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The Function and Cost of Market Milk Reserves and Balancing Supply with Demand

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AND BALANCING SUPPLY WITH DEMAND

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Rondo A. Christensen
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ECONOMICS RESEARCH INSTITUTE
Utah State University
Logan, Utah 84322

September 1979

Study Paper 79-8
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AND BALANCING SUPPLY WITH DEMAND

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This paper includes the data published in *The Function and Cost of Balancing Market Milk Supply with Demand*, Economics Research Institute, Utah State University, Logan, Utah 84322, Study Paper 79-5, August 1979, plus a new section on intermarket movement of milk.
Milk marketing has changed over the years, and so have the functions performed by fluid milk handlers and dairy cooperatives.

In the 1930s the typical situation was for local fluid milk processors to perform all the marketing functions starting with picking up the milk from independent dairymen at the farm, and ending with its delivery to the customer's doorstep. In most instances milk was picked up, processed and delivered daily. Each handler had to coordinate and balance his own milk supply and use. With sales about the same every day of the week, the major problem was balancing seasonal supplies during the flush production period.

Coordinating and balancing market milk supplies with demand is a more complicated task today. Milk is usually picked up from producers every other day, a majority of fluid milk sales are made through supermarkets with a concentration of sales on weekends, home deliveries are made only once or twice a week, and processing plants operate only four or five days a week. Both supply and demand fluctuate from day to day and seasonally.

Rondo A. Christensen is professor of Agricultural Economics and Douglas E. Petterson and Allan Swainston are former Research Graduate Assistants, Economics Department, Utah State University.
Many market milk handlers have accepted full supply arrangements with dairy cooperatives to avoid the high cost of procuring and coordinating a fluctuating supply to meet a variable demand, and to eliminate some of the uncertainty of obtaining an adequate supply. Under such arrangements, cooperatives undertake to supply the exact needs of handlers for milk for fluid use and oftentimes for ice cream, cottage cheese and yogurt, and also to make arrangements for handling the milk not required. Milk not needed by market milk handlers is manufactured by cooperatives into butter, powder and cheese in their own balance plants maintained for this purpose, or sold to other firms having manufacturing facilities.

With considerable variation in both supply and demand from day to day, the larger the volume under the control of a single agency such as a cooperative, the more individual plant variations tend to offset one another, and the more efficient handling reserve milk becomes compared with when each handler attempts to take care of his own. A single agency arrangement does not eliminate fluctuations, but it does reduce their impact on market milk handlers by giving them a relatively simple, routine means of adjusting supply to demand with a minimum of effort.

As cooperatives assume the function of balancing supply with demand, considerable costs formerly borne by processors become borne by cooperatives. Federal order minimum prices do not include a charge for these services. Some cooperatives assess a service charge to recover a part or all of what they estimate these costs to be.

Some market milk handlers continue to produce their own milk, or to maintain a partial supply of their own from independent producers. Typically they use all of their own milk, and then rely on cooperatives
for additional milk requirements as needed, especially during the short supply periods of the week and year.

Cooperatives must carry considerable amounts of reserve milk in order to supply on demand the milk requirements of market milk handlers. The greater the variation in sales of milk to plants the greater the amount of reserve milk that must be carried, and the greater the cost of balancing supply with demand.

This study was made to identify and determine the cost of market-wide services performed by cooperatives as they coordinate and balance supply of milk with demand, which accrue to the benefit of fluid milk handlers, market milk producers who are not members of cooperatives, and consumers.

METHODOLOGY

The analysis is based on daily deliveries of milk for a 12-month period during 1975-1976 by seven cooperatives to 55 market milk and 31 manufacturing and balance plants located in Western South Dakota, Colorado, Southern Wyoming, Utah, Southeastern Idaho, and Southern Nevada, use of milk by groups of handlers as reported by Federal milk orders operating in the area, and costs of coordinating and balancing supply with demand.

Most of the milk delivered was pooled in the Black Hills, Eastern Colorado, Great Basin, Lake Mead and Western Colorado Federal milk order markets. The seven cooperatives provided a full supply of milk to 37 of the 55 market milk plants, a major supply (less than 100 but more than 50 percent) to 3, and a minor supply (less than 50 percent) to 15, and supplied from 80 to 90 percent of the market milk sold to plants in the area studied. The cooperatives provided milk on demand to market milk
handlers, carried the necessary reserves to always be able to meet plant requirements, especially for fluid use, and operated balance plants to manufacture reserve supplies of milk in case no other suitable market was available.

Daily deliveries of milk were used to analyze fluctuations in supply and use of milk by type of plant - full supply, major supply and minor supply. Deliveries of milk to market milk plants were classified according to whether they were basic or supplemental. Basic deliveries included the amount of milk each group of plants took each day throughout the year, varying only with daily and seasonal fluctuations in production. Supplementary milk included all deliveries to plants in each plant group in excess of basic milk supplies. Reserve supplies of milk, which had to be carried during days and seasons of the year when demand was low relative to supply in order to meet peak demand requirements, were classified according to whether they were operating reserves to handle daily fluctuations or seasonal reserves to handle seasonal fluctuations in supply and demand.

Costs attributed to supply-demand balancing and coordination included extra hauling costs to move milk to short-supply areas and to divert reserve supplies to manufacturing and balance plants, costs of bulk storage used to hold milk supplies to meet peak demand days, personnel and office expenses involved in delivery coordination and rerouting bulk-tank trucks, shrinkage resulting from splitting loads and reloading to divert milk to manufacturing plants, general administration attributed to the function of coordinating supplies, health and quality inspection fees on reserve milk, market administration fees on reserve milk, and plant give-up costs. Plant give-up costs equaled the increase in cost per unit which occurred when reserve milk was withdrawn from balance plants to make supplemental shipments of milk to market milk...
handlers, times the amount of milk processed. Costs for each plant group were divided by the hundredweights of milk delivered to them to get the average cost per hundredweight of milk delivered on which a service charge might be assessed.

MILK DELIVERIES

The seven dairy cooperatives included in the study marketed 1,815.8 million pounds of market milk during the 12-month period of September 1975 through August 1976 (Table 1). Of this, 67.1 percent was delivered to market milk plants to which they provided a full supply, 6.1 percent to market milk plants to which they provided a major supply and 3.1 percent to market milk plants to which they provided a minor supply. The remaining 23.7 percent was delivered to manufacturing plants, including their own balance plants.

Daily Variation

Deliveries of milk to plants varied considerably by day of the week. Deliveries to full supply market milk plants were high Monday through Thursday and low Friday through Sunday. Deliveries on Tuesdays and Wednesdays, the peak delivery days, were 23.8 percent greater than on Saturdays, the lowest delivery day (Table 2 and Figure 1). Storage capacity, processing schedules and the tendency for supermarket sales of milk to be greatest during the latter part of the week influenced the timing of when plants took milk.

