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An Analysis of Processing and Distribution Productivity and Costs in 35 Fluid Milk Plants

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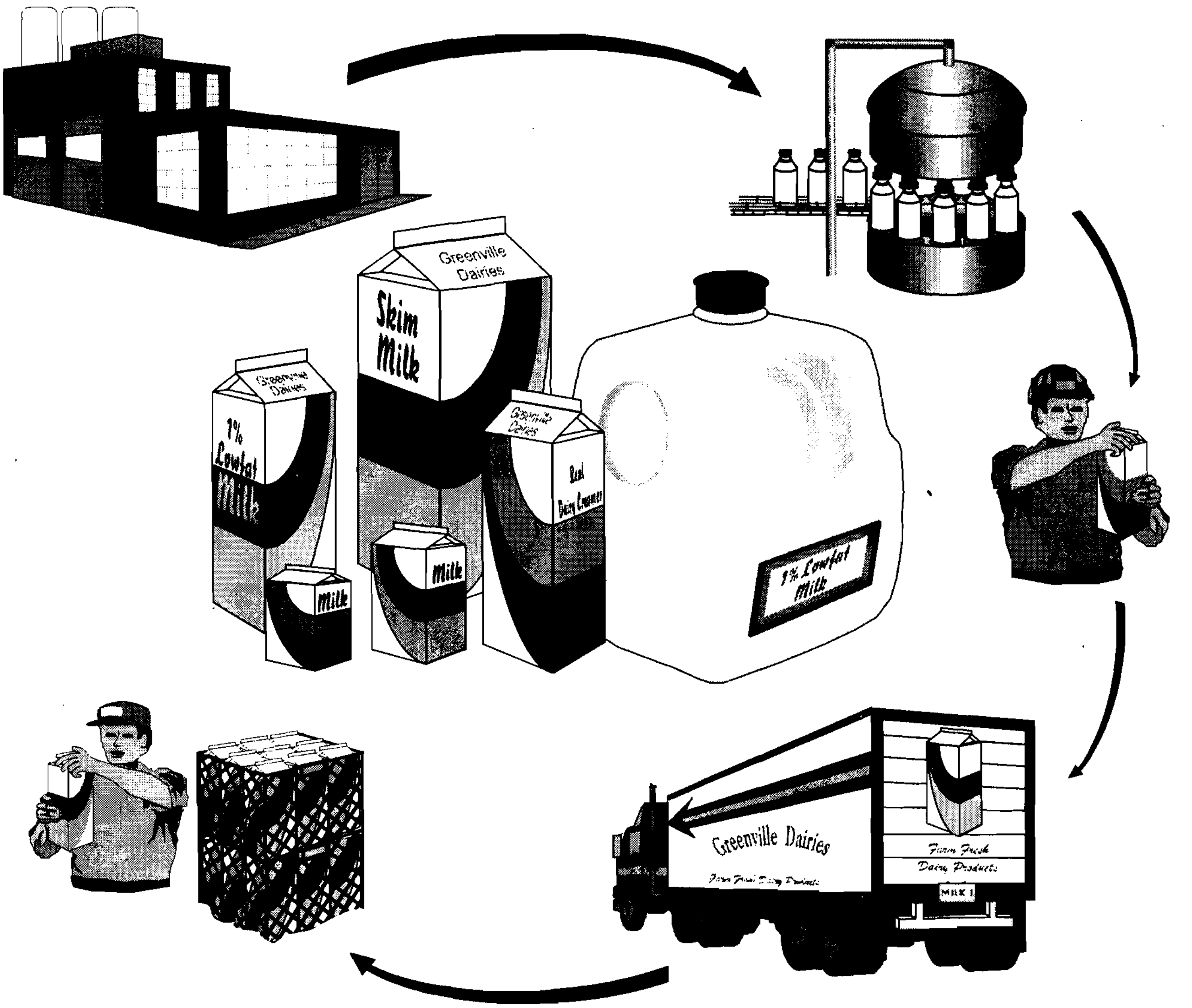

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Acknowledgments

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HIGHLIGHTS

The study focuses on plant and distribution route labor productivity and costs of 35 fluid milk plants in 15 states. We targeted medium and large plants that are well managed and have a significant market presence. The 35 operations are highly respected in the industry and are thought to be among the best fluid milk operations in the country. Of the 35 plants in the study, 8 are owned and operated by supermarket companies (i.e., captive plants), 5 are owned and operated by farmer milk marketing cooperatives, and the remaining 22 are independently owned and operated. Participating plants submitted data from a recent 12-month period. Most plants submitted data from 1993 or 1994 calendar years.

Key Characteristics of Survey Plants

The following table describes key characteristics of the 35 plants. The figures in the column labeled "High 3 Average" ("Low 3 Average") represent the average values of the highest 3 (lowest 3) plants calculated for each characteristic. High and low averages for each characteristic were computed independently.

Plant Characteristic	Average of 35 Plants	Low 3 Average	High 3 Average
All fluid products, million lbs. per month	27.7	13.3	51.4
SKUs processed	148	26	367
SKUs in cooler	250	40	539
Number of labels	11	2	34
Labor cost (including benefits), $ per hour	20.19	13.12	27.92
Electricity, ¢ per kwh	6.7	2.2	13.2
Natural gas, ¢ per therm	42.6	18.1	66.0
Level of processing & filling technology (1 to 10; 10 = highest)	7.4	4	9
Level of cooler & load out technology (1 to 10; 10 = highest)	5.9	1	10

Labor Productivity and Costs

We offer the following caveats for the summary of labor productivity and plant costs:

- The productivity and unit costs were calculated on a gallon equivalent basis and included all beverage products processed and packaged in the plant. Items in addition to fluid milk products included creamers, juices, drinks, bottled water, and ice cream mixes. Soft dairy products, such as yogurt, cottage cheese, and sour cream, were not included.

- Labor hours and labor costs reflected direct labor from the raw milk receiving bays through the cooler and load out area. Labor assigned to maintenance, plant quality control, plant office support, and plant management was also included. The blow mold area was excluded from plant cost and productivity measures but was analyzed separately.

- Labor hours and labor costs did not include any labor dedicated to production of soft products. Raw milk procurement, distribution, selling, and general and administrative expenses were also excluded.

- The plant with the highest labor productivity or the lowest cost per gallon was not necessarily the most profitable. Many factors affect profitability, and we did not attempt to analyze profitability in this report.

Detailed analyses were made of several plant performance measures. Averages and ranges are provided in the following table.

Measure of Performance	Average of 35 Plants	Low 3 Average	High 3 Average
Gallon equivalents per hour of labor	174	107	286
Labor cost, ¢ per gallon	12.3	7.7	17.1
Cost of utilities, ¢ per gallon	2.6	1.7	4.2
Plant cost, depreciation excl'd, ¢ per gallon	18.2	11.5	24.0
Plant cost, depreciation incl'd, ¢ per gallon	21.1	13.1	27.3
Gallon jugs produced per hour of blow mold labor	2,244	1,010	5,017
Cost of producing gallon jug, ¢ per jug	8.8	7.5	10.3

The next table summarizes the labor productivity and costs in the 35 plants by increments. Each increment, or quartile, represents 25% of the plants. Each line was computed independently so the 9 plants with the highest labor productivity were not necessarily the same 9 plants with the lowest costs.

Plant Characteristic	Average of Lowest 25%	Average of Next 25%	Average of Next 25%	Average of Highest 25%
Gallon equivalents per hour of labor	118	147	178	256
Labor cost, ¢ per gallon	8.3	11.2	13.9	16.1
Cost of utilities, ¢ per gallon	1.9	2.3	2.7	3.7
Plant cost, depreciation excl'd, ¢ per gallon	12.9	17.1	20.5	22.5
Plant cost, depreciation incl'd, ¢ per gallon	15.1	20.2	23.3	26.1
Gallon jugs produced per hour of blow mold labor	1,221	1,781	2,166	3,932
Cost of producing gallon jug, ¢ per jug	8.0	9.1	9.6	9.9

Why Does Plant Cost per Gallon Vary So Widely?

Ten factors were significant in explaining the wide variation in plant cost per gallon (exclusive of depreciation) in the 35 plants. However, the effects of some factors were much larger than other factors. The following factors were most important in explaining the wide variation in plant cost per gallon in the 35 plants:

- Whether or not the plant was owned by a supermarket chain (captive plant)
- Level of wages and fringe benefits

The following factors were somewhat important in explaining the variation in plant cost per gallon:

- Size of the plant as measured by gallon equivalents processed per month
- Percent of total volume packaged in gallon and half-gallon containers
- Extent to which plant capacity was used

Five other factors, although statistically significant, were much less important in explaining variations in plant cost per gallon:

- Level of technology in the processing and filling area
- Level of technology in the cooler and load out area
- Number of SKUs processed
- Location of plant
- Percent of product handled on pallets

Why Does Plant Labor Productivity Vary So Widely?

Nine factors were significant in explaining the wide variation in plant labor productivity in the 35 plants studied. Seven factors had large and positive effects on plant labor productivity:

- Whether or not the plant was a captive supermarket plant
- Percent of total volume packaged in gallon and half-gallon containers
- Level of wage rates and fringes
- Size of plant as measured by gallon equivalents processed per month
- Extent to which plant capacity was used
- Level of technology in the processing and filling area

Cooler technology, the number of SKUs processed and the use of pallets were statistically significant but had relatively minor effects on plant labor productivity.

Alternative Cost per Gallon and Plant Labor Productivity Results

In a separate Cornell study, the same plant data were analyzed using an increasingly popular method called neural networks (12). Neural networks "learn" from examples and can exhibit some capability for generalization beyond the data upon which the network is trained. The "learning" in this context is analogous to "estimation" in more traditional statistical analysis. Similarly, "training" data is analogous to "observed" data. We applied neural network models to plant data to asses the interrelationships among the factors affecting plant labor productivity and cost per gallon and to determine if factor effects differed by type of plant ownership.

The results of the neural network approach differed slightly from those obtained using regression analyses. While the analyses revealed strong agreement for most of the factor effects, other effects showed weak agreement or no agreement at all. For example, both analyses predicted positive effects of similar magnitude on labor productivity for captive plants, cost of labor, plant capacity utilization, plant size, and processing technology. For percent of volume packaged in gallon and half-gallon containers, percent of plant volume handled on pallets, cooler technology, and SKUs processed, the two techniques showed agreement in the direction of the impact but differed in terms of the magnitude of the effects. The regression analysis predicted that unionized workforces would be more productive than non-unionized workforces, but the neural network approach predicted the opposite effect for unionized labor. A more comprehensive review of the two sets of results is presented in the sections discussing the effects of factors on plant labor productivity and plant cost per gallon.

Key Characteristics of Wholesale Route Operations

All 35 plants submitted general information on their distribution operations. On average, over half of the product was distributed by specialized or supermarket routes. Customers served by the plants tended to be large. An average of 43% of the plants' customers ordered over 100 cases per delivery and accounted for an average of 64% of the plants' product distribution. The following table summarizes key characteristics of the wholesale route operations of the plants.

Route Operation Characteristic	Average All Plants	Average Low 3	Average High 3
Percent of plant volume distributed by:			
♦ specialized routes	52	5	100
♦ mixed or peddle routes	18	0	71
♦ branch, depot, dealer, or warehouse routes	26	0	47
♦ other routes	4	0	73
Size of customer:			
Over 100 cases per delivery			
♦ percent of customers	43	1	100
♦ percent of volume	64	2	100

Characteristics of Routes Dedicated to Serving Large Accounts

The remainder of the study of distribution operations focused only on "supermarket" or specialized routes. Specialized routes were defined as routes typically serving 1 to 8 large customers, such as supermarkets, club stores, or large convenience stores, per delivery day. Only 20 plants submitted complete surveys on their specialized routes. These 20 plants submitted data on 270 specialized routes. Key characteristics of the 270 specialized routes are presented in the following table:

Specialized Route Characteristic	Average Average All 270 Routes	Average Low 10% of Routes	High 10% of Routes
Cases delivered per month	18,900	10,200	35,000
Customer stops per month	97	48	168
Miles per month	3,150	745	6,850
Driver labor cost (including benefits), $ per hour	$23.39	$16.55	$32.27
Product on pallets, %	49	0	100
Dock deliveries, %	83	13	100

Specialized Route Labor Productivity and Costs

As you study this summary of route labor productivity and costs, remember that:

- The route labor productivity and costs only reflect the productivity and costs of routes serving large customers, such as supermarkets and club stores. These routes would typically use tractor-trailers for delivery, and an average of 5 customers per day were served by these specialized routes.

- **The cost per case of serving smaller customers, such as small convenience stores, Mom and Pop stores, delis and restaurants would be much higher than the direct delivery costs reported here.**

- The routes with the highest labor productivity or the lowest cost per case were not necessarily the most profitable. Many factors affect profitability, and we did not attempted to analyze profitability in this report.

Specialized Route Characteristic	Average of All Plants	Average Low 10% of Routes	Average High 10% of Routes
Cases delivered per hour of labor*	108	52	216
Driver labor cost, ¢ per case*	16.8	10.1	47.8
Direct delivery cost, ¢ per case**	36.8	17.3	63.1

* Reflects 270 specialized routes operated by 20 plants.

** Reflects 180 specialized routes operated by 15 plants which reported delivery vehicle costs and route labor costs.

Why Does Labor Productivity on Specialized Routes Vary?

While most of the 270 specialized routes studied delivered between 60 and 180 cases per hour, the bottom 10% of the routes averaged only 52 cases per hour. On the other hand, the top 10% of the routes averaged 216 cases per hour.

Five factors were significant in explaining the wide variation in driver labor productivity on the routes dedicated to serving large accounts. However, the effects of some were much larger than others. The three most important factors in explaining the variation in driver labor productivity were:

- Whether or not the routes were operated by a supermarket company
- Combined cost of driver wages and fringe benefits per hour
- Number of miles travelled per month

Two factors were associated with higher route labor productivity, but were less important than the three factors listed above:

- Higher percentage of product delivered on pallets
- Higher population density of the city in which the plant is located

Three factors were associated with lower route labor productivity, but were not statistically significant:

- Higher number of customer stops
- Higher percentage of dock-delivered orders
- Unionized drivers

Why Does Direct Delivery Cost per Case on Specialized Routes Vary?

While most of the 180 specialized routes studied for which vehicle and labor costs were reported fell between 19¢ per case and 58¢ per case, the bottom 10% of the routes averaged 63¢ per case. On the other hand, the top 10% of the routes averaged 17¢ per case.

Seven factors were significant in explaining the wide variation in direct delivery cost per case on the routes dedicated to serving large accounts. The two most important factors in explaining the variation in direct delivery cost per case were:

- Whether or not the routes were operated by a supermarket company
- The combined cost of driver wages and fringe benefits

Three factors of moderate importance also affected delivery costs, but were less influential than the two factors listed above:

- Miles travelled
- Number of customer stops
- Population density of the city in which the plant is located

Two other factors were associated with higher delivery costs, but were less important than the five factors above:

- Percent of dock-delivered orders
- Percent of product handled on pallets

INTRODUCTION

Objectives

This report details the results of a survey of 35 fluid milk plants and their associated distribution operations. The objectives of the study were to determine the costs of processing and distributing fluid milk products and to identify and to quantify the factors which contribute to differences in labor productivity, plant cost per gallon, and direct delivery cost per case. Specifically, we sought to answer the following questions:

- What are the key characteristics of the fluid milk operations in the study?
- What is the average labor productivity and cost per gallon in participating plants, and how much variation exists in these performance measures?
- What factors apparently cause labor productivity and plant cost per gallon to vary among the 35 plants in the study?
- What is the magnitude of the impact on labor productivity and cost per gallon for each of these factors?
- What are the characteristics of distribution routes operated by the participants?
- What are the route labor productivity and the direct delivery costs on "specialized" or supermarket routes?
- What factors explain the variation in route labor productivity and direct delivery cost per case on these supermarket routes?
- What is the magnitude of the impact on route labor productivity and direct delivery cost per case for each of these factors?

Profile of Fluid Milk Operations Studied

The study targeted fluid milk operations with processing volumes of at least 1.7 million gallons per month, effective management styles, high labor productivity, a significant market presence, and innovative or technologically advanced plant and cooler equipment. Our list of "benchmark" operations was constructed by consulting with fluid milk industry executives and federal milk marketing order administrators to identify the fluid operations that are highly respected. Thus, the plants did not represent a random sample from all fluid milk plants located throughout the country. A high percentage of the plants identified for the study agreed to participate. The 35 participating operations are thought to be among the best fluid milk processing operations in the U.S. Although the 35 plants account for only about 5% of the fluid milk plants, they process about 17% of the beverage milk consumed.

Data Collection Period

Plants were requested to submit data on plant operations for a recent 12-month period. The data collection period spanned just over 2 years, with the oldest data representing plant activities in January 1993 and the most recent representing activities in March 1995. Although most plants submitted data for 12 consecutive months, a few plants submitted quarterly or annual data.

Much of the data submitted were aggregated into monthly averages to simplify the report. Some plants submitted information based on different time frames (for example, 13 4-week periods). These data were converted to corresponding monthly figures to allow for comparisons among all plants. In several of the plants, soft manufactured dairy products (e. g., sour cream, cottage cheese, and yogurt) were produced in addition to the fluid beverage products. These plants reported neither the monthly production of these products nor their associated production costs.

Background Information On Fluid Milk Plants

History and Description of Fluid Milk Plants

In 1857, Louis Pasteur, a French chemist and bacteriologist, noted that heating milk postponed milk spoilage. Not coincidentally, commercialized firms that processed and marketed fluid milk products began to emerge soon after Pasteur's discovery. Before the proliferation of commercialized fluid milk processing and packaging, dairymen prepared and distributed milk, but as dairymen became more involved in milk production, these tasks became the responsibility of organizations specializing in milk processing and marketing (11).

In the mid to late 1800s, fluid milk processing and packaging was a relatively new industry, and improved techniques or mechanical innovations were rare. The introduction of returnable glass quart milk bottles in 1884 marked the beginning of several technologies introduced to increase the efficiency and safety of fluid milk processing. In 1886, automatic filling and capping equipment was developed for milk bottlers, and in 1911, automatic rotary bottle filling and capping equipment was perfected for large scale use which further increased the speed and efficiency of bottling plants (28). Between 1930 and 1950, high temperature–short time (HTST) continuous flow pasteurization replaced vat pasteurization as the primary method of preparing fluid milk for bottling. As bottling plants soon discovered, automation of fluid milk processing and filling equipment led to substantial increases in labor productivity and plant efficiency. The relatively recent developments of plastic-coated paper containers, plastic jug containers, clean–in–place (CIP) systems, case stackers, conveyors, and palletizers contributed further to efficiency gains of fluid bottlers.

Although fluid milk processing plants may differ in size and in form, the functional aspects are relatively consistent. As with any manufacturing plant, raw materials are transformed into finished products through process applications as the products "flow" through the plant. The raw materials in the case of fluid milk plants is milk which arrives at the plants via bulk milk trucks or tractor–trailers. In the receiving bays of the plant, the milk is pumped from the bulk transport tanks and passes through a plate cooler which reduces the temperature of the milk to 35° F before it reaches the raw milk storage tanks or silos. From the silos, a HTST process, which passes milk through a heat exchange plate, pasteurizes the milk. The process heats the milk to temperatures of 163° F to 170 ° F for 15 to 18 seconds, killing most of the microorganisms the milk may contain. After pasteurization, a separator removes the milkfat component from the skim portion of the milk. Excess cream may be stored for future processing, but it is often sold in bulk to ice cream or butter manufacturing plants. In–line standardization allows the removed cream to be added back to the skim portion as the milk continues to flow from the pasteurization area to the homogenizer. A homogenizer contains a series of high-speed pistons that breakdown milkfat particles; this process prevents cream from separating from the skim portion of milk. After homogenization, milk flows to pasteurized storage tanks. From these tanks, milk is either pumped or gravity-fed to filling equipment where it is packaged in plastic–coated paper containers, plastic jug containers, or polybags. Packaged milk is placed (usually automatically) into plastic, wire, or cardboard cases. The traditional milk case has been a 16-quart plastic case, but the introduction of disposable, nonreturnable corrugated cardboard cases has allowed for growth of one-way shipments of milk. After the packaged milk has been placed in cases, the product must move immediately into a cooler to prevent spoilage. Most plants use equipment to form stacks of 5 to 7 cases automatically. The stacked cases travel on a track conveyor embedded in the plant flooring which transports the product to the cooler where it is stored temporarily until it is loaded on a delivery vehicle for distribution.

In an attempt to use the facility as efficiently as possible, most fluid milk plants process other products which might include juices; flavored drinks; light, medium, and heavy creams; half and half; buttermilk; ice cream mixes; and bottled water. Generally, these items use the same plant equipment as fluid milk products. Some plants may also have soft dairy product processing capabilities and produce cottage cheese, yogurt, and sour cream in addition to the beverage products.

Previous Studies of Fluid Milk Plants

Results from fluid milk processing and distribution cost studies have a variety of uses. Fluid milk plant management and executive personnel may apply the results to their own operations to gauge or to benchmark the performance of their operations against other similar milk plants. Such studies may also reveal which aspects of fluid milk operations offer the most benefit from internal restructuring or capital investments. The results may also be useful for regulatory purposes, especially for states that regulate milk prices at the wholesale or retail level. At the academic level, cost of processing and distribution studies have been an invaluable component for modeling the dairy industry and projecting structural changes in milk markets.

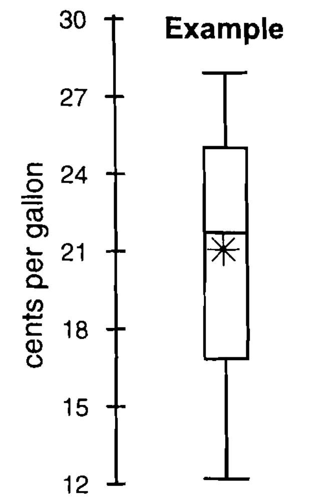
In the past 35 years, the cost of processing fluid milk has been analyzed several times. Studies by Blanchard et. al. (6) and Bond (7) partitioned plants into separate cost centers and used cost data to analyze differences in efficiencies among participating plants. Other research has investigated processor sales, costs of goods sold, operating costs, and gross and net margins for moderate-sized fluid milk plants (1, 18, 19, 25). Because of difficulties encountered in recruiting participants for processing cost studies or lack of an adequate number of representative plants, economic engineering studies have served as an alternative method of estimating minimum achievable processing costs per gallon and investigating the consequences of various plant volume capacities on per unit processing costs (8, 14, 17, 24, 26).

Studies that attempt to identify the factors that affect plant productivity and the cost of processing are less common. Thraen et. al. (27) estimated a functional relationship between total plant cost and plant volume based on data from 15 cooperatively owned and operated fluid milk plants, suggesting that per unit costs decrease with increases in plant processing volume. Metzger (23) found that, among 21 Maine dealers, plants with larger processing volumes were associated with lower per unit costs of processing and distributing fluid milk products. Aplin (2, 3) indicated that economies of scale, utilization of plant processing capacity, product mix, and level of technology in the processing and cooler areas were expected to influence the cost of processing as well as plant labor productivity.

The cost of fluid milk distribution has been studied frequently, but recent research in this area is lacking. Research by Angus and Brandow (1) presented a case study of two markets which investigated changes in milk distribution productivity over of a period of 18 years. The effect of distribution costs on marketing fluid milk and methods for measuring and improving the profitability of fluid milk distribution routes have also been studied (5, 9). More recently, Jacobs and Criner (17) and Fischer et. al. (14) used economic engineering methods to determine minimum achievable distribution costs under different route environments. Fischer et. al. modeled various distribution cost and labor productivity measures and suggested that the length of the route and the number of customer stops on the route were the main determinants of delivery cost per gallon and routeman labor productivity.

