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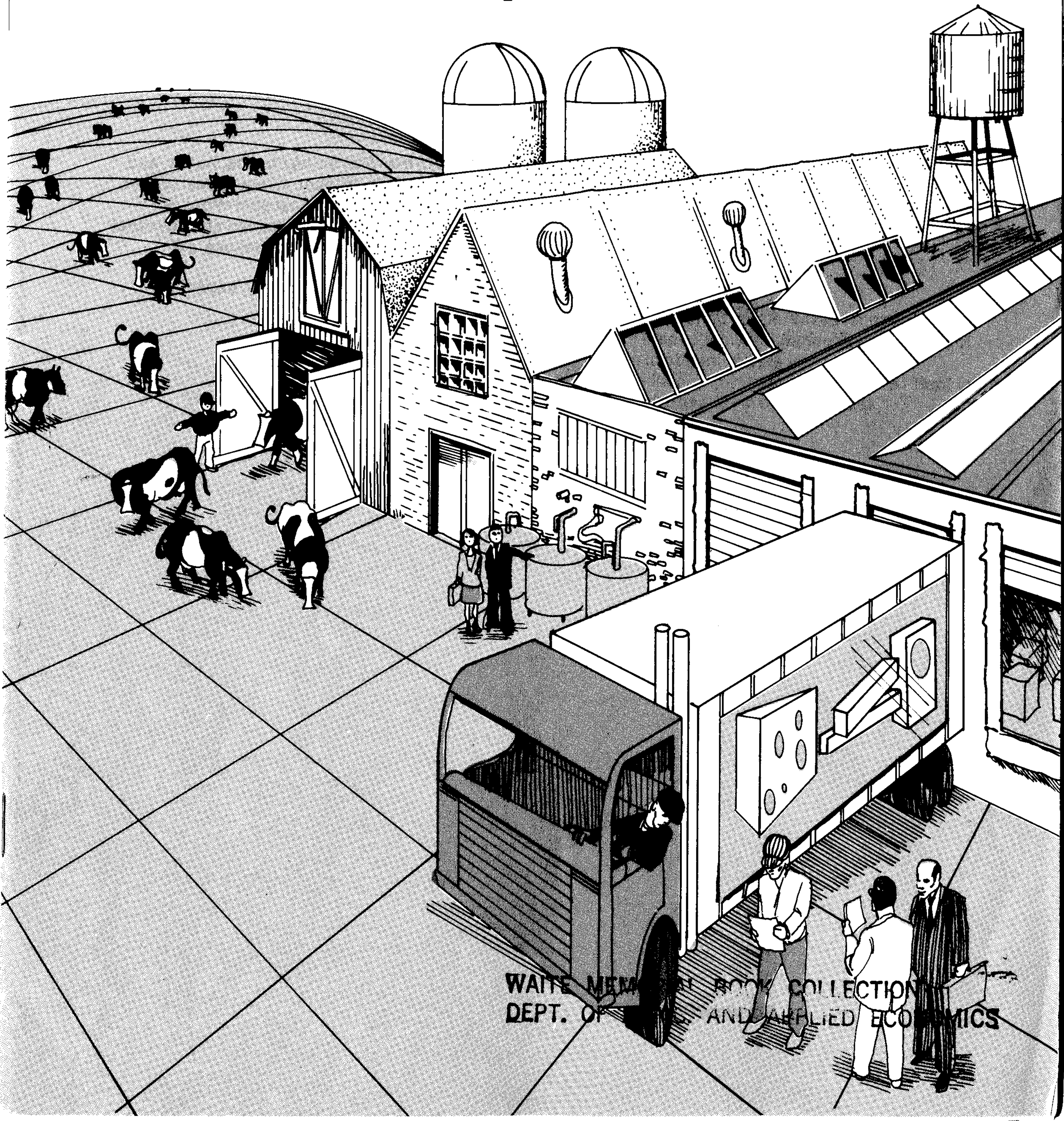
Agricultural
Cooperative
Service

ACS
Research Report
Number 34

Dairy Product Manufacturing Costs at Cooperative Plants



Abstract

Dairy Product Manufacturing Costs at Cooperative Plants

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ACS Research Report 34

Cost data are summarized for 14 plants manufacturing cheese, butter, and powder and average costs are presented for each product. Average cost curves are estimated for each plant. The scale of plant for least-cost operations is identified for plants of each product type. Plant capacity utilization and seasonal volume variation and their impacts on manufacturing cost are delineated.

Key words:Cooperatives, dairy, average cost curve, productivity, capacity utilization, seasonal variation, economies of scale.

November 1983

Preface

Dairy cooperatives are major manufacturers of hard products (cheese, butter, and powder). To operate the manufacturing plants most efficiently, cooperative managers must have standards for cost comparison purposes. They also must know how scale of plant, capacity utilization, and seasonal volume variation affect plant costs so they can adjust operations and make sound investment recommendations to their boards.

ACS works directly with individual cooperatives on a technical assistance basis by making feasibility studies on building new facilities, intercooperative coordination, and other types of cost analyses. In these studies, ACS often makes recommendations involving sizable investments and major organizational adjustments. Accordingly, the most accurate and up-to-date cost information available should serve as a basis for these recommendations. This report helps build a database for ACS, and should be of interest to dairy cooperatives as well.

Acknowledgments

The author wishes to thank the participating cooperatives for opening their books for analysis and their plants for inspection. Assistance from the State of California Bureau of Milk Stabilization in obtaining data is gratefully acknowledged. Thanks are also due William J. Monroe and James B. Roof for their assistance in the planning and implementation of this project.

Contents

Highlights and Conclusions

Dairy product manufacturing costs analyzed in this study are limited to inplant costs from the milk receiving deck to the product delivery deck. These costs are directly associated with the manufacturing operations of the seven cooperatives studied. They include labor (direct labor, supervisory/indirect labor, and fringe benefits), electricity, fuel, water and sewage, plant and cleaning supplies, repair and maintenance, depreciation, taxes and insurance, and miscellaneous expenses.

Findings presented in this report are based on the monthly data of five cheese plants, four butter plants, and five powder plants, belonging to seven cooperatives, for a 12-month period July 1981 through June 1982. They are but a small number of modern, efficient plants and do not constitute a representative sample. In 1982, there were 457 cheese plants, 231 butter plants, and 108 powder plants in the United States. Therefore, considerable caution should be used in any extrapolation of these findings to dairy manufacturing industries as a whole.

Weighted average inplant manufacturing cost for cheese was 7.52 cents per pound. Labor accounted for 57.4 percent of the cost and utilities (electricity and fuel), 15.2 percent. For butter, the manufacturing cost averaged 5.07 cents, 48.4 percent of which was labor, and 19.2 percent, utilities. Average cost per pound of powder was 10.69 cents, with utilities occupying a 38.9-percent share and labor, 33.8 percent.

Labor productivity was 388 pounds of cheese per work-hour of direct labor. The same measure of labor productivity was 834 pounds of butter or 651 pounds of powder.

When both electricity and fuel were converted to heat value, per therm energy productivity was 55.6 pounds of cheese, 116.7 pounds of butter, or 11.7 pounds of powder. This represented a productivity of electricity per kilowatt-hour of 9.6 pounds of cheese, 8.1 pounds of butter, or 6.7 pounds of powder; and a productivity per therm of fuel of 69.2 pounds of cheese, 229.9 pounds of butter, or 12.4 pounds of powder.

Among the three products cheese was the most labor intensive, while powder was the most energy intensive. On the basis of productivity per unit of labor or energy input, butter was both the least labor intensive and the least energy intensive. However, on the basis of input cost as a percent of total cost, powder was the least labor intensive and cheese the least energy intensive. Accordingly, it is important to know which basis is being used when discussing input intensity.

There were wide differences among plants on wage rate, fringe benefits as a percent of wages and salaries, and utility rates. After these input prices were standardized at the respective averages for plants of each product, it became feasible to report individual plant manufacturing cost without jeopardizing the confidentiality of such data. The plant of each product type with the most capacity was identified to be the least-cost plant to take the full advantage of economies of scale. They were cheese plant No. 5 at a daily capacity of 173,000 pounds of cheese, butter plant No. 4 at 90,520 pounds of butter, and powder plant No. 5 at 287,000 pounds of powder.

The estimated average cost curves indicated that cheese plant No. 4 and powder plant No. 4 had higher costs than could be expected from their respective "industry" longrun average cost curve. Powder plant No. 1 was also identified as a very low-cost operation for a small-scale plant. This powder plant had most of its major equipment almost fully depreciated.

Capacity utilization rate and seasonal volume variation strongly affected plant manufacturing cost. As a general rule, average cost was the lowest when the volume was at or near the plant capacity. Average cost rose when the volume deviated from the capacity.

In general, cheese plant capacity was more fully utilized than that for butter and powder plants. Butter plants had the distinction of being the least utilized and the most seasonal in operations.

Dairy Product Manufacturing Costs At Cooperative Plants

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Introduction

The number of dairy manufacturing plants in the United States has been decreasing. At the same time, Grade A milk in excess of fluid needs has become a large proportion of total milk used in making manufactured dairy products. Cooperatives now manufacture products from a very large part of the excess Grade A milk as well as a significant proportion of manufacturing grade milk. As of 1973, 35 percent of natural cheese, 66 percent of butter, and 85 percent of dry milk products were manufactured by dairy cooperatives.[1] The percentages today are estimated at 50, 75, and 85 percent, respectively.

Because of increased input costs of manufacturing dairy products, cooperatives have a vital interest in improving plant efficiency. Because farmer-members' income partly depends on the manufacturing operations, cooperatives must lead in reducing manufacturing costs. They must devise the most efficient longrun programs for handling milk used in manufacturing dairy products.

Dairy cooperatives also face problems of handling highly variable and uncertain volumes of milk on a daily and seasonal basis. As a result, plant operating schedules and costs vary.

In addition, cooperatives often face major decisions regarding mergers and plant expansion or contraction, all of which involve long-term and heavy investments. Precise cost data are essential for such major undertakings.

Cooperatives operate under quite dissimilar conditions of procurement, labor and other costs, energy availability, and regulatory and other constraints. The result is often an unequal ability to compete for some sector of the market. A cooperative must know its manufacturing costs to assess its comparative market position and pinpoint areas for improvement.

This study synthesizes cost data from manufacturing plants of seven dairy cooperatives. In total, there are five cheese plants, four butter plants, and five powder plants. They are of different sizes and located in the East, North Central, and West Coast regions. The monthly data cover a period of 1 year from July 1981 through June 1982.

Products in the study include American (Cheddar) cheese, butter, and nonfat dry milk (powder). Inplant costs are analyzed from the milk receiving deck to the product delivery deck. They exclude milk procurement costs, ingredients, packaging materials, transportation, administrative costs, and interest. Also excluded are costs associated with facilities for prolonged storage and/or offsite storage. Plants often combine ingredients and packaging materials in one account. Because plants package different product sizes and/or size mix, packaging materials are not always compatible among plants. Therefore, costs of packaging materials are not analyzed in detail in this study but are noted wherever appropriate for general reference.

