EFFICIENT ORGANIZATION OF THE FLUID MILK SUBSYSTEM OF SPAIN

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Eduardo Diez-Patier

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This is to certify that the

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presented by

Eduardo Diez-Patier

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of the requirements for

Ph.D. degree in Agricultural Economics

Vernon L. Sorenson
Major professor

Date January 12, 1976

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ABSTRACT

EFFICIENT ORGANIZATION OF THE FLUID MILK
SUBSYSTEM OF SPAIN

By

Eduardo Diez-Patier

The fluid milk subsystem of Spain has been tightly regulated by the government since 1966. Although the regulations are being progressively modified in order to correct some of the maladjustments identified in the subsystem, elements of misregulation still seem to be present. It was hypothesized that the present regulations are leading to the construction of an excessive number of fluid milk processing plants which are, with a few exceptions, too small to achieve efficient operation. At the same time, these regulations provide no incentive to extend the system of compulsory hygienization of milk, established in 1966, to all the country.

The purpose of this study was to provide information to assist in developing relevant public policy that would help to improve the performance of the fluid milk subsystem of Spain and also to assist the participants in their planning. More specifically, the objectives were: (1) to analyze the organization of the fluid milk subsystem of

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Spain; (2) to determine the effects of volume of production in individual plants upon the cost of processing fluid milk; (3) to determine the least cost number, location and size of fluid milk processing plants for Spain both for the 1973-74 marketing year and for 1978; and (4) to determine optimum interprovince price differentials for both raw and finished milk consistent with a minimum cost pattern.

The dairy subsector and fluid milk subsystem of Spain were defined and trends in milk production, consumption and import-export activities were reviewed. After a description of both the structure and government's role in the fluid milk market, a preliminary evaluation of the performance of the subsystem was made. Relative inefficiency, inadequate output levels, lack of sufficient consumer information, inadequate fluid milk product mix offered and elements of misregulation were found to be the main barriers to improved performance in the fluid milk subsystem of Spain.

Based on synthesized costs of in-plant fluid milk processing operations significant economies of size were found to be possible in Spain. The average unit processing cost decreased from 3.958 pesetas per liter of fluid milk for a plant processing 40,000 liters per day for an eight-hour workday, to 2.789 pesetas per liter for a plant processing 360,000 liters per day for an eight-hour workday, a decrease of about thirty percent, with most of the drop ing in the 40,000-

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being in the 40,000-120,000 liters category in which costs declined about twenty-two percent.

Using the fluid milk processing costs information obtained from the synthetic firm study and milk assembly and distribution cost data elaborated by the Ministry of Agriculture, a transshipment model was used to estimate the number, location and size of plants that minimized the aggregate assembly, processing and distribution costs for the actual 1973-74 milk marketings and fluid milk consumption, and the results were then compared with the minimum cost that could be attained under the existing pattern. Optimum number, locations and sizes of plants were also obtained for 1978, based on two alternative cost assumptions.

According to the least cost pattern obtained for 1973-74, twenty-two plants, processing a daily average volume of 316,316 liters per plant would have provided processed milk to all consumers at that year's consumption levels at an average cost of 4.07 pesetas per liter. The actual pattern of fifty-seven plants, processing a daily average of 80,975 liters per plant and providing an amount of processed milk which was less than two-thirds of the total milk consumed in fluid form in 1973-74 could have attained a minimum cost level of 4.61 pesetas per liter of processed milk. A more efficient product use allocation would have permitted the attainment, under 1973-74 conditions, of a unit cost of 4.56 pesetas per liter. Existing regulations, however, do not allow an optimum flow of processed milk produc

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For 1978, it was projected that 21.5 percent more milk than in 1973-74 will be needed for fluid consumption. If all the milk to be consumed in fluid form by 1978 were to be hygienized in fluid milk processing plants, the increase in processed milk needed with respect to the quantity supplied in the 1973-74 daily marketing year would be 83.3 percent. An optimum pattern of twenty-one plants, processing a daily average of 402,855 liters per plant could provide the needed amount of hygienized milk at minimum cost in 1978.

The study demonstrated relative economic advantages for moving toward a fluid milk processing industry which would be more concentrated and would have a greater capacity. While it would be very difficult to expect the dismissal of almost sixty percent of the plants existing in 1974, recommendations were made which would be helpful in keeping the subsystem from further deterioration under the present organization.

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A DISSERTATION

Submitted to
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1976

To

María Rosa

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Drs. John N. Ferris

members of my thesis

and Mr. Keith Olson

assistance.

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I am especially grateful to the Instituto Nacional de Investigaciones Agrarias of Spain for financing my entire program. It is my sincere hope that they realize an acceptable return on their investment.

Finally, I owe most special thanks to my wife María Rosa and our daughter Nuria for their contributions to this effort in the broader context of living in which it was realized.

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CHAPTER I

INTRODUCTION

The purposes of this chapter are to provide the necessary problem framework and research objectives from which the study will proceed and to present some of the theory and literature related to them.

Problem Setting

Considering, in a very simplified way, three alternative methods of organizing the fluid milk market of a country, namely: (1) Open market, without government intervention; (2) Partial government intervention; and (3) Total government control, the present organization of the fluid milk market of Spain comes under partial government intervention. Some of the reasons for choosing this alternative include the character of the product (especially the perishability, essential nature and peak-load supply conditions of the milk), farmers' uncertainty (and fixed assets), their perceived powerless position relative to those with whom they must deal, the need for consumer protection, etc.

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The basic administrative regulation of the dairy subsector of Spain is the Regulation of Fluid Milk Processing Plants and Other Dairy Industries (5), which defines and regulates milk production, establishes the general norms for the subsector and originally determined the way in which prices to farmers and distribution and selling margins of some processed products were to be set. This Regulation is being progressively modified in order to correct some of the typical maladjustments of the subsector. Important changes have been made by Decrees 544/1972 of March 9 (6), 588/1974 of March 15 (8) and 3520/1974 of December 20 (9).

Part IV of this Regulation established the compulsory hygienization of milk in every nucleus of population, with high priority for the more populated ones, assigning to the processing plants the function of providing hygienized milk for local direct consumption. The minimum daily processing capacity required is 25,000 liters, although in special cases processing plants can be authorized in towns or areas whose daily consumption does not reach this figure.[1] It is hypothesized that the present fluid milk processing plants of Spain are, with a few exceptions, too small to achieve efficient operation. At the same time, new transportation technology, changes in marketing channels,

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[1]As of March 1, 1974, four plants were operating in these conditions under article 64 of the Regulation, as modified by Decree 544/1972 (6).

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improved technology in plant operation, etc., suggest that adjustments in the size of plants could lead to improved efficiency.

The implementation of this part of the Regulation, moreover, seems to be leading to the construction of an excessive number of plants while, at the same time, it is failing to extend the system of hygienization of milk to all the country fast enough. It is also hypothesized, then, that adjustments in the number (and size) of plants are needed in order to improve the efficiency of the fluid milk subsystem and expand its capacity.

With respect to producer prices, on the other hand, the Regulation of the Dairy Marketing Years 1975-76, 1976-77 and 1977-78 (9) that has superseded Part V (Milk Prices) of the original Regulation (5), establishes interprovince differences of prices based on transportation costs of raw milk as opposed to the previous criterion of interprovince differences based on the real costs of production and the ecological, edaphic and farming characteristics (5) of the different dairy regions. Although, in fact, the present arrangement is considered an improvement with respect to the previous practice, it is hypothesized that the location differentials as presently computed (without incorporating the costs of processing milk) operate to provide less than optimum milk movements.

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The basic hypotheses which are considered important to test, therefore, are:

Hypothesis No. 1: Most of the present fluid milk processing plants of Spain are too small to achieve efficient operation.

Hypothesis No. 2: The number, size and location of the fluid milk processing plants of Spain do not coincide with the least cost pattern.

Hypothesis No. 3: The system of hygienization of milk can be extended to all the country with a reduction in unit costs through adjustments in the number, size and location of plants.

Hypothesis No. 4: Price location differentials as presently computed operate to provide less than optimum milk movements.

Research Objectives

The scope of the proposed study will, necessarily, be limited by the available resources. It is believed that the knowledge about both the fluid milk subsystem and the dairy subsector of Spain must be accumulated over time and, thus, a first objective of this research effort will be simply to attempt to provide a conceptual framework for organizing existing knowledge and to show the nature and importance of the missing information.

The general objectives of providing descriptive, diagnostic, predictive or projective and prescriptive information will include the following: (1) To describe the more important characteristics of the fluid milk subsystem of Spain; (2) To diagnose some of the shortcomings of the present system, identifying problems of the participants, unexploited opportunities, barriers to improved performance, etc.; (3) To estimate the future economic configuration of some significant variables; and (4) To prescribe possible changes leading to improved performance.

More specifically, the objectives of the study will be: (1) To analyze the present organization of the fluid milk subsystem; (2) To determine the effect of volume of production in individual plants upon the cost of processing fluid milk; (3) To determine the least cost number, size and location of fluid milk processing plants for Spain; and (4) To determine the optimum interprovince differences of prices to milk producers that will produce a least cost flow of milk from the surplus to the deficit provinces in order to minimize total transportation and processing costs.

Procedures

The first step will involve a description of the existing systems of organization and control for the fluid milk subsystem of Spain, directed toward evaluating its performance.

The second step will involve the realization of an economic engineering study to estimate the total costs and, through them, the unit costs of processing fluid milk for different plant sizes.

The third step will include the construction of a linear programming transshipment model to determine the optimum number, size and location of fluid milk processing plants for Spain. In analyzing this problem, an attempt will be made to minimize the aggregate costs of assembling raw milk, transporting it to the processing plants, processing it there and distributing the processed fluid milk products from the plants to the consumption centers. From the results of this model, optimum interprovince price location differentials that will produce optimum flow patterns of raw and processed milk in order to minimize total costs will be computed.

Theoretical Background

Some of the theory and literature related to this research is presented in this section in three parts.

Subsector Systems and Subsystems Research Concepts

The term subsector came into use in 1968 with a paper by Shaffer (65), being elaborated and somewhat modified later (Shaffer 66, 67, 68, 69). A subsector was defined as "the vertical set of activities in the production and distribution of a closely related set of commodities" (66, page 3), and also as "a meaningful grouping of economic activities related vertically and horizontally by market relationships" (68, page 5).[2] It differs from an

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[2]However, as Hildreth _et al_. have pointed out, "linkages within a subsector _can be_ 'market relationships' or a rich assortment of other arrangements, including contracts and government rules" (31, page 852).

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industry[3] as a unit of study in that a subsector includes both vertical and horizontal relationships, whereas in an industry the production units are related horizontally. A subsector, therefore, may include several industries.