The more that plants relied on their own milk production and only bought additional supplies as needed from cooperatives, the more deliveries to them varied during the week. For major supply plants, peak
Table 1. Total deliveries of market milk to plants by seven dairy cooperatives in the Intermountain area, by type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Type of plant</th>
<th>Number of plants</th>
<th>Milk delivered</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Million Tbs.</td>
<td></td>
</tr>
<tr>
<td>Market milk plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Full supply</td>
<td>37</td>
<td>1,218.3</td>
<td>67.1</td>
</tr>
<tr>
<td>Major supply</td>
<td>3</td>
<td>111.5</td>
<td>6.1</td>
</tr>
<tr>
<td>Minor supply</td>
<td>15</td>
<td>55.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>1,385.7</td>
<td>76.3</td>
</tr>
<tr>
<td>Manufacturing and balance plants</td>
<td>31</td>
<td>430.1</td>
<td>23.7</td>
</tr>
<tr>
<td>All plants</td>
<td>86</td>
<td>1,815.8</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 2. Variation in deliveries of milk by seven cooperatives in the Intermountain area to 86 milk plants, by day of week and type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Day of the week</th>
<th>Market milk plants</th>
<th>Average daily deliveries for the day of the week as a percent of average daily deliveries for the year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full supply</td>
<td>Major supply</td>
</tr>
<tr>
<td>Sunday</td>
<td>90.4</td>
<td>88.0</td>
</tr>
<tr>
<td>Monday</td>
<td>102.1</td>
<td>99.3</td>
</tr>
<tr>
<td>Tuesday</td>
<td>108.2</td>
<td>112.2</td>
</tr>
<tr>
<td>Wednesday</td>
<td>108.2</td>
<td>95.4</td>
</tr>
<tr>
<td>Thursday</td>
<td>107.8</td>
<td>111.2</td>
</tr>
<tr>
<td>Friday</td>
<td>95.6</td>
<td>109.1</td>
</tr>
<tr>
<td>Saturday</td>
<td>87.4</td>
<td>84.6</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Average daily deliveries during the high day of the week as a percent of the low day

123.8 132.6 715.3 129.6 178.1 113.9
Figure 1. Variation in deliveries of milk by seven cooperatives in the Intermountain area to 86 milk plants, by day of week and type of plant, September 1975 - August 1976.
deliveries were on Tuesdays and were 32.6 percent more than low deliveries on Saturday. For minor supply plants, peak deliveries were on Mondays and were 615.3 percent more than low deliveries on Saturday.

Milk supplies left over after meeting the requirements of market milk handlers were diverted to manufacturing and balance plants. Delivery patterns to them were opposite those for market milk plants. Deliveries were highest on weekends and lowest during the week. Peak day deliveries on Saturdays amounted to 78.1 percent more than low day deliveries on Wednesdays.

In addition to diverting excess supplies of market milk to manufacturing and balance plants, cooperatives also helped balance supply with demand by holding some milk back on farms, on assembly trucks and in supply plant storage tanks over the weekend. This is demonstrated by total deliveries of milk to all plants. Deliveries were reduced to less than average on Saturday, Sunday and Monday and increased to above average on Tuesday through Friday, even though production of milk would have been about the same each day of the week.

Seasonal Variation

The dairy cooperatives supplying milk to plants in the area have done much through management programs including the use of base-excess price plans to reduce seasonal variation in milk production to help coordinate seasonal milk supplies with fluid milk demand. Because of the biological processes involved in milk production, however, some variation still exists. Production, as indicated by average daily deliveries to all plants, varied from a low of 92.5 percent of average daily deliveries for the entire year in November, to a high of 108.9
percent in June (Table 3 and Figure 2). Average daily deliveries during the high production month were only 18 percent more than during the low month, compared with 21 percent for all Federal order pool plants in the U.S.

Deliveries of milk to plants in the Intermountain area by dairy cooperatives varied considerably by type of plant. Deliveries to full supply market milk plants were the most uniform throughout the year, and varied from a high in August of only 104.9 percent of average daily deliveries during the year to a low of 94.8 percent during December. Average daily deliveries during August were only 10.6 percent more than during December. Contributing to this relatively low variation in milk use from month to month was the fact that these plants bought all of their milk on a regular basis from the cooperatives throughout the entire year. Another factor was that increased use of milk by full supply plants for cottage cheese, ice cream and yogurt during the spring and summer months tended to offset the decreased use of milk for fluid milk and cream during that period of the year. Use of milk for fluid milk and cream was highest during the fall and winter months.

Deliveries to major supply plants varied from a high of 106.4 percent of average daily deliveries during the year during April to a low of 89.5 percent during June. Average daily deliveries during April were 18.9 percent more than during June. With some independent producers of their own, major supply plants relied less on cooperatives for a supply during the spring and summer when production of their own producers was up, and more in the winter when production was down.

Sales of milk to minor supply plants varied most of all. They relied on their own production or production of independent producers for most of their supply, and only bought supplemental supplies of milk
Table 3. Variation in deliveries of milk by seven cooperatives in the Intermountain area to 86 milk plants, by month and type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Month</th>
<th>Market milk plants</th>
<th></th>
<th></th>
<th>Mfg &amp; Total</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Full supply</td>
<td>Major supply</td>
<td>Minor supply</td>
<td>Total balance</td>
<td>deliveries</td>
</tr>
<tr>
<td>September</td>
<td>100.3</td>
<td>100.4</td>
<td>142.3</td>
<td>102.0</td>
<td>79.9</td>
<td>96.8</td>
</tr>
<tr>
<td>October</td>
<td>99.0</td>
<td>103.2</td>
<td>146.4</td>
<td>101.3</td>
<td>73.8</td>
<td>94.8</td>
</tr>
<tr>
<td>November</td>
<td>98.6</td>
<td>103.1</td>
<td>141.8</td>
<td>100.7</td>
<td>66.0</td>
<td>92.5</td>
</tr>
<tr>
<td>December</td>
<td>94.8</td>
<td>97.7</td>
<td>122.5</td>
<td>96.2</td>
<td>85.7</td>
<td>93.7</td>
</tr>
<tr>
<td>January</td>
<td>99.7</td>
<td>104.5</td>
<td>138.3</td>
<td>101.6</td>
<td>71.6</td>
<td>94.5</td>
</tr>
<tr>
<td>February</td>
<td>99.3</td>
<td>105.7</td>
<td>119.9</td>
<td>100.6</td>
<td>80.1</td>
<td>95.8</td>
</tr>
<tr>
<td>March</td>
<td>103.7</td>
<td>103.1</td>
<td>101.5</td>
<td>103.6</td>
<td>87.2</td>
<td>99.7</td>
</tr>
<tr>
<td>April</td>
<td>101.2</td>
<td>106.4</td>
<td>87.8</td>
<td>101.1</td>
<td>111.9</td>
<td>103.6</td>
</tr>
<tr>
<td>May</td>
<td>98.4</td>
<td>97.7</td>
<td>67.6</td>
<td>97.1</td>
<td>140.6</td>
<td>107.4</td>
</tr>
<tr>
<td>June</td>
<td>98.6</td>
<td>89.5</td>
<td>45.6</td>
<td>95.7</td>
<td>151.3</td>
<td>108.9</td>
</tr>
<tr>
<td>July</td>
<td>101.5</td>
<td>90.2</td>
<td>39.3</td>
<td>98.1</td>
<td>136.2</td>
<td>107.1</td>
</tr>
<tr>
<td>August</td>
<td>104.9</td>
<td>98.8</td>
<td>48.8</td>
<td>102.1</td>
<td>114.7</td>
<td>105.1</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Average daily deliveries for the month as a percent of average daily deliveries for the year

<table>
<thead>
<tr>
<th>Month</th>
<th>Full supply</th>
<th>Major supply</th>
<th>Minor supply</th>
<th>Total</th>
<th>balance</th>
<th>deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>September</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Average daily deliveries during the high month as a percent of the low month

|         | 110.6 | 118.9 | 372.5 | 108.3 | 229.2 | 117.7 |

(continued)
Figure 2. Variation in deliveries of milk by seven cooperatives in the Intermountain area to 86 milk plants, by month and type of plant, September 1975 - August 1976.
as needed from the cooperatives. Their purchases were low during the spring and summer and high in the fall and winter. Average daily deliveries by cooperatives to minor supply plants were 146.4 percent of average for the year in October and 39.3 percent in July, with peak deliveries in October being 272.5 percent more than deliveries in July.

Milk not required by market milk plants was diverted to manufacturing and co-op owned balance plants. Deliveries to them were lowest during fall and winter months and highest during spring and summer months, with peak month deliveries amounting to 129.2 percent more than low month deliveries.

