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SOME FINDINGS ON THE COMPARATIVE COST OF RECONSTITUTING BEVERAGE MILK PRODUCTS

Reconstitution vs. Fresh Milk Processing

by
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Preface

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Introduction

In August, 1979, the Community Nutrition Institute (CNI) and four individuals petitioned the Secretary of Agriculture to amend Federal Milk Marketing Order provisions affecting reconstituted milk. Current provisions essentially require regulated handlers to pay the difference between the Class I price and the basic formula price (the Class I differential) on the milk equivalent of all dried or condensed milk used to produce Class I milk products. The petitioners basically proposed that reconstituted milk be classified in the lowest use class (Class III in most orders) even if the reconstituted milk was used to make or was sold as a beverage milk product that would normally be in Class I .1/

After a considerable period during which opposing viewpoints were solicited and further studies were conducted, the Secretary of Agriculture announced in April, 1981, that the petitioners' request for a hearing on the pricing of reconstituted milk under all Federal Milk Marketing Orders was denied. During the course of the review by USDA, the CNI initiated legal action alleging that the "Secretary's inaction" constituted an arbitrary and capricious denial of a hearing and that present Order provisions on pricing reconstituted milk are illegal. This court action is pending at the time of this writing.

Objectives

Much of the discussion about the impact and merits of changing Federal Order provisions related to reconstituted milk has taken place in spite of a relative lack of hard facts. One particularly large gap in the available data is the cost of commercially reconstituting milk. This is especially important in that estimates of the decline in fluid milk prices that could result from the proposed changes are directly related to the cost of reconstituting Class I milk products in commercial bottling plants.

The purpose of this study is to measure the difference between the in-plant cost of using reconstituted milk to make Class I or beverage milk products and the cost of processing totally fresh milk. The difference between the two, referred to as the comparative cost of reconstituted milk, is calculated under a variety of assumptions about the processing environment and the cost of related production inputs. Given the importance of accurate cost figures in assessing price impacts, it is essential that current estimates of the cost of reconstitution be improved.

1/For further details and other background material, see Novakovic and Story (2).

Although it is commonly agreed that technical and economic conditions can affect costs and that such conditions could vary significantly from market to market, the implications and effects of cost variation have not been fully assessed and a number of factors that could affect cost have not been explored. This may be particularly important in measuring regional costs and the regional impact of the proposed changes.

This study will attempt to clearly describe input needs, raw ingredients used, final products produced, and the characteristics of the processing procedure and economic environment as they relate to the comparative cost of reconstituting milk. This study is confined to in-plant costs and does not attempt to measure possible differences in assembly and distribution costs.

Review of the Literature

To date, two comprehensive studies of the impact of changing Federal Order regulations as proposed by the CNI have been published (1, 3). Both studies assume that Class I prices and, consequently, blend prices would decline as a result of such changes. The focal point of these analyses is the measurement of the impact on farmers, processors, and consumers when Class I and blend prices drop.

The reductions in prices assumed by both study teams are a function of the cost of processing beverage milk products from reconstituted milk. A USDA study states, "The price of reconstituted milk would be based on the price of manufacturing milk and the cost of drying milk and reconstituting it" (3, p. 75965). Furthermore, it assumes that the cost of transporting dried or condensed ingredients would be minimal; because "the supply of locally produced milk would be adequate to produce all of the reconstituted milk consumed" (3, p. 75968). The authors of the USDA study do not clearly specify their estimates of the costs of drying and reconstituting milk, although they do specify their estimates of the absolute, incremental price advantage of packaged reconstituted milk over fresh milk. They estimate that retail prices of packaged reconstituted milk could be less than the price of fresh milk by as little as 3.2 cents per gallon in the Lake States and as much as 16.2 cents per gallon in the Southeast, based on 1978 prices (3, p. 75965).

Hammond et al. (1) are more specific on their methodology and cost estimates. (It appears that the USDA study relied on an update of Hammond's estimates and is based on the same methods and assumptions.) Hammond, et al. construct a regional cost function for reconstituted milk, defined as cost in excess of the manufacturing price (in essence, the Class III price), by estimating and summing: 1) the additional cost of Grade A milk used to produce nonfat dry milk and butter in the Upper Midwest, 2) the cost of processing whole milk into butter and nonfat dry milk, and 3) the cost of transporting and recombining butter and nonfat dry milk (1, p. 7-9). They estimate the additional cost of Grade A milk to be 15 cents per cwt. of milk equivalent (M.E.) (1, p. 8). Processing costs are assumed equal to the USDA make-allowance used in support price calculations, which was 92 cents per cwt. of M.E. in 1976 (1, p. 8). Transportation costs for butter and nonfat dry milk are calculated from an equation having a fixed cost of 5.2 cents per cwt. of M.E. and a variable cost of 1.7 cents per cwt. of M.E. per 100 miles transported. This equation was estimated from USDA data (1, p. 9).

Hammond et al. estimate recombining costs at 5 cents per cwt. of M.E., based on their professional judgment and the judgment of industry and University of Minnesota dairy processing technologists. They assume "no significant increase in equipment or labor is needed in existing fluid milk plants to use reconstituted milk" (1, p. 8). They estimate additional handling and storing costs of 1.5 cents per cwt. of M.E. and processing costs for reconstituting the ingredients for a large bottling plant of 3 cents per cwt. of M.E. (The 5 cents per cwt. apparently includes .5 cent per cwt. of miscellaneous costs or is a rounded figure.)

Neither study tries to estimate some of the possible variation in the cost of reconstituting milk. Hammond et al. state, [recombining] "costs undoubtedly vary with changes in plant size" (1, p. 9), but they do not pursue the implications of their statement. The USDA study recognizes that costs vary with the proportion of reconstituted milk relative to fresh milk in the output mix of a bottling plant (3, p. 75968). Beyond that, neither study specifically addresses some of the other factors which could affect reconstitution costs.

Methodology

Using an economic-engineering framework, this study will seek to estimate the incremental or comparative costs of reconstituting milk that would accrue to a hypothetical fluid milk bottler under a variety of technical, operating, and economic assumptions. The number reported as the comparative cost of reconstituted milk is the change in net cost incurred by a fluid milk bottler who replaces part of his Class I, fresh milk output with partially reconstituted or blended milk products.2/ It is the cost over and above the total cost of producing the same amount and type of fresh milk products.

The factors that will be controlled in the cost estimates include the following:

1. Plant Size - Costs will be calculated for plants having beverage milk capacities of 30,000 or 100,000 gallons per day.3/ All plants are assumed to operate at full capacity.

2/In this study, the terms "reconstituted milk" and "reconstituted skim milk" refer to mixtures of water and nonfat dry milk or condensed skim milk. The term "blended milk" refers to mixtures of reconstituted skim milk and fresh light cream or raw milk.

3/Throughout this study the term "beverage milk" refers to fresh or blended whole, lowfat, or skim milk products sold for drinking purposes and normally thought of as Class I products.

2. Product Mix - The percentage of a plant's output that is blended milk is allowed to equal 10 or 50 percent.

3. Raw Ingredients - In actuality, milk can be reconstituted from various forms of milk components. The source of reconstituted skim milk is restricted to nonfat dry milk or condensed skim milk (32% solids). Any butterfat needed to blend with reconstituted skim is assumed to come from light cream (20% butterfat) separated in the plant. If more butterfat is needed than that which is available from surplus light cream generated as a by-product of the fresh milk standardization operation, then raw milk is used.4/ The prices of these raw ingredients and the water needed to blend with them can be specified at any level.

4. Solids-Not-Fat Standard - The legal minimum content of solids-not-fat (SNF) in beverage milk products is 8.25 percent in most states; however the average SNF content of raw milk is about 8.62 percent. Since fluid bottlers are not permitted to standardize fresh milk on the basis of SNF content, fresh beverage milk products have the same SNF content as the raw whole and skim milk from which they are made. Presumably blended milk could be formulated to contain any level of SNF. This study measures the comparative cost of reconstitution assuming blended milk is reconstituted to SNF levels of either 8.7 or 8.25 percent.

5. Processing Inputs and Prices - The use of three principal factors of production can vary in plants that switch from fresh to blended milk. They are labor, electricity, and heat. The amount needed of each varies with plant size, product mix, raw ingredient, and SNF standard. Prices of these factors can be specified at any level.

6. Capital Costs - The cost of additional plant and equipment is based on current prices and the amount and type of plant and equipment that is needed, which depends on plant size, the type of raw ingredient used (nonfat dry milk or condensed skim), and the percentage of the plant's output that is blended. Since the comparative cost of reconstituting milk is calculated on a daily basis, the cost of new plant and equipment must be translated from current prices to daily costs. Hence, the presumed operating life of the capital goods, the interest rate used to discount the net value of the capital goods over their useful life, and the number of days the plant is assumed to operate in a year can affect the cost of capital purchases. The level of these three variables--operating life, discount rate, and operating days--can be specified at any level.

7. Income Taxes - Costs are calculated before and after federal and state income taxes. Changes in operating expenses, revenues, and capital expenditures can affect after-tax costs. The marginal tax rate used to calculate after-tax costs can be varied from zero to 100 percent. For tax purposes, new capital is

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4/In this study, the term "raw milk" refers to fresh whole milk purchased by plants from farmers or other plants.

depreciated on a straight line basis over 10 years and an investment tax credit of 10 percent is assumed.

8. Raw Milk Prices - The use of raw milk decreases in plants that reconstitute milk. Also, plants that reconstitute must use more light cream in Class I. These changes result in different amounts of raw milk used in Class I, Class II and Class III, which affects the comparative cost of reconstituting milk. Class I, II, and III prices can be specified at any level.

9. Product Prices - The final output of plants is fresh packaged milk, blended packaged milk, and any excess light cream (assumed to be used in Class II). Reconstituting milk requires more light cream to be used in beverage milk; hence light cream sales are less in a partially reconstituted plant than in a totally fresh plant, *ceteris paribus*. Changes in the output mix resulting from reconstitution imply different revenues that can be attributed to the reconstituting process, depending on the respective prices of the outputs. In addition, it is possible, although not necessary, that the wholesale price of blended products could be different than the wholesale price of fresh products. This would also imply different revenues in otherwise comparable fresh and partially reconstituted plants. Wholesale prices of fresh packaged milk, blended package milk, and light cream can be specified at any level.

10. Federal Order Regulations - The cost of reconstituting milk will change if reconstituted milk is deregulated rather than priced as a Class I product. Costs are estimated under existing pricing provisions and under the assumption that reconstituted milk is not subject to Federal Order pricing.

Organization of the Report

The model and assumptions used to calculate the cost of reconstituting milk are described in detail in Chapter II. The results and analysis are presented in Chapter III. Conclusions and policy implications are discussed in Chapter IV. Supplementary data and results are given in the Appendices.

Chapter II

The Model

Concepts and Assumptions

The figures reported in this study as the comparative costs of reconstituting milk can be interpreted as the additional in-plant expenses and revenues that would accrue to a fresh milk bottling plant that replaced part of its output mix with blended milk products. The comparative cost figures are actually net costs and are negative if added revenues exceed added expenses. A negative comparative cost means that the total net cost in a partially reconstituted plant is less than the total net cost in a totally fresh plant; i.e., blended milk costs less than fresh milk. A positive comparative cost means the reverse, i.e., blended milk costs more than fresh milk.

Revenues result from the sale of fresh beverage milk, blended beverage milk, and any excess light cream. Changes in expenses can result from changes in variable inputs--labor, heat, electricity, raw milk, nonfat dry milk (nfdm), condensed skim milk (condense), and water--and the discounted cost of capital investments in plant and equipment. In addition, comparative costs are calculated before and after income taxes; therefore tax rates will affect the reported costs.

Costs are calculated under various assumptions about technical factors and the operating and economic environment.5/ There are certain assumptions that hold constant across all cases. These are as follows:

1. Plants are operating normally in their market, exhibit typical current technology, produce with average to high efficiency, and generate a profit.

2. Bottling plants are assumed to produce beverage milk products and byproducts normally associated with bottling plants, including chocolate milk and drinks, cream, buttermilk, and fruit juices and drinks. Byproduct volume equals 20 percent of a plant's total capacity and this volume remains constant.

3. The typical plant has sufficient plant and equipment to reconstitute all byproducts plus an additional volume of reconstituted milk equal to at least 10 percent of the total beverage milk output but not as much as 50 percent of the beverage milk output.

5/Many of the assumptions were formulated in consultation with the Agricultural Cooperative Service and JAI Engineers.

4. The beverage milk product mix of the typical plant includes whole milk, lowfat milk and skim milk. Based on sales figures and average fat content of packaged milk products sold by handlers regulated under Federal Milk Marketing Orders in 1979, it is assumed that 60 percent of the typical plant's volume is whole milk standardized to 3.32 percent butterfat (BF), 24 percent of the volume is 2% BF milk, and 16 percent of the volume is 1% BF milk and skim milk (0 percent BF) testing an average 0.83 percent BF. Hence, the average fat content of all beverage milk products is 2.605 percent.

5. Beverage milk products are standardized by mixing raw milk and skim milk. Skim milk and light cream can be separated from raw milk at yields of 81.65 pounds of skim milk and 18.35 pounds of light cream per 100 pounds of raw milk. It is assumed that the industry would separate light cream instead of heavy cream. Light cream is 20 percent BF and 7.2 percent SNF. Skim milk is 0 percent BF and 8.94 percent SNF.

6. Total output of each product type (whole, 2%, 1%, and skim milk) is assumed constant across plants having the same capacity. Plants that reconstitute milk replace fresh milk volume with blended milk volume.

7. Beverage milk is packaged in gallon plastic containers and half-gallon, quart, and half-pint paper containers. Blended milk products are not mingled with fresh milk products, and there are separate and appropriately labeled bottles and cartons for each product type.

8. Butterfat for blended milk is assumed to be obtained solely from fresh light cream or raw milk. Although it is technically possible to reconstitute whole or lowfat milk products from other sources of butterfat, such as butter or anhydrous butterfat, products made from non-cream sources are not as likely to have desirable organoleptic qualities and be competitive with fresh milk as blended milk made with cream.

9. Blended milk products are made from reconstituted skim milk and only as much light cream and raw milk as are needed to supply the butterfat required for the final blended product. If the light cream separated in conjunction with the quantity of skim milk used in fresh products (see item 5 above) does not provide enough butterfat for the blended milk volume, then raw milk is added to the blend until the 2.605 percent BF level is reached. Given 1) the SNF level desired in the blended milk, 2) the SNF content of the light cream and raw milk used, and 3) the SNF content of nonfat dry milk or condense, the quantity of nfdm or condense required to provide sufficient SNF is calculated. Water is added to nonfat dry milk or condense, making reconstituted skim milk, in sufficient quantity to provide the necessary total volume for the final product.

10. Nonfat dry milk used for reconstituting beverage milk must be Grade A and of the low heat type, and it is assumed to be 97.5 percent solids-not-fat (SNF).

11. Condensed skim milk used for reconstituting is assumed to be 32 percent SNF. This is considered to be the highest concentration of solids that can be shipped in fluid form without causing unloading problems, such as solids precipitating out of solution and caking in the bottom of truck tanks.

12. The water used to reconstitute milk can affect the flavor of the reconstituted product. It is assumed that the typical plant already has sufficient equipment for filtering and removing odors from water, if the normal available water supply so requires.

13. Based on national averages, it is assumed that raw milk contains 3.67% BF and 8.62% SNF. All raw milk is purchased at prevailing Federal Order city zone minimum prices; in other words, over-order premiums or other factors which could affect the f.o.b. plant price are not included.

14. Nonfat dry milk and condensed skim milk are purchased at prevailing market prices in truckload quantities of 45,000 pounds and 5,292 gallons, respectively. These load sizes comply with typical road limits. Given the current state of technology for handling bulk powder, it is assumed nonfat dry milk is shipped in 50-pound paper bags.

Conversion factors and some of the product composition factors are summarized in Table 1. Conversion factors are used to convert product volumes to product weights. Butterfat and solids-not-fat composition factors refer to product weights, e.g., 100 pounds of raw milk contain 3.67 pounds of BF. All calculations involving products normally measured in different units first convert volume units (gallons) to pounds.

There are also assumptions related to the control variables, including plant size, blended milk volumes, SNF standards, and others, which are discussed below.

Plant Size

Plants of two sizes are examined. One produces 30,000 gallons of beverage milk per day and a total of 37,500 gallons of all products including byproducts; this represents a medium-size plant. The second plant, representing a large plant, produces 100,000 gallons of beverage milk per day and a total of 125,000 gallons, including byproducts. Since by-products are ignored in this study, we will refer to plant size in terms of beverage milk output, i.e., 30,000 and 100,000 gallons/day (not 37,500 and 125,000).

Table 1. Product Composition and Conversion Factors.

Product	Butterfat Content	Solids-Not-Fat Content	Conversion Factor
	(%)	(%)	(lbs./gal.)
Raw milk	3.67	8.62	8.6
Nonfat dry milk	0	97.5	--
Condensed skim milk	0	32.0	9.51
Fresh skim milk	0	8.94	8.64
Light cream	20.0	7.2	8.48
Water	0	0	8.34
Beverage milk	2.605	8.7[a]	8.62

Source: The New York-New Jersey Milk Marketing Order, the Agricultural Marketing Service (USDA), and the Agricultural Cooperative Service (USDA).

[a]Blended beverage milk products can be standardized to 8.25% SNF.

Reconstituted Volume

Plants are assumed to produce blended milk products at two levels-- 10 percent or 50 percent of total beverage output. This implies blended milk output of 3,000 or 15,000 gallons per day in the medium-size plant and 10,000 or 50,000 gallons per day in the large plant.

Solids-Not-Fat Standard

Although fresh milk products contain as much solids-not-fat as the raw milk and skim milk from which they are made, blended milk products can be formulated to contain any SNF level. It is assumed that blended milk products are formulated to contain either 8.7 percent SNF or 8.25 percent SNF; 8.25 percent is the typical legal minimum SNF content for packaged milk.

