Measuring Food Manufacturing Productivity: Gross- or Net-Output Approach?

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Abstract

The measured multifactor productivity index of the value of shipments shows a trend of declining and then moving up and down along the level of the base year 1975. The influence of technological changes to the output growth is rather limited. The measured labor productivity index of the value-added exhibits a trend of steady increase over years. The contribution of the food-manufacturing sector to the growth of GDP increased during 1975-97.

Keywords:

Food manufacturing, multifactor productivity, and labor productivity.

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Most agricultural productivity studies in the United States have focused on providing information about productivity changes and the relationship between inputs and outputs at farm levels. Considerably less attention has been devoted to research on productivity beyond the farm gate such as food manufacturing. Only a few studies, for example, Ball and Chambers (1982), Heien (1983), and McGuckin and Nguyen (1995) are concerned about the productivity of the U.S. food-manufacturing industries. In fact, the food-manufacturing industries in recent years have undergone substantial structural changes because of a high profile of mergers and acquisitions and a trend in substituting computers and automated machines for human operations. To better understand the effects of this evolution on the performance of the industries, it is important to evaluate their competitive strength by measuring their productivity.

In productivity studies, the gross-output approach by using the real value of sales as output in a production function was popularly used. Few studies, however, have addressed the issue of potential difference in productivity measurements from the gross-output approach as compared with the net-output approach by using the real value-added as output in a production function. The use of value-added in measuring productivity is important to avoid multiple counting of market value and provide a linkage of an industry's contribution to the gross domestic product (GDP). In addition to the multifactor productivity index, it would be useful to measure the labor productivity index, an important indicator commonly used to evaluate the effects of change in employment on the GDP.

This study measures the inter-temporal changes of multifactor and labor productivity indexes of the U.S. food-manufacturing industries in 1975-97 and identifies the specific determinants of the changes. Two alternative approaches for specifying a production function by taking either the value of shipments or the value-added as output are implemented, and the results of measured multifactor and labor productivity indexes are compared.

Methodology of Measuring Productivity

Following is a brief explanation about the methodology of measuring the multifactor and labor productivity indexes, and the way to modify the model for application to the U.S. food-manufacturing sector.

Derivation of multifactor and labor productivity measures

In productivity studies, the multifactor productivity is widely applied by taking account of various inputs into the 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

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

where variables are Q_t (real output), X_{it} (input of *i*th factor), 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

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

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 *i*th input, showing the percentage change in output per one-percent change in *i*th input.

In addition, under the assumption that a competitive economy is operating at long-run 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 *i*th 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 *i*th input) to represent $W_{it} X_{it} / P_t Q_t$, the multifactor productivity index can be shown as

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

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 with $\sum_i S_{it} = 1$.

Furthermore, the productivity index of *j*th input can be shown as

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

In particular, if the *j*th input is regarded as labor, then this equation represents the labor productivity equation. 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 required 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 *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

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

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 (1983).

Similarly, the Törnqvist index approximation to the *j*th input productivity of equation (4) becomes

(6) $ln(Q_t/Q_{t-1}) - ln(X_{jt}/X_{jt-1}) =$

$$ln(A_t/A_{t-1}) + \sum_{i,\, i\neq j} 1/2(S_{it} + S_{it-1})\, [\, ln(X_{it}/X_{it-1}) - ln(X_{jt}/X_{jt-1})]$$

Again, if the *j*th input is regarded as labor, then this equation represents the labor productivity equation. 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.

Empirical modeling

In applying the methodology of measuring productivity to the U.S. food-manufacturing sector, two commonly used output indicators, the value of shipments and the 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 can be applied.

One is the gross-output approach such that “gross” output or the real value of shipments is a function of capital, labor and all intermediate materials inputs as follows:

(7) $Q_t = A_t\, f(X_{1t}, X_{2t}, \ldots, X_{5t})$

where Q_t = the real value of shipments at 1982 prices,

X_{1t} = production worker-hours,

X_{2t} = charges of capital services at 1982 prices,

X_{3t} = purchased fuels and electricity energy at 1982 prices,

X_{4t} = cost of materials at 1982 prices,

X_{5t} = number of non-production workers, and

A_t = index of multifactor productivity for the value of shipments.

This gross-output production function is a comprehensive representation of a production structure by including the contribution of all factor inputs available in the data sources.