In addition to seasonal and day of the week variations in milk delivery patterns, some random variations undoubtedly also occur from time to time because of changes in the weather, equipment failure, disease, etc. Also, as a general rule, deliveries of milk tend to be low on holidays (including the entire Christmas season) and high the day after in response to changes in purchases and consumption of fluid milk products.

Basic and Supplemental Supplies

To better understand the role performed by cooperatives in supplying milk to plants on demand, and in preparation to calculating reserve supplies, deliveries of milk to market milk plants were divided into basic and supplemental deliveries, as indicated for each plant group in Figures 3-6.

Basic deliveries included the maximum amount of milk plants took on a regular basis each day of the year, with deliveries varying only with daily and seasonal variations in milk production, as supply would if
Figure 3. Basic and supplemental deliveries of milk by seven cooperatives to 37 full supply market milk plants plus necessary operating and seasonal reserves, by day, Intermountain area, September 1975 - August 1976.
Figure 4. Basic and supplemental deliveries of milk by seven cooperatives to 3 major supply market milk plants plus necessary operating and seasonal reserves, by day, Intermountain area, September 1975 - August 1976.
Figure 5. Basic and supplemental deliveries of milk by seven cooperatives to 15 minor supply market milk plants plus necessary operating and seasonal reserves, by day, Intermountain area, September 1975 - August 1976.
Figure 6. Basic and supplemental deliveries of milk by seven cooperatives to all 55 market milk plants analyzed as one group, plus necessary operating and seasonal reserves, by day, Intermountain area, September 1975 - August 1976.
plants were receiving milk from their own herds or from independent producers. This amount of milk was classified as basic because it could in theory, if not in practice, be picked up from the same group of producers and delivered to the same group of plants each day throughout the year, without continually having to reroute it in the process of balancing supplies with demand.

For all 55 market milk plants as a group, maximum basic supply of milk was established by deliveries on May 29 (Figure 6). All deliveries on that day were classified as basic supply, with none being classified as supplemental. Basic supply for the remainder of the year included the production of the same equivalent number of producers whose milk was delivered on May 29, with production varying from day to day and seasonally as did total production of all members of the seven cooperatives. Total production of milk each day was derived from data on deliveries by calculating a seven-day moving average and using it. A seven-day moving average of total deliveries of milk by the seven cooperatives was considered a better estimate of daily production than daily deliveries because deliveries were varied some to help balance supplies with variation in daily demand for milk by market milk handlers.

Basic milk supplies amounted to 758.2 million pounds, or 62.2 percent of total deliveries to full supply plants, compared with 37.0 million or 33.2 percent of deliveries to major supply plants (Table 4). No milk was delivered to minor supply plants on a regular basis, hence none qualified as basic supply. Basic milk deliveries as a percent of total deliveries to major supply plants may have been low partially because there were only three plants in the group. The larger the number of firms in a group the greater the tendency for variation in deliveries among plants to be offsetting and the more milk delivered on a regular basis each day.
Table 4. Basic and supplemental deliveries of milk to market milk plants by seven dairy cooperatives in the Intermountain area, by type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Milk supply</th>
<th>Type of plant</th>
<th>Full supply</th>
<th>Major supply</th>
<th>Minor supply</th>
<th>Total</th>
<th>All plants as one group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Millions of pounds</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic</td>
<td></td>
<td>758.2</td>
<td>37.0</td>
<td>0</td>
<td>795.2</td>
<td>848.6</td>
</tr>
<tr>
<td>Supplemental</td>
<td></td>
<td>460.1</td>
<td>74.5</td>
<td>55.9</td>
<td>590.5</td>
<td>537.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,218.3</td>
<td>111.5</td>
<td>55.9</td>
<td>1,385.7</td>
<td>1,385.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Milk supply</th>
<th>Percent of total</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic</td>
<td>62.2</td>
<td>33.2</td>
<td>0</td>
<td>57.4</td>
<td>61.2</td>
<td></td>
</tr>
<tr>
<td>Supplemental</td>
<td>37.8</td>
<td>66.8</td>
<td>100.0</td>
<td>42.6</td>
<td>38.8</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>
When basic deliveries of milk were calculated for each plant group and then added together, they amounted to 57.4 percent of total deliveries. When all 55 plants were analyzed as one group, basic milk supplies amounted to 61.2 percent of total deliveries. The latter procedure resulted in more milk being classified as basic supply because when all 55 plants were analyzed as one group instead of three, there was less variation in deliveries from day to day, and more milk delivered each day on a regular basis.

All milk delivered to market milk plants by the seven cooperatives in excess of basic deliveries was classified as supplemental milk. Delivery of supplemental milk varied widely by day of the week and season of the year, depending on handler requirements for additional milk. Part of the function of balancing supply with demand by cooperatives was accomplished by holding milk back from standby manufacturing plants to which it otherwise would go, rerouting it, and making supplemental or irregular deliveries of milk to market milk plants as needed.

Supplemental deliveries of milk to plants varied by type of plant. The less plants relied on the seven cooperatives for their milk, the more irregular were deliveries of milk to them, and the greater the portion of total deliveries that were classified as supplemental milk. Supplemental deliveries of milk amounted to 37.8 percent of total deliveries to full supply plants and 66.8 percent to major supply plants. All deliveries to minor plants were supplemental milk.

For the three groups of plants added together, supplemental milk accounted for 42.6 percent of total deliveries. For all 55 plants as one group, supplemental milk amounted to 38.8 percent of total deliveries.
Basic and supplemental deliveries of milk varied by day of the week and month of the year for each plant group as indicated in Appendix Tables 1-5. On a weekly basis, deliveries of supplemental milk were high during the middle of the week and low on weekends, and on a seasonal basis, they were high during the fall and winter when milk production was down, and low during the spring and early summer when milk production was up.

MILK RESERVES

Fresh market milk is fairly fixed in supply in the short run. Once milk production in an area has been established at a given level, supply cannot be varied much without the passage of time, assuming milk is to be supplied from within the area. The bulkiness and perishability of milk and health regulations limit the storing of milk for use at a later time. Some milk can be stored on weekends for use during the following week, but it is impractical to store fresh milk from one week to another or from one season to another. Also, it serves little purpose to store all milk delivered on weekends except perhaps in deficit supply areas and during the high demand-short supply season, since ample supplies are usually available during the week throughout the remainder of the year anyway.

In order for market milk plants to always have an ample supply of milk, those who produce the milk must have an available supply which is sufficiently large to meet peak plant requirements during each day of the year. Because of seasonal variation in production and daily and seasonal variations in demand for milk, this requires the production and handling of substantial supplies of reserve milk. The greater the variation in production and demand for milk, the more reserve milk that must be produced and handled in the market.
The burden of providing and handling reserve supplies of milk has largely fallen on dairy cooperatives in most markets throughout the U.S., including the Intermountain area included in this study. While it is more efficient and less costly for a few cooperatives to perform the function of balancing supplies with demand and to produce and handle the reserve supplies of milk that are necessary than it is for each handler to do it individually, it nevertheless is a function which must be done by someone, and one that can only be done at a cost to whoever does it.

Reserve supplies as used in this study included all of the extra milk which cooperatives had to produce because of variations in supply and demand in order to always be able to meet the market milk requirements of their customers on the days and in the quantities demanded. Total plant requirements were considered, not just milk for fluid milk products. While from a theoretical point of view, it is fresh packaged fluid milk that the dairy industry wants to assure is always available to consumers, from a practical point of view the supply-balance task that most cooperatives have to perform is to provide a full supply of milk to their customers without reference to how they intend to use it. Many plants which, in addition to packaging fluid milk products also process ice cream, cottage cheese and yogurt from market milk, are not equipped to receive or handle manufacturing milk, and do not have access to a local supply.