In a recent paper, French (24) found that subsector studies seem to mean different things to different people. In effect, Manchester, for example, regards the terms systems research and subsector research as being synonymous: "In ERS we have often used the terms systems research and subsector research as synonymous. Therefore, I will regard them as equivalent in meaning" (39, page 6). Shaffer, on the contrary, has a broader view, having suggested that subsector studies are "more of a departure in research organization rather than a departure from traditional approaches of Agricultural Research," adding that "Closely tied to my perception of subsector studies is what I call a systems orientation" (69, pages 333-4). By a systems orientation he simply means "The analysis of problems in the context of the broader system, an analysis which takes into account feedback, sequences and externalities" (67, page 44).

What emerges, French says, is a two-dimensional concept: (1) Subsector research systems, "a way of

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[3]An industry has been defined by Bain as consisting of a recognizable group of products which are close substitutes to buyers, are available to a common group of buyers, and are relatively distant substitutes for all products not included in the industry (1).

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organizing research" and (2) Subsector systems research, "a methodological approach in which a subsector is the unit of observation" (24, page 1014). This subsector framework may, in fact, play an important role as a focal point for the accumulation of research results and the structuring of research information systems. This orientation may "reveal holes and duplication of effort, lead to improved planning and have a general synergistic effect on research pertaining to the subsector" (24, page 1020).

But before progressing further, a reminder of the nature of the present research effort is in order. A subsector system is definitively too broad to become manageable to a single researcher and would surely become a source of frustration. A more viable research orientation, still consistent with the subsector approach, could be the division of the subsector system into subsystems. Dealing with a subsystem focuses attention in the vertical relationships and eliminates the shortcomings of focusing on a single function or level of activity.

An appropriate subsystem has been defined by Purcell as "A set of two or more interrelated parts of the total system which exhibits the important characteristics of the total system" (61). Once an appropriate subsystem is identified, therefore, attention can be directed to the development of a methodology which can both isolate and evaluate important economic relationships.

The Organizational Concept

When interested in the organization of some component part of the economy, a basic concern is how various kinds of organizations would affect its performance (and that of the economy). A relatively large body of economic theory has developed in the field of Industrial Organization, which seeks to identify variables which influence economic performance and to construct theories linking it to these variables. The broad descriptive model maintains that performance of a system depends upon the conduct of its participants and this conduct depends, in turn, upon its structure.[4] Structure and conduct are also influenced by various basic conditions and there are also feedback effects. The system performance is to be described from the observation of its basic conditions, structure and conduct.[5] It is also recognized that many other elements influence structure, conduct and performance at various stages in the production and marketing process.

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[4]Performance is, of course, a multidimensional attribute. Good performance embodies, at least, the following goals: Efficiency, progressiveness, product suitability, participants' rationality, adequate levels of profits, output and promotion expenses, absence of bad externalities, equity, full employment, conservation, absence of unfair methods of competition, good labor relations and absence of misregulation. These performance dimensions may not always be completely consistent with one another; nevertheless, to the extent possible, good performance implies maximum satisfaction of all fourteen goals.

[5]Conduct, however, is a controversial concept, which is viewed as having various degrees of importance. Most structuralists seem to argue that conduct is too difficult

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Although Organization and Structure are related, they are not synonymous. The organization of a system consists of "the matrix of power centers through which organization is controlled" (31). The basic dimensions of structure are the number, size and concentration of the entities composing the system. The organizational linkages may consist of markets or other arrangements for decision formulation and power transmission. In this study, a more efficient organization of the fluid milk subsystem of Spain will be proposed and the main consequences of moving toward it will be analyzed. It will not be possible, however, to deal directly with all the aspects of market performance.

Efficiency Considerations

According to French, most researchable issues pertaining to subsectors involve determining "how various measures of system performance are affected by instruments of change" (24). Of all the aspects of market performance it is considered both desirable and possible to deal with production efficiency in order to measure the consequences of moving toward a particular organization of the fluid milk subsystem of Spain.

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to deal with and that relationships can be established between structure and performance which make it less imperative to study conduct per se. On the other hand, behaviorists argue that Industrial Organization can do a much better job with a richer model which includes intermediate behavioral links.

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French has also noted that efficiency is a deceptively complex concept, whose definitions and dimensions "vary at different levels within the market economy and become increasingly complex as we move from the firm to an industry or group and on up to the total system" (23, page 3).

The individual firm is considered to be technically efficient if its production function "yields the greatest output for any set of inputs, given its particular location and environment" (23, page 3). The ratio of output obtained with the production function used to output attainable with the best function, given the input combinations, is a measure of the degree of technical efficiency for a firm.

Firm pricing (or allocative) efficiency is measured relative to the efficient production function as "the ratio of cost with optimal input proportions to cost with the input proportions actually used" (23, page 4). A firm may be technically efficient and still be inefficient in a pricing sense if it fails to combine inputs in such a way that marginal revenue products are equal to factor prices.

The product of the indices of technical and allocative efficiency is a measure of economic efficiency of the firm (23, page 4). Again, a firm may be both technically and economically efficient for its scale but inefficient with respect to its optimum scale. Optimum scale may also vary with relative factor prices.

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The degree to which the total marketing system or an industry subsystem (such as the fluid milk subsystem) achieves: (1) Economic efficiency (as above) for all firms; and (2) Full utilization of capacity and advantageous use of size and location economies, is referred to as productive efficiency.[6]

In analyzing areas of potential cost savings in an industry subsystem, at least two separate facets of productive efficiency become apparent. Two basic areas of inefficiency are the suboptimal use of available and potential resources within firms (existing primarily in the absence of a competitive environment), and the inefficient allocation of resources between the different firms constituting the industry, which manifests itself through maladjustments in the structure and concentration of firms (57).

It is considered that economic research relating to productive efficiency may lead to improved performance of the Spanish fluid milk subsystem. This can be attained by determining the relative efficiency of existing alternative production methods, scale of operations and business practice, and by formulating models of efficient organization within market areas for the subsystem which may serve as aids for planning and policy formulation.

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[6]The degree to which operation of the subsystem under exchange mechanisms generate prices which conform to a competitive standard is referred to as Pricing efficiency (12, pages 410-14), which, in this context, is different from pricing efficiency for the individual firm (considered above).

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This research effort attempts to obtain empirical results that will help the fluid milk subsystem of Spain move closer to optima in size and factor allocation. This intention was expressed earlier as a desire to devise a least cost, efficient pattern for milk assembly, processing and distribution that, furthermore, will allow for expansion of the capacity of the present system to provide hygienized milk to all consumers. The study is especially concerned with the assembly, processing and distribution operations within the subsystem, attempting to optimize the efficiency of the total subsystem (not necessarily each of these operations separately).

Organization of the Study

Chapter I has provided the objectives of the study and some background information.

Chapter II will define the dairy subsector and the fluid milk subsystem of Spain. It will characterize recent levels and trends in domestic production, consumption and international trade in the dairy subsector, describe the structure of the fluid milk market and the role of the government in it, and attempt a preliminary evaluation of the performance of the present system.

Chapter III will present the basic design model to be utilized in the analysis and some of the necessary assumptions.

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Chapter IV will report the results of the economic-engineering study addressed to the estimation of unit costs of processing milk for plants of different sizes and lengths of workday.

Chapter V will present the estimates of cow milk production, fluid milk consumption and milk assembly, processing and distribution costs and the designation of potential fluid milk plant sites as well as the empirical results of ex-post analyses to determine the optimum number, size and location of plants for 1973-74 and to compare them with actual costs. Chapter VI will present similar ex-ante analyses for 1978.

Chapter VII finally, will present the conclusions drawn from the study, and some recommendations to improve the efficiency of the fluid milk subsystem of Spain.

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CHAPTER II

THE DAIRY SUBSECTOR AND FLUID MILK SUBSYSTEM OF SPAIN

The purposes of this chapter are to define the dairy subsector and the fluid milk subsystem of Spain, to characterize recent levels and trends in domestic production, consumption and import-export activities and to analytically describe the structure and government's role in the fluid milk market with the aim of evaluating its performance.

Definition of the Dairy Subsector and Fluid Milk Subsystem

The definition of a subsector needs to be carefully composed. If too broad, it could become unmanageable and if too narrow, it would fail to capture the research benefits embodied in systems thinking. The definition of the dairy subsector of Spain that is proposed attempts to strike a comfortable compromise. It is definitively too broad to be fully exposed and elaborated in the present research effort, although it is felt that it is necessary to eate a subs

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delineate a subsector which is broad enough to be relevant, and to specify it in such a way that independent research efforts, such as this particular study, may plug into the definitional framework with little duplication of effort or incongruency.

The dairy subsector of Spain, then, shall include the farm production of milk and some aspects of the major inputs to milk production, especially the feed industry, manufacturing and distribution of specialized dairy equipment, artificial insemination and herd health among others; the assembly and processing of milk, including input industries as, for example, the prepack and paper distribution industries as inputs to processed fluid milk products, the manufacturing and distribution of specialized processing equipment, etc.; the distribution, retailing and consumer acquisition of fluid milk and other dairy products; the beef industry, as a user of a major product of dairy farming, etc. It is perhaps obvious that the boundaries of the subsector need to be set quite arbitrarily to make any research manageable.

The dairy subsector is, furthermore, influenced by a number of regulations which include minimum, indicative and intervention prices, location differentials, maximum resale prices for certain products, measures of protection to farm milk production, import-export actions, sanitary regulations, plant licensing, etc. Several agencies of different Ministerial Departments (Agriculture, Commerce, erior, . . .)

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Interior, . . .) are involved in the regulation of the subsector. Figure 1 presents a diagrammatic picture of this definition.

The fluid milk subsystem includes farm production and assembly of milk intended for fluid consumption, pasteurization or sterilization of milk, packaging of processed fluid milk, and distribution, retailing and consumer acquisition of fluid milk products. The subsystem could also be expanded to include some of the major inputs to these processes. Again, the boundaries of the subsystem have to be, somehow, set to make the research manageable. The relevant regulations and institutions, of course, must also be included.

Trends in Production, Consumption and International Trade

The dairy subsector is a large and vital part of the agricultural sector of Spain. Production of milk made up 23.8 percent of livestock production, or 9.1 percent of total agricultural production in 1972[7] (Table 1). The contribution of milk and dairy products to total agricultural production was 35.1 billion pesetas, plus the value of the on-farm consumption, estimated at 7.6 billion pesetas.

[7]Total agricultural production in Spain in 1972 was 382.1 billion pesetas, in sales at the farm level (43). One peseta equals $0.017.

