are low when compared with the BLS estimate of 1.25 percent a year for the whole manufacturing sector over the same period of time. The reason for the lower productivity growth in food manufacturing is not fully understood, but low investment in research and development (R&D) could be one reason. This study found that real private sector R&D expenditures for food manufacturing in the period 1975-97 grew 2.22 percent a year on average (table 6). These R&D expenditures represent only 0.23 percent of sales. Over the same period, the R&D expenditures for food manufacturing even grew slower than similar expenditures

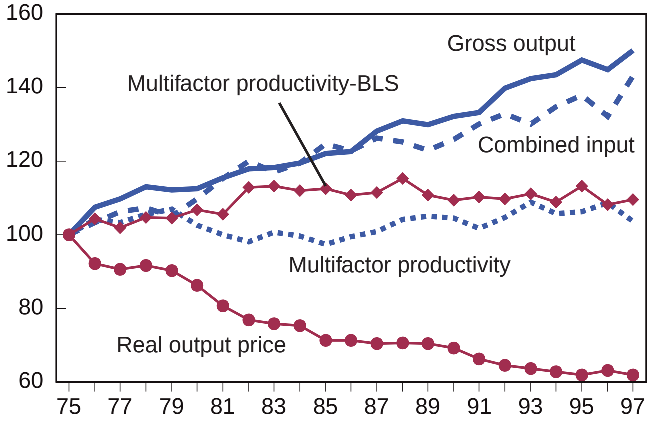
Table 5—Gross-output productivity and price of the food manufacturing sector, 1975-97

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Gross output	(1)	2.96	1.27	1.68	2.04	1.51	1.88
Inputs:							
Combined inputs	(2)	1.26	2.65	0.60	1.88	2.14	1.69
Nonlabor/labor intensity	(3)	0.00	4.58	-0.41	-0.13	1.62	1.14
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.70	-1.38	1.08	0.16	-0.63	0.19
Labor productivity	(5)=(3)+(4)	1.70	3.21	0.67	0.03	0.99	1.33
BLS multifactor productivity:							
Food and kindred products		1.12	1.43	-0.18	-0.35	0.29	0.45
Whole manufacturing		1.20	1.22	1.26	0.87	1.98	1.25
Real processed food price		-2.45	-3.58	-1.28	-2.27	-0.46	-2.13

Notes: Gross output = real adjusted value of shipments; Combined inputs = weighted average of all inputs;
Nonlabor/labor input = nonlabor intensity or combined nonlabor inputs per worker-hour;
Real processed food price is deflated by the consumer price index.
BLS Multifactor productivity is compiled from the BLS website (*http://stats.bls.gov/mfp/mprdload.html*).

Source: USDA/Economic Research Service.

Figure 5a
The food sector: Gross-output multifactor productivity and real output price



Source: USDA/Economic Research Service.

for agricultural input industries such as agricultural chemicals and plant breeding. Also, the National Science Foundation estimated that the real private R&D expenditures of all industries grew at much faster rates of 5.78 percent yearly in the same period.

Although productivity has been relatively low, food manufacturing output has grown significantly over the last two decades. According to this study, it was the expansion of combined factor inputs that provided the major impetus to the sector's output. Gross output measured at 1982 prices grew 1.88 percent a year during 1975-97. During this period the combined capital, labor, energy, and material inputs grew at an average annual rate of 1.69 percent. Material inputs grew the fastest at 2.25 percent a year. Food manufacturing is materials-intensive with material costs constituting about 60 percent or more of the value of gross output. A 3.06-percent annual decline in real producer prices of crude food and feedstuffs in the period 1975-97 fueled the expansion of input utilization.

This expansion of food manufacturing output benefited U.S. and global consumers. The real producer price of processed foods declined on average 2.13 percent a year between 1975 and 1997 (table 5 and fig. 5a). Researchers have hypothesized that advances in food manufacturing productivity would explain the decline in real prices of processed foods. To explain the cause of decline, this study estimates a log-linear regression by expressing the real producer price of processed foods (P_t) at time t as a function of the multifactor productivity index (A_t) and the real price index of crude food and feedstuffs (F_t) represented for material cost. The empirical results of the fitted price equation covering 1975-97 for the food manufacturing sector are shown below:

$$\ln P_t = 2.5593 - \underset{(0.1280)}{0.1381} \ln A_t + \underset{(0.0173)}{0.5854} \ln F_t \qquad R^2 = 0.99 \qquad (9)$$

The figures in parentheses are the standard errors. The estimated coefficient implies that a 1-percent decrease in the price index of crude food and feedstuffs (F_t) would reduce the real price of processed foods by 0.59 percent, and is statistically significant. The effect of a 1-percent increase in multifactor productivity (A_t), however, would reduce the real price of processed food by only 0.14 percent, but would not be statistically significant. The results found in this study indicate that a decrease in the prices of crude food and feed-

Table 6—Private research and development (R&D) expenditures, 1975-97

	1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
			Million $ at 1982 prices			
Total agricultural inputs	865	1,091	1,163	1,396	1,548	4.04
Plant breeding	89	123	173	237	288	6.31
Agricultural chemicals	346	522	606	754	804	5.60
Farm machinery	304	312	234	231	271	1.95
Veterinary pharmaceuticals	125	134	151	174	185	2.56
Food manufacturing products	497	604	687	609	644	2.22
Total agricultural R&D	1,362	1,695	1,850	2,005	2,192	3.34
All U.S. industries	28,721	40,692	54,000	66,419	80,499	5.78

Source: USDA/Economic Research Service; Data for all U.S.industries are compiled from National Science Foundation.

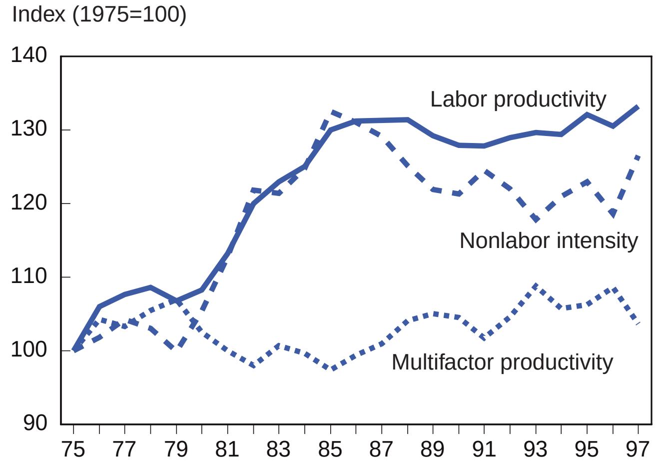
stuffs drove down the prices of processed foods paid by consumers. Productivity growth apparently contributed little to the price decline.

Another issue of much public interest has been the effect of many mergers and acquisitions in recent years on food manufacturing productivity. According to *Mergerstat Review*, which tracked purchases valued at $1 million or higher and transfers of ownership involving at least 10 percent of a company's equity, the pace of merger and acquisition activity in food processing increased steadily from 60 transactions in 1991 to 157 in 1998 (table 7). Annually, there was an average of 97 transactions involving 12 foreign buyers and 24 foreign sellers. Meanwhile, the number of transactions valued at $100 million or more increased from 10 in 1991 to 23 in 1998, with an annual average of 17. On the basis of the measured multifactor productivity index, it appears that heightened merger and acquisition activity had little effect on productivity. Some argued that R&D labs were consolidated and total resources reduced in association with a high number of mergers and acquisitions (Connor and Schiek, p. 385).

In measuring labor productivity, the major focus was on the productivity of production workers, who constitute more than 70 percent of the total labor force. As shown in table 5, the average annual rate of change in labor productivity was 1.33 percent. Labor productivity increased over all subperiods, with a peak at 3.21 percent in 1980-84, mainly because of the high growth of nonlabor input intensity, at an annual rate of 4.58 percent. Multifactor productivity, however, showed a negative growth rate of -1.38 percent in 1980-84. The labor productivity index (fig. 5b) moved steadily upward until leveling off somewhat after 1985, while the nonlabor intensity index closely mirrored this movement. Evidently, a yearly 1.33-percent growth in labor productivity was closely related to improvements in nonlabor intensity per production worker, especially with workers having more and better machinery.

Figure 5b

The food sector: Gross-output labor productivity



Source: USDA/Economic Research Service.

Table 8 presents the gross-output productivity results of each food manufacturing industry. In the table, the average rates of change in multifactor productivity range from -0.42 for meat products to 1.12 percent for beverages. Many food industries stay roughly even with the level in the base year 1975 with small gains and losses over the subperiods. In 1980-84, the multifactor productivity index sharply decreased for most food industries. For example, multifactor productivity of the dairy industry was estimated at -1.92 percent, because the growth rate of output was only 2.25 per-

Table 7—U.S. food processing merger and acquisition activity, 1990-1998

	1991	1992	1993	1994	1995	1996	1997	1998	Annual average
Number of transactions[1]	60	75	74	84	86	111	130	157	97
Number transactions of $100 million more	10	8	11	17	20	19	26	23	17
Foreign buyers	8	8	6	13	13	12	15	23	12
Foreign sellers	14	26	30	20	17	24	32	31	24
Value offered, million $	3,101	4,328	3,525	11,061	10,833	8,287	10,856	11,450	7,930
Foreign buyers value, million $	543	446	930	4,248	6,187	425	3,041	1,382	2,150
Foreign sellers value, million $	721	2,976	1,705	381	1,844	2,812	3,435	6,170	2,505

[1] Mergers are included only if the purchase price was at least $1 million and transfers of ownership involved at least 10 percent of a company's equity.

Source: Mergerstat Review. Selected issues.

Table 8—Gross-output productivity of the food manufacturing industries, 1975-97

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Meat products							
Gross output	(1)	3.56	-1.37	1.93	1.74	2.03	1.45
Inputs:							
Combined inputs	(2)	2.11	0.75	2.17	2.80	1.38	1.87
Nonlabor/labor intensity	(3)	0.89	1.55	-2.29	-1.35	-0.24	-0.34
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.46	-2.12	-0.24	-1.06	0.65	-0.42
Labor productivity	(5)=(3)+(4)	2.35	-0.57	-2.53	-2.41	0.41	-0.77
Dairy products							
Gross output	(1)	2.18	2.25	1.29	0.95	0.76	1.52
Inputs:							
Combined inputs	(2)	-0.20	4.17	1.11	1.60	1.41	1.72
Nonlabor/labor intensity	(3)	0.20	5.64	0.05	1.69	0.74	1.82
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.38	-1.92	0.18	-0.65	-0.65	-0.20
Labor productivity	(5)=(3)+(4)	2.58	3.72	0.23	1.04	0.09	1.62
Preserved fruits and vegetables							
Gross output	(1)	4.68	2.87	1.89	2.24	-0.95	2.31
Inputs:							
Combined inputs	(2)	2.61	3.27	0.38	2.16	-1.11	1.64
Nonlabor/labor intensity	(3)	0.72	5.67	0.87	1.51	0.10	1.97
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.08	-0.40	1.51	0.08	0.16	0.67
Labor productivity	(5)=(3)+(4)	2.79	5.27	2.38	1.59	0.26	2.64
Grain mill products							
Gross output	(1)	0.69	2.18	3.11	2.51	1.70	2.13
Inputs:							
Combined inputs	(2)	-0.51	3.49	1.29	1.98	4.90	2.11
Nonlabor/labor intensity	(3)	-0.25	6.92	0.19	0.97	5.45	2.53
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.21	-1.31	1.82	0.53	-3.20	0.02
Labor productivity	(5)=(3)+(4)	0.96	5.61	2.01	1.50	2.25	2.55
Bakery products							
Gross output	(1)	0.29	2.38	2.88	3.35	0.79	2.11
Inputs:							
Combined inputs	(2)	-1.80	2.50	1.14	1.90	1.46	1.13
Nonlabor/labor intensity	(3)	-1.84	5.34	0.25	-0.43	3.13	1.27
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.09	-0.12	1.74	1.45	-0.67	0.99
Labor productivity	(5)=(3)+(4)	0.25	5.22	1.99	1.03	2.46	2.25

Continued--

Table 8—Gross-output productivity of the food manufacturing industries, 1975-97--Continued

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Sugar and confections							
Gross output	(1)	-2.46	3.19	0.66	1.98	2.61	1.23
Inputs:							
Combined inputs	(2)	-3.26	3.49	-0.79	2.04	1.70	0.72
Nonlabor/labor intensity	(3)	-3.87	4.51	0.30	1.25	2.36	1.00
Productivity:							
Multifactor productivity	(4)=(1)-(2)	0.80	-0.30	1.44	-0.06	0.92	0.51
Labor productivity	(5)=(3)+(4)	-3.08	4.21	1.75	1.18	3.27	1.51
Fats and oils							
Gross output	(1)	3.55	-1.82	-1.55	-0.54	5.35	0.49
Inputs:							
Combined inputs	(2)	1.69	0.53	-2.46	1.06	5.62	0.87
Nonlabor/labor intensity	(3)	-0.59	6.06	1.06	2.11	7.42	3.00
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.86	-2.34	0.91	-1.59	-0.27	-0.38
Labor productivity	(5)=(3)+(4)	1.28	3.72	1.98	0.51	7.15	2.62
Beverages							
Gross output	(1)	3.96	3.32	1.72	2.70	2.15	2.77
Inputs:							
Combined inputs	(2)	2.31	4.41	-1.14	0.56	2.69	1.65
Nonlabor/labor intensity	(3)	1.82	7.35	2.74	0.49	-0.39	2.68
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.65	-1.09	2.87	2.15	-0.54	1.12
Labor productivity	(5)=(3)+(4)	3.48	6.26	5.61	2.64	-0.92	3.80
Miscellaneous foods							
Gross output	(1)	7.61	1.40	1.32	3.01	0.63	2.77
Inputs:							
Combined inputs	(2)	5.35	2.29	0.75	1.93	2.95	2.50
Nonlabor/labor intensity	(3)	-0.39	3.09	0.11	-0.22	1.09	0.75
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.27	-0.89	0.56	1.08	-2.33	0.27
Labor productivity	(5)=(3)+(4)	1.87	2.20	0.68	0.86	-1.24	1.02

Notes: Gross output = real adjusted value of shipments; Combined inputs = weighted average of all inputs; Nonlabor/labor input = nonlabor intensity or combined nonlabor inputs per worker-hour.

Source: USDA/Economic Research Service.

cent, far less than the 4.17-percent growth of the combined inputs. Some significant decreases in multifactor productivity in 1980-84 occurred in fats and oils (-2.34 percent) and meats (-2.12 percent). In 1995-97, the multifactor productivity indexes of most food industries showed little change or were negative for industries like grain mill products (-3.2 percent) and miscellaneous foods (-2.33 percent).