**Operating Reserves**

Operating reserves as determined and used in this study included all of the milk that had to be produced during the week for cooperatives to meet the peak day requirements of their market milk customers that was not used by them during the remainder of the week. Reserve milk was
diverted to manufacturing and balance plants. Operating reserves were calculated by multiplying peak day deliveries during the week by 7, the days in a week, and subtracting from this the amount of milk that was actually delivered during the week.

Operating reserves associated with deliveries to full supply plants amounted to 176.4 million pounds during the year (Table 5). They amounted to 30.5 million pounds for major supply plants and 40.2 million pounds for minor supply plants. Total operating reserves necessary to supply each of the three groups of plants separately amounted to 247.1 million pounds, but to supply all 55 plants as one group required only 200.3 million pounds.

Operating reserves were fairly well distributed throughout the year (Appendix Tables 1-5).

Seasonal Reserves

Milk production is seasonal in nature and tends to be highest in the spring and lowest in the fall. This is just the opposite of fluid milk consumption which tends to be highest in the fall and lowest in the spring. In order for cooperatives to fully supply plants with the milk they need when consumption is highest relative to production, they have to produce more milk than is needed at other times. The extra milk they must produce and handle because of seasonal variations in production of milk and use of milk by Grade A plants was classified as seasonal reserve.

Seasonal reserves were determined by first finding the total necessary supply of milk required to meet the needs of market milk handlers (including basic and supplemental deliveries and operating reserves) on the day of the year when milk was in shortest supply relative to demand. For all 55 plants as a group this was on January 11 during the year of
Table 5. Operating and seasonal reserves of milk produced and handled by seven dairy cooperatives to meet the varying demand for milk by 55 market milk plants in the Intermountain area, by type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Type of reserve</th>
<th>Full supply</th>
<th>Major supply</th>
<th>Minor supply</th>
<th>Total</th>
<th>All plants as one group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating</td>
<td>176.4</td>
<td>30.5</td>
<td>40.2</td>
<td>247.1</td>
<td>200.3</td>
</tr>
<tr>
<td>Seasonal</td>
<td>146.5</td>
<td>29.8</td>
<td>72.0</td>
<td>248.3</td>
<td>194.9</td>
</tr>
<tr>
<td>Total</td>
<td>322.9</td>
<td>60.3</td>
<td>112.2</td>
<td>495.4</td>
<td>395.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Millions of pounds</th>
<th>Percent of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seasonal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
the study (Figure 6). On that day total necessary supply did not include any seasonal reserve. Total necessary supply for the remainder of the year was determined to be the milk that the equivalent number of producers whose milk was needed on January 11 would produce each day with production varying only with daily and seasonal variations in production. Seasonal reserve was the difference between total necessary supply and basic and supplemental deliveries plus operating reserves.

Seasonal reserves associated with supplying milk to full supply plants amounted to 146.5 million pounds, 29.8 million pounds for major supply plants, 72.0 million for minor supply plants, or a total of 248.3 million pounds. Seasonal reserves amounted to 194.9 million pounds when all 55 plants were considered as one group. This amounted to about half of total necessary operating and seasonal reserves during the year (Table 5).

Because of the greater seasonal variation associated with their purchases of milk from cooperatives, a majority of the necessary reserves produced and handled for minor supply plants was seasonal in nature.

Seasonal reserves of milk were relatively low during the fall and winter months when milk production was low, and high in the spring and summer months when supplies were up (Appendix Tables 1-5).

In balancing supplies with demand and handling necessary reserves of milk, the seven cooperatives performed a greater service for major and minor supply plants than they did for full supply plants. This is brought into sharp focus when reserve milk supplies are related to deliveries of milk. For each 100 pounds of milk delivered to full supply plants cooperatives carried 27 pounds of reserve milk, compared with 54 pounds for major supply plants and 201 pounds for minor supply plants. Looked at from another point of view, reserve requirements per
100 pounds of milk delivered were about two times greater for major supply plants than full supply plants, and about seven times greater for minor supply plants.

TOTAL NECESSARY SUPPLY

Total necessary supply included basic and supplemental deliveries of milk, plus the operating and seasonal reserves that had to be produced and handled by the seven cooperatives in order for them to be able to meet the variable demands for milk by market milk plants throughout the year. Total necessary supply is shown on a day to day basis by plant group in Figures 3-6 and summarized for the year in Table 6.

The make-up of total necessary supply varied considerably by type of plant. The less plants relied on the seven cooperatives for their full milk requirements, the greater were supplemental deliveries of milk compared with deliveries of basic supply, and the greater were necessary reserves relative to total deliveries.

Basic deliveries of milk, for example, accounted for 49.2 percent of total necessary supply for full supply plants, 21.5 percent for major supply plants and 0 for minor supply plants (Table 6). Supplemental supplies for milk amounted to 29.8 percent of total necessary supply for full supply plants, and 43.4 percent for major supply plants, and 33.3 percent for minor supply plants.

Total basic and supplemental deliveries of milk amounted to 79.0 percent of total necessary supply for full supply plants, 64.9 percent for major supply plants and 33.3 percent for minor supply plants. On the other hand, total operating and seasonal reserves amounted to 21.0 percent for full supply plants, 35.1 percent for major supply plants, and 66.7 percent for minor supply plants.
Table 6. Total basic and supplemental deliveries of milk and reserve supplies of milk handled by seven dairy cooperatives in supplying 55 market milk customers in the Intermountain area, by type of plant, September 1975 - August 1976.

<table>
<thead>
<tr>
<th>Nature of milk supply</th>
<th>Type of plant</th>
<th>Millions of pounds</th>
<th>All plants as one group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full supply</td>
<td>Major supply</td>
<td>Minor supply</td>
</tr>
<tr>
<td>Market milk plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deliveries to plants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic supply</td>
<td>758.2</td>
<td>37.0</td>
<td>0</td>
</tr>
<tr>
<td>Supplemental supply</td>
<td>460.1</td>
<td>74.5</td>
<td>55.9</td>
</tr>
<tr>
<td>Total deliveries</td>
<td>1,218.3</td>
<td>111.5</td>
<td>55.9</td>
</tr>
<tr>
<td>Reserve supplies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating</td>
<td>176.4</td>
<td>30.5</td>
<td>40.2</td>
</tr>
<tr>
<td>Seasonal</td>
<td>146.5</td>
<td>29.8</td>
<td>72.0</td>
</tr>
<tr>
<td>Total reserves</td>
<td>322.9</td>
<td>60.3</td>
<td>112.2</td>
</tr>
<tr>
<td>Total necessary supply</td>
<td>1,541.2</td>
<td>171.8</td>
<td>168.1</td>
</tr>
<tr>
<td>Surplus milk</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Total production</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

| Market milk plants    |               |                    |                        |
| Deliveries to plants  |               |                    |                        |
| Basic supply          | 49.2          | 21.5               | 0                      | 42.3  | 47.6  |
| Supplemental supply   | 29.8          | 43.4               | 33.3                   | 31.4  | 30.2  |
| Total deliveries      | 79.0          | 64.9               | 33.3                   | 73.7  | 77.8  |
| Reserve supplies      |               |                    |                        |
| Operating             | 11.5          | 17.8               | 23.9                   | 13.1  | 11.3  |
| Seasonal              | 9.5           | 17.3               | 42.9                   | 13.2  | 10.9  |
| Total reserves        | 21.0          | 35.1               | 66.7                   | 26.3  | 22.2  |
| Total necessary supply| 100.0         | 100.0              | 100.0                  | 100.0 | 100.0 |
| Surplus milk          | ---           | ---                | ---                    | (3.5) | 2.0   |
| Total production      | ---           | ---                | ---                    | 96.5  | 102.0 |
For the three groups of plants summed together, total deliveries amounted to 1,385.7 million pounds, reserve supplies 495.4 million pounds, and total necessary supply 1,881.1 million pounds. This was 3.5 percent more than the total milk production of the seven cooperatives. In actual practice, however, rather than carrying reserve supplies separately for each group of plants, the reserves were carried for all 55 plants as a group.

