Total Factor Productivity and Sources of Growth in the Dairy Sector

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Abstract

One would expect to find differences in total factor productivity (TFP) associated with factor allocation, given the technological change in the dairy sector over time and the regional disparity of regulations affecting production The authors use a National Income and Product Accounting procedure to calculate total income and product, TFP, and sources of growth for seven dairy States in different regions The average TFP growth for the seven States was 2 5 percent per year Florida and California had higher TFP *growth* rates, but interspatial TFP estimates indicated Wisconsin and New York had greater relative TFP *levels* in both 1978 and 1982

Keywords

National Income and Product Accounting, intertemporal and interspatial total factor productivity, rates of return, sources of growth

One would think the dairy industry is fairly diverse regionally There has been considerable regulation of milk pricing and production within the dairy sector, but these regulations have differed markedly across regions, primarily because of Federal marketing orders, subsidized pricing, and different State-level effects of price-support programs Such regional differentiation of regulations within an industry leads one to expect differences in factor returns, allocations, and productivity by region Total factor productivity (TFP)—changes in output for a given level of total input—is usually associated with technological change or more efficient reallocation of a given level and quality of inputs In this article, we examine TFP differences across regions within the dairy sector

Productivity measures at the firm level are usually based on detailed enterprise data These measures are often estimated as yield per acre or pounds of milk per cow Insufficient data for performing the analysis on a milk-per-cow basis limited this analysis to the three-digit Standard Industrial Classification (SIC) of the dairy sector Furthermore, since a productivity measure such as pounds of milk per cow can provide a biased measure of productivity, a TFP index measure of productivity growth is useful because it corresponds more closely to a production function, that is, the TFP index relates output to an implicit function of all inputs (*5*)[1] Although the index number approach is relatively simple to implement, it assumes uniform technical parameters across all regions, whereas those regional parameters can be estimated with an econometric approach

We applied the analysis to seven regionally diverse dairy States Pennsylvania, New York, Vermont, Wisconsin, Florida, California, and Texas These States were selected as representative of diverse dairy-producing regions because their herd sizes and input costs differ considerably

We provide some insight into the relative productivity of these different regions by using a National Income and Product Accounting (NIPA) procedure These accounts provide a method consistent with the economic theory of production and income We

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[1]Italicized numbers in parentheses refer to References at the end of this article

use a procedure first proposed by Kendrick and Jones (*12*) in setting up the national agricultural income and product accounts. This method is used to derive gross national product at the national level where output (total product) is the final value of all goods and services at market prices. Income is the payment to all factors (that is, capital and labor). We chose this method because it enables us to account for all income and products in the dairy sector. The estimates of real factor payments and output allow us to calculate the difference between the growth in output and inputs, which is used to indicate productivity growth.

The NIPA method provides an accounting system with *all* inputs and outputs captured in a closed system, that is, all variables are defined such that total value of all factors is equal to the total value of output. Thus, we implicitly assume that dairy production is characterized by constant returns to scale, an assumption that may not apply to the dairy sector, but which cannot be tested in this type of analysis.[2] As a closed system, the procedure is complete in that it requires an accounting of all relevant variables. The requirement imposed by our analysis is no less a problem than it is for construction of the national accounts. However, for a particular sector, this type of accounting implies that the results regarding the sector's performance may be more suggestive than conclusive. Developing an income and product account of an economic sector is useful because it logically identifies key economic variables of that sector: gross product (value-added output), profit income (net farm income), property compensation, and rate of return to capital. By converting the value-added measure of output to a gross measure by including intermediate products and by estimating the service flows of capital, labor, and materials, one can estimate TFP. Using the estimates of the growth in factor inputs, outputs, and TFP, one can determine the sources of growth in output between the growth in factor inputs and technological change. We made regional comparisons for 2 census years, 1978 and 1982, and we calculated TFP levels and growth rates for this 5-year period.

In this article, we develop dairy-sector income and product accounts for the constant-dollar SIC, and we discuss regionally diverse incomes and returns. We derive aggregate productivity estimates. Finally, we perform a sources-of-growth analysis to quantify factors contributing to differences in the output growth across regions.

Income and Product Accounts

We first develop the income and product accounts for the SIC dairy farms. These accounts for the seven States are set up in both current and constant 1977 dollars for 1978 and 1982.

The Census of Agriculture classifies farms by two- and three-digit SIC codes at national and State levels. Farms where dairy products account for 50 percent or more of total farm sales are classified as three-digit SIC dairy farms. Income and product estimates reported here are based on data from the Census of Agriculture as used by Somwaru (*14*).