The labor productivity index increased steadily for most food industries and was closely related to increased use of inputs other than labor. Table 8 shows that the average annual rates of change in labor productivity range from -0.77 for meat products to 3.8 percent for beverages. In contrast to low multifactor productivity in 1980-84, the annual rate of change in labor productivity of the dairy industry was 3.72 percent because of a high growth rate (5.64 percent) of nonlabor intensity. In 1980-84, the labor productivity indexes showed significant increases in preserved fruits and vegetables (5.27 percent), grain mill products (5.61 percent), bakery products (5.22 percent), sugar and confections (4.21 percent), fats and oils (3.72 percent), and beverages (6.26 percent).

In 1995-97, fats and oils as a capital-intensive industry registered remarkably high labor productivity with an annual rate of 7.15 percent, which was related to the 7.42-percent increase in nonlabor intensity. For other industries, some high labor productivity growth rates were found in sugar and confections (3.27 percent), grain mill products (2.25 percent), and bakery products (2.46 percent), but others showed only a small increase.

Figures 6a to 6i show the movements of gross output, multifactor productivity, and labor productivity for nine food industries in 1975-97. The general pattern of variations for most industries was similar to variations in the overall food manufacturing sector, characterized by a steady upward movement of the gross output and labor productivity. On the other hand, the multifactor productivity indexes moved downward or were slightly above the base year level.

Net-Output Productivity Measures

The main purpose of measuring net-output productivity is to show the industry's contribution to the Nation's gross domestic product (GDP). Given the measured input-output relationships, a change in the quantity of inputs will affect the amount of combined inputs and capital intensity per production worker so that the quantity of net value added and labor productivity will be affected simultaneously. Therefore, net-output productivity results are useful indicators for showing the contribution of food manufacturing to the Nation's GDP.

Table 9 presents the net-output productivity results of the food manufacturing sector. The results are obtained from a production function in which the net output (real net value added) is a function of capital and labor. The information is arranged similar to that in table 5 by dividing the whole sample period into five subperiods. As indicated in the table, the annual rate of change in the multifactor productivity (4) is obtained by subtracting the combined inputs of capital and labor (2) from the net output (1). The annual rate of change in labor productivity (5) is a summation of capital intensity per worker-hour (3) and multifactor productivity (4).

In table 9, multifactor productivity of the net value added was characterized by a yearly 2.73-percent growth. The annual rate of change was 3.1 percent in 1975-79, increasing to a peak of 5.41 percent in 1985-89 before slowing to 4.21 percent in 1990-94 and -0.91 percent in 1995-97. The gains in the multifactor productivity index constituted the major force of growth in the net value added, which grew at an annual rate of 3.58 percent. The contribution of combined labor and capital inputs to the growth of the net value added, however, was not certain; there were significant contributions of 3.05 percent in 1980-84 and 2.58 percent in 1995-97, but not in other subperiods.

Table 9 also shows that the average annual rate of change in labor productivity was 3.03 percent. The productivity index showed a gain of 2.99 percent in 1975-79, reaching a peak of 5.43 percent in 1980-84 before slowing to 2.71 percent in 1985-89 and 1.14 percent in 1995-97. The rates of change in technological progress and capital intensity per production worker determine the rates of change in labor productivity. For example, the average annual rate of change in labor productivity peaked at 5.43 percent in 1980-84, mainly because of the high annual rates of growth in

Table 9—Net-output productivity of the food manufacturing sector, 1975-97

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Net output	(1)	4.24	3.50	3.73	4.13	1.66	3.58
Inputs:							
Combined inputs	(2)	1.15	3.05	-1.68	-0.08	2.58	0.85
Capital/labor intensity	(3)	-0.11	4.99	-2.69	-2.09	2.06	0.31
Productivity:							
Multifactor productivity	(4)=(1)-(2)	3.10	0.45	5.41	4.21	-0.91	2.73
Labor productivity	(5)=(3)+(4)	2.99	5.43	2.71	2.12	1.14	3.03

Notes: Net output = real net value added; Combined inputs = weighted average of all inputs; Capital/labor input = capital intensity or capital services per worker-hour.

Source: USDA/Economic Research Service.

Figure 6a
**Gross-output productivity:
Meat products**

Index (1975=100)

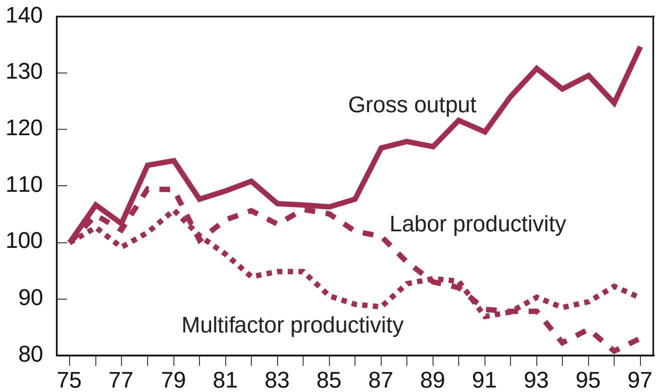


Figure 6b
**Gross-output productivity:
Dairy products**

Index (1975=100)

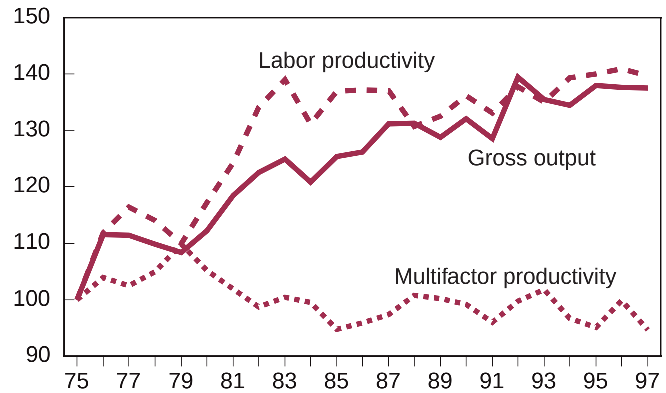


Figure 6c
**Gross-output productivity:
Preserved fruits and vegetables**

Index (1975=100)

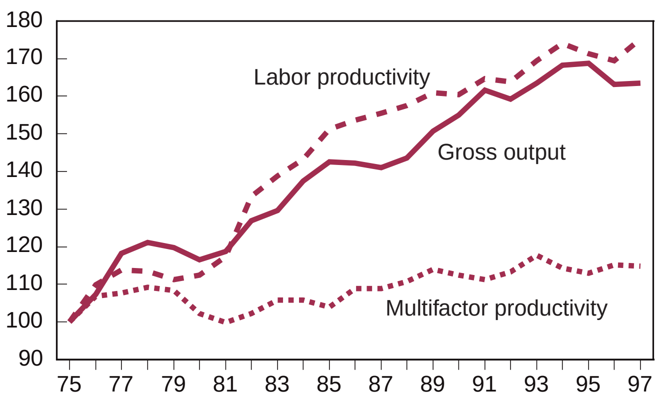


Figure 6d
**Gross-output productivity:
Grain mill products**

Index (1975=100)

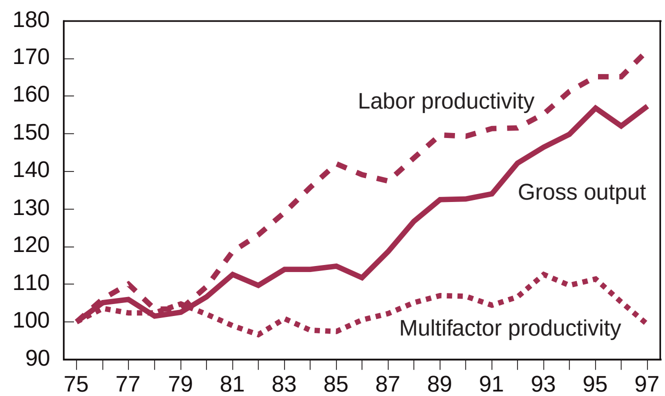


Figure 6e
**Gross-output productivity:
Bakery products**

Index (1975=100)

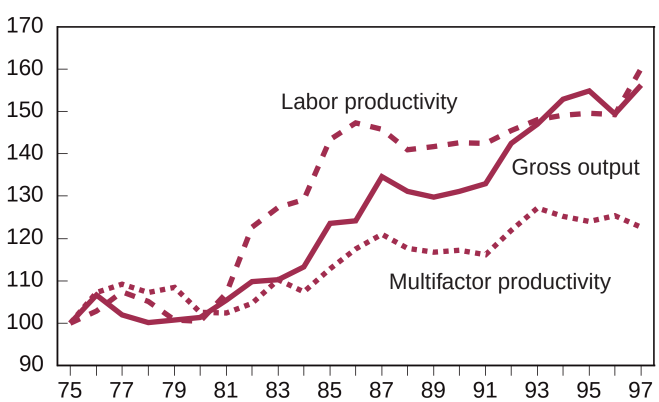
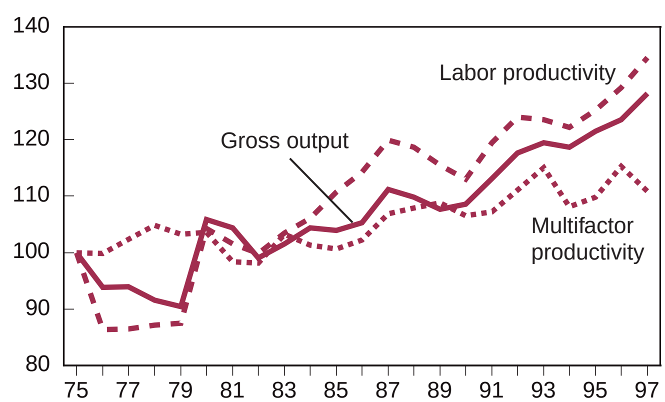


Figure 6f
**Gross-output productivity:
Sugar and confections**

Index (1975=100)



Source: USDA/Economic Research Service.

Figure 6g
Gross-output productivity: Fats and oils

Index (1975=100)

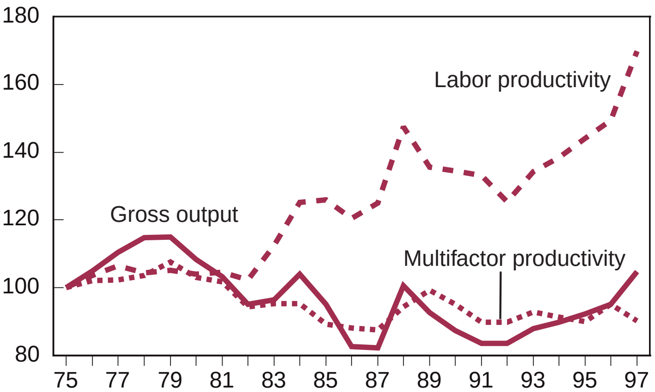


Figure 6h
Gross-output productivity: Beverages

Index (1975=100)

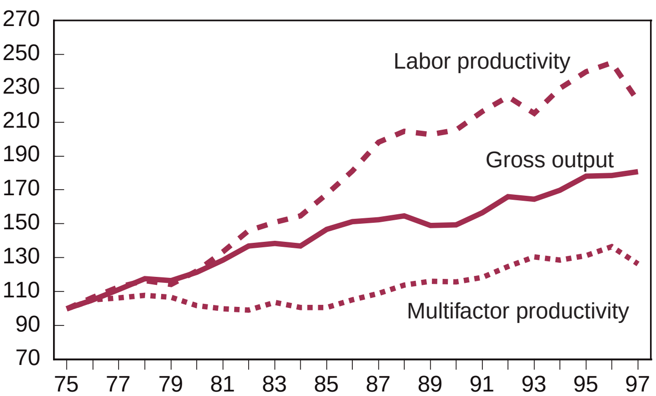
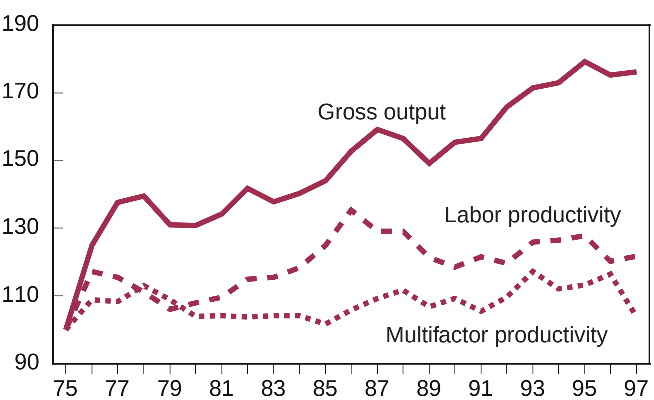


Figure 6i
Gross-output productivity: Miscellaneous foods

Index (1975=100)



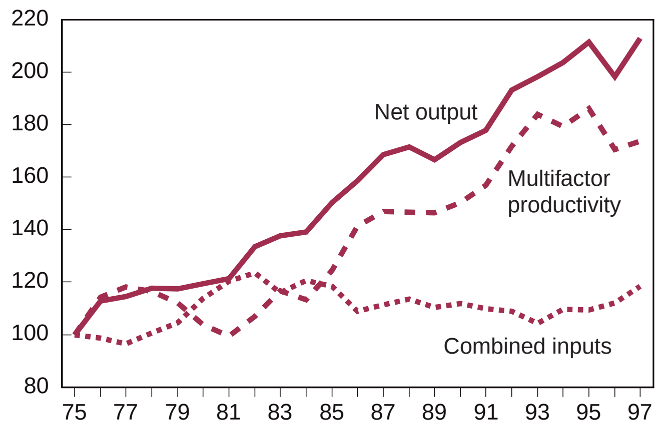
Source: USDA/Economic Research Service.

capital intensity of 4.99 percent. In 1975-79, however, labor productivity was 2.99 percent, mainly because of a significant increase in multifactor productivity of 3.1 percent. In general, it is difficult to ascertain the contribution of multifactor productivity or capital intensity to the growth of net-output labor productivity in the food manufacturing sector.