When all 55 market milk plants were considered as one group, total deliveries amounted to 1,385.7 million pounds, reserves 395.2 million pounds, and total necessary supply 1,780.9 million pounds. Total deliveries made up 77.8 percent of total necessary supply and reserves 22.2 percent. Total production by the seven cooperatives amounted to 1,815.9 million pounds. This was only 35.0 million pounds, or 2.0 percent more than total necessary supply. While this has been called surplus market milk, it might well be called annual reserve. In reality, it would provide only a small cushion with which to accommodate annual variations in plant requirements for milk.

**INTERMARKET MOVEMENT OF MILK**

Balancing market milk supplies with demand required substantial intermarket movement of milk. The seven cooperatives included in the study worked together through a regional federated association to supply the needs of their fluid milk customers, to coordinate the movement of milk from reserve supply areas to deficit areas, and to move surplus and reserve milk to manufacturing and balance plants. In doing so they often traded milk supplies among themselves in an effort to minimize the movement of milk and reduce hauling costs.
The largest population center in the markets served by the seven cooperatives is the Denver metropolitan area in Eastern Colorado. Eastern Colorado is a deficit milk area year-round. Lake Mead (Southern Utah and Southern Nevada) and central Wyoming are deficit during the short supply season. Western South Dakota, Western Colorado, Great Basin (Southeastern Idaho and Central and Northern Utah), and Southwestern Idaho have excess supplies of milk throughout the year.

During the fall and winter months of high fluid milk use and low production, milk basically moved from areas of excess supply to deficit areas, especially Eastern Colorado. About 8.5 million pounds, for example, were moved into Eastern Colorado during November, the shortest supply month (Table 7). During the spring and early summer months when fluid milk use was down and production was up, milk tended to stay in the areas where it was produced, or move to the Great Basin and Lake Mead areas where balance plants were located. During June, for example, a net of 1.4 million pounds were moved into the Lake Mead area and 4.6 million pounds into the Great Basin area, primarily to balance plants (Table 8). A net of only 1.1 million pounds were moved to Eastern Colorado to help meet fluid milk plant needs.

**UTILIZATION OF MILK**

Class I, II and III uses of milk by the 37 full supply plants included in the study were obtained from the Federal milk orders in which they were pool plants. Federal order data show that the 37 plants used 1,196.7 million pounds during the 12-month study period. Records of the seven cooperatives show that 1,218.1 million pounds of milk were shipped to them. This indicates that some milk was transferred to other pool plants or handlers. Both Federal order data and milk deliveries were adjusted to
Table 7. Source and disposition of producer milk, by area, seven dairy cooperatives in the Intermountain region, November, 1975.

<table>
<thead>
<tr>
<th>Source</th>
<th>Western Idaho</th>
<th>Great Basin</th>
<th>Lake Mead</th>
<th>Western Colorado</th>
<th>Eastern Colorado</th>
<th>South Dakota</th>
<th>Central Wyoming</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Idaho</td>
<td>17,019</td>
<td>10,451</td>
<td>2,699</td>
<td>3,869</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Great Basin</td>
<td>49,183</td>
<td>45,414</td>
<td>731</td>
<td>1,923</td>
<td>325</td>
<td>184</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lake Mead</td>
<td>5,566</td>
<td>90</td>
<td>5,231</td>
<td>245</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Western Colorado</td>
<td>6,183</td>
<td>100</td>
<td>4,126</td>
<td>1,957</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Colorado</td>
<td>50,763</td>
<td></td>
<td>50,763</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South Dakota</td>
<td>6,232</td>
<td></td>
<td></td>
<td>93</td>
<td>6,139</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central Wyoming</td>
<td>2,282</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,282</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>437</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>137,665</td>
<td>10,451</td>
<td>48,203</td>
<td>6,062</td>
<td>4,732</td>
<td>59,287</td>
<td>6,139</td>
<td>2,607</td>
</tr>
</tbody>
</table>

Thousands of pounds

<table>
<thead>
<tr>
<th>Source</th>
<th>6,568</th>
<th>3,769</th>
<th>335</th>
<th>2,057</th>
<th>93</th>
<th>437</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imported</td>
<td>13,259</td>
<td>2,789</td>
<td>831</td>
<td>606</td>
<td>8,524</td>
<td>325</td>
</tr>
<tr>
<td>Net exported (imported)</td>
<td>-0-</td>
<td>6,568</td>
<td>980</td>
<td>(496)</td>
<td>(8,524)</td>
<td>93</td>
</tr>
</tbody>
</table>

(325) 253
Table 8. Source and disposition of producer milk, by area, seven dairy cooperatives in the Intermountain region, June, 1976.

<table>
<thead>
<tr>
<th>Source</th>
<th>Western Idaho</th>
<th>Great Basin</th>
<th>Lake Mead</th>
<th>Western Colorado</th>
<th>Eastern Colorado</th>
<th>South Dakota</th>
<th>Central Wyoming</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Total</td>
<td>Idaho</td>
<td>Basin</td>
<td>Colorado</td>
<td>Colorado</td>
<td>Idaho Basin</td>
<td>Basin</td>
<td>Idaho</td>
</tr>
<tr>
<td>Western Idaho</td>
<td>20,868</td>
<td>17,720</td>
<td>2,930</td>
<td>218</td>
<td>625</td>
<td>111</td>
<td>744</td>
<td>87</td>
</tr>
<tr>
<td>Great Basin</td>
<td>58,246</td>
<td>57,510</td>
<td></td>
<td>625</td>
<td>542</td>
<td>111</td>
<td>744</td>
<td>87</td>
</tr>
<tr>
<td>Lake Mead</td>
<td>7,723</td>
<td>40</td>
<td>7,683</td>
<td>625</td>
<td>542</td>
<td>100</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Western Colorado</td>
<td>7,315</td>
<td>1,570</td>
<td>1,411</td>
<td>3,792</td>
<td>542</td>
<td>1,570</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>Eastern Colorado</td>
<td>56,453</td>
<td>744</td>
<td></td>
<td>55,709</td>
<td>87</td>
<td>55,709</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>South Dakota</td>
<td>8,771</td>
<td></td>
<td></td>
<td>48</td>
<td>8,723</td>
<td>48</td>
<td>8,723</td>
<td>2,132</td>
</tr>
<tr>
<td>Central Wyoming</td>
<td>2,575</td>
<td>100</td>
<td></td>
<td>343</td>
<td>2,132</td>
<td>2,132</td>
<td>2,132</td>
<td>2,132</td>
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<tr>
<td>Other</td>
<td>87</td>
<td></td>
<td></td>
<td>87</td>
<td>87</td>
<td>87</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>162,038</strong></td>
<td><strong>17,831</strong></td>
<td><strong>62,894</strong></td>
<td><strong>9,094</strong></td>
<td><strong>57,572</strong></td>
<td><strong>8,723</strong></td>
<td><strong>2,132</strong></td>
<td></td>
</tr>
<tr>
<td>Exported</td>
<td>8,769</td>
<td>3,148</td>
<td>736</td>
<td>40</td>
<td>3,523</td>
<td>744</td>
<td>48</td>
<td>443</td>
</tr>
<tr>
<td>Imported</td>
<td>8,769</td>
<td>111</td>
<td>5,384</td>
<td>1,411</td>
<td>1,863</td>
<td>48</td>
<td>443</td>
<td>87</td>
</tr>
<tr>
<td><strong>Net exported (imported)</strong></td>
<td><strong>0-</strong></td>
<td>3,037</td>
<td>(4,648)</td>
<td>(1,371)</td>
<td>3,523</td>
<td>(1,119)</td>
<td>48</td>
<td>443</td>
</tr>
</tbody>
</table>

Thousands of pounds
eliminate the milk shipped to pool plants operated by cooperatives that was used in supply-balancing manufacturing operations.