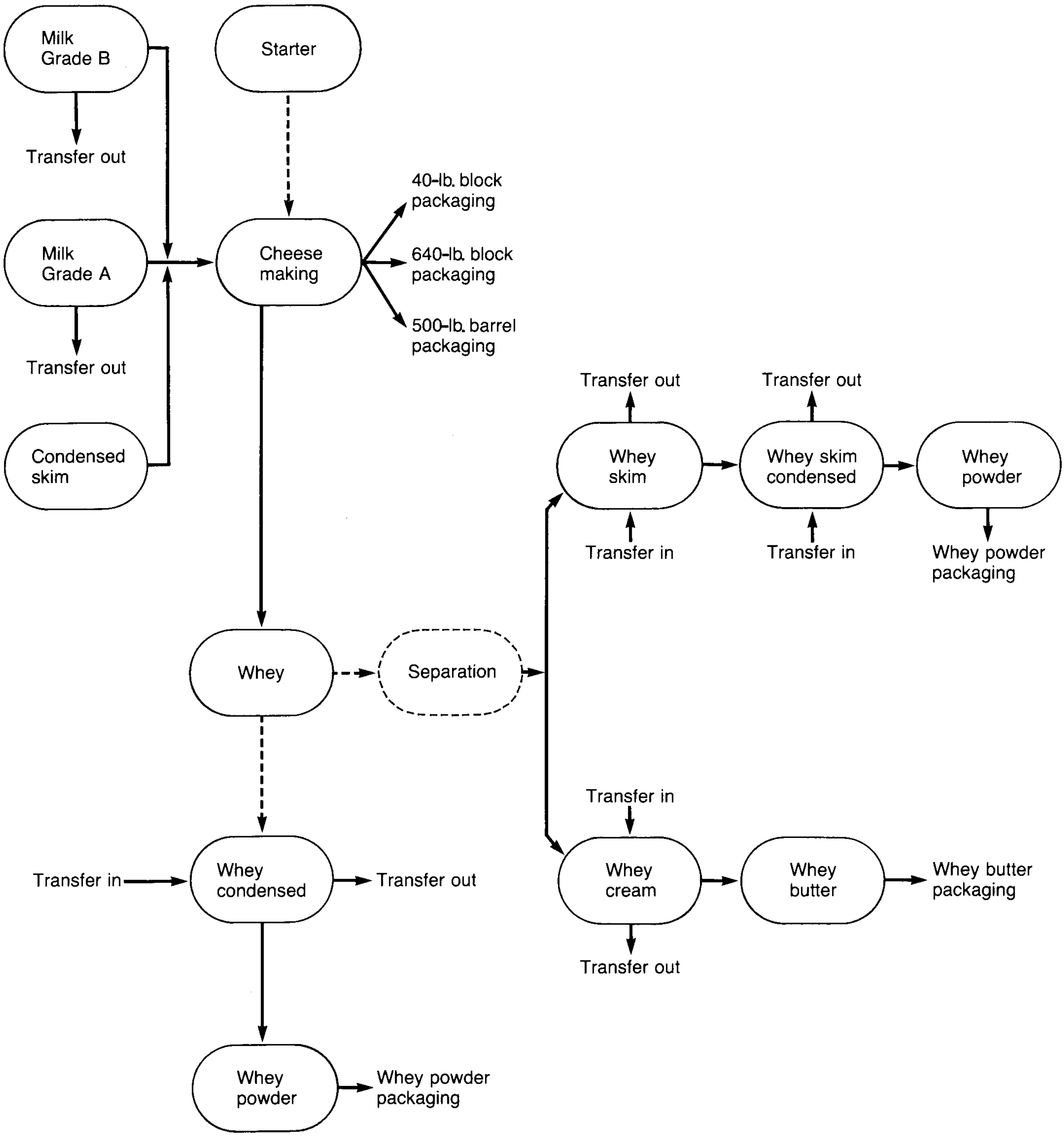
The following research procedures were followed:

- Plants of different capacity and with modern technology were deliberately selected so that cost variation due to scale of plant could be determined;
- Selected plants were visited to gain a general understanding of operations and to look for unique features at each site that might affect plant costs;
- Monthly plant operating statements were obtained, cost items were synchronized, irrelevant costs were removed, and a summary table presenting total costs and item cost ratios was prepared for each of the three products;
- To eliminate input price differences for meaningful interplant cost comparisons, wage rates, fringe benefits ratios, and utility costs were standardized;
- For each plant, average cost was examined, and an average cost curve and plant capacity were estimated;
- An "industry" longrun average cost curve was estimated for each type of plant;
- The scale of plant to take full advantage of economies of

[1] *Marketing Operations of Dairy Cooperatives*, FCS Research Report 38, Farmer Cooperative Service, USDA, June 1977.

Figure 1

Simplified product flow in a cheese plant



scale in manufacturing each product was identified; and

- Plant capacity utilization, seasonal volume variation, and the resulting cost fluctuation were examined and compared.

Costs of Manufacturing Cheese

Product Flow in a Cheese Plant

Product flow in a cheese plant is shown in figure 1. Both grade A and grade B milk may be received. Some milk may be shipped to other plants, with the remaining milk going into the manufacturing process. Some cheese plants also receive condensed skim to mix with raw milk, which raises the solid content of the milk.

Milk is piped through a pasteurization unit, then flows into cheese vats. Cheese starter and rennet are added. After the curd is formed and cooked out, it is pumped into cheddaring tables or through an automatic cheddaring machine. Cheese is usually packaged in a 40-pound block, 640-pound block, or 500-pound barrel, and then stored. In this study, four plants packaged cheese in 40-pound blocks. The one plant packaging 500-pound barrels had its packaging labor costs adjusted upward to reflect the cost it would have experienced if it had packaged 40-pound blocks.

The byproduct of cheesemaking is whey. Some plants simply dump the whey. Other plants pasteurize the whey, then dry it into whey powder and package it. Still others condense the whey and ship it out of the plant for further processing. Whey fat may be separated and shipped out or churned into whey butter.

Cheese plants are not homogeneous in their operations. Ideally, for comparing costs at each stage of the manufacturing process, costs incurred at each step of the product flow should be established. Then costs associated with transferring each intermediate product in and out of the plant should be netted out. This process would require detailed plant engineering data.

Due to time, cost, and other constraints, this study did not undertake such an involved procedure. Plant costs were taken from a plant's monthly manufacturing expense statements. Every effort was made to remove irrelevent costs. Whey products were allocated costs that could be directly identified with their processing. The remaining inplant costs were attributed to the end products.

Combined Costs of Five Cheese Plants

The manufacturing costs of the five cheese plants are summarized in table 1. The five plants incurred a total of $12.1 million in manufacturng expenses in the year. Labor costs accounted for $6.9 million, or 57.4 percent.

Table 1—Combined costs of manufacturing cheese at five cooperative plants, July 1981-June 1982

Cost item	Yearly cost	Cost per pound	Percent of total costs
	- - - - -*Dollars*- - - - -		*Percent*
Labor			
Direct labor	4,223,952	0.0264	35.1
Supervisory/indirect	1,052,407	.0066	8.7
Fringe benefits	1,640,316	.0102	13.6
Total labor	6,916,675	.0432	57.4
Utilities			
Electricity	856,949	.0054	7.1
Fuel	974,881	.0061	8.1
Total utilities	1,831,830	.0115	15.2
Water and sewage	214,076	.0013	1.8
Plant and cleaning supplies	839,062	.0052	7.0
Repair and maintenance	608,537	.0038	5.0
Depreciation	1,055,403	.0066	8.8
Taxes and insurance	403,750	.0025	3.3
Other expenses	183,107	.0011	1.5
Total costs[1]	12,052,440	.0752	100.0
Cheese manufactured	160,167,299 pounds		

[1]Four plants also reported a total of $2,948,581 for ingredients and packaging materials, at a unit cost of $0.0243 per pound of cheese.

The next major item was utilities. It represented 15.2 percent of the yearly costs, or $1.8 million. More than half of the utility cost was for fuel, while the remainder was for electricity. Natural gas was the primary fuel for cheese production, as well as for butter and powder. In some plants, propane gas and fuel oil supplemented natural gas when the latter was in short supply. However, the volume of these supplemental fuels was minor.

Depreciation was the third major cost item. At slightly more than $1 million, or 8.8 percent of the total costs, it was more expensive than fuel or electricity.

Plant and cleaning supplies accounted for 7 percent of manufacturing expenses. One plant did not separate the costs of the two. The four plants that did reported that cleaning supplies were overwhelmingly more expensive.

The four major cost items totaled 88.4 percent of the yearly manufacturing expenses. The remaining 11.6 percent was spread among repair and maintenance, taxes and insurance, water and sewage, and miniscule items.

Unit manufacturing cost was 7.52 cents per pound of the 160 million pounds of cheese produced. Of that figure, labor accounted for 4.32 cents; utilities, 1.15 cents; depreciation, 0.66 cent; and plant and cleaning supplies, 0.52 cent. Remaining items were even less.

Labor Costs in Manufacturing Cheese

Direct labor, supervisory/indirect labor, and fringe benefits are the three major categories of labor costs. Direct labor is usually identified with a particular work area and is paid on an hourly basis.

Supervisory/indirect labor usually includes plant manager and other supervisory personnel and laboratory technicians and is usually paid on a salary basis.[2] However, definitions of direct and supervisory/indirect labor are not consistent among plants.

Fringe benefits are usually paid on regular wages and salaries but not on overtime. Table 2 shows that fringe benefits were 31.1 percent of wages and salaries, including overtime, for the five plants in the study.

Total work-hours of direct labor were 413,126 hours, at an average wage rate of $10.22 per hour (including overtime).[3] Average labor productivity was 388 pounds of cheese per hour of direct labor, with a range of 271 pounds to 475 pounds. The highest productivity was achieved at the plant that used condensed skim to fortify the solids-not-fat content of the milk going into manufacturing.

[2]In this study, indirect labor does not include clerical workers.

[3]Unless otherwise specified, all averages in this report are weighted averages.

Table 2—Labor costs in manufacturing cheese at five cooperative plants

Item	Amount
Average wage rate (dollars/hour)	10.22
Average percent fringe benefits of wages and salaries (percent)	31.1
Productivity per hour of direct labor (pounds)	388
Productivity per dollar of total labor (pounds)	23.2
Total direct labor (work-hours)	413,126

The difference in labor productivity may be due partially to the discrepancy in the definition of direct labor. An alternative productivity measure may be product pounds per dollar of total labor, although it is known that wage rates are different among plants. The productivity average was 23.2 pounds per dollar of total labor, ranging from 12.6 to 33.7 pounds.

Utility Costs in Manufacturing Cheese

Electricity used by the five plants totaled 16,679,063 kilowatt-hours for the year (table 3). Cheese was manufactured at a rate of 9.6 pounds per kilowatt-hour. Electricity charges averaged 5.1 cents per kilowatt-hour, ranging from 2.1 cents to 7 cents.

As stated earlier, the principal fuel used in a plant was natural gas. When shortages of natural gas occasionally developed, propane gas, fuel oil, or another fuel was used. Because different batches of natural gas and different kinds of fuel have different heat values (measured in therms), it is useful to convert fuel usage to the same heat value unit.

Total fuel usage was 2,313,544 therms. For every therm of fuel used, an average of 69.2 pounds of cheese was produced. Average fuel cost was 42.1 cents per therm, with a low of 38.9 cents to a high of 49.7 cents.

When electricity and fuel were combined, total energy consumption was 2,882,634 therms, or 55.6 pounds of cheese per therm.

Costs of Manufacturing Butter

Product Flow in a Butter/Powder Plant

Milk receiving/shipping operations in a butter/powder plant is the same as in a cheese plant (fig. 2). Milk is then moved into

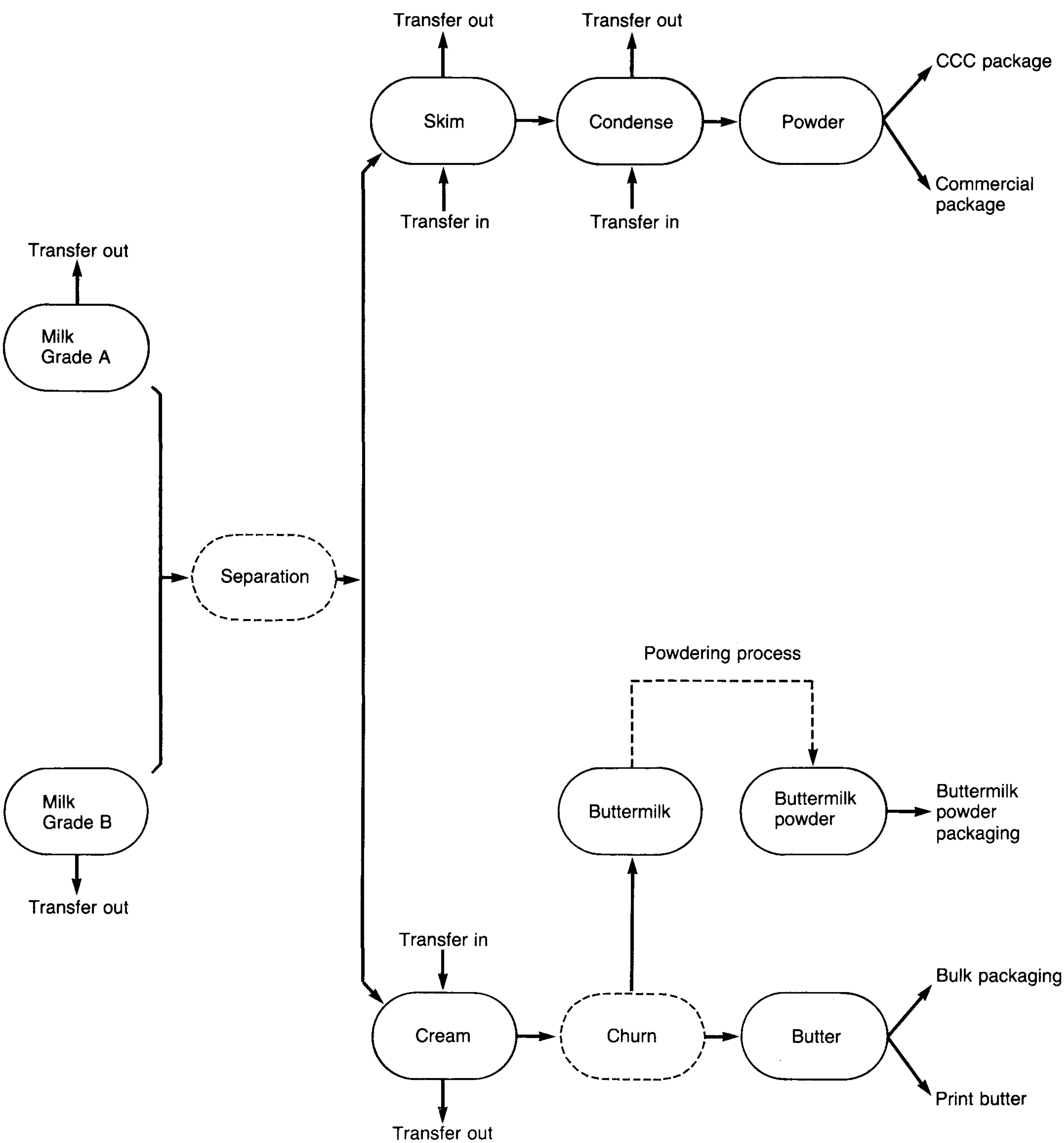
Table 3—Utility costs in manufacturing cheese at five cooperative plants

Item	Amount
Total electricity usage (KWH's)	16,679,063
Average electricity rate (cents/KWH)	5.1
Average productivity of electricity (pounds/KWH))	9.6
Total fuel usage (therms)	2,313,544
Average fuel rate (cents/therm)	42.1
Average productivity of fuel (pounds/therm)	69.2
Total energy usage (therms)[1]	2,882,634
Average productivity of energy (pounds/therm)	55.6

[1]One KWH = 3,412 BTU's = 0.03412 therm.