Using Boxplots to Report Results

Boxplots are used as descriptors of data points in many instances in this report. The following explanation regarding the information that they contain may help to interpret their meaning. The boxplot to the right illustrates plant cost per gallon for the 35 plants in the survey. Plant cost includes the costs of direct processing and filling labor, cooler and load-out labor, and all other plant labor, electricity, gas, water and sewage, building and equipment depreciation (excluding any depreciation charged to blow mold equipment), leases, repairs, parts, cleaners and lubricants, plant supplies, pest control, refuse collection, taxes, and insurance.



Plant Cost per Gallon

✳ mean = 21.1¢
median = 21.8¢

Boxplots are a method of displaying the central point and dispersion of data. The information is broken down into quartiles (25% of the ranked observations fall into each quartile). The center "box" which is composed of the two middle quartiles outlines the middle 50% of the observations. The horizontal line within the box indicates the median value of the data set. The median is the midpoint of the data. In other words, 50% of the observations lie above the median and 50% of the observations lie below the median. Here, the median plant cost is 21.8¢ per gallon. The sample mean, the location of which is represented in the boxplot by the starburst (✳), is the average value of the collected data. For this data set, the sample mean is 21.1¢ per gallon. The mean and the median are close in magnitude for this example which implies that the mean plant cost per gallon is not unexpectedly skewed toward a higher or lower cost per gallon. The sample mean and median need not be closely matched in magnitude as will be encountered in some of the following charts.

Outline of Report

This report is divided into five sections. The first section reviews basic plant information — volumes of milk and other beverage products processed, percent plant capacity utilizations, labor cost per hour, prices of packaging supplies, and numbers of labels and stock keeping units (SKUs) processed. A comparison of utility costs per gallon processed and utility rates for electricity and natural gas is also presented. The first section concludes with a look at specific performance measures used to evaluate the level of efficiency and costs in the plants. Despite similarities in plant size, product mix, and geographical location, labor productivity and plant cost per gallon varied widely among the 35 plants. The second section of the report discusses the factors help to explain the variation in plant labor productivity and plant cost per gallon.

The third section concentrates on basic descriptors of distribution operations of the participating fluid milk plants. Wholesale routes are emphasized, and the discussion includes type of routes operated, size and frequency of stops, cost of delivery equipment, and type of delivery vehicles used. Characteristics of specialized routes, which serve large accounts and service 1 to 8 customers per delivery day, are also discussed. The fourth section reports the results of regression model used to identify the factors which contribute to variations in direct delivery cost per case and labor productivity for specialized routes.

The fifth section reviews selling expenses and general and administrative costs as additional indirect processing and distribution costs.

SECTION I: GENERAL CHARACTERISTICS OF PLANTS STUDIED

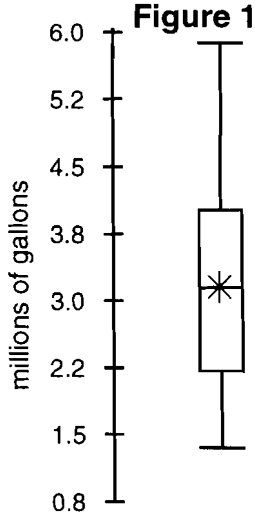
Plant Location and Ownership

The plants participating in the study were widely dispersed throughout the United States. Although 14 of the plants were located in the Northeast, 7 plants were located in Western and Mountain states, 7 were located in the Middle Atlantic and Southeast, and 7 were located in the Upper Midwest. Of the 35 plants in the study, 5 were owned and operated by milk marketing cooperatives, 8 were owned by vertically integrated supermarket chains (i. e., captive plants), and the remaining 22 were owned and operated by proprietary firms.

Volumes Processed

Figure 1 shows the average monthly volume of beverage milks and other fluid products processed by the 35 plants. Fluid products included all white and flavbored milk products, half and half, heavy cream, buttermilk, ice cream mix, juices, drinks, and bottled water. Other products, such as sour cream, yogurt, cottage cheese, and carbonated drinks were not included. Participating plants processed an average of 3.22 million gallons (27.7 million pounds) of products per month with a median of 3.18 million gallons (27.4 million pounds). Processing volume for all plants ranged from 1.36 million gallons to about 5.98 million gallons per month (11.7 million pounds to 51.5 million pounds).

Figure 1



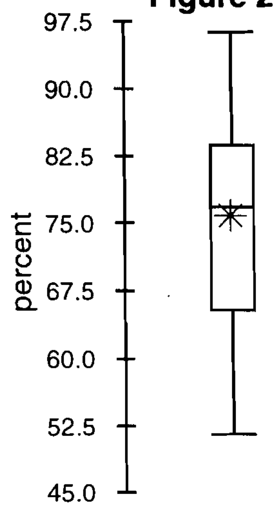
Gallons Processed per Month

✳ mean = 3.22 million
median = 3.18 million

Plant Capacities

The maximum capacity rating of each plant was defined as the level of processing that could be sustained without changing the existing equipment, buildings, product mix, or customer mix. Additional shifts of labor or additional processing days were allowed. Using the maximum capacity rating and the actual gallon equivalents of fluid products processed each month, a measure of capacity utilization was estimated. Only beverage products were considered when determining gallon equivalents processed each month, and consequently, plants that processed large volumes of soft dairy products were not included in the calculation of plant capacity utilization. All monthly estimates for plant capacity utilization were averaged to produce a single number (Figure 2). Capacity utilization ranged from about 51.8% to 96.5% with an average of 76.4%. It was evident that a number of facilities were operating far below their maximum sustainable capacity, and as a consequence, had excess plant capacity for several months throughout the year.

Figure 2

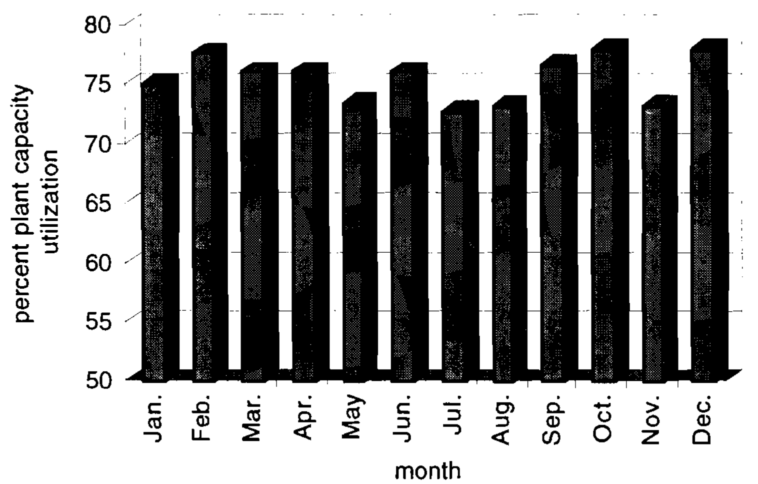


Perent Capacity Utilization
✳ mean = 76.4%
median = 77.0%

We compared plant capacity utilization by month. We calculated daily productions for each plant and then standardized all production data to 30.5 days to avoid potential bias encountered by comparing months of unequal lengths. The results revealed that there were small differences in average monthly plant capacity utilization (Figure 3).

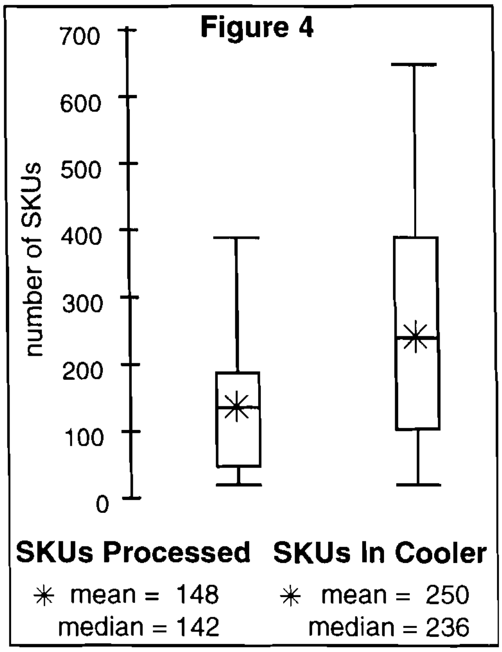
Plant capacity utilization was not expected to be high during the summer months. Milk supply typically increases during the spring and early summer, but demand for beverage dairy products tends to be lower. Although farm milk production typically drops off during the late fall and early winter, high capacity utilization was anticipated because of increased consumption of beverage milk products and production of seasonal beverages. This hypothesis was supported by the results. On average, plant capacity utilization was highest in December, followed by October, February, and September. Plant capacity was utilized the least in July, May, and August.

Figure 3. Average Percent Plant Capacity Utilization By Month

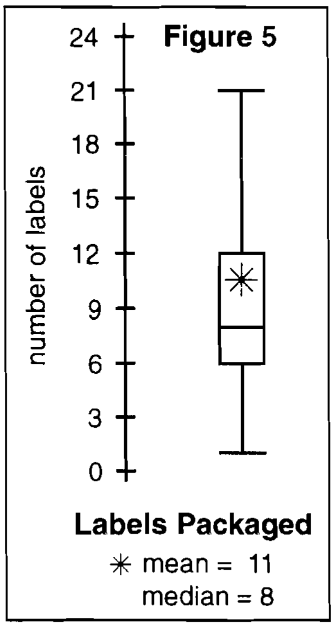


Number of Products, Labels, and SKUs Processed

None of the plants in the study was strictly a fluid milk plant, i. e., a plant that only processed beverage milk products. Many products were processed, packaged and stored along with the variety of beverage milk products. Very few plants processed and packaged UHT products, and the most common products processed with UHT technology were coffee creamers; half and half; and light, medium, and heavy creams. A few plants processed and packaged soft dairy products, such as sour cream, cottage cheese, and yogurt. Nearly all plants brought finished products into their coolers from other food manufacturers which were then distributed to wholesale or retail outlets with the products processed by the plant. However, a few plants did not bring any finished purchased products into their coolers. Figure 4 illustrates the range of stock keeping units (SKUs) that were plant-processed and the range of SKUs handled in the cooler. A stock keeping unit is a specific product with a specific label in a specific package size and type. On average, plants processed 148 SKUs and stored about 250 SKUs in the cooler. The data for each category was quite disperse with SKUs processed ranging from about 20 to nearly 400. The number of SKUs stored in the cooler ranged from about 25 to about 650.



Most plants indicated that they packaged products under multiple labels (Figure 5). Seven plants processed four or fewer labels, and six plants processed twenty or more labels. On average, the plants packaged beverage products under 11 labels. The number of SKUs processed was influenced by the number of labels processed. The correlation coefficient for number of labels and monthly volume processed was weak (r = 0.17), indicating that plants processing and packaging beverage products for a large number of labels were not necessarily large operations. The correlation coefficient for SKUs processed and monthly volume processed was also weak (r = 0.27), indicating that large facilities were not necessarily the plants processing and packaging a large number of SKUs.



Plant and Cooler Evaluation

A number of questions were posed in the survey to characterize the level of technology and automation. Automation and technology in the processing and filling area and in the cooler and load-out were evaluated by the plant manager at each plant. The managers were asked to use a 10-point scale to assess the levels of technology in the two areas of the plant (1 = the lowest level of technology, and 10 = the latest, most innovative technology). Similarly, cooler size and cooler design were assessed on 10-point scales (1 = too small; poor layout, and 10 = spacious; convenient design).

Automation and technology in the processing and filling area averaged 7.4 and ranged from 4 to 9 (Table 1). About 83% of the plants rated the technology and automation in their processing and filling area 7 or better. Automation and technology in the cooler and load-out area was more variable, ranging from 1 to 10 and averaged 5.9. About 50% of the plants rated the automation and technology in their cooler and load-out area 7 or better. The correlation between processing and filling technology and cooler and load-out technology was surprisingly low (r = 0.20), indicating that high ratings for technology in the processing and filling area were only weakly associated with high ratings for technology in the cooler and load-out area.

Ratings for cooler size and cooler design followed the same dispersed pattern as shown by cooler and load-out technology (Table 1). Among the 35 participating plants, cooler size averaged 5.7, and cooler design averaged 6.3. About one-third of the plants rated both the size and layout of their coolers 4 or less. Correlation coefficients among cooler and load-out technology, cooler size, and cooler design ranged from mildly strong to strong. The correlation coefficient for cooler size and cooler design indicated that larger coolers were also likely to be more conveniently designed (r = 0.63). The correlation coefficient for cooler and load-out technology and cooler design indicated that coolers with more automation were very likely to be more conveniently designed (r = 0.81). The correlation between cooler and load-out technology and cooler size indicated that coolers with more automation were likely be more spacious (r = 0.62).

Table 1. Ratings of Plant and Ccooler Characteristics By Plant Managers[1]

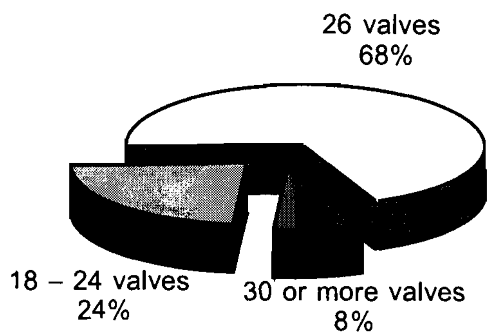
Characteristic rated:	Mean	Median	Minimum	Maximum
Processing and filling area	7.4	8	4	9
Cooler and load-out area	5.9	7	1	10
Cooler size	5.7	6	1	10
Cooler design and layout	6.3	7	2	10

[1] Automation and technology, cooler size, and cooler layout were evaluated by the plant manager at each facility. The managers were asked to use a 10-point scale to assess the levels of technology ("1" = older technology, and "10" = innovative technology). Similarly, cooler size and cooler design were assessed on 10-point scales ("1" = too small; poor layout, and "10" = spacious; convenient design).

Plastic Jug Filling Equipment

All plants operated plastic jug filling equipment and most operated paperboard container filling equipment as well. Plastic jug fillers were almost exclusively manufactured by Federal, although a small percentage of jug fillers were manufactured by Fogg. The size of plastic jug fillers, as measured by the number of valves per machine, was variable, but over two-thirds of jug fillers were equipped with 26 valves (Figure 6). Fillers with 18-valves were generally reserved for

Figure 6. Percent of gallon and half-gallon plastic jug fillers by number of valvles



filling half-gallon jugs, but it was not unusual for plants to fill gallon and half-gallon jugs on the same machine. The average age of all plastic jug fillers was 12 years and ranged from 1 year to 24 years (Figure 7). Actual filling speeds, as opposed to manufacturers' ratings, were reported for machinery used to fill gallon jugs. Plastic gallon jug filling equipment averaged 77 units per minute and ranged from 45 units per minute to 115 units per minute. The correlation coefficient for gallon jug filling speed and age of plastic gallon jug fillers indicated that older machines were somewhat more likely to operate at slower rates (r = -0.43).

Paperboard Filling Equipment

Manufacturers of paperboard fillers were more numerous than plastic jug fillers, but Cherry Burrell was clearly the dominant manufacturer of paperboard filling equipment in the participating plants (Figure 8). Forty-three percent of paperboard fillers were used exclusively for filling half-gallon containers. The other fillers were capable of handling a variety of package sizes. About 45% were capable of filling quart, pint, and half-pint containers, and the remaining 12% were used to package half-pint and 4-ounce NEP containers. The average age of all paperboard filling equipment was 10.9 years and ranged from 1 year to 19 years (Figure 9). Actual filling speeds, as opposed to manufacturers' ratings, were reported for half-gallon paperboard filling equipment. The average filling speed was 86 units per minute, and the range was 65 units per minute to 100 units per minute (Figure 9). The correlation coefficient for half-gallon paperboard filling speed and age of half-gallon paperboard fillers indicated that older machines were somewhat more likely to operate at slower speeds (r = -0.47).

Figure 7. Plastic Jug Fillers

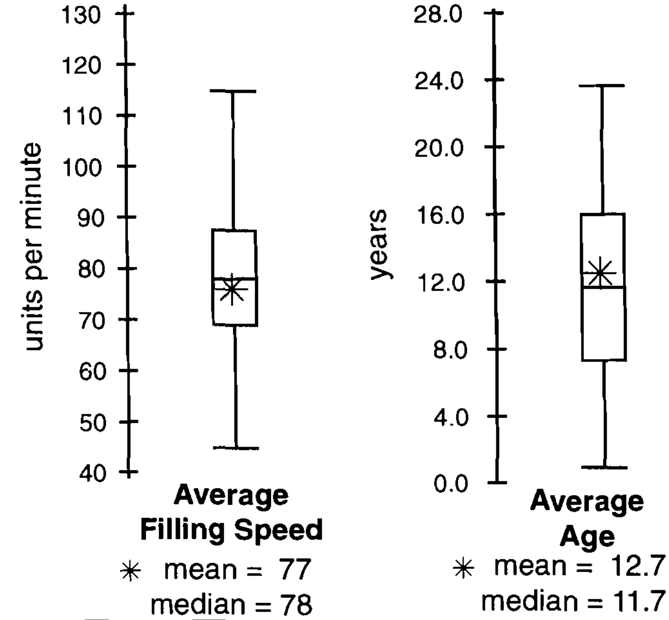


Figure 8. Percent of Half-gallon, Quart, Pint and Half-pint Paper Carton Fillers By Manufacturer

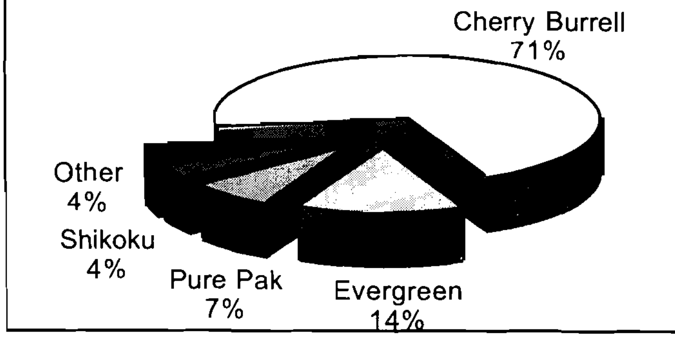
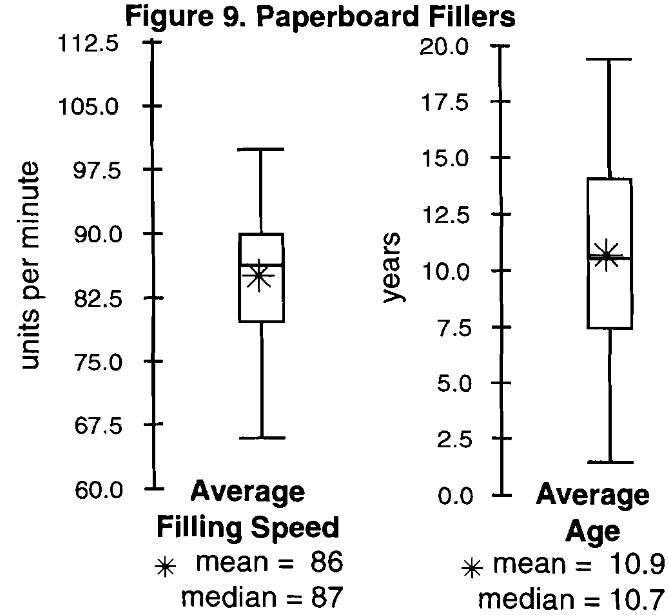


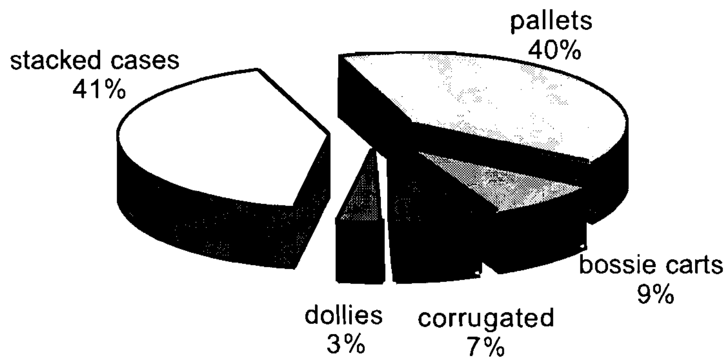
Figure 9. Paperboard Fillers



Product Handling In the Cooler and Product Loading

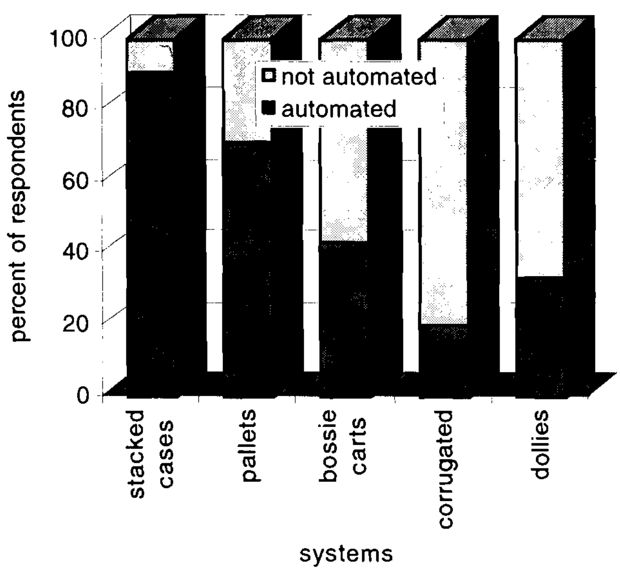
A wide variety of product handling systems were used in the coolers of the 35 plants in the study: stacked cases, corrugated boxes, bossie carts, dollies, and pallets. All but five of the plants used two or more of these product handling systems in their coolers. Product handled on pallets was packed in plastic cases, wire cases, or corrugated boxes prior to loading on a pallet. To eliminate any confusion with these different product handling systems, stacked cases or corrugated boxes placed on pallets were classified as pallets. Stacked cases and corrugated boxes refers only to the product handled in individual stacks. Pallets and stacked cases accounted for the largest shares of volume handled by the various systems (Figure 10). On average, 41% of the plants' volumes were handled using stacked cases, and 40% were handled on pallets. Bossie carts accounted for about 9% of the volume handled, and corrugated boxes and dollies combined for about 10% of the volume handled.

Figure 10. Percent of Plants Using Various Product Handling Methods In the Cooler



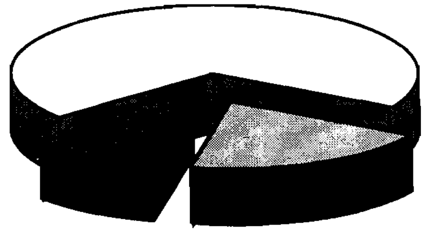
To characterize the handling systems and associated assembly processes, each product handling system of each plant was categorized as "automated" or "not automated". For example, case stackers and palletizers indicated automated product handling processes. Ninety percent of the plants using stacked cases to handle product indicated that mechanical case stackers were used (Figure 11). Three-fourths of the plants using pallets to handle product indicated that pallets were loaded by automated equipment. More than 55% of the plants using bossie carts responded that the carts were loaded manually. Similarly, corrugated boxes and dollies were less likely to be automated processes. For the less popular product handling systems, automation appeared to be associated with the volume of product handled. In other words, a plant that handles 5% of its volume on bossie carts may find it difficult to justify purchasing an automated cart loader whereas such a purchase might be justifiable for a plant that handles 30% of its volume on bossie carts.

Figure 11. Percent of Respondents Using Automated Product Handling Systems



When placed into the delivery vehicles, product was organized largely by store (store loading) or by product (peddle loading). "Store loading" means that orders were pre-picked in the cooler and then arranged on delivery vehicles by the stores receiving orders on the route. "Peddle loading" means that orders were not pre-picked, and the driver was responsible for assembling the order at the time of delivery. As such, products were arranged on the delivery vehicle to simplify order filling at the time of delivery. About 89% of all routes operated by the 35 plants were either store loaded or peddle loaded (Figure 12). The remaining 11% of the routes were loaded by other methods. The most popular alternative method was bulk loading trucks and trailers destined for warehouses or other drop points.