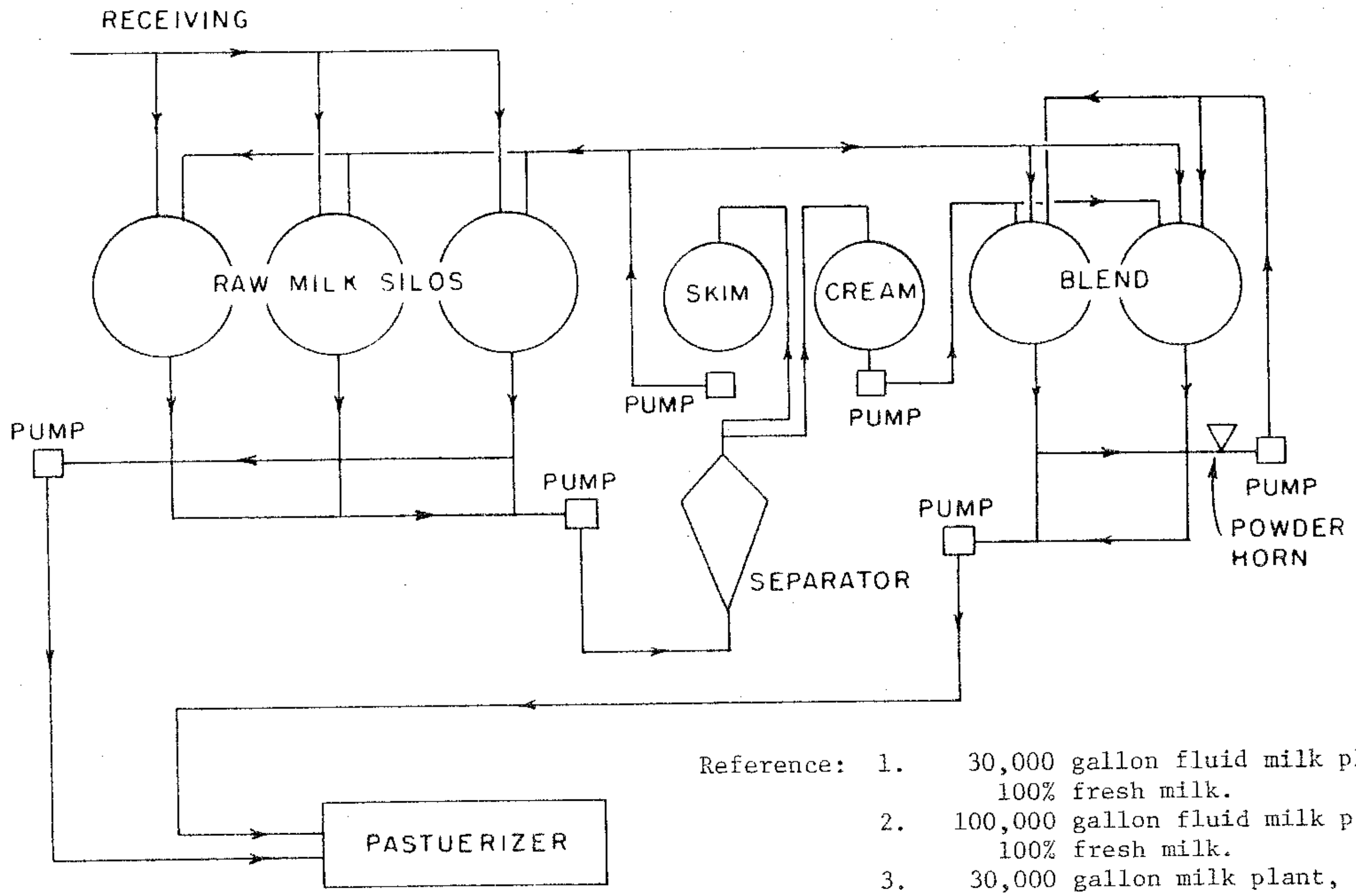
Plant and Equipment

Sketches of plant layouts for 10 typical plants are shown in Figures 1 to 4. The layouts are only for the portion of the plant that may be affected by the reconstituting process, e.g., bottling operations and shipping docks are not shown. Plant designs vary with the type of raw ingredient used to reconstitute skim milk and the relative volume of blended milk produced.

As the sketches indicate, much of the equipment and plant remains unchanged. For example, no changes are required of 1) raw milk storage capacity, 2) processing rate, 3) filling machinery variety or capacity, 4) cold storage or warehouse capacity, 5) truck loading or unloading facilities, and 6) administrative facilities. Moreover, no changes are required in plants that reconstitute no more than 10 percent of their beverage milk volume and use nonfat dry milk (see Figure 1).

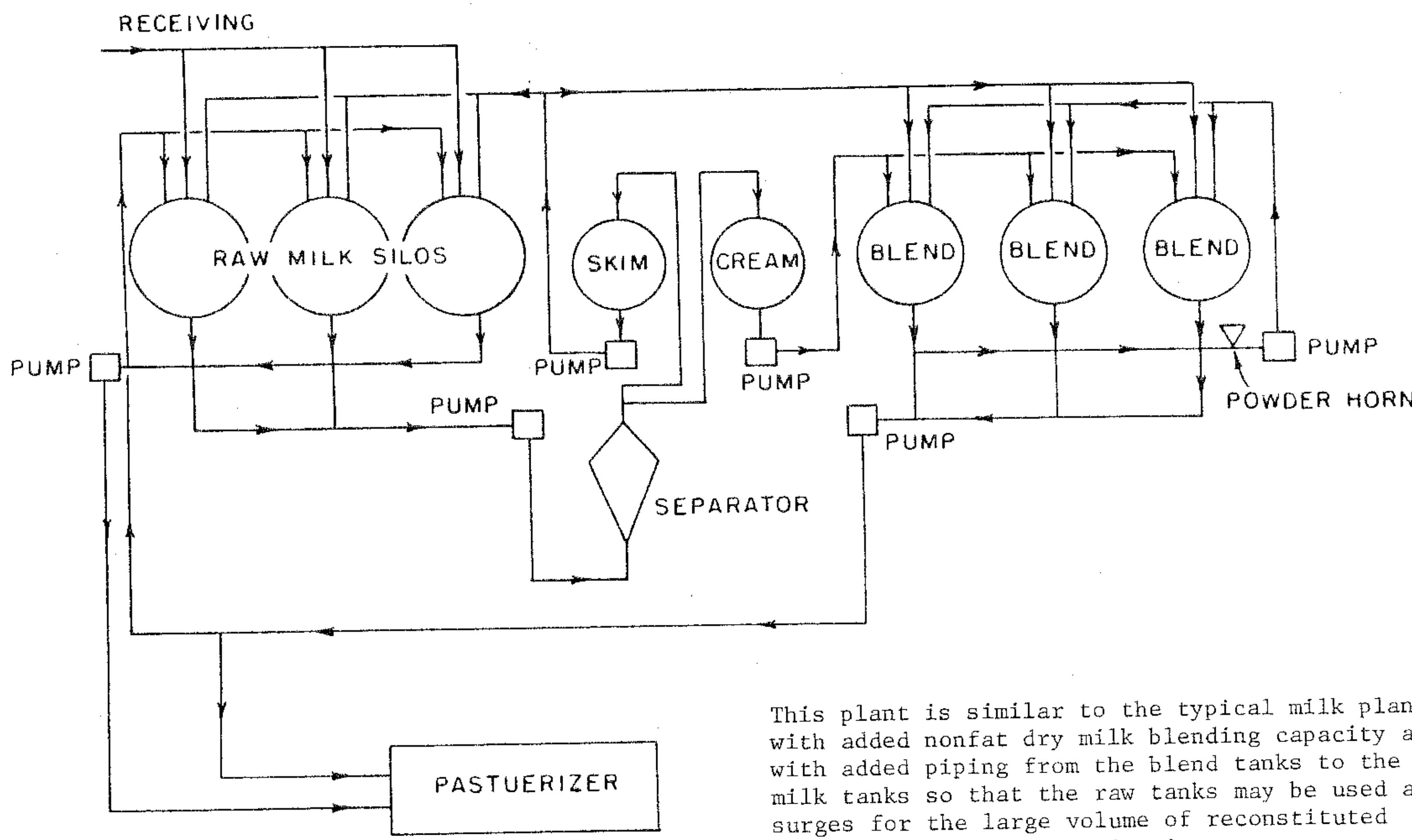
A 30,000 gallon plant partially reconstituting 50 percent of its beverage milk volume from nonfat dry milk (see Figure 2) requires an additional blend vat, increased blending capacity, refrigeration capacity for an additional 18,000 pounds of ice to cool water to 40° Farenheit, and additional trash handling capacity (for paper bags). A 100,000 gallon plant partially reconstituting 50 percent of its beverage milk volume from nonfat dry milk requires all of the above plus increased refrigeration capacity for 60,000 pounds of ice (instead of 18,000 pounds) and additional space in the blending room.

Plants of either size that partially reconstitute 10 percent of their beverage milk volume from condensed skim milk need two additional refrigerated tanks for receiving condense (see Figure 3). Plants of either size that partially reconstitute 50 percent of their Class I volume from condense require two refrigerated tanks, "in-line" blending machinery to mix condense and water, and additional refrigeration capacity to cool the blend water to 40° Farenheit (see Figure 4).



Reference: 1. 30,000 gallon fluid milk plant, 100% fresh milk.
2. 100,000 gallon fluid milk plant, 100% fresh milk.
3. 30,000 gallon milk plant, 10% of output partially reconstituted with nonfat dry milk.
4. 100,000 gallon milk plant, 10% of output partially reconstituted with nonfat dry milk.

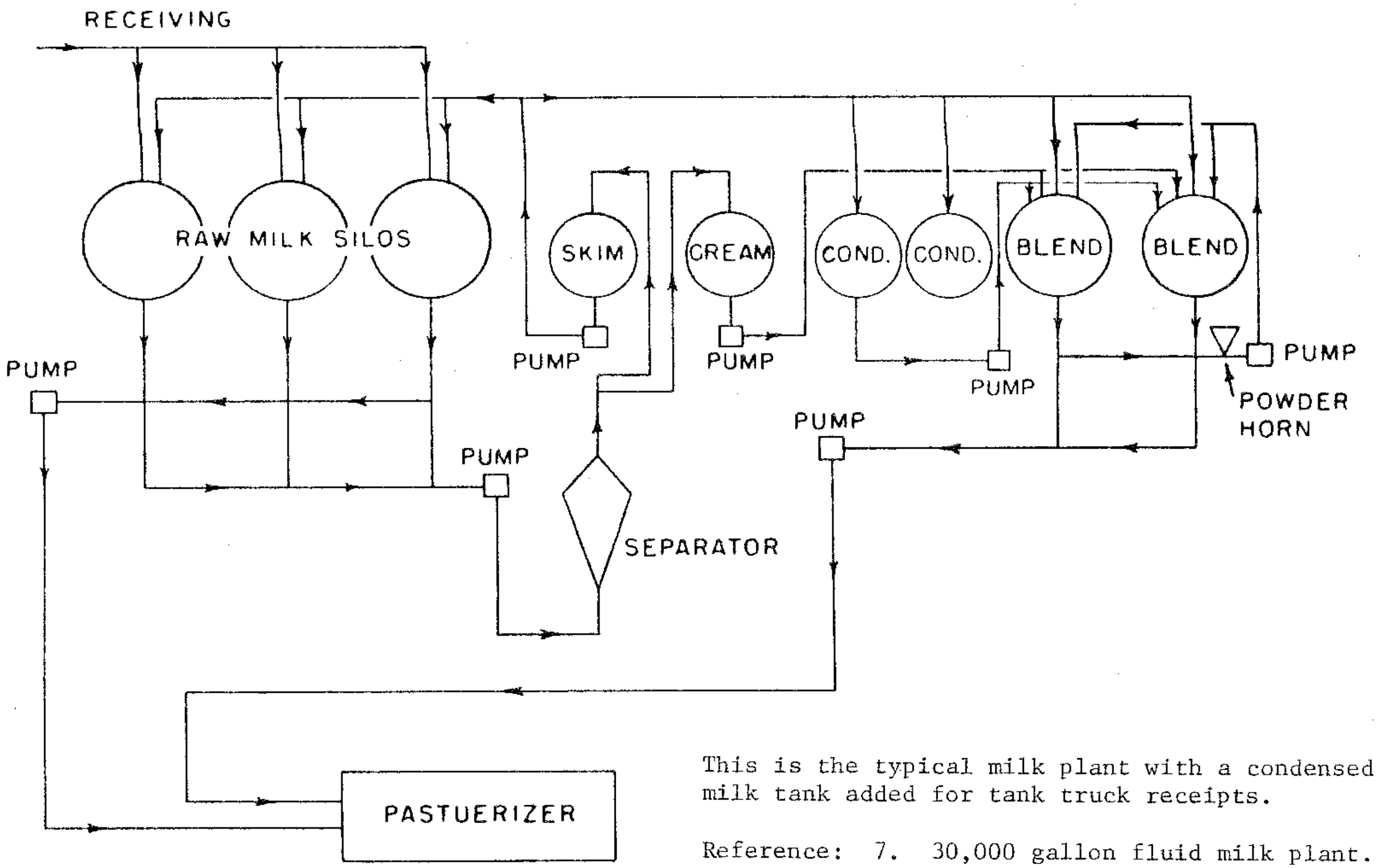
Figure 1. No. 1, 2, 3, and 4 Typical Milk Plants (Raw Milk Side)



This plant is similar to the typical milk plant with added nonfat dry milk blending capacity and with added piping from the blend tanks to the raw milk tanks so that the raw tanks may be used as surges for the large volume of reconstituted product prior to pastuerization.

Reference: 5. 30,000 gallon fluid milk plant.
6. 100,000 gallon fluid milk plant.

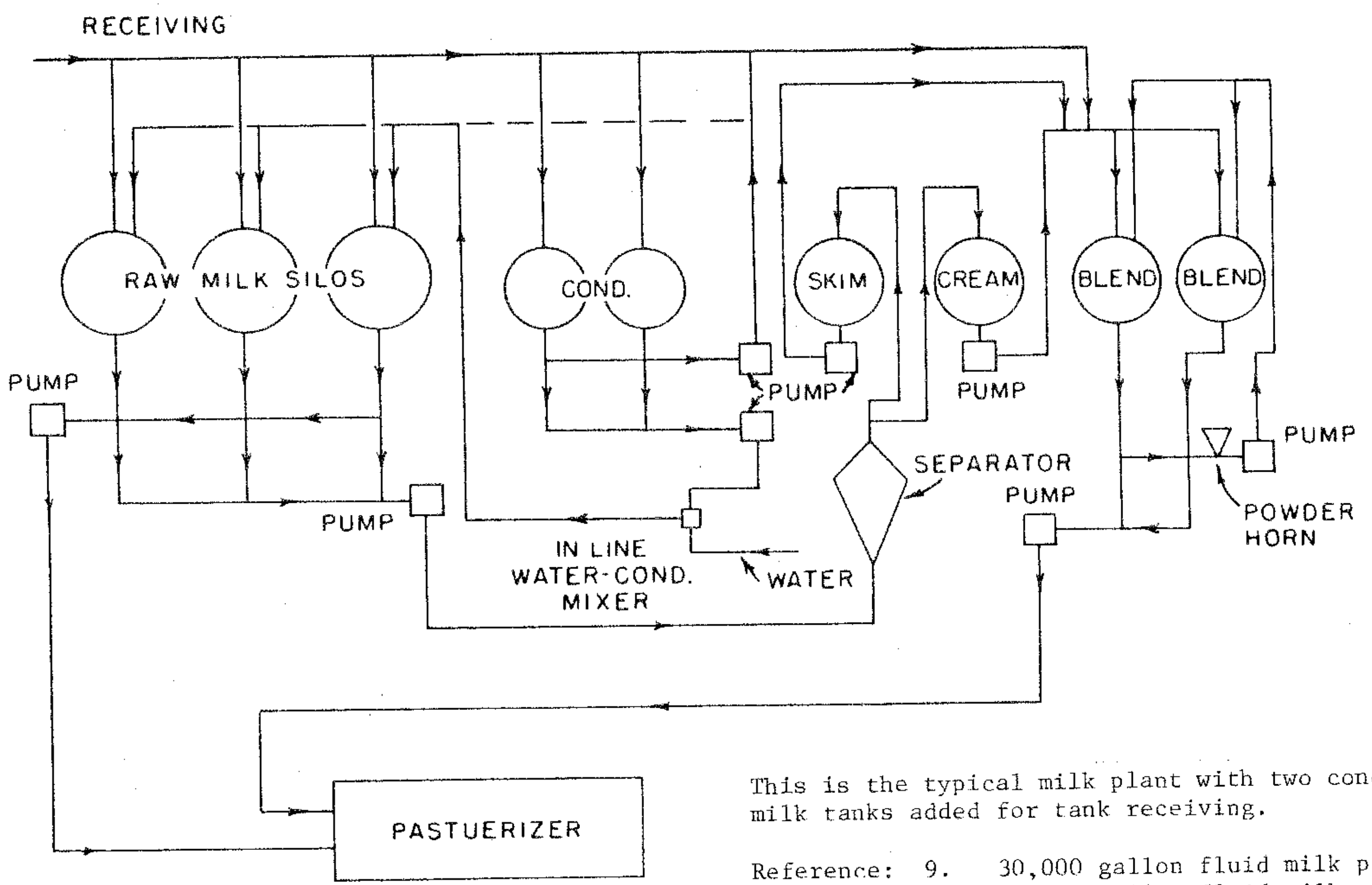
Figure 2. No. 5 and 6 Milk Plants, 50% Partially Reconstituted With Nonfat Dry Milk (Raw Milk Side).



This is the typical milk plant with a condensed milk tank added for tank truck receipts.

Reference: 7. 30,000 gallon fluid milk plant.
8. 100,000 gallon fluid milk plant.

Figure 3. No. 7 and 8 Milk Plants, 10% Reconstituted With Condensed Skim Milk (Raw Milk Side).



This is the typical milk plant with two condensed milk tanks added for tank receiving.

Reference: 9. 30,000 gallon fluid milk plant
10. 100,000 gallon fluid milk plant

Figure 4. No. 9 and 10 Milk Plants, 50% Partially Reconstituted with Condensed Skim Milk (Raw Milk Side).

The values of initial investments for all of the above configurations are given in Table 2. These values are based on average current prices for standard equipment and building materials (plus installation and construction costs). Salvage values at the end of the presumed 15-year operating life are assumed equal to 10 percent of the purchase price.

Labor, Heat, and Electricity Inputs

Plants that reconstitute milk need extra labor, heat and electricity above and beyond the variable inputs used in comparable plants that do not reconstitute milk. The additional amounts of these variable inputs vary with plant size and operating assumptions; the level required of each variable input under each set of assumptions is shown in Table 3. It is assumed that all inputs, including labor, can be purchased at the exact level specified in the table.

Reconstituting and Blending Processes

Given that comparative costs are calculated as the additional net costs resulting from plants converting from totally fresh products to partially reconstituted products, it is necessary to trace how the production process changes when a plant converts. We wish to identify and quantify 1) the raw ingredients used in production, 2) the final products produced, and 3) any intermediate products produced and used in the process. To begin, the production process for a totally fresh milk plant is established below.

The totally fresh milk plant produces fresh beverage milk products from raw milk. One batch of raw milk can be separated into skim milk and light cream. The skim milk can be mixed with another batch of raw milk to achieve a desired butterfat content for the mixed batch. Since the butterfat content of raw milk (3.67%) exceeds the average butterfat content of the final products (2.605%), the light cream generated through this process is not needed for the plant's beverage milk output. Excess light cream is assumed to be sold in a Class II use. The product flows of a typical, totally fresh milk plant producing 30,000 gallons of milk per day is shown in Figure 5. (Product flows in all plants are shown in Appendix A.)

Given two plant sizes, two levels of blended milk volume, two SNF standards for blended milk, and two types of raw ingredient that can be used to make reconstituted skim milk, there are 16 possible product flow combinations. As an example, Figure 6 illustrates the product flow in a 30,000 gallon per day plant which blends 50 percent of its output with nonfat dry milk and water and standardizes the blend to 8.7 percent SNF. (Product flows in all plants are shown in Appendix A.)

In a partially reconstituted milk plant, some raw milk is used directly in fresh milk products, some raw milk is separated into fresh

Table 2. Purchase Prices and Salvage Values of Additional Plant and Equipment Under Alternative Operating Assumptions.

Assumptions/Plant and Equipment	Value ($)	
I. Nonfat Dry Milk Used to Reconstitute		
A. 10% Blended Volume		
1. 30,000 gallon plant		0
2. 100,000 gallon plant		0
B. 50% Blended Volume		
1. 30,000 gallon plant		
a. blend vat	10,000	
b. blender and pipe	13,000	
c. refrigeration	18,000	
d. trash handling	14,000	
e. total		55,000
f. salvage value		5,500
2. 100,000 gallon plant		
a. blend vat	22,000	
b. blender and pipe	36,000	
c. refrigeration	60,000	
d. trash handling	36,000	
e. enlarge blend room	15,000	
f. total		169,000
g. salvage value		16,900
II. Condensed Skim Milk Used to Reconstitute		
A. 10% Blended Volume		
1. 30,000 gallon plant		
a. two used 3,000 gallon tanks	6,500	
b. installation	4,500	
c. pump and pipe	9,500	
d. total		20,500
e. salvage value		2,050
2. 100,000 gallon plant		
a. two used 6,000 gallon tanks	18,000	
b. installation	9,300	
c. pump and pipe	9,500	
d. total		36,800
e. salvage value		3,680

Table 2. (continued)

Assumptions/Plant and Equipment		Value ($)
B. 50% Blended Volume		
1. 30,000 gallon plant		
a. two used 6,000 gallon tanks	18,000	
b. installation	9,300	
c. pump and pipe	9,500	
d. in-line blender	28,000	
e. refrigeration	11,000	
f. total		75,800
g. salvage value		7,580
2. 100,000 gallon plant		
a. two used 15,000 gallon tanks	45,000	
b. installation, pump and pipe	31,000	
c. in-line blender	32,500	
d. refrigeration	44,500	
e. enlarge blend room	15,000	
f. total		168,000
g. salvage value		16,800

Source: JAI Engineers.