Figure 7a shows that the multifactor productivity index was in general moving upward continuously along with the net-output index during 1975-97, while the combined capital and labor inputs index showed little change. Figure 7b shows that the labor productivity

Figure 7a
The food sector: Net-output multifactor productivity

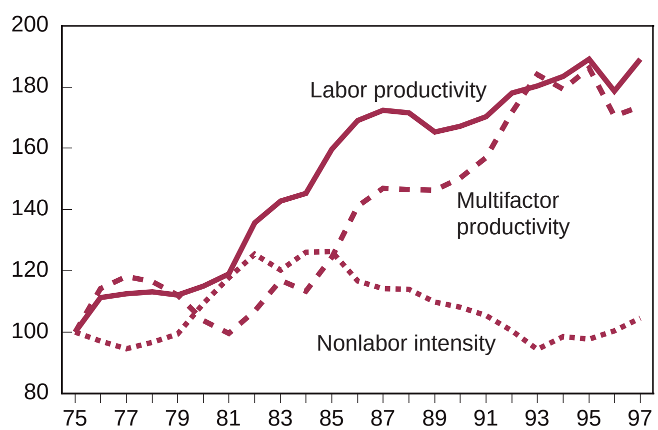
Index (1975=100)



Source: USDA/Economic Research Service.

Figure 7b
The food sector: Net-output labor productivity

Index (1975=100)



Source: USDA/Economic Research Service.

index is moving upward continuously along with the net-output index during 1975-97, while the multifactor productivity index decreases slightly before 1981 and then increases steadily over most years. The combined capital and nonproduction worker intensity index trended upward before 1985 and declined thereafter.

Table 10 presents the net-output productivity results of each food manufacturing industry. The average growth rates of the multifactor productivity indexes vary widely across industries ranging from grain mill products (1.99 percent) to beverages (3.66 percent). Multifactor productivity accounted for the major growth of net value added in some subperiods, but in other subperiods the combined labor and capital inputs contributed significantly to changes in net value added. In the meat industry, for example, the average growth rate of net value added in 1995-97 was 7.92 percent because of a 4.16-percent increase in multifactor productivity and a 3.76-percent increase in combined inputs. In 1980-84, the annual increase of net value added was 1.18 percent, mainly spurred by a 1.3-percent increase in combined inputs. In 1985-89, however, the annual increase of net value added was 4.4 percent, mainly due to a 3.7-percent increase in multifactor productivity.

Regarding net-output labor productivity, table 10 shows that most of the average annual changes in labor productivity are positive ranging from meat products (1.64 percent) to beverages (4.85 percent), implying that the productivity index increased over time. In 1980-84, the increase of capital intensity was vital to the growth of labor productivity for most industries. For example, in the grain mill products, a 7.89-percent increase in capital intensity during that period caused a 7.59-percent increase in labor productivity. On the other hand, the average annual rates of change in capital intensity for most food industries was negative in 1985-89 and 1990-94, which affected labor productivity during those subperiods. For example, the average growth rate of capital intensity for meat products was -3.76 percent in 1985-89, causing labor productivity to drop by 0.06 percent, substantially lower than the 3.7-percent increase in multifactor productivity.

Figures 8a to 8i show the movements of net output, multifactor productivity, and labor productivity for the nine food industries in 1975-97. These indexes moved upward continuously over time, but their growth rates varied among industries. For dairy products, bakery products, and sugar and confections, all three indexes were closely correlated. For grain mill products and

Figure 8a

Net-output productivity: Meat products

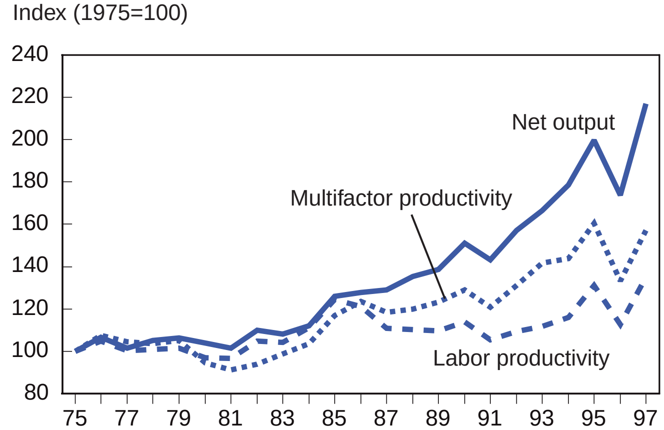


Figure 8b

Net-output productivity: Dairy products

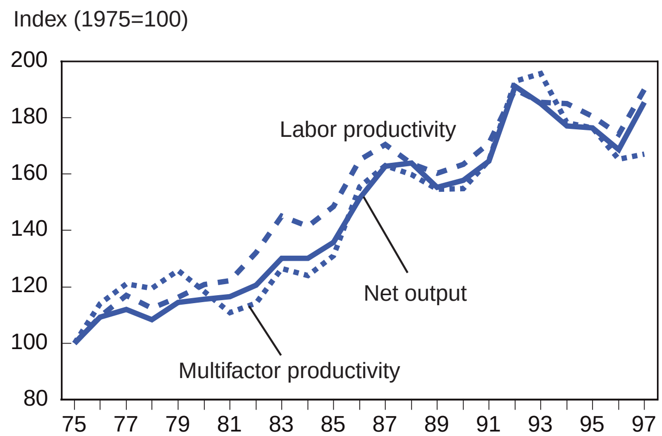
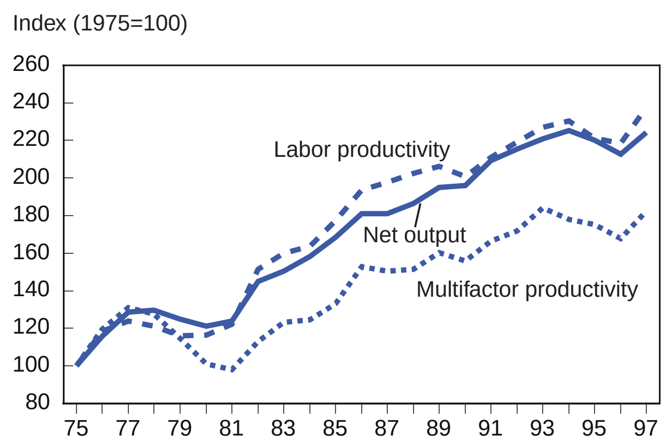


Figure 8c

Net-output productivity: Preserved fruits and vegetables



Source: USDA/Economic Research Service.

Figure 8d
Net-output productivity: Grain mill products

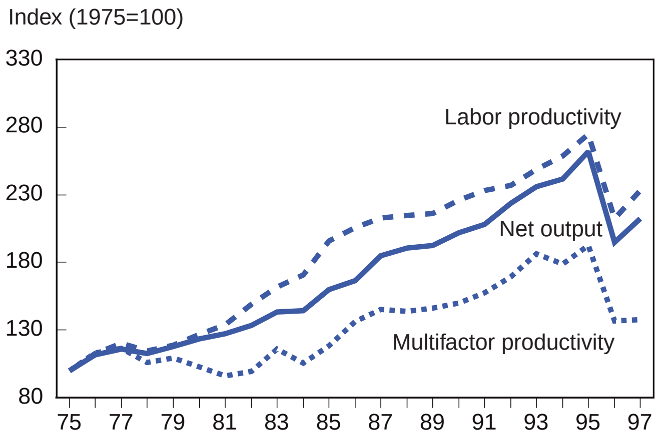


Figure 8e
Net-output productivity: Bakery products

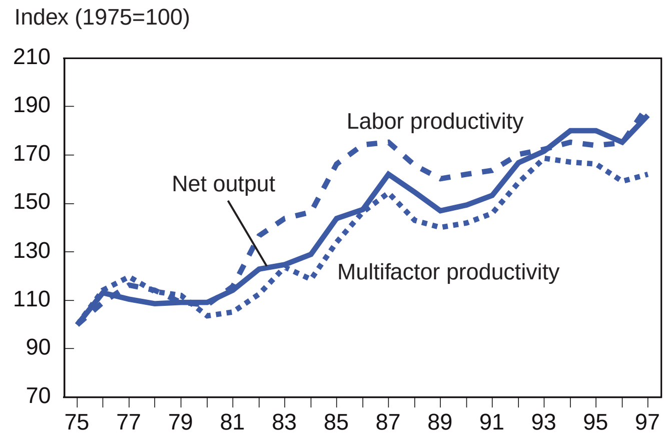


Figure 8f
Net-output productivity: Sugar and confections

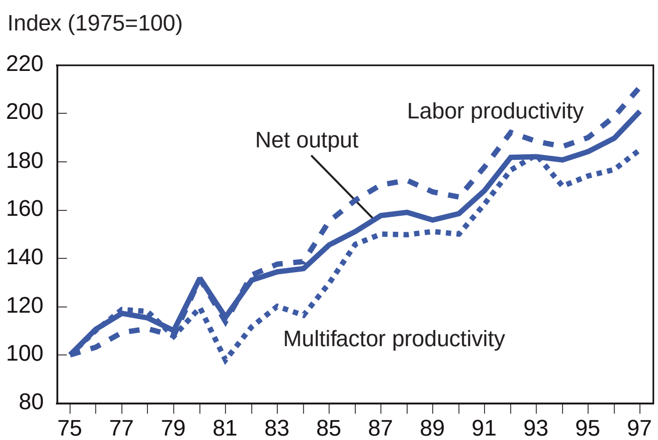


Figure 8g
Net-output productivity: Fats and oils

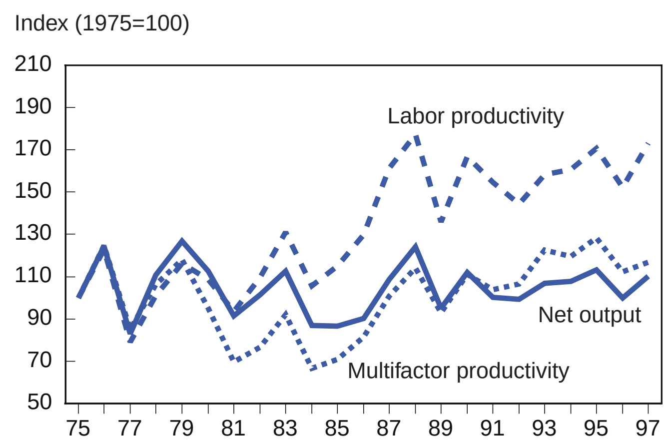


Figure 8h
Net-output productivity: Beverages

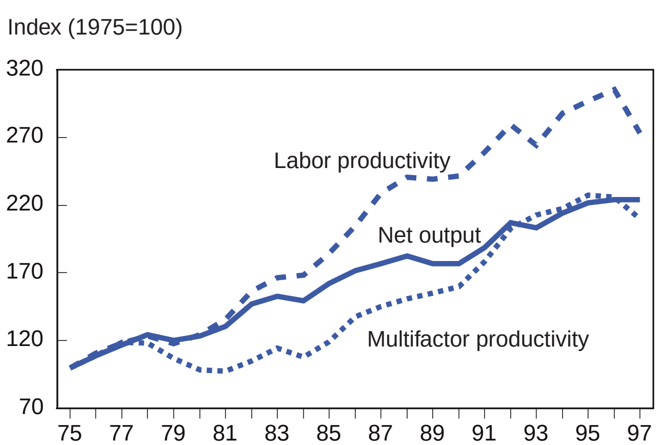
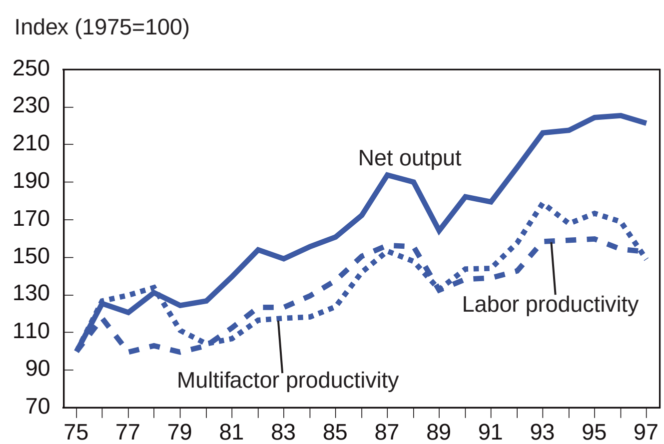


Figure 8i
Net-output productivity: Miscellaneous foods



Source: USDA/Economic Research Service.

Table 10—Net-output productivity of the food manufacturing industries, 1975-97

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Meat products							
Net output	(1)	1.62	1.18	4.40	5.34	7.92	3.86
Inputs:							
Combined inputs	(2)	0.30	1.30	0.70	2.07	3.76	1.49
Capital/labor intensity	(3)	-0.91	2.10	-3.76	-2.08	2.14	-0.72
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.32	-0.11	3.70	3.27	4.16	2.37
Labor productivity	(5)=(3)+(4)	0.41	1.99	-0.06	1.19	6.30	1.64
Dairy products							
Net output	(1)	3.54	2.65	3.73	2.93	1.71	2.99
Inputs:							
Combined inputs	(2)	-2.52	2.74	-1.07	-0.30	3.80	0.37
Capital/labor intensity	(3)	-2.12	4.21	-2.13	-0.21	3.12	0.47
Productivity:							
Multifactor productivity	(4)=(1)-(2)	6.06	-0.10	4.80	3.23	-2.09	2.62
Labor productivity	(5)=(3)+(4)	3.94	4.12	2.68	3.02	1.03	3.09
Preserved fruits and vegetables							
Net output	(1)	6.03	5.04	4.28	2.94	-0.04	3.88
Inputs:							
Combined inputs	(2)	1.96	2.93	-1.06	0.72	-0.98	0.81
Capital/labor intensity	(3)	0.07	5.33	-0.57	0.07	0.23	1.14
Productivity:							
Multifactor productivity	(4)=(1)-(2)	4.07	2.11	5.33	2.22	0.95	3.06
Labor productivity	(5)=(3)+(4)	4.14	7.44	4.77	2.29	1.17	4.21
Grain mill products							
Net output	(1)	4.28	4.16	6.05	4.64	-2.74	3.78
Inputs:							
Combined inputs	(2)	1.71	4.46	-0.85	0.42	4.14	1.79
Capital/labor intensity	(3)	1.98	7.89	-1.95	-0.59	4.68	2.21
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.57	-0.30	6.91	4.22	-6.87	1.99
Labor productivity	(5)=(3)+(4)	4.54	7.59	4.96	3.64	-2.19	4.20
Bakery products							
Net output	(1)	2.44	3.39	2.91	4.15	1.21	2.98
Inputs:							
Combined inputs	(2)	-0.74	2.03	-0.69	0.51	2.15	0.58
Capital/labor intensity	(3)	-0.77	4.87	-1.58	-1.82	3.83	0.72
Productivity:							
Multifactor productivity	(4)=(1)-(2)	3.17	1.37	3.60	3.65	-0.95	2.40
Labor productivity	(5)=(3)+(4)	2.40	6.24	2.02	1.83	2.88	3.12

Continued--

Table 10—Net-output productivity of the food manufacturing industries, 1975-97--Continued