Figure 2

Simplified product flow in a butter/powder plant



the first step in the manufacturing process, that of being separated into skim and cream. A plant also may ship and/or receive some skim and cream.

The next step in the skim flow is condensing. Again, some condensed skim may be shipped out or received at the plant. Condensed skim is then sent through the dryer to be made into powder. The powder may be vitamin D fortified or nonfortified. It may be packaged in bags meeting Commodity Credit Corporation (CCC) specifications or in commercial units.

Cream is churned into butter. Butter may be bulk-packaged in containers specified by CCC or in commercial cardboard boxes. Some butter may be printed for consumer packaging immediately after churning and then put in cold storage. Some may be stored in bulk form and printed before shipping.

Some plants may dump buttermilk, the residue from butter churning. Most modern plants put it through a condenser and dryer to make buttermilk powder.

Combined Costs of Four Butter Plants

The four butter plants incurred a total cost of $3.4 million in manufacturing 66.6 million pounds of butter (table 4). As in the case of cheese manufacturing, labor was the major expense. At $1.6 million, it accounted for 48.4 percent of the total cost.

The share of utilities in the cost of manufacturing butter was 19.2 percent, or $0.6 million. Eighty-two percent of the utility cost was for electricity and the other 18 percent was for fuel.

Depreciation was the third major cost item with a 10.2-percent share of the total. Repair and maintenance was the fourth major cost item in manufacturing butter, accounting for 7.4 percent.

The four major cost items represented 85.2 percent of the yearly manufacturing costs. Plant and cleaning supplies, taxes and insurance, water and sewage, and minor expenses shared the remaining 14.8 percent.

Unit manufacturing cost was 5.07 cents per pound of butter. Unit labor cost was 2.45 cents and unit utility cost, 0.98 cent.

Labor Costs in Manufacturing Butter

The 66.6 million pounds of butter took 79,798 work-hours of direct labor to produce (table 5), at an average wage rate of $10.50 per hour (including overtime). Fringe benefits averaged 32.1 percent of wages and salaries. Labor productivity ranged from 608 pounds to 1,216 pounds of butter per hour of direct labor and the average was 834 pounds. Productivity per dollar of total labor was 40.8 pounds, varying between 29.7 and 54.1 pounds.

Table 4—Combined costs of manufacturing butter at four cooperative plants, July 1981-June 1982

Cost item	Yearly cost	Cost per pound	Percent of total costs
	Dollars		*Percent*
Labor			
Direct labor	837,499	0.0126	24.8
Supervisory/indirect	398,603	.0060	11.8
Fringe benefits	396,558	.0059	11.8
Total labor	1,632,660	.0245[1]	48.4
Utilities			
Electricity	529,763	.0080	15.7
Fuel	117,126	.0018	3.5
Total utilities	646,889	.0098	19.2
Water and sewage	25,009	.0004	.7
Plant and cleaning supplies	163,956	.0024	4.9
Repair and maintenance	250,107	.0038	7.4
Depreciation	345,093	.0052	10.2
Taxes and insurance	138,318	.0021	4.1
Other expenses	171,077	.0026	5.1
Total costs[2]	3,373,110	.0507	100.0
Butter manufactured:	66,562,600 pounds		

[1]Labor cost might have been biased upward somewhat because 1-pound and 5-pound butter were printed at some plants. However, the small volume printed should not affect the cost in a material way.

[2]The four butter plants also reported $220,846 for ingredients and packaging materials, at a unit cost of $0.0033 per pound of butter.

Table 5—Labor costs in manufacturing butter at four cooperative plants

Item	Amount
Average wage rate (dollars/hour)	10.50
Average percent fringe benefits of wages and salaries (percent)	32.1
Productivity per hour of direct labor(pounds)	834
Productivity per dollar of total labor (pounds)	40.8
Total direct labor (work-hours)	79,798

Utility Costs in Manufacturing Butter

The four butter plants consumed 8,233,444 kilowatt-hours of electricity during the year (table 6). Productivity was 8.1 pounds of butter per kilowatt-hour. Average electricity rate was 6.4 cents per kilowatt-hour, ranging from 4.6 cents to 7.5 cents.

In heat value, 289,522 therms of fuel were used. Fuel productivity averaged 229.9 pounds of butter per therm at an average fuel rate of 40.5 cents per therm. The fuel rate range was between 31.5 cents and 48.1 cents.

Total energy (electricity and fuel) used was 570,447 therms. A therm of energy could produce an average of 116.7 pounds of butter.

Table 6—Utility costs in manufacturing butter at four cooperative plants

Item	Amount
Total electricity usage (KWH's)	8,233,444
Average electricity rate (cents/KWH)	6.4
Average productivity of electricity (pounds/KWH)	8.1
Total fuel usage (therms)	289,522
Average fuel rate (cents/therm)	40.5
Average productivity of fuel (pounds/therm))	229.9
Total energy usage (therms)[1]	570,447
Average productivity of energy (pounds/therm)	116.7

[1]One KWH = 3,412 BTU's = 0.03412 therm.

Costs of Manufacturing Nonfat Dry Milk

Combined Costs of Five Powder Plants

Table 7 summarizes the yearly costs of the five powder plants. Some 175 million pounds of powder was manufactured at a total cost of $18.7 million. The major cost was $7.3 million for utilities, or 38.9 percent of the total. Fuel cost was just over $6 million, or 32 percent, while electrical cost was $1.3 million, or 6.9 percent.

Total labor cost was $6.3 million, a 33.8-percent share. Depreciation was $1.5 million, or 7.8 percent of the total cost. Repair and maintenance cost was $1.3 million, a 6.9-percent share.

The above four major cost items accounted for 87.4 percent of the total manufacturing cost. The remaining 12.6 percent was shared by the other four relatively minor cost items.

On a per-unit basis, it cost 10.69 cents to manufacture a pound of powder. Unit labor cost was 3.62 cents and unit utility cost was 4.16 cents per pound. Depreciation cost 0.83 cent and repair and maintenance, 0.74 cent.

Labor Costs in Manufacturing Powder

Direct labor for the five plant operations combined was 269,538 work-hours (table 8), at an average wage rate of $11.37 per work-hour (including overtime). Fringe benefits on average were 35.2 percent of total wages and salaries.

Average labor productivity was 651 pounds of powder per work-hour of direct labor, ranging from 468 pounds to 820 pounds. Average output of powder per dollar of total labor was 27.6 pounds, with a low of 19.2 pounds and a high of 34.1 pounds.

Table 7—Combined costs of manufacturing nonfat dry milk at five cooperative plants, July 1981-June 1982

Cost item	Yearly cost	Cost per pound	Percent of total costs
	- - - - -*Dollars*- - - - -		*Percent*
Labor			
Direct labor	3,063,787	0.0175	16.3
Supervisory/indirect	1,630,485	.0093	8.7
Fringe benefits	1,651,000	.0094	8.8
Total labor	6,345,272	.0362	33.8
Utilities			
Electricity	1,293,203	.0074	6.9
Fuel	6,004,688	.0342	32.0
Total utilities	7,297,891	.0416	38.9
Water and sewage	208,977	.0012	1.1
Plant and cleaning supplies	954,616	.0054	5.1
Repair and maintenance	1,292,653	.0074	6.9
Depreciation	1,451,794	.0083	7.8
Taxes and insurance	541,323	.0031	2.9
Other expenses	652,650	.0037	3.5
Total costs[1]	18,745,176	.1069	100.0
Nonfat dry milk manufactured:175,387,637 pounds			

[1]The five plants also reported $1,763,861 for packaging materials, at a unit cost of $0.0101 per pound of powder.

Table 8—Labor costs in manufacturing powder at five cooperative plants

Item	Amount
Average wage rate (dollars/hour)	11.37
Average percent fringe benefits of wages and salaries (percent)	35.2
Productivity per hour of direct labor (pounds)	651
Productivity per dollar of total labor (pounds)	27.6
Total direct labor (work-hours)	269,538

Utility Costs in Manufacturing Powder

The five plant operations combined required 26,277,466 kilowatt-hours of electricity during the year (table 9). Electricity rate ranged from a low of 2.2 cents to a high of 7.4 cents, and averaged 4.9 cents per kilowatt-hour. Productivity was 6.7 pounds of powder per kilowatt-hour.

Total fuel consumption was 14,131,615 therms, at an average cost of 42.5 cents per therm. Fuel cost varied between 33.2 cents and 48.5 cents per therm. Productivity per therm of fuel was 12.4 pounds of powder.

Energy usage in total was 15,028,202 therms. It took 1 therm of energy to manufacture 11.7 pounds of powder.

Table 9—Utility costs in manufacturing powder at five cooperative plants

Item	Amount
Total electricity usage (KWH's)	26,277,466
Average electricity rate (cents/KWH)	4.9
Average productivity of electricity (pounds/KWH)	6.7
Total fuel usage (therms)	14,131,615
Average fuel rate (cents/therm)	42.5
Average productivity of fuel (pounds/therm)	12.4
Total energy usage (therms)[1]	15,028,202
Average productivity of energy (pounds/therm)	11.7

[1]One KWH = 3,412 BTU's = 0.03412 therm.

Table 10—Comparison of wage rates and fringe benefits for manufacturing cheese, butter, and powder

Product	Average wage rate[1]	Fringe benefits as a percent of wages and salaries
	Dollars/hour	*Percent*
Cheese	10.22	31.1
Butter	10.50	32.1
Powder	11.37	35.2

[1]Including overtime.

Comparisons of Manufacturing Costs For Cheese, Butter, and Nonfat Dry Milk

Comparison of Cost Structures

There were similarities but also marked differences in cost structures among the three products (tables 1, 4, and 7). The most remarkable contrast was between cheese and powder. Direct labor was the single most important input item and accounted for more than a third (35.1 percent) of the cost of manufacturing cheese. Fuel input was the most important in making powder and represented about a third (32 percent) of the powder manufacturing cost. Total labor cost of making cheese represented 57.4 percent of the manufacturing cost, while making powder was 33.8 percent. Share of utility cost in manufacturing cheese was 15.2 percent, compared with 38.9 percent in powder production.

Although all three products were heavy users of labor, cheese was the most labor intensive. Powder was the most energy intensive.

The three most important cost items for all three products were labor, utilities, and depreciation. Together, they accounted for about 80 percent of the total manufacturing cost of each product.

Comparison of Labor Costs

Average wage rate (including overtime) varied from $10.22 for manufacturing cheese to $10.50 for butter and $11.37 for powder (table 10). The variation reflects the differences in regional makeup of the plants. It also might reflect differences in the use of overtime labor.

Fringe benefits as a percentage of wages and salaries averaged 31.1 percent for cheese, 32.1 percent for butter, and 35.2 percent for powder. Individual plant cost data indicated that plants with higher wage rates also tended to have proportionately higher fringe benefits and vice versa.