Another is the net-output approach such that "net" output or the real value-added is a function of labor and capital inputs. The value-added in the *Census of Manufactures* is obtained by subtracting the cost of materials including fuels and electricity from the value of shipments. Since capital and labor are the relevant inputs in generating the value-added of an industry, a production function for the real value-added is specified as follows: :

(8) $Q_t^* = A_t^* f(L_t, K_t)$

where Q_t^* = the real value-added at 1982 prices,

L_t = production worker-hours,

K_t = charges of capital services at 1982 prices, and

A_t^* = index of multifactor productivity for the value-added.

Although the value-added in the census data is slightly different from the GDP originating because of including the purchased services, it is a close indicator showing an industry's contribution to the GDP.

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. These two approaches, however, may produce substantially different measures of the multifactor and labor productivity indexes. Basically, the economic meaning of the productivity measurements from the two approaches is different. For the multifactor productivity index, the gross-output approach measures the ability to produce more of the value of shipments from the same level of all inputs including materials, while the net-output approach measures the ability to produce more of the value-added from the same level of capital and labor. For the labor productivity index, the gross-output approach measures the value of shipments per unit of labor, while the net-output approach measures the value-added per unit of labor. Therefore, the productivity results obtained from these alternative approaches represent different economic indicators and applications.

In addition, the components included in the calculation of productivity indexes are different under these two approaches. Taking the measurement of multifactor productivity as an example, based on equation (5), the productivity index $ln(A_t/A_{t-1})$ is calculated by subtracting the weighted average of the rates of change in the concerned inputs $ln(X_{it}/X_{it-1})$ from the rate of change in output $ln(Q_t/Q_{t-1})$. By applying the gross-output approach, 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 rate of change in the combined input index causing the measured multifactor productivity index to be small. On the other hand, by applying the net-output approach, materials are not included in output or considered as input in a production function. The difference in the rates of change between the value-added and the combined capital and labor inputs, that is the net-output multifactor productivity index, would have more degrees of freedom to vary than otherwise under the gross-output approach.

Most food-manufacturing industries are characterized by materials intensive. The ratio of materials cost to the value of shipments in the U.S. food-manufacturing sector is more than 60 percent. The ratios for some food-manufacturing industries like meat products and fats-and-oils even reach 80 percent. Consequently, including or not materials as a component in a production function will affect substantially the results of measured productivity indexes. Given the potential difference in productivity results, which approach provides a better measurement of the productivity index for practical application? This issue will be discussed in the following section.

Empirical Results

A presentation of the empirical measurements of multifactor and labor productivity indexes for the U.S. food-manufacturing sector follows. The data used in this study was compiled from the Bureau of the Census in its *Census of Manufactures* and the *Annual Survey of Manufactures* SIC code 20 (Food and Kindred Products) and from the Bureau of Labor Statistics (BLS) for the producer price index of food and beverages. The data cover 1975-97, while the *1997 Census of Manufactures* was published for the first time based on the North American Industry Classification System (NAICS). This system is different from the Standard Industrial Classification System (SIC) used in previous censuses. To construct consistent time series data, this study compiles the 1997 data into a framework along with the SIC classification system.

Table 1 presents the productivity results including the multifactor and labor productivity indexes obtained from both the gross-output and net-output approaches. The upper part of the table shows the calculated annual rates of change, and the lower part shows the generated index numbers by taking 1975 as the base year. These index series are further used in figures 1 and 2.

For easy interpretation, the information contained in table 1 is rearranged into table 2 by dividing the whole sample period into five sub-periods with a 5-year interval for most periods and showing the average annual rates of change in productivity and related input measures for each period. The upper part of table 2 shows the results obtained from the gross-output approach, and the lower part shows the results obtained from the net-output approach. The items included in either part of the table show that the annual rate of change in multifactor productivity (3) is obtained by subtracting the combined input index (2) from the output index (1). The annual rate of change in labor productivity (6) is a summation of multifactor productivity (5) and the non-labor intensity per unit of labor (4).

Results from the gross-output approach

In selecting representative multifactor productivity measure, the productivity index obtained from the gross-output approach could be a better choice than that obtained from the net-output approach, because the production function for the value of shipments includes as many factor inputs as possible. The measured gross-output multifactor productivity index may closely represent changes through time in technology, and the potential change effects from unmeasured inputs can be avoided. On the other hand, a distinct drawback of applying the net-output approach is its assumption that materials inputs are separable from other inputs and cannot be the source of productivity growth. The BLS apparently supports using the gross-output approach to measure multifactor productivity. Gullickson (1995) indicated that the BLS has stopped showing the net-output multifactor productivity indexes in its news release of productivity trends for all manufacturing industries since 1994.