		1975-79	1980-84	1985-89	1990-94	1995-97	Average annual growth
		Calculated annual change rate (percent)					
Sugar and confections							
Net output	(1)	2.60	4.89	2.85	3.05	3.58	3.41
Inputs:							
Combined inputs	(2)	0.44	2.59	-2.62	0.51	0.69	0.28
Capital/labor intensity	(3)	-0.17	3.61	-1.54	-0.28	1.35	0.56
Productivity:							
Multifactor productivity	(4)=(1)-(2)	2.16	2.29	5.48	2.54	2.88	3.13
Labor productivity	(5)=(3)+(4)	1.99	5.91	3.94	2.26	4.24	3.69
Fats and oils							
Net output	(1)	9.77	-6.14	3.00	2.93	1.25	1.90
Inputs:							
Combined inputs	(2)	2.57	2.59	-4.99	-2.69	1.56	-0.47
Capital/labor intensity	(3)	0.29	8.13	-1.46	-1.64	3.36	1.65
Productivity:							
Multifactor productivity	(4)=(1)-(2)	7.20	-8.74	7.99	5.62	-0.31	2.37
Labor productivity	(5)=(3)+(4)	7.50	-0.60	6.52	3.98	3.05	4.03
Beverages							
Net output	(1)	4.84	4.54	3.47	4.01	1.55	3.83
Inputs:							
Combined inputs	(2)	2.89	4.10	-4.17	-3.05	2.57	0.17
Capital/labor intensity	(3)	2.40	7.04	-0.28	-3.11	-0.50	1.19
Productivity:							
Multifactor productivity	(4)=(1)-(2)	1.95	0.45	7.64	7.06	-1.02	3.66
Labor productivity	(5)=(3)+(4)	4.36	7.48	7.36	3.95	-1.52	4.85
Miscellaneous foods							
Net output	(1)	6.34	4.66	1.50	5.93	0.55	3.98
Inputs:							
Combined inputs	(2)	2.51	3.29	-1.22	0.88	4.30	1.71
Capital/labor intensity	(3)	-3.23	4.09	-1.86	-1.27	2.44	-0.04
Productivity:							
Multifactor productivity	(4)=(1)-(2)	3.83	1.37	2.72	5.05	-3.75	2.26
Labor productivity	(5)=(3)+(4)	0.60	5.46	0.86	3.78	-1.32	2.23

Notes: Net output = real net value added; Combined inputs = weighted average of all inputs;
Capital/labor input = capital intensity or capital services per worker-hours.

Source: USDA/Economic Research Service.

preserved fruits and vegetables, there was a close correlation between the output and labor productivity indexes. For beverages and fats and oils, there was a close correlation between the output and multifactor productivity indexes.

The net-output productivity results are useful indicators for showing the contribution of food manufacturing to the Nation's GDP. This report concludes by assessing the effects of an increase in capital, labor (including production and nonproduction workers), or both by 10 percent on the rates of change in net value added and labor productivity. The upper part of table 11 presents the simulated results, showing the increases in net value added compared with the yearly average for 1995-97. These base values, for example, are $135 billion for the food sector and $19 billion for meat products. The simulated results indicate that an increase in capital input by 10 percent would increase the net value added of the food sector by $3.3 billion, mainly from capital-intensive industries: beverages ($681 million), grain mill products ($476 million), and preserved fruits and vegetables ($463 million). A 10-percent increase in labor would increase the net value added of the food sector by $995 million, with the meat industry contributing the most among industries ($227 million) because of its labor-intensive meat-packing operations. The increase of both capital and labor would increase the value added of the food sector by $4.3 billion, with beverages contributing the most among all industries ($808 million).

The lower part of table 11 presents the simulated results, showing the increases in labor productivity compared with the yearly average in 1995-97. The base value of the food sector was $58.34 for the net value added per production worker-hour. Beverages and grain mill products, heavily capital-intensive industries, ranked high in labor productivity ($167.1 and $109.73 per worker-hour, respectively). On the other hand, labor productivity of the labor-intensive meat products industry ranked the lowest among the food industries—only $24.61 per worker-hour. A 10-percent increase in capital input alone would increase the food manufacturing sector's capital intensity, and consequently its labor productivity, by $1.43 per worker-hour. Most of the increases in labor productivity were realized by capital-intensive industries: $4.47 per worker-hour for beverages and $2.99 per worker-hour for grain mill products. A 10-percent increase in labor input alone would reduce the entire food manufacturing sector's capital intensity and cause a decrease in labor productivity of $1.58 per worker-hour. Finally, an increase of both capital and employees would yield a small increase in labor productivity of the food sector (15 cents per worker-hour), because of the counter-effects of changes between capital and labor.

Table 11—Effects of increases in inputs on net value added and labor productivity

	Base value	Changes in value added as a 10-percent increase of: Capital	Labor	Both capital and labor
		Million $ at 1982 prices		
Food sector	135,166	3,299	995	4,294
Meat products	19,045	378	227	605
Dairy products	11,838	278	98	376
Preserved fruits & vegetables	18,503	463	125	588
Grain mill products	17,473	476	79	555
Bakery products	15,556	342	152	494
Sugar and confections	9,174	224	67	291
Fats and oils	3,267	84	20	104
Beverages	25,432	681	127	808
Miscellaneous foods	14,878	372	100	473
		Changes in net value added per worker-hour (dollars)		
Food sector	58.34	1.43	-1.58	0.15
Meat products	24.61	0.49	-0.55	0.07
Dairy products	65.99	1.55	-1.79	0.24
Preserved fruits & vegetables	53.29	1.33	-1.43	0.10
Grain mill products	109.73	2.99	-3.17	0.18
Bakery products	57.30	1.26	-1.51	0.25
Sugar and confections	63.22	1.55	-1.69	0.15
Fats and oils	82.19	2.12	-2.31	0.19
Beverages	167.14	4.47	-4.90	0.42
Miscellaneous foods	59.93	1.50	-1.66	0.16

Note: All values are measured at 1982 prices deflated by producer price of processed foods and feeds.
Base value = yearly ave rage value in 1995-97. Labor = production and nonproduction workers.

Source: USDA/Economic Research Service.

Concluding Remarks

This report uses gross-output and net-output approaches to measure multifactor and labor productivity indexes of the U.S. food manufacturing sector. The gross-output approach relates the adjusted value of shipments as a function of capital, labor, energy, and all intermediate materials, while the net-output approach relates the net value added as a function of labor and capital. This study finds a striking difference in the multifactor productivity indexes obtained through different approaches. The gross-output approach yields no significant changes in multifactor productivity over the sample period, while the net-output approach indicates a steady increase in the productivity index.

The cause for different multifactor productivity results may be explained below. The productivity index is calculated by subtracting the rates of change in the combined input index from the output index. In the gross-output model, materials are considered both as input and output of a production function. If the cost of materials constitutes a large portion of the value of shipments, the rate of change in the output index would be close to the combined input index, causing the measured multifactor productivity index to be small. In the net-output model, materials are not included in output or considered as input in a production function. The difference in the rates of change between the net value added and the combined capital and labor inputs—that is, the net-output multifactor productivity index—shows more degrees of freedom to vary than under the gross-output model.

In fact, the food manufacturing sector is materials-intensive, with material costs constituting about 60 percent or more of the value of gross output. The ratios for some food manufacturing industries, such as meat products and fats and oils, even reach 75 percent or higher. These two industries depend on either relatively expensive meats as raw materials for processing or heavy use of soybeans for crushing or semi-refined soybean oil for refining. Consequently, including or excluding materials as a component in a production function will substantially affect the results of measured productivity indexes. Basically, the economic meaning of the productivity measurements from the two approaches is different, and they represent different applications. There are certain advantages for applying either the gross-output or net-output approach to measure the productivity indexes of the U.S. food manufacturing sector.

Results obtained from the gross-output approach should be used for interpreting food manufacturing productivity trends. The gross-output approach measures the ability to produce higher gross output from the same level of all inputs because of technological change. Under this approach, the production function is a comprehensive representation of a production structure that includes the contribution of all factor inputs available from the data sources. Therefore, the measured gross-output productivity index may closely represent technology changes over time, while the potential change effects from unmeasured inputs can be avoided. On the other hand, a distinct drawback of applying the net-output approach is the assumption that materials inputs are separable from other inputs and cannot be the source of productivity growth. The Bureau of Labor Statistics (BLS) apparently supports using the gross-output results to explain productivity trends. Gullickson indicated that the BLS has not included net-output productivity indexes in its news release of productivity trends for all manufacturing industries since 1994.

Productivity indexes obtained from the net-output approach should be used for evaluating the contribution of food manufacturing to the growth of the Nation's GDP, mainly because the definition of net output is the same as for gross-product-originating (value-added) GDP. As a common practice to evaluate the Nation's GDP in any year, the level of GDP is frequently regarded as dependent on the input of labor measured in worker-hours multiplied by the labor productivity measure as real value added per worker-hour. Therefore, the net-output labor productivity index using the net value added as output in a production function may directly show the contribution of the food manufacturing industries to the Nation's GDP. In addition, net-output labor productivity, which depends solely on capital and labor inputs, can be easily interpreted as dependent on technological progress and the quantity of capital goods available to workers. This provides a framework for easy interpretation of the substitution relationships between capital and labor inputs. These advantages in application, however, are not available in the gross-output labor productivity measure.

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Appendix A: Data Compilations

The data used in this study were compiled mainly from the *Census of Manufactures* and the *Annual Survey of Manufactures* SIC code 20 (Food and Kindred Products) and its nine three-digit industries for 1975-97 published by the Census Bureau of the U.S. Department of Commerce. The Census Bureau conducts the economic census (including food manufacturing) every 5 years, covering years ending in 2 and 7, (e.g., 1992 and 1997). In addition, the Census Bureau conducts the Annual Survey of Manufactures (ASM) in each of the 4 years between the economic censuses. The ASM is a probability-based sample of approximately 58,000 establishments and collects many of the same industry statistics as the economic census including employment, payroll, value of shipments, etc. However, there are some selected statistics not included in the ASM. Among these are the number of companies and establishments, detailed product and materials data, and sub-State geographic data.

The data in the *1997 Census of Manufactures* were published for the first time on the basis of the North American Industry Classification System (NAICS), which is different from the Standard Industrial Classification System (SIC) used in previous censuses. For food manufacturing industries, there is substantial difference in product classification between the NAICS and the SIC systems. For example, dog and cat food and other animal foods are included in animal food (code 3111) in the NAICS, but they are included in grain mill products (code 204) in the SIC. In the NAICS, seafood product preparation and packaging (code 3117) is added as a product category, but is included in miscellaneous food (code 209) under the SIC system.

To construct consistent time-series data dating back to 1975, this study converts the 1997 data under the NAICS classification system into a framework along with the SIC classification system. The converting procedure follows the Census Bureau's classification codes published on the web site "1997 Economic Census: Bridge Between SIC and NAICS." A list of the comparability of product codes used for converting the NAICS data into SIC data is presented in Appendix table A. For example, in the meat products, SIC code 2011 (meatpacking plants) is nearly equivalent to NAICS code 311611 (animal, except poultry, slaughtering).

Appendix table A—Comparability of product codes between SIC and NAICS for food and kindred products

	SIC code		NAICS code *	
Meat products	**201**			
Fresh frozen meat	2011	Meatpacking plants	311611	Animal (except poultry) slaughtering (99.9%)
Sausage	2013	Sausages and other prepared meats	311612	Meat processed from carcasses (93%)
Poultry	2015	Poultry slaughtering and processing	311615	Poultry processing
			311999	All other miscellaneous food (21%)
Dairy products	**202**			
Creamery butter	2021	Creamery butter	311512	Creamery butter
Cheese	2022	Cheese, natural and processed	311513	Cheese
Dry condensed milk	2023	Dry, condensed and evaporated dairy products	311514	Dry, condensed and evaporated dairy products
Ice cream	2024	Ice cream and frozen desserts	311520	Ice cream and frozen dessert
Fluid milk	2026	Fluid milk	311511	Fluid milk
Preserved fruits and vegetables	**203**			
Canned specialty	2032	Canned specialties	311422	Speciality canning
			311999	All other miscellaneous food (2%)
Canned fruits and vegetables	2033	Canned fruits and vegetables	311421	Fruit and vegetable canning (91%)
Dried fruits and vegetables	2034	Dehydrated fruits, vegetables, and soups	311423	Dried and dehydrated food (94%)
Pickles	2035	Pickles, sauces, and salad dressings	311941	Pickles, sauces, and salad dressings (96%)
			311421	Fruit and vegetable canning (9%)
Frozen fruits and vegetables	2037	Frozen fruits and vegetables	311411	Frozen fruit, juice, and vegetable
Frozen specialties	2038	Frozen specialties	311412	Frozen specialty food
Grain mill products	**204**			
Flour and gain mill products	2041	Flour and other grain mill products	311211	Flour milling
Breakfast cereals	2043	Cereal breakfast foods	311230	Breakfast cereal
Rice	2044	Rice milling	311212	Rice milling
Prepared flour mixes	2045	Prepared flour mixes and doughs	311822	Flour mixes and dough from flour
Wet corn	2046	Wet corn milling	311221	Wet corn milling
Dog and cat food	2047	Dog and cat food	311111	Dog and cat food
Prepared feeds	2048	Prepared feeds	311119	Other animal food
			311611	Animal (except poultry) slaughtering (0.1%)
Bakery products	**205**			
Cookies and crackers	2052	Cookies and crackers	311821	Cookies and crackers
			311919	Potato chips and other snack food (6%)
			311812	Commercial bakeries (0.2%)
Frozen bakery	2053	Frozen bakery products, except bread	311813	Frozen cake, pie, and other pastry
Sugar and confections	**206**			
Raw cane sugar	2061	Raw cane sugar	311311	Sugarcane mills
Cane sugar	2062	Cane sugar refining	311312	Cane sugar refining
Beet sugar	2063	Beet sugar	311313	Beet sugar
Candy	2064	Candy and other confectionery products and chewing gum	3113302	Confectionery products from chocolate (commercial)
		Nonchocolate confectionery manufacturing	3113402	Nonchocolate confectionery (commercial)
Chocolate	2066	Chocolate and cocoa products	311320	Chocolate and confectionery from cacao beans
Nuts and peanuts	2068	Salted and roasted nuts and seeds	311911	Roasted nuts and peanut butter (80%)

Continued--

Appendix table A—Comparability of product codes between SIC and NAICS for food and kindred products--Continued

Fats and oils	**207**			
Soybean oil	2075	Soybean oil mills	311222	Soybean processing
			311225	Fats and oils refining and blending (12%)
Other oilseed	2076	Vegetable and cotton oil mills	311223	Other oilseed processing
			311225	Fats and oils refining and blending (2%)
Animal fats and oils	2077	Animal and marine fats and oils	311613	Rendering and meat byproduct processing
			311711	Seafood canning (1%)
Edible fats and oils	2079	Edible fats and oils	311225	Fats and oils refining and blending (86%)
Beverages	**208**			
Malt beverages	2082	Malt beverages	312120	Breweries
Malt	2083	Malt	311213	Malt
Wines	2084	Wines, brandy, and brandy spirits	312130	Wineries
Distillery	2085	Distilled and blended liquors	312140	Distilleries
Soft drink	2086	Soft drink	312111	Soft drink
	2086	Bottled water	312112	Bottled water
Flavoring syrups	2087	Flavoring syrup and concentrate	311930	Flavoring syrup and concentrate
			311942	Spice and extract (20%)
			311999	All other miscellaneous food (8%)
Miscellaneous foods	**209**			
Seafood canned	2091	Canned and cured fish and seafoods	311711	Seafood canning (99%)
Seafood fresh	2092	Fresh or frozen prepared fish	311712	Fresh and frozen seafood processing
Roasted coffee	2095	Roasted coffee	311920	Coffee and tea (90%)
Potato chips	2096	Potato chips and similar snacks	311919	Potato chips and other snack food (94%)
Manufactured ice	2097	Manufactured ice	312113	Manufactured ice
Macaroni and spaghetti	2098	Macaroni and spaghetti	311823	Dry pasta
Food preparation	2099	Food preparations	311830	Tortilla
			311942	Spice and extract (80%)
			311991	Perishable prepared food
			311999	All other miscellaneous food (69%)
			311423	Dried and dehydrated food (6%)
			311911	Roasted nuts and peanut butter (20%)
			311920	Coffee and tea (10%)
			311941	Mayonnaise, dressing & sauce (4%)

* The percent in parentheses indicates that the percentage of a NAICS code is allocated to a corresponding SIC code.