Table 3. Additional Labor, Heat and Electricity Inputs Required at Plants Converting to Partially Reconstituted Products Under Various Operating Assumptions.

Input Requirements	10% Blended Milk Volume[a]				50% Blended Milk Volume[b]			
	30,000 gal. plant[c]		100,000 gal. plant[d]		30,000 gal. plant[c]		100,000 gal. plant[d]	
	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]
Additional Labor (man hours/day)								
Receive tanker milk	- .4	- .4	-1.0	-1.0	-3.8	-3.8	-5.0	-5.0
Receive nfdm	.5	--	1.5	--	1.3	--	4.5	--
Receive condense	--	.6	--	.8	--	1.8	--	2.3
Blending nfdm	.7	--	2.0	--	2.0	--	2.9	--
Blending condense	--	.3	--	1.0	--	1.6	--	1.7
Trash handling	.7	0	2.0	0	2.0	--	2.9	--
Changeover on fillers	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Clean blend equipment	--	--	.3	--	.3	--	.3	--
Clean condense tanks	--	.6	--	.6	--	.6	--	.6
Material handling in cooler	.8	.8	1.7	1.7	.8	.8	1.7	1.7
Delivery and administration	1.0	1.0	2.5	2.5	1.0	1.0	2.5	2.5
TOTAL	4.8	4.4	10.5	7.1	5.1	3.5	11.3	5.3
Additional Heat (100,000 btu/hour)								
Pasteurizing	11.2	11.2	29.6	29.6	11.2	11.2	29.6	29.6
Cleaning tanks	--	3.8	--	5.4	2.7	2.7	2.7	5.4
TOTAL	11.2	15.0	29.6	35.0	13.9	13.9	32.3	35.0

Table 3. (continued)

Input Requirements	10% Blended Milk Volume[a]				50% Blended Milk Volume[b]			
	30,000 gal. plant[c]		100,000 gal. plant[d]		30,000 gal. plant[c]		100,000 gal. plant[d]	
	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]	Nfdm[e]	Condense[f]
Additional Electricity (kilowatt hours)								
Raw milk pumping, receiving	-3.0	-3.0	-15.0	-15.0	-28.4	-28.4	-75.0	-75.0
Condense pumping, receiving	--	3.3	--	9.1	--	9.9	--	26.1
Nfdm blending	.4	--	.6	--	6.0	--	22.4	--
Condense blending	--	.5	--	4.0	--	6.4	--	12.9
Agitate raw milk	--	--	--	--	-54.0	-54.0	-90.0	-90.0
Agitate reconstituted skim	--	--	--	--	13.5	13.5	15.0	15.0
Agitate condense	--	36.0	--	54.0	--	54.0	--	90.0
Pasteurize and homogenize	7.6	7.6	16.6	16.6	7.6	7.6	16.6	16.6
Changeover on fillers	110.0	110.0	110.0	110.0	110.0	110.0	110.0	110.0
Plant lighting	.2	.2	.2	.2	.2	.2	.2	.2
Conveyor system	12.0	12.0	76.4	76.4	12.0	12.0	76.4	76.4
Refrigerate blend water	74.2	56.2	244.0	150.0	370.0	225.0	1200.0	901.0
CIP systems	--	15.0	--	15.0	--	15.0	--	15.0
TOTAL	201.4	237.8	432.8	420.3	436.9	371.2	1275.6	1098.2

Source: JAI Engineers.

[a] Blended milk equals 10 percent of total beverage milk volume.
[b] Blended milk equals 50 percent of total beverage milk volume.
[c] Beverage milk volume equals 30,000 gallons of beverage milk products per day.
[d] Beverage milk volume equals 100,000 gallons of beverage milk products per day.
[e] Nonfat dry milk is used for reconstitution.
[f] Condensed skim milk is used for reconstitution.

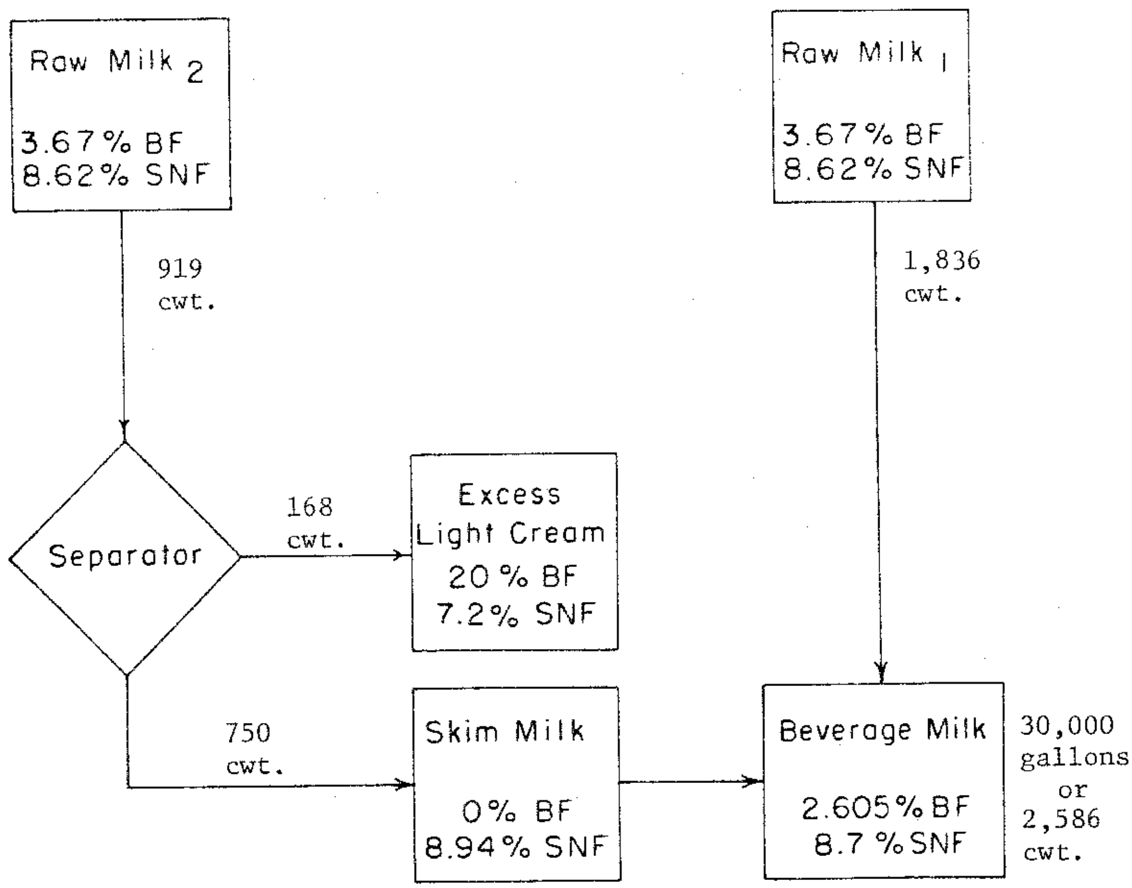


Figure 5. Product Flows in a Plant Producing 30,000 Gallons of Fresh Beverage Milk per Day.

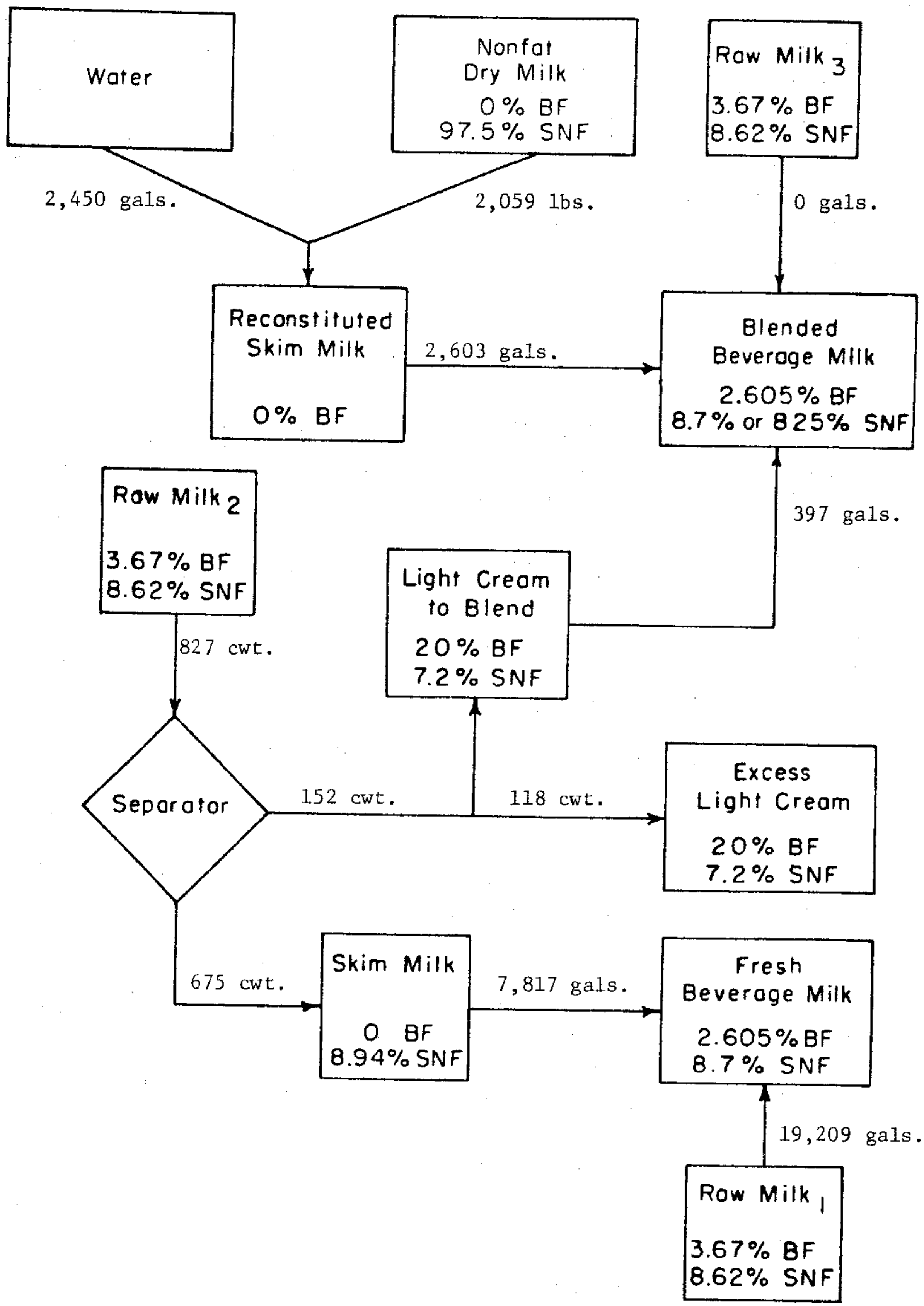


Figure 6. Product Flows in a 30,000 gallon/day Plant Which Blends 10% of Its Milk Volume at 8.75% SNF.

skim milk and light cream, and some reconstituted skim milk is produced. Fresh skim milk is mixed with raw milk to produce butterfat standardized fresh milk products. Light cream is mixed with reconstituted skim milk to the extent butterfat is needed in blended milk products. If the light cream produced contains more butterfat than is needed, then the excess light cream is sold in Class II. If blended milk products require more butterfat than is available in light cream, then additional butterfat is obtained by adding raw milk to the blend. The exact procedure used to calculate product flows is presented in Appendix A.

Cost Calculations

Conceptual Design

The comparative cost of reconstituting beverage milk products is defined herein as the difference between net revenues in a plant that does not reconstitute beverage milk products and a plant that does, ceteris paribus. This cost includes variable costs, capital costs, and gross revenues.

Conceptually, the in-plant net revenues of bottling plants can be expressed as follows:

$$NR = TR - TC$$

$$TR = \sum_j WPM_j \cdot M_j + PIILC \cdot ELC + PB \cdot B$$

$$TC = PI \cdot \sum_j M_j' + PII \cdot (ELC + B') + TVC + TCC$$

$$TVC = \sum_i P_i X_i$$

where

NR = net revenue ($)

TR = total revenue ($)

TC = total cost ($)

WPM_j = wholesale price of the j^{th} beverage milk product ($/gal.)

M_j = volume of the j^{th} beverage milk product sold daily by plants (gal.)

PIILC = Class II price of light cream ($/cwt.)

ELC = light cream sold by plants for use in Class II (cwt.)

PB = wholesale price of byproducts ($/gal.)

B = volume of byproducts sold by plants in Class II (gal.)

PI = Class I price for raw milk adjusted for the fat content of raw milk--BFRM ($/cwt.)

$\sum_j M_j'$ = amount of milk used in Class I (cwt.)

PII = Class II price for raw milk ($/cwt.)

B' = amount of milk used in Class II and sold as byproducts (cwt.)

TVC = total variable cost ($)

TCC = total capital cost ($)

P_i = the price of the i^{th} variable input ($/unit)

X_i = the amount of the i^{th} variable input used to produce all dairy products (unit)

Given this framework, the cost that can be attributed to reconstituting milk is defined as follows:

$$CCR = NR^T - NR^P$$

where

CCR = comparative cost of reconstituting milk

and, the superscripts T and P denote net revenues (NR) for plants that sell totally fresh beverage milk products and partially reconstituted beverage milk products, respectively.

Clearly, any element of NR^T that is identical to an element of NR^P will cancel out in the calculation of CCR. This is true of 1) all variable inputs except labor, heat, electricity, raw milk, water and nonfat dry milk, and condensed skim milk, 2) all capital costs except for the cost of plant and equipment added to facilitate reconstitution, and 3) revenues from all byproducts. From here on, only the variable costs and capital investments that represent the differences between totally fresh and partially reconstituted milk plants will be specified, and revenues from byproducts are excluded. Furthermore, beverage milk products (M_j) will be restricted to two general types--fresh milk and blended milk products.

Mathematical Model

Given this conceptual design, the specific cost equations used in this study can be formulated. Beginning with the totally fresh milk plant and ignoring 1) the factors that will not change between fresh and partially reconstituted milk plants, and 2) costs outside the plant (i.e., assembly and distribution), the <u>total revenue of the totally fresh milk plant</u> is defined as follows:

$$TR^T = (WPM_F \cdot PS) \quad (1.1)$$
$$+ (PIILC \cdot ELC^T) \quad (1.2)$$

where

WPM_F = the wholesale price of fresh milk products ($/gallon)

PS = plant size or total volume of beverage milk products

and the other variables are as defined above.

The term (1.1) is the revenue resulting from the sale of fresh beverage milk products. The term (1.2) is the revenue from the sale of excess light cream sold in Class II.

Ignoring, again, the factors that will not change between plants and costs outside the plant, <u>total cost in the totally fresh milk plant</u> is as follows:

$$TC^T = (PI \cdot PS \cdot CFM \div 100) \quad (2.1)$$

$$+ (PII \cdot ELC^T) \quad (2.2)$$

where

$PS \cdot CFM \div 100$ = plant size in hundredweight (as defined in Appendix A).

The term (2.1) is the cost of raw milk used in Class I, and the term (2.2) is the cost of raw milk used in Class II.

Ignoring, again, the factors that will not change between plants and costs outside the plant, <u>total revenue in the partially reconstituted plant</u> is as follows:

$$TR^P = (WPM_F \cdot PS \cdot FV) \quad (3.1)$$

$$+ (WPM_R \cdot PS \cdot RV) \quad (3.2)$$

$$+ (PIILC \cdot ELC^P) \quad (3.3)$$

where

WPM_R = the wholesale price of blended milk products

$PS \cdot FV$ = fresh milk product volume (as defined in Appendix A)

$PS \cdot RV$ = blended milk product volume (as defined in Appendix A)

The term (3.1) is the revenue from the sale of fresh beverage milk products. (It should be noted that the wholesale prices of fresh and blended milk products need not be different.) The term (3.2) is the revenue from the sale of blended milk products. And, the term (3.3) is the revenue from the sale of excess light cream sold in Class II.

Total cost in the partially reconstituted milk plant will vary depending on how reconstituted milk is classified under Federal Milk Marketing Orders. If reconstituted milk is priced as a Class I product, as is the case under current provisions, then the handler would be assessed the difference between the Class I price and the Class III price (the Class I differential) on the quantity of reconstituted skim milk used in blended milk products. Ignoring, again, the factors that will not change between plants and costs outside the plant, total cost in the partially reconstituted, regulated milk plant is as follows:

$$TC_R^P = (PI \cdot PS \cdot FV \cdot CFM \div 100) \quad (4.1)$$

$$+ PI \cdot (BLC + RM_3) \quad (4.2)$$

$$+ PII \cdot (ELC^P) \quad (4.3)$$

$$+ (PI - PIII) \cdot ((PS \cdot RV \cdot CFM \div 100) - BLC - RM_3) \quad (4.4)$$

$$+ (P_{RI} \cdot X_{RI}) + (P_W \cdot X_W) \quad (4.5)$$

$$+ (P_L \cdot X_L + P_H \cdot X_H) + (P_E \cdot X_E) \quad (4.6)$$

$$+ CC \quad (4.7)$$

where,

$PS \cdot FV \cdot CFM \div 100$ = fresh milk product volume converted to hundredweight (as defined in Appendix A)

$BLC+RM_3$ = light cream and raw milk used in blended milk products (as defined in Appendix A) (cwt.)

PIII = the Class III price for raw milk ($/cwt.)

$PS \cdot RV \cdot CFM \div 100$ = blended milk product volume converted to hundredweight (as defined in Appendix A)

P_{RI} = the price of nonfat dry milk or condensed skim milk ($/lb.)

X_{RI} = the pounds of nfdm or gallons of condense used in blended milk products

P_W = the price of water ($/gal.)

X_W = the gallons of water used in blended milk products

P_L = price of labor, wages and fringes ($/hour)

X_L = the hours of labor used to produce blended milk products above and beyond the labor used to produce an equal volume of fresh milk products

P_H = the price of heat (\$/MBH)

X_H = the amount of heat used to produce blended milk products above and beyond the heat used to produce an equal volume of fresh milk products (MBH or 100,000 BTUs/hour)

P_E = the price of electricity (\$/KWH)

X_E = the amount of electricity used to produce blended milk products above and beyond the electricity used to produce an equal volume of fresh milk products (KWH or kilowatts/hour)

CC = the cost of plant and equipment above and beyond the capital cost associated with an equal volume of fresh milk products, i.e., $TCC^P - TCC^T$ (\$)

The term (4.1) denotes the cost of raw milk used in totally fresh Class I milk products. The term (4.2) denotes the cost of raw milk used in blended milk products in the form of light cream and raw whole milk. The term (4.3) represents the cost of raw milk sold in Class II as excess light cream. The term (4.4) denotes the Federal Order assessment on the reconstituted skim milk used in blended milk products. The term (4.5) is the cost of nonfat dry milk or condensed milk and water needed for reconstituting. The term (4.6) represents the cost of additional variable inputs--labor, heat, and electricity. The term (4.7) denotes the added capital costs (which are discussed in detail below).