The derivation of dairy income and product follows the procedure used for the Gross Farm Product and Income account (*9, 12*) by the Bureau of Economic Analysis of the U.S. Department of Commerce. Total value of output is the sum of crop and livestock receipts (including net Commodity Credit Corporation (CCC) payments), Government payments, and income from custom work, rentals, and recreational services (tables 1 and 2). Including Government payments may be problematic because these payments may increase while actual production is constant, thus giving a policy-distorted increase in total output. When this potential distortion in total returns affects the allocation of inputs, including Government payments certainly is valid. The imputed value of home consumption of farm products and the change in crop and livestock inventories are included in other income.

One derives gross dairy product by subtracting the costs of intermediate products (feed, seed, energy, fertilizer, and so forth), custom work, rent, and repairs from total output. This figure yields the value-added measure of output for the dairy sector, that is, it contains the value of all dairy and nondairy products produced by the sector net of intermediate products that contribute to dairy produc-

[2]One makes several assumptions when using a NIPA framework. First, the longrun competitive price-taking behavior of producers is associated with profit maximization. Next, the SIC delineation of the dairy sector implies that firms are multiple-output producers. Furthermore, one assumes a constant-returns-to-scale multiple output transformation function and that value added output implies that production is separable from intermediate inputs.

Table 1—Gross dairy product and income, constant 1977 dollars, 1978

Item	Pennsylvania	Vermont	Florida	Wisconsin	California	New York	Texas
	1,000 dollars						
Crop cash receipts							
Grain	24,509	62	405	62,020	2,816	11,688	1,953
Cotton and cottonseed	0	0	0	0	14,548	0	407
Tobacco	5,300	0	239	5,657	0	0	0
Field seeds, hay, forage, and silage	15,215	876	200	23,898	4,956	9,995	679
Vegetables, sweet corn, and melons	1,673	116	468	8,430	1,738	2,645	82
Fruits, nuts, and berries	362	130	299	320	7,976	1,371	43
Nursery and greenhouse products	215	5	165	56	0	56	0
Other crops	662	12	211	684	1,070	343	729
Livestock cash receipts							
Poultry and products	3,425	58	390	2,011	5	910	132
Dairy products	748,321	224,605	229,643	1,854,628	1,150,241	1,026,498	351,657
Cattle and calves	59,881	14,070	16,899	170,221	78,381	72,831	28,760
Hogs and pigs	5,893	70	183	36,856	247	789	504
Sheep, lambs, and wool	150	17	0	303	143	102	169
Other livestock	385	67	74	481	119	280	70
Government payments	2,262	261	45	4,571	2,160	1,536	2,541
Custom work	3,826	250	65	10,204	2,614	2,704	1,519
Rents	419	153	154	1,536	334	640	502
Recreational services	2,348	532	85	6,862	456	2,569	511
Other income							
Home consumption	7,161	1,601	214	21,014	1,339	7,820	1,387
Change in inventories							
Crops	15,750	1,047	558	35,274	7,893	10,322	1,608
Livestock	(16,511)	(4,777)	(4,965)	(41,941)	(24,633)	(22,104)	(7,686)
Total value of output	881,246	239,155	245,332	2,203,085	1,252,403	1,130,995	385,567
Intermediate expenses							
– Intermediate products	277,562	93,598	124,674	565,393	555,006	402,995	179,970
– Custom work expense	7,820	882	726	20,343	11,975	7,042	2,728
– Rent expense	11,970	3,350	1,108	26,981	3,389	15,223	7,322
– Repairs	58,057	13,764	2,564	179,142	15,937	69,798	10,135
– Other expenses	23,884	6,941	6,999	56,613	30,963	31,368	10,831
= Gross dairy product	501,953	120,620	109,261	1,354,613	635,133	604,569	174,581
– Capital consumption	133,978	31,763	5,917	413,403	36,777	161,072	23,388
– Property taxes	18,767	3,449	2,097	40,628	8,592	14,361	4,608
= Income originating	349,208	85,408	101,247	900,582	589,764	429,136	146,585
– Labor compensation	47,052	16,185	24,043	93,692	84,817	71,564	22,257
= Property compensation	302,156	69,223	77,204	806,890	504,947	357,572	124,328
– Net interest	55,256	13,964	15,109	116,491	64,091	59,480	23,338
= Net farm income	246,900	55,259	62,095	690,399	440,856	298,092	100,990