On a product pound basis, productivity per hour of direct labor or per dollar of total labor was the highest for butter and the lowest for cheese (table 11). Cheese was the most labor-

Table 11—Comparison of labor productivity in manufacturing cheese, butter, and powder

Product	Productivity per hour of direct labor	Range	Productivity per dollar of total labor	Range
		Pounds		
Cheese	388	271-475	23.2	12.6-33.7
Butter	834	608-1,216	40.8	29.7-54.1
Powder	651	468-820	27.6	19.2-34.1

Table 12—Comparison of utility rates in manufacturing cheese, butter, and powder

Product	Electricity		Fuel	
	Average rate	Range	Average rate	Range
	Cents/KWH		*Cents/therm*	
Cheese	5.1	2.1-7.0	42.1	38.9-49.7
Butter	6.4	4.6-7.5	40.5	31.5-48.1
Powder	4.9	2.2-7.4	42.5	33.2-48.5

Table 13—Comparison of energy productivity in manufacturing cheese, butter, and powder

Product	Electricity	Fuel	Total utility
	Pounds/KWH	- - -*Pounds/therm*- - -	
Cheese	9.6	69.2	55.6
Butter	8.1	229.9	116.7
Powder	6.7	12.4	11.7

Table 14—Summary of average input costs of the cheese, butter, and powder plants

Product	Wage rate	Fringe benefits as a percent of wages and salaries	Electricity rate	Fuel rate
	Dollars/hour	*Percent*	*Cents/KWH*	*Cents/therm*
Cheese	10.22	31.1	5.1	42.1
Butter	10.50	32.1	6.4	40.5
Powder	11.37	35.2	4.9	42.5

intensive product, based either on the cost ratio basis (tables 1, 4, and 7) or on the labor productivity basis (table 11).

Measured by physical productivity per unit of labor (table 11), butter was the least labor intensive. However, measured by input cost as a percent of total cost (tables 1, 4, and 7), powder was the least labor intensive. Therefore, which product was the least labor intensive depends on the definition of the term.

Comparison of Utility Costs

As in the case of wage rate, the variation in electricity and fuel rates reflects regional differences of the plants for each product. The electricity rate varied from a low of 2.1 cents per kilowatt-hour to a high of 7.5 cents (table 12). Variation in the fuel rate was more moderate. The low was 31.5 cents per therm and the high 49.7 cents.

Cheese production was 9.6 pounds per kilowatt-hour, the highest productivity by electricity among the three products (table 13). The lowest was powder at 6.7 pounds. Productivity by fuel was the highest for butter at a rate of 229.9 pounds per therm. Powder was again the lowest at 12.4 pounds.

When electricity was also converted to its heat value (1 kilowatt-hour = 0.03412 therm), the per therm productivity by combined energy was 116.7 pounds of butter, 55.6 pounds of cheese, or 11.7 pounds of powder.

While powder was clearly the most energy-intensive product, it was not certain which product was the least. On a cost ratio basis (tables 1, 4, and 7), cheese was the least energy intensive. When measured on a physical productivity per unit of energy input basis, butter was the least energy intensive. Whether cheese or butter is the least energy intensive depends on how the term is defined.

Compared with cheese and powder manufacturing, butter production is a less involved process. This might help explain the relatively high labor and energy productivity in butter manufacturing. As far as physical productivity is concerned, butter is the least labor intensive and the least energy intensive among the three products.

Plant Capacities, Rates of Utilization, Seasonal Variations, and Manufacturing Costs

Scale of plant, utilization of capacity, and seasonal variation affect the costs of manufacturing cheese, butter, and powder. Average input costs of the five cheese plants, four butter plants, and five powder plants reported in the previous sections are used to replace wage rate, fringe benefit ratio, and electricity and fuel rates for each individual plant (table 14). The direct to supervisory/indirect labor ratio remains at the previous level of each plant.

There are two reasons for using the average input costs throughout all plants. First, differences in input prices among plants can be minimized. This makes cost comparisons among plants of different sizes and rates of capacity utilization more meaningful. Labor and utility costs account for 72.6 percent of the manufacturing cost in cheese (table 1), 67.6 percent in butter (table 4), and 72.7 percent in powder (table 7). By using the average input costs, two-thirds to three-quarters of input prices in manufacturing the three products are standardized.

Second, the true manufacturing cost of an individual plant is hidden. This makes it possible to present the cost function of each plant without jeopardizing the confidentiality of privileged cost information.

Another adjustment is made on utility costs. Annual total kilowatt-hours and total therms, and the associated costs at each plant, were allocated to each month based on the pounds of products manufactured. This is because utility bills tend not to correspond exactly to the production schedule at a plant and the meter reading cycle is often erratic. Short of exactly metering utility usages, the adjustment in this section is necessary to minimize cost distortions. The same adjustment is also made on water and sewage bills.

The Five Cheese Plants

Average costs of the five cheese plants for the 12 months are plotted in figure 3. Average cost generally decreased with the increase in the scale of plant. The highest average cost occurred in plant No. 1 in April 1982 at 20.9 cents per pound of the 14,000 pounds of cheese manufactured daily. Plant No. 5 had the lowest average cost in September 1981 at 5.47 cents a pound when 173,209 pounds of cheese a day was made. Because wage rates for direct labor and utility rates have been standardized, differences in the average cost among plants would reflect differences in labor efficiency, energy efficiencies, supervisory/indirect labor, depreciation, repair and maintenance, supplies, and other costs.

Average cost fluctuated even within a plant. Even when daily production was the same or similar for 2 months, average costs between the months might be different. There were probably two principal reasons, among others, responsible for the cost gyration. Plant and cleaning supplies and materials for repair and maintenance might have been recorded in the month when they were purchased rather than when they were used. The other reason was that common accounting practice would allocate depreciation, taxes, and insurance to each month on a 12-month basis. When the monthly costs were allocated to a daily basis, they were somewhat distorted.

The average costs of the cheese plants followed the shape of Average Cost (AC) curves prescribed in classical economics. An AC curve was estimated for each plant by using the Ordinary Least Squares (OLS) regression method (fig. 4).

The AC curve for plant No. 1 indicates the average cost decreases at a decreasing rate as volume increases and reaches its lowest point A at the plant's estimated daily capacity of 25,890 pounds when the cost is 14.56 cents. After point A, average cost increases as plant operates beyond capacity. Actual average cost fluctuated around the AC curve.

For plant No. 2, the AC curve is similar to plant No. 1, but the curve is flatter because at a higher volume AC tends to decrease (or increase) at a slower rate. The capacity of the plant is estimated at point B, where daily production is 56,360 pounds at a cost of 8.31 cents per pound. Beyond point B, if the plant operates beyond its capacity, AC would rise.

AC curve for plant No. 3 could not be estimated accurately by the regression method. It appeared that plant No. 3 operated beyond its capacity after point C. In that case, while the fixed cost component would decrease, the variable cost component would increase depending on how severely the increased production causes inefficiency and downtime. As a result, its average cost would tend to rise but fluctuate very irregularly. This would cause problems for estimating cost curves. However, it appears that plant No. 3 has an AC curve as indicated in figure 4. Its capacity is represented by point C, at an estimated 103,000 pounds per day and an average cost of 6.36 cents per pound.

Similarly, the AC curve for plant No. 4 could not be accurately estimated. It seems that this plant has a capacity of around 100,000 pounds of cheese a day and had been operating beyond its capacity during the 12-month study period. Its average costs were constantly higher than a plant of similar size (plant No. 3).

Plant No. 5 has the most capacity of the five. Its AC curve appears to be very flat. Its daily capacity is estimated at 173,000 pounds, at a cost of 5.55 cents per pound. During the 12 months, the plant reached its capacity only once. However, because its AC curve is very flat, minimum AC can be achieved so long as the volume is maintained approaching capacity. The plant seems to have followed that practice during the major part of the year.

Scales of plants and their associated average costs at capacity are summarized in table 15. With the increases in capacities, economies of scale decrease at a decreasing rate. When the plant capacity increases by 30,470 pounds from plant No. 1 to plant No. 2, average cost decreases 6.25 cents. From plant No. 2 to plant No. 3, plant capacity increases by 46,640 pounds, while average cost decreases 2.95 cents. When the plant capacity further increases another 70,000 pounds to plant No. 5, average cost decreases only 0.81 cents. It appears that plant No. 5 is approaching the least-cost scale of plant of the cheese industry.

Based on the cost data of the four cheese plants (except plant No. 4), a Longrun Average Cost (LAC) curve was also estimated (fig. 5).[4] From the shape of this cost curve it might

[4]In theory, a longrun average cost curve is an envelope curve tangent to the average cost curves of various plant scales. Such an envelope curve is not easily attainable as it requires data from a large number of plants to estimate. The longrun average cost curve estimated here is an approximation.