The productivity measurements obtained from the gross-output approach are contained in the upper part of table 2. In the table, the average annual rates of change in the value of shipments were positive, ranging from 1.3 to 3 percent throughout the periods. The major force of the growth of output was accounted for by the expansion of the combined factor inputs including capital, labor and all intermediate materials inputs with growth rates ranging from 1.2 to 2.6 percent per year. The effect of the multifactor productivity on the growth of output was not significant. The rates of change in multifactor productivity were a gain of 1.8 percent in 1975-79, then a loss of -0.9 percent in 1980-84, rebounding to 0.3 percent in 1985-89, and then again having negative rates of change of -0.6 and -0.3 percent in the last two periods. The yearly movement of the multifactor productivity index is depicted in figure 1, which shows a trend of declining and then moving up and down along the level of the base year 1975. This may imply that the influence of technological changes to the growth of the value of shipments is rather limited.

The reasons for the decline of the multifactor productivity index are unclear. A possible explanation for the factors that could have influenced the decline is given in Connor and

Schiek (1997, p.385). These factors are the slowdown in real growth of R&D (research and development) expenditures, an increasing emphasis on new product introductions at the expense of new process development, and a high number of mergers and acquisitions in which R&D labs were consolidated and total resources reduced. McGuckin and Nguyen (1995) in the Bureau of the Census, however, indicated that merger and acquisition might improve productivity in their study of 28,407 U.S. food manufacturing plants during 1977-87. They found that the acquired plants became more productive after an ownership change. In addition, with the exception of large plants, those plants with above average productivity were the ones most likely to be acquired.

The gross-output labor productivity index is also presented in the upper part of table 2. As indicated in next section, this productivity index is shown for comparison but not considered as a representative productivity measure. The table shows that the average annual rates of change in the labor productivity are positive over periods, implying a steady increase in its index. The average annual rate of change in the labor productivity was at a peak of 3.2 percent in 1980-84, mainly because of the high growth of non-labor input intensity at an annual rate of 4.1 percent. The contribution of multifactor productivity in that period, however, showed a negative growth rate of -0.9 percent. On the other hand, in 1975-79, the labor productivity was 1.7 percent, mainly because of an increase in multifactor productivity at 1.8 percent but a negligible contribution from non-labor input intensity.

Results from the net-output approach

In selecting a representative labor productivity measure, the productivity index obtained from the net-output approach would be a better choice than that obtained from the gross-output approach. Although the net-output labor productivity index is obtained under a rigid assumption of a production function that materials inputs are separable from other inputs and cannot be the source of productivity growth, there are certain advantages for using the value-added as output in productivity analysis. As a common practice to evaluate the nation's GDP in any year, the level of GDP is frequently regarded as depending on the input of labor measured in worker-hours multiplied by the labor productivity measure as real value-added per worker per hour. Therefore, the net-output labor productivity index may directly show the contribution of an industry to the nation's GDP. In addition, the net-output labor productivity can be easily interpreted as depending 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.

The productivity measurements obtained from the net-output approach are contained in the lower part of table 2. In the table, the average annual rates of change in the labor productivity were positive throughout the periods. There was a gain of 2.7 percent in 1980-84, reaching a peak of 5.5 percent in 1980-84, and then gradually slowing down from 2.7 percent in 1985-89 to 0.9 percent in 1995-97. As shown in figure 2, the pattern of the labor productivity index was moving upward continuously over years, implying that the contribution of the food-manufacturing sector to the growth of GDP increased during 1975-97. In a comparison with figure 1, the labor productivity indexes obtained from either gross- or net-output approach are similar increasing over the years**.**

Using 1995-97 as an example to demonstrate the linkage of the net-output labor productivity to the GDP, the annual average of the value-added (including purchased services) was $139.9 billion at 1982 prices and a utilization of 2,322 million hours of production workers. The value-added per worker-hour was then calculated to be $60.26. Given the same size of the labor force, the annual rate of change of 0.93 percent in the labor productivity implies that the food-manufacturing sector could increase its annual contribution about $1,301 million to the growth of GDP; that is 0.93 percent of the amount of value added. Moreover, given a 10 percent increase in the labor force, the food-manufacturing sector could increase its annual contribution about $1,431 million to the growth of GDP; that is 1.023 percent (0.93 multiplied by 1.1) percent of the amount of value added.