If the provisions suggested by the CNI were in effect, then reconstituted skim milk would not be charged the Class I differential and the term (4.4) would be eliminated from the formula. Ignoring, again, the factors that will not change between plants and costs outside the plant, total cost in the partially reconstituted, unregulated milk plant is as follows:

$$TC_R^P = (PI \cdot PS \cdot FV \cdot CFM \div 100) \quad (4.1)$$

$$+ PI \cdot (BLC + RM_3) \quad (4.2)$$

$$+ PII \cdot (ELC^P) \quad (4.3)$$

$$+ (P_{RI} \cdot X_{RI}) + (P_W \cdot X_W) \quad (4.5)$$

$$+ (P_L \cdot X_L + P_H \cdot X_H) + (P_E \cdot X_E) \quad (4.6)$$

$$+ CC \quad (4.7)$$

Capital Costs

Capital costs or the cost of added fixed assets (plant and equipment) must be calculated so as to be comparable to variable costs, which are calculated as costs per operating day. The purchase price of capital goods must be annualized over the operating life of the capital goods. The salvage value of the capital goods must be discounted, and the present value of initial capital purchases less their discounted salvage value must then also be annualized over the life of the capital goods. The annualized costs must then be converted to daily costs, based on the number of days a plant operates in a year. This can be expressed mathematically as

$$CC = \frac{CI-DSV}{\Theta \cdot OD}$$

where

$$DSV = SV \cdot \Theta$$
$$\Theta = \frac{(1-\Omega)100}{DR}$$

$$\Omega = (1 + \frac{DR}{100})^{-OL}$$

and,

CI = capital investment or the purchase price value of plant and equipment needed to produce blended milk products in addition to plant and equipment needed to produce an equal volume of fresh milk ($)

SV = salvage value of added plant and equipment ($)

OD = number of days a plant operates in a year

DR = the annual interest rate used to discount and annualize the value of added plant and equipment

OL = the operating life of added plant and equipment (years).

The variable Ω is the standard factor used to compute the present value of a future expense (or revenue). The variable Θ is the standard factor used to annualize a current expense (or revenue) over a period of years.

Cost of Reconstituting Milk

Given all of the above equations for total costs and revenues, the comparative cost of reconstituting milk can be derived under either current or proposed Federal Order pricing provisions for reconstituted milk. Under current provisions the comparative cost attributed to reconstituting milk (CCR_R) is:

$$CCR_R = NR^T - N_R^P$$

$$CCR_R = TR^T - TC^T - TR^P + TC^P$$

$$\begin{aligned} CCR_R = {} & [(WPM_F \cdot PS) + (PIILC \cdot ELC^T)] \\ & - [(PI \cdot PS \cdot CFM \div 100) + (PII \cdot ELC^T)] \\ & - [(WPM_F \cdot PS \cdot FV) + WPM_R \cdot PS \cdot RV) + (PIILC \cdot ELC^P)] \\ & + [(PI \cdot PS' \cdot FV) + PI \cdot (BLC + RM_3) + (PII \cdot ELC^P) \\ & + (PI - PIII) \cdot ((PS \cdot RV \cdot CFM \div 100) - BLC - RM_3) \\ & + (P_{RI} \cdot X_{RI}) + (P_W \cdot X_W) + (P_L \cdot X_L) \\ & + (P_H \cdot X_H) + (P_E \cdot X_E) + (CI - (SV \cdot \Omega)) \div (\Theta \cdot OD)] \end{aligned}$$

$$\begin{aligned} CCR_R = {} & (WPM_F - WPM_R) \cdot PS \cdot RV && (5.1) \\ & + PIILC \cdot (ELC^T - ELC^P) && (5.2) \\ & - PII \cdot (ELC^T - ELC^P) && (5.3) \\ & - PIII \cdot ((PS \cdot RV \cdot CFM \div 100) - BLC - RM_3) && (5.4) \\ & + (P_{RI} \cdot X_{RI}) + (P_W \cdot X_W) && (5.5) \\ & + (P_L \cdot X_L) + (P_H \cdot X_H) + (P_E \cdot X_E) && (5.6) \\ & + (CI - (SV \cdot \Omega)) \div (\Theta \cdot OD) && (5.7) \end{aligned}$$

The term (5.1) is the comparative change in net revenue resulting from selling a given volume of milk as blended milk instead of fresh milk. If

$$WPM_R < WPM_F$$

as the CNI suggests would happen, then the comparative cost of reconstituting milk is increased accordingly. If

$$WPM_R = WPM_F$$

there is no change in revenues on that volume of blended milk, and this term drops out of the calculation.

The term (5.2) is the comparative difference in revenues resulting from a change in light cream sales. Since light cream must be used in blended milk, there is always more excess light cream in a totally fresh milk plant, i.e.:

$$ELC^T > ELC^P$$

and the comparative cost of reconstituting milk is always increased accordingly.

The term (5.3) represents the comparative decrease in the cost of raw milk priced in Class II because there is less milk sold as light cream in the partially reconstituted plant.

The term (5.4) represents the comparative decrease in the cost of raw milk that is displaced by reconstituted skim milk. Because the Class I differential is charged to the reconstituted skim milk, only the Class III value of the displaced raw milk is saved. It might be noted that current Federal Order provisions are intended to result in a cost of reconstituted skim milk (nonfat dry milk or condensed skim milk and water) (5.5) that is approximately equal to the Class III value of an equal volume of fresh skim milk (5.4).

The term (5.5) represents the added cost of water and nonfat dry milk or condensed skim milk, which is used to make reconstituted skim milk.

The term (5.6) represents the comparative cost of added variable inputs.

The term (5.7) represents the comparative cost of additional plant and equipment.

If reconstituted milk is priced according to the CNI proposal and term (4.4) is dropped as discussed above, then the comparative cost that can be attributed to reconstituted milk (CCR_U) reduces to the following:

$$CCR_U = (WPM_F - WPM_R) \cdot PS \cdot RV \qquad (6.1)$$

$$+ PIILC \cdot (ELC^T - ELC^P) \qquad (6.2)$$

$$- PII \cdot (ELC^T - ELC^P) \qquad (6.3)$$

$$- PI \cdot ((PS \cdot RV \cdot CFM \div 100) - BLC - RM_3) \qquad (6.4)$$

$$+ (P_{RI} \cdot X_{RI}) + (P_W \cdot X_W) \qquad (6.5)$$

$$+ (P_L \cdot X_L) + (P_H \cdot X_H) + (P_E \cdot X_E) \qquad (6.6)$$

$$+ (CI - (SV \cdot \Omega)) \div (\Theta \cdot OD) \qquad (6.7)$$

The terms (6.1), (6.2), (6.3), (6.5), (6.6), and (6.7) are identical to (5.1), (5.2), (5.3), (5.5), (5.6), and (5.7) and may be interpreted the same.

The term (6.4) is the same as (5.4) except that the Class I price is used instead of the Class III price. This term also represents the savings in the cost of raw milk that is displaced by reconstituted skim milk, but now that savings reflects the full Class I value of the displaced raw milk; because there is no counterveiling charge on the reconstituted skim milk. Obviously,

$$CCR_R > CCR_U$$

that is, the comparative cost of reconstitution is always higher under current pricing provisions than in the unregulated case.

Income Taxes

Up to this point all cost figures have excluded income taxes. In studies such as this one, this is commonly done; however, it is the authors' opinion that income taxes are a necessary expense associated with any business operation and should be incorporated into the cost calculation so as to arrive at the most complete cost calculation possible.

Income taxes will increase (or decrease) as net revenue increases (or decreases). In the problem outlined above, there are taxes on operating revenues and expenses, and there are investment tax credits on added plant and equipment. For the purposes of this study, a 10 percent investment tax credit is assumed. In addition, a straight line depreciation of capital is assumed to determine the value of taxes on depreciating capital. All new plant and equipment is assumed to be fully depreciated in 10 years.

Net cost in the partially reconstituted plant can be adjusted for added taxes by subtracting the following expression for taxes from the equations for CCR_R or CCR_U:

$$T = (CCR - CC)\cdot AT \qquad (7.1)$$

$$+ \left(\frac{CI - SV}{10} \div OD\right)\cdot AT \qquad (7.2)$$

$$+ \frac{0.1\cdot CI}{OD\cdot \Theta} \qquad (7.3)$$

where,

T = net taxes resulting from net costs associated with reconstituted milk ($)
AT = the marginal tax rate.

The term (7.1) is the net change in income taxes associated with the comparative cost of reconstituted milk, excluding the capital cost. Capital costs are excluded because it is assumed that capital can be depreciated at a faster rate for tax purposes.

The term (7.2) represents the decrease in taxes resulting from the depreciation of added plant and equipment. For tax purposes, capital investments are depreciated in 10 years.

The term (7.3) denotes the value of the 10 percent investment tax credit permitted in the year in which the added plant and equipment are purchased, after the credit has been annualized over the actual operating life of the capital goods.

Chapter III

Results and Analysis

The first section of this chapter presents estimates of the comparative costs of reconstituting beverage milk in various parts of the U.S. under the several assumptions outlined in the previous chapter. The second section explores the sensitivity of the comparative cost estimates for one area to changes in assumptions about technical factors and the operating and economic environment.

Test Cases

The comparative cost of reconstituting beverage milk is calculated for hypothetical plants operating under a variety of assumptions. Some of these deal with technical factors and relationships that are held constant across all test cases (e.g., see Table 1). Alternative levels of four principal variables define the basic characteristics of assumed operating environments; these four variables are: 1) plant size, 2) blended milk volume, 3) raw ingredient used to reconstitute skim milk, and 4) SNF standard. A fifth variable, which describes an aspect of the economic environment, deals with Federal Order pricing provisions, i.e., whether current provisions in effect or not. As discussed earlier, two alternatives are examined for each of the five variables above. This results in 32 different plant situations that will be associated with different comparative costs of reconstitution. Each combination is identified with a test case number in Table 4.

Although the same technical and operating assumptions about the physical characteristics of plants and plant inputs and outputs may be valid in all areas of the country, factor and product prices may vary regionally. Six cities are chosen to reflect a broad range of possible prices for labor, raw milk, etc. These cities are: 1) Boston, Massachusetts; 2) Chicago, Illinois; 3) Dallas, Texas; 4) Jacksonville, Florida; 5) Knoxville, Tennessee; and 6) New York, New York. The price and other economic assumptions associated with each of these locations are given in Table 5.

There are 192 combinations of operating and economic assumptions, as defined in Table 4 (32 cases) and Table 5 (6 price sets). In the analysis which follows, the comparative costs of reconstituting milk are calculated for selected test cases. To provide a consistent view of the impact of the entire range of operating assumptions, comparative costs based on New York prices are calculated for all of the 32 cases shown in Table 4. For the sake of brevity, only cases 17 through 28 are studied for the remaining five cities. These cases look only at unregulated reconstituted milk prices and exclude cases in which both condensed skim

Table 4. Principal Operating Assumptions for Test Cases

Case No.[a]		Plant Size[b]		Blended Volume[c]		Raw Ingredients[d]		SNF Standard[e]	
Reg.	Unreg.	30K	100K	10%	50%	NFDM	Condense	8.7%	8.25%
1	17	X		X		X		X	
2	18	X			X	X		X	
3	19		X	X		X		X	
4	20		X		X	X		X	
5	21	X		X			X	X	
6	22	X			X		X	X	
7	23		X	X			X	X	
8	24		X		X		X	X	
9	25	X		X		X			X
10	26	X			X	X			X
11	27		X	X		X			X
12	28		X		X	X			X
13	29	X		X			X		X
14	30	X			X		X		X
15	31		X	X			X		X
16	32		X		X		X		X

[a]Reconstituted milk is priced under Federal Orders according to current provisions (Regulated) or it is not priced under Federal Orders (Unregulated).

[b]Plants process either 30,000 (30K) or 100,000 (100K) gallons of beverage milk per day.

[c]The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[d]Either nonfat dry milk (NFDM) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[e]Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 5. Basic Price and Other Economic Assumptions for Plants in Six Cities.[a]

	Boston	Chicago	Dallas	Jacksonville	Knoxville	New York
Price of Labor ($/hour)	10.45	12.52	8.59	7.02	9.71	16.50
Price of Heat ($/MBH)	1.86	1.86	1.86	1.86	1.86	1.86
Price of Electricity (¢/KWH)	7.0	3.32	3.81	8.03	4.73	9.0
Price of Water (¢/gallon)	0.4	0.4	0.4	0.4	0.4	0.4
Price of Nonfat Dry Milk (¢/lb.)	96.1	94.75	96.73	96.73	96.73	96.1
Price of 32% Condensed Skim Milk (¢/lb. of wet solids)	95.0	92.0	102.0	103.0	98.0	93.6
Price of Class I Milk ($/cwt.)	15.56	13.90	14.96	15.49	14.74	15.25
Price of Class II Milk ($/cwt.)	12.62	12.90	12.90	12.82	12.90	12.70
Price of Class III Milk ($/cwt.)	--	12.67	12.67	--	12.67	--
Difference Between Wholesale Prices of Fresh and Blended Beverage Milk ($/gallon)	0.0	0.0	0.0	0.0	0.0	0.0
Operating Life of New Physical Capital (years)	15	15	15	15	15	15
Discount Rate (nominal)	14%	14%	14%	14%	14%	14%
No. of Plant Operating Days per Year	312	312	312	312	312	312
Marginal Tax Rate	52.5%	52.5%	52.5%	52.5%	52.5%	52.5%

[a] Raw milk, nfdm and condense prices are for March 1981 and are from the Agricultural Marketing Service, USDA. Factor prices are from JAI Engineers.

milk is used and blended milk is standardized to 8.25 percent SNF. The selected cases should provide a sufficient measure and flavor of the likely comparative costs of reconstituting milk in the various locations. Other cases will be referred to selectively to illustrate a point when necessary.

Selected Results for Six Cities

Total comparative (after-taxes) costs are reported in Table 6 for the 12 cases that are examined under the prices assumed for the six test locations. (Before-tax costs are reported in Appendix B.) These 12 cases result in a range of comparative costs from -3.8 ¢/gal. in Boston (Case 27) (the lowest cost is actually -4.9 ¢/gal. for Case 31) to 4.0 ¢/gal. in Chicago (Case 17). (The reader is reminded that these 12 cases all assume that reconstituted milk is <u>not</u> priced in Class I. Comparative costs are always positive and always <u>higher</u> for otherwise comparable cases when current pricing provisions are in effect.) Prices in Boston, Jacksonville and New York result in a cost savings that can be attributed to reconstituted milk. Chicago prices result in a (positive) cost due to reconstitution in almost all cases (the comparative costs for cases 30 and 32 are -.7 and -.8, respectively), and Dallas and Knoxville prices lead to mixed results. Thus, there would seem to be clear economic incentives for fluid milk processors in Boston, Jacksonville, and New York to replace part of their fresh beverage milk volume with blended milk products. Processors in Dallas and Knoxville have similar incentives only if they can formulate their blend to a low solids level--8.25% SNF. Processors in Chicago have virtually no economic incentive to reconstitute milk.

At this point, a caveat is in order, these results are sensitive to the price levels chosen for the various cities; a different set of prices, especially the major dairy prices, could result in somewhat different results. The effect of choosing different prices is examined later in this chapter.

The comparative costs of reconstituting milk are always higher in the cases in which:

1. plant size equals 30,000 gallons of beverage milk per day (e.g., compare cases 17 and 19),

2. blended milk contains 8.7% SNF (e.g., compare cases 17 and 25), or

3. current Federal Order pricing provisions prevail, (e.g., compare cases 1 and 17, see footnote a) <u>ceteris paribus</u>.

The comparative costs of reconstituting milk is usually higher in the cases in which blended milk volume is 10 percent of plant size, <u>ceteris paribus</u> (viz. Cases 21 and 22). In some instances the reverse is true. There appears to be two reasons for this. One, comparative capital costs are zero in plants that use nonfat dry and produce 10 percent

Table 6. Total Comparative Costs of Reconstituting Milk, After Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Cost by Location						
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston[e]	Chicago[e]	Dallas[e]	Jacksonville[e]	Knoxville[e]	New York[e]	New York[f]
17	30,000	10%	nfdm	8.7%	-1.5	4.0	0.6	-1.3	1.5	0.1	9.2
18	30,000	50%	nfdm	8.7%	-1.5	2.2	0.0	-1.2	0.6	-0.6	5.5
19	100,000	10%	nfdm	8.7%	-1.9	3.6	0.2	-1.6	1.1	-0.5	8.6
20	100,000	50%	nfdm	8.7%	-1.6	2.1	-0.1	-1.3	0.5	-0.7	5.3
21	30,000	10%	condense	8.7%	-2.4	2.6	1.7	0.2	1.4	-1.2	7.9
22	30,000	50%	condense	8.7%	-2.3	1.0	0.6	-0.4	0.3	-1.7	4.3
23	100,000	10%	condense	8.7%	-3.1	1.8	1.1	-0.4	0.7	-2.2	6.9
24	100,000	50%	condense	8.7%	-2.4	0.9	0.5	-0.6	0.1	-1.9	4.1
25	30,000	10%	nfdm	8.25%	-3.3	2.2	-1.3	-3.1	-0.4	-1.7	7.4
26	30,000	50%	nfdm	8.25%	-3.3	0.4	-1.8	-3.0	-1.3	-2.4	3.6
27	100,000	10%	nfdm	8.25%	-3.8	1.8	-1.6	-3.5	-0.7	-2.3	6.8
28	100,000	50%	nfdm	8.25%	-3.4	0.3	-1.9	-3.1	-1.4	-2.6	3.5

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

[f] These are Cases 1 through 12, which are identical to Cases 17 through 28 except they assume that reconstituted milk is priced in Class I according to current Federal Order pricing provisions.

blended milk. In some situations, that is sufficient to make total comparative costs lower in the 10 percent plant than in the otherwise comparable 50 percent plant (viz., Cases 17 and 18 in Jacksonville or 21 and 22 in Boston). The second reason is based on differences in processing costs, in particular the prices of electricity between cities and the amounts of electricity needed in 10 percent plants versus comparable 50 percent plants. Electricity rates in Boston, Jacksonville, and New York are about twice those in Chicago, Dallas, and Knoxville. This and the fact that electrical usage increases sharply (compared to blended milk volume) between plants that blend 10 percent of their volume and those that blend 50 percent means that in some instances high electricity costs in 50 percent plants will offset the other cost advantages of the 50 percent plant, such that the 50 percent plant has a higher comparative cost per unit of blended milk than does a comparable 10 percent plant (viz., Cases 23 and 24 in New York, Cases 27 and 28 in Boston, and Cases 19 and 20 in Jacksonville). This is most often true in comparing the larger plants; because electricity usage increases especially sharply in large, 50 percent plants due to equipment purchases.

In all cities except Dallas and Jacksonville, the comparative costs of reconstituting milk are higher when nonfat dry milk is used to make reconstituted skim milk. This is due to the regional difference between the price of nonfat dry milk relative to the price of condensed skim milk.

Processing Costs

Comparative processing costs refer to the comparative costs associated with changes in the use of labor, electricity, and heat. Specifically, they are derived from term 5.6 (or 6.6) in Chapter II.

The comparative processing costs based on prices in the six test markets are shown in Table 7 for Cases 17 through 24. This represents the total range of comparative processing costs because these costs vary only with plant size, blended milk volume, and raw ingredient used (nfdm or condense). Ranging from 0.1 to 1.9 cents per gallon, processing costs do not vary a great deal across the six test markets even though labor costs differ across regions from $7.02 to $16.50 per hour and electricity rates range from 3.32 to 9.0 cents per kilowatt hour. (Heat costs are held constant at $1.86/ MBH.)

Capital Costs

Comparative capital costs refer to the comparative costs associated with additional investments in plant and equipment. Specifically, they refer to term 5.7 (or 6.7) in Chapter II.

Since the economic assumptions about the operating life of capital goods, number of operating days, and the discount rate are held constant; comparative capital costs do not vary across the six test markets. These

Table 7. Comparative Processing Costs of Reconstituting Milk, After Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Cost by Location					
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston[e]	Chicago[e]	Dallas[e]	Jacksonville[e]	Knoxville[e]	New York[e]
17	30,000	10%	nfdm	8.7%	1.4	1.4	1.1	1.1	1.2	1.9
18	30,000	50%	nfdm	8.7%	0.4	0.3	0.3	0.3	0.3	0.5
19	100,000	10%	nfdm	8.7%	0.9	1.0	0.8	0.8	0.8	1.3
20	100,000	50%	nfdm	8.7%	0.3	0.2	0.2	0.2	0.2	0.3
21	30,000	10%	condense	8.7%	1.4	1.4	1.2	1.2	1.3	1.9
22	30,000	50%	condense	8.7%	0.3	0.3	0.2	0.3	0.3	0.4
23	100,000	10%	condense	8.7%	0.2	0.8	0.7	0.7	0.7	1.1
24	100,000	50%	condense	8.7%	0.2	0.2	0.1	0.2	0.2	0.2

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

costs do vary with plant size, blended milk volume, and raw ingredient (nfdm or condense), as is shown in Table 8. Comparative capital costs are a relatively small component of total comparative costs, ranging from 0.0 to 0.2 cents per gallon.