Figure 3

Average Manufacturing Costs of Five Cheese Plants

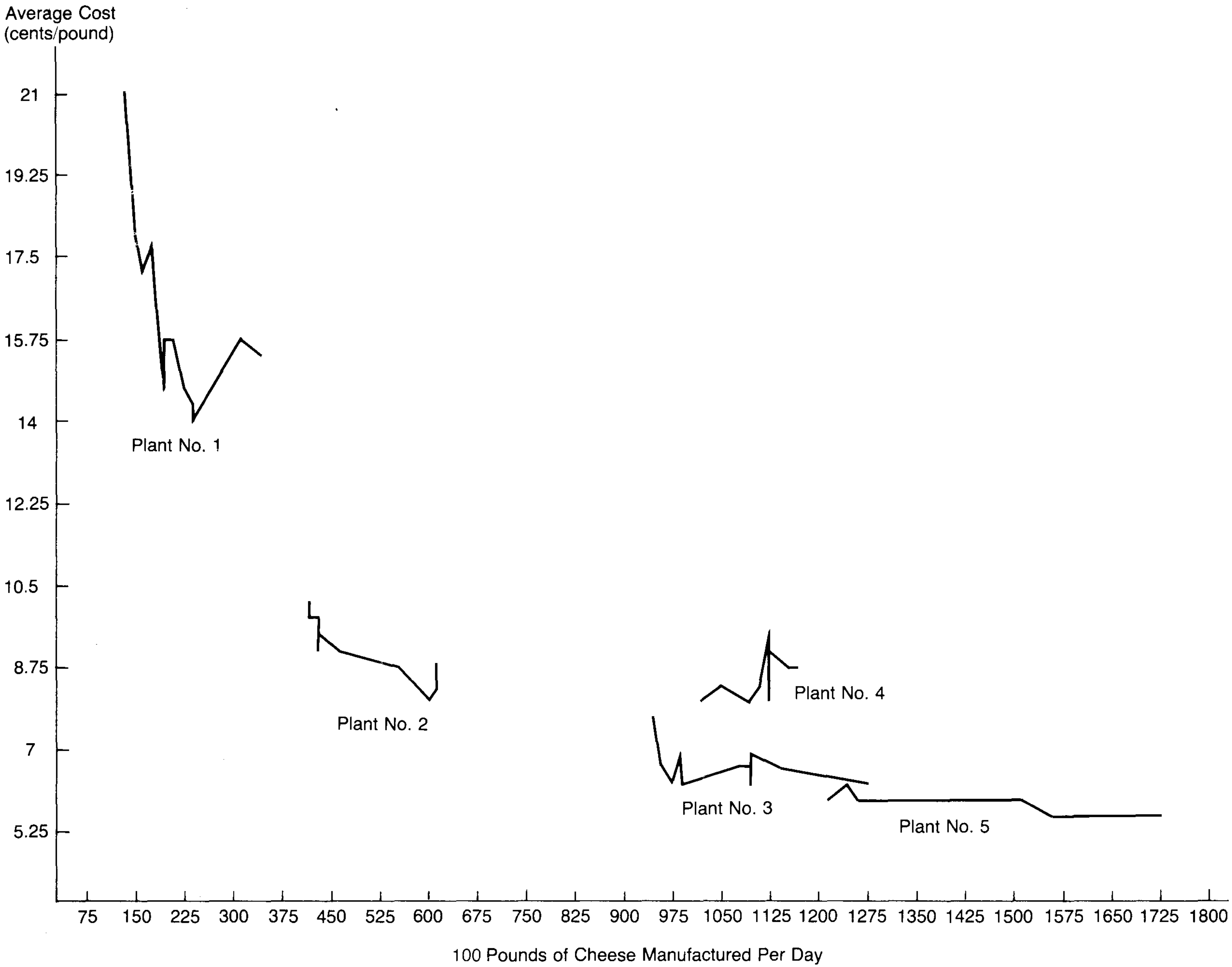


Figure 4

Average Cost Curves of Five Cheese Plants

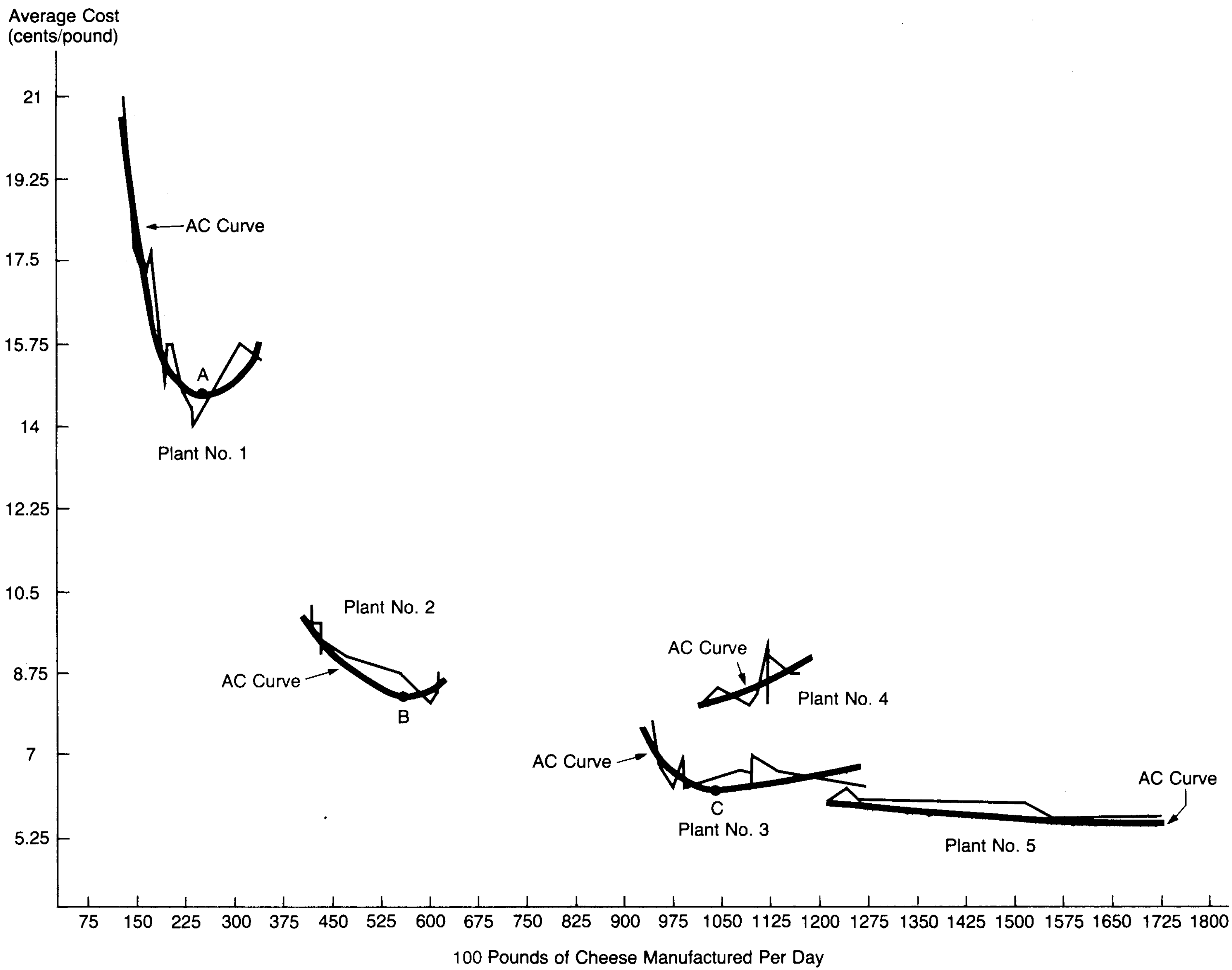


Figure 5

Longrun Average Cost Curve Based on Four Cheese Plant Data

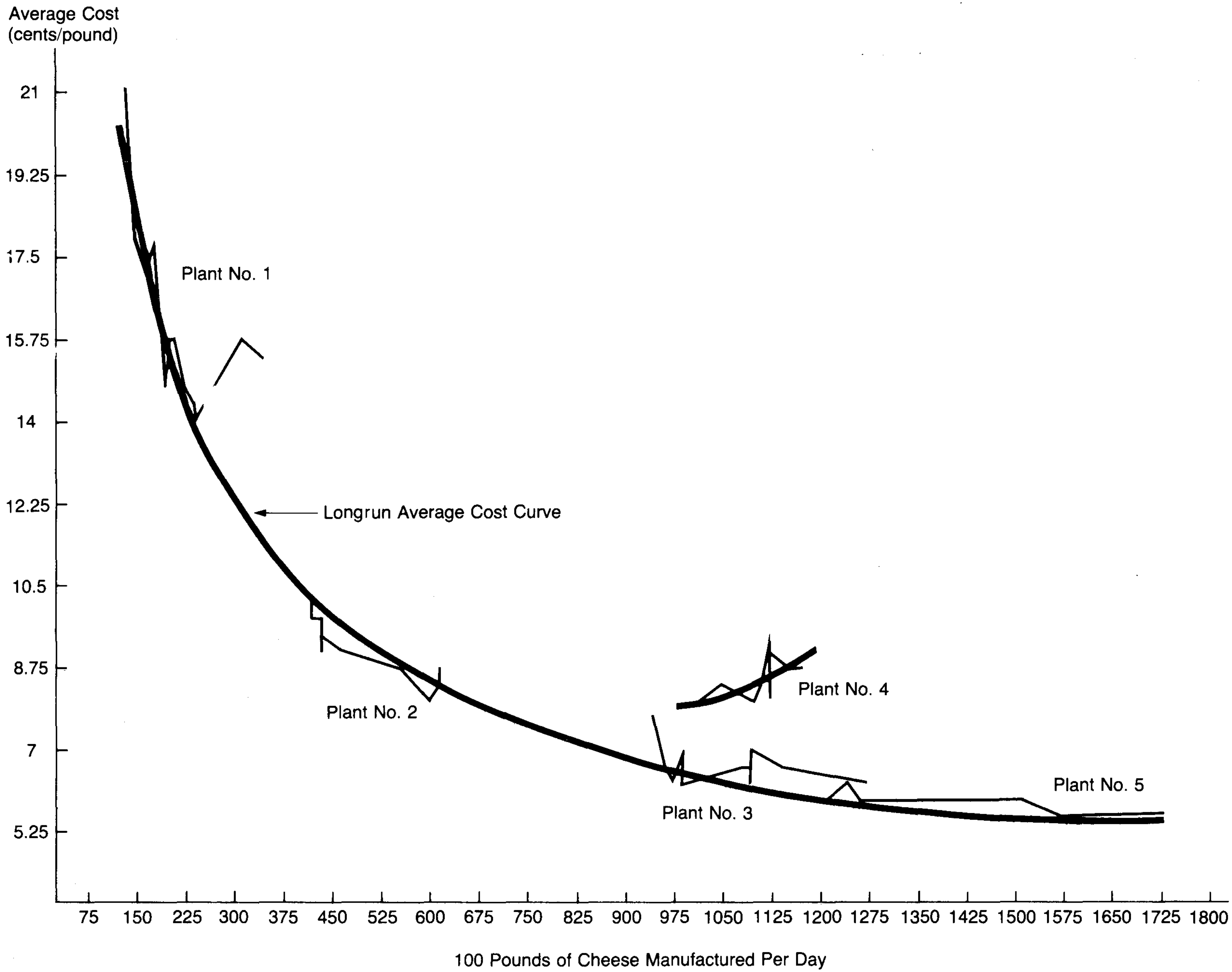


Table 15—Cheese plant sizes and average costs at capacity

Plant number	Estimated plant capacity	Difference from plant next in capacity	Average cost at capacity	Cost difference from plant next in capacity
	- - -Pounds/day- - -		- -Cents per pounds- -	
1	25,890	–	14.56	–
2	56,360	30,470	8.31	−6.25
3	103,000	46,640	6.36	−2.95
4	[1]100,000	–	–	–
5	173,000	70,000	5.55	−0.81

– not applicable.

[1]Size of this plant could not be accurately estimated by the OLS method.

be concluded that under current technology, few cost savings from economies of scale can be gained by building a plant with a capacity larger than 180,000 pounds of cheese a day.

Seasonal variation in average cost reflects seasonal fluctuation of volume manufactured. Average cost and production index as a percent of estimated plant capacity in figure 6 show that (except for plant No. 4), average costs are almost mirror images of the production indexes. In other words, when production was high, average cost tended to be low, and vice versa. This was generally true when the volume did not exceed the estimated plant capacity. When the volume was higher than the plant capacity, average cost tended to rise and fall with the volume manufactured.

Plant No. 1 fit the description very well. During the 10 months prior to May 1982, its volume fluctuated below plant capacity. Its average cost fluctuated almost inversely with the volume. Average cost was the lowest in March when the daily output approached plant capacity. When the volume fell to its lowest level in April, average cost was the highest, compared with other months. When the volume increased in May and June to a seasonally high level far exceeding plant capacity, average cost fell somewhat but remained at a high level. Plants No. 2 and No. 3 are similar. Plant No. 3 appeared to have attempted to maintain its volume around the plant capacity, except in May and June when the plant performed a seasonal balancing function.

Plant No. 4 had the lowest average cost in November 1981 when its volume fell to the level close to the plant capacity. Because the plant exceeded its capacity throughout the year, its average cost rose and fell with the fluctuation of volume manufactured.