Numbers in parentheses denote negative values

Table 2—Gross dairy product and income, constant 1977 dollars, 1982

Item	Pennsylvania	Vermont	Florida	Wisconsin	California	New York	Texas
				1,000 dollars			
Crop cash receipts							
Grain	34,715	346	465	112,506	5,559	23,005	3,641
Cotton and cottonseed	0	0	0	0	27,629	0	0
Tobacco	5,632	0	0	5,589	0	0	0
Field seeds, hay, forage, and silage	5,982	1,724	470	10,604	8,744	5,927	1,488
Vegetables, sweet corn, and melons	2,156	105	0	9,540	2,102	3,039	202
Fruits, nuts, and berries	328	98	1,057	215	5,442	1,138	304
Nursery and greenhouse products	190	11	0	60	0	52	0
Other crops	1,233	12	352	1,303	1,150	624	1,135
Livestock cash receipts							
Poultry and products	3,876	130	463	1,639	5	1,020	334
Dairy products	831,969	242,399	254,291	2,146,801	1,403,769	1,092,155	370,677
Cattle and calves	58,515	14,543	17,175	186,709	89,615	66,357	27,244
Hogs and pigs	5,396	60	181	31,190	679	595	735
Sheep, lambs, and wool	112	19	0	319	88	126	34
Other livestock	483	119	4	583	83	314	172
Government payments	2,192	325	135	5,385	1,479	2,138	577
Custom work	5,648	558	42	14,921	4,560	3,734	1,626
Rents	264	77	37	900	231	209	317
Recreational services	2,148	471	62	6,278	417	2,350	467
Other income							
Home consumption	5,953	1,308	130	17,228	1,114	6,144	1,054
Change in inventories							
Crops	(10,873)	(463)	(466)	(26,601)	(7,059)	(6,438)	(1,239)
Livestock	(8,023)	(2,257)	(2,391)	(20,964)	(13,131)	(10,189)	(3,516)
Total value of output	947,826	259,585	272,007	2,504,205	1,532,476	1,192,300	405,252
Intermediate expenses							
– Intermediate products	245,700	83,865	108,296	652,172	581,628	370,994	158,451
– Custom work expense	1,563	210	128	4,099	3,557	1,218	430
– Rent expense	10,036	2,439	810	24,311	3,005	11,526	5,415
– Repairs	49,345	11,331	2,365	156,261	14,636	58,492	9,243
– Other expenses	42,499	9,957	9,681	95,927	50,136	45,535	15,205
= Gross dairy product	598,683	151,783	150,727	1,571,435	879,514	704,535	216,508
– Capital consumption	127,824	29,352	6,127	404,787	37,914	151,521	23,943
– Property taxes	18,515	3,409	2,102	44,792	12,526	13,759	5,289
= Income originating	452,344	119,022	142,498	1,121,856	829,074	539,255	187,276
– Labor compensation	48,754	19,232	26,764	113,397	99,622	86,214	22,107
= Property compensation	403,590	99,790	115,734	988,459	729,452	453,041	165,169
– Net interest	104,996	22,413	22,550	228,516	119,716	94,003	38,159
= Net farm income	298,594	77,377	93,184	759,943	609,736	359,038	127,010

Numbers in parentheses denote negative values tion Subtracting capital consumption allowances and indirect business taxes (property taxes) from gross dairy product yields income originating in the dairy sector Income originating in the sector is defined as the sum of all factor payments (that is, all payments to capital and labor), therefore, subtracting labor compensation yields property compensation or income earned by capital Finally, property compensation less net interest (payments less receipts) yields sectoral net farm income or profit

One derives constant dollar estimates of income and product by deflating separate components of the account by the respective prices received and paid by farmers using 1977 as the base year For example, grain is deflated by the index of prices received for food grains Cotton and cottonseed are deflated by the index of prices received for cotton and so on [3] These deflators come from the *Agricultural Prices* annual summary *(18)* Because item-specific regional deflators are not available, the deflators used reflect national prices and are applied to all States

Income and Returns

Using the gross dairy income and product account, we can derive some indicators for the sector's performance, including TFP growth and the capital-labor and capital-output ratios The latter two ratios are of interest because they indicate relative factor intensity We are interested primarily in the rate of return to capital One can calculate this rate in each period by dividing the constant dollar value of property compensation (income from capital) by the constant dollar value of total capital stocks This quotient yields capital income as a percentage of the value of capital stocks, that is, the amount of income flowing from capital stocks The percentage is a real rate of return in the sense that it is derived as a ratio of constant-dollar-valued income and capital stocks

This rate is used to calculate capital services Because we do not have a direct measure for the rate at which capital is used, as we have for the hours of labor services, we must convert the stock of capital to a flow of capital services Capital services are calculated as the product of the rate of return to capital and the weighted sum of capital stocks where the weights are the portions of each component of capital to the total [4]

Capital stocks include land and structures, machinery and equipment, livestock inventories, and crop inventories The current dollar value of land and structures and that of machinery and equipment valued at market prices are taken from the Agricultural Census We derived constant dollar values of these capital stocks by deflating each component of capital by its respective price index (see the appendix for the list of deflators) Constant dollar livestock inventories are calculated from Census numbers of head times the price index for livestock We derived crop inventories from State balance sheet data *(16, 17)* and prorated them to the SIC dairy sector using Census benchmarks (table 3). We measured producer durables (machinery and equipment) gross of depreciation because, given repairs and maintenance, the productive capacity of the equipment will endure *(11)*