The technological progress and the capital intensity per unit of labor determine the rates of change in the labor productivity. The increase of labor productivity may be related to the improvements of health, training, education, motivation of workers, and capital intensity when workers have more and better machinery with which to work. The average annual rate of change in the labor productivity was at a peak of 5.5 percent in 1980-84, mainly because of the high annual rates of growth in capital intensity of 2.8 percent and multifactor productivity of 2.7 percent. In 1975-79, for example, the labor productivity was 2.7 percent, mainly because of an increase in multifactor productivity at 4.1 percent but a negative contribution from capital intensity of -1.4 percent. In general, the growth of labor productivity in the food-manufacturing sector was mainly accounted for by the growth of multifactor productivity ranging from 0.5 to 4.1 percent. The contribution of capital intensity to the labor productivity was not significant for most periods, except in 1980-84 with a high rate of change at 2.8 percent.

For comparison, the multifactor productivity index obtained from the net-output approach is also presented in the lower part of table 2. The table shows that the average annual rates of change in the value-added were positive ranging from 1.7 to 4 percent throughout the periods. The major force of growth in value-added was accounted for by the growth in multifactor productivity with average annual rates of change ranging from 0.5 to 4.1 percent. The annual rates of change in the multifactor productivity are characterized by uniform gains over periods with rates of 2.6 percent in 1975-79, increasing to a peak of 4.1 percent in 1985-89, and then slowing to 3 and 0.5 percent in 1990-94 and 1995-97. The contribution of the combined labor and capital inputs to the growth of the value-added, however, was less significant, about 1 percent in most periods. The yearly movement of the multifactor productivity index is depicted in figure 2, which shows that the productivity index was moving upward continuously along with the value-added during 1975-97. This is a striking difference in comparison with the multifactor productivity index for the value of shipments, which shows no significant changes over years.

Concluding Remarks

Two alternative approaches in specifying a production function are applied in this study to measure the multifactor and labor productivity indexes for the U.S. food-manufacturing sector. One is the gross-output approach by using the real value of shipments as a function of capital, labor and all intermediate materials inputs. Another is the net-output approach by using the real value-added as a function of labor and capital inputs. Because most food-manufacturing industries are characterized by materials intensive, including or not materials as a component in a production function will affect substantially the results of measured productivity index. Which approach provides a better measurement of productivity index for practical application is a major issue addressed in this paper.

The multifactor productivity index obtained from the gross-output approach is considered as representative productivity measure for the U.S. food-manufacturing sector. The productivity index may represent closely the changes through time in technology, because the measure is derived from a comprehensive production function by including all factor input available in the data source. The measured multifactor productivity index of the value of shipments shows a trend of declining and then moving up and down along the level of the base year 1975. The results imply that the influence of technological changes to the growth of output (the value of shipments) in the U.S. food-manufacturing sector is rather limited.

The labor productivity index obtained from the net-output approach is considered as representative productivity measure for the U.S. food-manufacturing sector. The labor productivity index is a useful indicator to show directly how the food-manufacturing sector can contribute to the GDP and the substitution relationships between capital and labor inputs. The annual rates of change in the sector's contribution to the growth of GDP depend on the rates of change in the labor productivity and the size of labor force. The measured labor productivity index of the value-added exhibits a trend of steady increase over years. The results imply that the contribution of the food-manufacturing sector to the growth of GDP increased during 1975-97.

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Table 1--Measured productivity of U.S. food manufacturing