Figure 6

Seasonal Variation of Cheese Production and Cost

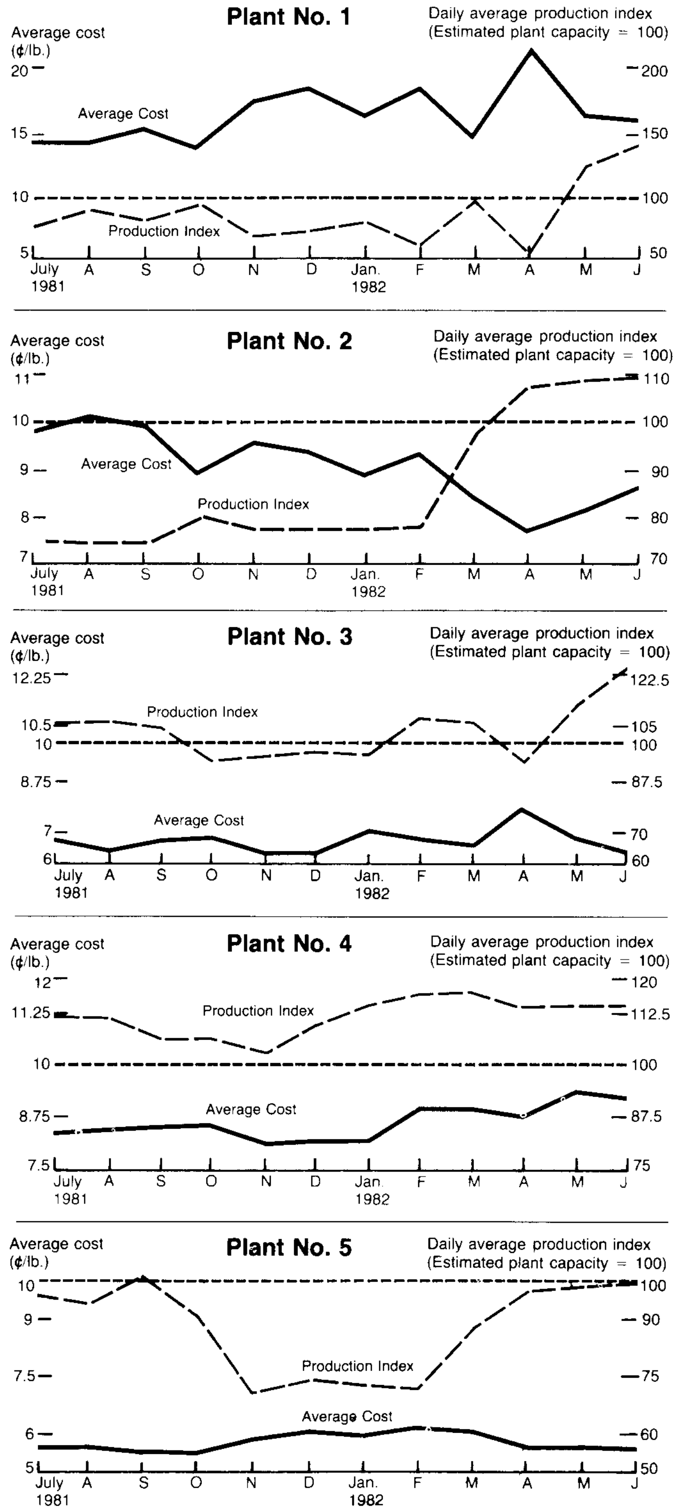


Figure 7

Average Manufacturing Costs of Four Butter Plants

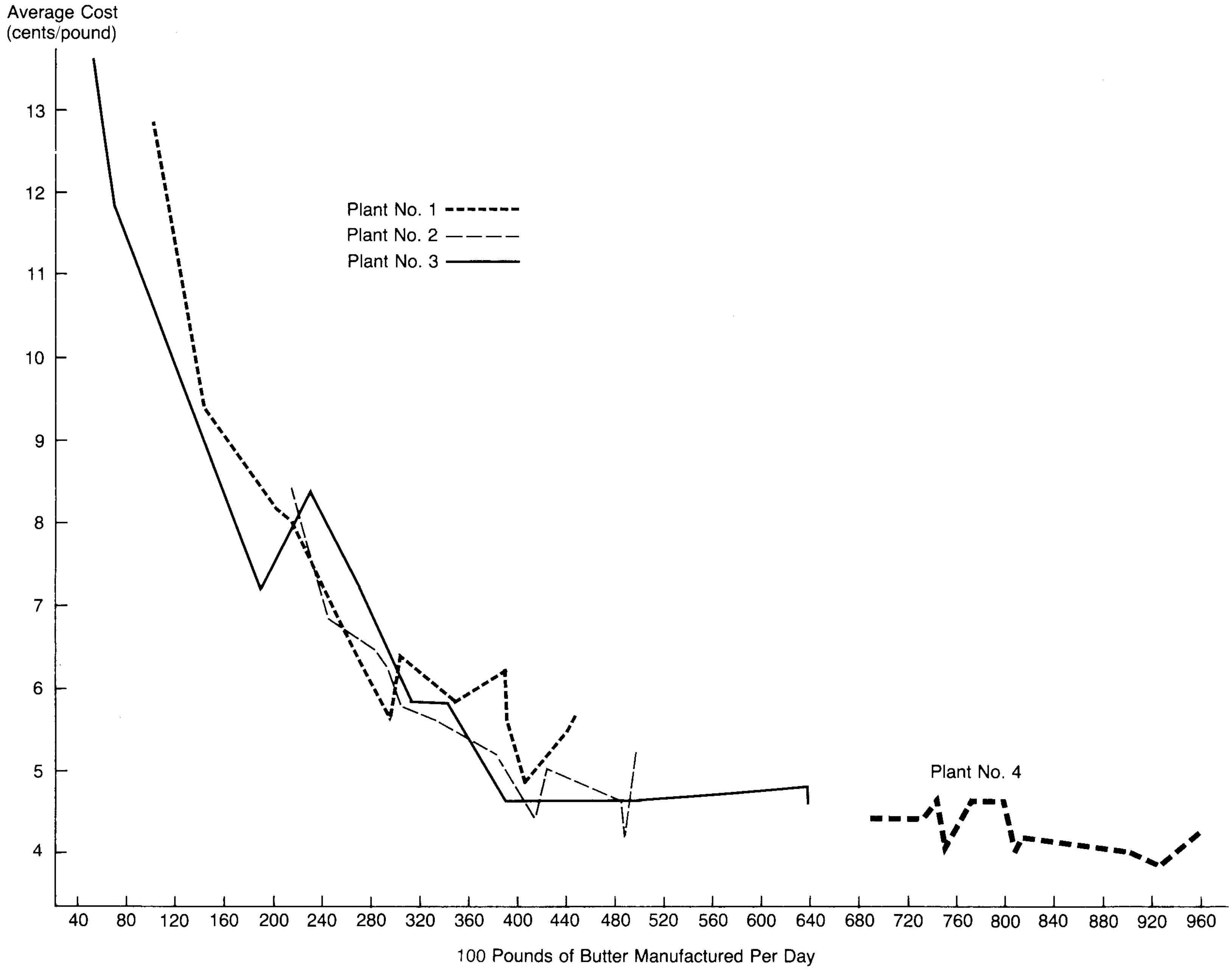
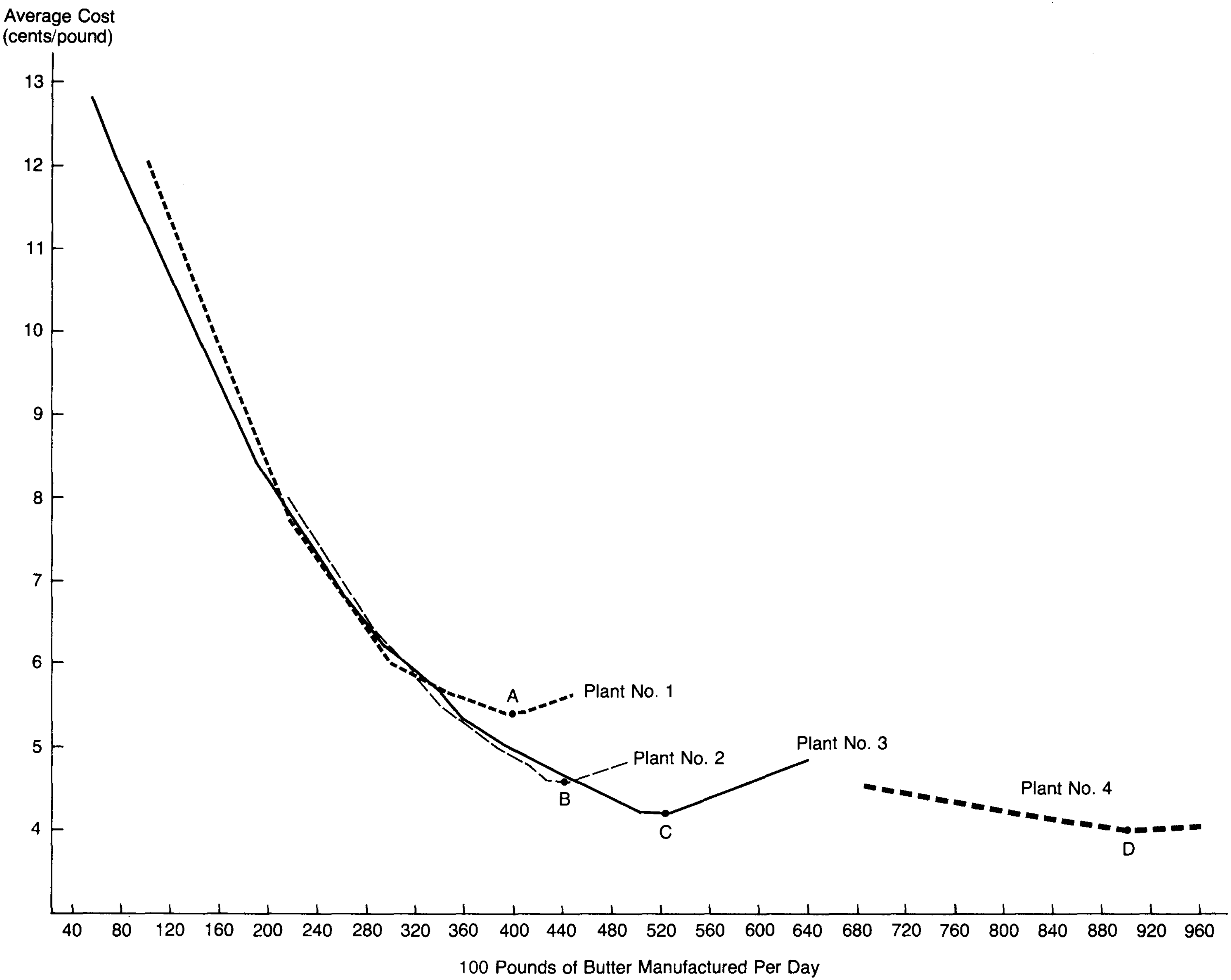


Figure 8

Average Cost Curves of Four Butter Plants



Operating below the capacity throughout the year was plant No. 5, except for September 1981 when it operated at full capacity. Average cost also was the lowest that month. The other two low-average-cost months were May and June 1982 when the volume was near capacity. Average cost was the highest when the volume was at its seasonal low from November through February.

The Four Butter Plants

Average costs of the four butter plants are plotted in figure 7. The chart suggests the three smaller plants are of similar scales and have similar manufacturing technology. The highest average cost occurred in plant No. 3 in February 1982 when it manufactured 5,426 pounds of butter at a unit cost of 13.6 cents. In the same month, plant No. 4 manufactured 93,114 pounds at 3.9 cents per pound, the lowest manufacturing cost among all average costs.

Average cost curves were estimated for the four plants and are shown in figure 8. Plant No. 1 had the smallest scale among the four. The daily capacity of the plant was estimated at 39,140 pounds (point A). At that point the minimum average cost was 5.43 cents.

The estimated capacity for plant No. 2 was 45,370 pounds of butter (point B). The average cost at the full capacity was 4.65 cents. The scale of plant No. 3 was slightly larger. Point C indicates the capacity of the plant was 52,840 pounds at a cost of 4.26 cents per pound. Plant No. 4 had the largest scale, with a daily capacity of 90,520 pounds and a minimum average cost of 3.92 cents, as denoted by point D. Table 16 summarizes the plants' costs at capacity.

When capacity increases 6,230 pounds from plant No. 1 to plant No. 2, average cost decreases 0.78 cent. The reduction in average cost is 0.39 cent when plant capacity increases another 7,470 pounds from plant No. 2 to plant No. 3. When plant capacity further increases another 37,680 pounds to the largest plant No. 4, average cost decreases only 0.34 cent. The decrease in average cost is at a decreasing rate as the plant capacity increases. Of the four plants, No. 4 probably can best take full advantage of economies of scale, as suggested by the longrun average cost curve in figure 9.

Butter plants display a very seasonal nature of operations. Generally, volume of butter manufactured is higher in the winter and spring months and is very low in summer (fig. 10). The main function of these plants is probably for balancing seasonal milk supplies.

Plant No. 1 operated at only 27 percent of capacity in July 1981. The utilization rate increased to 112 percent of capacity in January 1982 and to 114 percent in February, then declined to 37 percent in June. The same pattern was followed by plant No. 2. Its capacity utilization rate was 47 percent in July 1981, increased to 109 percent in March 1982, and slipped to 108 percent in April. It then plummeted to 64 percent in May.

Table 16—Butter plant sizes and average costs at capacity

Plant number	Estimated plant capacity	Difference from plant next in capacity	Average cost at capacity	Cost difference from plant next in capacity
	- - -*Pounds/day*- - -		- -*Cents per pounds*- -	
1	39,140	—	5.43	—
2	45,370	6,230	4.65	−0.78
3	52,840	7,470	4.26	−.39
4	90,520	37,680	3.92	−.34

For plant No. 3, the capacity utilization rate was as low as 13 percent in July 1981 and 10 percent in August. It rose to 65 percent in October and fluctuated between 50 and 75 percent through February 1982. It then jumped to 122 percent in March and April, and dropped to 45 percent in June.

For the major part of the year, plant No. 4 appeared to have attempted to hold its volume between 80 and 90 percent of capacity. It operated slightly above capacity in January and February 1982 and at capacity for the next 2 months. Average cost was the lowest during the 3 months, February through April.

As in the case of cheese, average cost of manufacturing butter reflects seasonal variation of product pounds manufactured. As a general rule, when the manufacturing operation is at or near full capacity, average cost is the lowest. Average cost increases as the product volume deviates from the plant capacity. This is clearly delineated in figure 10.