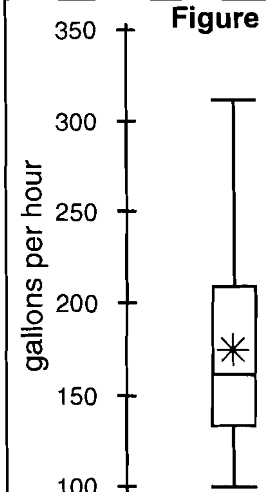
Figure 12. Percent of All Distribution Routes Loaded By Various Methods



PLANT LABOR PRODUCTIVITY

Plant labor productivity is one measure of plant efficiency. Plant labor productivity for the 35 plants reflected volume processed, in gallon equivalents, relative to the hours worked by direct plant, cooler, and all other plant labor. All milks, creams, buttermilks, juices, drinks, bottled water, and ice cream mixes were included in the calculation of volume processed. Direct processing labor included all processing plant employees from the receiving bay to the cooler wall, and cooler labor included employees in the cooler and load-out areas as well as any labor used to move trailers in and out of the loading bays. "All other plant labor" was a general plant labor category that included maintenance, engineers, plant quality control, plant office support, and plant management. Plant labor productivity did not include any work from the blow mold operation, nor did it include any labor used in producing soft dairy products (e. g., cottage cheese, sour cream, and yogurt). Hours worked in milk procurement, research and development, distribution, selling, and general and administrative personnel were also excluded.

Figure 13



Plant Labor Productivity

∗ mean = 174
median = 162

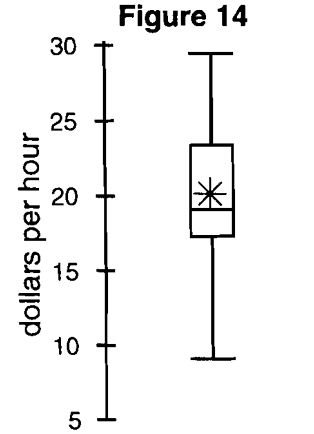
Plant labor productivity ranged from about 100 gallons per hour to over 320 gallons per hour (Figure 13). The top ten plants, eight of which were captive supermarket plants, averaged more than 210 gallons per hour. A small number of highly productive plants influenced the average plant labor productivity as evidenced by the large difference between the mean and median (174 gallons per hour versus 162 gallons per hour). Twenty-two of the 35 plants fell in the range of 100 gallons per hour to 170 gallons per hour.

PLANT LABOR COSTS

Hourly Cost of Labor

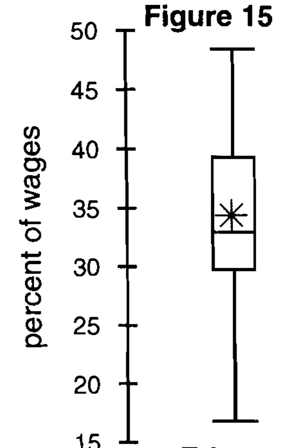
Information on cost per hour of labor (wages and fringe benefits) was calculated by dividing the sum of the direct plant, cooler, and all other plant labor costs by the total number of hours worked in the plant. Labor assigned to the blow mold, research and development, distribution, selling, general and administrative personnel was not included in this category.

Cost of plant labor averaged about $20.19 per hour, but there was a tremendous range among plants (Figure 14). Plant location and the availability of other competitive occupational opportunities may explain some of the variation in cost of labor per hour. For example, New York City Metropolitan Area plants paid an average of $24.88 per hour for plant labor while the cost of labor in all other plants averaged $19.42 per hour.



Cost of Plant Labor per Hour

✳ mean = $20.19
median = $19.27



Fringe Benefits

✳ mean = 35%
median = 33%

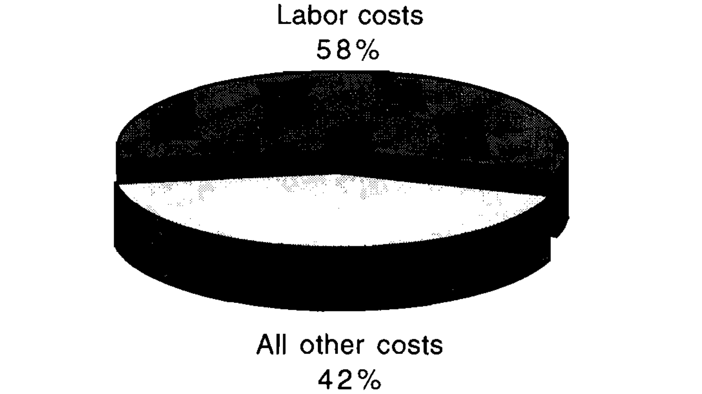
Fringe Benefits

Fringe benefits included employer contributions to medical insurance, employees' pension fund, vacation, and gifts as well as the mandatory contributions to FICA, workman's compensation, and unemployment insurance. Not all plants contributed to all benefit categories. Benefits as a percentage of labor wages ranged from about 17% to 48% with an average of 35%, but 85% of the plants fell in the range of 18% to 40% of wages (Figure 15).

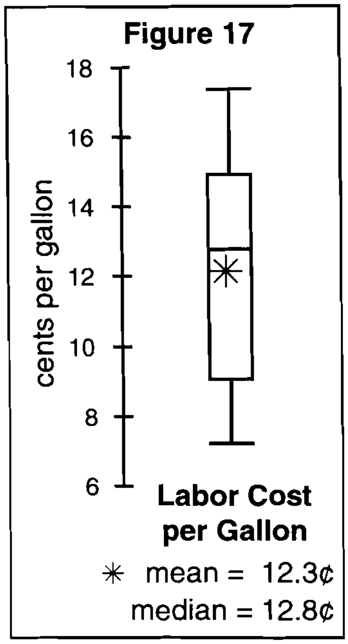
Labor Cost per Gallon

The cost of labor was the largest single factor in determining plant cost per gallon (Figure 16). The percent of plant cost per gallon attributable to labor costs ranged from 41% to 70% with a mean of 58%. The average labor cost was 12.3¢ per gallon of fluid products processed, and the median labor cost was 12.8¢ per gallon (Figure 17). Labor cost per gallon was influenced by a number of factors, including plant location. For example, plants in and around New York City

Figure 16. Labor Cost Relative to Other Plant Costs



tended to have higher labor costs per gallon than plants in other parts of the country. Plants around the New York City Metropolitan Area averaged 14.3¢ per gallon for labor costs, and all of the plants outside this area averaged 12.1¢ per gallon.



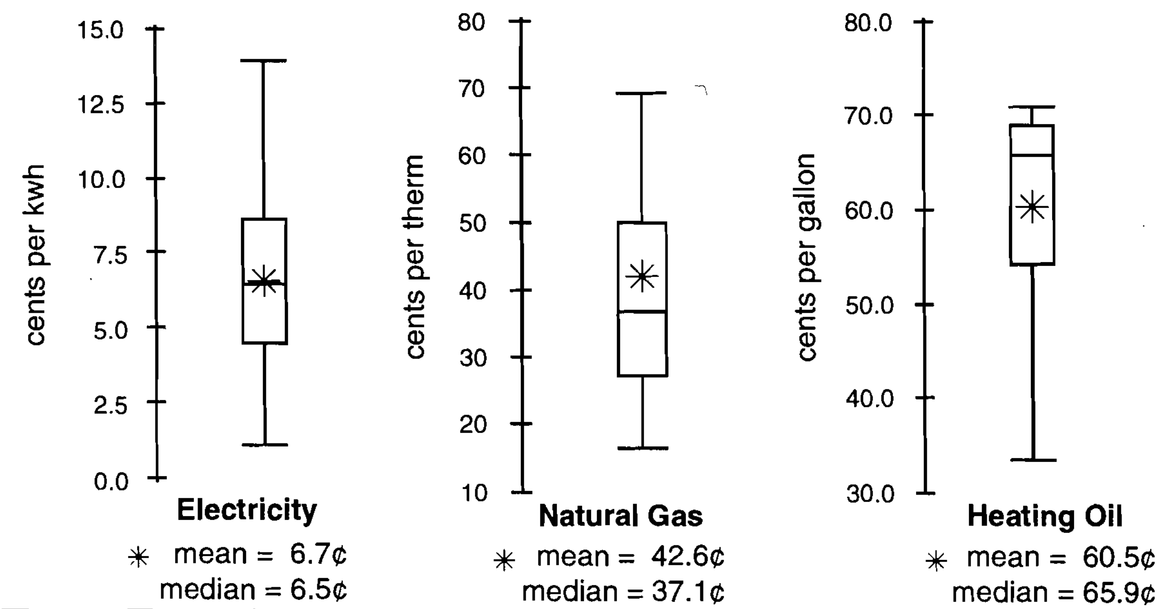
COST OF UTILITIES

All participating plants reported per unit electricity and natural gas costs. Heating oil and liquid propane were also used as fuels but far less frequently than electricity and natural gas. The common unit of measure of electricity was kilowatt-hour (kwh), but natural gas was measured in therms, decitherms, hundred cubic feet (ccf), and thousand cubic feet (mcf). To make meaningful comparisons, all unit costs for natural gas were converted to cents per therm.

There were substantial differences among the lowest and highest per unit costs for electricity and natural gas (Figure 18). Cost of electricity averaged 6.7¢ per kwh with a median of 6.5¢ per kwh. About 85% of the plants reported units costs between 3.5¢ per kwh and 10.0¢ per kwh. Natural gas costs ranged from 17¢ per therm to 70¢ per therm. The average cost of natural gas was 42.6¢ per therm with a median of 37.1¢ per therm. The data were uniformly distributed around the median, i. e., reported per unit costs did not tend to cluster around any certain costs. Plants that paid high per unit costs for electricity were likely to pay high per unit costs for natural gas (r = 0.60).

Unit costs for electricity and natural gas were dependent on plant location. For example, plants in and around New York City reported higher unit costs than plants in

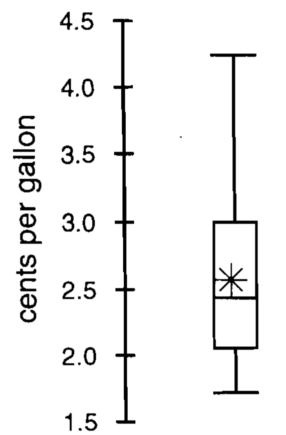
Figure 18. Unit Costs of Fuels



other parts of the country. Plants around the New York City Metropolitan Area averaged 9.9¢ per kwh and 53.4¢ per therm, and all of the plants outside this area averaged 6.2¢ per kwh and 36.8¢ per therm.

Only a handful of plants used fuel oil, and the majority of those plants did not specify which grade of fuel oil was used in the plant. Therefore, the average and median prices paid per gallon reflected the reported costs of all grades of fuel oil. Oil prices averaged 60.5¢ per gallon and were influenced by plant location as well as grade. The use of fuel oil in fluid milk plants was generally limited to late fall and winter months, and other fuel sources were used in plant operations during the remainder of the year.

Figure 19



Cost of Utilities per Gallon

✳ mean = 2.6¢
median = 2.4¢

The total cost of utilities per gallon processed varied widely (Figure 19). Cost of utilities per gallon was calculated as the 12-month average cost of utilities divided by the 12-month average volume processed by the plant. Utilities included electricity, natural gas, heating oil and other fuels, water, and sewage. Cost of utilities ranged from 1.7¢ per gallon to 4.3¢ per gallon and averaged 2.6¢ per gallon of product processed. Two-thirds of the plants had utility costs between 2.0¢ per gallon and 3.7¢ per gallon.

PLANT COSTS

Two measures were developed to assess the cost of operating each of the 35 fluid plants. Both measures represented plant cost per gallon of fluid product processed, but while one measure included the cost of depreciation, the other did not. Depreciation is an expense, albeit a non-cash expense, and it could be argued that depreciation costs should be included to paint a more accurate and complete portrait of plant costs. On the other hand, including reported depreciation costs in the calculation may be misleading because depreciation costs as reported in this study are based on bookkeeping methods. For older equipment and older plants, depreciation costs are low if the building and much of the equipment is fully depreciated. In addition, depreciation costs for new equipment and new plants may be determined on an accelerated basis which shows up as a higher depreciation cost in the early stages of the useful life of the assets.

The true economic cost of the investment in these fluid milk plants is not the accounting depreciation that was reported. Rather, it is the economic depreciation of the assets based on current replacement costs and the cost of capital tied-up in the assets (opportunity cost of capital). Unfortunately, neither economic depreciation nor opportunity cost information lent itself well to straightforward assessments by accounting personnel or controllers at the participating plants.

To avoid bias associated with bookkeeping depreciation in plant cost comparisons, we included two separate measures of plant cost per gallon. Specifically, one measure of plant cost accounted for the costs of labor, electricity, gas, water, sewage, building and equipment depreciation (excluding any depreciation charged to blow molding equipment), leases, repairs, maintenance, parts, cleaners, lubricants, plant supplies, pest control, refuse collection, taxes, and insurance relative to the volume processed in gallon equivalents. The second measure summarized variable costs and included all of the above items **except depreciation expenses.**

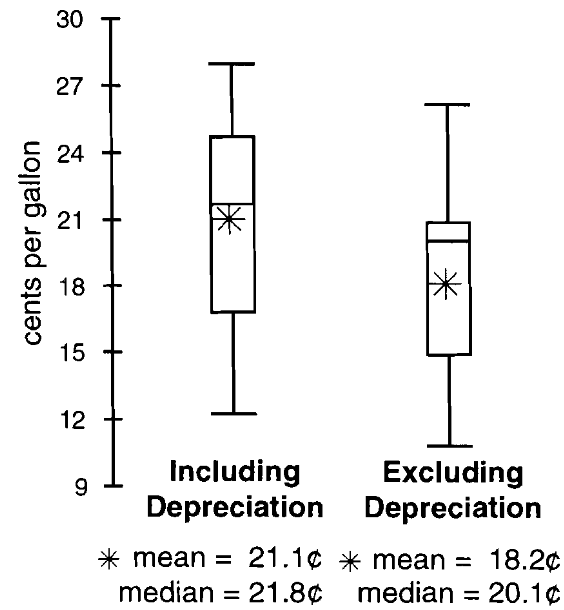
Ingredient costs were not included in either the calculation of total plant costs per gallon or variable costs per gallon. We excluded packaging costs from both of the plant cost measures because we found that unit purchase prices followed a time-series progression, i.e., the plants that submitted plant data in the early stages of the study had significantly lower packaging material costs than the plants that submitted plant data later in the study. Any labor used in producing soft dairy products (e. g., cottage cheese, sour cream, and yogurt) was also excluded, as well as the costs of rnilk procurement, research and development, distribution, selling, and general and administrative personnel.

Plant Cost per Gallon

Among the 35 plants, plant cost per gallon, including depreciation, showed large variability, ranging from 12.3¢ per gallon to 28.0¢ per gallon (Figure 20). The average cost was 21.1¢ per gallon. About 65% of the plants fell within the range of 15¢ per gallon to 25¢ per gallon. One-third of the plants had calculated plant costs of less than 18¢ per gallon.

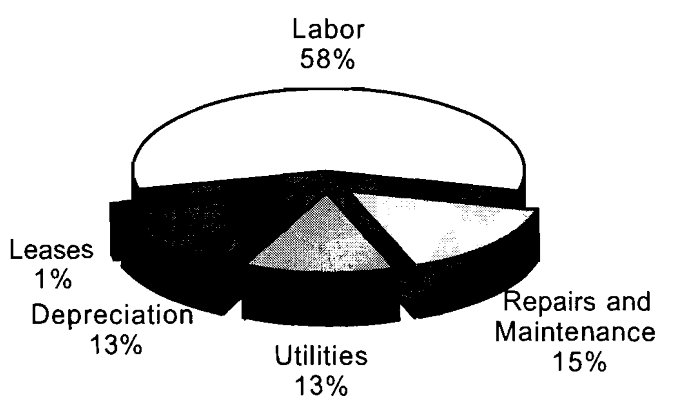
When depreciation expenses were excluded, variable costs per gallon dropped to an average of 18.2¢ per gallon and ranged from 10.9¢ per gallon to 26.2¢ per gallon (Figure 20). About three-fourths of the plants fell within the range of 13¢ per gallon to 23¢ per gallon.

Figure 20. Plant Cost per Gallon



When depreciation expenses were included, labor costs constituted 58% of plant cost per gallon (Figure 21). Building and equipment depreciation accounted for 13%, and the cost of water, sewage, electricity, and other fuels accounted for an additional 13%. As a group, repairs, maintenance, parts, cleaners, lubricants, plant supplies, pest control, refuse collection, taxes, and insurance totaled 15% of plant cost per gallon. Leases accounted for about 1% of plant cost per gallon.

Figure 21. Breakdown of Plant Cost Per Gallon



PURCHASED PACKAGING MATERIALS

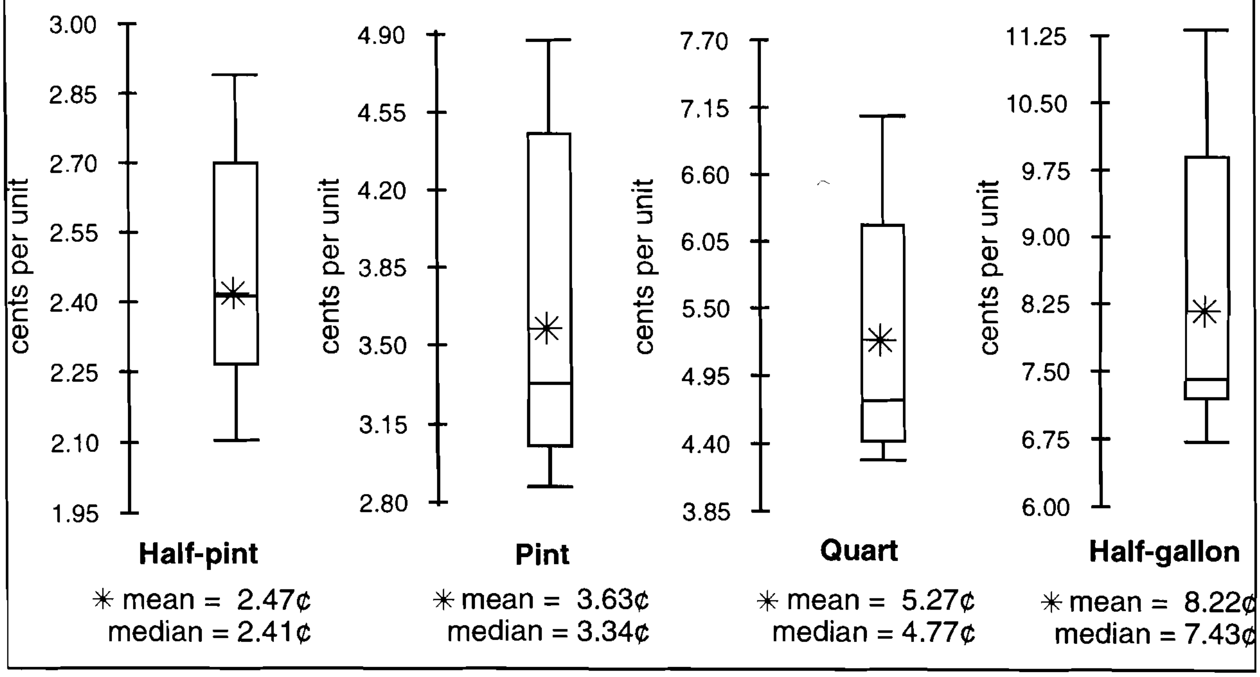
Paper containers were purchased while plastic containers, especially gallon jugs, were typically manufactured in-house. About one-third of the plants purchased plastic half-gallon and/or gallon containers, but no plants reported purchasing plastic quart containers. About 60% of the plants purchased polybags which ranged in size from 3 gallons to 6 gallons. Loss factors for plastic and paper packaging materials averaged about 1.4% and 1.1%, respectively.

Unit purchase prices for packaging materials showed tremendous variation among the participating plants. Because the cost data collected from the 35 plants reflected net delivered costs from September 1994 through October 1995, differences based on time of data submission were likely to be present. To reduce the variation in costs resulting from time of data submission, a sample of costs reported by 13 plants from January 1995 through June 1995 was used to generate summary statistics.

The cost for a half-pint container averaged about 2.5¢ and ranged from 2.1¢ to 2.9¢ (Figure 22). Other containers showed more variability. For example, quart containers averaged 5.3¢ but ranged from 4.3¢ to 7.1¢, and half-gallon containers averaged 8.2¢ but ranged from 6.8¢ to 11.3¢.

Polybags were the most costly of all container types. Two sizes of polybags, 5 and 6 gallons, were the most popular sizes used by plants, and thus reported net delivered costs reflected prices paid for 5 gallon and 6 gallon bags. Most reported prices from January 1995 through June 1995 were in the range of 45¢ to 70¢, but a few plants re-

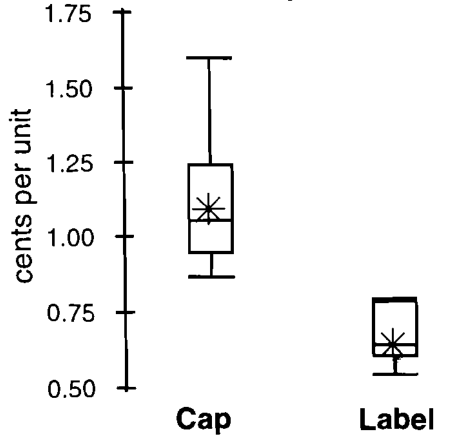
Figure 22. Net Delivered Costs for Paperboard Cartons



ported costs of over $1.00 per unit. Five gallon polybags were slightly less costly than 6 gallon polybags on average (64.0¢ vs. 76.0¢). Because the 13 plants that were used to generate the purchased packaging material summary statistics and boxplots were split between 5 gallon and 6 gallon polybags, there were too few observations to generate satisfactory boxplots.

Nearly all plants purchased plastic caps for plastic jug containers rather than manufacture their own caps, and all plants purchased labels for plastic jugs. The unit plastic cap cost averaged about 1.1¢ each and ranged from 0.9¢ to 1.6¢. The unit label cost averaged about 0.7¢ and ranged from 0.6¢ to 0.8¢ (Figure 23).

Figure 23. Net Delivered Costs for Cap and Label



	Cap	Label
✳ mean:	1.10¢	0.68¢
median:	1.06¢	0.65¢

BLOW MOLD OPERATIONS

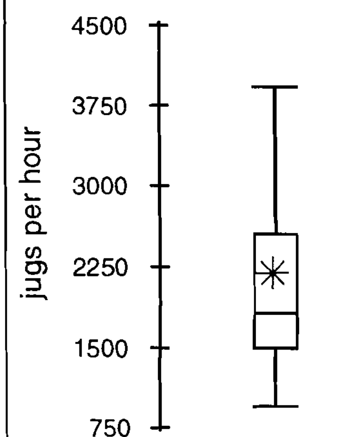
Blow mold facilities were operated in 33 of the 35 plants in the study. All blow mold operations produced plastic gallon jugs, and about one-third of the plants also produced quart and/or half-gallon plastic jugs.

The typical blow mold operation was not able to produce jugs as rapidly as needed by the filling operation, and, consequently, a number of plants relied on a bag-on and bag-off system. Under this system, the blow mold center continued to produce jugs after daily filling operations were completed, and the jugs were diverted to a plastic bagging machine rather than the filling line. When the filling operations restarted, a plant employee was responsible for removing jugs from the plastic bags and placing them on a conveyor which transported the jugs to the filler. Some plants operated a large number of blow molds which produced enough jugs to keep pace with the filling operation. In a few plants, jugs in excess of the needs of the plants were sold to other beverage filling facilities.

Blow Mold Labor Productivity

The number of jugs produced per hour of blow mold labor ranged from about 975 to over 3,750 and averaged about 2,244 (Figure 24). The number of jugs included all container sizes produced at each facility, but 91.5% of all jugs produced were gallon containers (range: 53% to 100%). Although the blow mold labor productivity in a few plants was exceptional, about 85% of the plants operating a blow mold facility produced fewer than 2,600 jugs per hour of labor.