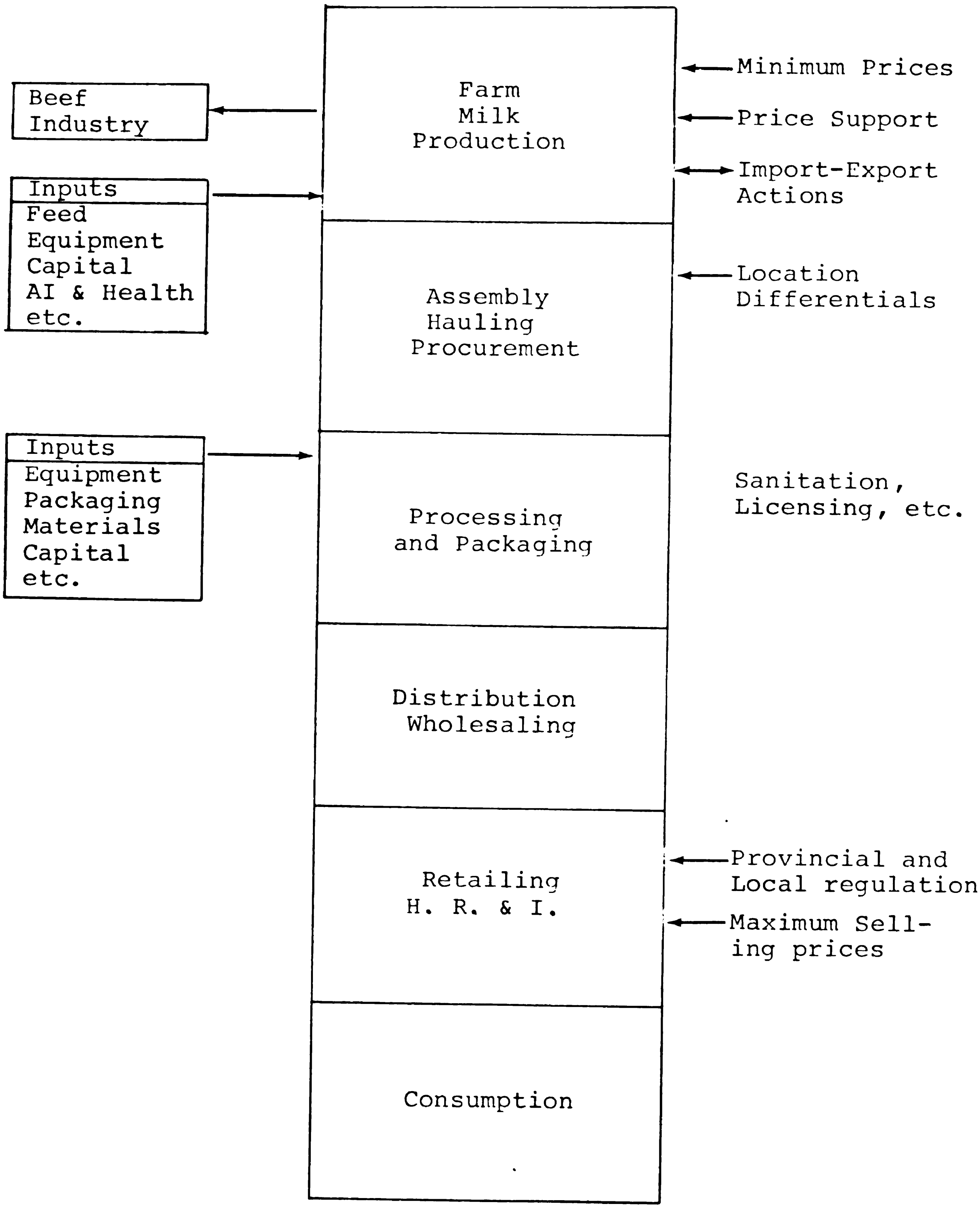

Figure 1. Actors, Functions and Institutions in the Spanish Dairy Subsector.

Table 1. Value of
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Source: Ministeri
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Table 1. Value of Livestock and Livestock Products, in Billion Pesetas. Spain, 1972.

Product	Value	Percentage of Total
Livestock	94.3	63.9
Milk	35.1	23.8
Eggs	17.2	11.7
Wool	0.7	0.5
Honey & Beeswax	0.2	0.1
Total	147.5	100.0

Source: Ministerio de Agricultura, Spain. La Agricultura Española en 1972.

Ten dairy firms were included among the four hundred top manufacturing firms in 1972 (Table 2). Three multinational corporations were present in the dairy industry (Table 3).

Milk Production

Since 1959 there has been a gradual increase in the quantity of cow milk produced in Spain. Cow milk production in 1973 reached 4.79 billion liters (52) compared to 2.50 billion liters in 1959 (Table 4).[8]

Nevertheless, this seems to be a low figure, when the facts that the population of Spain is more than thirty-five million and that she receives a very large number of

[8]One liter of milk is equivalent to 2.27 pounds or 1.056 liquid quarts.

Table 2. Ranking of
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Source: Ministeri
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NESTLE	
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DANONE	
KRAFT CO.	

Source: Confede
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Table 2. Ranking of Dairy Firms Among the 400 Top Manufacturing Firms, by Sales Volume. Spain, 1972.

Ranking	Firm	Sales (million pts.)
20	Nestle AEPA	10,019
110	La Lactaria Española SA	2,272
134	Danone S.A.	1,979
167	CLESA	1,632
247	Kraft Leonesa S.A.	1,027
277	Productos Lácteos Freixas S.A.	949
280	Derivados Lácteos S.A.	921
360	Cooperativa Lechera SAM	671
362	GURELESA	666
382	S.A. LETONA	595

Source: Ministerio de Industria, Spain. <u>Las 400 primeras empresas industriales en 1972</u>.

Table 3. Multinational Corporations in the Spanish Dairy Industry, 1974.

Firm	Participation (Percentage)	Spanish Firm
NESTLE	100.0	Scdad. NESTLE, AEPA.
NESTLE	99.0	Derivados Lácteos, S.A.
DANONE	17.0	DANONE
KRAFT CO.	100.0	Kraft Leonesas

Source: Confederación Española de Cajas de Ahorros: <u>Comentario Sociológico</u>.

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Table 4. Total Cow Milk Production, Spain, 1959-73.

Year	Amount (Billion liters)	Production as a Percentage of 1959
1959	2.50	100.0
1960	2.60	104.0
1961	2.86	114.4
1962	2.89	115.6
1963	3.12	124.8
1964	3.13	125.2
1965	3.28	131.2
1966	3.71	148.4
1967	3.73	149.2
1968	4.01	160.4
1969	4.29	171.6
1970	4.32	172.8
1971	4.26	170.4
1972	4.51	180.4
1973	4.79	191.6

Sources: Ministerio de Agricultura, Spain. Anuario de Estadistica Agraria, 1972 (1959-72); and Boletin Mensual de Estadistica 2/74 (1973).

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visitors each year are taken into account. This relatively low production prevails despite the fact that some regions of Spain are very suitable for milk production. This is a cause of concern to policymakers.[9] A priori, structural problems, migration, limited capacity of existing plants, the pricing system, lack of consumer information, etc. seem to be negative factors with respect to an increased production.

Most milk sold by farmers in 1972 was in the form of whole milk, and 54.1 percent of the milk marketed that year was consumed as fluid milk (Table 5).

The number of dairy cows on farms in September 1973 was 1,285,023, which represented an increase of 7.6 percent with respect to a year before. Of these, 934,178 were Friesians and 676,649 were dual purpose cows (Table 6). Milk output per cow was extremely variable depending on breed and feed conditions. The existance of both exclusive dairy cows and dual purpose cows that are milked makes the average national milk output per cow, of about 2,476 liters per year in 1973, next to meaningless.

Milk production tends to be concentrated in the Northern part of the country. Oviedo, with 543.67 million

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[9]During the informative session held at the Spanish Parliament on February 3, 1975, for example, the Minister of Agriculture expressed the need to take actions to "adjust" the prices of milk in the short run. In the medium range, he said plans are needed to increase the supply of milk, not only to attain self sufficiency but also to form stocks (ABC, February 4, 1975).

Table 5. Use of Mil

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Condensed milk	
Butter	
Powdered milk	
Others	
Fed to calves	
Total	

Source: Ministerio
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Table 6. Number o
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Breed	Nu
Friesians	8
Brown Swiss	1
Other Breeds	
Total Dairy	1,
Dual Purpose	
Total	1,

Sources: 1972--
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Table 5. Use of Milk. Spain, 1972.

Use	Amount (million liters)	Percentage of Total
Fluid milk	2,441.3	54.1
Cheese	557.9	12.3
Condensed milk	232.4	5.1
Butter	214.3	4.8
Powdered milk	152.6	3.4
Others	191.9	4.3
Fed to calves	721.2	16.0
Total	4,511.6	100.0

Source: Ministerio de Agricultura, Spain. Anuario de Estadistica Agraria, 1972.

Table 6. Number of Dairy Cows on Farms, by Breeds, Spain. September 1972 and 1973.

	1972		1973	
Breed	Number	Percentage	Number	Percentage
Friesians	872,302	45.8	934,178	48.3
Brown Swiss	170,160	9.1	188,177	9.7
Other Breeds	151,514	9.0	162,668	8.4
Total Dairy	1,193,982	63.9	1,285,023	66.4
Dual Purpose	676,649	36.1	649,981	33.6
Total	1,870,631	100.0	1,935,004	100.0

Sources: 1972--Ministerio de Agricultura, Spain. Censo de la Ganaderia Española, Septiembre 1972;
1973--Ministerio de Agricultura, Spain. Boletin Mensual de Estadistica 2/74.

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Table 7. Ten Leadi...
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Position	Provin...
1	Oviedo
2	Santa...
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4	La Co...
5	Leon
6	Ponte...
7	Vizca...
8	Geron...
9	Madri...
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Source: Minister...
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liters, was the leading producer province in 1972, followed by Santander with 450.84, Lugo with 389.8 and La Coruña with 377.14. These four northern provinces contributed almost forty percent of the milk produced in the country's fifty provinces that year. Table 7 gives the ten leading producer provinces of Spain in 1972.

Table 7. Ten Leading Provinces in Milk Production, Spain, 1972.

Position	Province	Total Production (Thousand liters)	Percentage of Total
1	Oviedo	543,675	12.0
2	Santander	450,845	9.9
3	Lugo	389,805	8.6
4	La Coruña	377,147	8.3
5	Leon	245,916	5.4
6	Pontevedra	199,302	4.3
7	Vizcaya	155,716	3.4
8	Gerona	136,496	3.0
9	Madrid	128,504	2.8
10	Orense	110,345	2.4
	Total	2,737,751	60.1

Source: Ministerio de Agricultura, Spain. Anuario de Estadistica Agraria 1972.

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Milk Consumption

Per capita consumption of fluid milk and dairy products have been increasing since 1965. In 1972, consumption of fluid milk was about 85 liters per person, which represented a forty-three percent increase with respect to that of 1965. Consumption of dairy products in the same year was 6.5 Kilograms[10] per person, a thirty percent increase with respect to 1965 (Table 8).