The Five Powder Plants

Average costs of the five powder plants, along with their estimated average cost curves, are shown in figure 11. Unlike cheese and butter where cost curves tend to line up from upper-left corner of the chart for the plant with the least capacity to lower-right corner for the largest plant, the relation between the scale of powder plant and average manufacturing cost is not so clear. As also shown in table 17, plant No. 1 at a capacity of 32,000 pounds of powder a day had an average cost 1.69 cents lower than a plant nearly double its capacity (plant No. 2), 1.96 cents lower than a plant triple its capacity (plant No. 3), and only 0.07 cent higher than a plant more than four times its capacity (plant No. 4). Plant No. 2 had an average cost 0.27 cent less than plant No. 3, which had 50 percent

Figure 9

Longrun Average Cost Curve Based on Four Butter Plant Data

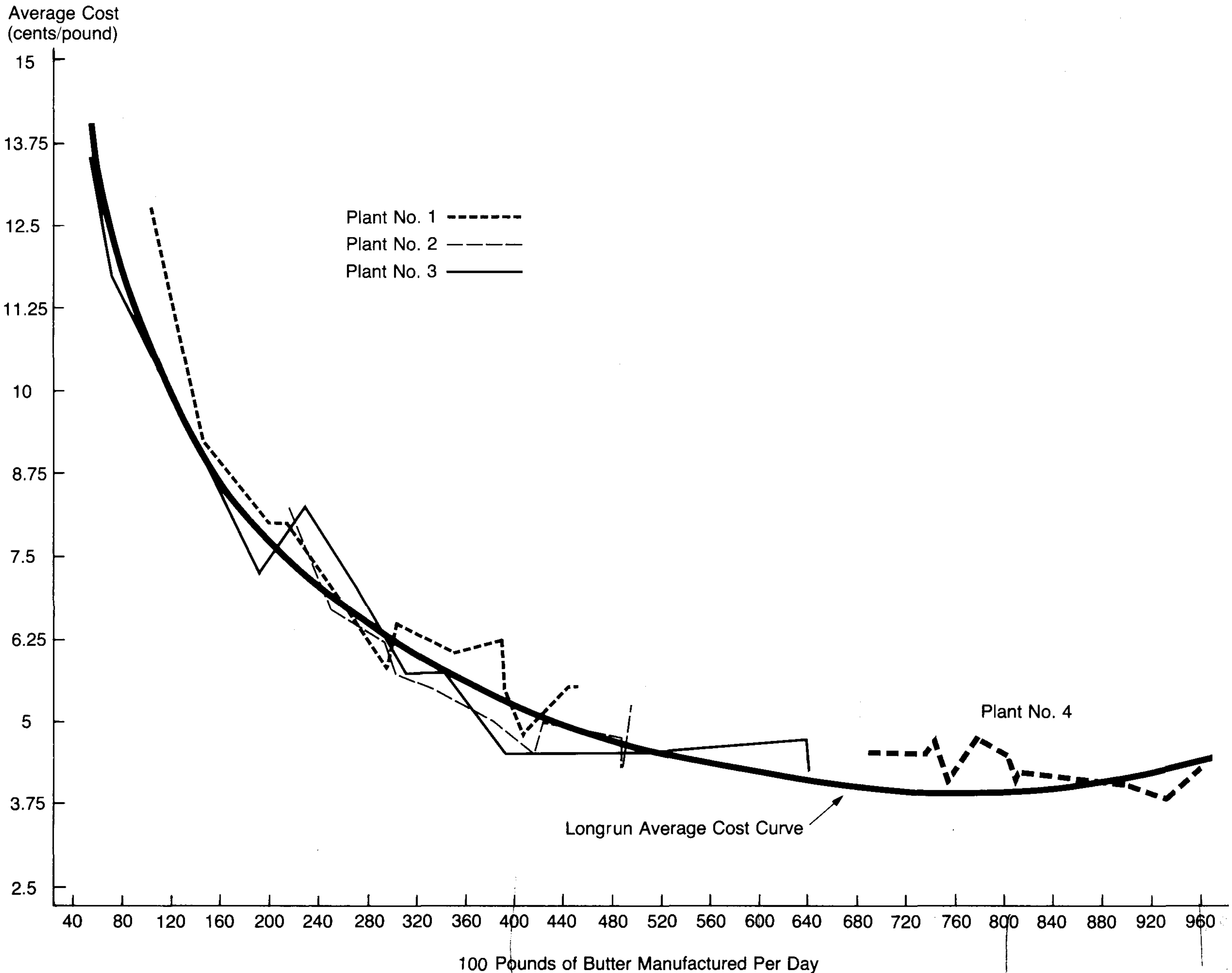


Figure 10

Seasonal Variation of Butter Production and Cost

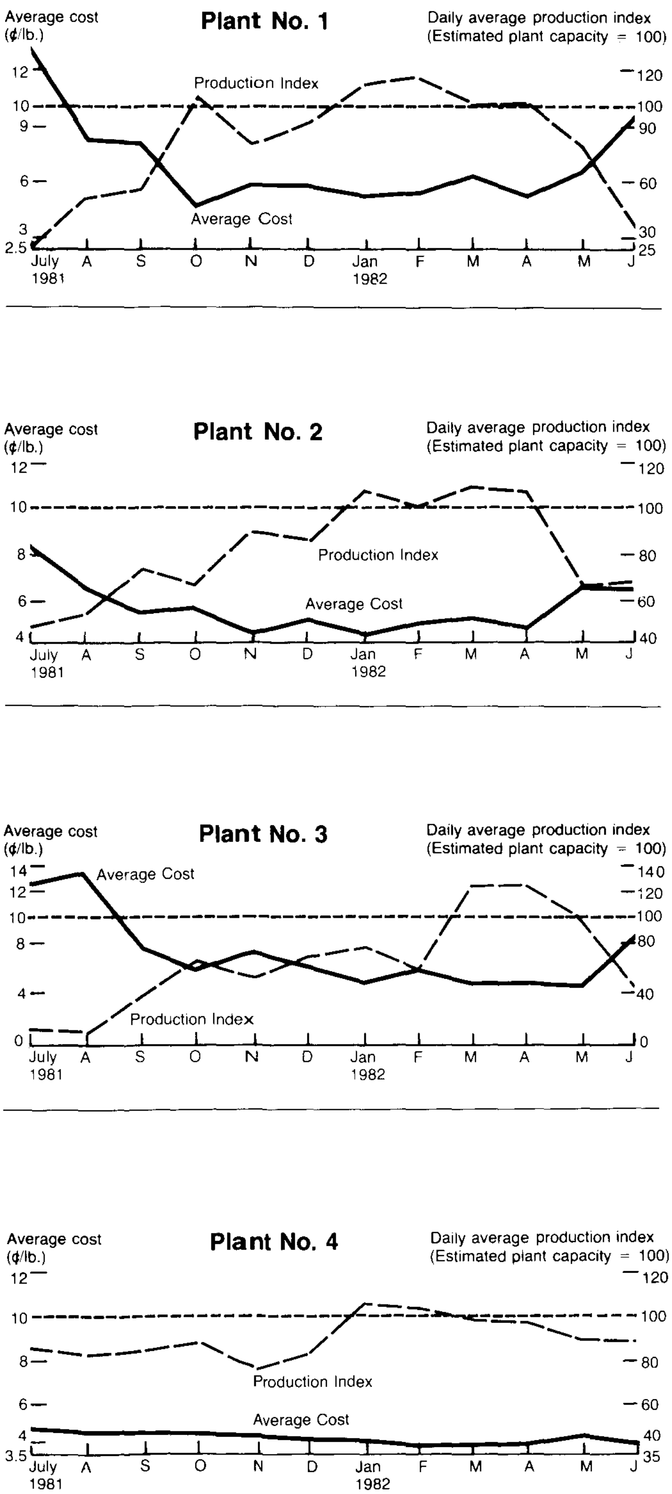


Table 17—Powder plant sizes and average costs at capacity

Plant number	Estimated plant capacity	Difference from plant next in capacity	Average cost at capacity	Cost difference from plant next in capacity
	- - -*Pounds/day*- - -		- -*Cents per pounds* - -	
1	32,000	—	11.19	—
2	63,000	31,000	12.88	1.69
3	97,000	34,000	13.15	0.27
4	137,000	40,000	11.12	−2.03
5	287,000	150,000	7.08	−4.04

more capacity. As a matter of fact, among all the powder plants, the highest average cost occurred in plant No. 3 in November 1981 when it manufactured 52,127 pounds of powder at 17.57 cents a pound. The lowest was 6.97 cents when plant No. 5 manufactured 228,494 pounds a day in March 1982.

The small-scale condenser and dryer of plant No. 1 have been nearly fully depreciated. They also appear to have been well maintained. On a per pound basis, the depreciation at this plant was 0.45 cent, compared to 0.77 cent for plant No. 4 and between 0.85 cent and 0.89 cent for the other three plants. The cost of repair and maintenance at 0.69 cent per pound was about half that of plant No. 2 and less than one-third that of plant No. 3.

The five powder plants are not as homogeneous as the cheese and butter plants. The estimation of a longrun average cost curve is therefore very difficult. Perhaps a longrun average cost curve can be estimated by using cost data of plant No's. 2, 3, and 5, as is done in figure 12. In this case, the selection of plants for estimating the longrun average cost curve is purely judgmental. Therefore, the curve shown in figure 12 is for reference only.

Plant No. 5 might have approached minimum-cost scale of plant. The slope of its average cost curve (fig. 11) is approaching horizontal. Its average cost can remain relatively stable even if its volume varies considerably. The longrun average cost curve (fig. 12) also suggests that plant No. 5 is taking full advantage of economies of scale.

Except for plant No. 1, the powder plants generally manufactured higher volumes in spring 1982 than in the remaining months. This would suggest the seasonal nature of plant operations, although the seasonality was not as pronounced as in the case of butter. The general rule that average cost is the lowest when the volume is around the capacity of the plant, and is higher when the volume deviates from the capacity, still applies (fig. 13).

Figure 11

Average Cost Curves of Five Powder Plants

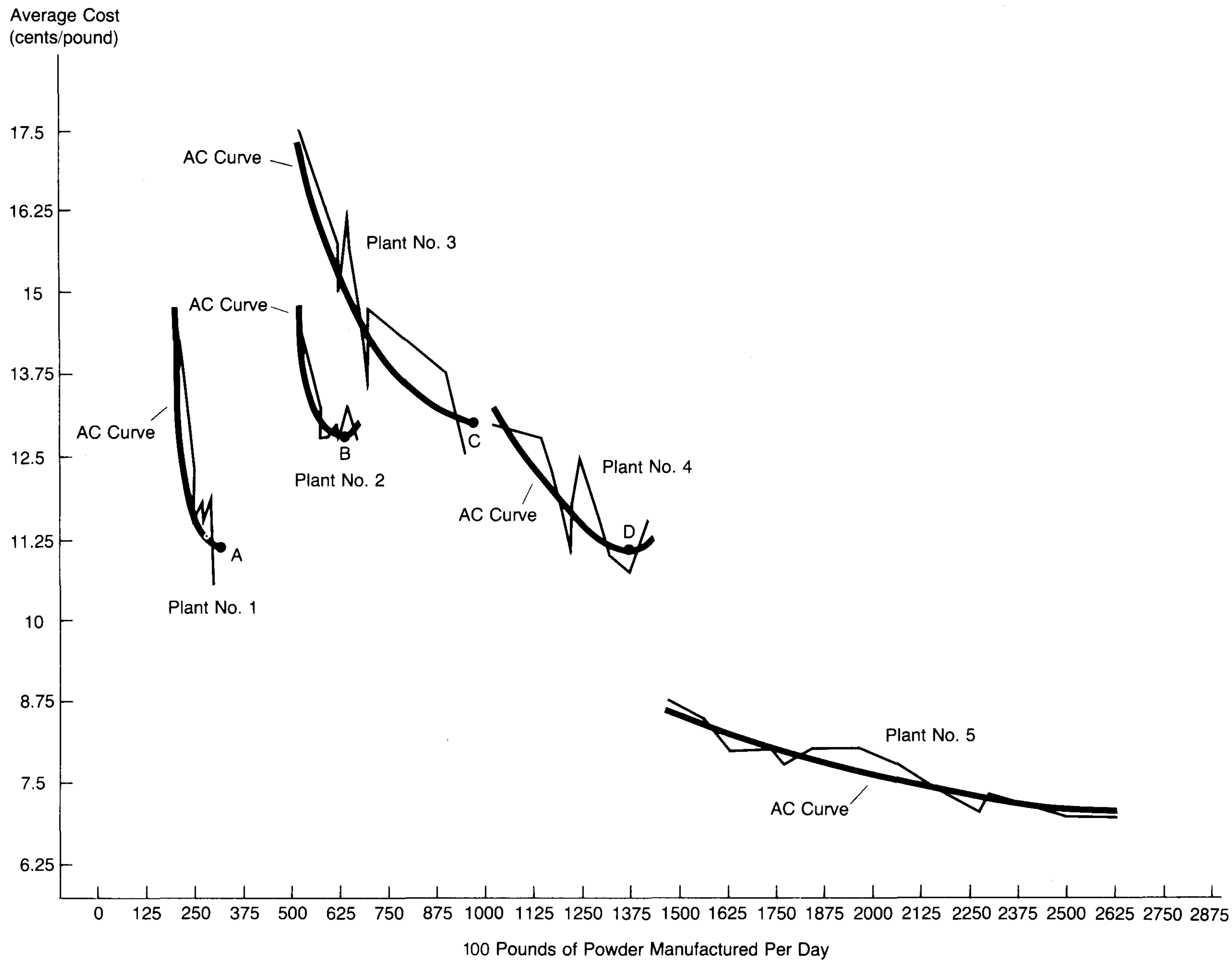
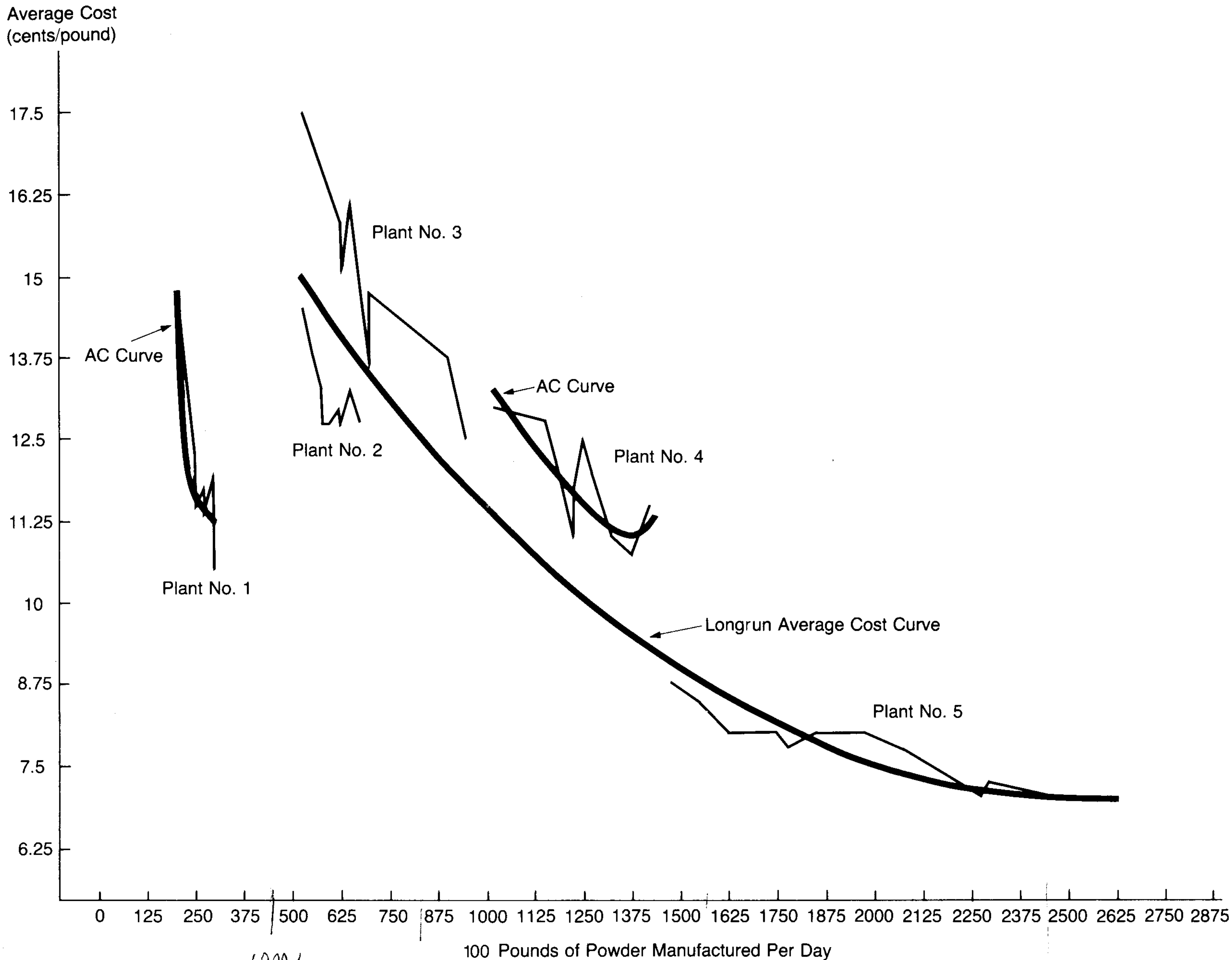