Raw Ingredients and Milk Costs

Comparative raw ingredients and milk costs refer to that portion of total comparative costs which can be attributed to expenditures for nonfat dry milk, condensed skim milk, water, and raw milk. Calculated as the sum of 5.3, 5.4, and 5.5 (or 6.3, 6.4, and 6.5) in Chapter II, these costs are given in Table 9 and range from -37.1 to -20.1 cents per gallon. Comparative raw ingredients costs do not vary, on a per unit basis, with plant size; hence the results reported for 30,000 gallon plants apply to otherwise similar 100,000 gallon plants.

Since a partially reconstituted milk plant will invariably use less raw milk than a comparable totally fresh milk plant, the raw milk component of the comparative raw ingredients cost is always negative, i.e., there is a cost savings on raw milk. In fact, comparative raw ingredient costs are negative in all of the test cases, implying that the cost of the nfdm or condense and water is less than the cost of the raw milk displaced by reconstituted skim milk.[6] As the only component of total comparative cost that is negative, comparative raw ingredients costs are clearly responsible when total comparative costs are negative, i.e., when it is cheaper to partially reconstitute beverage milk than to bottle totally fresh beverage milk.

Revenue Losses

Comparative revenue losses refer to the portion of total comparative costs that results from 1) lost light cream sales and 2) differences in the values of fresh and blended milk products, as derived from the sum of 5.1 and 5.2 (or 6.1 and 6.2) from Chapter II. In all of the six test markets, the wholesale prices of fresh and blended milk products are assumed equal; hence that component of the comparative revenue loss term (5.1) drops out. Although it has been argued that the prices of reconstituted (or blended) milk products would be less than the prices of similar fresh milk products, there is very little evidence on which to base a specific estimate of price impacts. Differences between wholesale prices will depend on the consumer demand for blended milk, the retail

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6/This is not to say that the cost of the raw ingredients in a given volume of reconstituted skim milk is always more than the price of an equal volume of fresh skim milk. In fact, it is easily shown that the opposite is true in those areas which have relatively lower Class I prices, such as Chicago. The cost figure reported in this report sums the cost of raw ingredients used to reconstitute skim milk and the savings on displaced raw (whole) milk, including the cream that accompanies the fresh skim milk component of the whole milk.

Table 8. Comparative Capital Costs of Reconstituting Milk, After Taxes, (cents per gallon of blended milk).

Case No. and Characteristics					
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Cost in All Locations
17	30,000	10%	nfdm	8.7%	0.0
18	30,000	50%	nfdm	8.7%	0.1
19	100,000	10%	nfdm	8.7%	0.0
20	100,000	50%	nfdm	8.7%	0.1
21	30,000	10%	condense	8.7%	0.2
22	30,000	50%	condense	8.7%	0.2
23	100,000	10%	condense	8.7%	0.1
24	100,000	50%	condense	8.7%	0.1

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

Table 9. Comparative Raw Ingredients and Milk Costs of Reconstituting Milk, After Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Costs by Location					
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston	Chicago	Dallas	Jacksonville	Knoxville	New York
17	30,000	10%	nfdm	8.7%	-35.3	-30.0	-33.2	-35.0	-32.4	-34.2
18	30,000	50%	nfdm	8.7%	-23.6	-20.1	-22.2	-23.4	-21.6	-22.9
21	30,000	10%	condense	8.7%	-36.5	-31.7	-32.3	-33.8	-32.8	-35.9
22	30,000	50%	condense	8.7%	-24.3	-21.2	-21.6	-22.6	-21.9	-23.9
25	30,000	10%	nfdm	8.25%	-37.1	-31.8	-35.0	-36.8	-34.2	-36.1
26	30,000	50%	nfdm	8.25%	-25.4	-21.9	-24.0	-25.2	-23.5	-24.7

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

margins and pricing strategies that milk retailers would choose or be able to obtain, and the pricing strategy that wholesalers would choose or be able to follow, as well as the comparative cost of producing blended milk products. One could only speculate on what difference between prices might exist. At this point, we choose to avoid such speculation; however, a measure of the possible differences between wholesale prices of fresh and blended milk products will be discussed in the next section of Chapter III and again in the concluding chapter.

Because wholesale prices of blended milk products are assumed equal to wholesale prices of fresh products, the only difference in revenues between totally fresh plants and partially reconstituted plants results from differences in sales of surplus light cream. The quantity of excess light cream available for sale in a plant varies only with blended milk volume. In addition, it is assumed that the value of excess light cream is based on the Class II price and Class II prices are equal in Chicago, Dallas, and Knoxville; therefore, comparative revenue losses are the same in these three cities. Examples of the two levels of lost cream sales and the associated revenue losses in the four test markets having unique Class II prices are given in Table 10.

Although Class II prices range from $12.62 to $12.90, the difference in comparative revenue losses between cities is barely significant. By virtue of the pricing scheme, comparative revenue losses will be slightly higher in those Federal Order areas regulated under a three-class system, in which the Class II price is somewhat higher than the basic formula price.

Sensitivity Analyses

The sensitivity of the results to the assumptions about the operating and economic environment is explored in this section. These assumptions refer to plant size, relative blended milk volume, the raw ingredient used to make reconstituted skim milk, the solids-not-fat standard, and Federal Milk Marketing Order pricing provisions pertaining to reconstituted milk; they also include economic factors such as the prices of labor, electricity, raw milk, etc., the operating life of added plant and equipment, and marginal tax rates.

To reduce the number of calculations, the sensitivity analyses are confined to the results based on New York prices. Results based on prices in other areas should behave comparably.

Plant Size

As indicated earlier, the larger plant size is always associated with lower comparative costs of reconstituting milk. As shown in Table 11, the difference in comparative costs between two cases in which all assumptions are identical except for plant size ranges from 0.2 to 1.0 cents per gallon of blended milk and averages 0.5 cents. Moreover,

Table 10. Comparative Revenue Losses from Reconstituted Milk, After Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Costs by Location			
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston	Chicago-Dallas-Knoxville	Jacksonville	New York
17	30,000	10%	nfdm	8.7%	32.4	32.6	32.6	32.5
21	30,000	10%	condense	8.7%	32.4	32.6	32.6	32.5
18	30,000	50%	nfdm	8.7%	21.6	21.8	21.7	21.7
28	100,000	50%	nfdm	8.25%	21.6	21.8	21.7	21.7

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

Table 11. The Impact of Plant Size on Comparative Total Costs, After Taxes (cents per gallon of blended milk).

Case[a]	Total Cost		
	30,000 gal.	100,000 gal.	Difference
	(a)	(b)	(b-a)
1 and 3	9.2	8.6	-0.6
2 and 4	5.5	5.3	-0.2
5 and 7	7.9	6.9	-1.0
6 and 8	4.3	4.1	-0.2
9 and 11	7.4	6.8	-0.6
10 and 12	3.6	3.5	-0.1
13 and 15	6.1	5.2	-1.0
14 and 16	2.6	2.4	-0.2
17 and 19	0.1	-0.5	-0.6
18 and 20	-0.6	-0.7	-0.1
21 and 23	-1.2	-2.2	-1.0
22 and 24	-1.7	-1.9	-0.1
25 and 27	-1.7	-2.3	-0.6
26 and 28	-2.4	-2.6	-0.2
29 and 31	-2.9	-3.9	-1.0
30 and 32	-3.5	-3.6	-0.2

[a] Each pair of test cases represent two sets of assumptions about the operating and economic environment that are identical with the exception that plant size in the first is 30,000 gallons per day and in the second it is 100,000 gallons per day; see Table 4 for a complete description of case characteristics.

the greatest difference occurs in the cases in which blended milk equals 10 percent of plant size and condensed skim milk is used to reconstitute milk. The smallest difference occurs in cases in which blended milk volume equals 50 percent of plant size.

Blended Milk Volume

As discussed earlier, plants having blended milk volume equal to 50 percent of plant size usually have lower comparative costs of reconstituting. As shown in Table 12, the difference in comparative costs due to different relative blended milk volumes between otherwise identical cases ranges from 0.2 to 3.8 cents per gallon of blended milk and averages 1.9 cents. The difference is always greater (by an average 3 cents per gallon of blended milk) in the cases in which current Federal Order provisions are assumed to prevail (compare 1 through 16 with 17 through 32 in Table 12). In addition, the difference between comparative costs is greater in the cases in which plant size equals 30,000 gallons of beverage milk per day, _ceteris paribus_ (compare 1 and 2 with 3 and 4 in Table 12), and the difference is slightly larger in the cases in which nonfat dry milk is used to reconstitute milk (compare 1 and 2 with 5 and 6 in Table 12).

Raw Ingredient Used to Reconstitute Milk

As indicated earlier, the relative prices assumed for nonfat dry milk and condensed skim milk lead to lower comparative costs when condense is used to reconstitute skim milk in all cities except Dallas and Jacksonville. Table 13 shows the difference in comparative costs between cases that are identical except for the raw ingredient used. The difference ranges from 0.9 to 1.6 cents per gallon of blended milk and averages 1.2 cents.

The difference is greater when blended milk contains 8.7 percent SNF, _ceteris paribus_. The smaller differences are associated with cases in which the volume of blended milk equals 50 percent of plant size, _ceteris paribus_. The larger difference occurs in those cases in which plant size equals 100,000 gallons of beverage milk per day and blended milk volume equals 10 percent of plant size. The difference does not vary with the assumption regarding Federal Order regulations.

Solids-Not-Fat Standard

As indicated above, less SNF in blended milk always implies lower comparative costs. Table 14 shows the difference in comparative costs between cases which are identical except for the SNF standard assumed. The savings resulting from lowering the SNF content of blended milk from 8.7 percent to 8.25 percent, _ceteris paribus_, is nearly constant across all otherwise comparable cases at 1.8 cents per gallon of blended milk.

Table 12. The Impact of Blended Milk Volume on Comparative Total Costs, After Taxes (cents per gallon of blended milk).

Case[a]	Total Cost 10%	50%	Difference
	(a)	(b)	(b-a)
1 and 2	9.2	5.5	-3.7
3 and 4	8.6	5.3	-3.3
5 and 6	7.9	4.3	-3.6
7 and 8	6.9	4.1	-2.8
9 and 10	7.4	3.6	-3.8
11 and 12	6.8	3.5	-3.3
13 and 14	6.1	2.6	-3.6
15 and 16	5.2	2.4	-2.8
17 and 18	0.1	-0.6	-0.7
19 and 20	-0.5	-0.7	-0.2
21 and 22	-1.2	-1.7	-0.6
23 and 24	-2.2	-1.9	0.3
25 and 26	-1.7	-2.4	-0.7
27 and 28	-2.3	-2.6	-0.3
29 and 30	-2.9	-3.5	-0.6
31 and 32	-3.9	-3.6	-0.2

[a] Each pair of test cases represents two sets of assumptions about the operating and economic environment that are identical with the exception that blended milk volume equals 10 percent of plant size in the first and 50 percent in the second; see Table 4 for a complete description of case characteristics.

Table 13. The Impact of Raw Ingredient on Comparative Total Costs, After Taxes (cents per gallon of blended milk).

Case[a]	Total Cost		
	Nfdm	Condense	Difference
	(a)	(b)	(b-a)
1 and 5	9.2	7.9	-1.2
2 and 6	5.5	4.3	-1.1
3 and 7	8.6	6.9	-1.6
4 and 8	5.3	4.1	-1.1
9 and 13	7.4	6.1	-1.1
10 and 14	3.6	2.6	-0.9
11 and 15	6.8	5.2	-1.5
12 and 16	3.5	2.4	-1.0
17 and 21	0.1	-1.2	-1.2
18 and 22	-0.6	-1.7	-1.1
19 and 23	-0.5	-2.2	-1.6
20 and 24	-0.7	-1.9	-1.1
25 and 29	-1.7	-2.9	-1.1
26 and 30	-2.4	-3.5	-1.0
27 and 31	-2.3	-3.9	-1.5
28 and 32	-2.6	-3.6	-1.0

[a] Each pair of test cases represents two sets of assumptions about the operating and economic environment that are identical with the exception that nonfat dry milk is the raw ingredient used in the first and condensed skim milk is used on the second; see Table 4 for a complete description of case characteristics.

Table 14. The Impact of the Solids-Not-Fat Standard on Comparative Total Costs, After Taxes (cents per gallon of blended milk).

Case[a]	Total Cost		
	8.7%	8.25%	Difference
	(a)	(b)	(b-a)
1 and 9	9.2	7.4	-1.8
2 and 10	5.5	3.6	-1.9
3 and 11	8.6	6.8	-1.8
4 and 12	5.3	3.5	-1.8
5 and 13	7.9	6.1	-1.7
6 and 14	4.3	2.6	-1.7
7 and 15	6.9	5.2	-1.7
8 and 16	4.1	2.4	-1.7
17 and 25	0.1	-1.7	-1.8
18 and 26	-0.6	-2.4	-1.8
19 and 27	-0.5	-2.3	-1.8
20 and 28	-0.7	-2.6	-1.9
21 and 29	-1.2	-2.9	-1.7
22 and 30	-1.7	-3.5	-1.7
23 and 31	-2.2	-3.9	-1.7
24 and 32	-1.9	-3.6	-1.8

[a] Each pair of test cases represents two sets of assumptions about the operating and economic environment that are identical with the exception that solids-not-fat in blended milk are standardized to 8.7 percent in the first and 8.25 percent in the second; see Table 4 for a complete description of case characteristics.

Federal Order Pricing Provisions

As indicated before, deregulation of reconstituted milk under Federal Orders always leads to a lower comparative cost of reconstituting milk, ceteris paribus. The difference in total comparative cost between cases that are identical except for the Federal Order pricing policy assumption is about 9.1 cents per gallon in cases in which blended milk is 10 percent of the beverage milk volume and about 6.1 cents per gallon when blended milk is 50 percent of the beverage milk volume as shown in Table 15. In other words, the savings (as measured by the comparative cost per gallon of blended milk) resulting from deregulation decreases as the relative volume of blended milk in a plant increases.[7]

The decrease in comparative costs that results from deregulation is especially significant because it may change the sign of the comparative cost. In other words, blended milk may cost less to produce than fresh milk (under some price assumptions) when Federal Order provisions regarding reconstituted milk are suspended or ignored, but blended milk always costs more than fresh milk under current price policies.

Economic Assumptions

In the section below, the impact of selectively varying the prices of labor, electricity, raw milk, and so forth on the comparative cost of reconstituting milk is discussed. To reduce the number of calculations, the results of these sensitivity analyses are reported only for four test cases, and, again, only New York prices are used. The four test cases (17, 20, 22, and 31) are selected because they represent high and low cost scenarios and, combined, they encompass all variations of the assumptions about the operating environment. Each economic assumption (price, etc.) is varied one at a time within a range that is selected because it more or less reflects the range of each economic variable associated with all six test markets. For example, the base price of labor ranges from a low of $7.02 per hour in Jacksonville to a high of $16.50 per hour in New York; in the sensitivity analysis below, comparative costs are calculated for labor prices ranging from $5 to $21 per hour.

7/If a linear relationship exists between relative blended milk volume and the difference between the comparative costs of reconstituted milk with regulation and without regulation, then this would imply that a plant with 100 percent blended milk would save 2.35 cents per gallon of blended milk when reconstituted milk is unregulated rather than regulated according to current policy. Such extrapolations should be interpreted very cautiously and, probably, avoided altogether; since it is not known whether the relationship between relative blended milk volume and the savings due to deregulation is linear or not.

Table 15. The Impact of Federal Order Pricing Provisions on Comparative Total Costs, After Taxes (cents per gallon of blended milk).

Case[a]	Total Cost		
	Regulated	Unregulated	Difference
	(a)	(b)	(b-a)
1 and 17	9.2	0.1	-9.1
2 and 18	5.5	-0.6	-6.1
3 and 19	8.6	-0.5	-9.1
4 and 20	5.3	-0.7	-6.0
5 and 21	7.9	-1.2	-9.1
6 and 22	4.3	-1.7	-6.1
7 and 23	6.9	-2.2	-9.1
8 and 24	4.1	-1.9	-6.1
9 and 25	7.4	-1.7	-9.1
10 and 26	3.6	-2.4	-6.0
11 and 27	6.8	-2.3	-9.1
12 and 28	3.5	-2.6	-6.1
13 and 29	6.1	-2.9	-9.1
14 and 30	2.6	-3.5	-6.1
15 and 31	5.2	-3.9	-9.1
16 and 32	2.4	-3.6	-6.1

[a] Each pair of test cases represents two sets of assumptions about the operating and economic environment that are identical with the exception that current Federal Order pricing provisions are assumed to prevail in the first and reconstituted milk is assumed to be unregulated in the second; see Table 4 for a complete description of case characteristics.

Price of Labor

The sensitivity of comparative processing and total costs to changes in the price of labor is illustrated in Table 16. Whereas the price of labor is allowed to more than quadruple from its low of $5 per hour to its high of $21 per hour, processing costs double in response to this change in the labor price. Processing costs and total comparative costs of reconstituting milk increase between .01 and .08 cents per gallon of blended milk for every $1 per hour increase in the price of labor.

Price of Heat

The price of heat is a hybrid variable intended to reflect the cost of all heat, no matter how it is generated. The price of heat is assumed to be the same in all cities because there is little reason to believe otherwise.[8/] Table 17 illustrates that rather large changes in the price of heat do not greatly affect comparative costs. Doubling the price of heat from $1.20 to $2.40 per MBH increases processing costs by no more than .02 cents per gallon of blended milk, and a 50 cent increase in the price per MBH adds less than 0.1 cents to the comparative cost of reconstituting milk.

Price of Electricity

The price of electricity in the test cities is assumed lowest in Chicago at 3.32 cents per KWH and highest in New York at 9.0 cents per KWH. The sensitivity of costs to electricity prices ranging from 3 to 11 cents per KWH is shown in Table 18. Nearly quadrupling the price of electricity (an 8 cent increase) results in barely perceptible changes in comparative processing and total costs. A one cent per KWH increase in the price of electricity results in at most a .03 cent per gallon of blended milk increase in the comparative cost of reconstituting milk.

Price of Water

Like the price of heat, the price of water is not assumed to vary across the test cities. As shown in Table 19, significant changes in the price of water do not substantially affect the comparative cost of reconstituting milk. A 10 cent increase in the price of a gallon of water results in less than a .05 cent per gallon of blended milk increase in the comparative cost of reconstituting milk.

Price of Nonfat Dry Milk

The price of nonfat dry milk is assumed to range from a low of 94.75 cents per pound in Chicago to a high of 96.73 cents per pound in Dallas,

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8/ Based on information from JAI Engineers.

Table 16. The Sensitivity of Comparative Processing and Total Costs, After Taxes, to Changes in the Price of Labor (cents per gallon of blended milk).

Case No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Price of Labor ($/hr.) 5	9	13	17	21	Change Per $1 Price Increase
Processing										
17	30,000	10%	nfdm	8.7%	1.0	1.3	1.6	1.9	2.2	.08
20	100,000	50%	nfdm	8.7%	0.2	0.3	0.3	0.4	0.4	.01
22	30,000	50%	condense	8.7%	0.2	0.3	0.3	0.4	0.4	.01
31	100,000	10%	condense	8.25%	0.7	0.8	0.9	1.1	1.2	.04
Total										
17	30,000	10%	nfdm	8.7%	-0.8	-0.5	-0.2	0.2	0.5	.08
20	100,000	50%	nfdm	8.7%	-0.9	-0.8	-0.8	-0.7	-0.7	.01
22	30,000	50%	condense	8.7%	-1.8	-1.7	-1.7	-1.7	-1.6	.01
31	100,000	10%	condense	8.25%	-4.3	-4.2	-4.0	-3.9	-3.8	.04

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 17. The Sensitivity of Comparative Processing and Total Costs, After Taxes, to Changes in the Price of Heat (cents per gallon of blended milk).