In 1978, California received more than twice the rate of return (16 7 percent) as did the northern States Florida and Texas also had rates greater than the northern States, receiving 11 8 percent and 9 2 percent, respectively Pennsylvania, Vermont, Wisconsin and New York had similar rates In 1982, both Florida and California had rates near 20 percent, suggesting a considerable growth in income and a potential underinvestment in capital The return to capital increased in all northern States, but increased the least in Wisconsin

These returns imply that operations in California and Florida earn a higher rate of return to more capital-intensive operations (in terms of the capital-output ratio) than do the smaller operations of the northern and Lake States However, the reasons for these high returns in California and Florida differ For example, Florida had high-valued returns because it received the benefit of the highest

[3]The specific items and their deflators appear in the appendix

[4]One usually formulates the capital service price following Hall and Jorgenson *(8)*

$$p_t = q_t(r_t + d + T_t - g_t)$$

where q_t is the acquisition price, r_t is the rate of return, d is the depreciation rate, T_t is the tax rate applied to capital, and g_t is capital gains We did not use this method for several reasons, chiefly because we lacked the data to support this method Furthermore, we gained no additional information in our limited attempt to use this formula

Table 3—Constant 1977 dollar capital stocks and rate of return to capital, 1978 and 1982

Year and item	Pennsylvania	Vermont	Florida	Wisconsin	California	New York	Texas
				1,000 dollars			
1978							
Land and structure	3,602,362	662,014	402,650	7,798,694	1,649,246	2,756,702	884,634
Machinery and equipment	668,287	158,435	29,514	2,062,073	183,446	803,434	116,661
Livestock inventories	719,618	209,149	216,893	1,824,302	1,077,285	965,958	335,177
Crop inventories	157,694	3,720	6,550	337,484	103,416	85,590	12,649
Total capital	5,147,961	1,033,318	655,607	12,022,553	3,013,393	4,611,684	1,349,121
				Percent			
Return to capital	5 87	6 70	11 78	6 71	16 76	7 75	9 22
				1,000 dollars			
1982							
Land and structure	2,501,003	532,191	328,169	6,992,821	1,955,601	2,148,060	825,681
Machinery and equipment	492,184	145,474	30,368	2,006,194	187,908	750,964	118,666
Livestock inventories	941,982	273,006	274,470	2,551,538	1,347,751	1,233,106	435,793
Crop inventories	157,293	1,187	278	265,660	12,790	61,946	33,986
Total capital	4,092,462	951,858	633,285	11,816,213	3,504,050	4,194,076	1,414,126
				Percent			
Return to capital	9 86	10 48	18 28	8 37	20 82	10 80	11 68

average milk prices for the seven States because of local marketing order prices In contrast, California received a far lower average price for milk, suggesting that marginal productivity and, therefore, the efficiency of its capital are considerably higher than in the northern and Lake States [5]

Separating the influence of dairy-support programs from returns earned under a strictly market-oriented environment would be helpful in assessing differences in regional returns Dairy programs simultaneously affect relative prices and production, and they partially explain the differential returns, however, we do not disentangle these effects here

[5]One reviewer pointed out that the difference in nondairy outputs across States appears to make total outputs noncomparable Although weighting the various outputs by their relative contribution to total revenue would allow for aggregation, we see, upon close inspection, that individual nondairy outputs constitute less than 1 percent of output, in fact, the total of all nondairy components of output represents only a little over 10 percent This comparison demonstrates the advantage of using SIC classifications because the primary output is the one defined by the classification To examine whether the interstate price differential has a significant effect on TFP, we looked at the average price received for milk in each State for 1978 and 1982 We compared each State's price with the seven-State average We discovered Florida's price was approximately two standard deviations above the mean, whereas California's was one standard deviation below All other States were very close to the mean Florida was biased upward, but California was biased downward

The variation among States in the average of the ratio of capital services to output for both years, which measures capital intensity, shows the differences in relative factor usage among regions The ratio is larger in California (0 82), Florida (0 74), and Texas (0 77), relative to all States where values averaged 0 63 Although the ratio of capital to output is highest in the southern and western States, their rates of return to capital imply underinvestment in capital, which suggests these States should invest in more capital, making them considerably more capital-intensive relative to the other States

Productivity Estimates

Productivity estimates are made from two perspectives time (a comparison between 1978 and 1982) and region (a bilateral comparison of productivity between one arbitrarily chosen State, Pennsylvania, and the other States) Measuring the growth in TFP for different regions will enable us to compare relative efficiencies among regions That is, after controlling for differences in input levels among regions, we can determine how much more output one region can produce than another for a given set of inputs