Source: U.S. Census Bureau. 1997 Economic Census: Bridge Between SIC and NAICS: Food and kindred products. (*http://www.Census.gov/epcd/ec97brdg*)

Appendix B: Estimated Capital Depreciation Equations

To measure depreciation charges for capital, data are available and reported only for 1977-85. Depreciation charges for the remaining period 1986-97 are projected on the basis of a log-linear regression by fitting the depreciation charges (D_t) at time t as a function of beginning-of-year structure and equipment assets (K_t) for 1977-85. That is,

$$\ln D_t = \alpha + \beta \ln K_t.$$

A complete listing of fitted depreciation equations for the food manufacturing sector and all individual food manufacturing industries is listed in the following table:

Appendix table B—Estimation results of capital depreciation equations

	Estimated constant	Estimated slope	R-square	D.W.
Food sector	-3.3203	1.0630	0.99	2.60
	(0.3156)	(0.0292)		
Meat products	-2.5058	1.0028	0.87	2.61
	(1.2503)	(0.1460)		
Dairy products	-2.9143	1.0412	2.61	1.68
	(0.7790)	(0.0927)		
Preserved fruits and vegetables	-3.2090	1.0591	0.98	1.86
	(0.4354)	(0.0497)		
Grain mill products	-3.8491	1.1222	0.94	1.70
	(0.9448)	(0.1076)		
Bakery products	-3.4243	1.1039	0.96	2.18
	(0.7369)	(0.0891)		
Sugar and confections	-2.8632	1.0051	0.96	1.92
	(0.6141)	(0.0737)		
Fats and oils	-4.0580	1.1716	0.99	3.16
	(0.3755)	(0.0473)		
Beverages	-3.7038	1.1149	0.99	1.84
	(0.4264)	(0.0457)		
Miscellaneous foods	-1.1906	0.8327	0.89	1.34
	(0.9152)	(0.1108)		

Notes: The depreciation equation is a log-linear form by fitting the depreciation charges as a function of the assets at the beginning-of-year. For each pair of estimates, the upper part is the estimated coefficient, and the lower part in parentheses is the standard error. D.W. = Durbin-Watson statistic.

Source: USDA/Economic Research Service.

Appendix C: Yearly Productivity Measures

For applying the methodology of measuring productivity to U.S. food manufacturing, two commonly used output indicators, the value of shipments and value added, are available in the *Census of Manufactures* and the *Annual Survey of Manufactures*. Therefore, two alternative approaches in specifying a production function for measuring multifactor and labor productivity indexes are applied in this study. One approach is specifying the "gross" output or real adjusted value of shipments as a function of capital, labor, and intermediate materials inputs. The results from the gross-output approach are presented in appendix tables C1 to C10. Another approach is specifying the "net" output or real net value-added as a function of capital and labor inputs. The results from the net-output approach are presented in appendix tables C11 to C20.

Each table contains the detailed results of yearly productivity indexes and related measures. The upper part of each table shows the calculated annual rates of changes in output, inputs, and multifactor and labor productivity indexes. The lower part of each table shows and the generated index values using 1975 as the base year. These index series showing the movements of the generated index numbers for output, multifactor, and labor productivity are the input information for use in the figures appearing in the text.

Appendix table C-1—Gross-output productivity of the food manufacturing sector

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
			Calculated annual change rate (percent)		
1976	7.49	3.30	1.78	4.19	5.97
1977	2.01	2.85	2.41	-0.83	1.58
1978	3.02	0.96	-1.17	2.06	0.89
1979	-0.70	-2.08	-3.01	1.39	-1.62
1980	0.24	4.40	5.48	-4.16	1.32
1981	2.74	5.17	7.03	-2.43	4.60
1982	2.06	4.01	7.94	-1.94	6.00
1983	0.31	-2.44	-0.31	2.75	2.44
1984	0.99	2.09	2.79	-1.10	1.68
1985	2.21	4.39	6.21	-2.18	4.03
1986	0.44	-1.60	-1.14	2.04	0.90
1987	4.45	2.94	-1.47	1.51	0.04
1988	2.21	-0.96	-3.06	3.18	0.12
1989	-0.89	-1.75	-2.60	0.86	-1.73
1990	1.83	2.38	-0.46	-0.54	-1.00
1991	0.73	3.36	2.62	-2.63	-0.02
1992	4.92	2.07	-2.02	2.85	0.83
1993	1.95	-2.04	-3.43	3.99	0.56
1994	0.78	3.62	2.64	-2.85	-0.21
1995	2.75	2.31	1.67	0.44	2.11
1996	-1.78	-4.08	-3.51	2.29	-1.21
1997	3.56	8.18	6.70	-4.63	2.07
			Generated index number (1975=100)		
1975	100.0	100.0	100.0	100.0	100.0
1976	107.5	103.3	101.8	104.2	106.0
1977	109.7	106.2	104.2	103.3	107.6
1978	113.0	107.3	103.0	105.5	108.6
1979	112.2	105.0	99.9	106.9	106.8
1980	112.5	109.7	105.4	102.5	108.2
1981	115.5	115.3	112.8	100.0	113.2
1982	117.9	119.9	121.8	98.0	120.0
1983	118.3	117.0	121.4	100.7	122.9
1984	119.5	119.5	124.8	99.6	125.0
1985	122.1	124.7	132.5	97.4	130.0
1986	122.6	122.7	131.0	99.4	131.2
1987	128.1	126.3	129.1	100.9	131.3
1988	130.9	125.1	125.1	104.1	131.4
1989	129.8	122.9	121.9	105.0	129.2
1990	132.1	125.8	121.3	104.5	127.9
1991	133.1	130.1	124.5	101.7	127.8
1992	139.7	132.8	122.0	104.6	128.9
1993	142.4	130.1	117.8	108.8	129.6
1994	143.5	134.8	120.9	105.7	129.4
1995	147.4	137.9	122.9	106.2	132.1
1996	144.8	132.2	118.6	108.6	130.5
1997	150.0	143.1	126.5	103.6	133.2

Appendix table C-2—Gross-output productivity of the meat products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
			Calculated annual change rate (percent)		
1976	6.75	4.10	2.17	2.65	4.82
1977	-3.17	0.22	0.86	-3.39	-2.53
1978	10.00	7.38	4.56	2.62	7.18
1979	0.68	-3.26	-4.00	3.95	-0.05
1980	-5.89	-1.58	-3.93	-4.30	-8.23
1981	1.35	4.67	6.88	-3.32	3.56
1982	1.45	5.42	5.53	-3.96	1.57
1983	-3.48	-4.41	-3.17	0.94	-2.23
1984	-0.31	-0.36	2.46	0.04	2.50
1985	-0.31	4.21	3.83	-4.52	-0.69
1986	1.32	3.04	-1.27	-1.72	-2.99
1987	8.37	8.87	-0.34	-0.50	-0.84
1988	1.02	-3.60	-9.08	4.62	-4.46
1989	-0.75	-1.68	-4.60	0.93	-3.67
1990	3.94	4.39	-0.72	-0.45	-1.17
1991	-1.67	5.08	2.67	-6.75	-4.09
1992	5.21	4.27	-1.47	0.94	-0.53
1993	3.97	1.00	-2.96	2.96	0.00
1994	-2.75	-0.76	-4.26	-2.00	-6.25
1995	1.84	0.64	1.78	1.20	2.98
1996	-3.72	-6.65	-7.51	2.93	-4.58
1997	7.99	10.16	5.01	-2.18	2.83
			Generated index number (1975=100)		
1975	100.0	100.0	100.0	100.0	100.0
1976	106.7	104.1	102.2	102.7	104.8
1977	103.4	104.3	103.0	99.2	102.2
1978	113.7	112.0	107.7	101.8	109.5
1979	114.5	108.4	103.4	105.8	109.4
1980	107.7	106.6	99.4	101.2	100.4
1981	109.2	111.6	106.2	97.9	104.0
1982	110.8	117.7	112.1	94.0	105.6
1983	106.9	112.5	108.5	94.9	103.3
1984	106.6	112.1	111.2	94.9	105.9
1985	106.3	116.8	115.4	90.6	105.1
1986	107.7	120.3	114.0	89.1	102.0
1987	116.7	131.0	113.6	88.6	101.1
1988	117.9	126.3	103.3	92.7	96.6
1989	117.0	124.2	98.5	93.6	93.1
1990	121.6	129.6	97.8	93.2	92.0
1991	119.6	136.2	100.4	86.9	88.2
1992	125.8	142.0	98.9	87.7	87.8
1993	130.8	143.5	96.0	90.3	87.8
1994	127.2	142.4	91.9	88.5	82.3
1995	129.5	143.3	93.6	89.5	84.7
1996	124.7	133.7	86.5	92.2	80.8
1997	134.7	147.3	90.9	90.2	83.1

Appendix table C-3—Gross-output productivity of the dairy products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	11.45	7.44	7.87	4.02	11.89
1977	-0.03	1.47	5.49	-1.50	3.99
1978	-1.42	-3.93	-4.50	2.51	-1.99
1979	-1.27	-5.78	-8.07	4.51	-3.56
1980	3.49	7.61	10.70	-4.12	6.58
1981	5.58	8.75	9.09	-3.16	5.93
1982	3.47	6.65	11.16	-3.18	7.98
1983	1.85	0.12	1.94	1.73	3.67
1984	-3.15	-2.26	-4.68	-0.89	-5.56
1985	3.71	8.47	9.07	-4.76	4.31
1986	0.58	-0.64	-1.00	1.22	0.22
1987	4.02	2.51	-1.58	1.51	-0.07
1988	0.09	-3.48	-8.24	3.57	-4.67
1989	-1.97	-1.33	2.01	-0.65	1.36
1990	2.62	3.62	3.73	-1.00	2.73
1991	-2.64	0.58	1.03	-3.21	-2.18
1992	8.40	4.39	-0.54	4.01	3.46
1993	-2.81	-4.73	-3.92	1.92	-2.00
1994	-0.80	4.15	8.16	-4.95	3.21
1995	2.63	4.30	2.16	-1.67	0.50
1996	-0.25	-5.32	-4.42	5.07	0.64
1997	-0.10	5.25	4.47	-5.35	-0.88
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	111.5	107.4	107.9	104.0	111.9
1977	111.4	109.0	113.8	102.5	116.4
1978	109.8	104.7	108.7	105.0	114.0
1979	108.4	98.7	99.9	109.8	110.0
1980	112.2	106.2	110.6	105.2	117.2
1981	118.5	115.5	120.6	101.9	124.2
1982	122.6	123.2	134.1	98.7	134.1
1983	124.9	123.3	136.7	100.4	139.0
1984	120.9	120.5	130.3	99.5	131.2
1985	125.4	130.7	142.1	94.8	136.9
1986	126.2	129.9	140.7	95.9	137.2
1987	131.2	133.1	138.5	97.4	137.1
1988	131.3	128.5	127.1	100.8	130.7
1989	128.8	126.8	129.6	100.2	132.5
1990	132.1	131.4	134.5	99.2	136.1
1991	128.6	132.2	135.8	96.0	133.1
1992	139.4	138.0	135.1	99.8	137.7
1993	135.5	131.4	129.8	101.8	135.0
1994	134.4	136.9	140.4	96.7	139.3
1995	138.0	142.8	143.4	95.1	140.0
1996	137.6	135.2	137.1	99.9	140.9
1997	137.5	142.3	143.2	94.6	139.7

Appendix table C-4—Gross-output productivity of the preserved fruits and vegetables industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	7.26	0.37	2.97	6.89	9.86
1977	10.16	9.39	2.85	0.77	3.61
1978	2.49	1.07	-1.80	1.42	-0.39
1979	-1.18	-0.41	-1.15	-0.77	-1.92
1980	-2.53	3.22	6.81	-5.74	1.06
1981	1.75	3.96	6.64	-2.21	4.43
1982	6.89	4.62	11.40	2.28	13.68
1983	2.20	-1.46	0.39	3.67	4.06
1984	6.03	6.02	3.09	0.01	3.10
1985	3.67	5.63	7.58	-1.96	5.62
1986	-0.18	-5.02	-3.24	4.85	1.60
1987	-0.85	-0.88	1.20	0.04	1.24
1988	1.80	0.16	-0.36	1.64	1.28
1989	5.01	2.05	-0.80	2.96	2.16
1990	2.81	4.22	1.11	-1.41	-0.30
1991	4.25	5.21	3.59	-0.96	2.63
1992	-1.42	-3.16	-2.26	1.74	-0.52
1993	2.53	-1.36	-0.44	3.88	3.44
1994	3.01	5.88	5.57	-2.87	2.70
1995	0.33	1.55	-0.35	-1.22	-1.57
1996	-3.37	-5.41	-3.14	2.05	-1.10
1997	0.19	0.54	3.80	-0.35	3.45
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	106.7	104.1	102.2	102.7	104.8
1977	103.4	104.3	103.0	99.2	102.2
1978	113.7	112.0	107.7	101.8	109.5
1979	114.5	108.4	103.4	105.8	109.4
1980	107.7	106.6	99.4	101.2	100.4
1981	109.2	111.6	106.2	97.9	104.0
1982	110.8	117.7	112.1	94.0	105.6
1983	106.9	112.5	108.5	94.9	103.3
1984	106.6	112.1	111.2	94.9	105.9
1985	106.3	116.8	115.4	90.6	105.1
1986	107.7	120.3	114.0	89.1	102.0
1987	116.7	131.0	113.6	88.6	101.1
1988	117.9	126.3	103.3	92.7	96.6
1989	117.0	124.2	98.5	93.6	93.1
1990	121.6	129.6	97.8	93.2	92.0
1991	119.6	136.2	100.4	86.9	88.2
1992	125.8	142.0	98.9	87.7	87.8
1993	130.8	143.5	96.0	90.3	87.8
1994	127.2	142.4	91.9	88.5	82.3
1995	129.5	143.3	93.6	89.5	84.7
1996	124.7	133.7	86.5	92.2	80.8
1997	134.7	147.3	90.9	90.2	83.1