Table 9 shows the levels of milk utilization that might be expected by fluid milk plants when not only Class I but also Class II and III milk and milk reserves are considered part of total necessary supply.

As a percent of total milk used, Class I use amounted to 79.6 percent and Class II and III, 20.4 percent. Necessary operating and seasonal reserves amounted to 28.6 percent of milk used.

As a percent of total necessary supply, Class I use amounted to 61.9 percent, Class II and III 15.9 percent, and reserves 22.2 percent.

These data tend to indicate that if fluid milk plants are to be supplied market milk for their Class II and III uses (primarily cottage cheese, ice cream and yogurt), and necessary milk reserves are to be carried within the regular supply area, not much more than 60 percent of total necessary supply can be expected to be used in Class I products.

Average daily Class I, II and III use of milk and necessary reserves varied by the month, and are shown in Figure 7.

COST OF SUPPLY-DEMAND COORDINATION AND BALANCING

Give-up Cost

Necessary reserves plus deliveries of supplemental milk by the seven cooperatives to the 55 market milk handlers during the year of the study amounted to about 2.5 million pounds per day, or about 10 billion pounds during the entire year. As can be seen in Figure 8, on some days handlers took delivery on all or nearly all of this milk. On other days all or nearly all was diverted to manufacturing plants as cooperatives
Table 9. Estimated use of milk plus necessary operating and seasonal reserves, 37 full supply fluid milk plants, Intermountain area, September 1975 - August 1976*.

<table>
<thead>
<tr>
<th>Item</th>
<th>Percent of milk used</th>
<th>Percent of total necessary supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class I</td>
<td>79.6</td>
<td>61.9</td>
</tr>
<tr>
<td>Class II</td>
<td>12.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Class III</td>
<td>8.4</td>
<td>6.5</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>77.8</td>
</tr>
<tr>
<td>Reserves</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating</td>
<td>14.5</td>
<td>11.3</td>
</tr>
<tr>
<td>Seasonal</td>
<td>14.1</td>
<td>10.9</td>
</tr>
<tr>
<td>Total</td>
<td>28.6</td>
<td>22.2</td>
</tr>
<tr>
<td>Total necessary supply</td>
<td>128.6</td>
<td>100.0</td>
</tr>
</tbody>
</table>

*Does not include milk used in manufacturing operations to balance supplies in full supply plants operated by cooperatives.
Figure 7. Estimated use of milk plus necessary operating and seasonal reserves, 37 full supply fluid milk plants, Intermountain area, September 1975 - August 1976.
Figure 8. Balancing supply with demand by withdrawing reserve milk from 31 manufacturing and balance plants to make deliveries of supplemental milk to 55 market milk plants, seven dairy cooperatives in the Intermountain area, by day, September 1975 - August 1976.
balanced supply with demand. Since on some occasions handlers took little or no supplemental milk, cooperatives had to maintain manufacturing capacity of their own or in conjunction with other manufacturers to handle the full 2.5 million pounds per day. When handlers required supplemental milk in addition to the basic supplies they were receiving each day, milk was in effect held back from manufacturing plants and delivered to market milk handlers. Manufacturing plants equipped to handle large volumes operate inefficiently when supply is reduced and when supply is eradic as is the supply of reserve milk. The daily supply of reserve milk delivered to manufacturing and balance plants is shown in Figure 9.

The cost of maintaining and operating facilities for manufacturing reserve milk is clearly one of the costs of coordinating and balancing supply with demand. The question is how does one logically determine the cost of this service. One way would be to determine the extra costs associated with maintaining extra manufacturing capacity to handle reserve milk and the extra cost of processing it on weekends and under conditions of widely fluctuating supply. This approach assumes that market milk is produced only for market milk handlers, and only in the quantity that they require, and that it is their responsibility to pay for the cost of handling necessary reserve supplies not needed during some days and seasons of the year. While there is some logic to this approach, it does not conform completely with reality, and is awkward to handle. Typically handlers do not commit themselves to buy all of the milk cooperatives may supply. Sometimes more milk is produced than handlers need, including reserves. In practice reserve supplies are not easily determined, and are not associated directly with market milk handlers. Also, this approach would result in determining a cost for
Figure 9. Reserve supplies of market milk delivered to 31 manufacturing and balance plants by 7 dairy cooperatives in the Intermountain area, by day, September 1975 - August 1976.
handling milk which market milk handlers neither buy nor use, making it difficult to associate the cost with a service charge per hundredweight of milk bought.

An alternative would be to assume that cooperatives should maintain and operate manufacturing facilities to handle milk not needed by market milk handlers, to assure that there will always be a market for their milk. Sufficient plant capacity would be required to handle all milk not needed by handlers, even on days and during seasons of the year when they required little or no supplemental milk. Then when milk is withheld from manufacturing plants to make supplemental deliveries to market milk plants, determine the give-up cost and pass it on to market milk handlers as a service charge.

The latter approach was used in this study. Give-up cost per hundredweight included the increased cost per unit that resulted when reserve milk was withdrawn from balance plants to make supplemental deliveries to market milk handlers, times the remaining units manufactured, divided by the amount of milk delivered to market milk plants. Under some circumstances where a profit is being made on the production and sale of cheese or butter and powder made from reserve milk, give-up cost might also include the profit foregone on the product that would have been produced had reserve milk been left in the balance plant. This was not done in this study, however.

Give-up costs were determined from an analysis of the cost of operating a balance plant operated by the cooperatives in which cheese was made. This plant was assumed to be typical of other plants operated by the cooperatives. It would have taken five plants the size of the
one analyzed to handle all reserve milk. Give-up costs as determined from this plant were used for all supplemental milk deliveries even though the cooperatives did not handle all reserve milk in their own plants. A give-up cost was experienced on milk held back from other manufacturing firms to make supplemental deliveries of milk to market milk handlers because in doing so cooperatives gave up a premium paid by manufacturing plants of up to 50 cents per hundredweight, and in some cases they incurred additional transportation costs to move the milk to market milk plants.

A least squares regression of monthly costs of operating the balance plant for the period September 1976 through December 1977, resulted in the following total cost function:

Total monthly cost = $51,000 + $23.71 \times (lbs of milk received)^{0.513240}

The correlation coefficient ($r^2$) for this function was 0.92, indicating a good fit to the data, and that the function explained most of the variation in costs from month to month.

Marginal and average cost functions were derived from the total cost function. They are as follows:

Marginal cost = $12.17 \times (lbs of milk received)^{0.48676}$

Average cost = $\frac{51,000}{lbs of milk received} + \frac{23.71}{lbs of milk received} \times (lbs of milk received)^{0.513240}$

Receipts of milk at the plant varied from a low of 5.5 million pounds during November 1977 to a high of 14.0 million pounds during June 1977. Total, marginal and average costs are shown in Table 10 for various levels of milk processed per month. As volume processed increased, total costs increased and marginal and average costs decreased.
Table 10. Total, average and marginal costs of operating a manufacturing balance plant, seven dairy cooperatives, September 1976 - December 1977.