Because this is an industry study, output is measured gross of intermediate products rather than value added Christensen (*2*) points out that, although aggregate productivity studies use value added because intermediate products are canceled out across sectors (that is, one sector's output is another sector's input), intermediate products do not cancel at the sector or industry level

We assume the dairy sector is characterized by constant returns to scale (CRS), which implies that the necessary condition for producer equilibrium is that the shares of intermediate inputs and value added to total gross product sum to unity (*10*) Assuming away increasing (decreasing) returns to scale may yield a positive (negative) bias in the TFP estimates (*4*) We maintain CRS because that assumption is implicit in the data construction and, unless we econometrically estimate a dairy production function, we do not know the degree of returns to scale

The input categories consist of capital services (K), labor (L), and materials (M) One calculates capital services by weighting capital stocks by the rate of return to capital [6] Labor is defined as the value of hired labor compensation plus self-employed and unpaid family labor valued at the hired wage rate Material inputs include all intermediate purchased inputs and services such as feed, seed, energy, agricultural chemicals, and veterinary services Assuming CRS and perfect competition in factor markets implies that we can define factor cost shares as input weights equivalent to output elasticities With these assumptions, we can aggregate total input using a Tornqvist approximation to the Divisia index (*5*) Aggregating all factors with a Divisia index procedure permits us to estimate TFP growth that is not biased by the lack of factor substitution possibilities implied by average product productivity measures (for example, a Laspeyres index of TFP) The index is written as

$$\ln(X_T/X_O) = 1/2 \sum_i (S_{iT} + S_{iO}) \ln(X_{iT}/X_{iO}) \qquad (1)$$

where X is total input in period T and the base period O, and S is the cost share of input X_i Total output, input, and average factor shares appear in table 4

All factor shares tended to be comparable across most States The share of labor was fairly constant at about 9-15 percent Materials were most important in 1978 at 50 percent or more for all States and then declined to 40-45 percent in 1982 Capital varied within a range of 33-40 percent in 1978 and rose to 44 percent in 1982 Capital's share increased in the latter period, decreasing the shares of the other two inputs This rise in capital's share was largely a function of the general increase in the calculated rate of return to capital

The TFP index procedure also uses the Tornqvist index This procedure allows us to define growth in TFP as growth in output minus the factor share-weighted growth in inputs Because the growth rates are calculated as natural logarithms, by taking the exponential of the growth rates, we can convert them to index levels, which results in the base period being equal to 1 To compare the productivity level across States, we use a method of bilateral comparison (*3*) The productivity level of one State is selected as the base (that is, equal to 100), and each State is individually compared with it in both periods Both intertemporal and interspatial indexes are produced by use of the Tornqvist index The Tornqvist index for TFP growth is written as,

$$\ln(TFP_T/TFP_O) = \ln(Y_T/Y_O) - 1/2 \sum_i (S_{iT} + S_{iO}) \ln (X_{iT}/X_{iO}) \qquad (2)$$

where Y is output, and the other variables are as in equation 1 The time subscripts can be replaced with subscripts denoting regions This substitution provides a measure of productivity differentials across regions The intertemporal and interspatial levels of productivity appear in table 5 If 1978 = 100, the average annual TFP growth rate for the seven States was 2 5 percent This growth rate is considerably less than the 11-percent annual growth in output per labor hour since 1979 reported by Fallert and others (*7*) Their study suggests the reasons for the rather large increase in productivity were the loss of some less efficient farms, substantial increases in capital, and improved breeding, feeding, and management Our results (which are

[6] It is interesting to note the possible effects of increases in capital consumption allowances (CCA) and indirect business taxes (IBT) on capital services and subsequently on TFP Because one derives capital income by subtracting labor compensation, CCA, and IBT, an increase in CCA or IBT will reduce the rate of return to capital That process will then decrease the value of capital services according to our method and thereby increase TFP

Table 4—Constant 1977 dollar value of output, input, and factor shares, 1978 and 1982

Item	Pennsylvania	Vermont	Florida	Wisconsin	California	New York	Texas
				1,000 dollars			
1978							
Output	501,953	120,620	109,261	1,354,613	635,133	604,569	174,581
Capital	314,126	72,573	78,312	833,871	508,336	372,795	131,650
Total labor	106,134	29,017	27,031	258,675	103,275	132,745	36,977
Materials	359,503	114,303	134,237	801,148	601,906	504,161	200,936
Sum of share-weighted inputs	306,737	88,813	103,861	741,457	520,275	406,829	159,849
				Percent			
Capital share	40 3	33 6	32 7	44 0	41 9	36 9	35 6
Labor share	13 6	13 4	11 3	13 7	8 5	13 1	10 0
Materials share	46 1	52 9	56 0	42 3	49 6	49 9	54 4
				1,000 dollars			
1982							
Output	598,683	151,783	150,727	1,571,435	879,514	704,535	216,508
Capital	413,626	102,229	116,544	1,012,770	732,457	464,567	170,584
Total labor	121,922	35,144	29,278	328,403	120,614	164,003	38,075
Materials	337,544	105,153	120,342	904,360	646,400	475,021	182,899
Sum of share-weighted inputs	343,477	93,776	108,662	869,022	646,144	424,400	163,451
				Percent			
Capital share	47 4	42 2	43 8	45 1	48 8	42 1	43 6
Labor share	14 0	14 5	11 0	14 6	8 0	14 9	9 7
Materials share	38 7	43 4	45 2	40 3	43 1	43 0	46 7