Figure 24



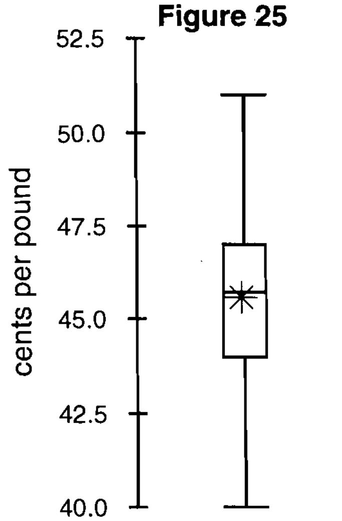
Jugs per Hour of Blow Mold Labor

✳ mean = 2,244
median = 1,833

Cost of Resin per Pound

Most of the plants reported the cost of resin per pound, but seven plants did not report any information regarding the cost of resin. Because the reported costs reflected net delivered costs from September 1994 through October 1995, substantial differences based on time of data submission were evident. Plants reporting resin costs in 1994 noted that the cost of resin increased by about 35% during the latter months of 1994. To reduce the variation in resin cost resulting from time of data submission, a sample of costs reported by 13 plants from January 1995 through June 1995 was used to generate summary statistics. Resin cost averaged 45.8¢ per pound and ranged from 40.0¢ to 52.0¢ (Figure 25).

Figure 25



Resin Cost per Pound

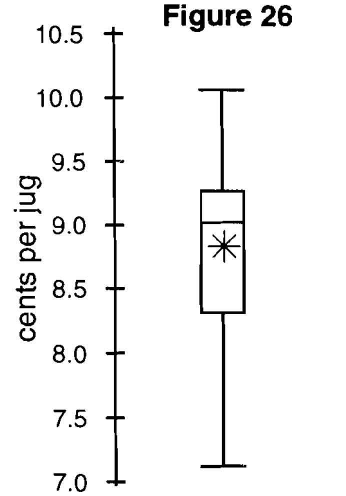
✳ mean = 45.8¢
median = 45.8¢

Cost of Producing a Jug

Because some plants did not meter blow mold utilities separately, two cost of production figures were developed for blow molding. One cost of production estimate included the cost of resin, labor, depreciation on blow mold equipment, cap, and label. The second cost of production estimate included the same cost categories as well as the cost of utilities per jug. Because resin cost per pound was lower for plants that submitted data in the fall of 1994, a single resin cost was calculated by using the resin costs submitted by 13 plants from January 1995 to June 1995. A resin cost of 45.8¢ per pound was assigned to all plants operating a blow molding facility.

The cost of producing a plastic jug, excluding the cost of utilities, ranged from about 7.1¢ to 10.1¢ with a mean of 8.8¢ (Figure 26). The highest calculated cost per jug was about 42% higher than the lowest. The limited data from plants metering utilities separately indicated that the cost of utilities per jug was low, averaging 0.3¢ per jug.

Figure 26



Cost of Producing a Plastic Jug

✳ mean = 8.8¢
median = 9.0¢

Resin accounted for about 64% of the cost of producing a jug (Figure 27). Labor cost and the cost of a cap were nearly equal, each accounting for about 11% of jug production cost. The cost of a label, the cost of utilities, and the cost of depreciation on blow molding equipment comprised the remaining 15% of the production costs.

The variation in jug weights was one of the factors contributing to the variation in the cost of producing a jug. There were surprisingly large variations in gallon and half-gallon jug weights among the plants (Figure 28). Half-gallon jugs averaged 40.6 grams, but ranged from 37 grams to 45 grams. Likewise, gallon jugs averaged 60.4 grams, but ranged from 58 grams to 64 grams. Because resin cost represented such a large share of the jug production cost, decreasing jug weights may present an avenue for decreasing jug production costs. For example, if the cost of resin was stable at 45.8 ¢ per pound, decreasing the weight of a gallon jug from 64g to 60g would decrease production costs by 0.4¢ per jug.

Figure 27. Breakdown of the Cost of Producing a Plastic Jug

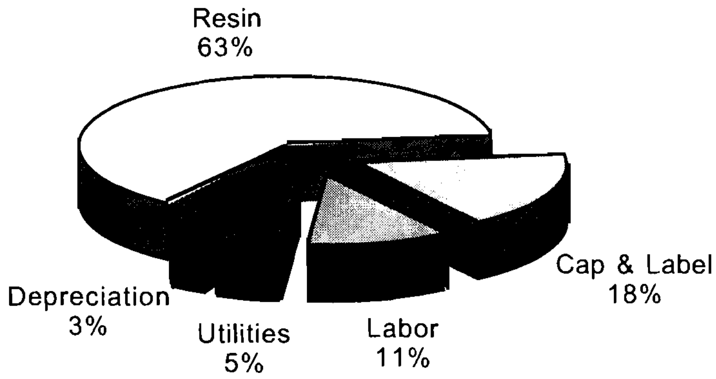
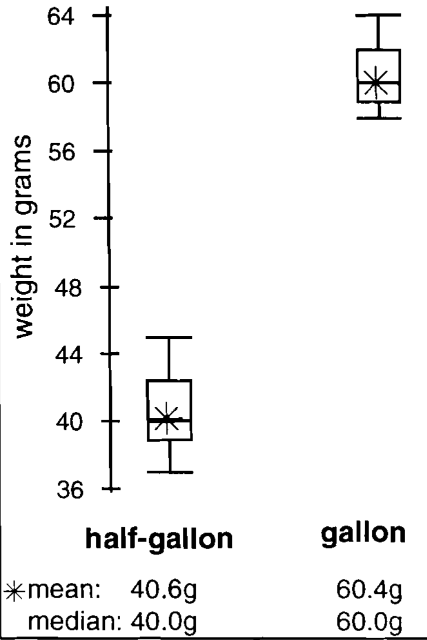


Figure 28. Plastic Jug Weights



SECTION II: DETERMINING THE IMPACT OF VARIOUS FACTORS ON LABOR PRODUCTIVITY AND PLANT COST PER GALLON

Overview

In the previous section, we reviewed general characteristics of the plants in the study. In this section, we attempt to disentangle the effects of a number of these factors on labor productivity and cost per gallon. We used regression analyses to quantify the impacts of each of the factors. In a related but separate study, we used the same plant data but used a different data analysis technique called neural networks, a type of data mining (12). The results of the two studies indicated that type of plant ownership and cost of labor had the largest impacts on labor productivity and cost per gallon. Five other factors, plant size, the percentage of product packaged in gallon and half-gallon containers, percent plant capacity utilization, and level of processing and filling technology had smaller but nonetheless significant implications for plant labor productivity and plant cost per gallon. Other factors, such as cooler and load out technology, number of SKUs processed, and percentage of product handled on pallets, did not have significant ramifications for labor productivity or cost per gallon. The two analytical techniques gave inconclusive results regarding the effect of unionized labor on labor productivity and costs.

Developing Measures to Analyze Fluid Milk Plants

We developed four measures of fluid milk plant efficiency and costs that were consistent with the goals and objectives of the project. They can be categorized generally as plant labor efficiency and plant cost per gallon:

- Gallon equivalents of products processed per hour of processing, cooler, and all other plant labor

- Gallon equivalents of product processed per hour of processing and filling labor
- Cases of product (produced and purchased) handled in the cooler per hour of cooler and load out labor
- Plant cost per gallon in cents per gallon equivalent processed

To ensure that comparable cost and labor productivity figures were analyzed among all participants, we calculated plant labor productivity, processing and filling labor productivity, cooler and load out labor productivity, and cost per gallon from the accounting data submitted. Plant labor productivity (PROD) was defined as the volume processed per month, measured in gallon equivalents, divided by the total monthly hours logged by processing and filling labor and cooler and load out labor, as well as any other plant labor that was not assigned to a specific cost center (for example, maintenance, quality control and, plant management). The hours worked by plant employees assigned to the blow molding area, personnel involved in sales, and general and administrative personnel were not included in the calculation of labor productivity.

Labor productivity in the processing and filling area (PPROD) and labor productivity in the cooler and load out area (CPROD) represented two partial plant labor productivity measures. The purpose of including these partial measures of productivity was to determine which factors were responsible for influencing labor productivity in two major centers of operation in the plant. The blow mold operation represented a third important center. With the exception of utility costs, information on the blow mold operation was not included in any of the calculations. Processing and filling labor productivity was defined as the gallon equivalents processed per hour by plant employees assigned to any processes or functions from the receiving bay to the cooler wall. Likewise, cooler and load out labor productivity was defined as the number of cases (processed products and purchased finished products) handled per hour by plant employees assigned to any functions or processes from cooler wall through the load out area. Other plant labor, e.g., maintenance, quality control, and plant management, that was considered when evaluating total plant labor productivity was not allocated to the two centers individually.

Cost per gallon (COST) accounted for the cost of processing and filling labor, cooler and load out labor, and any other plant labor that was not assigned to a specific cost center; utilities; plant maintenance and repairs; cleaners and lubricants; plant supplies; pest control; refuse collection; security; leases; property taxes; and insurance. The cost of depreciation on equipment and structures, cost of labor for blow molding, cost of packaging materials, cost of ingredients, cost of distribution, selling expenses, and general and administrative expenses were not included in the calculation of cost per gallon.

Selecting the Independent Variables

A central problem in our analysis was specifying appropriate models, i.e., models which were logical, hence consistent with economic theory and with the manner in which the data were generated. Decisions concerning which factors were tested in which models were guided by our understanding of fluid milk operations, input from managers, and the plant information which we were able to collect. A number of key factors tested were basic plant descriptors, such as gallon equivalents processed per month (GAL), number of SKUs processed (SKU), number of SKUs stored in the cooler (CSKU), percentage of processing volume loaded on pallets (PALLET), and average cost of wages and benefits for plant employees (WAGE). Other independent variables, such as the percentage of plant capacity utilized (CAP) and percentage of processing volume packaged in gallon and half-gallon containers (GHG), were calculated from data submitted from the participating plants. We also expected that differences in plant and cooler technology would affect labor productivity and costs. The degree of automation and technology in the cooler and load out area (CTECH) and the degree of automation and technology in the processing and filling area (PTECH) were evaluated by the plant manager at each participating plant. A 10-point scale was used to assess the level of technology (1 = the lowest level of technology, and 10 = the latest, most innovative technology).

Earlier results obtained from our study of fluid milk plants in the Northeast and Middle Atlantic indicated that the type of plant ownership had significant consequences for labor productivity and plant cost per gallon (10). We categorized participating companies as captive plants (CAPTIVE), cooperative plants (COOP), or proprietary plants. Captive plants are owned and operated by supermarket chains, and cooperative plants are owned and operated by farmer–owned cooperatives. Proprietary firms are best described as independently owned and operated plants.

In the earlier study of the fluid milk plants, we also found that nearly all plants maintained contracts with labor unions, and consequently, there were an insufficient number of non-unionized plants to investigate the possible effect of unionization on plant labor productivity and cost per gallon. However, the addition of 19 plants outside the Northeast and Middle Atlantic included several plants that were not unionized, presenting an opportunity to examine the effect of unionization. We included an indicator variable (UNION) to capture the effect of unionization on each of the labor productivity and cost measures.

Finally, plants located in densely populated areas have indicated that the cost of operations are higher than plants located in more rural areas. To test this hypothesis, we included a measure of population density (POPDENSE) for each plant location.

Table 2 describes the mean, median, minimum, and maximum values for each of the factors considered, based on the data collected from the 35 fluid milk plants.

<u>Other Possible Variables to Consider</u>

Quality of management and quality of the workforce are two factors which are likely to impact the cost and productivity profiles of a even well-managed plants. However, neither quality of management nor quality of the workforce lent itself to a systematic, quantitative evaluation among participating plants.

Wood et. al. (29) demonstrated that the cost of processing and packaging milk using UHT technology was significantly higher than the cost of processing and packaging using high temperature - short time (HTST) technology. UHT technology tends to be very capital intensive but less labor intensive than HTST. The containers used in UHT operations were singled out as being responsible for a large portion of the difference in cost. Although we had initially planned to investigate further possible labor productivity and cost increases attributable to UHT technology, we had an insufficient number of plants using UHT to justify the inclusion of UHT in our analysis.

Factors for which we did not collect data or did not measure appropriately were not incorporated into the study. For example, we did not collect any data on age of the facility,

Table 2. Summary Statistics for Plant Efficiency and Cost Measures and Factors Affecting Each

	Mean	Median	Low 3 Average[1]	High 3 Average[1]
Efficiency and cost measures:				
Plant labor productivity (PROD), gal/hr	174	162	107	286
Processing labor productivity (PPROD), gal/hr	492	459	246	952
Cooler labor productivity (CPROD), cases/hr	151	131	72	296
Plant cost per gallon excluding depreciation (COST), ¢/gal	18.2	20.1	11.5	24.0
Factors affecting efficiency and cost:				
Volume processed (GAL), million gal/month	3.2	3.2	1.6	6.0
Average labor cost (WAGE), $/hr	20.2	19.3	13.1	27.9
Processing labor cost (PWAGE), $/hr	20.2	19.5	12.4	28.0
Cooler labor cost (CWAGE), $/hr	19.1	18.2	12.0	27.2
Plant capacity utilization (CAP), %	76.4	77.0	42.8	100.0
Volume in gallons and half-gallons (GHG), %	85.6	86.8	55.2	100.0
Processing technology (PTECH), score	7.4	8	4	9
Cooler technology (CTECH), score	5.9	7	1	10
SKUs processed (SKU)	148	142	26	367
SKUs stored in cooler (CSKU)	250	236	40	539
Volume handled on pallets (PALLET), %	40.6	19	0	100.0
Population density (POPDENSE), 1,000/sq. mile	5.3	1.7	0.5	31.4

[1]High (Low) 3 Average represents the average values of the highest 3 (lowest 3) plants for each characteristic.

and therefore, we could not test the hypothesis that newer plants are more efficient than older plants. Furthermore, although we inquired about the design and layout of the cooler, we did not use any of the responses in the analyses. We felt that the questions that we asked did not successfully reveal the major characteristics of the coolers.

Model Specification

We developed four models that were consistent with the goals and objectives of the study. All equations were based on exponential regression models. Although more flexible functional forms could have been used, generalizations to accommodate the large number of variables we wished to include would have imposed severe restrictions on the model (4, 20, 22).

In log-transformation form, the equation used to model labor productivity was specified as

$$\begin{aligned} \ln PROD_{it} = {} & \beta_{10} + \beta_{11} \ln GAL_{it} + \beta_{12} \ln WAGE_{it} + \beta_{13} \ln CAP_{it} + \beta_{14} \ln GHG_{it} \\ & + \beta_{15} \ln SKU_i + \beta_{16} \ln PALLET_i + \beta_{17} \ln PTECH_i + \beta_{18} \ln CTECH_i \\ & + \beta_{19} CAPTIVE_i + \beta_{110} COOP_i + \beta_{111} UNION_i + \varepsilon_{it} \end{aligned} \quad [1]$$

To model labor productivity in the processing and filling area and in the cooler and load out area, we proposed the two following equations

$$\begin{aligned} \ln PPROD_{it} = {} & \beta_{20} + \beta_{21}\ln GAL_{it} + \beta_{22}\ln PWAGE_{it} + \beta_{23}\ln CAP_{it} + \beta_{24}\ln GHG_{it} \\ & + \beta_{25}\ln SKU_{i} + \beta_{26}\ln PTECH_{i} + \beta_{27}CAPTIVE_{i} + \beta_{28}COOP_{i} \\ & + \beta_{29}UNION_{i} + \varphi_{it} \end{aligned} \qquad [2]$$

$$\begin{aligned} \ln CPROD_{it} = {} & \beta_{30} + \beta_{31}\ln GAL_{it} + \beta_{32}\ln CWAGE_{it} + \beta_{33}\ln GHG_{it} + \beta_{34}\ln CSKU_{i} \\ & + \beta_{35}\ln PALLET_{i} + \beta_{36}\ln CTECH_{i} + \beta_{37}CAPTIVE_{i} + \beta_{38}COOP_{i} \\ & + \beta_{39}UNION_{i} + \gamma_{it} \end{aligned} \qquad [3]$$

The equation used to model plant cost per gallon was specified as

$$\begin{aligned} \ln COST_{it} = {} & \beta_{40} + \beta_{41}\ln PROD_{it} + \beta_{42}\ln GAL_{it} + \beta_{43}\ln WAGE_{it} + \beta_{44}\ln PTECH_{i} \\ & + \beta_{45}\ln CTECH_{i} + \beta_{46}CAPTIVE_{i} + \beta_{47}COOP_{i} + \beta_{48}\ln POPDENSE_{i} + \upsilon_{it} \end{aligned} \qquad [4]$$

where i = 1,...,35 plants and t = 1,...,12 months, and ε_{it}, φ_{it}, γ_{it}, and υ_{it} were random disturbances.

Pooling Cross-Section and Time-Series Data

Because the study involved pooling cross-section and time series observations, we combined assumptions frequently made about cross-section observations with those often made about time series data. Under such an approach, regression disturbances were assumed to be mutually independent but heteroskedastic and autoregressive. Specifically, we assumed that, for model [1],

$$\begin{aligned} E(\varepsilon_{it}) &= \sigma_{it}^2 \\ E(\varepsilon_{it}, \varepsilon_{jt}) &= 0 \ \forall \ i \neq j \\ \varepsilon_{it} &= \rho_i \varepsilon_{i,t-1} + \nu_{it} \\ \nu_{it} &\sim N(0, \sigma_{vi}^2) \\ \varepsilon_{10} &\sim N(0, \frac{\sigma_{vi}^2}{1-\rho_i^2}) \\ E(\varepsilon_{i,t-1}, \nu_{j,t}) &= 0 \ \forall \ i, j \end{aligned}$$

with identical assumptions applied to models [2], [3], and [4]. Many possible remedial measures were available to correct for the heteroskedastic and autoregressive nature of the data. As described by Kmenta (21), we subjected the observations to a double transformation — one transformation to correct the data for autocorrelation, and one transformation to correct the data for heteroskedasticity — and then applied ordinary least squares (OLS) to the transformed data.

For the purposes of illustration, we present the transformations in general terms with Y_{it} representing the dependent variable and $X_{it,k}$ representing the k independent variables. The first transformation entailed estimating ρ_i from regression residuals and forming

$$Y^{*}_{it} = \alpha_{10} + \alpha_{11}X^{*}_{it,1} + \alpha_{12}X^{*}_{it,2} + \ldots + \alpha_{1k}X^{*}_{it,k} + u^{*}_{it} \quad [5]$$

where:

$$Y^{*}_{it} = \ln Y_{it} - \rho_i \ln Y_{it-1}$$ for Y_{it}= PROD, PPROD, CPROD, COST

$$X^{*}_{it} = \ln X_{it,k} - \rho_i \ln X_{it-1,k}$$ for $X_{it,k}$= GAL, WAGE, PWAGE, CWAGE, CAP, GHG

$$u^{*}_{it} = \varepsilon_{it} - \rho_i \varepsilon_{it-1}$$

The regression residuals obtained from applying OLS to [5] were used to calculate s_{ui}^2, the estimated variance of u_{it}. The second transformation was completed by dividing each side of [5] by s_{ui} which led to

$$Y^{**}_{it} = \beta_{10} + \beta_{11}X^{**}_{it,1} + \beta_{12}X^{**}_{it,2} + \ldots + \beta_{1k}X^{**}_{it,k} + u^{**}_{it} \quad [6]$$

where:

$$Y^{**}_{it} = \frac{Y^{*}_{it}}{s_{ui}}$$ for Y^{*}_{it}= PROD, PPROD, CPROD, COST

$$X^{**}_{it,k} = \frac{X^{*}_{it,k}}{s_{ui}}$$ for $X^{*}_{it,k}$= GAL, WAGE, PWAGE,CWAGE, CAP, GHG

$$X^{**}_{i,k} = \frac{X_{i,k}}{s_{ui}}$$ for $X_{i,k}$= PALLET, SKU, CSKU, CAPTIVE, COOP, UNION, POPDENSE

$$u^{**}_{it} = \frac{u^{*}_{it}}{s_{ui}}$$

The two transformations resulted in a disturbance term that was asymptotically non-autoregressive and homoskedastic.

Contemporaneous Correlation and Recursive Systems

Correlation between disturbances from different equations for a given time period is known as contemporaneous correlation. When contemporaneous correlation exists, it may be more efficient to estimate the equations jointly rather than estimate each equation separately. Although joint estimation techniques are generally described for time-series data, they can be relevant for cross-sectional data as well. For example, if cross-sectional fluid milk plant data were used to estimate a cost function, then there is a chance that some immeasurable characteristic or event impacting a given plant had similar effects across all plants in the sample.

The hypothesized relationship between cost per gallon and plant labor productivity might suggest a simultaneous–equation problem in equations [1] and [4]. If contemporaneous correlation does not exist, OLS applied separately to each equation is fully efficient (16, 20). Thus, it was useful to test whether the contemporaneous covariances were zero.

Because plant labor productivity influenced cost per gallon but the reverse was not likely to occur, we proposed a recursive model framework for equations [1] and [4]. The right-hand side of [1] contained only exogenous variables, and because they were assumed to be uncorrelated with the disturbance term, ε_{it}, OLS was applied directly. Equation [4] contained the endogenous variable PROD as an explanatory variable along with the exogenous explanatory variables, and therefore, a test for contemporaneous correlation was necessary before proceeding with the estimation procedure.

We used the procedure outlined by Judge et. al. (20) which entailed calculating a test statistic and comparing it to a critical value from a Chi-square distribution with 1 degree of freedom. Because our test statistic (2.286) was less than the critical value at the 5% level of significance (3.841), we could not reject the hypothesis that contemporaneous covariance was zero. As a consequence, labor productivity was a predetermined variable insofar as cost per gallon was concerned. As such, the unilateral causal dependence specified for models [1] and [4] allowed for the application of OLS to each equation separately and led to unbiased and consistent estimates.

Interpreting the Results of the Analyses

An attractive feature of exponential regression models is that the slope coefficients, β_{it}, measure the elasticity of the dependent variable with respect to an independent variable. That is, it measures the percentage change in the dependent variable for a small change in one of the independent variables. We present the slope coefficients from the regression analyses assuming a 1% change in the independent variables. The coefficients for the indicator variables (CAPTIVE, COOP, and UNION) can interpreted as the relative change in the dependent variable for a given absolute change in the value of the regressor (e.g., changing from 0 to 1). Multiplying the coefficient by 100 gives the percentage change in the dependent variable for changing the indicator variable from 0 to 1. The variables CAPTIVE and COOP measure changes in labor productivity and cost per gallon relative proprietary plants, and the variable UNION measures the changes in labor productivity and cost per gallon relative to non-unionized workforces.

RESULTS OF THE ANALYSES

Plant Labor Productivity

Overview of Results

Plant labor productivity for the 35 plants averaged 174 gallons per hour of labor. The three least productive plants averaged 107 gallons per hour, and the three most productive plants averaged 286 gallons per hour. The results of our analysis, for the most part, supported what seems intuitive about plant labor productivity. Type of ownership had the largest effect with captive plants outperforming both cooperative and proprietary plants (Table 3). In the regression analysis, labor productivity in plants with unionized labor was higher than plants with non-unionized labor. However, when analyzed with a neural network system, the same data yielded opposite results, i.e., unionized labor was associated with lower labor productivity. Thus, the effect of unionization on plant labor productivity was inconclusive. Higher cost of labor, packaging more products in gallon and half-gallon containers, increasing plant capacity utilization, processing fewer SKUs and increasing the volume of product handled on pallets increased plant labor productivity. Despite the large scale of the operations in the study, larger plants, as measured by actual monthly processing volume, realized slight gains in labor productivity. Although the effect was comparatively small, more automated processing and filling equipment increased plant labor productivity. Cooler technology and cooperative plants were not statistically significant factors affecting plant labor productivity.