<table>
<thead>
<tr>
<th>Quantity received (pounds per month)</th>
<th>Total cost</th>
<th>Marginal cost</th>
<th>Average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$51,000.00</td>
<td>$5.559993</td>
<td>$10,210.83309</td>
</tr>
<tr>
<td>5</td>
<td>51,054.17</td>
<td>3.967755</td>
<td>5,107.30772</td>
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<tr>
<td>10</td>
<td>51,077.31</td>
<td>1.812651</td>
<td>1,023.53177</td>
</tr>
<tr>
<td>50</td>
<td>51,176.59</td>
<td>1.293555</td>
<td>512.52036</td>
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<tr>
<td>100</td>
<td>51,252.04</td>
<td>0.590955</td>
<td>103.15142</td>
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<tr>
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<td>10.57538</td>
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<tr>
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<td>0.07947</td>
</tr>
<tr>
<td>10,000</td>
<td>53,678.82</td>
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<tr>
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<td>0.02321</td>
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<tr>
<td>2,000,000</td>
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<td>0.007947</td>
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<tr>
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<tr>
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</tr>
<tr>
<td>6,000,000</td>
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<tr>
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<td>128,296.70</td>
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<td>0.002321</td>
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<tr>
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<td>143,824.55</td>
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<tr>
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<td>16,000,000</td>
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<td>0.002321</td>
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</table>
Table 10. Total, average and marginal costs of operating a manufacturing balance plant, seven dairy cooperatives, September 1976 - December 1977.

<table>
<thead>
<tr>
<th>Quantity received (pounds per month)</th>
<th>Total cost</th>
<th>Marginal cost</th>
<th>Average cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$51,000.00</td>
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<td>1.812651</td>
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The elasticity of average cost was -0.71 at 5.5 million pounds per month and -0.65 at 14.0 million pounds per month. These coefficients indicate that for every 10 percent reduction in milk supply at the balance plant to make deliveries of supplemental milk to market milk handlers, average cost per remaining unit processed went up from 6.5 to 7.1 percent.

Give-up costs September 1976 through December 1977, assuming five plants similar in size and cost of operation to the one analyzed, amounted to 18.9 cents per hundredweight of milk delivered (including both basic and supplemental milk) to full supply plants, 62.2 cents per hundredweight delivered to major supply plants, 108.7 per hundredweight delivered to minor supply plants, or an average of 21.4 cents per hundredweight of milk delivered to all market milk handlers (Table 11).

The greater deliveries of supplemental milk were relative to total deliveries of both basic and supplemental milk, the greater were give-up costs per hundredweight of milk delivered. Give-up costs varied from month to month as supplemental milk deliveries varied in relation to total deliveries of milk during the month.

Other Costs

Many other costs in addition to give-up costs were associated with coordinating and balancing milk supply with demand for market milk handlers. These included extra hauling costs to make split-load deliveries, transportation of milk for out-of-area sales and movement of reserve supplies to balance and manufacturing plants, cost of operating bulk tank storage of milk to hold milk over from day to day at supply plants, especially on weekends, office and labor cost of coordinating delivery of supplemental and reserve milk, extra shrinkage associated with moving milk
Table 11. Balance plant give-up costs per hundredweight of total milk delivered as reserve milk is withdrawn to make supplemental deliveries to market milk plants, by type of plant, September 1976 - December 1977.

<table>
<thead>
<tr>
<th>Month</th>
<th>Type of plant</th>
<th></th>
<th></th>
<th>All plants as one group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full supply</td>
<td>Major supply</td>
<td>Minor supply</td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td>Cents per hundredweight</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>21.2</td>
<td>68.8</td>
<td>113.6</td>
<td>30.2</td>
</tr>
<tr>
<td>October</td>
<td>21.4</td>
<td>71.2</td>
<td>116.4</td>
<td>31.0</td>
</tr>
<tr>
<td>November</td>
<td>23.1</td>
<td>78.6</td>
<td>129.2</td>
<td>33.7</td>
</tr>
<tr>
<td>December</td>
<td>19.7</td>
<td>63.0</td>
<td>102.6</td>
<td>27.5</td>
</tr>
<tr>
<td>January</td>
<td>21.7</td>
<td>73.5</td>
<td>119.9</td>
<td>31.4</td>
</tr>
<tr>
<td>February</td>
<td>22.0</td>
<td>73.2</td>
<td>119.5</td>
<td>31.0</td>
</tr>
<tr>
<td>March</td>
<td>20.3</td>
<td>65.6</td>
<td>109.0</td>
<td>27.4</td>
</tr>
<tr>
<td>April</td>
<td>17.7</td>
<td>57.2</td>
<td>93.5</td>
<td>27.2</td>
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<tr>
<td>May</td>
<td>14.0</td>
<td>45.0</td>
<td>76.0</td>
<td>18.2</td>
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<tr>
<td>June</td>
<td>13.5</td>
<td>41.4</td>
<td>73.6</td>
<td>16.8</td>
</tr>
<tr>
<td>July</td>
<td>14.9</td>
<td>49.4</td>
<td>88.0</td>
<td>18.7</td>
</tr>
<tr>
<td>August</td>
<td>17.8</td>
<td>54.3</td>
<td>92.3</td>
<td>22.1</td>
</tr>
<tr>
<td>Average</td>
<td>18.9</td>
<td>62.2</td>
<td>108.7</td>
<td>26.0</td>
</tr>
</tbody>
</table>
for supply-demand balancing purposes, general administration, and health inspection and Federal order market administration fees on reserve milk.

All of these additional costs combined amounted to an average of 16.3 cents per hundredweight of milk delivered to market milk plants during 1977 (Table 12).

The total cost of coordinating and balancing supply with demand during 1977, including give-up and other costs, amounted to 35.2 cents per hundredweight of milk delivered to full supply plants, 78.5 cents for major supply and 125.0 cents for minor supply plants. The cost per hundredweight of milk delivered to all plants was 42.3 cents when the three plant groups were summed together, and 37.7 cents when all 55 plants were analyzed as one group. Based on changes in the wholesale price index, it is estimated that costs would have increased about 17.5 percent by mid 1979. This would result in an average cost of about 44.3 cents per hundredweight of milk delivered to all plants as a group during 1979.

About 79.6 percent of milk used by full supply plants was for Class I use. The cost of coordinating and balancing supply per hundredweight of Class I milk delivered to full supply plants amounted to 44.2 cents during 1977, or an estimated 51.9 cents during 1979. The percent of deliveries to major supply and minor supply plants used for Class I was not known.
Table 12. Total cost of coordinating and balancing supply with demand for 55 fluid milk handlers by seven dairy cooperatives in the Intermountain area, by type of plant, 1977.

<table>
<thead>
<tr>
<th>Function</th>
<th>Type of plant</th>
<th>All plants as one group</th>
</tr>
</thead>
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<tr>
<td></td>
<td>Full supply</td>
<td>Major supply</td>
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<tr>
<td>Give-up cost</td>
<td>18.9</td>
<td>62.2</td>
</tr>
<tr>
<td>Other costs:</td>
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<td></td>
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<tr>
<td>Hauling</td>
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<td>Bulk storage</td>
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<tr>
<td>Delivery Coordination</td>
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<tr>
<td>Shrinkage</td>
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<td>.3</td>
</tr>
<tr>
<td>General administration</td>
<td>.3</td>
<td>.3</td>
</tr>
<tr>
<td>Health inspection</td>
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<td>.8</td>
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<tr>
<td>Market administration</td>
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<td>1.0</td>
</tr>
<tr>
<td>Total, other costs</td>
<td>16.3</td>
<td>16.3</td>
</tr>
<tr>
<td>Total, all costs</td>
<td>35.2*</td>
<td>78.5</td>
</tr>
</tbody>
</table>

*This amounted to 44.2 cents per hundredweight of milk used for Class I, since Class I utilization for full supply plants was 79.6 percent as indicated in Table 9.
SUMMARY

This study is an analysis of the function and cost of coordinating and balancing market milk supply with demand. It shows how this is largely being done by dairy cooperatives in the Intermountain area. The study is based on daily deliveries of milk for a 12-month period during 1975-76 by seven dairy cooperatives to 55 market milk and 31 manufacturing and balance plants located in South Dakota, Colorado, Wyoming, Utah, Idaho and Nevada, and the cost of operating a manufacturing balance plant. The cooperatives provided a full supply of milk to 37 market milk plants, a major supply to 3, and a minor supply to 15. They supplied milk on demand to handlers, maintained necessary reserves to ensure an adequate supply, especially for fluid use, and operated facilities to manufacture milk not needed from day to day for which there was not a better market.