International Trade

Spain is still a net importer of milk and dairy products, although imports, and especially those of fluid milk, are declining (Table 9). Imports of milk and dairy products in 1973 showed an eleven percent decrease with respect to those in the previous year, the sharper decrease being that for fresh milk in which imports were reduced twenty-five percent with respect to those in the previous year and seventy percent with respect to 1971. All of the fresh milk imported came from France.[11]

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[10] One kilogram is equivalent to 2.2 pounds.

[11] Dairy farmers, of course, are opposed to milk imports and in this sense the Livestock Group of the Agricultural Syndical Official Chamber of Lugo, for example, agreed last April to ask for the "immediate discontinuation of milk imports from France" (ABC, April 24, 1975). In any case, self sufficiency in milk production is an important goal to Spanish policymakers and as such it was expressed, for example, by the Minister of Agriculture at Las Cortes on February 3, 1975 (ABC, February 4, 1975).

Table 8. Per Capita Consumption of Fluid Milk and Dairy Products, Spain 1965-72.

Year	Milk (Kilograms)	Consumption as a Percentage of 1965	Other Dairy Products (Kilograms)	Consumption as a Percentage of 1965
1965	59.9	100.0	5.0	100.0
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Table 8. Per Capita Consumption of Fluid Milk and Dairy Products. Spain 1965-72.

Year	Milk (Kilograms)	Consumption as a Percentage of 1965	Other Dairy Products (Kilograms)	Consumption as a Percentage of 1965
1965	59.9	100.0	5.0	100.0
1966	67.0	112.8	5.8	116.0
1967	75.0	126.2	5.5	110.0
1968	78.8	132.6	5.9	118.0
1969	80.1	134.8	5.8	116.0
1970	80.9	136.1	5.5	110.0
1971	84.2	141.7	6.3	126.0
1972	85.0	143.0	6.5	130.0

Source: Ministerio de Agricultura, Spain. La Agricultura Española en 1972.

[illegible]

	1971			1972			1973		
	Imports	Exports	Net Imports	Imports	Exports	Net Imports	Imports	Exports	Net Imports
Fresh Milk	175,347	477	174,870	62,641	1296	61,345	46,932	1148	45,784

Table 9. International Trade in Milk and Dairy Products. Spain 1971-73 (Metric Tons).[a]

	1971			1972			1973		
	Imports	Exports	Net Imports	Imports	Exports	Net Imports	Imports	Exports	Net Imports
Fresh Milk	175,347	477	174,870	62,641	1296	61,345	46,932	1148	45,784
Powered Milk	7,324	---	7,324	15,535	235	15,300	12,039	1826	10,213
Denatured Powdered Milk[b]	39,214	---	39,214	35,333	5	35,328	39,799	---	39,799
Butter	1,401	---	1,401	1,122	12	1,100	1,331	14	1,317
Cheese	5,562	102	5,460	8,404	145	8,259	9,328	145	9,183

[a]One metric ton equals 1.10 short tons or .98 long tons.

[b]Powdered milk destined to mixed feed manufacturing, denatured by mixing generally with alfalfa.

Source: 1971--Ministerio de Agricultura, Spain. La Agricultura Española en 1972.
1972-73--Ministerio de Agricultura, Spain. La Agricultura Española en 1973.

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Marketing Channels for Fluid Milk and Dairy Products

Milk moves from the farm to the consumer in three main stages. The first involves the assembly and transportation of raw milk from the dairy farms to the processing plants,[12] the second includes the processing and packaging of fluid milk or its transformation to other dairy products, and the third, finally, involves the distribution of processed and packaged fluid milk and dairy products to the consumers.

The marketing channels for fluid milk and dairy products in Spain are fairly simple (Figure 2). The more important one is that from farmers to processing plants, to retailers and to consumers. The farmer to retailer and/or to consumer direct channel is legally restricted to

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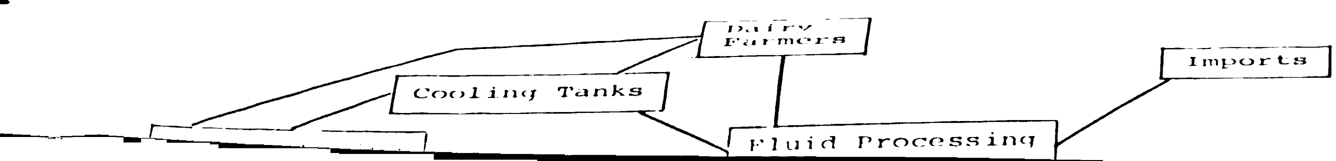
[12] The assembly and transporation of raw milk from farm to plant is made in several ways (48). In some cases, the farmer takes his product to the plant by his own means; in other cases, dairymen collectively organize the assembly and transportation (in such cases it is quite normal that the farmers group have its own assembly center to which each farmer takes his product). Milk is transported either in cans or isotermic tanks. Most of the times, however, it is the plant which picks up the milk from farms or assembly centers and transports it in cans or tanks to its receiving room. Finally, in zones where production is widely scattered and output per farmer is low (Galicia, Oviedo, Santander), a "recogedor" gathers the milk of several farmers and takes it to the plant or assembly center for a fee (averaging 0.15 pesetas per liter for 1973). Assembly and transportation costs from farm to plant vary with the dispersion of production, width of assembly zone, number of pick-ups per day, etc. Assembly costs reached, in the most favorable cases, from 0.20 to 0.25 pesetas per liter and, in the most extreme ones (Galicia), up to 0.70 pesetas per liter in 1973 (48).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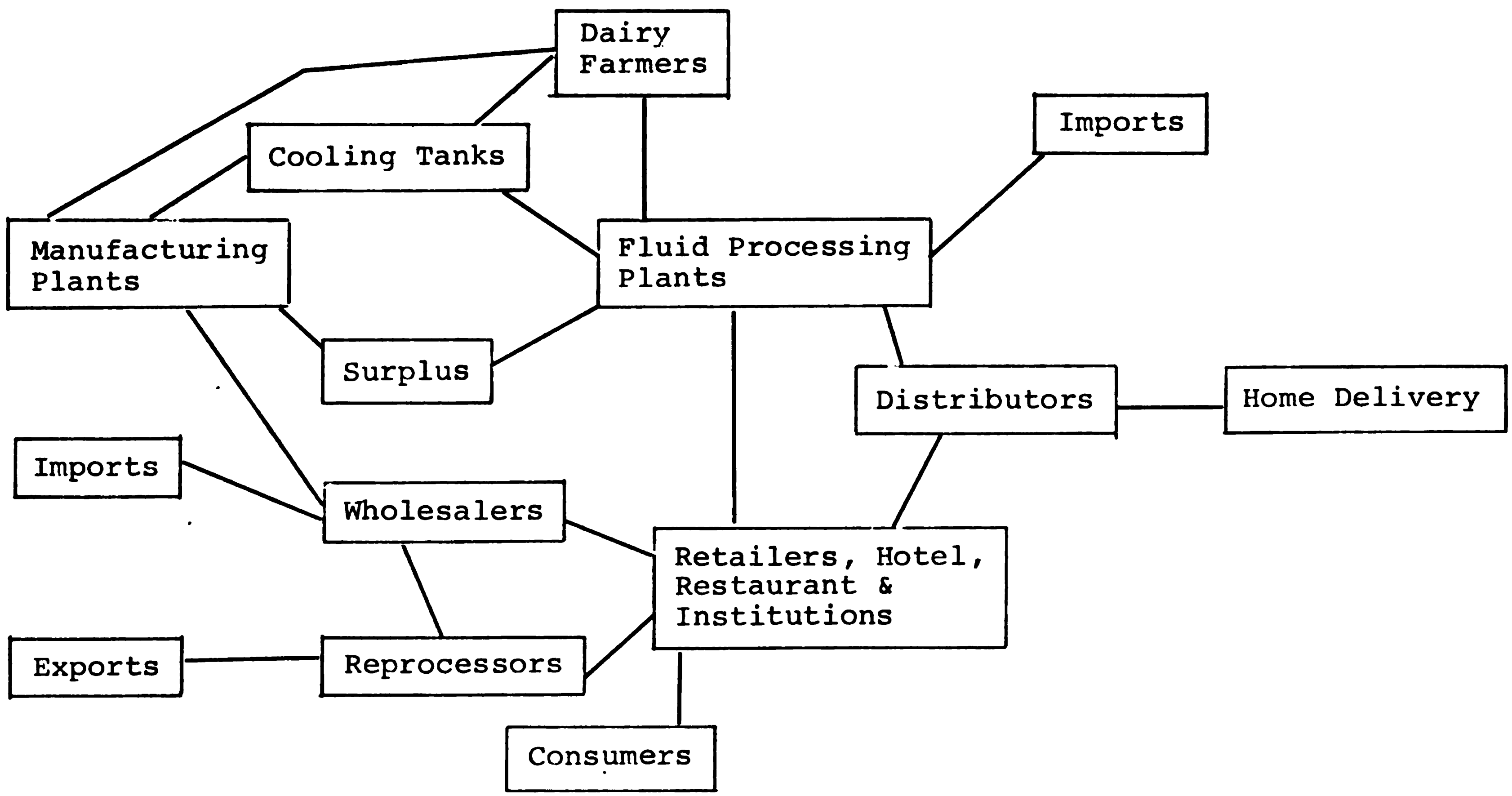

Figure 2. Marketing Channels for Fluid Milk and Dairy Products.

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certified milk, although the latter probably includes some raw milk. Cooling tanks, distributors and home delivery are relatively insignificant.

Structure of the Fluid Milk Industry of Spain

In a recent paper, Manchester has noted that in most empirical studies of market structure, conduct and performance, it is necessary to compare different industries since most are organized on a national basis. The fluid milk industry, however, is organized on a more local basis and presents an excellent opportunity to study the interrelationships between market structure and performance (40).

Fluid milk markets in Spain are local in nature. While in recent years improved highways, larger payloads, new refrigeration equipment and the increase in the proportion of sterilized milk processed have significantly broadened local markets, most fluid milk is still transported relatively few kilometers due to high transportation costs caused by the weight and volume of the milk relative to value and, in the case of pasteurized milk, to existing regulation, high perishability and the expense of refrigeration equipment needed to handle it.

Types of Products

According to present regulations (5), milk intended for fluid consumption in Spain can be: (1) Natural milk; (2) Certified milk; (3) Hygienized milk; or (4) Sterilized milk.