Table 3. Regression Results Plant Labor Productivity[1]

Variable[2]	Coefficient	SE	Probability
Constant	-0.033	0.021	0.1202
CAPTIVE	0.280	0.010	<0.0001
COOP	0.001	0.004	0.9735
WAGE	0.471	0.024	<0.0001
CAP	0.249	0.041	<0.0001
GHG	0.590	0.036	<0.0001
SKU	-0.008	0.004	0.0483
PALLET	0.014	0.001	<0.0001
GAL	0.035	0.025	0.1598
PTECH	0.048	0.008	<0.0001
CTECH	0.005	0.004	0.2595
UNION	0.024	0.008	0.0019

[1]The R^2 for the untransformed data was 74.6%, and the R^2 for the transformed data was 99.9%.

[2]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
COOP = (dis)advantage of cooperative plant relative to proprietary plant;
WAGE = average cost of wages and benefits for plant labor;
CAP = percentage of plant capacity utilized;
GHG = percentage of products packaged in gallon and half-gallon containers;
SKU = number of stock keeping units processed;
PALLET = percentage of product handled on pallets;
GAL = plant size as measured by gallon equivalents processed per month;
PTECH = degree of automation or technology in the processing and filling area;
CTECH = degree of automation or technology in the cooler and load out area;
UNION = (dis)advantage of unionized labor relative to non-unionized labor.

Plants Owned by Supermarket Companies

Type of plant ownership had significant ramifications for labor productivity. While we did not find any statistical difference in labor productivity among the cooperative and proprietary plants, captive plants owned by supermarket companies realized significantly higher labor productivity. Compared to full-line proprietary, captive plants realized a 28% increase in plant labor productivity. **This effect was net of the other factors specified in Table 3.** For example, after accounting for differences in labor cost, percent of product packaged in gallon and half-gallon containers, percent plant capacity utilization, SKUs processed, and plant technology, captive plants had an advantage of 28% in labor productivity compared to plants under different ownership.

For those who are not familiar with captive plants, it may be insightful to review some of the differences between captive plants and full-line dairies. For example, captive plants typically maintain narrower product mixes, i. e., they process fewer products under fewer labels and use fewer packaging sizes. Furthermore, most products are packaged in gallon and half-gallon containers, and only a small percentage of products are packaged in quart, pint or half-pint containers. Because captives only serve their own stores, there is a greater opportunity to handle products on less labor intensive systems, such as bossie carts and pallets. At least some of the advantages realized by captive plants in these respects were captured by the factors listed in Table 3. Relative to the total number of products handled, few (if any) finished products from outside sources are brought into the coolers of captive plants for distribution, reducing the number of products in the cooler and simplifying filling of orders and load out procedures. On the distribution side, captives serve supermarket stores that place orders for similar mixes of products with relatively little variation in order size. In combination, the characteristics described point toward operations with high product turnover and high labor productivity, which are inherently, less complex and easier to manage.

Labor Cost per Hour

Labor cost, including benefits, averaged $20.20 per hour. The three plants with the lowest labor costs averaged $13.10 per hour, and the three plants with the highest labor costs averaged $27.90 per hour. The results demonstrate that differences in labor productivity were attributable to differences in labor cost. For example, plants hiring labor at $20.40 (a 1% increase over the average) had a 0.47% advantage in labor productivity over plants hiring labor at the average cost. A 0.47% increase in labor productivity amounted to an increase of about 0.85 gallons per hour for the average plant. The implication of the result is that plants hiring plant employees at a higher cost have more productive work forces, perhaps because the higher wages attract and keep more motivated and efficient workers. This effect should not be confused with any possible result of rewarding existing plant employees with higher wages. Furthermore, as noted in a later section, higher labor cost per hour was associated with higher plant cost per gallon despite leading to higher labor productivity.

Container Mix

The percentage of product packaged in gallon and half-gallon containers ranged from about 55% to 100% with an average of 86%. Conventional wisdom regarding container size presumes that packaging products in smaller containers sizes (e. g., quarts, pints, and half-pints) reduces the productivity of plant personnel.

Filling machinery for quart containers operates at speeds of 80 to 120 units per minute, and filling machinery for half-pint containers operates at speeds of 150 to 200 units per minute. On the other hand, filling speeds for half-gallon and gallon containers ranges from 70 to 90 units per minute and 60 to 100 units per minute, respectively. Although half-gallon and gallon fillers operate at slower speeds, the difference in volume of product more than compensates for the lower per minute production.

This notion was supported by the results, which indicated that a 1% increase in the volume packaged in half-gallon and gallon containers increased productivity by about 0.59%. A 0.59% increase in labor productivity amounted to an increase of about 1.05 gallons per hour in the average plant.

Plant Capacity Utilization

Most plants did not fully utilize their processing and filling capacity. On average, plants used about 76% of their capacity (Table 2). However, there were a few of plants operating far below their maximum sustainable capacity, just as there were a few plants operating at over 95% of their maximum capacity. We expected that plants that more fully utilized their operations to have higher labor productivity through better use of labor.

The results of the analyses supported our hypothesis and indicated that plants operating closer to their maximum sustainable capacity realized significant gains in labor productivity. A 1% increase in percent capacity utilization resulted in a 0.24% (0.45 gallons per hour) increase in labor productivity. This effect was net of any other factors tested that have an effect on plant labor productivity. For example, after accounting for the effects of labor cost per hour, percent of product packaged in gallon and half-gallon containers, size of plant, and so forth, increasing plant capacity utilization by 1% increased plant labor productivity by 0.25%.

Number of SKUs and Product Handling

The number of SKUs processed and percent of product shipped on pallets had relatively insignificant effects on plant labor productivity (Table 3). We proposed that the more SKUs processed, the more complicated the logistics of changing processing lines, switching labels, and changing container sizes and types. As we expected, a greater number of SKUs processed by plants decreased labor productivity. However, a 1% increase from the average number of SKUs processed only decreased labor productivity by 0.008%.

Although we expected pallets to offer plants a sizable advantage in handling product after filling, the results suggested that the impact of handling product on pallets was relatively small. A 1% increase in product handled on pallets increased labor productivity but only by 0.014%.

Although the effects of these two factors on plant labor productivity were unexpectedly small, it was a clear indication that, in the study of 35 top quality fluid milk plants, the number of SKUs processed and the percent of product handled on pallets were not relevant factors for determining labor productivity after accounting for the other factors tested.

Level of Automation

Although the level of automation in the cooler and load out area was more variable among the participating plants than the level of automation in the processing and filling area, the effect of increasing automation in the cooler on labor productivity, at least to the extent we succeeded in measuring it, was quite small (Table 3). In contrast, despite the relatively narrow range of data rating the technology in the processing and filling area, significant gains in labor productivity were achieved by plants with more modern processing and filling facilities. For example, increasing automation and technology in the processing and filling area from 4 to 6 increased labor productivity by 2.4%. A similar change in cooler and load out area technology increased labor productivity by only 0.2%. The result may be more of an indication of the shortcomings of our approach to the assessment of technology than a caution against investing in more modern cooler and loading equipment. We delegated the responsibility of rating coolers to the individual plant managers rather than developing a specific list of requirements for each level of technology (e.g., a cooler rated as 8 must conform to a specified list of requirements). It is possible that this led to a "slippery" assessment of cooler technology — some good coolers were likely to be underrated, and some poorer coolers were likely to be overrated.

Size of Plant

By industry standards, the participating plants were large. On average, the plants processed and packaged 3.2 million gallons per month with a range of 1.1 million gallons per month to about 6 million gallons per month. Although the size of plants in the study was not representative of fluid milk plants throughout the U.S., plant size was investigated as a potential factor affecting labor productivity. Despite the relatively large size of the 35 plants, the results revealed that plant size was a marginally relevant factor affecting labor productivity, and relatively large changes in plant size were required to affect plant labor productivity appreciably. As plant size increased from about 2 million gallons per month to 3 million gallons per month, labor productivity increased by about 1.7%. Furthermore, increasing plant size from 3 million gallons per month to 4 million gallons per month increased labor productivity by about 1.1%.

Comparing Regression and Neural Network Results

In a separate study, an increasingly popular method of data analysis called neural networks was used to investigate the relationships among the factors affecting labor productivity and cost per gallon (12). Neural network methods encompass a broad class of flexible nonlinear regression and discriminant models, data reduction models, and nonlinear dynamical systems. Neural networks "learn" from examples and can exhibit some capability for generalization beyond the training data. The "learning" in this context is analogous to "estimation" in more traditional statistical analysis. Similarly, "training" data is analogous to "observed" data. Neural networks are useful for classification and function approximation problems which are tolerant of some imprecision, but to which strict rules cannot be applied easily. We used a neural network model to predict the effect of different factors on plant labor productivity and cost per gallon and to determine if factor effects differed by type of plant ownership.

Although some overlap between a neural network approach and a regression approach exists, the two methods of data analysis are quite different. Standard regression models start out with a specified functional form (e.g., linear, polynomial, logarithmic) which may include interaction terms in addition to the independent variables. Ordinary least squares (OLS) seeks to minimize the sum of the squared differences between the regression line (or curve) and the data points. In other words, after the functional form is specified, OLS tries to find estimates for the model parameters that produce the best fit to the line or curve. With neural network models, a similar process is used with the exception of specifying a functional form; there are no assumptions concerning the form of the model. Simply put, neural network models let the data reveal the shape that best fits the data rather than forcing the data to fit a pre-specified shape. In general, regression analysis requires that the researcher theorize how a variable enters a model and guess as to which variables are relevant for the model. Neural network models do not require these tasks of the researcher. The network decides which variables are important and how best to use each relevant variable. Despite these appealing characteristics, neural networks have a disadvantage from a statistical viewpoint in that no probabilistic statements regarding the significance of the variables can be obtained.

The results of the neural network approach differed in some respects from those obtained using regression analysis. While the analysis revealed strong agreement for most of the factor effects, other effects showed weak agreement or no agreement at all. For example, both analyses predicted positive effects of similar magnitude on labor productivity for captive plants, cost of labor, plant capacity utilization, plant size, and processing technology. For percentage of volume packaged in gallon and half-gallon containers, percentage of plant volume handled on pallets, cooler technology, and SKUs processed, the two techniques showed agreement in the direction of the impact but differed in terms of the magnitude of the effects.

The regression analysis predicted that unionized workforces would be slightly more productive than non-unionized workforces, but the neural network approach predicted that unionized labor would be significantly less productive than non–unionized labor.

Although exact agreement among the results would be appealing, the differences are not surprising. We contend that the different results are largely related to the dissimilarities in data analyses encompassed by each technique. Specifically, we attribute the differences in our results to differences in model specification, presence of interaction terms, and functional form.

Unionization

As noted above, the two methods of data analysis produced conflicting results as to the effect of unionization on plant labor productivity, and consequently, the effect of unionization was determined to be inconclusive. Incidentally, there was no clear consensus among fluid milk industry executives concerning the impact of unionized labor on labor productivity and costs per gallon. Some managers with whom we consulted expected unionized labor to lead to lower labor productivity due to narrow job descriptions, jurisdictional limitations, work rules, and reduced workforce flexibility. Other industry executives expected unionization to have a positive effect on labor productivity. They argued that unions tend to lead to lower job turnover rates, more experienced and skilled workers, and more stability and order in the work environment. Some managers contended that unions may compel company executives to become better managers.

Although the negative effects of unionized labor are probably valid and are highly publicized, these positive effects are not as well known. We expected that the total effect of unionized labor would very likely encompass a combination of both the positive and negative effects, but we were undecided as to the direction of the net effect of unionization. Other studies of productivity and unionized labor have been similarly inconclusive (15).

Processing and Filling Labor Productivity

Overview of Results

In addition to analyzing total plant labor productivity, we also attempted to determine the factors which affect labor productivity in the processing and filling area. This included all labor from the raw milk receiving bays up to the cooler wall. Processing and filling labor for the 35 plants averaged 492 gallons per hour and ranged from about 246 gallons per hour in the three least productive plants to 952 gallons per hour in the three most productive plants.

A number of the factors which were shown to affect plant labor productivity also impacted processing and filling labor productivity (Table 4). Larger plants, as measured by actual monthly processing volumes, had advantages in processing and filling labor productivity. Type of ownership had a moderate effect with captive plants outperforming both cooperative and proprietary plants. Proprietary plants processed slightly more volume per hour of processing and filling labor than cooperative plants. The regression analysis indicated that unionized labor was more productive in the processing and filling area relative to plants without unionized labor. The neural network methodology was not applied to the processing and filling labor data. However, given the conflicting results of the effect of unionization on plant labor productivity, we are reluctant to place much weight on the result obtained from the regression analysis. Higher wage rates, packaging more products in gallon and half-gallon containers, increasing plant capacity utilization, and processing fewer SKUs increased processing and filling labor productivity. Plants with more advanced equipment in the processing and filling area had advantages in processing and filling labor productivity, but the effect was comparatively small.

Table 4. Regression Results for Processing and Filling Labor Productivity[1]

Variable[2]	Coefficient	SE	Probability
Constant	-0.008	0.014	0.5409
CAPTIVE	0.069	0.008	<0.0001
COOP	-0.022	0.009	0.0097
PWAGE	0.561	0.029	<0.0001
CAP	0.668	0.059	<0.0001
GHG	0.280	0.044	<0.0001
SKU	-0.008	0.005	0.1370
GAL	0.255	0.028	<0.0001
PTECH	0.048	0.008	<0.0001
UNION	0.022	0.005	<0.0001

[1]The R^2 for the untransformed data was 83.7%, and the R^2 for the transformed data was 99.9%.

[2]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
COOP = (dis)advantage of cooperative plant relative to proprietary plant;
PWAGE = average cost of wages and benefits for processing and filling labor;
CAP = percentage of plant capacity utilized;
GHG = percentage of products packaged in gallon and half-gallon containers;
SKU = number of stock keeping units processed;
GAL = plant size as measured by gallon equivalents processed per month;
PTECH = degree of automation or technology in the processing and filling area;
UNION = (dis)advantage of unionized labor relative to non-unionized labor.

Plant Size

Do larger plants realize gains in processing and filling labor productivity? Our results suggested that they do, and the effect of running a larger plant was quite substantial. One of the premises behind building and operating a larger plant is that a plant which is capable of processing twice as much volume does not require twice as many inputs (e. g., labor, utilities, repairs, maintenance, and so forth) to do so. Increasing plant size from 2 million gallons per month to 3 million gallons per month increased processing and filling labor productivity by 12.8% (50% increase in volume processed x 0.255 = 12.75%). Smaller but still substantial gains were made when plant size increased further.

Plants Owned by Supermarket Companies and Milk Cooperatives

Type of plant ownership had a significant impact on processing and filling labor productivity (Table 4). Compared to full-line proprietary milk plants, captive plants realized 6.9% higher processing and filling labor productivity. Labor productivity in cooperative plants was about 2.2% lower than proprietary plants, and about 9.1% (6.9% + 2.2%) lower than captive plants. Again, this was net of the effects of all the other variables included in the model (e.g., labor cost per hour, plant capacity utilization, size of plant, etc.).

Labor Cost per Hour

Labor cost, including benefits, for processing and filling labor averaged $20.20 per hour, and the summary data found in Table 2 showed that there were substantial differences in processing and filling labor compensation. The results indicated that some of the variation in processing and filling labor productivity were attributable to differences in labor cost per hour (Table 4). For example, plants hiring labor at $20.40 (1% higher than the average) had a 0.56% advantage in processing and filling labor productivity over plants hiring labor at the average cost of labor. A 0.56% increase in processing and filling labor productivity amounted to an increase of about 2.8 gallons per hour in the average plant.

Container Mix

As indicated earlier, container mix was thought to affect plant labor productivity. An extension of this notion contends that plants with container mixes weighted toward gallon and half-gallon containers realized higher processing and filling labor productivity. This idea was supported by the results. The results indicated that a 1% increase in the volume packaged in half-gallon and gallon containers increased processing and filling productivity by about 0.28%. A 0.28% increase in processing labor productivity amounted to an increase of about 1.4 gallons per hour in the average plant.

Plant Capacity Utilization

The results of the analyses indicated that plants operating closer to their maximum sustainable capacity realized substantial gains in processing and filling labor productivity, regardless of plant size. A 1% increase in percent capacity utilization resulted in a 0.67% increase in processing and filling labor productivity. A 0.67% increase in processing labor productivity amounted to an increase of about 3.3 gallons per hour.

Level of Automation

Despite the relatively narrow range of data rating the technology in the processing and filling area, small but significant gains in labor productivity were achieved by plants with more modern facilities. For example, increasing automation and technology in the processing and filling area from 4 to 6 increased labor productivity by 1.4%. Investing in processing and filling technology to improve from 6 to 8 increased processing and filling labor productivity by 1.0%. The implication of the results was that lower levels of processing and filling technology did not significantly reduce the labor productivity achieved in this area of the plant.

Number of SKUs

The number of SKUs processed had a relatively insignificant effect on processing and filling labor productivity (Table 4). As we expected, a greater number of SKUs processed by plants decreased processing and filling labor productivity. However, a 1% increase from the average number of SKUs processed only decreased processing and filling labor productivity by 0.008%.

Cooler and Load Out Labor Productivity

Overview of Results

The cooler and load out area is being scrutinized for improvements by many company executives. Even with the outstanding plants participating in the study, the level of automation and technology in this area of the plant was exceptionally variable. While most plant managers rated their processing and filling area in the range of 6 to 9 on a 10-point scale, cooler and load out ratings were much more widely dispersed. For example, about 31% of the plants rated their coolers as 7 or better, and 23% rated their coolers as 3 or worse. From an analytical point of view, the greater range in cooler and load out ratings gave us an opportunity to disentangle the effect of more modern cooler equipment on cooler and load out labor productivity from other factors. We included all labor from the cooler wall up through the load out area in our assessment of cooler and load out labor productivity. Cooler and load out labor productivity for the 35 plants averaged 151 cases handled per hour and ranged from about 72 cases per hour in the three least productive coolers to 296 cases per hour in the three most productive coolers.

Larger plants, as measured by actual monthly processing volume, realized higher labor productivity in the cooler and load out area (Table 5). Type of ownership had a moderate effect with captive plants outperforming both cooperative and proprietary plants. Cooperative plants handled slightly more cases per hour than proprietary plants. Higher labor rates, packaging more products in gallon and half-gallon containers, and storing fewer SKUs in the cooler increased cooler and load out labor productivity. Percent of product handled on pallets did not affect labor productivity greatly. More automated cooler and load out facilities increased cooler and load out labor productivity slightly. Plants with unionized labor were notably less productive in the cooler and load out area than plants without unionized labor. However, we offer the same caveats for this result as we outlined for the effect of unionization on processing and filling labor productivity. Plant capacity utilization was found to have a statistically insignificant effect on cooler and load out labor productivity.

Table 5. Regression Results for Cooler and Load out Labor Productivity[1]

Variable[2]	Coefficient	SE	Probability
Constant	0.021	0.018	0.2526
CAPTIVE	0.110	0.016	<0.0001
COOP	0.014	0.010	0.1571
CWAGE	0.736	0.044	<0.0001
CAP	0.020	0.053	0.7069
GHG	0.532	0.054	<0.0001
CSKU	-0.028	0.005	0.1370
GAL	0.242	0.029	<0.0001
CTECH	0.052	0.008	<0.0001
PALLET	0.024	0.002	<0.0001
UNION	-0.094	0.011	<0.0001

[1]The R^2 for the untransformed data was 75.8%, and the R^2 for the transformed data was 99.9%.

[2]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
COOP = (dis)advantage of cooperative plant relative to proprietary plant;
CWAGE = average cost of wages and benefits for cooler and load out labor;
CAP = percentage of plant capacity utilized;
GHG = percentage of products packaged in gallon and half-gallon containers;
CSKU = number of stock keeping units processed;
GAL = plant size as measured by gallon equivalents processed per month;
CTECH = degree of automation or technology in the processing and filling area;
PALLET = percentage of product handled on pallets;
UNION = (dis)advantage of unionized labor relative to non-unionized labor.

Plant Size

Results reported in earlier sections indicated that larger plants realized gains in both total plant labor productivity and processing and filling labor productivity. We anticipated that larger plants would realize efficiency gains in the cooler. Our results suggested that they do, and the effect of operating a larger plant on cooler and load out labor productivity was quite large. Increasing plant size from 2 million gallons per month to 3 million gallons per month increased cooler and load out labor productivity by 12.1%. Increasing plant size from 3 to 4 million gallons per month resulted in an increase of 8.0%. An increase of 12.1% in cooler labor productivity amounted to an additional 18 cases handled per hour of labor.

With the impressive gains in processing and filling labor productivity and cooler and load out labor productivity determined for larger plants, it may seem inconsistent that plant size did not have a larger effect on total plant labor productivity (see Table 2). However, plant labor productivity was not composed of the sum of the two major centers in the plant. A third component was included in the calculation of total plant labor productivity – other plant labor not assigned to a specific area of the plant (e. g., maintenance, quality control, and plant management). As might be expected, larger plants maintained a larger number of personnel in these "overhead labor" categories, which, in effect, reduced the overall effect of plant size on total plant labor productivity.

Plants Owned by Supermarket Companies and Milk Cooperatives

Compared to full-line proprietary milk plants, captive plants realized 11% higher labor productivity in the cooler and load out area. This effect was net of any other factors tested that have an effect on cooler and load out labor productivity. Compared to cooperative dairies, captive dairies had a 9.6% (11% - 1.4%) advantage in cooler labor productivity. Cooler and load out labor in cooperative plants outperformed that of proprietary plants, handling about 2 cases more per hour on average.

Labor Cost per Hour

Labor cost, including benefits, for cooler and load out labor averaged $19.05 per hour. Note that the average cost of cooler and load out labor was over $1.00 per hour less than the average cost of processing and filling labor. The results indicated that a portion of the differences in cooler labor productivity were attributable to differences in labor cost per hour (Table 5). For example, plants hiring labor at $19.24 (1% higher than the average) handled 0.74% more cases per hour of cooler and load out labor than plants hiring labor at the average cost. This amounted to an increase in labor productivity of about 1 case handled per hour of cooler labor.

Container Mix

The effect of container mix on processing and filling operations was expected, but we were less certain about the effect of a higher percentage of gallon and half-gallon containers on cooler and load out operations. After all, work in this area of the plant revolves around cases of product, not individual units. Our results indicated that there was a measurable effect on cooler labor productivity from packaging a higher percentage of product in gallon and half-gallon containers, and the effect was significant. From Table 5, a 1% increase in the percentage of product packaged in gallon and half-gallon containers resulted in a 0.53% increase in cooler and load out labor productivity. Perhaps this is an indication that the speed of product flow from the processing and filling area to the cooler area is increased when more product is packaged in gallon and half-gallon containers.

Product Handling and SKUs Stored in the Cooler

Pallets allow for the handling of fifty or more cases of product as a single unit. We reasoned that plants that handled a significant portion of product on pallets would have a sizable advantage in cooler and load out productivity. We also believed that plants that stored a large number of SKUs in the cooler would experience a decrease in cooler and load out labor productivity because of the logistics involved in coordinating the storage and retrieval of a large number of products. The number of SKUs stored in the cooler included all products in the cooler whether processed by the plant or purchased from other food manufacturers or distributors.

Our hypotheses were correct, but the percentage of product handled on pallets and number of SKUs stored in the cooler had relatively small effects on cooler and load out labor productivity unless very large changes in either factor were made. As we had expected, handling a significant amount of product on pallets increased labor productivity in the cooler and load out area. However, a 1% increase in the percentage of product handled on pallets increased labor productivity by only 0.024%. Furthermore, a 1% increase in the number of SKUs stored in the cooler only decreased cooler and load out labor productivity by only 0.028%.

Although these two factors do affect cooler and load out labor productivity, our results indicated that, in the study of 35 top quality fluid milk plants, the number of SKUs stored in the cooler and the percentage of product handled on pallets did not greatly affect cooler and load out labor productivity after accounting for the other factors tested.