Appendix table C-5—Gross-output productivity of the grain mill products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
			Calculated annual change rate (percent)		
1976	5.14	1.46	2.45	3.68	6.13
1977	0.86	2.09	4.95	-1.24	3.72
1978	-4.16	-4.18	-6.10	0.02	-6.07
1979	0.93	-1.43	-2.31	2.36	0.05
1980	3.96	6.71	8.55	-2.74	5.80
1981	5.70	8.60	11.33	-2.90	8.43
1982	-2.64	-0.20	6.14	-2.43	3.71
1983	3.87	-0.56	0.49	4.43	4.93
1984	0.00	2.93	8.10	-2.93	5.16
1985	0.75	1.14	5.05	-0.38	4.66
1986	-2.68	-5.74	-5.16	3.06	-2.10
1987	6.29	4.55	-2.96	1.74	-1.22
1988	6.69	3.82	1.55	2.87	4.42
1989	4.49	2.67	2.48	1.82	4.29
1990	0.18	0.39	0.06	-0.22	-0.15
1991	1.09	3.30	3.50	-2.21	1.29
1992	6.01	4.05	-1.84	1.96	0.13
1993	2.99	-2.78	-3.21	5.77	2.56
1994	2.26	4.91	6.35	-2.66	3.69
1995	4.75	3.21	0.97	1.54	2.51
1996	-3.02	2.47	5.46	-5.49	-0.03
1997	3.37	9.03	9.91	-5.65	4.26
			Generated index number (1975=100)		
1975	100.0	100.0	100.0	100.0	100.0
1976	105.1	101.5	102.5	103.7	106.1
1977	106.0	103.6	107.5	102.4	110.1
1978	101.6	99.3	101.0	102.4	103.4
1979	102.6	97.8	98.6	104.8	103.4
1980	106.6	104.4	107.1	102.0	109.4
1981	112.7	113.4	119.2	99.0	118.7
1982	109.7	113.1	126.5	96.6	123.1
1983	114.0	112.5	127.1	100.9	129.1
1984	114.0	115.8	137.4	97.9	135.8
1985	114.9	117.1	144.4	97.5	142.1
1986	111.8	110.4	136.9	100.5	139.1
1987	118.8	115.4	132.9	102.3	137.4
1988	126.8	119.8	134.9	105.2	143.5
1989	132.5	123.0	138.3	107.1	149.7
1990	132.7	123.5	138.3	106.9	149.4
1991	134.1	127.6	143.2	104.5	151.4
1992	142.2	132.8	140.6	106.6	151.6
1993	146.5	129.1	136.0	112.7	155.4
1994	149.8	135.4	144.7	109.7	161.2
1995	156.9	139.8	146.1	111.4	165.2
1996	152.1	143.2	154.1	105.3	165.2
1997	157.3	156.2	169.3	99.4	172.2

Appendix table C-6—Gross-output productivity of the bakery products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	6.74	-0.59	-4.45	7.33	2.88
1977	-4.41	-6.12	2.71	1.71	4.42
1978	-1.85	-0.01	-0.36	-1.83	-2.19
1979	0.67	-0.49	-5.26	1.16	-4.11
1980	0.53	5.93	5.08	-5.39	-0.31
1981	4.05	4.25	6.79	-0.20	6.60
1982	4.14	1.90	12.28	2.24	14.52
1983	0.31	-5.10	-1.60	5.40	3.81
1984	2.84	5.51	4.15	-2.67	1.48
1985	9.02	3.98	5.99	5.04	11.03
1986	0.49	-3.75	-1.56	4.24	2.68
1987	8.44	5.50	-3.93	2.94	-0.99
1988	-2.60	0.13	-0.63	-2.73	-3.36
1989	-0.98	-0.17	1.40	-0.81	0.59
1990	1.08	0.71	0.27	0.36	0.63
1991	1.37	2.19	0.63	-0.82	-0.19
1992	7.05	2.16	-2.69	4.89	2.21
1993	3.24	-1.13	-2.63	4.37	1.74
1994	4.01	5.56	2.29	-1.55	0.75
1995	1.24	2.25	1.28	-1.01	0.27
1996	-3.49	-4.60	-1.26	1.11	-0.15
1997	4.62	6.72	9.37	-2.10	7.27
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	106.7	99.4	95.6	107.3	102.9
1977	102.0	93.3	98.1	109.2	107.4
1978	100.1	93.3	97.8	107.2	105.1
1979	100.8	92.9	92.6	108.4	100.8
1980	101.3	98.4	97.4	102.6	100.4
1981	105.5	102.5	104.0	102.4	107.1
1982	109.8	104.5	116.7	104.6	122.6
1983	110.2	99.2	114.9	110.3	127.3
1984	113.3	104.6	119.6	107.4	129.2
1985	123.5	108.8	126.8	112.8	143.4
1986	124.1	104.7	124.8	117.5	147.3
1987	134.6	110.5	119.9	121.0	145.8
1988	131.1	110.6	119.2	117.7	140.9
1989	129.8	110.4	120.8	116.7	141.7
1990	131.2	111.2	121.2	117.2	142.6
1991	133.0	113.7	121.9	116.2	142.4
1992	142.4	116.1	118.6	121.9	145.5
1993	147.0	114.8	115.5	127.2	148.0
1994	152.9	121.2	118.2	125.3	149.1
1995	154.8	123.9	119.7	124.0	149.5
1996	149.4	118.2	118.2	125.4	149.3
1997	156.3	126.1	129.2	122.7	160.2

Appendix table C-7—Gross-output productivity of the sugar and confections industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	-6.18	-5.97	-13.40	-0.20	-13.60
1977	0.04	-2.46	-2.40	2.50	0.10
1978	-2.37	-4.79	-1.78	2.43	0.65
1979	-1.35	0.19	2.09	-1.54	0.54
1980	17.16	16.74	18.80	0.42	19.22
1981	-1.43	3.59	2.30	-5.02	-2.72
1982	-5.19	-4.99	-1.39	-0.20	-1.59
1983	2.66	-2.43	-1.42	5.09	3.66
1984	2.77	4.56	4.30	-1.79	2.50
1985	-0.48	0.26	5.07	-0.74	4.33
1986	1.28	-0.35	1.50	1.63	3.13
1987	5.59	1.05	0.41	4.54	4.95
1988	-1.22	-2.21	-1.92	0.98	-0.94
1989	-1.89	-2.68	-3.54	0.79	-2.75
1990	0.83	2.94	0.01	-2.11	-2.10
1991	4.14	3.49	5.09	0.64	5.73
1992	4.01	0.32	0.04	3.69	3.73
1993	1.55	-1.90	-3.83	3.45	-0.38
1994	-0.66	5.35	4.94	-6.00	-1.07
1995	2.36	0.77	0.84	1.58	2.42
1996	1.63	-3.38	-1.81	5.01	3.21
1997	3.85	7.70	8.03	-3.84	4.19
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	93.8	94.0	86.6	99.8	86.4
1977	93.9	91.7	84.5	102.3	86.5
1978	91.6	87.3	83.0	104.8	87.1
1979	90.4	87.5	84.8	103.2	87.5
1980	105.9	102.1	100.7	103.6	104.3
1981	104.4	105.8	103.0	98.4	101.5
1982	99.0	100.5	101.6	98.2	99.9
1983	101.6	98.1	100.1	103.2	103.5
1984	104.4	102.6	104.4	101.3	106.1
1985	103.9	102.8	109.7	100.6	110.7
1986	105.3	102.5	111.4	102.2	114.2
1987	111.2	103.5	111.8	106.9	119.9
1988	109.8	101.3	109.7	107.9	118.7
1989	107.7	98.5	105.8	108.8	115.5
1990	108.6	101.4	105.8	106.5	113.0
1991	113.1	105.0	111.2	107.2	119.5
1992	117.6	105.3	111.2	111.1	124.0
1993	119.5	103.3	107.0	115.0	123.5
1994	118.7	108.8	112.2	108.1	122.2
1995	121.5	109.7	113.2	109.8	125.2
1996	123.5	106.0	111.1	115.3	129.2
1997	128.2	114.1	120.1	110.8	134.6

Appendix table C-8—Gross-output productivity of the fats and oils industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	5.05	2.99	1.55	2.06	3.60
1977	5.15	4.78	2.42	0.37	2.79
1978	3.97	2.87	-3.17	1.10	-2.07
1979	0.05	-3.88	-3.14	3.92	0.78
1980	-5.65	-1.34	3.34	-4.31	-0.97
1981	-4.70	-3.58	1.49	-1.11	0.38
1982	-7.82	-0.51	5.35	-7.32	-1.96
1983	1.34	0.28	8.92	1.05	9.98
1984	7.74	7.77	11.22	-0.03	11.18
1985	-8.57	-2.24	6.92	-6.32	0.60
1986	-13.12	-11.86	-3.18	-1.26	-4.44
1987	-0.31	0.42	4.45	-0.73	3.72
1988	22.35	14.55	10.29	7.79	18.08
1989	-8.08	-13.18	-13.18	5.10	-8.08
1990	-5.73	-1.58	3.42	-4.15	-0.73
1991	-4.21	1.31	4.53	-5.52	-0.99
1992	-0.06	-0.08	-5.95	0.03	-5.93
1993	5.22	1.96	3.88	3.26	7.14
1994	2.10	3.68	4.65	-1.58	3.07
1995	2.79	4.14	5.37	-1.35	4.02
1996	3.07	-2.62	-1.88	5.69	3.81
1997	10.19	15.34	18.76	-5.15	13.61
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	105.0	103.0	101.5	102.1	103.6
1977	110.5	107.9	104.0	102.4	106.5
1978	114.8	111.0	100.7	103.6	104.3
1979	114.9	106.7	97.5	107.6	105.1
1980	108.4	105.3	100.8	103.0	104.1
1981	103.3	101.5	102.3	101.8	104.5
1982	95.2	101.0	107.8	94.4	102.4
1983	96.5	101.3	117.4	95.4	112.6
1984	104.0	109.1	130.6	95.4	125.2
1985	95.1	106.7	139.6	89.3	126.0
1986	82.6	94.0	135.1	88.2	120.4
1987	82.3	94.4	141.2	87.6	124.9
1988	100.7	108.2	155.7	94.4	147.5
1989	92.6	93.9	135.2	99.2	135.5
1990	87.3	92.4	139.8	95.1	134.5
1991	83.6	93.7	146.1	89.8	133.2
1992	83.6	93.6	137.4	89.8	125.3
1993	87.9	95.4	142.8	92.8	134.3
1994	89.8	98.9	149.4	91.3	138.4
1995	92.3	103.0	157.4	90.1	144.0
1996	95.1	100.3	154.5	95.2	149.4
1997	104.8	115.7	183.5	90.3	169.8

Appendix table C-9—Gross-output productivity of the beverages industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
			Calculated annual change rate (percent)		
1976	4.96	-0.07	1.56	5.04	6.60
1977	5.93	4.61	4.51	1.32	5.83
1978	5.80	4.34	1.72	1.47	3.19
1979	-0.84	0.36	-0.51	-1.20	-1.71
1980	3.97	8.74	11.43	-4.77	6.66
1981	5.98	7.84	11.32	-1.86	9.46
1982	6.49	6.92	9.68	-0.43	9.24
1983	1.26	-3.32	-1.13	4.58	3.45
1984	-1.09	1.88	5.45	-2.97	2.48
1985	7.11	7.14	8.20	-0.03	8.18
1986	3.09	-1.48	3.74	4.57	8.31
1987	0.75	-2.55	5.96	3.30	9.26
1988	1.47	-3.03	-1.13	4.50	3.36
1989	-3.81	-5.80	-3.06	2.00	-1.06
1990	0.44	0.55	1.50	-0.11	1.40
1991	4.69	2.46	3.01	2.23	5.24
1992	5.99	0.55	-1.43	5.44	4.02
1993	-0.87	-5.39	-8.84	4.53	-4.32
1994	3.26	4.60	8.19	-1.35	6.85
1995	4.81	2.89	2.35	1.92	4.27
1996	0.30	-3.85	-1.95	4.15	2.20
1997	1.35	9.02	-1.56	-7.67	-9.23
			Generated index number (1975=100)		
1975	100.0	100.0	100.0	100.0	100.0
1976	105.0	99.9	101.6	105.0	106.6
1977	111.2	104.5	106.1	106.4	112.8
1978	117.6	109.1	108.0	108.0	116.4
1979	116.7	109.5	107.4	106.7	114.4
1980	121.3	119.0	119.7	101.6	122.0
1981	128.5	128.4	133.2	99.7	133.6
1982	136.9	137.2	146.1	99.3	145.9
1983	138.6	132.7	144.5	103.8	151.0
1984	137.1	135.2	152.4	100.7	154.7
1985	146.8	144.8	164.9	100.7	167.4
1986	151.4	142.7	171.0	105.3	181.3
1987	152.5	139.0	181.2	108.8	198.0
1988	154.7	134.8	179.2	113.7	204.7
1989	148.9	127.0	173.7	116.0	202.5
1990	149.5	127.7	176.3	115.8	205.4
1991	156.5	130.9	181.6	118.4	216.1
1992	165.9	131.6	179.0	124.8	224.8
1993	164.5	124.5	163.2	130.5	215.1
1994	169.8	130.2	176.6	128.7	229.8
1995	178.0	134.0	180.7	131.2	239.6
1996	178.5	128.8	177.2	136.7	244.9
1997	180.9	140.4	174.4	126.2	222.3