Figure 12

Longrun Average Cost Curve Based on Three Powder Plant Data

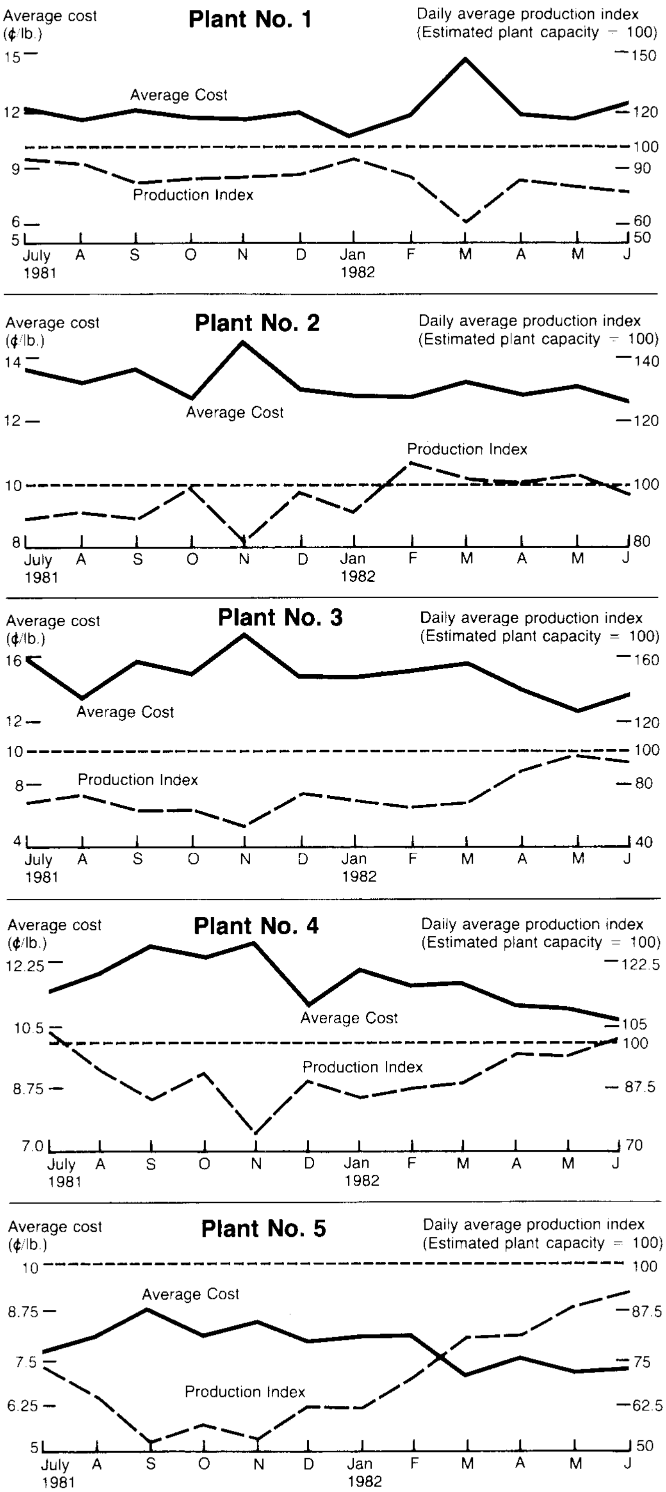


10M/yr 20M/yr 40M/yr 30 M/yr

at 250 days

Figure 13

Seasonal Variation of Powder Production and Cost



The powder plants were operated at a relatively stable volume. For the major part of the year, plant No. 1 operated at between 80 and 90 percent of capacity. Its average cost was the lowest in January 1982 when the volume was the highest and approaching capacity. The opposite occurred in March.

Plant No. 2, except for the lowest volume in November 1981 and the highest volume in February 1982, operated at 88 percent to full capacity. Average cost at this plant was very stable, except for November.

The rate of capacity utilization was maintained between 63 and 73 percent for 8 months in plant No. 3. It was the lowest in November 1981 and was approaching full capacity in April through June 1982. Average cost was the lowest in May.

For 7 months, plant No. 4 operated between 85 and 95 percent of capacity. The lowest volume was 75 percent in November 1981. The plant operated around capacity for the remaining 4 months. The lowest average cost occurred in April through June 1982 when volume was nearest to capacity.

Capacity utilization rate for plant No. 5 was 72 percent in July 1981. It declined to 51.5 percent in September and remained between 51 and 62 percent for 5 months. It then increased to 69 percent in February 1982, to 80 percent in March and April, and to 87 percent in May and 91 percent in June. This plant apparently performed seasonal balancing functions.

Although plant No. 5 had wide fluctuations of volume, its average cost varied over a range of only 1.68 cents between 6.97 cents and 8.65 cents. This manifests the advantage of a large-scale plant.

Comparison of the Variations of Plant Operations

The cheese, butter, and powder plants all displayed seasonal patterns of operations. Table 18 summarizes their capacity utilization rates and measures of seasonal variation.

The 12-month average rate of capacity utilization for cheese plants varied from 83.8 percent for plant No. 1 to 110.7 percent for plant No. 4. For butter plants, the average rate was as low as 63.2 percent for plant No. 3 to a high of 90.3 percent for plant No. 4. The average rate for powder plants was from 69 percent for plant No. 5 to 95.5 percent for plant No. 2. Generally speaking, cheese plants utilized their capacities more fully than the other plants.

There are two measures of seasonal variation calculated for comparison purposes. One is the range between the high capacity utilization rate and the low utilization rate. The other is called standard deviation, which is an indicator of how widely dispersed the monthly plant utilization rates are around the 12-month simple average rate.

Table 18—Comparison of rates of capacity utilization of cheese, butter, and powder plants, July 1981-June 1982

Plant number	12-month average rate of utilization[1]	Range between high and low	Standard deviation around the average rate
	Percent of plant capacity		
Cheese plant			
1	83.8	54.0-134.9 (80.9)	24.3
2	86.6	74.0-109.7 (35.7)	14.5
3	103.1	92.4-123.4 (31.0)	9.0
4	110.7	102.3-116.7 (14.4)	4.3
5	87.5	70.5-100.1 (29.6)	12.0
Butter plant			
1	78.7	26.6-113.9 (87.3)	29.8
2	80.6	47.5-109.2 (61.7)	21.5
3	63.2	10.3-121.7 (111.4)	36.3
4	90.3	76.1-105.8 (29.7)	9.5
Powder plant			
1	82.4	59.1- 93.7 (34.6)	9.0
2	95.5	81.6-106.9 (25.3)	7.2
3	72.9	53.7- 98.4 (44.7)	13.3
4	91.4	74.9-104.3 (29.4)	8.0
5	69.0	51.5- 91.0 (39.5)	13.1

[1]Simple averages.

Table 19—Production of cheese, butter, and powder, United States, 1980-82

Products	Year	Plants	Total production	Average plant production per day
		Number	*1,000 pounds*	*Pounds*
American cheese	1980	483	2,375,756	13,439
	1981	483	2,642,263	14,988
	1982	457	2,750,451	16,489
Butter	1980	258	1,145,254	1[illegible]28
	1981	238	1,228,190	14,138
	1982	231	1,256,964	14,908
Nonfat dry milk (for human food)	1980	113	1,160,691	28,141
	1981	114	1,314,270	31,585
	1982	108	1,400,63[illegible]	35,531

Source: Dairy Products, Annual Summary 1981 and 1982, Crop Reporting Board, SRS, USDA.

Table 18 indicates that butter plants displayed the widest utilization range. Butter plant No. 3 had a plant utilization rate between 10.3 and 121.7 percent, or a range of 111.4 percentage points. The other three butter plants had a range of 87.3, 61.7, and 29.7 percentage points, respectively.

The ranges for cheese plants were between 14.4 and 35.7 percentage points, except for plant No. 1, which had a range of 80.9 percentage points. The five powder plants had ranges between 25.3 and 44.7 percentage points.

It is also shown in table 18 that monthly capacity utilization rates of butter plants were more widely dispersed around the 12-month average rate. The standard deviation for the first three butter plants was between 21.5 and 36.3 percentage points around the 12-month average rate. The standard deviation for butter plant No. 4 was 9.5 percentage points.

The standard deviation for the last four cheese plants was between 4.3 and 14.5 percentage points. Cheese plant No. 1 had a standard deviaton of 24.3 percentage points around its average rate. For powder plants, the standard deviation was between 7.2 and 13.3 percentage points.

Because butter plants generally had wider ranges of capacity utilization rates and showed wider dispersion of monthly plant utilization, it might be concluded that butter plant operations were more seasonal. The butter plants' automatic churns may have made their operations more flexible than the other plants.

The National Picture

Except for powder plant No. 1, plants included in this study are larger in scale than the national averages (compare table 19 with tables 15, 16, and 17). In 1982, nationally 457 American cheese plants were producing an average of 16,489 pounds of cheese per plant per day; 231 butter plants were producing an average of 14,908 pounds of butter; and 108 powder plants were producing an average of 35,531 pounds of powder. The average cheese or butter plant had a volume less than cheese plant No. 1 (21,742 pounds) or butter plant No. 1 (30,734 pounds). The volume of the average powder plant was higher than powder plant No. 1 (26,384 pounds) but far less than powder plant No. 2 (60,107 pounds). It is conceivable that in each case, national average manufacturing cost might be higher than the cost experienced by even the smallest scale of plant included in this study. Although the average plant increased its volume for each product in the last 3 years (table 19), it will take some time before the average plant reaches the same scale of operations as the included plants.