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Natural milk is the "whole product, neither altered nor adulterated and without calostrum, of the hygienic, regular, complete and uninterrupted milking of healthy and well fed cows" (5).[13]

Certified milk is "that proceeding from licensed (or of proven sanitary conditions) farms, registered in the Ministry of Agriculture (General Directorate of Livestock) in which the processes of production, milking, bottling and distribution are subject to a rigorous official sanitary control which guarantees the innocuousness and nutritive value of the product" (5).[14]

Hygienized milk is the "natural milk subjected to a process of heating in such conditions of temperature and time which insure the total destruction of the pathogenic germs and almost the totality of the banal flora, without

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[13]The natural milk, when delivered to the consumer or processing plant, must have the following characteristics: Fat, minimum 3.1 percent; Lactose, minimum 4.2 percent; Protein, minimum 3.1 percent; Ashes, minimum 0.65 percent; Nonfat dry matter, minimum 8.2 percent; Macroscopic impurities, maximum degree 1 (of the scale of impurities); Acidity, maximum 0.2 percent (weight of lactic acid per 100 of milk in volume); and Proof of the reductase with blue of metylene, more than two hours ([5], article 6, as modified by [6]).

[14]Certified milk, when delivered to the consumer must have, in addition to the characteristics of natural milk, the following: Macroscopic impurities, degree 0; Acidity, maximum 0.19 percent; Proof of the mycrobian reductase with blue of metylene, more than five hours (5, Art. 18).

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sensible modification of its physiochemical nature, biological characteristics and nutritive quality" (5).[15]

Sterilized milk, finally, is the "natural milk subjected to a process of heating in such conditions of temperature and time which insure the destruction of germs and the inactivity of their resistance forms" (5).[16]

For the purpose of this study, however, only hygienized (pasteurized and sterilized) milk, in which there are processing operations involved, will be considered.

Shipments of Fluid Milk Products

Processed fluid milk products include pasteurized milk (which can be packaged in glass bottles, plastic bags or paper packages with capacities of one liter, half liter and quarter liter) and sterilized milk (which can be packaged in glass bottles and tetraedric and prismatic paper packages with capacities of one liter, half liter and quarter liter and plastic bottles with capacities of one and one-half liter, one liter and a half liter).

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[15]Hygienized milk, when delivered to the consumer must have the characteristics given for natural milk, with the following differences: Impurities, degree 0; Acidity, maximum 0.19 percent; Number of colonies per mililiter of milk, less than 100,000; Germs of Escherichia Aerobacter group in 0.1 mililiter of milk, absence; Proof of the phosphatase, negative (5).

[16]Sterilized milk, when delivered to the consumer, must have, in addition to the general characteristics of composition of natural milk, the following: Protein, minimum 3.0 percent; Nonfat dry matter, minimum 8.1 percent; Macroscopic impurities, degree 0; Acidity, maximum 0.19 percent; Alive germs in one mililiter of milk, after incubation at 37° and 55°C during 48 hours, absence (5, Art. 30).

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The value of shipments of fluid milk products by processing plants is estimated to have totaled about 37.5 billion pesetas in the 1973-74 marketing year. Shipments of fluid milk products are made from plants classified as Fluid Milk Processing Plants (Centrales Lecheras) and from specially authorized Dairy Manufacturing Plants (5, Art. 64). Only about two percent of the total value is estimated to have come from such other plants.

Numbers and Types of Firms

The form of business organization affects industry conduct and performance in various ways. In the fluid milk industry, for example, large multi-unit firms with geographically dispersed operations may have competitive advantages, as compared with firms operating in only one or a few markets. In addition, corporations and some cooperatives may have advantages over individual proprietorships and partnerships in obtaining capital, e.g., and these may affect their operation.

On March 1, 1974, fifty-one firms, operating fifty-eight plants, were engaged in the processing of fluid milk products (Table 10). Only four of these firms could be considered more than local in the scope of their fluid milk operations. These four firms, representing less than eight percent of the total processors, operated almost twenty percent of the plants and accounted for more than thirty

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Table 10. Number of Firms Operating Fluid Milk Processing Plants, by Type of Firm, Spain, March 1974.

	Firms		Plants Operated	
Type of Firm	Number	Percent	Number	Percent
Corporations	28	54.9	35	60.3
Cooperatives	13	25.4	13	22.4
Syndical Groups	5	9.8	5	8.8
Individually owned	2	3.9	2	3.4
Limited Partnership	1	2.0	1	1.7
Municipal (Leased)	1	2.0	1	1.7
Other Associations	1	2.0	1	1.7
Total	51	100.0	58	100.0

Source: Ministerio de Agricultura, Spain. Relación de Centrales Lecheras.

percent of total sales (Table 11). All of them were corporations.

Local proprietary single plant firms accounted for more than fifty-six percent of total firms, operated half of the plants and accounted for more than a third of total sales. More than eighty percent were private corporations.

Farmer cooperatives and Syndical Groups accounted for about thirty-five percent of the firms and operated thirty-one percent of the plants. All of them were single plant operations. Farmer cooperatives and Syndical Groups together accounted for about one-fourth of total sales.

Table 11. Companies, Plants and Annual Fluid Milk Sales by Type of Firm: Spain
March 1974.

Type of Firm	Companies	Plants	Percentage of Total		
			Companies	Plants	Total Sales
National [illegible]	4	11	7.9	19.9	31.4

Table 11. Companies, Plants and Annual Fluid Milk Sales by Type of Firm. Spain March 1974.

			Percentage of Total		
Type of Firm	Companies	Plants	Companies	Plants	Total Sales
National					
Corporations	4	11	7.9	19.9	31.4
Local					
Proprietary					
Corporation	24	24	47.0	40.4	33.4
Individually Owned	2	2	3.9	3.4	3.6
Limited Partnership	1	1	2.0	1.7	2.6
Association	1	1	2.0	1.7	1.8
Municipal	1	1	2.0	1.7	1.1
Coops and S. Groups					
Cooperatives	13	13	25.4	22.4	17.4
Syndical Groups	5	5	9.8	8.8	8.5
Total	51	58	100.0	100.0	100.0

Source: Elaborated by the author from confidential information.

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Number of Size Distribution of Plants

On March 1, 1974, fifty-eight plants were engaged in the processing of milk intended for fluid consumption (54). Fifty four were classified as Fluid Milk Processing Plants and the other four were Dairy Manufacturing Plants authorized to sell pasteurized milk under Art. 64 of the present regulation (5 as modified by 6). Eleven additional plants were under construction at that time.

The approximate distribution of Fluid Milk Processing Plants in the different size groups is indicated in Tables 12 and 13.

Market Shares

Data on market shares for the nation, as shown in the last column of Table 11, have limited usefulness, even in a country of the size of Spain, in appraising competitive behavior because the relevant market is not that large. For fluid milk, the size of the market geographically is limited by the bulk of the product. In addition, perishability and existing regulations make the relevant market for pasteurized milk a city or a territory of a few kilometers in radius from the plant, while that for sterilized milk is theoretically the whole country.

Data are not available on all competitors within the relevant markets. Potential competitors should be included with those physically located in the market.

Table 12. Number o
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Volume
Less than 10,000
10,001-25,000
25,001-50,000
50,001-100,000
100,001-200,000
200,001-300,000
More than 300,001
Total

Source: Minister
Centrale

Table 13. Number
In Lit

Volume
10,000-25,000
25,001-50,000
50,001-100,000
100,001-200,000
200,001-300,000
300,001-400,000
More than 400,0
Total

Source: Elabor

Table 12. Number of Plants, by Minimum Authorized Processing Capacity, in Liters per Eight-hour Workday. Spain March 1974.

Volume	Number of Plants	Percentage
Less than 10,000	3	5.2
10,001-25,000	13	22.4
25,001-50,000	23	39.7
50,001-100,000	16	27.6
100,001-200,000	1	1.7
200,001-300,000	1	1.7
More than 300,001	1	1.7
Total	58	100.0

Source: Ministerio de Agricultura, Spain. Relación de Centrales Lecheras.

Table 13. Number of Plants, by Actual Processing Capacity, In Liters Per Day. Spain 1974.

Volume	Number of Plants	Percentage
10,000-25,000	10	17.2
25,001-50,000	11	19.1
50,001-100,000	15	25.9
100,001-200,000	13	22.4
200,001-300,000	7	12.0
300,001-400,000	1	1.7
More than 400,001	1	1.7
Total	58	100.0

Source: Elaborated by the author.

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Product Differentiation

Product differentiation refers to any action taken by a seller to induce customers to view his product as being distinct from those of his competitors with the end of insulating himself from the actions of these competitors. Within this framework, product differentiation may take many forms, including physical product differences, container differences, branding and advertising and the differentiation of services which are accessory to the product itself. Examples of these various forms of product differentiation are fat content, level of non-fat solids, homogeneization, size of container (one and one-half liter, liter, half liter, quarter liter, etc.), packaging material (glass or plastic bottles, plastic bags, tetraedric and prismatic paper packages, etc.), radio, T.V., newspaper, billboards, signs, etc. advertisement, general and in store promotion, wholesale delivery services, hours open, credit conditions, service to customers, etc.

Physical product differences are probably the least important of the various types of product differentiation used by fluid milk sellers in Spain. However, potential for increased product differentiation of this type is present, as diet conscious customers will surely increase their demand for low-fat fluid milk products.[17]

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[17]The sale of sterilized milk or lower fat content is authorized, indicating on the label "low fat" and the fat percentage if between one and three percent, or "skim" if lower than one percent.

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Fortification with vitamin D could also be used for purposes of product differentiation.

Variations in container sizes and container types have been more extensively used for differentiation. The introduction of new types of containers has been important as a competitive device. Single service containers, which reduced the bottle return problem for both sellers and consumers and reduced weight and bulk of loads have been important in the expansion of markets. Container policy, moreover, may affect operating costs because of important economies of scale in packaging milk. Higher volume containers can be expected to receive increased attention in the near future among fluid milk sellers in Spain as a means of product differentiation.

Advertising in the fluid milk industry of Spain is at relatively low levels, except for generic promotion by government agencies and some advertising by large national firms. One important aspect of brand differentiation observed in Spain is the tendency to keep using the old labels after mergers or changes of ownership of processing firms have taken place. Differentiation of services is also at a low level.

To summarize, limitations imposed by sanitary regulations, definition of identity and other legal constraints seem to make fluid milk products quite homogeneous. Potential for more product differentiation, however, does

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seem to exist among fluid milk processors and could be important in determining market conduct and performance in the near future.

Barriers to Entry and Exit

Barriers to entry and exit are important characteristics of the market structure in the fluid milk processing industry. The general types of barriers to entry found in the fluid milk market are institutional barriers and economies of size. Product differentiation, on the other hand, cannot be considered at this point an important barrier to entry.

The effects of institutional barriers to entry and exist are probably the most important. Some of the barriers to entry affecting the fluid milk industry are plant licensing requirements and product and sanitary ordinances and they will be analyzed in some detail in the next section. To a lesser extent, established relationships in markets between existing sellers and buyers also constitute an institutional barrier to entry.