Appendix table C-10—Gross-output productivity of the miscellaneous foods industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	25.00	16.14	8.44	8.86	17.30
1977	10.08	10.62	-1.03	-0.54	-1.57
1978	1.45	-2.95	-8.05	4.41	-3.65
1979	-6.07	-2.41	-0.93	-3.66	-4.59
1980	-0.14	4.33	6.17	-4.47	1.70
1981	2.51	2.41	1.42	0.10	1.52
1982	5.60	5.85	5.10	-0.25	4.85
1983	-2.75	-3.06	0.27	0.31	0.58
1984	1.80	1.92	2.50	-0.12	2.38
1985	2.59	4.88	7.89	-2.28	5.61
1986	6.14	2.10	4.28	4.04	8.32
1987	4.18	1.00	-7.73	3.18	-4.55
1988	-1.64	-3.93	-2.32	2.30	-0.03
1989	-4.69	-0.27	-1.55	-4.41	-5.97
1990	4.12	1.77	-4.75	2.35	-2.40
1991	0.72	4.17	5.95	-3.44	2.50
1992	5.85	1.96	-5.49	3.89	-1.60
1993	3.48	-3.52	-1.71	7.00	5.29
1994	0.88	5.27	4.89	-4.39	0.50
1995	3.65	2.74	0.07	0.91	0.98
1996	-2.19	-5.03	-8.74	2.84	-5.91
1997	0.42	11.15	11.94	-10.72	1.21
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	125.0	116.1	108.4	108.9	117.3
1977	137.6	128.5	107.3	108.3	115.5
1978	139.6	124.7	98.7	113.0	111.2
1979	131.1	121.7	97.8	108.9	106.1
1980	130.9	126.9	103.8	104.0	107.9
1981	134.2	130.0	105.3	104.1	109.6
1982	141.7	137.6	110.6	103.9	114.9
1983	137.8	133.4	110.9	104.2	115.6
1984	140.3	135.9	113.7	104.1	118.3
1985	144.0	142.6	122.7	101.7	124.9
1986	152.8	145.6	127.9	105.8	135.3
1987	159.2	147.0	118.0	109.2	129.2
1988	156.6	141.2	115.3	111.7	129.2
1989	149.2	140.9	113.5	106.8	121.4
1990	155.4	143.3	108.1	109.3	118.5
1991	156.5	149.3	114.5	105.5	121.5
1992	165.7	152.2	108.3	109.6	119.6
1993	171.4	146.9	106.4	117.3	125.9
1994	172.9	154.6	111.6	112.1	126.5
1995	179.3	158.9	111.7	113.2	127.8
1996	175.3	150.9	101.9	116.4	120.2
1997	176.1	167.7	114.1	103.9	121.7

Appendix table C-11—Net-output productivity of the food manufacturing sector

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	12.82	-1.39	-2.92	14.21	11.30
1977	1.40	-2.10	-2.54	3.50	0.96
1978	2.83	4.28	2.15	-1.45	0.70
1979	-0.08	3.80	2.87	-3.87	-1.00
1980	1.67	8.94	10.02	-7.27	2.75
1981	1.56	5.77	7.63	-4.21	3.42
1982	10.08	2.60	6.53	7.48	14.01
1983	3.09	-6.18	-4.05	9.27	5.22
1984	1.08	4.12	4.82	-3.05	1.77
1985	8.03	-1.78	0.04	9.82	9.85
1986	5.43	-8.09	-7.62	13.52	5.89
1987	6.32	2.29	-2.12	4.03	1.92
1988	1.72	1.91	-0.19	-0.19	-0.37
1989	-2.88	-2.73	-3.58	-0.14	-3.72
1990	3.93	1.28	-1.56	2.65	1.10
1991	2.71	-1.69	-2.43	4.40	1.96
1992	8.61	-0.85	-4.94	9.46	4.52
1993	2.69	-4.46	-5.86	7.16	1.30
1994	2.70	5.31	4.32	-2.61	1.71
1995	3.73	-0.16	-0.79	3.89	3.10
1996	-6.16	2.25	2.82	-8.41	-5.59
1997	7.41	5.64	4.15	1.77	5.92
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	112.8	98.6	97.1	114.2	111.3
1977	114.4	96.5	94.6	118.2	112.4
1978	117.6	100.7	96.6	116.5	113.1
1979	117.5	104.5	99.4	112.0	112.0
1980	119.5	113.8	109.4	103.8	115.1
1981	121.4	120.4	117.7	99.5	119.0
1982	133.6	123.5	125.4	106.9	135.7
1983	137.7	115.9	120.3	116.8	142.8
1984	139.2	120.7	126.1	113.3	145.3
1985	150.4	118.5	126.2	124.4	159.6
1986	158.6	108.9	116.6	141.2	169.0
1987	168.6	111.4	114.1	146.9	172.3
1988	171.5	113.5	113.9	146.6	171.6
1989	166.6	110.4	109.8	146.4	165.3
1990	173.1	111.9	108.1	150.3	167.1
1991	177.8	110.0	105.5	156.9	170.3
1992	193.1	109.0	100.3	171.7	178.0
1993	198.3	104.2	94.4	184.0	180.4
1994	203.7	109.7	98.5	179.2	183.5
1995	211.3	109.5	97.7	186.2	189.1
1996	198.3	112.0	100.4	170.6	178.6
1997	212.9	118.3	104.6	173.6	189.1

Appendix table C-12—Net-output productivity of the meat products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	6.65	-0.86	-2.79	7.51	4.73
1977	-4.93	-2.24	-1.60	-2.69	-4.29
1978	3.52	4.58	1.76	-1.06	0.70
1979	1.23	-0.27	-1.01	1.51	0.50
1980	-2.17	7.84	5.49	-10.01	-4.52
1981	-2.34	1.10	3.31	-3.44	-0.13
1982	8.24	5.26	5.37	2.99	8.36
1983	-1.75	-6.90	-5.66	5.15	-0.50
1984	3.93	-0.82	2.00	4.75	6.74
1985	12.20	-0.74	-1.12	12.93	11.82
1986	1.54	-4.22	-8.53	5.76	-2.77
1987	0.93	5.15	-4.06	-4.22	-8.28
1988	4.83	3.50	-1.98	1.33	-0.66
1989	2.50	-0.20	-3.12	2.70	-0.42
1990	8.90	4.23	-0.88	4.66	3.78
1991	-5.16	1.23	-1.19	-6.39	-7.58
1992	9.64	1.14	-4.60	8.50	3.90
1993	6.14	-1.89	-5.85	8.02	2.17
1994	7.18	5.62	2.12	1.56	3.68
1995	11.86	0.23	1.37	11.63	13.00
1996	-13.10	3.95	3.09	-17.04	-13.95
1997	25.00	7.10	1.95	17.89	19.84
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	106.7	99.1	97.2	107.5	104.7
1977	101.4	96.9	95.7	104.6	100.2
1978	105.0	101.4	97.3	103.5	100.9
1979	106.3	101.1	96.4	105.1	101.4
1980	104.0	109.0	101.6	94.6	96.9
1981	101.5	110.2	105.0	91.3	96.7
1982	109.9	116.0	110.7	94.0	104.8
1983	108.0	108.0	104.4	98.9	104.3
1984	112.2	107.1	106.5	103.6	111.3
1985	125.9	106.3	105.3	117.0	124.5
1986	127.8	101.8	96.3	123.7	121.0
1987	129.0	107.1	92.4	118.5	111.0
1988	135.2	110.8	90.6	120.0	110.3
1989	138.6	110.6	87.7	123.3	109.8
1990	151.0	115.3	87.0	129.0	114.0
1991	143.2	116.7	85.9	120.8	105.3
1992	157.0	118.0	82.0	131.1	109.4
1993	166.6	115.8	77.2	141.6	111.8
1994	178.6	122.3	78.8	143.8	115.9
1995	199.7	122.6	79.9	160.5	131.0
1996	173.6	127.4	82.4	133.2	112.7
1997	217.0	136.5	84.0	157.0	135.1

Appendix table C-13—Net-output productivity of the dairy products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	9.17	-4.94	-4.50	14.10	9.60
1977	2.61	-3.39	0.63	6.01	6.63
1978	-3.26	-1.93	-2.50	-1.33	-3.83
1979	5.65	0.20	-2.09	5.45	3.35
1980	1.02	6.93	10.02	-5.91	4.11
1981	0.78	7.21	7.55	-6.43	1.12
1982	3.56	0.36	4.87	3.20	8.08
1983	7.88	-2.72	-0.91	10.60	9.70
1984	-0.01	1.93	-0.49	-1.93	-2.42
1985	4.31	-1.32	-0.73	5.64	4.91
1986	11.55	-7.17	-7.53	18.72	11.19
1987	7.39	2.65	-1.44	4.74	3.30
1988	0.74	2.65	-2.11	-1.91	-4.02
1989	-5.34	-2.16	1.17	-3.18	-2.00
1990	1.77	1.71	1.82	0.06	1.88
1991	4.25	-2.19	-1.74	6.44	4.70
1992	16.10	-0.97	-5.90	17.07	11.16
1993	-3.23	-4.62	-3.81	1.39	-2.41
1994	-4.25	4.58	8.59	-8.83	-0.24
1995	-0.38	0.72	-1.41	-1.10	-2.52
1996	-4.39	1.94	2.84	-6.33	-3.50
1997	9.89	8.72	7.95	1.17	9.12
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	109.2	95.1	95.5	114.1	109.6
1977	112.0	91.8	96.1	121.0	116.9
1978	108.4	90.1	93.7	119.4	112.4
1979	114.5	90.2	91.7	125.9	116.2
1980	115.7	96.5	100.9	118.4	120.9
1981	116.5	103.4	108.5	110.8	122.3
1982	120.7	103.8	113.8	114.3	132.2
1983	130.2	101.0	112.8	126.5	145.0
1984	130.2	102.9	112.3	124.0	141.5
1985	135.8	101.6	111.4	131.0	148.4
1986	151.5	94.3	103.0	155.5	165.0
1987	162.7	96.8	101.6	162.9	170.5
1988	163.9	99.4	99.4	159.8	163.6
1989	155.2	97.2	100.6	154.7	160.3
1990	157.9	98.9	102.4	154.8	163.4
1991	164.6	96.7	100.6	164.8	171.0
1992	191.1	95.8	94.7	192.9	190.1
1993	184.9	91.3	91.1	195.6	185.5
1994	177.1	95.5	98.9	178.3	185.1
1995	176.4	96.2	97.5	176.4	180.4
1996	168.7	98.1	100.3	165.2	174.1
1997	185.4	106.6	108.3	167.1	190.0

Appendix table C-14—Net-output productivity of the preserved fruits and vegetables industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	15.86	-3.52	-0.92	19.38	18.45
1977	11.11	1.44	-5.11	9.67	4.57
1978	0.67	3.30	0.43	-2.63	-2.21
1979	-3.51	6.61	5.87	-10.13	-4.26
1980	-3.12	8.65	12.24	-11.77	0.48
1981	2.28	5.14	7.83	-2.86	4.97
1982	17.00	1.89	8.68	15.11	23.79
1983	3.68	-5.42	-3.57	9.10	5.53
1984	5.35	4.41	1.48	0.94	2.42
1985	6.47	-0.41	1.54	6.87	8.42
1986	7.33	-7.50	-5.72	14.83	9.11
1987	0.07	1.58	3.66	-1.51	2.15
1988	2.97	2.44	1.92	0.53	2.45
1989	4.56	-1.39	-4.24	5.95	1.71
1990	0.49	3.12	0.01	-2.63	-2.62
1991	6.82	0.20	-1.42	6.62	5.21
1992	2.98	-0.42	0.49	3.40	3.88
1993	2.48	-4.53	-3.62	7.01	3.39
1994	1.91	5.23	4.91	-3.31	1.60
1995	-2.15	-0.66	-2.56	-1.49	-4.04
1996	-3.40	0.90	3.17	-4.30	-1.13
1997	5.44	-3.19	0.07	8.63	8.70
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	115.9	96.5	99.1	119.4	118.5
1977	128.7	97.9	94.0	130.9	123.9
1978	129.6	101.1	94.4	127.5	121.1
1979	125.0	107.8	100.0	114.6	116.0
1980	121.1	117.1	112.2	101.1	116.5
1981	123.9	123.1	121.0	98.2	122.3
1982	145.0	125.5	131.5	113.0	151.4
1983	150.3	118.7	126.8	123.3	159.8
1984	158.3	123.9	128.7	124.5	163.7
1985	168.6	123.4	130.7	133.0	177.4
1986	180.9	114.1	123.2	152.8	193.6
1987	181.1	115.9	127.7	150.5	197.8
1988	186.4	118.8	130.1	151.3	202.6
1989	194.9	117.1	124.6	160.3	206.1
1990	195.9	120.8	124.6	156.0	200.7
1991	209.3	121.0	122.9	166.4	211.1
1992	215.5	120.5	123.5	172.0	219.3
1993	220.8	115.0	119.0	184.1	226.8
1994	225.1	121.0	124.8	178.0	230.4
1995	220.2	120.3	121.7	175.3	221.1
1996	212.7	121.3	125.5	167.8	218.6
1997	224.3	117.5	125.6	182.3	237.6

Appendix table C-15—Net-output productivity of the grain mill products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	11.74	-1.33	-0.33	13.07	12.73
1977	3.69	0.63	3.49	3.06	6.55
1978	-2.92	6.19	4.27	-9.11	-4.84
1979	4.60	1.35	0.47	3.25	3.72
1980	5.06	11.20	13.04	-6.14	6.90
1981	2.82	8.99	11.72	-6.17	5.55
1982	4.94	1.79	8.13	3.15	11.29
1983	7.62	-9.16	-8.11	16.78	8.67
1984	0.36	9.49	14.66	-9.14	5.52
1985	10.91	-1.42	2.49	12.33	14.83
1986	4.34	-10.56	-9.97	14.90	4.92
1987	10.98	4.33	-3.19	6.65	3.46
1988	3.13	4.02	1.74	-0.88	0.86
1989	0.91	-0.64	-0.83	1.55	0.71
1990	4.79	2.10	1.77	2.69	4.46
1991	3.06	-1.86	-1.66	4.92	3.26
1992	7.58	-0.07	-5.96	7.65	1.69
1993	5.41	-4.55	-4.98	9.96	4.98
1994	2.37	6.48	7.91	-4.11	3.80
1995	8.59	0.90	-1.33	7.69	6.36
1996	-25.64	3.22	6.21	-28.87	-22.65
1997	8.83	8.28	9.16	0.55	9.72
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	111.7	98.7	99.7	113.1	112.7
1977	115.9	99.3	103.1	116.5	120.1
1978	112.5	105.4	107.6	105.9	114.3
1979	117.7	106.9	108.1	109.3	118.6
1980	123.6	118.8	122.2	102.6	126.7
1981	127.1	129.5	136.5	96.3	133.8
1982	133.4	131.8	147.6	99.3	148.9
1983	143.5	119.8	135.6	116.0	161.8
1984	144.1	131.1	155.5	105.4	170.7
1985	159.8	129.3	159.4	118.4	196.0
1986	166.7	115.6	143.5	136.1	205.7
1987	185.0	120.6	138.9	145.1	212.8
1988	190.8	125.5	141.3	143.8	214.6
1989	192.5	124.7	140.1	146.0	216.2
1990	201.8	127.3	142.6	150.0	225.8
1991	207.9	124.9	140.2	157.3	233.1
1992	223.7	124.8	131.9	169.4	237.1
1993	235.8	119.2	125.3	186.3	248.9
1994	241.4	126.9	135.2	178.6	258.4
1995	262.1	128.0	133.4	192.3	274.8
1996	194.9	132.1	141.7	136.8	212.5
1997	212.1	143.1	154.7	137.6	233.2