Level of Automation

Despite the wide range of ratings for the technology in the cooler and load out area, we did not find enormous gains in cooler and load out labor productivity for plants with more modern facilities. For example, increasing automation and technology in the cooler and load area from 4 to 6 increased labor productivity by 2.6%. Investing in cooler and load out technology to improve from 6 to 8 increased labor productivity by about 1.7%. This result may be more of an indication of the shortcomings of our approach to technology assessment rather than modest returns from investing in more modern cooler and loading equipment.

Plant Cost per Gallon

Overview of Results

Cost per gallon, as calculated in this study, included the cost of processing and filling labor, cooler and load out labor, and all other plant labor that was not assigned to a specific cost center; utilities; plant maintenance and repairs; cleaners and lubricants; plant supplies; pest control; refuse collection; security; leases; property taxes; and insurance. We did **not** include the cost of labor for blow molding, cost of packaging materials, cost of ingredients, depreciation expenses on equipment and structures, cost of distribution, selling expenses, and general and administrative expenses in the calculation of cost per gallon. Plant cost for the 35 plants averaged 18.2¢ per gallon and ranged from about 11.5¢ per gallon to 24.0¢ per gallon.

Not surprisingly, the analysis showed that a number of factors found to affect plant labor productivity also directly impacted costs. Factors which affect labor productivity (and thus costs) and that also directly impact costs were:

- labor cost per hour
- size of plant
- plant capacity utilization
- level of technology in the processing and filling area
- level of technology in the cooler and load out area
- type of ownership.

However, we also determined that several factors affected only labor productivity and did not directly affect costs. These were:

- volume packaged in gallon and half-gallon containers
- use of pallets to handle product
- SKUs processed
- unionized labor

The results reported in Table 6 indicates only the direct effect of each factor. Table 7 accounts for the total effect of each variable. For those factors in the first bulleted list, the total effect included the indirect effect on cost (through changes in labor productivity) as well as the direct effect on cost. For the factors in the second bulleted list, the values presented describe only the indirect effect of each factor on cost per gallon. Because of the method of deriving the total effect of each variable on cost per gallon, no probabilistic statements can be made.

Type of plant ownership, labor cost per hour, and size of plant had large impacts on plant cost per gallon (Tables 6 & 7). Although captive plants had lower costs per gallon than plants under different ownership, we found no large differences in plant cost per gallon among cooperative and proprietary plants. Hiring labor at a higher cost led to higher plant cost per gallon. Larger plants, as measured by actual monthly processing volume, realized significantly lower costs per gallon. Higher plant

Table 6. Regression Results for Plant Cost per Gallon[1]

Variable[2]	Coefficient	SE	Probability
Constant	0.011	0.023	0.6317
PROD	-0.283	0.023	<0.0001
CAPTIVE	-0.074	0.008	<0.0001
COOP	0.007	0.005	0.1979
WAGE	1.024	0.056	<0.0001
CAP	-0.024	0.003	<0.0001
GAL	-0.071	0.017	<0.0001
PTECH	0.004	0.002	0.0143
CTECH	0.005	0.002	0.0054
POPDENSE	0.013	0.002	<0.0001

[1]The R^2 for the untransformed data was 75.9%, and the R^2 for the transformed data was 99.8%.

[2]PROD = gallon equivalents of product processed per hour of labor;
CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
COOP = (dis)advantage of cooperative plant relative to proprietary plant;
WAGE = average cost of wages and benefits for plant labor;
CAP = percentage of plant capacity utilized;
GAL = plant size as measured by gallon equivalents processed per month;
PTECH = degree of automation or technology in the processing and filling area;
CTECH = degree of automation or technology in the cooler and load out area;
POPDENSE = population density of city in which plant is located.

capacity utilization also decreased plant cost per gallon. Although we did not include depreciation in our calculation of cost per gallon, more automated processing and filling equipment decreased plant cost per gallon only slightly. In the cooler, more advanced product handling systems increased cost per gallon very slightly. Finally, population density was determined to increase plant cost per gallon, but the effect was small.

Plants Owned by Supermarket Companies

We found very little difference in cost per gallon among proprietary plants and cooperative plants. However, captive plants had cost advantages over full-line plants. Through higher labor productivity and lower operating costs, cost per gallon for captive plants was about 15.3% lower than plants under different ownership. Reasons for the lower cost per gallon realized by captive plants were likely to be identical to the reasons cited for their advantage in plant labor productivity.

The cost advantage of captive plants over full-line plants reported in this study does not suggest that it is a good decision unequivocally for a supermarket chain to build and operate its own fluid milk plant. Costs do not determine prices or profits. Moreover, a supermarket chain must be concerned with the costs of all dairy products that it buys from fluid milk suppliers, not just the beverage products typically processed and packaged in captive plants. Thus, it is not a foregone conclusion that it is more profitable for a retail chain to establish its own plant, especially one designed to process and package only fluid milk products.

Our study does not take into account the capital outlays required to establish a fluid milk plant or the cost of capital involved in such a venture. These types of considerations lead many retail chains to decide that investing in their own fluid milk plant would not yield an adequate return on investment.

Table 7. Total Effects of Various Factors On Plant Cost per Gallon

Variable[1]	Direct Effect	Indirect Effect	Total Effect[2]
CAPTIVE	-0.074	-0.079	-0.153
COOP	0.007	0.000	0.007
WAGE	1.024	-0.133	0.891
CAP	-0.024	-0.070	-0.094
GAL	-0.071	-0.010	-0.081
PTECH	0.004	-0.014	-0.100
CTECH	0.005	-0.001	0.004
POPDENSE	0.013	---	0.013
GHG	---	-0.167	-0.167
SKU	---	-0.002	-0.002
PALLET	---	-0.004	-0.004
UNION	---	-0.007	-0.007

[1]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
COOP = (dis)advantage of cooperative plant relative to proprietary plant;
WAGE = average cost of wages and benefits for plant labor;
CAP = percentage of plant capacity utilized;
GAL = plant size as measured by gallon equivalents processed per month;
PTECH = degree of automation or technology in the processing and filling area;
CTECH = degree of automation or technology in the cooler and load out area;
POPDENSE = population density of city in which plant is located;
GHG = percentage of products packaged in gallon and half-gallon containers;
SKU = number of stock keeping units processed;
PALLET = percentage of product handled on pallets;
UNION = (dis)advantage of unionized labor relative to non-unionized labor.

[2] Total effect = direct effect + indirect effect

Labor Cost per Hour

Despite the positive effect of labor cost per hour on labor productivity, the overall or net effect of higher labor cost per hour was to increase plant cost per gallon. A 1% increase in labor cost per hour, e. g., increasing from $20.60 per hour to $20.81 per hour in the average plant, increased plant cost per gallon by 0.89%. This reflected labor's overwhelming contribution to plant cost per gallon. On average, cost of labor accounted for about 67% of non-ingredient cost per gallon, excluding depreciation. The effect of hiring labor at 1% over the average labor cost per hour was to increase plant cost by 0.16¢ per gallon for the average plant.

Plant Size and Plant Capacity Utilization

Larger plant size and higher plant capacity utilization were earlier shown to increase plant labor productivity. Furthermore, we hypothesized that both factors also directly impacted plant cost per gallon. The total effect of operating a larger plant, considering both the direct effect on cost per gallon and the indirect effect on costs through increased labor productivity, was substantial if plant size changed significantly. For example, increasing from 2 million gallons per month to 3 million gallons per month decreased plant cost per gallon by 4.1%. Increasing from 3 million gallons per month to 4 million gallons per month further decreased plant cost per gallon by 2.7%. Given our analysis was based on costs exclusive of depreciation, the cost advantage of larger plants when including depreciation is undoubtedly even larger because the investment per gallon is lower in larger plants.

The total effect on cost per gallon attributed to changes in percent plant capacity utilization was negative, but the effect was rather small. Earlier results showed that higher plant capacity utilization increased labor productivity, and we anticipated that the total effect of this factor would be a decrease in plant cost per gallon. The results in Table 7 supported this hypothesis, but the effect was relatively small unless large changes in plant capacity utilization were made. Increasing plant utilization by 1% decreased plant cost per gallon by 0.09%.

Level of Automation

We believed initially that plants with more modern equipment, especially in the cooler and load out area, would have significant savings in labor costs, utility costs, and repair and maintenance costs. In our analysis of plant cost per gallon, we did not include the cost of depreciation. By doing so, we hoped to avoid misleading results which might indicate that newer and more advanced equipment was more costly than older and more fully depreciated equipment. However, our attempt to capture the effects of technology on plant cost per gallon was not as successful as we had hoped it would be. We found that increasing cooler and load out technology resulted in very small increases in cost per gallon. For example, increasing in cooler and load out technology from 4 to 6 increased plant cost per gallon by 0.2% (a 50% increase in cooler score x 0.004 = 0.20). We also found that increasing processing and filling technology only slightly decreased cost per gallon. Specifically, increasing processing and filling technology from 4 to 6 decreased plant cost per gallon by 0.5%.

Population Density

Several plants located in large cities mentioned problems that they thought were unique to metropolitan areas. We tested this idea by including the number of inhabitants per square mile for each plant in the study as a relevant variable to explain differences in cost. The average population density was 5,300 people per square mile, but there was tremendous variation among the 35 plants. Plants in rural areas or small towns typically had population densities of less than 1,000 people per square mile, but plants in large metropolitan areas had population densities 8 to 10 times higher. In the most extreme cases, population density averaged 33,400 people per square mile for the three plants located in the most urban settings.

Given the tremendous range in population densities, we expected to find a significant effect for population density. Specifically, we expected that plants located in more densely populated cities would have higher costs per gallon than plants located in more rural settings. The results supported our hypothesis - plants located in large cities experienced higher costs per gallon. Specifically, a plant located in a city with 10,000 people per square mile had plant costs 1.3% higher than a plant located in a city with 5,000 people per square mile.

Factors That Affect Cost Indirectly

We assumed that four factors affected plant cost per gallon only through their effects on plant labor productivity. Specifically, we believed that unionized labor, container mix, number of SKUs processed, and percentage of product handled on pallets fell into this category. Because these factors affected labor productivity, and labor productivity affected plant cost per gallon, unionized labor, SKUs processed, container mix, and percentage of product handled on pallets indirectly affected cost. To reflect this, we calculated the impact of each of the four factors on plant cost per gallon (Table 7).

While the effects of any of these factors on cost per gallon were not insignificant, they were not extraordinary either. For example, unionized labor decreased cost per gallon by 0.7% through its effect on plant labor productivity. Similarly, increasing the percentage of volume packaged in gallon and half-gallon containers by 10% (e. g., from 85% to 94%) decreased plant cost per gallon by 1.7%. The number of SKUs processed and the percentage of volume handled on pallets impacted cost per gallon by less than 1% for corresponding changes of less than 10%.

Comparing Regression and Neural Network Results

As with plant labor productivity, the plant cost data were analyzed using a neural network approach (12). The agreement between the two approaches was remarkably uniform despite the dissimilar data analysis techniques used. For example, both analyses predicted comparable decreases in cost per gallon for captive plant ownership, higher percentage of plant capacity utilization, and higher percentage of product packaged in gallon and half-gallon containers. A few of the results of the neural network approach differed slightly from those obtained using regression analysis in terms of the magnitude of the impact although the direction of the impact was identical for both analyses. Percentage of plant volume handled on pallets, processing technology, SKUs processed, and plant size fell into this category. The regression analysis predicted that unionized workforces would be slightly less costly on a gallon basis than non-unionized workforces, that more advanced cooler technology increase cost per gallon very slightly, and that cooperative plants had costs per gallon about equal to those of proprietary plants. The neural network approach predicted that unionized labor would be significantly more costly than non-unionized labor, that more advanced cooler equipment would decrease cost per gallon very slightly, and that cost per gallon in cooperative plants was higher than those of captive plants and proprietary plants. These incongruous results imply that the effects of unionization, cooler technology, and cooperative ownership on plant cost per gallon were not determined conclusively by the two analyses.

We contend that the different results are largely related to the dissimilarities in data analyses encompassed by each technique. Specifically, we attribute the differences in our results to differences in model specification, presence of interaction terms, and functional form.

SECTION III: CHARACTERISTICS OF FLUID MILK DISTRIBUTION OPERATIONS

Types of Wholesale Routes

A distribution system for a fluid milk plant is complicated and unique to a particular plant. Even plants with similar physical characteristics and product mixes can have vastly different types of customers and methods of distributing their products. Wholesale routes can be categorized by the types of customers served and include branch/depot routes, dealer routes, company operated routes and other specialty routes.

The delivery point of a branch/depot route is a distribution center where the delivered product can be "cross-docked" to other delivery vehicles or temporarily held in the distribution center. Although the branch/depot may be owned and operated by the milk plant itself, it need not be. A warehouse operation is an example of branch or depot which may be owned and operated by an organization other than the milk plant.

A dealer route is loaded by milk plant personnel, but the actual route is owned and operated by an independent distributor. The product is purchased F. O. B. the plant dock, and the independent distributor incurs all expenses of delivering the product to customers.

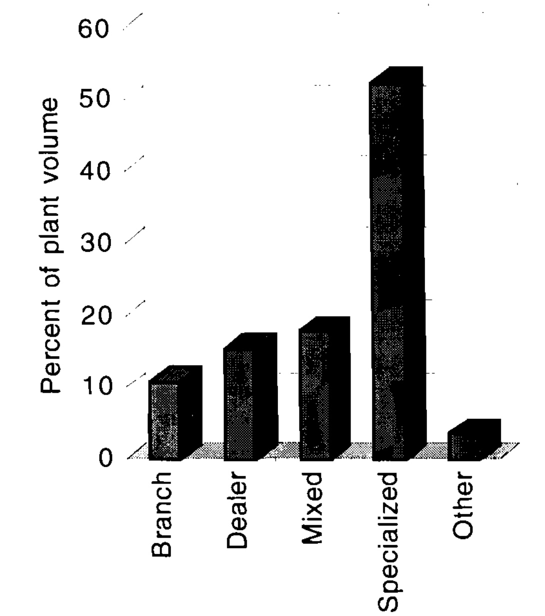
Most of the products stored in the coolers of the participating plants were distributed by company operated routes. As such, the milk company operated (or contracted with) a distribution fleet that serviced customers with direct store deliveries (DSD). The exact delivery agreement may vary, but a customer's order was typically delivered to the customer's dock or placed in the customer's cooler.

Company operated routes can be broken down further into regular mixed routes and specialized routes. Mixed routes, sometimes called "peddle routes", differ from specialized routes by the types of customer served and the number of stops per day made by each route delivery vehicle. A mixed route may be scheduled to make 15 to 30 stops per delivery day and serves a wide variety of customers, including convenience stores, small grocery stores, restaurants, delis and, in some cases, a limited number of supermarkets. A specialized route is typically scheduled to serve 1 to 8 customers per delivery day and serves only large customers — supermarket stores, large convenience stores or club stores (e. g., Price Club, Pace, Sam's Club).

Figure 29 provides a graphical description of the average percent of plant volume distributed on various types of wholesale routes by the participating plants. The volume of product distributed through specialized routes dominated all other distribution categories, representing about 52% of all volume distributed.

With regular mixed routes accounting for another 17%, about 70% of all product volume was distributed through company operated routes serving customers directly from the plant. Branch/depot routes, which included warehouse deliveries, accounted for only about 11% of the total plant volume distributed, although several participants express interest in the possibility of further developing these types of routes.

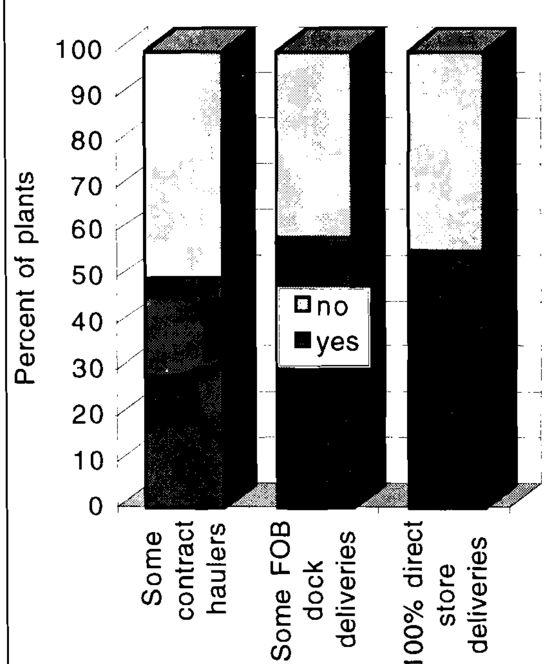
Figure 29. Percent of plant volume distributed by various methods



Other descriptors of wholesale routes included use of contract haulers, extent of direct store deliveries (DSD), and arrangements with customers concerning order deliveries. About 55% of the plants maintained DSD with all of their wholesale accounts (Figure 30). About 50% of the respondents indicated that they used contract haulers for at least one wholesale route, and they offered several reasons for contracting with independent haulers. The most common explanation was that the location of certain accounts was out of the standard delivery area covered by the plant. Another reason offered for using contract haulers was the lack of availability of backhaul materials (usually packaging) or products in outlying delivery areas. In other words, backhauls can offset some of the costs of delivering to outlying areas, and if backhauls are not available, delivery costs may be lowered by contracting with independent haulers.

About 60% of the plants in the survey maintained F. O. B. agreements with one or more customers, but the actual percentage of F. O. B. customers within a single plant tended to be small.

Figure 30. Miscellaneous distribution information



Size of Wholesale Customers

Case size was variable among fluid milk plants, but all participating plants used 16–quart, 20–quart, or 24–quart cases. Because over three-fourths of all plants surveyed used 16–quart cases, we standardized case size in all plants to 16–quart equivalents. When categorized by the number of cases taken per delivery, customers accepting over 100 cases per delivery accounted for an average of 42% the of customers and 63% of the volume distributed by the plants (Figure 31). Not surprisingly, customers that receive small orders accounted for a very small percentage of the volume distributed by the plants. For example, customers that receive less than 5 cases per delivery represented about 8% of all wholesale customers, but only accounted for an average of 1% of the volume distributed by each plant's wholesale routes. The two largest customer categories (customers receiving more than 50 cases per delivery) represented about 53% of the customers and over three–fourths of the volume distributed by plants. Many of these accounts would typically be served by the specialized routes.

Cost of Delivery Implements

Summary statistics for reported replacement costs, offsets, and life expectancies for various delivery implements are presented in Table 8. In general, most dairies did not require customers to contribute cost offsets (deposits) on delivery equipment. Deposits were not required for some delivery equipment, such as handtrucks and pallets, but deposits were required on some of the equipment left with the customers, such as bossie carts and plastic cases.

The most frequently used product handling implements were plastic cases and pallets. Plastic cases averaged about $2.03 each with a range of $1.58 to $2.70 per case, while cost of pallets averaged about $9.37, and ranged from $3.80 to $15.00 per pallet. About half of the dairies in the study required a deposit for plastic cases. The amount of the offset varied widely among plants. The minimum reported case deposit was $0.25, and the maximum reported deposit was $2.00. None of the dairies required deposits for pallets. The life expectancy of a plastic

Figure 31. Size of wholesale deliveries by percent of customers and percent of plant volume

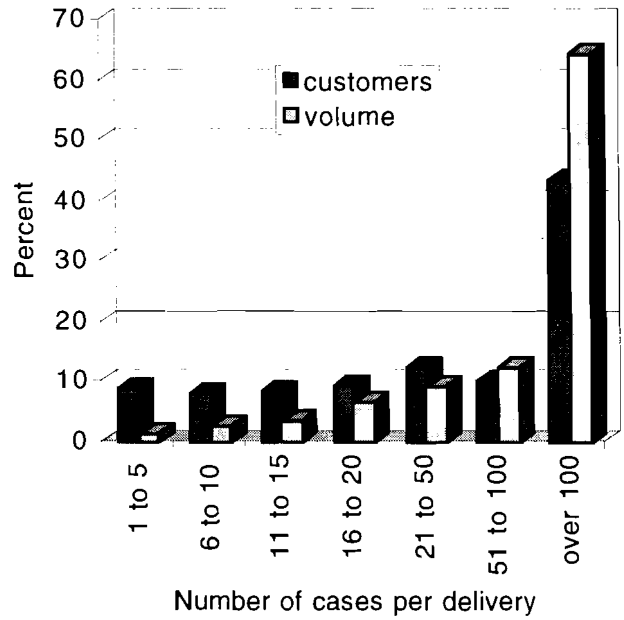


Table 8. Costs per Unit, Life Expectancies, and Deposits for Various Delivery Implements

	Cost	Life Expectancy	Deposit
Plastic case:			
average	$2.03	3.1 years	$1.42
low	1.58	1.0	0.25
high	2.70	5.0	2.00
median	2.00	3.0	2.00
Pallet:			
average	$9.37	2.6 years	$0
low	3.80	0.5	0
high	15.10	5.0	0
median	7.75	2.0	0
Handtruck:			
average	$135	4.4 years	$0
low	100	1.0	0
high	215	15.0	0
median	122	2.5	0
Bossie cart:			
average	$530	6.7 years	$483
low	250	1.0	100
high	754	20.0	750
median	536	6.0	600
Dolly:			
average	$52	4.6 years	$0
low	28	3.0	0
high	70	8.0	0
median	53	4.5	0

case, as measured by years of use, averaged 3.1 years. Some dairies in the Northeast reported life expectancies as trippage, i.e., the number of trips made before the case was retired or missing. Under this type of evaluation, plastic cases averaged about 31 trips. The life expectancy for pallets averaged 2.6 years, and ranged from 6 months to 5 years.

Among the equipment commonly used during delivery, bossie carts were the most costly to replace, but they were expected to have the longest useful life of all delivery equipment. The average replacement cost for a bossie cart was $530, and despite the high replacement cost, most dairies did not require a deposit on bossie carts. Bossie carts were generally expected to last a minimum of five years, although a few dairies reported life expectancies of less than 3 years.

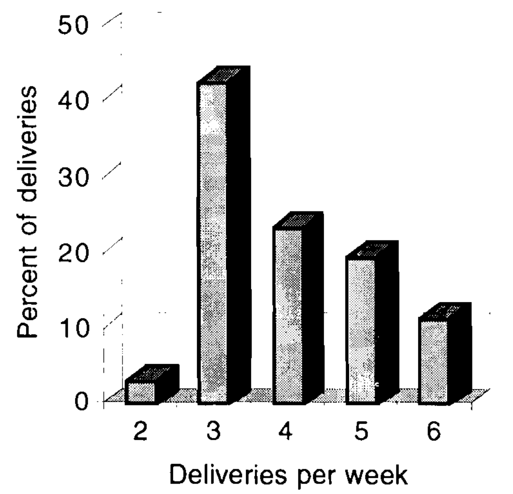
Description of Specialized Routes

A specialized or "supermarket" route typically serves 1 to 8 customers per delivery day and serves only large customers — supermarket stores, large convenience stores or club stores. Specialized routes are targeted in this study for two reasons. First, the costs of serving 15 to 30 individual customers on regular mixed or peddle routes vary widely because of the tremendous differences in the size of delivery taken by each customer and differences in levels of service. Consequently, an average delivery cost per case for regular mixed routes is not meaningful for comparative purposes. Second, about 66% of milk purchased for off-premise family consumption is sold through food chain stores, and supermarket chains account for about 55% (13). The unit costs of serving customers on specialized routes are generally considered similar across customers, and although order sizes and service arrangements may differ between customers, the variation is not likely to be highly significant. Furthermore, because of the large size of the deliveries, the per case fixed costs of serving each customer are small. Consequently, an average cost of delivery per case for specialized routes carries more meaning for comparative purposes than its mixed route counterpart. The remainder of the discussion on distribution operations concentrates exclusively on specialized routes.