Case No. and Characteristics					Price of Heat ($/MBH)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	1.20	1.50	1.80	2.10	2.40	Change Per $.50 Price Increase
Processing										
17	30,000	10%	nfdm	8.7%	1.8	1.8	1.9	1.9	2.0	.08
20	100,000	50%	nfdm	8.7%	0.3	0.3	0.3	0.4	0.4	.02
22	30,000	50%	condense	8.7%	0.3	0.3	0.4	0.4	0.4	.02
31	100,000	10%	condense	8.25%	0.9	1.0	1.0	1.1	1.1	.08
Total										
17	30,000	10%	nfdm	8.7%	-0.0	0.0	0.1	0.2	0.2	.08
20	100,000	50%	nfdm	8.7%	-0.8	-0.8	-0.8	-0.7	-0.7	.02
22	30,000	50%	condense	8.7%	-1.7	-1.7	-1.7	-1.6	-1.6	.02
31	100,000	10%	condense	8.25%	-4.0	-4.0	-3.9	-3.9	-3.8	.08

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 18. The Sensitivity of Comparative Processing and Total Costs, After Taxes, to Changes in the Price of Electricity (cents per gallon of blended milk).

	Case No. and Characteristics				Price of Electricity (¢/KWH)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	3	5	7	9	11	Change Per 1¢ Price Increase
Processing										
17	30,000	10%	nfdm	8.7%	1.7	1.7	1.8	1.9	1.9	.03
20	100,000	50%	nfdm	8.7%	0.3	0.3	0.3	0.3	0.4	.015
22	30,000	50%	condense	8.7%	0.3	0.3	0.4	0.4	0.4	.01
31	100,000	10%	condense	8.25%	0.9	1.0	1.0	1.1	1.1	.02
Total										
17	30,000	10%	nfdm	8.7%	-0.1	-0.0	-0.0	0.1	0.2	.03
20	100,000	50%	nfdm	8.7%	-0.8	-0.8	-0.8	-0.7	-0.7	.015
22	30,000	50%	condense	8.7%	-1.7	-1.7	-1.7	-1.7	-1.8	.01
31	100,000	10%	condense	8.25%	-4.0	-4.0	-4.0	-3.9	-3.9	.02

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 19. The Sensitivity of Comparative Raw Ingredients and Total Costs, After Taxes, to Changes in the Price of Water (cents per gallon of blended milk).

Case No. and Characteristics					Price of Water (¢/gal.)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	.30	.35	.40	.45	.50	Change Per 0.1¢ Price Increase
Raw Ingredients										
17	30,000	10%	nfdm	8.7%	-34.3	-34.3	-34.2	-34.2	-34.2	.04
20	100,000	50%	nfdm	8.7%	-22.9	-22.9	-22.0	-22.9	-22.8	.02
22	30,000	50%	condense	8.7%	-23.9	-23.9	-23.9	-23.9	-23.8	.02
31	100,000	10%	condense	8.25%	-37.6	-37.6	-37.6	-37.5	-37.5	.04
Total										
17	30,000	10%	nfdm	8.7%	0.1	0.1	0.1	0.1	0.2	.04
20	100,000	50%	nfdm	8.7%	0.8	0.8	0.7	0.7	0.7	.02
22	30,000	50%	condense	8.7%	-1.7	-1.7	-1.7	-1.6	-1.6	.02
31	100,000	10%	condense	8.25%	-4.0	-3.9	-3.9	-3.9	-3.9	.04

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Jacksonville, and Knoxville. As shown in Table 20, realistic changes in the price of nonfat dry milk result in a measurable and relevant difference in comparative costs. An increase in the nfdm price of 5 cents per pound leads to an increase in comparative costs of 1 to 2 cents per gallon of blended milk.

Price of Condensed Skim Milk

The price of condensed skim milk (32% solids) is assumed to be highest in Jacksonville at $1.03 per pound of wet solids and lowest in Chicago at $0.92 per pound of wet solids. In the cases shown in Table 21, such differences in the price of condense lead to significant changes in the comparative cost of reconstituting milk. Increasing the price of condense by 5 cents per pound of wet solids will increase comparative costs by 3 to 5 cents per gallon of blended milk.

Price of Class I Milk

Class I prices are highest in Boston at $15.56 per cwt. and are lowest in Chicago at $13.90 per cwt. Table 22 illustrates the effect of changes in the Class I price within that range on comparative costs, ceteris paribus. A 50 cent increase in the Class I price decreases the comparative cost of reconstituting milk by 1 to 2 cents per gallon of blended milk.

The essence of previous recent studies of reconstituted milk has been to estimate the drop in Class I prices that is hypothesized to occur when reconstituted milk is deregulated (1,3). It is not the purpose of this study to make such estimates; however, it is possible to determine the Class I price that would equalize the cost of blended milk with the cost of fresh milk for any city and case defined in this study. Although a thorough analysis of this question has not been completed, preliminary results are illustrated in Table 23. The cases listed by each city in this table are the cases which resulted in the lowest comparative cost of reconstitution; the prices that are listed use the prices that tend to equalize costs of reconstituting and blending. (Prices were not calculated in fractions of cents so the price reported is the one which results in the positive cost closest to zero.) The maximum reduction in Class I prices required to eliminate any possible cost savings due to reconstitution range from $0.35 per cwt. in Chicago to $1.37 per cwt. in Boston.

Price of Class II Milk

Class II prices vary within a rather narrow band from a high of $12.90 in the three-class markets, i.e., Chicago, Dallas, and Knoxville, to a low of $12.62 in Boston. Given that it has been assumed that the value of excess light cream is directly related to the Class II price,

Table 20. The Sensitivity of Comparative Raw Ingredients and Total Costs, After Taxes, to Changes in the Price of Nonfat Dry Milk (cents per gallon of blended milk).

Case No. and Characteristics					Price of Nonfat Dry Milk (¢/lb.)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	92.5	95.0	97.5	100.0	102.5	Change Per 5¢ Price Increase
Raw Ingredients										
17	30,000	10%	nfdm	8.7%	-35.4	-34.6	-33.8	-33.0	-32.2	1.6
20	100,000	50%	nfdm	8.7%	-23.7	-23.1	-22.6	-22.0	-21.5	1.1
Total										
17	30,000	10%	nfdm	8.7%	- 0.1	- 0.3	0.6	1.4	2.2	1.6
20	100,000	50%	nfdm	8.7%	- 1.5	- 1.0	- 0.4	0.1	0.7	1.1

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 21. The Sensitivity of Comparative Raw Ingredients and Total Costs, After Taxes, to Changes in the Price of Condensed Skim Milk (cents per gallon of blended milk).

Case No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Price of Condensed Skim Milk (¢/lb.SNF) 90	94	98	102	106	Change Per 5¢ Price Increase
Raw Ingredients										
22	30,000	50%	condense	8.7%	-24.7	-22.1	-19.4	-16.8	-14.1	3.3
31	100,000	10%	condense	8.7%	-38.8	-35.0	-31.3	-27.5	-23.8	4.8
Total										
22	30,000	50%	condense	8.7%	- 2.5	0.2	2.8	5.5	8.1	3.3
31	100,000	10%	condense	8.7%	- 5.1	- 1.4	2.6	6.1	10.1	4.8

a Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

b The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

c Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

d Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 22. The Sensitivity of Comparative Raw Ingredients and Total Costs, After Taxes, to Changes in the Price of Class I Milk (cents per gallon of blended milk).

Case No. and Characteristics					Price of Class I Milk ($/cwt.)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	14.00	14.50	15.00	15.50	16.00	Change Per $.50 Price Increase
Raw Ingredients										
17	30,000	10%	nfdm	8.7%	-29.8	-31.6	-33.4	-35.1	-36.9	-1.8
20	100,000	50%	nfdm	8.7%	-19.9	-21.1	-22.3	-23.5	-24.7	-1.2
22	30,000	50%	condense	8.7%	-20.9	-22.1	-23.3	-24.5	-25.6	-1.2
31	100,000	10%	condense	8.25%	-33.1	-34.9	-36.7	-38.5	-40.2	-1.8
Total										
17	30,000	10%	nfdm	8.7%	4.6	2.8	1.0	- 0.8	- 2.6	-1.8
20	100,000	50%	nfdm	8.7%	2.2	1.0	- 0.2	- 1.3	- 2.5	-1.2
22	30,000	50%	condense	8.7%	1.3	0.1	- 1.1	- 2.3	- 3.4	-1.2
31	100,000	10%	condense	8.25%	0.7	- 1.2	- 3.0	- 4.8	- 6.6	-1.8

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 23. Changes in Class I Prices Required to Eliminate All Possible Cost Savings Associated with Reconstituted Milk, Based on Comparative Costs, after Taxes, in Six Cities.

City/Case	Current Class I Price	Current Cost	Breakeven Class I Price	Comparative Cost	Class I Price Reduction
	($/cwt.)	(¢/gal. blended milk)	($/cwt.)	(¢/gal. blended milk)	($/cwt.)
Boston/31	15.56	-4.9	14.19	0.02	1.37
Chicago/32	13.90	-0.8	13.55	0.01	0.35
Dallas/28	14.96	-1.9	14.16	0.01	0.80
Jacksonville/27	15.49	-3.5	14.51	0.03	0.98
Knoxville/32	14.74	-1.7	14.04	0.00	0.70
New York/31	15.25	-3.9	14.14	0.02	1.11

changes in the price of Class II milk affect the raw ingredients and revenue loss components of the total comparative cost with equal but opposite effect, as shown in Table 24.[9] Thus, changes in the Class II price, ceteris paribus, do not affect the comparative cost of reconstituting milk.

Dairy Prices from Different Time Periods

Farm prices for raw milk, i.e., Class I, II, and III prices, have historically exhibited different seasonal patterns of increase than have wholesale prices of nonfat dry milk or condensed skim milk. In recent years, raw milk prices have tended to increase gradually through the year, whereas nonfat dry milk prices tended to hold fairly steady prior to adjustments in the CCC purchase price and then jump to the level of the CCC purchase price in April and October. Prices of condensed skim milk tend to follow the price of nonfat dry milk. Since raw milk prices enter the comparative cost equation as a source of cost reduction and nonfat dry milk and condense prices enter the equation as a source of cost additions, the relative difference between raw milk prices and nonfat dry milk or condense prices can affect the magnitude of the comparative cost of reconstitution. Since this relative price difference can vary seasonally, one should examine prices from several time periods.

The prices for Class I, II, and III milk, nonfat dry milk and condensed skim milk used for the various cities are the reported prices for March 1981. At the time data were being assembled, these were the most recent available prices. To get some measure of the sensitivity of the results to the choice of time period for which prices are collected, dairy price data for New York were also assembled for October 1980 and the average of all months in 1980. October represents a month in which nonfat dry milk and condensed skim milk prices would be expected to be relatively close to raw milk prices, whereas these prices would be relatively farther apart in March. At this time, a thorough analysis of prices in other months, years, or market areas has not been completed, but the preliminary results are given below.

The comparative cost of reconstituting milk is calculated for these alternative New York dairy prices for four cases reported in Table 25. Representing high and low cost cases, the cases shown should illustrate the general impact of choosing prices from different time periods.

As shown in Table 25, there are significant differences in the comparative costs of reconstitution based on dairy prices from these three time periods. Case 17 has the highest comparative cost, based on New York prices; even with the original March 1981 prices, the comparative cost of reconstitution for case 17 was slightly positive. With October

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[9] For the cases shown, changes in the Class II price impact only on the cost of raw milk sold as light cream and the imputed value of excess light cream. This is true and appropriate whether the market area uses a two- or three-class system; since, as it is used here, excess light cream is a Class II use in either situation.

Table 24. The Sensitivity of Comparative Raw Ingredients, Revenue Loss and Total Costs, After Taxes, to Changes in the Price of Class II Milk (cents per gallon of blended milk).

Case No. and Characteristics					Price of Class II Milk ($/cwt.)					
	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	12.50	12.75	13.00	13.25	13.50	Change Per $.50 Price Increase
Raw Ingredients										
17	30,000	10%	nfdm	8.7%	-34.1	-34.3	-34.5	-34.7	-34.9	-0.4
20	100,000	50%	nfdm	8.7%	-22.8	-22.9	-23.0	-23.1	-23.3	-0.2
22	30,000	50%	condense	8.7%	-23.8	-23.9	-24.0	-24.2	-24.3	-0.2
31	100,000	10%	condense	8.25%	-37.4	-37.6	-37.8	-38.0	-38.2	-0.4
Revenue Loss										
17	30,000	10%	nfdm	8.7%	32.3	32.5	32.7	32.9	33.1	0.4
20	100,000	50%	nfdm	8.7%	21.6	21.7	21.8	22.0	22.1	0.2
22	30,000	50%	condense	8.7%	21.6	21.7	21.8	22.0	22.1	0.2
31	100,000	10%	condense	8.25%	32.3	32.5	32.7	32.9	33.1	0.4
Total										
17	30,000	10%	nfdm	8.7%	0.1	0.1	0.1	0.1	0.1	0
20	100,000	50%	nfdm	8.7%	-0.7	-0.7	-0.7	-0.7	-0.7	0
22	30,000	50%	condense	8.7%	-1.7	-1.7	-1.7	-1.7	-1.7	0
31	100,000	10%	condense	8.25%	-3.9	-3.9	-3.9	-3.9	-3.9	0

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 25. The Comparative Costs of Reconstituting Milk, After Taxes, Based on Dairy Prices for Three Time Periods.

	October 1980	Annual Average 1980	March 1981
Prices:			
Class I ($/cwt.)	14.47	14.28	15.25
Class II ($/cwt.)	12.56	11.96	12.70
Nonfat Dry Milk (¢/lb.)	96.63	91.46	96.1
Condensed Skim Milk (¢/lb. of wet solids)	93.64	89.86	93.6
Comparative Cost of Reconstitution, for Cases:[a]			
17	3.1	2.1	0.1
23	0.6	0.1	-2.2
25	1.2	0.3	-1.7
31	-1.1	-1.6	-3.8

[a] See Table 4 for a detailed description of the characteristics of these cases.

or annual average 1980 prices, there is no doubt that it is more expensive to reconstitute milk in New York under the conditions of case 17. At the other end of the spectrum, case 31, the lowest cost case, results in a cost savings attributable to reconstitution under all three price sets. Case 23 results in the lowest comparative cost among all cases in which 1) reconstituted milk is unregulated and 2) the SNF standard is held at 8.7 percent, based on March 1981 prices in New York. There is no cost savings for these types of cases when October or annual average 1980 prices are used (cases 17 and 23 represent the high and low costs among these types of cases). Moreover, not all of the cases in which the SNF standard is reduced to 8.25 percent exhibit comparative cost savings when the other dairy prices are used. Cases 25 and 31 represent the high and low cost cases which assume 1) reconstituted milk is unregulated and 2) the SNF standard is reduced to 8.25 percent. Both cases result in comparative cost savings when March prices are used, but the cost advantage of reconstituted milk is eliminated for case 25 (and presumably a few others) when October and annual average 1980 prices are used.

To summarize, the results with March 1981 prices for New York indicated that it was cheaper to reconstitute milk than to process fresh milk under virtually all of the test case configurations; however, when prices from other time periods are chosen, the cost advantage of reconstituted milk is eliminated for all cases in which SNF standards are maintained at 8.7 percent and even some of the cases in which the SNF standard is reduced to 8.25 percent.

If the prices of nonfat dry milk and condensed skim milk exhibit the same seasonal relationship to milk prices in the other cities as they do in New York, as one would expect, one would hypothesize that there would be no cost advantage to reconstitution in Dallas and Knoxville when October and annual average 1980 prices are used, and the cost advantage in Boston and Jacksonville is reduced and probably eliminated in many, if not most, cases.[10/]

Wholesale Price of Beverage Milk Products

As term 5.1 (or 6.1) of the comparative cost equation in Chapter II states, the level of wholesale beverage milk prices does not affect costs but the difference, if any, between the wholesale prices for fresh and blended milk products can. In all previous test cases, wholesale prices of fresh and blended milk products are assumed equal, such that their difference is zero. In Table 26, the impact of the wholesale price of blended milk products being less than the price of fresh milk products is illustrated. A 5-cent per gallon difference between these wholesale

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[10/]The difference between comparative cost in New York and Boston, based on March prices is about one cent, but the difference between comparative costs in New York based on March 1981 and October 1980 prices is almost three cents.

Table 26. The Sensitivity of Comparative Revenue Loss and Total Costs, After Taxes, to Changes in the Difference Between the Wholesale Prices for Fresh and Blended Beverage Milk Products (cents per gallon of blended milk).

Case No. and Characteristics					Difference Between Fresh and Blended Milk Prices (¢/gal.)					Change Per 5¢ Increase in Difference
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	0	5	10	15	20	
Revenue Loss										
17	30,000	10%	nfdm	8.7%	32.5	42.0	44.4	46.7	49.1	2.4
20	100,000	50%	nfdm	8.7%	21.7	24.1	26.4	28.8	31.2	2.4
22	30,000	50%	condense	8.7%	21.7	24.1	26.4	28.8	31.2	2.4
31	100,000	10%	condense	8.25%	32.5	34.9	37.2	39.6	42.0	2.4
Total										
17	30,000	10%	nfdm	8.7%	0.1	9.6	12.0	14.4	16.7	2.4
20	100,000	50%	nfdm	8.7%	-0.7	1.6	4.0	6.4	8.8	2.4
22	30,000	50%	condense	8.7%	-1.7	0.7	3.1	5.5	7.9	2.4
31	100,000	10%	condense	8.25%	-3.8	-1.4	0.9	3.3	5.7	2.4

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

prices results in a 2.4-cent per gallon of blended milk increase in the comparative cost of reconstituting milk.11/

For any given set of assumptions, one can estimate how much the wholesale price of blended milk has to drop relative to the price of fresh milk until any comparative cost advantage to reconstitution is eliminated. A thorough analysis of this question has not been completed, but some preliminary results are reported in Table 27. This table reports the reduction in the wholesale price of blended milk relative to the fresh milk price that would equalize the costs of blending milk and processing fresh milk in the case that results in the greatest comparative cost savings in each of the six test cities. Insofar as Table 25 and the preceding discussion indicates that March 1981 dairy prices, upon which the results shown in Table 27 are based, seem to result in relatively low comparative costs of reconstitution, the price reductions shown in Table 27 may approach the maximum price reduction that would be required to eliminate any possible advantage to reconstituting milk in each city. (Prices were not calculated in fractions of cents so the price reported is the one which results in the positive cost closest to zero.) The results indicate that if the wholesale price of blended milk is as little as two cents per gallon less than the wholesale price of fresh milk in Chicago, as much as 11 cents per gallon less than the fresh milk price in Boston, there would be no incentive to produce blended milk products in these locations, regardless of plant structure and so on, at least within the range of our assumptions.

Prices of Capital Goods

The total, initial purchase prices of added plant and equipment needed under various plant conditions range from $20,500 to $169,000 (see Table 2). To measure the sensitivity of comparative capital and total costs to changes in the purchase price of capital goods, several cases representing low and high capital cost cases were run using capital prices ten percent higher than the values used in the base cases. The impact of a ten percent increase in these prices is barely noticeable. A ten percent increase in the cases involving the highest initial capital investments (e.g., 20, 24, 28, and 32) resulted in an increase in comparative capital costs and total costs of .01 cents per gallon of blended milk.

Operating Life of New Physical Capital

The operating life of new plant and equipment does not vary by location and is assumed equal to 15 years in the test cases. There is

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11/As can be readily seen from term 5.1 (or 6.1), the before-tax comparative cost per gallon of blended milk changes by the same absolute level as the difference between the wholesale prices. Thus the difference between the wholesale price of fresh and blended milk products has a direct and marked influence on the comparative cost of reconstituting milk.