Appendix table C-16—Net-output productivity of the bakery products industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	13.17	-0.89	-4.75	14.06	9.31
1977	-2.30	-7.30	1.54	4.99	6.53
1978	-1.64	3.45	3.10	-5.10	-1.99
1979	0.52	1.79	-2.98	-1.27	-4.25
1980	-0.18	7.43	6.59	-7.61	-1.02
1981	4.59	3.13	5.67	1.46	7.13
1982	7.68	0.74	11.12	6.95	18.07
1983	1.67	-8.26	-4.76	9.93	5.17
1984	3.20	7.11	5.74	-3.91	1.84
1985	11.49	-1.34	0.67	12.83	13.50
1986	2.55	-6.81	-4.63	9.36	4.73
1987	10.06	4.70	-4.73	5.36	0.63
1988	-4.59	2.84	2.08	-7.43	-5.35
1989	-4.96	-2.85	-1.29	-2.11	-3.40
1990	1.55	0.13	-0.31	1.42	1.10
1991	2.64	-0.20	-1.76	2.84	1.07
1992	8.82	0.10	-4.74	8.72	3.98
1993	2.78	-3.41	-4.91	6.19	1.28
1994	4.98	5.92	2.66	-0.94	1.72
1995	0.08	0.51	-0.46	-0.42	-0.89
1996	-2.63	1.63	4.98	-4.26	0.71
1997	6.17	4.32	6.97	1.85	8.82
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	113.2	99.1	95.2	114.1	109.3
1977	110.6	91.9	96.7	119.8	116.4
1978	108.7	95.0	99.7	113.7	114.1
1979	109.3	96.8	96.7	112.2	109.3
1980	109.1	103.9	103.1	103.7	108.2
1981	114.1	107.2	109.0	105.2	115.9
1982	122.9	108.0	121.1	112.5	136.8
1983	124.9	99.1	115.3	123.7	143.9
1984	128.9	106.1	121.9	118.8	146.5
1985	143.8	104.7	122.8	134.1	166.3
1986	147.4	97.5	117.1	146.6	174.2
1987	162.2	102.1	111.5	154.5	175.3
1988	154.8	105.0	113.9	143.0	165.9
1989	147.1	102.0	112.4	140.0	160.3
1990	149.4	102.2	112.0	142.0	162.0
1991	153.3	102.0	110.1	146.0	163.8
1992	166.9	102.1	104.8	158.7	170.3
1993	171.5	98.6	99.7	168.6	172.5
1994	180.0	104.4	102.3	167.0	175.4
1995	180.2	104.9	101.9	166.3	173.9
1996	175.4	106.7	106.9	159.2	175.1
1997	186.3	111.3	114.4	162.1	190.5

Appendix table C-17—Net-output productivity of the sugar and confections industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
			Calculated annual change rate (percent)		
1976	10.76	0.42	-7.01	10.34	3.34
1977	5.78	-2.09	-2.02	7.86	5.84
1978	-1.54	-0.84	2.17	-0.69	1.48
1979	-4.58	4.28	6.17	-8.86	-2.69
1980	19.86	8.74	10.80	11.12	21.92
1981	-12.22	5.80	4.51	-18.02	-13.51
1982	13.24	-0.54	3.06	13.78	16.84
1983	2.44	-5.10	-4.09	7.54	3.44
1984	1.11	4.06	3.79	-2.95	0.84
1985	7.21	-4.14	0.67	11.35	12.02
1986	3.71	-8.69	-6.84	12.40	5.56
1987	4.48	1.52	0.87	2.96	3.84
1988	0.83	1.01	1.30	-0.18	1.12
1989	-1.97	-2.82	-3.67	0.85	-2.82
1990	1.66	2.43	-0.50	-0.77	-1.27
1991	6.03	-2.29	-0.69	8.32	7.63
1992	8.22	-0.42	-0.70	8.64	7.94
1993	0.12	-3.45	-5.38	3.57	-1.81
1994	-0.77	6.26	5.85	-7.04	-1.18
1995	1.89	-0.55	-0.48	2.44	1.96
1996	2.99	1.37	2.95	1.62	4.57
1997	5.85	1.27	1.60	4.59	6.19
			Generated index number (1975=100)		
1975	100.0	100.0	100.0	100.0	100.0
1976	110.8	100.4	93.0	110.3	103.3
1977	117.2	98.3	91.1	119.0	109.4
1978	115.4	97.5	93.1	118.2	111.0
1979	110.1	101.7	98.8	107.7	108.0
1980	131.9	110.5	109.5	119.7	131.7
1981	115.8	117.0	114.4	98.1	113.9
1982	131.2	116.3	117.9	111.7	133.1
1983	134.4	110.4	113.1	120.1	137.7
1984	135.8	114.9	117.4	116.5	138.8
1985	145.6	110.1	118.2	129.8	155.5
1986	151.1	100.6	110.1	145.9	164.1
1987	157.8	102.1	111.1	150.2	170.4
1988	159.1	103.1	112.5	149.9	172.4
1989	156.0	100.2	108.4	151.2	167.5
1990	158.6	102.7	107.8	150.0	165.4
1991	168.2	100.3	107.1	162.5	178.0
1992	182.0	99.9	106.3	176.5	192.1
1993	182.2	96.4	100.6	182.8	188.6
1994	180.8	102.5	106.5	170.0	186.4
1995	184.2	101.9	106.0	174.1	190.0
1996	189.7	103.3	109.1	176.9	198.7
1997	200.8	104.6	110.9	185.1	211.0

Appendix table C-18—Net-output productivity of the fats and oils industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	24.39	-0.38	-1.82	24.77	22.94
1977	-33.32	-1.52	-3.88	-31.79	-35.68
1978	33.69	8.67	2.64	25.02	27.66
1979	14.32	3.51	4.24	10.82	15.06
1980	-11.19	8.20	12.88	-19.40	-6.51
1981	-18.90	7.87	12.95	-26.77	-13.83
1982	11.18	1.30	7.15	9.88	17.04
1983	10.98	-9.47	-0.83	20.45	19.62
1984	-22.78	5.06	8.50	-27.83	-19.34
1985	-0.30	-7.07	2.09	6.76	8.86
1986	4.12	-10.85	-2.17	14.97	12.81
1987	20.34	-3.17	0.86	23.50	24.37
1988	14.15	0.90	-3.36	13.24	9.88
1989	-23.30	-4.75	-4.75	-18.55	-23.30
1990	17.56	-1.93	3.06	19.50	22.56
1991	-10.54	-4.08	-0.85	-6.47	-7.32
1992	-0.74	-3.44	-9.31	2.70	-6.61
1993	7.71	-7.20	-5.28	14.91	9.63
1994	0.67	3.21	4.19	-2.54	1.64
1995	5.01	-2.43	-1.20	7.43	6.24
1996	-11.61	0.78	1.52	-12.39	-10.86
1997	10.34	6.33	9.75	4.01	13.76
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	124.4	99.6	98.2	124.8	122.9
1977	82.9	98.1	94.4	85.1	79.1
1978	110.9	106.6	96.9	106.4	101.0
1979	126.8	110.4	101.0	117.9	116.2
1980	112.6	119.4	114.0	95.0	108.6
1981	91.3	128.8	128.7	69.6	93.6
1982	101.5	130.5	137.9	76.5	109.5
1983	112.7	118.1	136.8	92.1	131.0
1984	87.0	124.1	148.4	66.5	105.7
1985	86.7	115.3	151.5	71.0	115.0
1986	90.3	102.8	148.3	81.6	129.8
1987	108.7	99.6	149.5	100.8	161.4
1988	124.1	100.5	144.5	114.1	177.3
1989	95.2	95.7	137.6	92.9	136.0
1990	111.9	93.8	141.9	111.1	166.7
1991	100.1	90.0	140.6	103.9	154.5
1992	99.3	86.9	127.6	106.7	144.3
1993	107.0	80.7	120.8	122.6	158.2
1994	107.7	83.3	125.9	119.5	160.8
1995	113.1	81.2	124.4	128.3	170.8
1996	100.0	81.9	126.3	112.4	152.3
1997	110.3	87.0	138.6	116.9	173.2

Appendix table C-19—Net-output productivity of the beverages industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	8.92	-0.01	1.62	8.94	10.56
1977	7.08	-1.65	-1.75	8.74	6.98
1978	6.75	6.93	4.31	-0.18	4.13
1979	-3.38	6.30	5.42	-9.67	-4.25
1980	2.77	10.78	13.47	-8.01	5.46
1981	5.68	6.70	10.19	-1.03	9.16
1982	12.62	4.82	7.58	7.80	15.38
1983	3.90	-5.42	-3.23	9.32	6.09
1984	-2.26	3.60	7.17	-5.86	1.31
1985	8.53	-1.98	-0.91	10.51	9.60
1986	5.72	-9.82	-4.60	15.54	10.94
1987	3.22	-2.09	6.42	5.31	11.73
1988	3.21	-0.76	1.13	3.97	5.11
1989	-3.34	-6.20	-3.45	2.86	-0.60
1990	0.16	-2.74	-1.79	2.90	1.11
1991	6.74	-4.96	-4.41	11.70	7.29
1992	9.71	-3.96	-5.94	13.67	7.73
1993	-1.87	-6.74	-10.20	4.87	-5.33
1994	5.33	3.18	6.77	2.15	8.92
1995	3.64	-1.09	-1.63	4.73	3.10
1996	0.93	1.64	3.54	-0.71	2.83
1997	0.08	7.16	-3.42	-7.07	-10.50
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	108.9	100.0	101.6	108.9	110.6
1977	116.6	98.3	99.8	118.5	118.3
1978	124.5	105.1	104.1	118.2	123.2
1979	120.3	111.8	109.8	106.8	117.9
1980	123.6	123.8	124.6	98.2	124.4
1981	130.7	132.1	137.3	97.2	135.8
1982	147.2	138.5	147.7	104.8	156.7
1983	152.9	131.0	142.9	114.6	166.2
1984	149.4	135.7	153.2	107.9	168.4
1985	162.2	133.0	151.8	119.2	184.5
1986	171.5	120.0	144.8	137.8	204.7
1987	177.0	117.4	154.1	145.1	228.7
1988	182.7	116.5	155.8	150.8	240.4
1989	176.6	109.3	150.4	155.1	239.0
1990	176.8	106.3	147.7	159.6	241.6
1991	188.8	101.0	141.2	178.3	259.2
1992	207.1	97.0	132.8	202.7	279.3
1993	203.2	90.5	119.3	212.6	264.4
1994	214.1	93.4	127.4	217.2	288.0
1995	221.9	92.4	125.3	227.4	297.0
1996	223.9	93.9	129.7	225.8	305.4
1997	224.1	100.6	125.3	209.8	273.3

Appendix table C-20—Net-output productivity of the miscellaneous foods industry

Year	Output	Inputs		Productivity	
		Combined	Nonlabor/labor	Multifactor	Labor
	(1)	(2)	(3)	(4)=(1)-(2)	(5)=(3)+(4)
		Calculated annual change rate (percent)			
1976	25.42	-1.24	-8.93	26.66	17.72
1977	-3.81	-6.43	-18.08	2.62	-15.46
1978	8.70	5.73	0.63	2.97	3.60
1979	-4.95	11.97	13.45	-16.92	-3.47
1980	1.78	8.03	9.87	-6.25	3.62
1981	10.01	7.69	6.69	2.32	9.01
1982	10.51	1.19	0.44	9.32	9.76
1983	-3.22	-3.96	-0.63	0.74	0.11
1984	4.24	3.50	4.08	0.75	4.83
1985	3.29	-1.33	1.68	4.62	6.30
1986	7.25	-7.60	-5.42	14.85	9.43
1987	12.53	4.80	-3.93	7.73	3.81
1988	-2.00	1.50	3.11	-3.49	-0.39
1989	-13.57	-3.48	-4.76	-10.09	-14.85
1990	10.95	2.58	-3.93	8.37	4.44
1991	-1.45	-1.56	0.22	0.11	0.33
1992	10.16	0.76	-6.68	9.40	2.72
1993	9.26	-4.12	-2.31	13.38	11.07
1994	0.74	6.75	6.37	-6.01	0.36
1995	3.12	0.04	-2.63	3.08	0.45
1996	0.37	2.91	-0.81	-2.54	-3.35
1997	-1.84	9.96	10.75	-11.79	-1.05
		Generated index number (1975=100)			
1975	100.0	100.0	100.0	100.0	100.0
1976	125.4	98.8	91.1	126.7	117.7
1977	120.6	92.4	74.6	130.0	99.5
1978	131.1	97.7	75.1	133.8	103.1
1979	124.6	109.4	85.2	111.2	99.5
1980	126.9	118.2	93.6	104.2	103.1
1981	139.6	127.3	99.8	106.7	112.4
1982	154.2	128.8	100.3	116.6	123.4
1983	149.3	123.7	99.6	117.5	123.5
1984	155.6	128.0	103.7	118.3	129.5
1985	160.7	126.3	105.5	123.8	137.7
1986	172.4	116.7	99.7	142.2	150.6
1987	194.0	122.3	95.8	153.2	156.4
1988	190.1	124.1	98.8	147.8	155.8
1989	164.3	119.8	94.1	132.9	132.6
1990	182.3	122.9	90.4	144.0	138.5
1991	179.6	121.0	90.6	144.2	139.0
1992	197.9	121.9	84.5	157.7	142.7
1993	216.2	116.9	82.6	178.9	158.5
1994	217.8	124.8	87.8	168.1	159.1
1995	224.6	124.8	85.5	173.3	159.8
1996	225.4	128.5	84.8	168.9	154.5
1997	221.3	141.3	94.0	149.0	152.9