Table 5—Total factor productivity, intertemporal and interspatial comparisons, 1978 and 1982

State	Intertemporal		Interspatial	
	1978	1982	1978	1982
	Percent			
	1978 = 100		Pennsylvania = 100	
Pennsylvania	100 0	106 5	100 0	100 0
Vermont	100 0	112 0	86 8	91 3
Florida	100 0	124 1	70 9	82 6
Wisconsin	100 0	97 8	111 1	102 1
California	100 0	112 1	81 4	85 7
New York	100 0	106 6	93 0	93 1
Texas	100 0	117 0	73 4	80 7

consistent with those suggestions) illustrate that, when output is compared with the total measure of input, the productivity measure is often considerably less than the partial measure Nonetheless, there are other significant influences (such as loss of farms and management) that are difficult, if not impossible, to measure and that are important to the productivity result

Florida had the highest annual average rate of growth in productivity, 5 4 percent Texas, California, and Vermont had annual growth rates of 3 9, 2 8, and 2 8 percent, respectively New York, Pennsylvania, and Wisconsin had lower growth rates of 1 6, 1 58, and −0 55 percent per year, respectively Except for Vermont, the traditional dairy States—especially Wisconsin—had TFP growth rates below the mean Florida, Texas, and California had above-average TFP growth rates

The higher TFP rates of the southern and western States may be a result of their relative capital intensity, that is, capital may contribute more to output than the other inputs do. If one region has more capital relative to labor or materials (for example, larger herds), this does not necessarily mean that other regions have different technologies. It does imply that they face different relative input price ratios and, therefore, have a different mix of inputs, that is, these regions are at different points along an isoquant. However, Florida and Texas have newer enterprises, therefore, they may have an advantage of operating with new capital equipment having technological improvements. The northern States generally have traditional dairy farms with older types of capital technology with fewer technological improvements than the southern and western States. These two regions may not share the same type of capital and, thus, may not be directly comparable.

Comparing bilateral productivity highlights spatial differences. If Pennsylvania's level of productivity is set to equal 100, Wisconsin was more efficient than Pennsylvania, however, New York and Vermont were less efficient than Pennsylvania in 1978, but increased somewhat in 1982. California, Florida, and Texas were less efficient than Pennsylvania in both 1978 and 1982. These comparisons are bilateral, not multilateral, therefore, we cannot compare TFP among States, but only individually with Pennsylvania. Nonetheless, productivity differs somewhat between the northern and southern regions. Finally, the important distinction between the intertemporal and interspatial productivity comparisons is interesting. Although the rate of growth in TFP over time is generally higher in the southern States, it does not mean that at a given time these States are the most efficient producers. However, according to TFP growth rates, they have certainly improved.

One advantage of having both intertemporal and interspatial TFP estimates is that the combination illustrates regional comparative advantage. For example, given their relative TFP levels in 1982, Wisconsin and Pennsylvania could probably survive an unexpected increase in production costs better than Florida or Texas could. The northern States appear to have this advantage because Wisconsin and Pennsylvania produce more output for a given level of input than the southern States. However, if we can extrapolate 1982 TFP growth rates into the future, the southern States will probably be more efficient and have a comparative advantage later. For example, let us compare Florida and Pennsylvania. In 1982, Florida had a TFP level of 82.5 and a growth rate of 5.4 percent, compared with Pennsylvania's TFP level of 100 and growth rate of 1.6 percent. Using a compound growth rate formula, we find Florida will exceed Pennsylvania's TFP level in just 3 years. Of course, this projection assumes current production practices remain the same across regions.