Frequency of Delivery to Large Customers

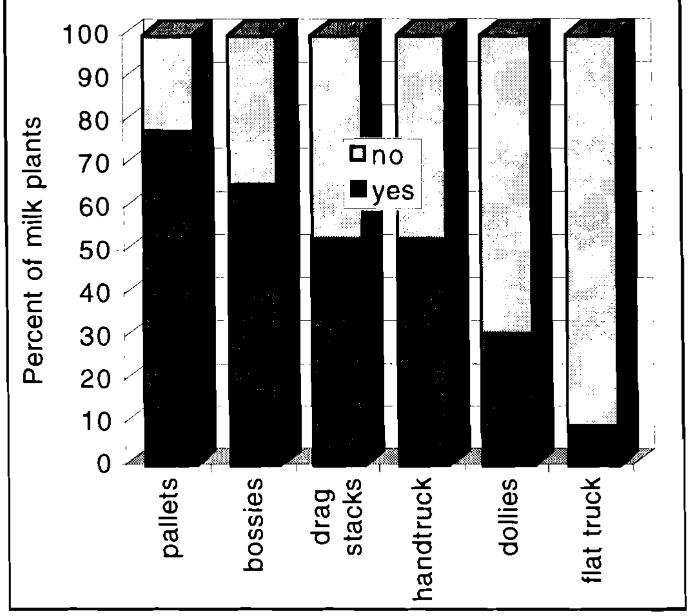
On average, most of the large account customers received shipments three or four days a week (Figure 32). The combination of these two categories totaled about two-thirds of all large accounts. About 20% of large account customers received deliveries five days a week, and another 11% received deliveries six days per week. Only about 3% received shipments two days per week, and less than 1% received deliveries 7 days per week. Although not indicated by the barchart, there was substantial variation among the participating plants. For example, several plants indicated that at least 80% of their large accounts received deliveries three days per week.

Figure 32. Weekly frequency of deliveries to large accounts



Delivery Methods for Large Accounts

Figure 33. Percent of plants using various delivery implements on specialized routes



The delivery methods most frequently used on specialized routes were pallets, bossies, drag stacks, and handtrucks (Figure 33). Nearly 80% of the participants indicated that pallets were used when delivering orders to large customers. A single pallet handles a large volume of product — about 54 16–quart cases (216 gallon equivalents). Pallets are handled by forklifts or electric hand jacks and are generally reserved for accounts that accept over 100 cases per delivery. About 65% of the plants used bossie carts for delivering product. Bossie carts are available in two sizes — 120 gallon units and 90 gallon units. The 90 gallon units are gaining acceptance because of their increased maneuverability over their larger counterparts. Bossie carts tend to be favored by retailers because of the ease of product handling in their coolers. Although there were some exceptions, the volume of product handled on bossie carts within a single plant tended to be small. However, captive plants tended to use bossie carts, as well as pallets, as the sole means of handling product on their specialized routes.

Roughly an equal percentage of plants reported using drag stacks and handtrucks to deliver orders to large accounts. The drag stacks method, which appears to be the most physically demanding of all delivery methods, involves dragging a stack of five or six cases with a metal hook from the delivery vehicle to the customer's dock or cooler. A little over half of the respondents report using handtrucks to transfer product from the delivery vehicle to the customer's dock or cooler. As with drag stacks, handtrucks are limited to moving one stack of cases at a time. Dollies and flat trucks are less frequently used methods for delivering product. About 31% of the plants used dollies, but as with bossie carts, the actual percentage of volume handled on dollies within a single plant tended to be small.

Type of Driver Compensation on Specialized Routes

Figures 34 and 35 provide a graphical summary of information on driver compensation plans for specialized route drivers. About 78% of the drivers were paid on an hourly basis, and another 18% were paid on base/commission plans. Only about 4% of the drivers were paid on a salary basis. Although the majority of drivers were paid hourly, only about 65% of the dairies reported paying overtime to drivers (Figure 34). Nearly all participating plants reported that only one person, the delivery vehicle driver, was typically required to distribute product to customers (Figure 35). However, some plants indicated that a driver may be accompanied by a second person during the training period for a newly-hired routeman. Dairies reporting regular use of multiple route personnel indicated that a

Figure 34. Methods of driver payment on specialized routes

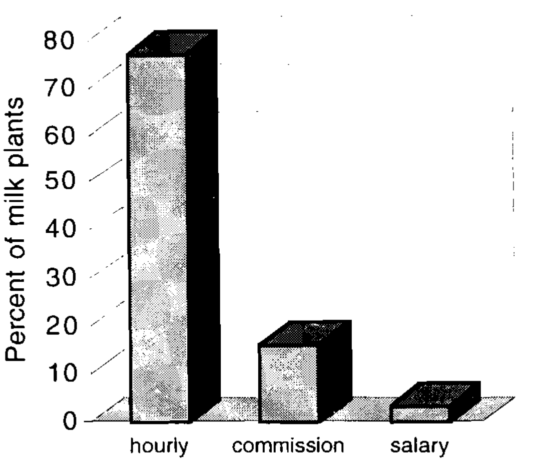
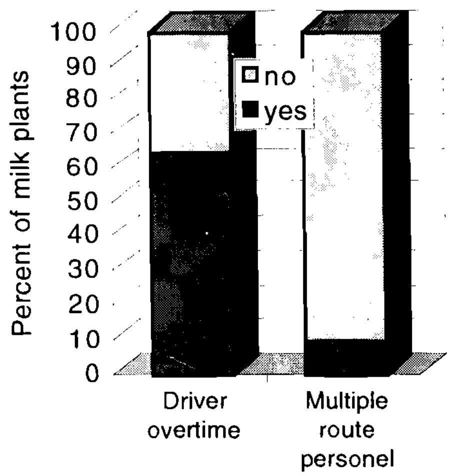


Figure 35. Miscellaneous specialized route drivery information

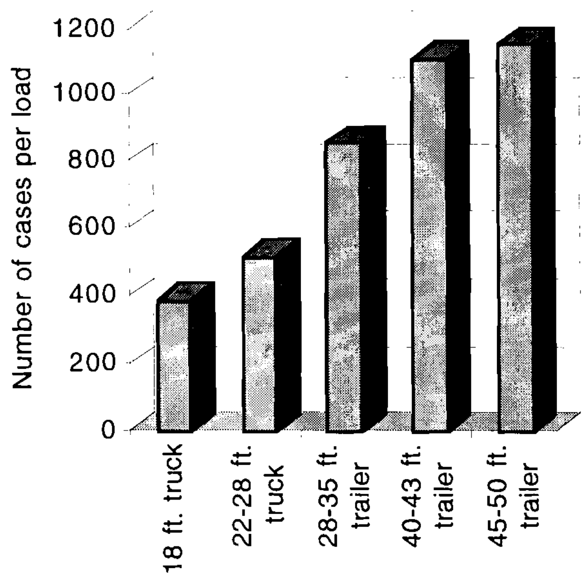


second person was needed for security reasons.

Delivery Vehicles for Specialized Routes

Because specialized routes serve customers who take large quantities of product, tractor-trailers were often used for deliveries. However, some plants with specialized routes maintained some straight-chassis trucks in the delivery fleet to deliver orders to large accounts. Clearly, the size of the loads carried on various types of delivery vehicles varies with the size of the truck or trailer (Figure 36). Working load sizes for straight chassis trucks were considerably smaller than those of trailers. Trucks carried about 390 to 520 cases, depending on the length of the truck. Trailers of length 28– to 35–feet carried an average load size of 855 cases. There was little reported difference between 40– to 43–foot trailers and 44– to 50– foot trailers in terms of working case capacity. Trailers of length 40– to 43–feet carried an average of 1,100 cases per load, and 44– to 50–foot trailers averaged 1,150 cases per load. Although some companies reported a carrying capacity of 1,300 cases or more for 45–foot trailers, there was some reported concern over road weight limits. The most common delivery vehicle on specialized routes for most of the plants in the study was the 45–foot trailer. About two-thirds of the companies reported using 45–foot trailers in some delivery capacity. Furthermore,

Figure 36. Working load size in cases for vehicles on specialized routes



*all capacities standardized to 16-quart cases fourteen companies reported that 75% or more of their delivery fleet consists of 45–foot trailers. Another three companies used 48-foot or 50–foot trailers as the main delivery vehicle on specialized routes.

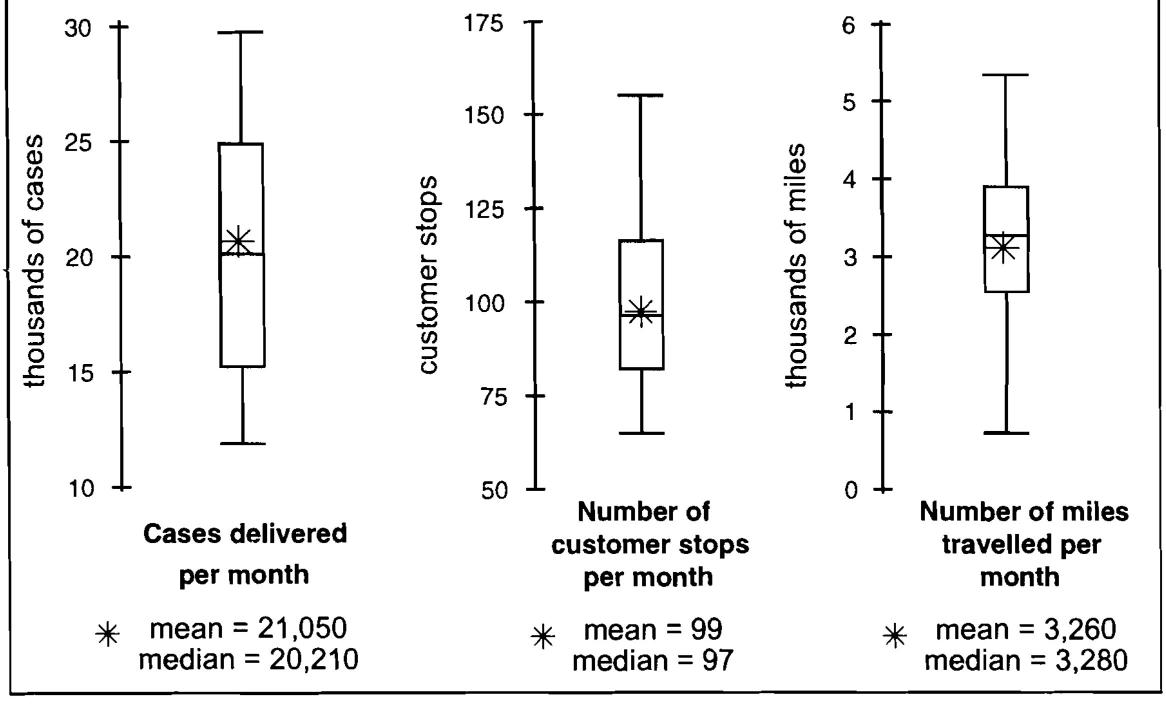
Characteristics, Productivity and Costs of Specialized Routes

A total of 35 plants submitted information on their distribution operations. Not all plants returned complete surveys, and consequently, the calculations within this section were based on data submitted by 20 operations. A great deal of variability in responses was observed in many of the topics covered.

Within a single distribution operation, route data was variable. In order to reduce the data to more manageable figures, the data for all routes operated by one plant were averaged. For example, although the direct delivery cost per case varied from route to route for a single plant, the boxplots only describe the average direct delivery cost for that operation.

The following section analyzes data collected on 270 specialized routes serving large customers submitted by 20 companies. Basic descriptive information, such as number of cases delivered per month, number of customer stops per month, number of miles traveled per month and cost of driver labor per hour are covered. The section concludes with a look at three cost and efficiency measures: driver labor productivity, cost of driver labor per case, and direct delivery cost per case.

Figure 37 - Descriptors of Specialized Routes



Number of Cases, Number of Stops and Miles Travelled

Figure 37 presents some basic descriptors of specialized routes. An average of 21,050 cases was delivered per month (4,895 cases per week) on specialized routes with a median of 20,210 cases (4,700 cases per week). The number of cases delivered ranged from about 12,000 to more than 30,000 cases per month (2,790 to 9,300 cases per week).

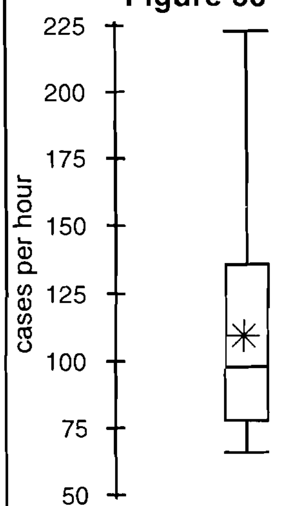
During the course of delivering these cases of product, an average of 99 stops per month (23 stops per week) were made on these specialized routes serving large accounts. The number of customer stops needed by each plant to serve all of its large accounts varied widely, but after excluding the plants with an unusually high or low number of stops, most plants report between 80 and 135 customer stops per month on specialized routes (19 to 32 stops per week).

Figure 37 also reveals the range in the number of miles travelled each month on specialized routes. The average number of miles travelled was surprisingly variable and ranged from about 750 miles to about 5,360 miles per month (175 to 1,245 miles per week). All plants averaged about 3,260 miles per month. Furthermore, the median was about 3,280 miles, indicating that the specialized routes of half of the plants travel more than an average of 3,280 miles per month, and half travel fewer than an average of 3,280 miles per month.

Driver Labor Productivity

The measure of labor productivity used for the delivery operations was the number of cases of product delivered per hour of driver labor. Driver labor productivity was calculated as the number of cases delivered per month on a specialized route divided by the number of hours worked per month by the driver(s). For each distribution operation, we averaged driver labor productivity on specialized routes for which data was submitted to generate one measure per operation. Figure 38 shows the dispersion of driver labor productivity for the participating distribution operations. On average, 111 cases were delivered per hour of driver labor, and driver labor productivity ranged from 67 cases per hour to 223 cases per hour. The large difference between the mean and median indicated that a few highly productive distribution operations were influencing the average driver labor productivity. In fact, while most operations delivered 70 to 120 cases per hour of driver labor, five operations delivered more than 150 cases per hour of driver labor.

Figure 38



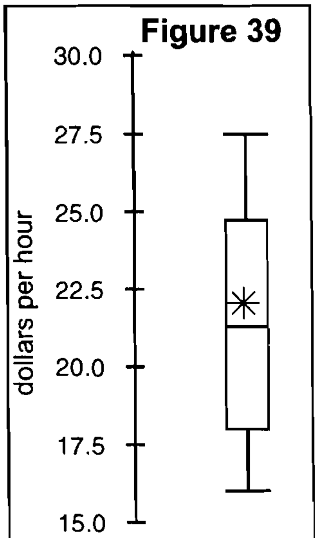
Cases delivered per hour

mean = 111
median = 99

Cost of Driver Labor per Hour

Labor cost included driver wages and company contributions to benefits packages. The average cost of driver labor on the specialized routes serving large accounts was about $22.05 per hour with a median of $21.30 per hour (Figure 39). The range was about $16.10 to over $27.50 per hour.

The most frequently selected benefits to which companies contributed were FICA, workman's compensation, unemployment, medical, vacation, pension and gifts. However, not all companies made contributions to all of these categories.



Cost of driver labor per hour

✳ mean = $22.05
median = $21.30

Cost of Labor per Case

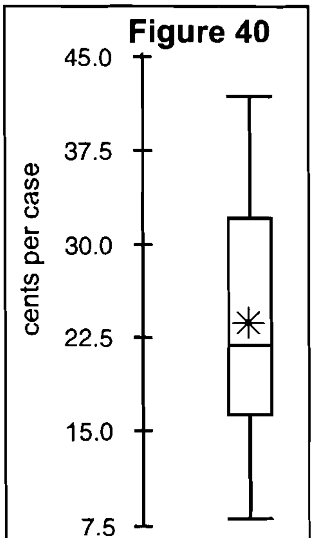
The average cost of driver labor was 23.4¢ per case (Figure 40). The lowest reported cost of driver labor was about 8.2¢ per case, and the highest was about 42¢ per case. For each distribution operation, we averaged the cost of labor per case on all specialized routes to generate one measure per operation.

Direct Delivery Cost per Case

We used two cost components to determine direct delivery cost per case for specialized routes — the cost of driver labor and the cost of operating the delivery vehicle. The cost of operating a delivery vehicle included depreciation, lease payments, insurance, fuel, oil, tires, maintenance, repairs, garage costs, truck washing expenses, registration fees, and highway taxes. For each distribution operation, we averaged total labor and vehicle cost per case on all specialized routes for which data was submitted to generate one measure per operation. Direct delivery cost averaged 38.8¢ per case and ranged from 21.6¢ per case to 54.1¢ per case (Figure 41). The median direct delivery cost was 40.5¢ per case.

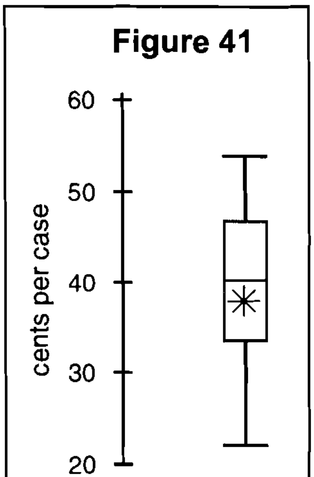
The cost of operating the delivery vehicle contributed an average of 43% to direct deliver cost per case. Cost of driver labor contributed the remaining 57%. However, vehicle operating costs ranged from 21% to 53% of direct delivery cost per case.

NOTE: *Direct delivery cost per case only reflected the cost of serving large customers, such as supermarkets and club stores, on routes that largely use tractor-trailers for delivery. An average of 5 customers per day were served on these specialized routes. The cost per case of serving smaller customers such as small convenience stores, Mom and Pop stores, delis and restaurants is expected to be much higher than the direct delivery cost reported here.*



Cost of Labor per case

✳ mean = 23.4¢
median = 22.3¢



Direct delivery cost per case

✳ mean = 38.8¢
median = 40.5¢

SECTION IV: FACTORS CAUSING ROUTE LABOR PRODUCTIVITY AND COSTS TO VARY ON SPECIALIZED ROUTES

Overview

In the previous section, we reviewed general characteristics of the distribution operations of the plants in the study. In this section, we attempt to disentangle the effects of various factors on route labor productivity and direct delivery cost per case. We used regression analyses to quantify the impacts of each of the factors. We found that type of plant ownership and cost of labor had the largest impacts on route labor productivity and delivery cost per case.

Developing Measures to Test

We investigated three measures of efficiency that were consistent with the goals and objectives of the project. They can be generally categorized as route labor efficiency and route cost measures:

- Cases of products delivered per hour of driver labor
- Cost of driver labor per delivered case
- Cost of driver labor and vehicle operation per delivered case

Driver labor productivity, cost of driver labor per case, and direct delivery cost per case were calculated from survey data to ensure that comparable cost and labor productivity figures were analyzed.

Driver labor productivity (DPROD) was defined as the number of cases of processed and purchased products delivered per month, divided by the total hours logged by drivers during the course of delivering the orders. We did not include the hours worked by any plant employees, including the load out area, personnel involved in sales, or general and administrative personnel in the calculation of driver labor productivity.

Because the cost of labor contributed an average of nearly 60% to direct delivery cost, we investigated the effects of various factors on driver labor cost per case. Driver labor cost per case (DRCOST) was defined as the monthly cost of wages and benefits divided by the number of cases delivered per month. We did not include the cost of any plant employees, including the load out area, personnel involved in sales, or general and administrative personnel in the calculation of driver labor cost per case.

As an extension of driver labor cost per case, we also analyzed the direct delivery cost per case. Direct delivery cost per case (DELCOST) was defined as the sum of the cost of driver labor (wages and benefits) and the cost of operating the delivery vehicle divided by the number of cases delivered. Vehicle operating costs included depreciation, lease payments, insurance, fuel, oil, tires, maintenance, repairs, garage costs, truck washing expenses, registration fees, and highway taxes. We did not include the cost of plant labor, including the cost of load out labor, other plant costs, selling expenses, and general and administrative expenses in the calculation of direct delivery cost.

Selecting the Independent Variables

A number of key factors tested were basic route descriptors, such as driver wages and benefits cost per hour (DRWAGE), miles travelled per month (MILES), number of customer stops per month (STOPS), percentage of product that was delivered to the customers' dock as opposed to the customers' cooler (DOCK), and the percentage of product delivered on pallets (PALLET). We also identified routes operated by captive plants (CAPTIVE) and distinguished them from routes operated by proprietary and cooperative companies. Differences in population densities may affect labor productivity. We hypothesized that more densely populated areas reduced driver labor productivity. We recognized that many plants operated routes which do not require deliveries within the city in which the plant is located. Nonetheless, we included population density (POPDENSE) as a factor affecting labor productivity. Finally, we were interested to see if unionized driver labor (UNION) had any measureable effect on route labor productivity and costs.

Notes On Distribution Data

Data on specialized route labor were reported for 270 routes, submitted by 20 dairies. The analyses of driver labor productivity was based on this data set. Only 15 dairies submitted information on route labor and delivery vehicle costs, and consequently, the analysis of direct delivery cost per case was based on only 180 routes.

Summary statistics for the independent variables are often helpful in providing orientation while analyzing the results of the analysis. Because we used two different data sets to complete the analyses, separate summary statistics are provided for each data set (Table 9 below and Table 13 on p. 57). Unlike the data used for the boxplots in the previous section, the summary statistics presented in Tables 9 and 13 were calculated from individual specialized routes; they are not averages for each operation.

Table 9. Summary Statistics for Various Factors Affecting Driver Labor Productivity and Driver Cost per Gallon[1]

Measures of Efficiency and Cost	Mean	Median	Average Low 10%	Average High 10%
Driver labor productivity (DPROD), cases/hr	108	97	52	216
Cost of driver labor (DRCOST), ¢/case	16.8	15.0	10.1	47.8
Independent Variables				
Driver labor cost (DRWAGE), $/hr	23.39	23.41	16.55	32.27
Miles travelled (MILES), thousand/month	3.15	2.98	0.74	6.85
Customer stops (STOPS), number/month	97	93	48	168
Orders delivered on pallets (PALLETS), %	49.3	40.0	0.0	100.0
Orders delivered to dock (DOCK), %	82.9	100.0	13.0	100.0
Population density (POPDENSE), 1,000/sq. mile	4.60	1.01	0.50	22.50

[1]Reflects 270 specialized routes operated by 20 companies for which labor costs were reported.

The figures in the column labeled "Average High 10%" ("Average Low 10%") represent the average values of the highest 10% (lowest 10%) of the routes. High and low averages for each characteristic were computed independently. For example, the 10% of the routes that travelled the most miles were not necessarily the same 10% routes that had the highest labor cost per hour, or any other category.

Model Specification

We developed three models that were consistent with the goals and objectives of the study. All equations were based on exponential regression models. In log-transformation, the equation used to model route labor productivity was specified as:

$$\begin{aligned}\ln DRPROD_{it} &= \beta_{10} + \beta_{11}\ln DRWAGE_{it} + \beta_{12}\ln MILES_{it} + \beta_{13}\ln STOP_{it} + \beta_{14}\ln DOCK_{it} \\ &+\beta_{15}\ln PALLET_{it} + \beta_{16}CAPTIVE_{i} + \beta_{17}UNION_{i} + \beta_{18}\ln POPDENSE_{i} + \varepsilon_{it}\end{aligned} \quad [7]$$

To model driver labor cost per case and direct delivery cost per case, we proposed the following two models

$$\begin{aligned}\ln DRCOST_{it} &= \beta_{20} + \beta_{21}\ln DRPROD_{it} + \beta_{22}\ln POPDENSE_{it} + \beta_{23}CAPTIVE_{it} \\ &+\beta_{24}UNION_{it} + \upsilon_{it}\end{aligned} \quad [8]$$

$$\begin{aligned}\ln DELCOST_{jt} &= \beta_{30} + \beta_{31}\ln DRPROD_{jt} + \beta_{32}\ln DRWAGE_{jt} + \beta_{33}\ln MILES_{jt} \\ &+\beta_{34}\ln STOPS_{jt} + \beta_{35}CAPTIVE_{j} + \beta_{36}\ln POPDENSE_{j} + \nu_{jt}\end{aligned} \quad [9]$$

where i=1,....,270 routes, j=1,...,180 routes, t=1,...,12 months, and ε_{it}, υ_{it}, and ν_{it} were random disturbances.