Economies of size in the processing, distribution and promotion of fluid milk products does not seem to constitute an important barrier to entry in Spain at the present moment. Although, as it will be shown in Chapter IV, unit costs in fluid milk plants decline with increasing volume until an output of 360,000 liters per day is reached, large majority o

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a large majority of the fluid milk plants in Spain are below the minimum size needed for efficient operation (see Table 13). Government regulation would appear to account for this.

Economies of size in distribution and promotion, on the other hand, are not well established on empirical grounds, but there does not seem to exist a necessary relationship between size of plant and economies of distribution.

Vertical Coordination and Integration

According to Marion, Vertical Organization refers to the structural anatomy of a subsector and includes "the functions that are performed, the number of stages, the propietary and authority structures, and the institutions and arrangements that are an integral part" (41, page 3). Vertical Coordination, on the other hand, is a process which refers to "those activities that integrate and synchronize the functional inputs of subsector members, so that the subsector in total responds to market demands" (41, page 3). Vertical Integration, finally, provides one of various mechanisms for "adjusting the scope of functions performed by firms at different stages so that they are in line with the new economic conditions" (41, page 5).

Vertical coordination in the dairy subsector of Spain is facilitated through producer or cooperative agreements with handlers of various sorts, government regulation nd information tra

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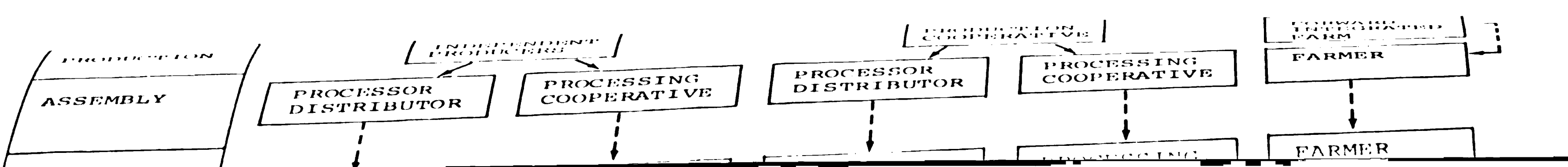
and information transfer, support measures, and others. Figure 3 displays the most common arrangements existing in the dairy subsector for product transfer (both physical and legal) as it moves through the six functions in the marketing channel.

Integration among sellers can be vertical and horizontal. In the first case it can be either forward (integration by producer cooperatives into processing and by processors into the operation of retail stores), or backward (integration by food retailing groups into processing and even dairy farming). Vertical integration in the dairy subsector of Spain into processing and distribution of processed fluid milk and other dairy products is most prevalent among cooperatives. On the other hand, integration by processors into retailing is practically non-existent.

Finally, with respect to horizontal integration (which has less to do with a firm's market power than does vertical integration), eleven plants in Spain were operated by four multi-plant companies in 1974, an average of less than three plants per multiplant company, and less than twenty percent of total processing plants.

Government Regulation

The Spanish Government regulates the Fluid Milk Subsystem in many ways. The basic administrative regulation is the Regulation of Fluid Milk Processing Plants and



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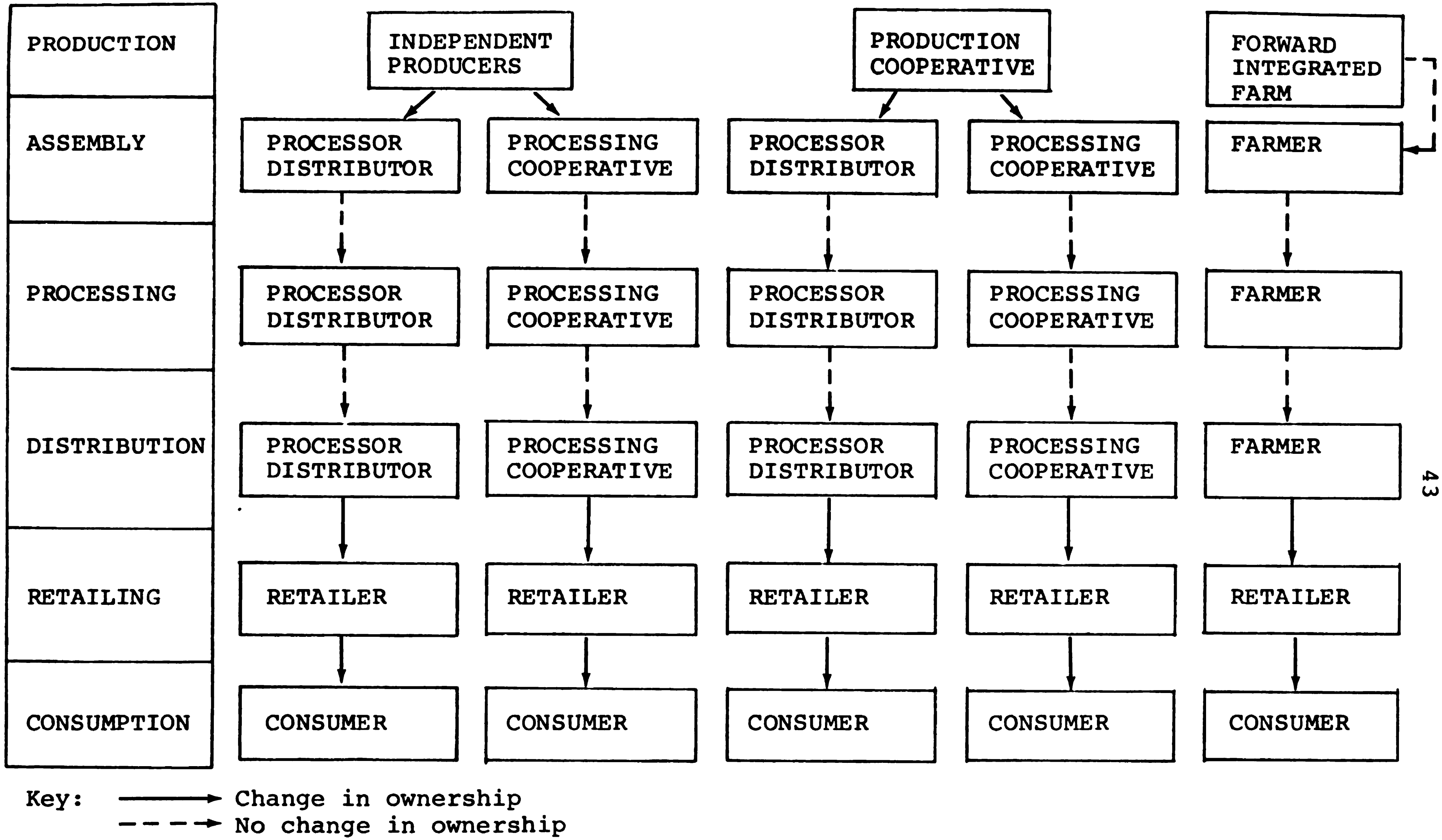

Figure 3. Product Transfer Arrangements in the Spanish Dairy Subsector.

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Other Dairy Industries (5) already mentioned. The four basic aspects of government regulation in Spain that will be described at this point are: (1) Sanitary Regulations; (2) Plant Licensing; (3) Producer Prices; and (4) Resale Prices.

Sanitary Regulations

Sanitary regulation of milk is based on the need to protect the public health. Milk is of primary importance in the diet, especially for children, given its content in proteins, lipids, carbohydrates, vitamins and minerals--especially calcium. By its own richness in nutritive substances, milk is an appropriate medium for the development of all kinds of micro-organisms and special handling is required to avoid transmitting pathogenic micro-organisms to the consumers. The need for sanitary regulation of milk supplies and processing is now universally recognized.

Parts I (General), II (Milk for direct consumption) and III (Preserved milk) of the Regulation (5) define the different types of milk and their characteristics as well as the requisites for their production. Changes in this regulation have been made by Decrees 544/1972 (6) and 758/1974 (8).

Part IV (Hygienization Plants) established the implantation of the system of compulsory hygienization of milk in every population nucleus, with high priority for more populated

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Plant Licensing

In Spain, permits are required for the operation of fluid milk plants. Part IV of the Regulation (5) defines the functions of the processing plants, the required technological conditions, the minimum processing capacity, licensing requirements, etc. Eleven articles and parts of five others of the original regulation have been modified posteriorly.

The issuance of licenses is generally restricted in the geographical area in which a plant is permitted to serve. Usually, only the plants authorized to serve a particular market are permitted to sell pasteurized milk within it.[18] Such restrictive licensing practices constitute a barrier to entry or to market expansion.

Producer Prices

Prices paid to producers for their milk are also regulated by the government. Originally, Part V (Milk

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[18]At the same time, no major restrictions are imposed on the sale of sterilized milk, which can help to explain the increasingly higher percentage of total processed milk that is sterilized (sixty percent at present) instead of pasteurized.

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Prices) of the original Regulations of Fluid Milk Processing Plants and Other Dairy Industries (5) dealt with minimum producer prices, pricing of milk in accordance with its quality, etc. Minimum producer prices were proposed every year "considering the real costs of production and by zones of similar ecological, edaphic and farming characteristics" (5, page 12697). These criteria ran counter to the specialization of the different provinces in the products in which they had a comparative advantage and created several problems, since the differences in costs of production did not necessarily coincide with the transfer cost between them. This part of the regulation was superseded by Decree 3520/1974 of December 20 (9), which will regulate the dairy marketing years 1975-76, 1976-77 and 1977-78. The new pricing regulation establishes two different marketing periods and the criteria for determining minimum producer prices (based on "interprovince transportation factors"), pricing of milk in accordance with its quality, indicative and intervention prices, location differentials, maximum selling prices for pasteurized and concentrated milk at plant and retail levels, etc. The regulation also establishes measures of protection to milk producers, import coordination, etc. Complementary norms are to be established annually. Decree 3521/1974 of December 20 (10) for example, established the complementary norms for the dairy marketing year 1975-76.

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Resale Prices

Wholesale and retail resale prices are also regulated for some fluid milk products. Maximum resale prices for hygienized and concentrated milk for the 1975-76 marketing year have been established by an order published on the Boletin Oficial del Estado on January 31, 1975, according to what was anticipated by Decree 3520/1974 of December 20 (9). The country was divided into seven zones with different prices for the two periods (February 1-August 31 and September 1-February 29, 1976) and different maximum prices were fixed for pasteurized milk packaged in glass and plastic bottles, tetraedric and prismatic paper packages and plastic bags of different capacities, as well as for glass-bottled concentrated milk.

Performance of the Fluid Milk Subsystem

The starting fundamental assumption is that what the Spanish society wants from the fluid milk subsystem is good performance. Performance is considered recognizing that a perfectly competitive economy probably cannot be achieved in practice and that even if this were possible, it might not be desirable. Instead of perfect competition, the accepted goal has become "workable" competition. As defined by Markham: "An industry is judged to be workably competitive when, after the structural characteristics of its markets and the dynamic forces that shaped them have thoroughly e

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been thoroughly examined, there is no clearly indicated change that can be effected through public policy measures that would result in greater social gains than in social losses" (42).