A policy change like the Dairy Herd Buy-Out provision of the 1985 farm act could significantly change regional productivity. This provision reduces milk production by 12 billion pounds from April 1986 to August 1987. To do so, the Government will buy out whole dairy herds and not permit other farmers to use the associated dairy facilities. Although using 1982 regional TFP estimates to examine events in 1986 may be inappropriate, participation rates in the buy-out program are highest in the regions where estimated TFP levels are lowest. This finding is not surprising since one would expect marginal producers to leave the sector first. Differing opportunity costs associated with staying in production also explain differential participation. For example, some of the reasons given for the exit of marginal producers are low returns, financial problems, and attractive alternatives. Lower participation rates in the northern States result from fewer alternatives for these producers or for their land and equipment. The higher TFP *growth* rates in the southern and western States suggest they had become more productive. If they are financially stressed now and see this program as an opportunity to liquidate, the buy-out program may encourage the potentially most productive producers to move out of the sector, which will probably affect the milk price structure. Therefore, although the program may have little impact on northern producers, the potentially more productive dairy farms in the South and West may produce less milk, altering regional productivity differentials.

Sources of Growth

After determining a measure of aggregate TFP, we investigated the extent to which growth in output is a result of either productivity gains or growth in various factor inputs. We can thus clarify the relationship between technological change and structure (where structure is defined as the relationship between, and the growth of, inputs).

Utilizing the relationship that growth in output should equal the weighted-average growth in inputs, we can determine the sources of growth in output (*13*) Assuming an aggregate production function for dairy, we can express the rate of change in output as[7]

$$\hat{Y} = w_k \hat{K} + w_l \hat{L} + w_m \hat{M} + \hat{A} \qquad (3)$$

where $\wedge$ denotes proportionate rates of change and w_i are the factor share weights of total output The share-weighted growth of an individual input indicates the contributions of that input to output growth We can also express the growth rate of inputs and productivity as a percentage of the growth of output This procedure suggests which portion of the growth in output can be attributed to specific inputs or to productivity For example, the growth of output in New York was almost twice the growth in inputs, implying that input growth accounts for roughly half the growth in output The residual, or $\hat{A}$ from equation 3, is the portion of output growth not explicitly explained by input growth, it is attributed to productivity growth[8]

The contribution of total input growth to output varied considerably for all States (table 6) In California, input growth accounted for as much as 65 percent of output growth, in Texas and Florida, input growth acccounted for only 27 and 33 percent,

[7]As indicated in footnote 2, we really assume a multiple-output production function For simplicity in the growth accounting procedure, we assume outputs to be aggregated as a single index The derivative of the share weighted growth in output follows Denny, Fuss, and Waverman (*4*) and Solow (*13*) We can express the production function as

$$y = f(x_i, t) \qquad (A\ 1)$$

where t represents time Totally differentiating equation A 1 with respect to time and dividing by y yields

$$(dy/dt)(1/y) = \sum_i (df/dx_i)(dx_i/dt)(1/y) + (df/dt)(1/y) \qquad (A\ 2)$$

Define the last term on the RHS as a Hicks' neutral proportionate shift in the production function, and denote it as $\hat{A}$ Multiplying the second term by x_i/x_i produces the x_i output elasticities Assuming competitive markets, the output elasticities will equal factor shares of output Therefore we can express equation A 2 as

$$\hat{Y} = \sum_i w_i \hat{X}_i + \hat{A} \qquad (A\ 3)$$

[8]The residual is an unknown It could contain such elements as effects of changing input quality, changes in capacity utilization, economies of scale, or management and entrepreneurial capacity Given the size of the residual and the number of possibilities that may explain it, it has also been called a "measure of our ignorance" (*1*)

Table 6—Sources of growth, 1978-82

Item	Pennsylvania	Vermont	Florida	Wisconsin	California	New York	Texas
				Percent			
Average annual growth rates							
Output	4 41	5 75	8 04	3 71	8 14	3 83	5 38
Total input	2 83	2 91	2 64	4 26	5 29	2 22	1 45
Capital	3 02	3 24	3 80	2 17	4 14	2 17	2 56
Labor	48	67	22	84	32	74	07
Materials	− 67	−1 00	−1 38	1 25	83	− 69	−1 19
Total factor productivity (TFP)	1 58	2 84	5 40	− 55	2 85	1 60	3 93
Growth in inputs and TFP[1]							
Total input	64 13	50 64	32 82	114 78	65 01	58 09	26 92
Capital	68 44	56 48	47 25	58 34	50 91	56 82	47 66
Labor	10 85	11 64	2 76	22 73	3 95	19 35	1 34
Materials	−15 16	−17 48	−17 19	33 70	10 16	−18 09	−22 08
TFP	35 87	49 36	67 18	−14 78	34 99	41 91	73 08

[1]As a percentage of the growth of output

respectively The growth in inputs in Wisconsin was so great relative to output that inputs had negative growth in TFP Capital was a major contributor to input growth in all States The largest increases were in California and Florida, probably a result of large calculated returns to capital To determine if these rates of return alone accounted for capital's significant role, we calculated capital services with both a lower rate of return and the same rate for all States In both cases, the role of capital was significant