Table 27. Reductions in the Wholesale Price of Blended Milk Required to Eliminate All Possible Cost Savings Associated with Reconstituted Milk, Based on Comparative Costs, After Taxes, in Six Cities.

City/Case	Comparative Cost With No Difference Between the Wholesale Prices of Fresh and Blended Milk (¢/gal. blended milk)	Breakeven Decrease in Blended Milk Price (¢/gallon)	Comparative Cost at Breakeven Price Difference (¢/gal. blended milk)
Boston/31	-4.9	11	0.36
Chicago/32	-0.8	2	0.12
Dallas/28	-1.9	4	0.01
Jacksonville/27	-3.5	8	0.34
Knoxville/32	-1.7	4	0.24
New York/31	-3.9	9	0.34

virtually no difference in comparative capital and total costs when the operating life is assumed to be 10 years or 20 years. A one-year increase in the assumed operating life of new plant and equipment decreases comparative costs by less than .01 cents per gallon of blended milk.

Discount Rate

Like the previous variable, the discount rate is assumed to be equal in all test cities. The 14 percent discount rate is used to calculate the discounted and annualized value of new capital investment. Table 28 illustrates the impact of varying the discount rate between 10 and 22 percent. The impact of doubling the discount rate is barely perceptible. A 1-point increase in the discount rate increases the comparative cost of reconstituting milk by less than .01 cents per gallon of blended milk.

Operating Days

The number of days per year which a plant is assumed to be in operation is also held constant across all test locations. The number of operating days is used to convert discounted, annualized capital costs to a daily basis. The impact on the comparative cost of reconstituting milk of assuming 5 or 6 operating days per week is imperceptible.

Marginal Tax Rate

Although combined Federal and State income tax rates vary by State, the marginal tax rate is assumed equal to 52.5 percent in all test cities. This is approximately the highest combined marginal rate expected. Under a progressive tax structure, marginal tax rates increase with taxable income. Although the data are not available to substantiate it, it is assumed that most plants in the test cases would fall in the upper tax bracket. Table 29 demonstrates the affect of assuming lower marginal tax rates applied. The marginal tax rates chosen are based on current marginal rates for Federal taxes plus 6.5 percent for State income taxes.

Lower tax rates tend to increase the absolute value of the comparative cost of reconstituting milk; i.e., if the comparative cost is positive, a lower tax rate will increase the after-tax cost; if the comparative cost is negative a lower tax rate will decrease the after-tax cost. Although a one-point change in the marginal tax rate changes comparative costs, after taxes, by less than 0.1 cents per gallon of blended milk, moving from one bracket to the next can significantly affect after-tax costs. We have assumed that most dairy plants would qualify for the highest rate.

Table 28. The Sensitivity of Comparative Capital and Total Costs, After Taxes, to Changes in the Discount Rate (cents per gallon of blended milk).

Case No. and Characteristics					Discount Rate (%)			
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	10	14	18	22
Capital								
20	100,000	50%	nfdm	8.7%	0.1	0.1	0.1	0.2
22	30,000	50%	condense	8.7%	0.1	0.1	0.2	0.3
31	100,000	10%	condense	8.25%	0.1	0.1	0.1	0.2
Total								
20	100,000	50%	nfdm	8.7%	-0.8	-0.7	-0.7	-0.7
22	30,000	50%	condense	8.7%	-1.7	-1.7	-1.6	-1.6
31	100,000	10%	condense	8.25%	-4.0	-3.9	-3.9	-3.8

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Table 29. The Sensitivity of Comparative Capital and Total Costs, After Taxes, to Changes in the Marginal Tax Rate (cents per gallon of blended milk).

Case No. and Characteristics					Marginal Tax Rate (%)			
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	26.5	36.5	46.5	52.5
Capital								
17	30,000	10%	nfdm	8.7%	0.2	0.1	0.1	0.1
20	100,000	50%	nfdm	8.7%	-1.2	-1.0	-0.9	-0.7
22	30,000	50%	condense	8.7%	-2.6	-2.2	-1.9	-1.7
31	100,000	10%	condense	8.25%	-6.0	-5.2	-4.4	-3.9

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

Chapter IV

Summary and Conclusions

The cost of reconstituting milk has not been rigorously estimated in the past. Recent efforts by the Community Nutrition Institute and others to eliminate current Federal Milk Marketing Order pricing provisions relating to reconstituted milk have raised questions about the cost of reconstituting milk compared to the cost of processing fresh beverage milk products. The purpose of this study is to measure the comparative cost of using reconstituted milk to make Class I or beverage milk products given various assumptions about the processing or operating environment and economic conditions.

Ultimately, policy analysts will wish to compare the cost of reconstituting milk products with the cost of processing comparable fresh milk products. Hence, this study uses the approach of directly measuring the difference between the costs of producing fresh and partially reconstituted milk products. This difference is denoted as the comparative cost of producing reconstituted milk, and it refers to the added or incremental cost that would be incurred by a fresh fluid milk bottler who replaced part of his output with blended or partially reconstituted milk products. If the cost of reconstituting beverage milk products exceeds the cost of processing fresh beverage milk products, the comparative cost of reconstituting milk, i.e., the difference between the two, is positive. If fresh milk costs more to process than reconstituted milk, then the comparative cost of reconstituted milk is negative.

This study attempts to measure the comparative cost of reconstituting milk under a variety of realistic assumptions about technical factors and the operating and economic environment. An economic-engineering approach is used to estimate the comparative cost of reconstituting milk. Various plant conditions and processing environments are engineered to represent alternative, realistic operating conditions. Several assumptions are made about prices and other economic conditions which can also affect costs, in particular prices are collected for six cities -- Boston, Chicago, Dallas, Jacksonville, Knoxville, and New York. This approach does not result in just one number representing <u>the</u> comparative cost of reconstituting milk; rather it allows one to measure the comparative cost of reconstituting milk under several sets of realistic assumptions about the operating and economic conditions which influence costs.

Assumptions and Model Design

Various technical data are collected and assumptions are made to help specify the model. The technical characteristics of the model include the following:

1. Bottling plants produce 80 percent beverage milk products and 20 percent byproducts. Plants have plant and equipment to reconstitute byproducts and sufficient excess capacity to reconstitute at least 10 percent but not as much as 50 percent of the beverage milk output.

2. The beverage milk product mix includes whole milk, lowfat milk, and skim milk. Based on 1979 data for Federal Milk Marketing Orders, it is assumed that the average fat content of beverage milk products is 2.605%.

3. Fresh milk products are standardized to 2.605% BF by combining fresh raw milk with an appropriate amount of fresh skim milk. Excess light cream is generated as a result.

4. Raw milk contains 3.67% butterfat (BF) and 8.62% solids-not-fat (SNF). One hundred pounds of raw milk can be separated into 18.35 pounds of light cream and 81.65 pounds of skim milk. Light cream is 20% BF and 7.2% SNF. Skim milk is 0% BF and 8.94% SNF.

5. Reconstituted skim milk is manufactured from water and nonfat dry milk or condensed skim milk. Nonfat dry milk is Grade A and of the low heat type and contains 97.5% SNF. Condensed skim milk is 32% SNF, which is considered to be the highest concentration of solids that can be shipped in fluid form without causing unloading problems. The typical plant has equipment for filtering and removing odors from water, if the normal water supply so requires.

6. Plants that reconstitute milk mix reconstituted skim milk with excess light cream (and raw milk, if needed) to produce partially reconstituted or blended milk products in sizes, containers, and product types comparable to the fresh product line. Blended milk products average 2.605% BF. Butterfat is first obtained from surplus light cream. If more butterfat is needed than what is available from cream normally separated at the plant, the deficit is obtained by adding raw milk to the blend.

7. Reconstituted skim milk can be formulated to yield any level of SNF in a blended milk product. Two levels of SNF content are studied: 8.7% SNF which approximates the average SNF content of fresh milk products and 8.25% SNF which is the legal minimum SNF content for fluid milk products in most states.

8. State or Federal regulations proscribing the reconstitution of milk are ignored except that it is assumed that blended milk products must be packaged in appropriately labeled containers separate from fresh milk.

9. Raw milk is purchased at prevailing Federal Order minimum prices. Nonfat dry milk, condensed skim milk, and all other inputs are purchased at prevailing market prices.

10. Nonfat dry milk and condensed skim milk are purchased in truckload quantities of 45,000 pounds and 5,292 gallons respectively. Given the state of current technology for bulk powder, it is assumed that nonfat dry milk is shipped in 50-pound bags.

11. Two sizes of plants are modeled. One, representing a moderate size plant, handles 30,000 gallons of beverage milk per day. The second produces 100,000 gallons of beverage milk per day and represents a large plant.

12. Plants are assumed to produce blended milk products in volumes equal to 10 or 50 percent of the total beverage milk output.

13. Prices may vary regionally; therefore six plant sites and their associated prices are identified. The comparative cost of reconstituting milk is calculated for Boston, Massachusetts; Chicago, Illinois; Dallas, Texas; Jacksonville, Florida; Knoxville, Tennessee; and New York, New York.

Based on these data and assumptions, professional engineering consultants at JAI Engineers developed prototype designs for plants (see Figures 1 through 4) and calculated input requirements (see Tables 2 and 3) and product flows (see Figures 5 and 6 and Appendix A). The comparative cost of reconstituting milk is calculated from the changes in quantities of inputs required and outputs sold under various sets of assumptions (see Table 4) and from the prices of inputs and outputs at each city location (see Table 5).

Total comparative costs of reconstitution can be separated into four major components, as follows:

Processing costs: processing costs are the costs incurred due to added labor, heat, and electricity needed in plants that reconstitute milk as compared to otherwise comparable plants that do not reconstitute milk.

Capital costs: most plants that replace part of their fresh product output with blended milk require additional equipment and expanded plant space. The cost of new investments in plant and equipment is based on the purchase prices of new capital goods, salvage values at the end of the operating lives of the new capital goods, and appropriate interest rates to determine the annualized values of capital goods over their operating life.

Raw Ingredients costs: raw ingredients are defined herein as raw milk, water, nonfat dry milk, and condensed skim milk. Changes in the cost of acquiring raw ingredients are due to changes in the amounts of raw ingredients required and/or the prices of raw ingredients. The comparative cost of raw ingredients will vary with Federal Order pricing policy. Under current rules, plants must pay the Class I differential on all reconstituted milk used in Class I, thus adding to raw ingredients costs. Under the proposals advanced by the Community Nutrition Institute and others, this added charge is eliminated.

Revenue Losses: totally fresh milk plants generate a surplus of light cream under the plant designs and assumptions of this study. Plants that blend milk products require some or all of the surplus cream as a high quality source of butterfat to blend with reconstituted skim milk. Consequently, revenues from the sale of excess cream drop. Another revenue loss that can be reflected in the comparative cost of reconstituting milk is the change in revenues that would result if the price of blended milk products was less than the price of fresh milk products, as some have suggested would happen. Although the model accommodates this possibility, this study assumes prices of comparable blended and fresh products are equal; since measurement of the possible impact of reconstitution on product prices or any other price was not among the primary objectives of this study.

The comparative cost of reconstituting milk is also calculated after adjustments for income taxes. Although most cost studies ignore taxes, income taxes are a necessary and relatively easily measured expense associated with any business operation. Hence, before-and after-tax costs are calculated. Income taxes tend to reduce added before-tax costs as taxable incomes decline or reduce added before-tax savings as taxable incomes increase.

The cost figure reported here refers only to in-plant costs; costs associated with assembly and distribution are not measured (receiving costs are determined from the point at which the product enters the plant and loading costs are measured up to the point that trucks leave the loading dock). We hypothesize that the fluid milk bottler who replaces part of his fresh milk output with blended milk products might achieve reduced per-unit assembly costs and increased per-unit distribution costs, but it is our judgment that the potential individual reduction in one and increase in the other are very small and the offsetting difference between the two would have a negligible impact if we included it in our cost calculations.

Results

The comparative cost of reconstituting milk can be calculated for as many as 192 possible combinations of the various plant and price data. Results for 84 of these combinations are reported in Table 30. The results indicate that, other things being the same, the comparative cost of reconstituting milk per gallon of blended milk output is always higher for 1) the smaller plant (30,000 gallons of beverage milk per day), 2) blended milk containing more solids-not-fat (8.7% SNF), or 3) current Federal Order pricing provisions. In fact, reconstituting milk is always more expensive than bottling fresh milk when current pricing provisions are in effect. The minimum after-tax cost under current Federal Order price policy is 5.6 cents per gallon of blended milk (Case 15 in Boston). Per unit comparative costs tend to be higher when blended milk volume is lower (10 percent of plant size), *ceteris paribus*, but this is not always true. Given the prevailing prices, comparative costs of reconstituting

Table 30. Total Comparative Costs of Reconstituting Milk, After Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Cost by Location						
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston[e]	Chicago[e]	Dallas[e]	Jacksonville[e]	Knoxville[e]	New York[e]	New York[f]
17	30,000	10%	nfdm	8.7%	-1.5	4.0	0.6	-1.3	1.5	0.1	9.2
18	30,000	50%	nfdm	8.7%	-1.5	2.2	0.0	-1.2	0.6	-0.6	5.5
19	100,000	10%	nfdm	8.7%	-1.9	3.6	0.2	-1.6	1.1	-0.5	8.6
20	100,000	50%	nfdm	8.7%	-1.6	2.1	-0.1	-1.3	0.5	-0.7	5.3
21	30,000	10%	condense	8.7%	-2.4	2.6	1.7	0.2	1.4	-1.2	7.9
22	30,000	50%	condense	8.7%	-2.3	1.0	0.6	-0.4	0.3	-1.7	4.3
23	100,000	10%	condense	8.7%	-3.1	1.8	1.1	-0.4	0.7	-2.2	6.9
24	100,000	50%	condense	8.7%	-2.4	0.9	0.5	-0.6	0.1	-1.9	4.1
25	30,000	10%	nfdm	8.25%	-3.3	2.2	-1.3	-3.1	-0.4	-1.7	7.4
26	30,000	50%	nfdm	8.25%	-3.3	0.4	-1.8	-3.0	-1.3	-2.4	3.6
27	100,000	10%	nfdm	8.25%	-3.8	1.8	-1.6	-3.5	-0.7	-2.3	6.8
28	100,000	50%	nfdm	8.25%	-3.4	0.3	-1.9	-3.1	-1.4	-2.6	3.5

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

[f] These are Cases 1 through 12, which are identical to Cases 17 through 28 except they assume that reconstituted milk is priced in Class I according to current Federal Order pricing provisions.

milk are higher when nonfat dry milk is used to make reconstituted skim milk in all cities except Dallas and Jacksonville.

Based on New York prices, moving to the larger plant size results in comparative cost reductions, after taxes, of 0.2 to 1.0 cents per gallon of blended milk (see Table 11). Expanding blended milk volume to 50 percent of plant size reduces comparative costs, after taxes, by 2.8 to 3.8 cents per gallon of blended milk when current Federal Order provisions prevail and by -.03 to 0.7 cents when current pricing provisions are ignored (see Table 12). Reducing the solids-not-fat content of blended milk to 8.25% lowers the comparative cost of reconstitution by about 1.8 cents per gallon of blended milk (see Table 14). Eliminating the relevant Federal Order pricing provisions reduces the comparative cost of reconstitution, after taxes, by 9.1 cents per gallon of blended milk in plants that have a blended milk volume equal to 10 percent of plant size and by 6.1 cents per gallon in plants having a blended milk volume equal to 50% of plant size (see Table 15).

Given prevailing market prices in the six cities, the comparative cost of reconstituting milk by city can be ranked from low to high as follows: 1) Boston, 2) Jacksonville, 3) New York, 4) Dallas, 5) Knoxville, and 6) Chicago. The highest after-tax comparative cost per gallon of blended milk output is 8.4 cents (before taxes it is 17.6 cents) and occurs in Chicago under the following operating assumptions (Case 1):

1. plant size equals 30,000 gallons of beverage milk per day,
2. blended milk volume equals 10 percent of plant size,
3. nonfat dry milk is used to make reconstituted skim milk,
4. blended milk is standardized to 8.7 percent SNF, and
5. current Federal Order pricing provisions are in effect.

The lowest after-tax comparative cost per gallon of blended milk is -4.9 cents (-10.3 cents before taxes) and occurs in Boston under the following assumptions (Case 31):

1. plant size equals 100,000 gallons of beverage milk per day,
2. blended milk volume equals 10 percent of plant size,
3. condensed skim milk is used to make reconstituted skim milk,
4. blended milk is standardized to 8.25 percent SNF, and
5. reconstituted milk is not priced under Federal Orders.

Comparative processing costs, after taxes, are calculated to range from 0.1 to 1.9 cents per gallon of blended milk. Comparative capital costs, after taxes, range from 0.0 to 0.2 cents per gallon. It is difficult to compare these estimates with those from other studies; insofar as no equally comprehensive study of such costs are known. Hammond et al. assumed that reconstituted milk would require additional processing costs of five cents per cwt. of reconstituted milk and no additional capital costs (1, pp. 8-9). Direct comparison of these numbers should be made cautiously because of the conceptual difference between the two studies. Our costs are after-tax costs for blended milk products made from reconstituted skim milk, light cream, and (possibly) raw milk and composed of 2.605 percent butterfat and 8.7 or 8.25 percent solids-not-fat. The study by Hammond et al. refers to blended milk products made from reconstituted skim milk, butter, and fresh milk (1, p. 24). The product composition is not defined, but they probably assumed that the blend was formulated to approximate current averages of fresh milk, which we assumed to be 2.605 percent BF and 8.7 percent SNF.

Thus, if one wishes to compare our processing and capital costs with those of Hammond et al., our before-tax costs should be used, costs for blended milk of 8.25 percent SNF should be excluded, and costs should be adjusted to a hundredweight basis. Making these adjustments, our before-tax processing plus capital costs range from 3.5 to 52.2 cents per hundred pounds of blended milk. Allowing for inflation, this would suggest that the estimate used by Hammond et al. is low.

The cost estimates reported herein are obviously sensitive to the prices and other economic assumptions that are used. Moreover, it is somewhat difficult to pinpoint the reason(s) why comparative costs are higher in one city or lower in another when all prices are different in different locations. Hence, it should be useful to explore the sensitivity of the estimates to changes in the economic parameters.

Sensitivity analyses have been conducted on virtually all price and other economic variables. Within the range of prices reflected in the six city markets, it is possible to identify the variables that seem to play a greater role in influencing the level of comparative costs. In general, processing costs seem to be a relatively minor component of total comparative costs. Rather large changes in the prices of labor, heat, and electricity barely affect the comparative cost of reconstituting milk (see Tables 16 to 18). Likewise, water costs and changes in the price of water do not seem to have much impact on total comparative costs (see Table 19). Changes in the initial price of added plant and equipment, the operating life of capital, the discount rate, and the number of operating days, which directly affect capital costs, also appear to have a negligible impact on total comparative cost (see Tables 28 and 29). Changes in the Class II price have no impact whatsoever on total comparative costs because any resulting change in raw ingredient cost is exactly offset by the change in revenue losses, under the assumptions of this study (see Table 24).

The factors that seem to influence the comparative cost of reconstituting milk most are the prices of nonfat dry milk, condensed skim milk, Class I milk, and blended milk products relative to fresh milk products. A five cent increase in the prices of nonfat dry milk and condensed skim milk will increase the after-tax comparative cost of reconstituting milk approximately one to two cents and three to five cents, respectively (see Tables 20 and 21). For every five cents that the price of blended milk products is less than the price of fresh milk products after-tax comparative costs increase 2.4 cents per gallon of blended milk (see Table 26). A 50 cent increase in the Class I price results in a one to two cent decrease in the after-tax comparative cost of reconstituting milk (see Table 22).

Although it would be difficult to rank the importance of these variables, it is clear that, within a realistic range of possible prices, the prices of nonfat dry milk, condensed skim milk, Class I milk, and blended and fresh milk products are far more important in determining the magnitude of the comparative cost of reconstitution than the prices of labor, water, and the other variables are.