Value judgements in the appraisal of market performance begin with the selection of a set of performance criteria. Criteria that are considered important for the fluid milk subsystem include efficiency, progressiveness, product suitability, participants rationality, adequate levels of output, and absence of misregulation.[19]

Efficiency

Decisions as to what, how much and how to produce should be efficient both in the use of available and potential resources within each firm and in the allocation of resources among different firms. Production is considered to be efficient when maximum output is obtained with minimal resource input.

The main standard of production efficiency is the measurement of how well firms in the different vertical

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[19]Other aspects of market performance usually identified are: Adequate levels of profits and promotion expenses, absence of bad externalities, equity, full employment, conservation, good labor relations, absence of unfair methods of competition, etc. Some of these traditional aspects of performance, however, do not seem to be relevant or important in the fluid milk subsystem of Spain. Promotion expenses, for example, are at such low levels that they do not appear to be of major importance in appraising market performance. Externalities, including those involved in solid waste container disposal

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levels of the subsystem approximate the lowest practically attainable real costs for the output they produce and/or distribute. A good static framework for measuring costs and analyzing the production efficiency of individual firms is now available (see French, 23) and methodological approaches to cost measurement are also well established, with economic engineering emerging as the most powerful, effective and widely used method. With respect to the measurement of the production efficiency of an industry as a whole, methods of solving programming problems required to determine optimum numbers, sizes and locations of facilities within market areas have also developed rapidly in recent years. An attempt to measure production efficiency in the fluid milk subsystem will be made in the following chapters, and, therefore, a discussion of this performance dimension will be postponed until Chapter VII.

In addition to production efficiency, efficient transfer of goods from producers to consumers is essential for the maximization of satisfaction and resource use. Several standards that are usually accepted are: (1) Price formation and the pairing of buyers and sellers should not be unreasonably costly; (2) price flexibility should not

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problems and water pollution problems do not seem to warrant study at this time. Conservation of non-renewable resources does not appear to be a performance issue in the fluid milk subsystem either. On the other hand, it was not possible to deal directly with profit levels, equity, full employment and labor relations as facets of market performance in this study.

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generate costly search for information or inefficient accomodation for uncertainty; (3) prices should be high enough to avoid excess demand and low enough to avoid undesirable stock accumulation; (4) transportation costs should not be persistently and needlessly large; and (5) economic facilities should exist at assembly points (26).

Exchange efficiency is rather difficult to appraise in the fluid milk subsystem. Producer and resale prices, for example, are based on minimum and maximum prices, respectively, under government regulation. Since the fluid milk market is strongly regulated by the government, exchange efficiency does not appear to be a major consideration in evaluating performance.

Progressiveness

The operations of producers in the fluid milk subsystem should be progressive, taking advantage of inventions and innovations for both "increasing output per unit of input and making available to consumers superior new products" (64, page 4). Since the ideal level of progress is probably indeterminable, however, precise evaluation of progressiveness cannot be attained. Nevertheless, some unquantified criteria that could be used to appraise the progressiveness of the fluid milk subsystem are (1) There should be no missinvestment, i.e., "optimum" plant and equipment sh

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Again, the first point will be discussed at a later chapter. With respect to the other aspects, since 1966 a relatively large number of changes in container types and sizes, products and services have been introduced in the fluid milk subsystem and have persisted. They were, in fact, innovations when they were introduced. The "test" of the marketplace, therefore, seems to indicate that the fluid milk subsystem of Spain is fairly progressive, with no indication of suppressed innovations and some evidence of adequate diffusion of technological information.

Product Suitability

The general quality and kinds of goods produced should strike a balance between the variety and price most desired by consumers. The possibilities that consumers would rather pay higher prices in order to gain improvements in quality or variety or that they might prefer to sacrifice some of both in order to receive cheaper products are indeed relevant.

Several standards derived from this criterion are: (1) sellers should not suppress product inventions nor persistently offer less than maximum quantity available at given costs; (2) worthless or troublesome differences in products sh

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products should not persist without good reasons; and (3) sufficient product variety should be available (26, page 34).

Two causes of concern with respect to product suitability in the fluid milk subsystem of Spain are: occasional frauds and adulteration of products, and production of an amount of sterilized milk which is probably beyond what is needed, at the expense of pasteurized fluid milk products.

The most common causes of fines to fluid milk processing firms, periodically announced by the General Directorate of Commercial Information and Inspection of the Ministry of Commerce, are the sale of milk with lower content in protein, nonfat dry matter, etc. than required, or of fluid milk products with glucose, water and other substances added.

The proportion of sterilized milk produced, estimated at about sixty percent of total processed milk, is considered to be excessive. Weighed against the obvious advantages of sterilized milk products (its long duration and the fact that it needs no refrigeration) are its higher cost and lower quality (specially in terms of flavor, vitamin content, etc.). Although the existence of sterile fluid milk products is considered to be important from the viewpoint of product suitability, these high proportions of sterilized milk produced should not persist.

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Participant Rationality

Participant should have a reasonable opportunity to be well informed and should exercise freedom of choice rationally in their own interest. Aids to participant rationality from the viewpoint of information include a common terminology, standard weights and measures, common packaging standards, product descriptions and price posting.

At present, there is widespread lack of consumer education with respect to fluid milk products in Spain. Most consumers fail to perceive pasteurized and sterilized milk as different products and, when they are, sterilized milk is generally considered better (basically because of its higher price). Some consumers still boil the processed fluid products they purchase.

A certain amount of advertising devoted to informational purposes directed towards helping the consumer to make a reasoned selection among alternatives is essential to the effective working of the fluid milk subsystem.

Output Levels

Output should be "consistent with a good allocation of resources" (1), and should not be "deliberately restricted so as to raise prices, ensure unjustifiable profits and raise the level of expenditures by consumers" (71).

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At present, it is estimated that less than seventy percent of the commercialized milk that is consumed in fluid form is processed. While there is no evidence of deliberate restriction of output, it is considered that the system of hygienization of milk could be easily extended to the totality of fluid milk supply with no increase in unit costs, through appropriate actions.

Misregulation

Government action or inaction that fosters inefficiency should not exist (71).

Government intervention in the fluid milk subsystem was briefly described in a previous section. The Regulation established by Decree 2478/1966 of October 6 (5)[20] has been progressively corrected and modified during the last few years" in such a way that it was possible to correct the maladjustments of all kinds that appear with relative frequency in the sector" (7).

Critical analyses of some aspects of the regulation of the Spanish milk market have been made recently by Caldentey (13, pages 61-71) and Diez-Patier (21, pages 36-43).[21]

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[20]It replaced the Decree of April 18, 1952 which provided for the creation of the fluid milk processing plants and the Order of July 31 of that same year approving the Regulation developed in the previous Decree.

[21]The establishment of location differentials in producer prices based on real costs of production were probably the main source of criticism. In these two papers,

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The main aspects of possible misregulation still present in the fluid milk subsystem are: (1) the minimum processing capacity established by the regulation, 25,000 liters per day, seems to be too low to allow efficient operation; yet, even smaller plants are exceptionally authorized. This is resulting in the construction of an excessive number of plants which are unable to supply processed milk to all the country at present levels of consumption; (2) the restrictive licensing practices constitute an important barrier to entry. Once a plant is established in a geographical area, it is relatively difficult for a new plant to be authorized; (3) the restrictions with respect to the geographical area in which a plant is permitted to sell pasteurized milk causes less than optimum processed milk movements to take place and contribute to an increased production of sterilized milk, beyond the amount that is needed; (4) the establishment of producer price location differentials without taking into account processing costs, contributes to less than optimum milk movements; (5) the establishment of maximum resale prices for regulated products based on processing costs of plants of relatively small capacity (25,000 to 35,000 liters per

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a system of location differentials based on transportation costs and supply-demand conditions was proposed. Even though these studies dealt with different marketing years and used different sources of data, the results were quite similar. A system analogous to the one proposed in both papers has been established for the first time in the 1975-76 dairy marketing year (9).

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Performance Summary

The sketchy information available suggests that, on the whole, the fluid milk subsystem of Spain has been progressive in recent years. On the other hand, the fluid milk product mix offered to consumers does not seem to be adequate and lack of consumer information, inadequate output levels and elements of possible misregulation seem to be present.

While the evaluation of the fluid milk subsystem is no doubt partial and can only be considered as preliminary, there seems to be substantial room for improvement.

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CHAPTER III

METHODOLOGICAL PROCEDURES

This chapter presents the basic economic, mathematical and computer models underlying the problem to be investigated, and briefly describes the analytical procedure that will be followed. Some of the necessary simplifying assumptions are also stated.

Efficient Organization Within Market Areas

Research dealing with efficient organization of marketing subsystems generally focuses on the determination of optimum assembly and distribution patterns and optimum number, size and location of marketing facilities. The overall problem has been tackled basically in two ways. One group of models treats space as continuous for purposes of defining optimal marketing areas for individual plants, while another group assumes discontinuity of space.

The continuous approach was first used by Olson (58) in a study of milk assembly. Another early example of this approach is the study by Williamson (81), which provided a more general spatial equilibrium framework for plant location.

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Two crucial assumptions, that uniform marketing exists in each producing area (page 953), and that a constant relationship exists between air and road distances (page 954) were made by Williamson. Under these and other fairly heroic assumptions and "ignoring nonuniformity of terrain and nonuniformity or discontinuity in transportation facilities, assembly costs will be minimized by assembling any given quantity of commodity from a circular supply area" (81, page 954).

In the continuous approach, therefore, the problem of plant location is essentially assumed away. Once the market circle is constructed, a single plant firm or industry would find its optimal location at the center of that circle. The multiplant solution for optimal location would be only slightly more difficult. The continuous approach, then, does not seem to be suited for this research, the major difficulty being that supply and demand densities are not uniform and supply and demand areas are not regular and continuous in shape.

The alternative to the continuous approach is to group supply and demand areas into a finite number of point locations and to consider some predetermined set of potential plant sites. One of the first studies using this discontinuous approach was the one by Stollsteimer (74). The Stollsteimer model was developed to answer practically the same questions that this study attempts to answer: "How many plants should we have? Where should our plants be loca

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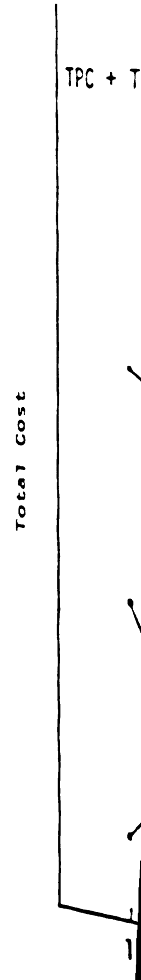
plants be located? How large should each plant be? Where should the raw material processed in each plant be obtained? What customers should be serviced by each plant?" (74, page 631). Stollsteimer's model, however, did not consider assembly, processing and distribution costs separately, but only processing and either assembly or distribution costs (or both as a composite function).