Total necessary supply to meet the needs of the 55 market milk plants as a group amounted to 1.8 billion pounds of milk for the year. Of this, 47.6 percent consisted of basic milk supplies delivered each day of the year on a regular basis, 30.2 percent supplemental supplies delivered during peak demand days of the week and seasons of the year, and 22.2 percent operating and seasonal reserves. The cooperatives had a surplus of milk in excess of total necessary supply, including reserves to meet the needs of fluid milk handlers, of only 2 percent.

Supplemental or irregular deliveries of milk made up 38 percent of total deliveries to full supply plants, 67 percent to major supply plants, and 100 percent to minor supply plants.

Delivery of milk to market milk plants varied widely according to demand. On a daily basis, deliveries were highest on Tuesday, Wednesday
and Thursday and were 25 percent more than on Saturday and Sunday for all market milk plants. The less handlers relied on the cooperatives for their full supply, the more deliveries varied. Peak day deliveries during the week were 24 percent more than low day deliveries for full supply plants, 33 percent for major supply plants, and 615 percent for minor supply plants.

Seasonally, average daily deliveries were highest in March, and were 8.3 percent more than during June, the lowest month, for all market milk plants. Average daily deliveries during the high month of the year were 11 percent more than during the low month for full supply plants, 19 percent more for major supply plants and 272 more for minor supply plants.

The greater the variation in handler purchases of milk, the more reserve milk cooperatives had to produce and handle to always be able to meet their needs. For each 100 pounds of milk delivered, cooperatives had to carry 27 pounds of reserve milk to service full supply plants, 54 pounds to service major supply plants, and 201 pounds to service minor supply plants.

Balancing market milk supplies with demand required substantial intermarket movement of milk. During the fall and winter months of high fluid milk use and low production, milk moved from areas of excess supply to deficit areas, especially Eastern Colorado. About 8.5 million pounds were moved into Eastern Colorado during November, the shortest supply month of the year, and a net of about one million pounds during June, the month when supplies were greatest relative to fluid milk plant demand. During the spring and early summer months when fluid milk use was down and production was up, milk tended to stay in the areas where it was produced, or move to the Great Basin and Lake Mead areas where balance
plants were located. During June, a net of 1.4 million pounds were moved into the Lake Mead area and 4.6 million pounds into the Great Basin area.

Full supply market milk plants, not including balance plant manufacturing operations of full supply plants operated by cooperatives, had a Class I utilization of 79.6 percent. Class I sales made up only 61.9 percent of total necessary supply, however, including milk used in Class II and Class III products, and necessary reserves. The latter is about as high a Class I utilization as can be expected in a market that carries its own reserves and where fluid milk plants are supplied with market milk for their Class II and III uses.

As cooperatives have assumed the function of balancing supply with demand, considerable costs formerly borne by processors have become borne by cooperatives. Federal order minimum prices do not include a charge for these services. Some cooperatives assess a service charge to recover a part or all of what they estimate these costs to be.

Following procedures used in this study, the cost incurred by cooperatives during 1977 in coordinating and balancing supply with demand for full supply plants served amounted to 35.2 cents per hundredweight of milk delivered, or 44.2 cents per hundredweight of Class I milk delivered. For major supply plants the cost was 78.5 cents per hundredweight of milk delivered, and for minor supply plants the cost was $1.25 per hundredweight delivered. For all plants as a group, the cost averaged 37.7 cents per hundredweight delivered.

Assuming an increase in costs of 17.5 percent between mid 1977 and mid 1979, the cost of coordinating and balancing supply with demand incurred by the cooperatives included in the study during 1979 would have increased to 44.2 cents per hundredweight of milk delivered to all plants as a group. The cost per hundredweight of Class I milk delivered
to full supply plants would have increased to 51.9 cents.

These costs include extra handling costs and give-up costs incurred at balance plants as reserve milk is withdrawn to make deliveries of supplemental milk to market milk handlers. They do not include, however, profit foregone on the product that would have been produced and sold had the reserve milk been left in the balance plants throughout the year. Foregone profits might also be included as a give-up cost if profits are usually made operating balance plants during months of the year when deliveries of supplemental milk to market milk handlers are low.

Give-up costs may also be understated somewhat in this study to the extent that the cost function used, based on monthly variations in costs and volume of milk handled at a balance plant, did not fully capture the variation in costs which occur from day to day as reserve milk is withdrawn to make deliveries of supplemental milk on demand to market milk plants.
Appendix Table 1. Deliveries of milk to 37 full supply market milk plants and necessary reserves handled to supply them by seven dairy cooperatives in the Intermountain area, by month, August 1975 - September 1976.

<table>
<thead>
<tr>
<th>Month</th>
<th>Deliveries</th>
<th>Reserves</th>
<th>Total necessary supply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Basic supply</td>
<td>Supplemental supply</td>
<td>Operating</td>
</tr>
<tr>
<td></td>
<td>Millions of pounds</td>
<td>Millions of pounds</td>
<td>Millions of pounds</td>
</tr>
<tr>
<td>September</td>
<td>60.3</td>
<td>39.8</td>
<td>14.0</td>
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<td>July</td>
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Appendix Table 2. Deliveries of milk to 3 major supply market milk plants and necessary reserves handled to supply them by seven dairy cooperatives in the Intermountain area, by month, August 1975 - September 1976.

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<th>Total necessary supply</th>
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<td>Supplemental supply</td>
<td>Operating</td>
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<td></td>
<td>Millions of pounds</td>
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<td></td>
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<tr>
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<td>6.786</td>
<td>2.693</td>
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<td>1.979</td>
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<td>2.563</td>
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<td>4.887</td>
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Percent of total necessary supply

| Month  | September | 21.6 | 45.6 | 19.0 | 13.8 | 100.0 |
| April | 21.6 | 45.2 | 15.9 | 17.3 | 100.0 |
| May | 21.6 | 37.2 | 12.0 | 29.2 | 100.0 |
| June | 21.6 | 31.9 | 14.0 | 32.5 | 100.0 |
| July | 21.6 | 33.1 | 22.5 | 22.8 | 100.0 |
| August | 21.6 | 39.5 | 21.2 | 17.7 | 100.0 |
| Year | 21.6 | 43.3 | 17.7 | 17.4 | 100.0 |
Appendix Table 3. Deliveries of milk to 15 minor supply market milk plants and necessary reserves handled to supply them by seven dairy cooperatives in the Intermountain area, by month, August 1975 - September 1976.

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<td>Operating</td>
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<tr>
<td></td>
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Percent of total necessary supply

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<td>26.9</td>
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Appendix Table 4. Sum of deliveries of milk to 37 full, 3 major and 15 minor supply market milk plants and necessary reserves handled to supply them by seven dairy cooperatives in the Intermountain area, by month, August 1975 - September 1976.

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<th>Total production</th>
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<td>53.9</td>
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<td>7.1</td>
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Percent of total necessary supply

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Appendix Table 5. Deliveries of milk to all 55 full, major and minor supply market milk plants analyzed as one group and necessary reserves handled to supply them by seven dairy cooperatives in the Intermountain area, by month, August 1975 - September 1976.

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Percent of total necessary supply

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<th>December</th>
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