Statistical Notes

As with the plant regression analyses, we treated the distribution data as panel data, and as such we assumed the regression disturbances to be both heteroskedastic and autoregressive. To correct the data, we used identical transformation procedures as described in Section II.

In order to use a recursive framework as specified for models [7] and [8] and models [7] and [9], it was necessary to test whether the contemporaneous covariances were zero. We tested the two sets of equations to determine if our hypothesis of zero contemporaneous covariances was correct. Because our test statistics (2.582, 1.641) were less than the critical value for a Chi-square distribution with 1 degree of freedom at the 5% level of significance (3.841), we could not reject the hypothesis that contemporaneous covariances were zero. As a consequence, route labor productivity was a predetermined variable insofar as route labor cost per case and direct delivery cost per case were concerned. As such, the unilateral causal dependence specified for models [7] and [8] and models [7] and [9] allowed for the application of OLS to each equation separately and led to unbiased and consistent estimates.

RESULTS OF THE ANALYSES

Route Labor Productivity

Overview of Results

Route labor productivity on the 270 specialized routes averaged 108 cases delivered per hour of driver labor and ranged from about 52 cases per hour on the top 10% of the routes to about 216 cases per hour on the bottom 10% of the routes. The results supported what seems intuitive about driver labor productivity (Table 10). Type of ownership had the largest effect with routes operated by captive plants outperforming routes operated by cooperative and proprietary plants. Hiring labor at a higher cost and increasing the volume of product handled on pallets increased driver labor productivity. Routes with higher mileage were found to have lower driver labor productivity. Although we had anticipated that population density would decrease driver labor productivity, the results indicated that plants located in more densely cities realized significant gains in driver labor productivity. Larger volumes of product delivered to the customers' dock (as opposed to the cooler) and larger number of stops per month were not significant variables affecting route labor productivity. Route labor productivity for operations that employed unionized drivers was not significantly different from that on routes that used non-unionized labor.

Routes Operated by Captive Plants

Captive plants realized significantly higher driver labor productivity than routes operated by full-line dairies. Routemen of captive plants delivered 23.7% more cases per hour than those of cooperative or proprietary plants. This effect was net of the other relevant variables and accounted for differences in labor cost per hour, percentage of product handled on pallets, route mileage, and number of customer stops. On average, this amounted to about 26 cases per hour.

What might explain the higher routeman labor productivity on routes operated by captive plants? Because supermarket personnel and routemen work for the same organization, scheduling and coordination of deliveries are likely to be better than that experienced on other routes. Furthermore, routemen are more likely to receive assistance from store personnel

Table 10. Regression Results for Route Labor Productivity[1]

Variable[2]	Coefficient	SE	Probability
Constant	-0.215	0.122	0.0786
CAPTIVE	0.237	0.059	<0.0001
UNION	-0.049	0.367	0.8946
DRWAGE	0.892	0.178	<0.0001
MILES	-0.136	0.038	0.0004
STOPS	-0.075	0.077	0.3275
PALLET	0.047	0.025	0.0589
DOCK	0.120	0.136	0.3787
POPDENSE	0.403	0.034	<0.0001

[1]The R^2 for the untransformed data was 74.1%, and the R^2 for the transformed data was 98.2%.

[2]CAPTIVE = (dis)advantage of captive plant relative to full-line plants;
UNION = (dis)advantage of unionized labor relative to non-unionized labor;
DRWAGE = average cost of wages and benefits for routemen;
MILES = number of miles travelled per month;
STOPS = number of customer stops made per month;
PALLET = percentage of orders handled on pallets;
DOCK = percentage of orders delivered to customer's dock;
POPDENSE= inhabitants per square mile of city in which plant is located.

during the course of delivery. Finally, deliveries from captive plants to their supermarkets may also get priority when unloading. For example, if several delivery vehicles are waiting to unload, the supermarket may give its own trucks the privilege of moving to the front of the line. Although we have attempted to provide some insight to the result, there may be other reasons to account for the higher labor productivity on routes operated by captive plants.

Labor Cost per Hour

Labor cost, including benefits, averaged $23.39 per hour, and Table 9 indicated that there were substantial differences in route labor compensation. The regression results presented in Table 10 also indicated that differences in route labor productivity were attributable to differences in labor cost. For example, plants hiring labor at 1% over the average had 0.89% higher labor productivity than plants hiring labor at the average cost. A 0.89% increase in labor productivity amounted to an increase of about 1 case per hour.

Miles Traveled

Specialized routes covered an average of 3,150 miles per month. However, about 10% of the routes covered less than 1,000 miles per month, and about 14% covered more than 6,000 miles per month. With the tremendous differences in miles traveled, we believed this factor would have significant implications for driver labor productivity. Although the results supported our hypothesis, the effect of miles traveled on driver labor productivity was not enormous. Increasing route mileage by 1% decreased route labor productivity by 0.14%. These results indicated that labor productivity is not greatly affected unless very large changes in mileage occur.

Number of Customer Stops

Each stop on a route requires tasks that are independent of the size of the order delivered. These include decelerating and stopping the vehicle, waiting to unload, backing the tractor–trailer unit to the dock, meeting with store personnel to record the delivery, and retrieving empty cases, bossie carts, or pallets, secure trailer doors, and exiting the delivery area. We believed that the time required to complete these "fixed" tasks would accrue for a route with a large number of stops and would subsequently impact driver labor productivity. Again, the results showed that the number of stops decreased driver labor productivity, but the effect was not statistically significant.

Product on Pallets

Specialized routes typically serve customers that take 50 or more cases per delivery. The large order sizes seem well-suited for pallets which can handle 54 16-quart cases. About 39% of the routes did not use pallets to handle products. On the other hand, about 41% of the routes handled 100% of the products delivered on pallets. The percentage of product handled on pallets for the remaining 20% of the routes ranged from 20% to 75%. A higher percentage of products handled on pallets would seem to suggest significant savings in the time required to move product from the trailer to the customers' docks or coolers. However, we found that for a 1% increase in the percentage of product handled on pallets, driver labor productivity increased by only 0.047%.

The very minor effect of pallets on route labor productivity prompted us to speak with industry executives about the use of pallets. We found that although using pallets was expected to require less physical effort on the part of the routeman, the time savings associated with pallets was expected to be small. In particular, a significant amount of time may be expended searching for or waiting for a pallet jack to unload the delivery, reducing any time savings imparted by moving a large amount of product on a single pallet.

Dock Deliveries

The percent of product that was delivered to the customers' dock ranged from 13% to 100% with an average of 82.9%. Although some variation was evident, most routes deliver to the customers' dock. As with use of pallets, dock-deliveries tended to be all–or–none. In other words, the percentage of dock-delivered product for any specific route was usually 0% or 100%. We hypothesized that a higher percentage of dock–deliveries would increase driver labor productivity because placing orders in the cooler increases the time needed to complete a delivery. Although the results indicated that dock deliveries increase driver labor productivity, the effect was not statistically significant.

Population Density

We had hypothesized that more populated areas would decrease route labor productivity. Our reasoning was that congestion in the cities would slow drivers traveling from customer to customer. However, the results revealed that the opposite is true — the higher the population density of the city in which the plant was located, the higher the productivity of the driver. For example, a routeman operating in a city with population density 10% higher than the average delivered 4.0% more cases per hour. While it may be tempting to attribute the advantage to fewer miles travelled, it would be incorrect. We have accounted for differences in miles travelled, number of customer stops, and so forth.

We offer two alternative explanations for the advantage in route labor productivity for plants located in densely populated areas. First, customers located near the plant may accept larger order sizes than customers located further from the plant and in less densely populated areas. Second, population density may serve as a proxy for time of delivery. With increased traffic congestion in more densely populated cities, deliveries may be scheduled for times that are more favorable for travel, i. e., early morning or late evening.

Unionized Labor

Most of the routes for which we collected data employed unionized driver labor, but about 15% of the routes did not use unionized driver labor. We theorized that differences in labor productivity attributable to unionized/non–unionized labor would be evident. However, we did not find any difference in labor productivity among the routes with and without unionized labor. There was no statistical evidence to suggest that unionized labor was more productive or less productive than non–unionized labor after accounting for differences in labor cost per hour, miles travelled per month, number of stops per month, percentage of product handled on pallets, and so forth.

Driver Labor Cost per Case

Overview of Results

Driver labor cost per case was calculated as the total of routeman wages and benefits divided by the total number of cases delivered by the routeman. Driver labor cost per case on the 270 specialized routes averaged 16.8 ¢ per case and ranged from about 10.1¢ per case to about 47.8¢ per case.

We assumed that two of the three factors that affected route labor productivity also impacted driver labor cost per case directly. These factors were:

- type of ownership (i.e., route operated by captive plant or full-line plant)
- population density of city in which plant is located

However, we also determined that four factors affected driver labor productivity only and did not affect labor costs directly. These factors were:

- miles travelled
- number of customer stops
- percentage of product delivered on pallets
- percentage of orders delivered to the customers' dock

The results reported in Table 11 indicates only the direct effect of each factor. Table 12 indicates the total effect of each variable. For those factors in the first bulleted list, the total effect included the indirect effect on driver labor cost (through changes in labor productivity) as well as the direct impact on cost. For the factors in the second bulleted list, the values presented describe only the indirect effect of each of the significant factors, as determined by the analysis of route labor productivity. Because of the method of deriving the total effect of each variable on cost per gallon, no probabilistic statements can be made.

The results supported what seems intuitive about driver labor cost per case (Tables 11 and 12). Type of ownership had the most noticeable effect with routes operated by captive plants outperforming routes operated by cooperative and proprietary plants. Routes operated by unionized drivers had higher labor cost per case than routes operated by non–unionized drivers. By its effects on route labor productivity, higher mileage was found to have higher driver labor cost per case, but the effect was small. Population density and use of pallets decreased labor cost per case, but their effects were small as well.

Routes Operated by Captive Plants

Whether or not the route was operated by a captive plant had significant ramifications for driver labor cost per case. Labor cost per case was 40.8% lower for captive plants (Table 12). This effect was net of any other factors included in the model for driver labor cost per case. For example, after accounting for differences in percentage of product handled on pallets, route mileage, and number of customer stops, driver labor cost per case on routes operated by captive plants was 41% lower than routes under different ownership. This amounted to a difference of about 6.8¢ per case.

Given the earlier results which indicated that routes operated by captive plants delivered more cases per hour of driver labor, we anticipated this result. However, the effect of captive–owned routes was considerably larger than we expected. Closer analysis of this curious result revealed that captive plants tended to pay less for driver labor than proprietary or cooperative plants. The combination of higher labor productivity and lower driver labor cost per hour probably explains, to some degree, the low driver labor cost per case that captive plants experienced.

Table 11. Regression Results for Driver Labor Cost per Case[1]

Variable[2]	Coefficient	SE	Probability
Constant	1.232	0.697	0.0783
CAPTIVE	-0.306	0.102	0.0031
UNION	0.160	0.066	0.0019
DRPROD	-0.432	0.062	<0.0001
POPDENSE	0.120	0.051	<0.0203

[1]The R^2 for the untransformed data was 65.4%, and the R^2 for the transformed data was 77.6%.
[2]CAPTIVE = (dis)advantage of captive plant relative to full-line plants;
UNION = (dis)advantage of unionized labor relative to non-unionized labor;
DRPROD = number of cases delivered per hour of driver labor;
POPDENSE= inhabitants per square mile of city in which plant is located.

Table 12. Total Effects of Various Factors On Driver Labor Cost per Case

Variable[1]	Direct Effect	Indirect Effect	Total Effect[2]
CAPTIVE	-0.306	-0.102	-0.408
UNION	0.160	0.021	0.181
POPDENSE	0.120	-0.174	-0.054
MILES	---	0.059	-0.059
PALLET	---	-0.020	-0.020

[1]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
UNION = (dis)advantage of unionized labor relative to non-unionized labor;
POPDENSE= inhabitants per square mile of city in which plant is located;
MILES = number of miles travelled per month;
PALLET = percentage of orders handled on pallets.

[2] Total effect = direct effect + indirect effect

Unionized Labor

Although we did not find differences in route labor productivity attributable to the presence or absence of unionized labor, we did find differences in driver labor cost per case. Our results indicated that routes with unionized drivers had higher labor cost per case than routes with non–unionized drivers. Specifically, labor cost per case was about 18% higher for routes with unionized drivers. This effect is net of differences in type of route ownership, miles travelled per month, percentage of product handled on pallets, and so forth. We suspected that the reason for the higher labor cost per case on routes with unionized drivers was directly related to higher labor cost per hour, which included wages and benefits.

Population Density

We found earlier that the higher the population density of the city in which the plant was located, the higher the productivity of the driver. Although this effect on productivity was expected to decrease driver labor cost per case (indirectly), we were not certain that the total effect of population density would decrease driver labor cost per case.

As shown in Table 12, the total effect of population density served to decrease driver labor cost per case, but the effect was relatively small. For example, a plant located in a city with population density 10% higher than the average in the sample had driver labor cost that was 0.5% lower per case.

Variables That Affect Cost Indirectly

We determined that two factors affected labor cost per case only through their effects on route labor productivity. Specifically, we believed that miles travelled and the percentage of product delivered on pallets fell into this category. The indirect effect of each on driver labor cost per case is reported in Table 12.

The effects of the two factors on driver labor cost per case were not extraordinary. For example, increasing miles travelled by 1% over the average increased driver labor cost per case by 0.059%. The percentage of orders handled on pallets had even less of an impact on driver labor cost per case.

Direct Delivery Cost per Case

Overview of Results

Only 15 dairies submitted information on route labor and delivery vehicle costs, and consequently, the analysis of direct delivery cost per case was based on 180 routes. Direct delivery cost was the sum of the cost of driver labor (wages and benefits) and the cost of operating the delivery vehicle. Vehicle operating costs included depreciation, lease payments, insurance, fuel, oil, tires, maintenance, repairs, garage costs, truck washing expenses, registration fees, and highway taxes. We did not include the cost of plant labor, including the cost of load out labor, other plant costs, selling expenses, and general and administrative expenses in the calculation of direct deliver cost.

Table 13. Summary Statistics for Factors Affecting Direct Delivery Cost per Case[1]

Measures of Efficiency and Cost	Mean	Median	Average Low 10%	Average High 10%
Direct delivery cost (DELCOST), ¢/case	36.8	34.4	17.3	63.1
Factors Used to Explain Variation				
Driver labor productivity (DPROD), cases/hr	124	112	69	208
Driver labor cost (DRWAGE), $/hr	22.62	23.07	16.83	34.24
Miles travelled (MILES), thousand/month	3.19	2.98	0.70	7.11
Customer stops (STOPS), number/month	98	95	47	179
Orders delivered on pallets (PALLETS), %	62.5	100.0	0.0	100.0
Orders delivered to dock (DOCK), %	81.9	100.0	18.2	100.0
Population density (POPDENSE), 1,000/sq. mile	4.60	1.01	0.50	28.4

[1]Reflects 180 specialized routes operated by 15 companies for which labor costs and vehcile operating costs were reported.

Summary statistics for the influential factors are often helpful in providing orientation while analyzing the results of the analysis. The summary statistics presented in Table 13 were calculated from individual specialized routes and are not averages for each operation.

Direct delivery cost per case averaged 36.8¢ per case and ranged from about 17.3¢ per case to about 63.1¢ per case on the 180 specialized routes for which both labor costs and vehicle operating costs were reported.

As we determined with driver labor cost per case, five factors found to affect driver labor productivity also directly impacted direct delivery cost per case. Factors which affect labor productivity (and thus impact delivery costs indirectly) and that also directly impact delivery costs were:

- type of ownership (i.e., route operated by captive plant or full-line plant)
- driver labor cost per hour
- miles travelled
- number of customer stops
- population density

However, we also determined that two factors affected only driver labor productivity and did not directly affect delivery costs. These were:

- percentage of product delivered on pallets
- percentage of orders delivered to the customers' dock

The results reported in Table 14 indicates only the direct effect of each factor. Table 15 indicates the total effect of each variable. For those factors in the first bulleted list, the total effect included the indirect effect on direct delivery cost per case (through changes in labor productivity) as well as the direct impact on delivery cost. Of the two variables in the second bulleted list, only the percentage of orders delivered on pallets was found to be significant, as determined by the analysis of route labor productivity. Because of the method of deriving the total effect of each variable on cost per gallon, no probabilistic statements can be made.

Table 14. Regression Results for Direct Delivery Cost per Case[1]

Variable[2]	Coefficient	SE	Probability
Constant	2.447	0.626	0.0001
DRPROD	-0.676	0.030	<0.0001
CAPTIVE	0.112	0.036	<0.0022
DRWAGE	0.892	0.178	<0.0001
MILES	0.195	0.022	<0.0001
STOPS	0.061	0.037	0.1036
POPDENSE	-0.048	0.012	<0.0001

[1]The R^2 for the untransformed data was 83.8%, and the R^2 for the transformed data was 99.5%.

[2]CAPTIVE = (dis)advantage of captive plant relative to full-line plants;
DRPROD = number of cases delivered per hour of driver labor;
DRWAGE = average cost of wages and benefits for routemen;
MILES = number of miles travelled per month;
STOPS = number of customer stops made per month;
POPDENSE= inhabitants per square mile of city in which plant is located.

As we remarked earlier, we did not find differences in driver labor productivity attributable to the presence or absence of unionized labor, but we did find differences in driver labor cost per case for routes with unionized labor. We suspected that the reason for the higher labor cost per case on routes with unionized drivers was directly related to labor cost per hour, which includes wages and benefits. For this reason, we did not include unionized labor as a separate factor for direct delivery cost per case.

Table 15. Total Effects of Various Factors On Direct Delivery Cost per Case

Variable[1]	Direct Effect	Indirect Effect	Total Effect[2]
CAPTIVE	-0.112	-0.160	-0.272
DRWAGE	1.362	-0.603	0.759
MILES	0.195	0.092	0.287
STOPS	0.061	0.051	0.112
POPDENSE	-0.048	-0.272	-0.320
PALLET	---	-0.032	-0.032

[1]CAPTIVE = (dis)advantage of captive plant relative to proprietary plant;
DRWAGE = average cost of wages and benefits for routemen;
MILES = number of miles travelled per month;
STOPS = number of customer stops made per month;
POPDENSE= inhabitants per square mile of city in which plant is located;
PALLET = percentage of orders handled on pallets.

[2] Total effect = direct effect + indirect effect

The results supported what seems intuitive about direct delivery cost per case (Tables 14 and 15). Routes operated by captive plants had lower direct delivery costs per case relative to cooperative and proprietary plants. Direct delivery cost per case was also higher for routes which paid more per hour for driver labor. Routes with higher mileage and more customer stops were found to have higher direct delivery cost per case. Plants located in cities with higher population density had lower direct delivery costs per case. Percentage of product handled on pallets decreased direct delivery cost per case slightly, but its effect was small.

Routes Operated by Captive Plants

Given the results presented earlier, it was not unexpected that routes operated by captive plants had lower direct delivery costs per case. Specifically, we found that the direct delivery cost per case of routes operated by captive plants was 27.2% lower than routes operated by proprietary or cooperative milk plants. This effect was net of any other variables included in the model of direct delivery cost per case and amounted to about 9.9¢ per case.

Perhaps the earlier results for driver labor productivity and labor cost per case for routes owned by captive plants would suggest that the difference in direct delivery cost per case for captive and non-captive routes would be even higher. However, closer analysis of the data revealed that vehicle costs for captive routes tended to be higher than routes operated by proprietary or cooperative plants.

What might explain the lower delivery cost on routes operated by captive plants? We would assert that the same factors that contribute to higher labor productivity on routes operated by captive plants also contribute to lower direct delivery costs. Briefly, scheduling of deliveries are likely to be more coordinated than that experienced on other routes because supermarket personnel and routemen work for the same organization. Furthermore, routemen are more likely to receive assistance from store personnel during the course of delivery. Finally, deliveries from captive plants to their supermarkets may also receive top priority when unloading.

Labor Cost per Hour

Differences in direct delivery cost per case were attributable to differences in labor cost. For example, plants hiring drivers at 1% more than the average had 0.76% higher direct delivery cost per case than plants hiring labor at the average cost. This accounts for the corresponding increase in route labor productivity.

Miles Traveled and Number of Customer Stops

Routes with high mileages and numerous customer stops were shown to decrease route labor productivity. We tested miles travelled and number of customer stops under the presumption that both factors also affected costs directly. The total effect of each factor was significant (Table 15). For example, a 1% increase in miles travelled per month increased direct delivery cost by 0.29% per case. Similarly, a 1% increase in the number of customer stops made per month increased direct delivery cost by 0.11% per case.

Population Density

One unexpected result presented earlier suggested that route labor productivity was higher for plants located in densely populated areas. We speculated that delivery costs would be affected directly by population density as well as the effect on driver labor productivity. Our results indicated that plants located in more densely populated areas had lower direct delivery costs per case. For example, a plant located in a city with about 4,650 inhabitants per square mile (1% more dense than the average for all plants) had direct delivery costs that were 0.32% lower per case than the average plant.

SECTION V: SELLING EXPENSES AND GENERAL AND ADMINISTRATIVE EXPENSES

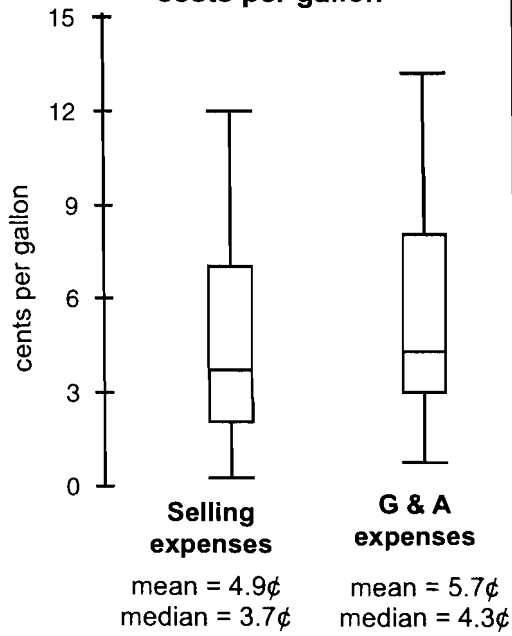
Selling expenses and general and administrative (G & A) expenses were not included in calculations of plant costs or the distribution costs. These "overhead" expenses were required to support both the plant and distribution operations and were not incurred to support only specialized routes.

In reporting these expenses, no attempt was made to allocate the selling expenses among different types of routes, nor was any attempt made to allocate the G & A expenses between the plant and distribution operations. The selling expenses and G & A expenses are reported on the basis of total cost per gallon of all beverage product processed and packaged in the plant. Thirty-five plants reported G & A expenses, and 25 plants reported selling expenses. In general, captive plants did not report selling expenses.

Selling expenses included wages and benefits for distribution management, sales management, route supervision foremen, sales representatives and order takers, advertising and promotion expenses and bad debt expenses. For G & A, expenses included wages and benefits for office personnel, salaries and benefits for administrative personnel, office overhead (electricity, depreciation, supples, dues data processing, communications, contributions and public relations), interplant hauling fees, snow removal, security, legal fees, consulting fees and allocated corporate overhead.

Selling expenses and G & A expenses are presented as costs per gallon of product processed (Figure 42). For the 25 plants reporting, selling expenses averaged 4.9¢ per gallon and ranged from less than 1¢ per gallon to over 12¢ per gallon. G & A expenses ranged from about 1¢ per gallon to about 13¢ per gallon and averaged about 5.7¢ per gallon. Captive plants tended to have lower G & A expenses per gallon than full-line operations. The 8 captive plants averaged 4.1¢ per gallon, and the proprietary and cooperative plants averaged 6.2¢ per gallon.

Figure 42 - Selling and G & A costs per gallon



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