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
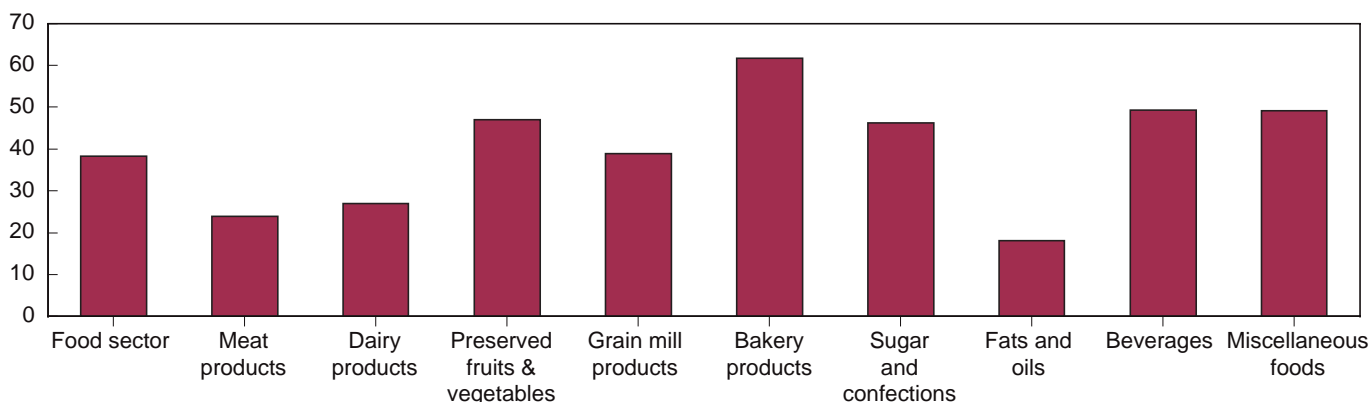
Percent

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
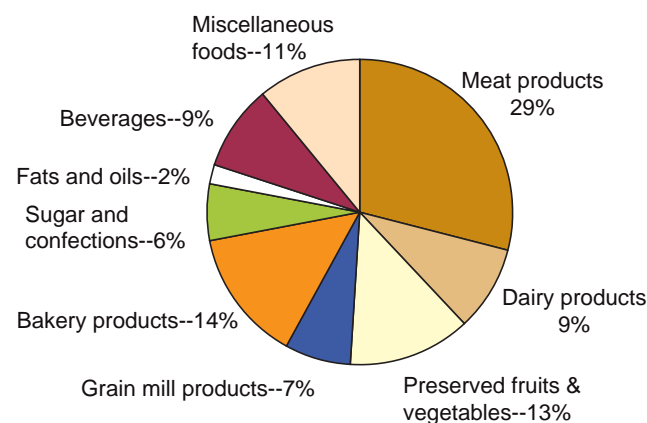
Source: USDA/Economic Research Service.

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:

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

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 pur-

chased 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
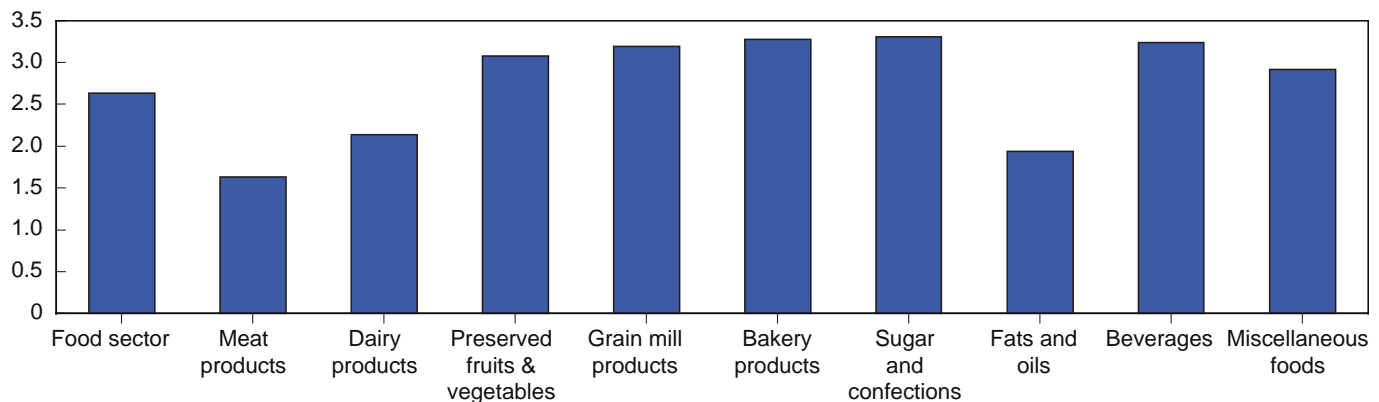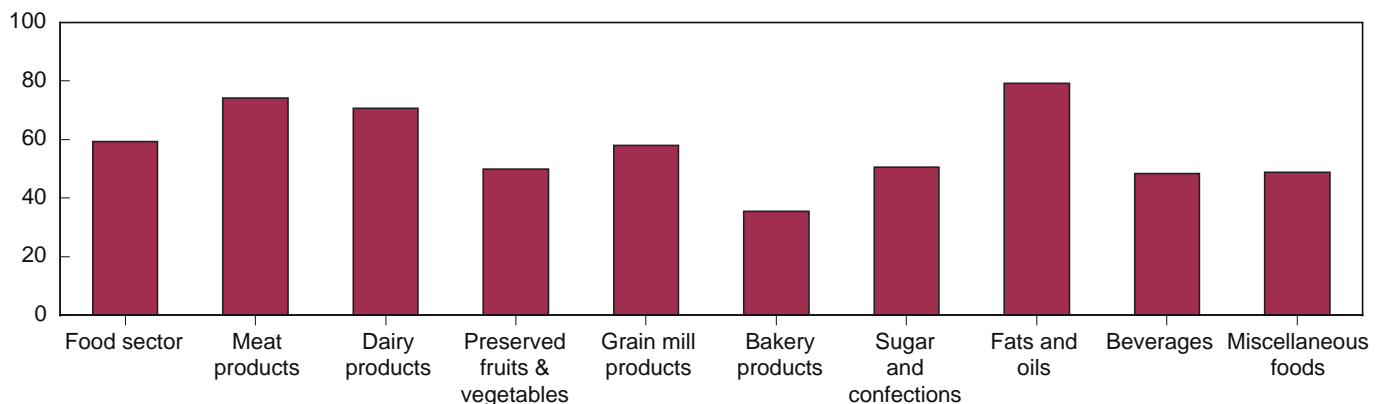
Percent

Source: USDA/Economic Research Service.

Figure 4
Ratio of material cost to gross output, 1995-97 average

Percent

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.