Given the way that prices are currently aligned geographically, it appears that the Class I price is the most dominating factor. There is a high correlation between Class I prices and comparative costs; cities having higher Class I prices seem to have lower comparative costs of reconstituting milk. Higher Class I prices tend to increase the desirability of replacing fresh raw milk with reconstituted milk.

The dominating effect of the Class I price is primarily due to the relative difference between dairy prices across markets. The Class I price in Boston is $1.66 (12%) higher than the Chicago price, but the price of condensed skim milk in these cities differs by only 3 cents (3%). This is true because Class III prices or manufacturing milk prices are relatively uniform across the U.S., but Class I prices increase steadily with the distance of a market from the upper Midwest. Given this price structure, the level of Class I prices will probably be the singlemost important economic variable in determining the level of the comparative cost of reconstituting milk.

The thrust of the study by Hammond et al. (1) is to measure the impact of reductions in Class I prices that are hypothesized to result from the deregulation of reconstituted milk. The hypothesized reduction is assumed to equalize the costs of reconstitution and fresh milk processing. The purpose of this study has not been to analyze the policy questions surrounding reconstituted milk nor has it been to thoroughly examine the implications for Class I prices of deregulation; however some preliminary estimates of the potential impact on Class I prices can be discussed.

Reducing Class I prices will increase the comparative cost of reconstituting milk. For each case which resulted in the lowest comparative cost in each city, a new Class I price that would equalize the cost of reconstituting milk and the cost of fresh milk processing (i.e., make the comparative cost of reconstituting milk equal zero) has been calculated. The maximum reduction in Class I prices required to eliminate any potential savings from reconstitution is: $1.37 in Boston, $0.35 in Chicago, $0.80 in Dallas, $0.98 in Jacksonville, $0.70 in Knoxville, and $1.11 in New York. Hammond et al. estimate a short-run reduction in Class I prices for 1976 of $1.08 in the Northeast, $0.14 in the Lake States, $0.83 in the South Central States, and $1.57 in the Southeast (1, p. 16).

The reader is urged to make comparisons cautiously and draw conclusions carefully. As was shown in Chapter III, the comparative cost of reconstituting milk is sensitive to the choice of price data; prices from a different month or year can significantly alter the magnitude of the comparative cost of reconstitution (see Table 25). We are not prepared to make a final or conclusive judgment on likely or potential impacts of reconstituted milk deregulation on Class I prices. Given this important caveat, it would appear that the estimates of Hammond et al. are somewhat high, allowing for inflation and the nature of our breakeven prices. In addition, by comparison to our numbers, the regional impacts estimated by

Hammond et al. may be somewhat overstated in the Southeast and somewhat understated in the Northeast.

In addition to Class I prices, the comparative cost of reconstituting milk can be significantly altered by differences between the wholesale prices of fresh and blended milk products. Although it has been assumed that there is no difference between these prices throughout most of the analyses herein, the impact of reducing the wholesale price of blended milk relative to the price of fresh milk was demonstrated in Chapter III (see Table 26).

Like Class I prices, the wholesale price of blended milk can be reduced to equalize the costs of reconstituting milk and fresh milk processing, wholesale prices have been calculated which result in comparative costs of reconstitution equal to zero for the lowest cost case in each of the six cities. In order to eliminate any possible savings from reconstituting milk, the wholesale price of blended milk would have to be less than the wholesale price of fresh milk by 11 cents per gallon in Boston, 2 cents in Chicago, 4 cents in Dallas and Knoxville, 8 cents in Jacksonville, and 9 cents in New York.

Although a caveat about making direct comparisons is again in order, these figures can be examined in light of estimates reported by the USDA (3). The USDA study reports estimates of the difference between the retail prices for fresh milk and "blended reconstituted milk," with their blended milk being of the type described by Hammond et al. (3, p. 75968). They also calculate price differences for three different blends of reconstituted milk and fresh milk -- 50 percent reconstituted, 60 percent reconstituted, and 70 percent reconstituted. In our study, reconstituted skim milk is 87 percent of the volume of blended milk in all plants which blend 10 percent of their beverage milk output, and it is 58 percent of the volume of blended milk in plants which blend 50 percent of their beverage milk. The cases for Boston, Jacksonville, and New York that are associated with the breakeven wholesale price differences mentioned above (11, 8, and 9 cents/gallon, respectively) represent plants that have 58 percent reconstituted skim milk in their blend. The difference between retail prices for fresh milk and blended milk containing 60 percent reconstituted milk is calculated by the USDA to be 8 cents per gallon in the Northeast and 9.8 cents per gallon in the Southeast, based on 1978 data (3, p. 75968). The cases for Chicago, Dallas, and Knoxville that are associated with the breakeven wholesale price differences mentioned above (2, 4, and 4 cents per gallon, respectively) represent plants that have 87 percent reconstituted skim milk in their blend. The difference between retail prices for fresh milk and blended milk containing 70 percent reconstituted milk is calculated by the USDA to be 2.2 cents per gallon in the Lake States, 4.4 cents per gallon in the Corn Belt, and 7.0 cents per gallon in the South Central States.

Suggestions for Further Research

Although it is hoped that the research reported here sheds some light on the comparative cost of reconstituted milk, there remain a host of unanswered questions and questions raised by the research. Four major areas of research are suggested, dealing with 1) assumed prices, 2) alternative recipes for reconstituted and blended milk products, 3) the demand for reconstituted and blended milk, and 4) related policy issues.

The prices used for most of the analyses reported herein are for a particular month and year. As has been demonstrated, prices from different time periods can result in different comparative costs of reconstituting milk, to the point of changing a cost savings to a cost addition. Further work is required to assess the importance, impact, and relevance of seasonal and annual variation in relative prices.

In most cases, the prices assumed by this study are prevailing market prices; prices for raw milk, however, are Federal Order minimum prices, which may be but usually are not identical to market prices. The implications and impact of including Class I or other over-order price premiums should be examined.

Throughout this study, it has been assumed that reconstituted skim milk and blended milk products are made according to a rather narrowly defined formula. Butterfat sources are restricted to light cream and raw milk, and solids-not-fat sources are restricted to nonfat dry milk and condensed skim milk (32 percent SNF). These ingredients were chosen because it was felt that they would lead to the most palatable product and/or they would be preferred by dairy processors. It is possible to use other milk components, such as butter, anhydrous butterfat, whey solids, and casein. Along these lines it is also possible that heavy cream could be substituted for light cream, in fact there is some indication that this would be likely to occur in the Northeast. The implications and likelihood of using other raw ingredients to make reconstituted milk and blended milk products should be investigated.

Regardless of how reconstituted or blended milk is formulated, very little is known about the demand for reconstituted or blended milk. Although these products can be formulated to be nutritionally equivalent to fresh milk, it is not known whether other real or perceived differences would exist or be observed by consumers. Is the flavor of a particular blended milk the same as or worse than fresh milk? If it is worse, how much does it affect demand? Would consumer demand for blended milk products be different from the demand for fresh milk products even if fresh and blended products were identical in all sensory and nutritional respects? The answers to these questions are essential if one is to make a reasonably precise estimate of consumer acceptance of reconstituted or blended milk and the likely price of reconstituted or blended milk relative to fresh milk.

The impact of deregulating reconstituted milk on farm milk prices and consumer prices for dairy products is an important question for policymakers as well as the dairy industry and consumers. Although this study has some policy implications, these implications are only briefly addressed and partially analyzed. A thorough study of the policy aspects of this question based on this study and the suggested research is needed to flesh-out the implications hinted and alluded to by this report.

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Appendix A

Product Flows in Totally Fresh and Partially Reconstituted Milk Plants

Appendix A

Product Flows in Totally Fresh and Partially Reconstituted Milk Plants

The procedure used to calculate input requirements and product flows for plants producing fresh and/or partially reconstituted milk is explained below. The product flows in specific plants are also illustrated.

Mathematically, the steps for calculating the product flows are as follows:

1. Establish the amount of fresh and blended milk,

   $PS \cdot FV$ = fresh beverage milk volume (gallons)

   $PS \cdot RV$ = blended beverage milk volume (gallons)

   where,

   PS = plant size or total beverage milk volume (gallons)

   FV = percentage of beverage milk volume that is fresh

   RV = percentage of beverage milk volume that is blended.

2. Calculate the amount of raw whole milk needed for fresh beverage milk based on the butterfat content of each[1/]

   $$RM_1 = (PS \cdot FV \cdot CFM \div 100) \cdot BFM \div BFRM$$

   where,

   RM_1 = raw whole milk needed for fresh beverage milk products (hundredweight)

   CFM = conversion factor, pounds of beverage milk products per gallon of beverage milk products (see Table 1)

   BFM = average butterfat content (%) of beverage milk products (see Table 1)

   BFRM = average butterfat content (%) of raw milk (see Table 1).

1/Percentage butterfat and solids-not-fat figures are always based on a weight basis, not a volume basis.

3. Calculate the amount of skim milk needed for fresh beverage milk products

$$SM = (PS \cdot FV \cdot CFM \div 100) - RM_1$$

where,

SM = skim milk needed for fresh beverage milk products (hundredweight).

4. Calculate the amount of raw milk needed to yield the desired quantity of skim milk

$$RM_2 = SM \div YSM$$

where,

RM_2 = raw whole milk that is separated into skim milk and light cream (hundredweight)

YSM = yield of skim milk from the separator (see Table 1).

5. Calculate the amount of light cream produced from the raw milk that is separated

$$SLC = RM_2 - SM$$

where,

SLC = light cream separated from skim milk (hundredweight).

6. Calculate the amount of butterfat needed for blended beverage milk products

$$BFN = (PS \cdot RV \cdot CFM \div 100) \cdot BFM$$

where,

BFN = butterfat needed for blended products (hundredweight).

7. Calculate the butterfat available from light cream

$$BFA = SLC \cdot BFLC$$

where,

BFA = butterfat available from light cream (hundredweight)

BFLC = butterfat content (%) of light cream (see Table 1).

8. Compute the difference between the butterfat needed and the butterfat available from light cream for blended products. If

$$BFN - BFA < 0$$

then there is excess light cream available for sale and

$$ELC = (BFA - BFN) \div BFLC$$

where,

ELC = excess light cream available for sale in Class II (hundredweight).

If,

$$BFN - BFA = 0$$

then the quantity of light cream separated (SLC) is exactly equal to the quantity of light cream needed in blended milk products (BLC) and

$$ELC = 0.$$

If,

$$BFN - BFA > 0$$

then the quantity of light cream separated (SLC) does not supply a sufficient quantity of butterfat for blended products,

$$ELC = 0$$

and, additional raw milk is needed as a supplemental source of butterfat

$$RM_3 = (BFN - BFA) \div BFRM$$

where,

RM_3 = raw whole milk used in blended milk products (hundredweight).

9. Establish which raw ingredient is used to produce reconstituted skim milk and what the SNF standard for blended milk is. Calculate the amount of raw ingredient needed to produce reconstituted skim milk. If the raw ingredient is nonfat dry milk, then

$$RI_N = [(PS \cdot RV \cdot CFM \cdot ST) - (BLC \cdot 100 \cdot SNFLC) - (RM_3 \cdot 100 \cdot SNFRM)] \div SNFNDM$$

where,

RI_N = nonfat dry milk needed to produce reconstituted skim milk (pounds)

ST = SNF standard (%) for blended milk (see Table 1)

BLC = light cream used in blended milk or SLC-ELC (hundredweight)

SNFLC = SNF content (%) of light cream (see Table 1)

SNFRM = SNF content (%) of raw milk (see Table 1)

SNFNDM = SNF content (%) of nonfat dry milk (see Table 1).

If the raw ingredient is condensed skim milk, then

$$RI_C = [(PS \cdot RV \cdot CFM \cdot ST) - (BLC \cdot 100 \cdot SNFLC) - (RM_3 \cdot 100 \cdot SNFRM)] \div SNFC$$

where,

RI_C = condensed skim milk needed to produce reconstituted skim milk (hundredweight)

SNFC = SNF content (%) of condense (see Table 1).

10. Calculate the water needed to reconstitute the desired amount of skim milk. If the raw ingredient is nonfat dry milk, then

$$XW = [PS \cdot RV \cdot CFM \cdot (1-BFM-ST) - BLC \cdot 100 \cdot (1-BFLC-SNFLCW) - RM_3 \cdot 100 \cdot (1-BFRM-SNFRM) - RI_N \cdot (1-SNFNDM)] \div CF$$

where,

$PS \cdot RV \cdot CFM \cdot (1-BFM-ST)$ = pounds of water needed in blended products

$BLC \cdot 100 \cdot (1-BFLC-SNFLC)$ = pounds of water available from light cream used to produce blended products

$RM_3 \cdot 100 \cdot (1-BFRM-SNFRM)$ = pounds of water available from raw milk used to produce blended products

$RI_N \cdot (1-SNFNDM)$ = the pounds of water available from nonfat dry milk

and,

XW = water needed to produce reconstituted skim (gallons)

CFW = conversion factor, pounds of water per gallon of water

If the raw ingredient is condensed skim milk, then

$$XW = [PS \cdot RV \cdot CFM \cdot (1-BFM-ST) - BLC \cdot 100 \cdot (1-BFLC-SNFLC) - RM_3 \cdot 100 \cdot (1-BFRM \cdot SNFRM) - RI_C \cdot (1-SNFC)] \div CFW$$

where,

$RI_C \cdot (1\text{-}SNFC)$ = the pounds of water available from condensed skim milk.

The product flows for specific plant size and other assumptions about the operating characteristics of plants are shown on the following tables.

Table A1. Product Flows in Plants Producing 30,000 Gallons of Beverage Milk Per Day.[a]

Totally Fresh (Per Day)	Totally Fresh Milk Plant	Plant with 10% Blended Milk		Plant with 50% Blended Milk	
		8.7%[b]	8.25%[c]	8.7%[b]	8.25%[c]
Raw Ingredients:					
Raw Milk (cwt.)	2,755	2,479	2,479	1,836	1,836
Nonfat Dry Milk (lbs.)[d]	0	2,059	1,939	6,894	6,267
Water (gals.)[d]	0	2,450	2,464	8,175	8,247
Condensed Skim Milk (lbs.)[d]	0	6,273	5,909	20,912	19,094
Water (gals.)[d]	0	1,945	1,988	6,491	6,709
Intermediate Products:					
Skim Milk (cwt.)	750	675	675	375	375
Light Cream (cwt.)	169	152	152	84	84
Produced from:					
Raw Milk (cwt.)	919	827	827	460	460
Final Products:					
Fresh Milk (gals.)	30,000	27,000	27,000	15,000	15,000
Produced from:					
Raw Milk (gals.)	21,344	19,209	19,209	10,672	10,672
Skim Milk (gals.)	8,686	7,817	7,817	4,343	4,343
Excess Light Cream (cwt.)	169	118	118	0	0
Blended Milk (gals.)	0	3,000	3,000	15,000	15,000
Produced from:					
Raw Milk (gals.)	0	0	0	5,328	5,328
Light Cream (gals.)	0	397	397	994	994
Reconstituted Skim (gals.)	0	2,603	2,603	8,686	8,686

[a] Quantities are reported in pounds and gallons; sums may not add exactly due to rounding errors introduced when converting pounds to gallons.

[b] Solids-not-fat are standardized to 8.7 percent.

[c] Solids-not-fat are standardized to 8.25 percent.

[d] Plants use either nonfat dry milk and the corresponding water <u>or</u> condensed skim milk and the corresponding water, not both at once.

Table A2. Product Flows in Plants Producing 100,000 Gallons of Beverage Milk Per Day.[a]

Products (Per Day)	Totally Fresh Milk Plant	Plant with 10% Blended Milk		Plant with 50% Blended Milk	
		8.7%[b]	8.25%[c]	8.7%[b]	8.25%[c]
Raw Ingredients:					
Raw Milk (cwt.)	9,182	8,264	8,264	6,119	6,119
Nonfat Dry Milk (lbs.)[d]	0	6,863	6,465	22,878	20,889
Water (gals.)[d]	0	8,167	8,214	27,250	27,489
Condensed Skim Milk (lbs.)[d]	0	20,909	19,697	69,707	63,647
Water (gals.)[d]	0	6,482	6,628	21,635	22,362
Intermediate Products:					
Skim Milk (cwt.)	2,501	2,251	2,251	1,251	1,251
Light Cream (cwt.)	562	506	506	281	281
Produced from:					
Raw Milk (cwt.)	3,064	2,757	2,757	1,532	1,532
Final Products:					
Fresh Milk (gals.)	100,000	90,000	90,000	50,000	50,000
Produced from:					
Raw Milk (gals.)	71,146	64,031	64,031	35,573	35,573
Skim Milk (gals.)	28,952	26,057	26,057	14,476	14,476
Excess Light Cream (cwt.)	562	394	394	0	0
Blended Milk (gals.)	0	10,000	10,000	50,000	50,000
Produced from:					
Raw Milk (gals.)	0	0	0	17,761	17,761
Light Cream (gals.)	0	1,324	1,324	3,315	3,315
Reconstituted Skim (gals.)	0	8,677	8,677	28,952	28,952

[a] Quantities are reported in pounds and gallons; sums may not add exactly due to rounding errors introduced when converting pounds to gallons.

[b] Solids-not-fat are standardized to 8.7 percent.

[c] Solids-not-fat are standardized to 8.25 percent.

[d] Plants use either nonfat dry milk and the corresponding water or condensed skim milk and the corresponding water, not both at once.

Appendix B

Comparative Costs of Reconstituting Milk, Before Income Taxes

Table B1. Total Comparative Costs of Reconstituting Milk, Before Taxes, Based on Prices in Six Test Markets (cents per gallon of blended milk).

Case No. and Characteristics					Cost by Location						
No.	Plant Size[a]	Blended Volume[b]	Raw Ingredient[c]	SNF Standard[d]	Boston[e]	Chicago[e]	Dallas[e]	Jacksonville[e]	Knoxville[e]	New York[e]	New York[f]
17	30,000	10%	nfdm	8.7%	-3.2	8.4	1.2	-2.7	3.1	0.2	19.4
18	30,000	50%	nfdm	8.7%	-3.1	4.5	0.0	-2.6	1.2	-1.3	11.4
19	100,000	10%	nfdm	8.7%	-4.1	7.5	0.5	-3.4	2.3	-1.0	18.1
20	100,000	50%	nfdm	8.7%	-3.4	4.3	-0.2	-2.8	1.0	-1.6	11.1
21	30,000	10%	condense	8.7%	-5.1	5.3	3.5	0.3	2.8	-2.7	16.4
22	30,000	50%	condense	8.7%	-4.9	2.1	1.2	-1.0	0.5	-3.7	9.0
23	100,000	10%	condense	8.7%	-6.6	3.8	2.3	-0.9	1.4	-4.7	14.4
24	100,000	50%	condense	8.7%	-5.1	1.8	0.9	-1.2	0.3	-4.1	8.7
25	30,000	10%	nfdm	8.25%	-7.0	4.6	-2.6	-6.6	-0.7	-3.6	15.5
26	30,000	50%	nfdm	8.25%	-7.0	0.7	-3.9	-6.4	-2.7	-5.2	7.6
27	100,000	10%	nfdm	8.25%	-7.9	3.7	-3.3	-7.3	-1.5	-4.9	14.3
28	100,000	50%	nfdm	8.25%	-7.2	0.5	-4.0	-6.6	-2.9	-5.4	7.3

[a] Plants process either 30,000 or 100,000 gallons of beverage milk output per day.

[b] The volume of blended beverage milk equals 10 or 50 percent of the total beverage milk output per day.

[c] Either nonfat dry milk (nfdm) or 32% condensed skim milk (condense) is used to make reconstituted skim milk.

[d] Solids-not-fat in blended beverage milk products are standardized to either 8.7 or 8.25 percent.

[e] Reconstituted milk is not priced under Federal Orders (regulated).

[f] These are Cases 1 through 12, which are identical to Cases 17 through 28 except they assume that reconstituted milk is priced in Class I according to current Federal Order pricing provisions.