Year	Gross-output approach: Output	Inputs: Non-L/L	Inputs: Comb.	Productivity: Multi.	Productivity: Labor	Net-output approach: Output	Inputs: Cap./L	Inputs: Comb.	Productivity: Multi.	Productivity: Labor
	Calculated annual change rate, percent									
76	7.49	4.35	2.83	3.14	5.97	11.67	0.15	-1.38	11.52	10.15
77	2.01	3.83	3.39	-1.81	1.58	1.65	-0.47	-0.91	2.12	1.21
78	3.02	0.08	-2.06	2.95	0.89	2.98	3.32	1.18	-0.34	0.85
79	-0.70	-3.47	-4.40	2.78	-1.62	-0.50	2.43	1.50	-2.93	-1.42
80	0.24	2.66	3.74	-2.42	1.32	1.35	4.36	5.44	-3.01	2.42
81	2.74	4.43	6.29	-1.68	4.60	3.71	2.63	4.49	1.08	5.57
82	2.06	3.82	7.76	-1.76	6.00	7.91	-0.12	3.81	8.03	11.85
83	0.31	-1.28	0.85	1.59	2.44	3.74	-4.60	-2.48	8.34	5.86
84	0.99	1.20	1.89	-0.21	1.68	1.33	2.23	2.92	-0.90	2.02
85	2.21	5.90	7.72	-3.69	4.03	7.86	-1.93	-0.11	9.80	9.69
86	0.44	0.81	1.28	-0.38	0.90	5.62	-4.67	-4.21	10.29	6.09
87	4.45	3.18	-1.23	1.27	0.04	5.71	3.50	-0.91	2.21	1.31
88	2.21	-1.88	-3.98	4.10	0.12	1.37	2.11	0.02	-0.74	-0.72
89	-0.89	-1.22	-2.07	0.34	-1.73	-1.92	-0.90	-1.75	-1.02	-2.77
90	1.83	2.75	-0.08	-0.92	-1.00	3.13	2.16	-0.68	0.97	0.30
91	0.73	5.12	4.37	-4.39	-0.02	3.05	-0.42	-1.17	3.47	2.30
92	4.92	3.37	-0.72	1.55	0.83	7.71	1.82	-2.28	5.89	3.61
93	1.95	-0.62	-2.01	2.57	0.56	3.67	-1.30	-2.70	4.98	2.28
94	0.78	2.48	1.50	-1.71	-0.21	2.55	3.09	2.11	-0.55	1.56
95	2.75	3.27	2.63	-0.52	2.11	3.25	0.28	-0.35	2.97	2.61
96	-1.78	-6.58	-6.01	4.79	-1.21	-5.40	0.70	1.28	-6.11	-4.83
97	3.83	9.08	6.94	-5.26	1.68	7.17	2.57	0.43	4.59	5.02
	Generated index number, percent (1975=100)									
75	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
76	107.5	104.4	102.8	103.1	106.0	111.7	100.1	98.6	111.5	110.1
77	109.7	108.3	106.3	101.3	107.6	113.5	99.7	97.7	113.9	111.5
78	113.0	108.4	104.1	104.3	108.6	116.9	103.0	98.9	113.5	112.4
79	112.2	104.7	99.5	107.1	106.8	116.3	105.5	100.4	110.2	110.8
80	112.5	107.4	103.3	104.6	108.2	117.9	110.1	105.8	106.9	113.5
81	115.5	112.2	109.8	102.8	113.2	122.3	113.0	110.6	108.0	119.8
82	117.9	116.5	118.3	101.0	120.0	131.9	112.8	114.8	116.7	134.0
83	118.3	115.0	119.3	102.6	122.9	136.9	107.6	112.0	126.4	141.9
84	119.5	116.4	121.5	102.4	125.0	138.7	110.0	115.2	125.3	144.8
85	122.1	123.2	130.9	98.6	130.0	149.6	107.9	115.1	137.6	158.8
86	122.6	124.3	132.6	98.2	131.2	158.0	102.9	110.3	151.7	168.4
87	128.1	128.2	131.0	99.5	131.3	167.0	106.5	109.3	155.1	170.6
88	130.9	125.8	125.8	103.6	131.4	169.3	108.7	109.3	153.9	169.4
89	129.8	124.2	123.2	103.9	129.2	166.1	107.7	107.4	152.4	164.7
90	132.1	127.7	123.1	102.9	127.9	171.3	110.1	106.6	153.9	165.2
91	133.1	134.2	128.4	98.4	127.8	176.5	109.6	105.4	159.2	169.0
92	139.7	138.7	127.5	100.0	128.9	190.1	111.6	103.0	168.6	175.1
93	142.4	137.9	124.9	102.5	129.6	197.1	110.1	100.2	177.0	179.1
94	143.5	141.3	126.8	100.8	129.4	202.1	113.5	102.3	176.0	181.9
95	147.4	145.9	130.1	100.3	132.1	208.6	113.9	102.0	181.2	186.7
96	144.8	136.3	122.3	105.1	130.5	197.4	114.7	103.3	170.1	177.7
97	150.3	148.7	130.8	99.5	132.7	211.5	117.6	103.7	178.0	186.6

Notes: Gross-output approach: Output (value of shipments), Inputs (capital, labor, energy and materials), Non-L/L (non-labor intensity), Comb. (combined inputs), and Multi. (multifactor).

Net output-approach: Output (value-added), Inputs (capital and labor), Cap./L (capital intensity), and Comb. (combined inputs), and Multi. (multifactor).