The contribution of labor to output growth in the northern dairy States exceeded that in the southern and western States Although operator labor may be undervalued when the hired wage rate is used, technology in the South and West is far more capital intensive than in the North The relatively high capital growth rates in Florida and California are also consistent with the high relative rates of return to capital that attract capital investment Furthermore, the northern and eastern States are characterized by smaller and more numerous farms with more operators and, hence, are more labor intensive relative to output

The role of materials is problematic The real quantity of material inputs may have declined in the 1978-82 period However, it is more likely that the effective quantity or quality-adjusted quantity increased This increase was probably due to the index number problem, that is, either inappropriate deflators were used for inputs (and outputs) or quantity weights in the indexes were not quality-adjusted and, therefore, do not reflect their true productive capacity For example, greater use of improved feed additives and improved breeding practices and veterinary services would have increased the productive capacity of these purchased inputs The role of materials appears most important in Wisconsin and less important in California One possible explanation is that feed is generally purchased in California, whereas it is grown on farms in Wisconsin and other northern States, thereby requiring farmers to purchase seeds, fertilizers, and other material inputs

TFP was the major source of output growth in all States except Wisconsin Texas and Florida received the largest contributions from TFP because of declines in material inputs relative to a positive growth in output One should remember that TFP is a residual measure, that is, the residual captures the productive qualities that do exist and are not accounted for by the input measurements Accurate input measurement thus requires that all inputs be measured in efficiency units Because of the new technologies, improved breeds and the use of feed additives, the contribution of both capital and the material input may be underestimated

Conclusions

We have demonstrated a method to determine the differences in TFP within an industry and at the regional level We developed constant dollar income and product accounts for the three-digit SIC dairy sector for Pennsylvania, Wisconsin, New York, Vermont, California, Florida, and Texas We showed the importance and usefulness of income and product accounts as an economic tool by examining several variables gross dairy product (valued-added output), profit income (net farm income), property compensation, and the rate of return to capital The southern and western States had higher rates of return to capital than the northern States The average TFP growth for the seven States from 1978 to 1982 was estimated at 2 5 percent per year, considerably lower than previous estimates of output per labor hour for the entire dairy sector TFP estimates indicate that the southern States generally had higher TFP growth rates than the northern dairy States

Bilateral interspatial TFP estimates were made for 1978 and 1982 Although the southern and western States had higher TFP growth rates over time, the northern States were generally more efficient in both periods It is important to distinguish the two types of productivity Capital was an important source of output growth in all regions, and materials were less important The contribution of labor was more important in the more traditional regions and less important in the more capital-intensive regions Productivity growth was significant in all regions

These findings suggest two things First, structure (in terms of relative factor intensity and growth) is important in explaining output growth and productivity differences across regions Second, TFP growth and technological change are important contributors to regional output growth differentials TFP is a residual based on measured items that can have measurement error, therefore, part of the residual is TFP, and part is measurement error Nonetheless, the basic income accounting procedure is useful When properly used, it can identify and examine the sources of growth and productivity of different regions

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Appendix table—Deflator sources

Item	Source/price index	Deflators 1978	Deflators 1982
		1977 = 100	
Crop cash receipts			
Grain	Food grains	122	146
Cotton and cottonseed	Cotton	91	92
Tobacco	Tobacco	109	153
Field seeds, hay, forage, and silage	Feed grains and hay	101	120
Vegetables, sweet corn, and melons	Commercial vegetables	105	126
Fruits, nuts, and berries	Fruit	137	175
Nursery and greenhouse products	All crops	105	121
Other crops	do	105	121
Livestock cash receipts			
Poultry and products	Poultry and eggs	106	110
Dairy products	Dairy products	109	140
Cattle and calves	Meat animals	134	155
Hogs and pigs	do	134	155
Sheep, lambs, and wool	do	134	155
Other livestock	Livestock and products	124	145
Government payments	All farm products	115	133
Custom work	Farm services and cash rent	107	145
Rents	do	107	145
Recreational services	Consumer price index, all items (*6*)	107	172
Other income			
Home consumption	All farm products	115	133
Change in inventories			
Crops	All crops	105	121
Livestock	Livestock and products	124	145
Intermediate products	Production items	108	155
Custom work expense	Farm services and cash rent	107	145
Rent expense	do	107	145
Labor compensation	Wage rates	107	144
Repairs	Production items	108	155
Other expenses	do	108	155
Capital consumption	Farm producer durable equipment (*19*)	108	148
Property taxes	Taxes	100	124
Net interest	Interest	117	241
Capital stocks			
Land and structure	Real estate values (*15*)	109	157
Machinery and equipment	Farm producer durable equipment (*19*)	109	165
Livestock inventories	Livestock and products	124	145
Crop inventories	All crops	105	121

Source All items from (*18*), except where noted