Table 2--Comparison of alternative productivity measurements

Period		1975-79	1980-84	1985-89	1990-94	1995-97
		Calculated annual rate of change, percent				
		Gross-output approach				
Value of shipments	(1)	2.96	1.27	1.68	2.04	1.60
Combined inputs *	(2)	1.20	2.17	1.36	2.62	1.92
Multifactor productivity	(3)=(1)-(2)	1.76	-0.90	0.33	-0.58	-0.33
Non-labor/labor intensity	(4)	-0.06	4.10	0.35	0.61	1.19
Multifactor productivity	(5)	1.76	-0.90	0.33	-0.58	-0.33
Labor productivity	(6)=(4)+(5)	1.70	3.21	0.67	0.03	0.86
		Net-output approach				
Value-added	(1)	3.95	3.61	3.73	4.02	1.67
Combined inputs **	(2)	1.35	0.90	-0.38	1.07	1.19
Multifactor productivity	(3)=(1)-(2)	2.60	2.71	4.11	2.95	0.48
Capital/labor intensity	(4)	0.10	2.84	-1.39	-0.94	0.45
Multifactor productivity	(5)	2.60	2.71	4.11	2.95	0.48
Labor productivity	(6)=(4)+(5)	2.70	5.54	2.72	2.01	0.93

Notes: * Combined inputs include capital, labor, energy and materials

** Combined inputs include capital and labor

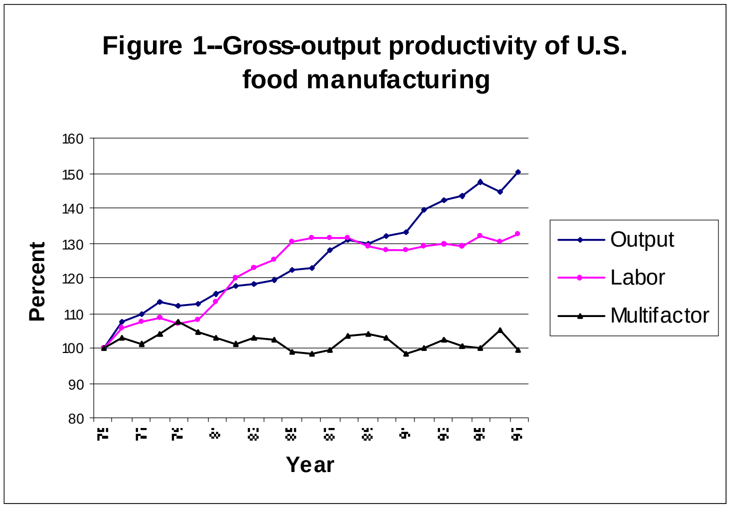

Figure 1--Gross-output productivity of U.S. food manufacturing
Percent
160
150
140
130
120
110
100
90
80
Year
Output
Labor
Multifactor

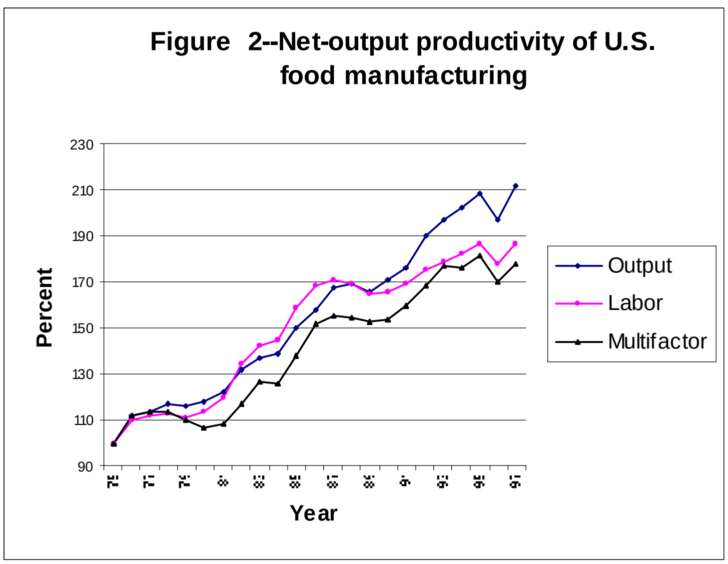

Figure 2--Net-output productivity of U.S. food manufacturing
Percent
230
210
190
170
150
130
110
90
Year
Output
Labor
Multifactor