The essence of the Stollsteimer model can be expressed graphically as in Figure 4. Total (or plant) processing costs, TPC, and total transportation (assembly or distribution) costs, TTC, are calculated and then added; the lowest point of the total cost curve gives the minimum cost solution. Four different cases are dealt with in Stollsteimer's paper. These include two cases of economies of scale (one where plant costs are independent of plant location, another where plant costs vary with location) and two similar cases without economies of scale. Finally, the paper reported the effects of technical change and output expansion on the optimum number, size and location of pear marketing facilities in a fairly homogeneous California pear producing region.

The Stollsteimer model was posteriorly modified by Polopolus (59), Chern and Polopolus (14), Warrack and Fletcher (78) and Ladd and Halvorson (36). Polopolus extended the model to include multiple product plants. Chern and Polopolus substituted a discontinuous plant function for a continuous one, made an explicit distinction



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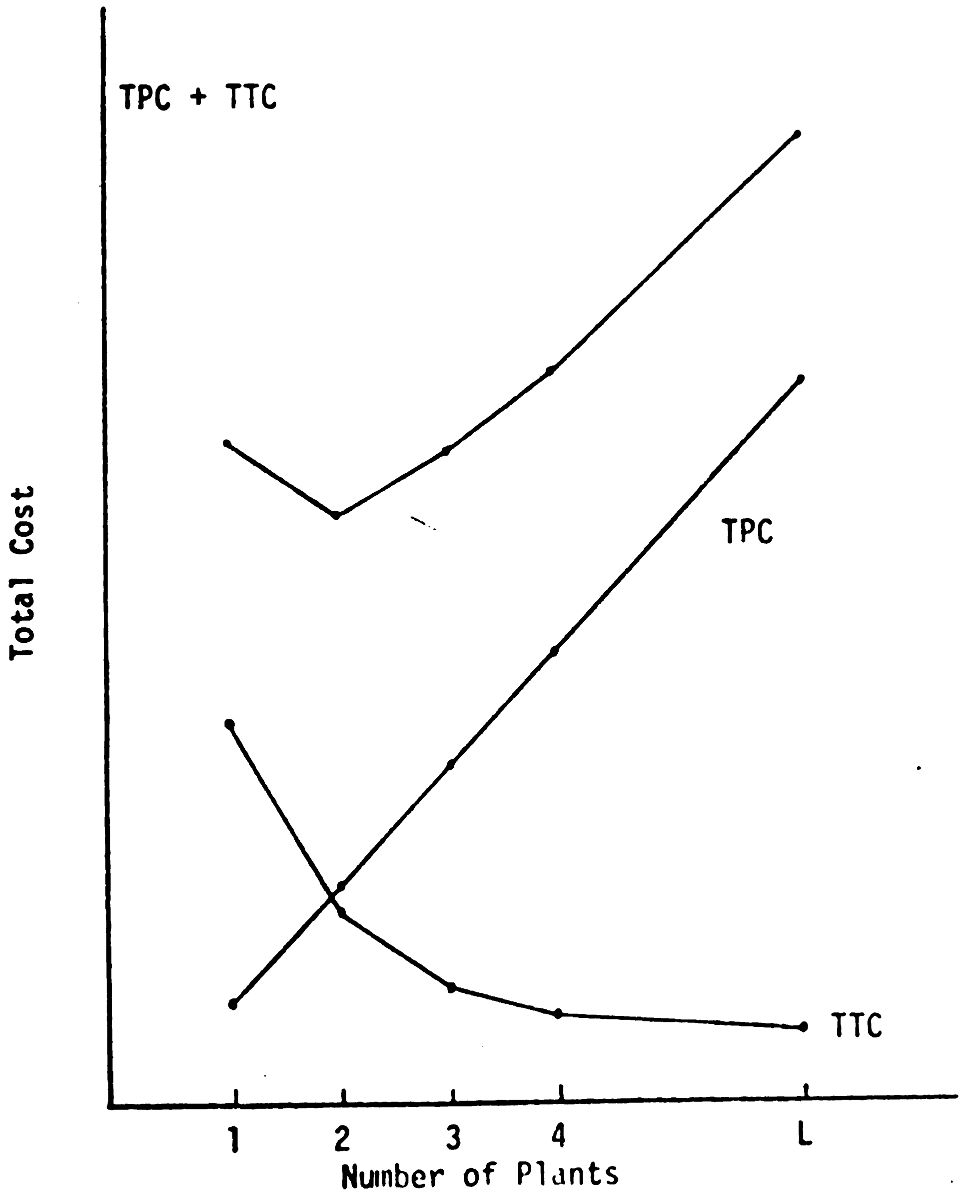

Figure 4. Stollsteimer's Model.

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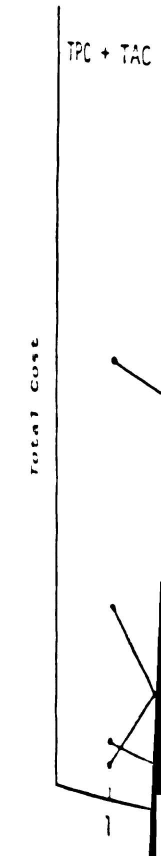
between plant numbers and plant locations, introduced their maximum plant size concept and measured excess plant capacity by optimal solution. Warrack and Fletcher incorporated a suboptimization technique to solve large problems using the Stollsteimer model, and Ladd and Halvorson presented a procedure for determining the sensitivity of a Stollsteimer model solution and the effects of continuous change in the parameters of the minimum cost solution.

The main difficulty with Stollsteimer's model is its inability to handle both assembly and distribution cost functions. Where it is necessary to incorporate both functions one approach has been to use a transshipment model instead. King and Logan were among the first to apply this transshipment approach to agricultural marketing in a study of livestock slaughter plant location (34). Assembly, processing and distribution cost functions can be calculated separately with the simplest method available and aggregated in a manner almost identical to the one used by Stollsteimer, as it can be seen in Figure 5.

The transshipment model was also extended posteriorly by Hurt and Tramel (32) and Leath and Martin (37). Hurt and Tramel further developed the model to handle more than one plant at each level and more than one final product. Leath and Martin extended the model to include inequality restraints. A procedure for testing the sensitivity of the model to change in cost elements of the model (especially



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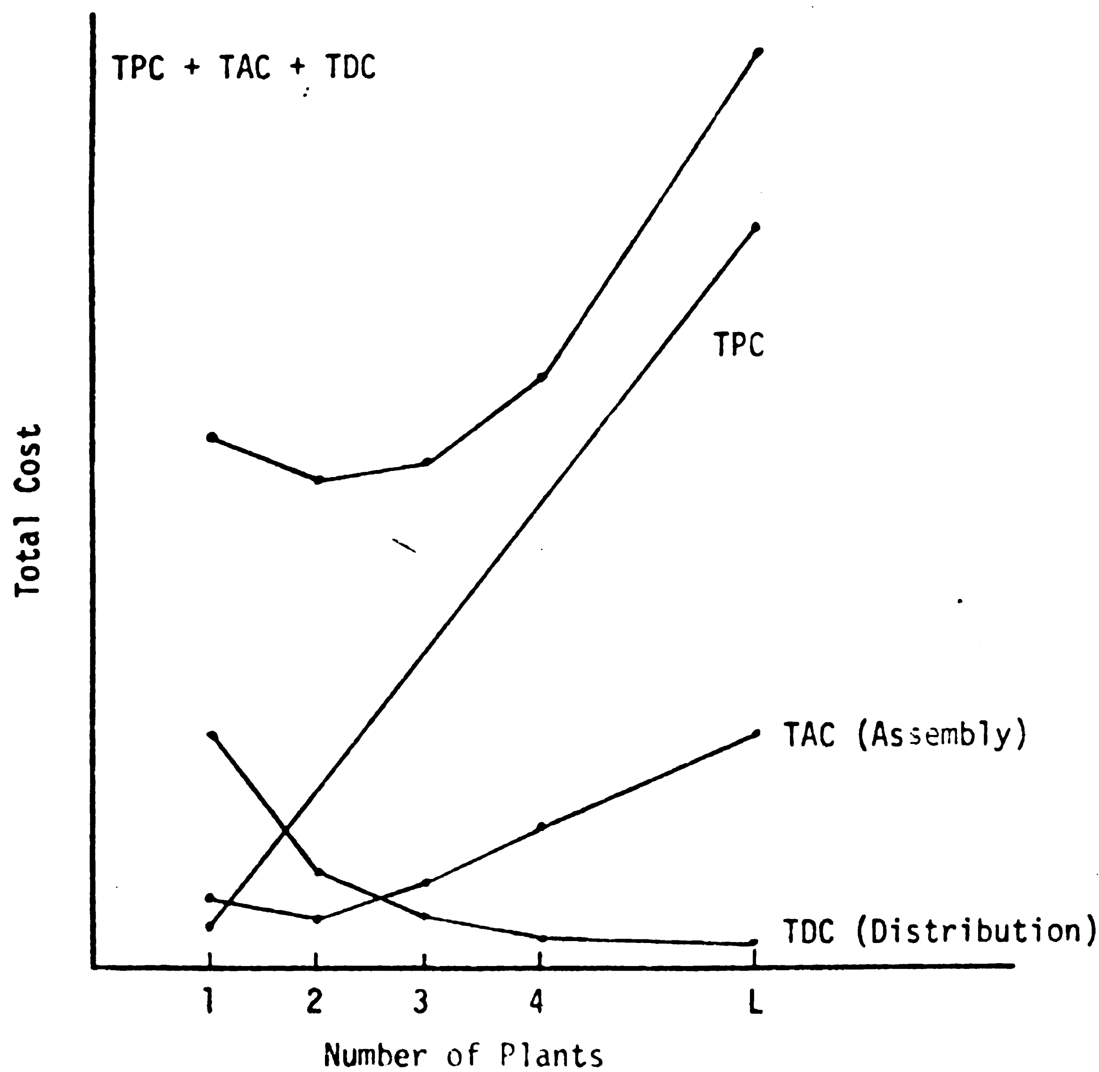

Figure 5. Total Cost Minimization Model.

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Chapter I.

processing costs) was developed by Toft, Cassidy and McCarthy (76). Examples of applications of the transshipment model dealing with fluid milk plant location include a study in Washington by Bobst and Waananen (3) and another in Colorado by Tung, Reu and Millar (77).

Other variants of linear and nonlinear programming procedures have also been used to solve this type of problem. In the case of milk, again, separable programming, for example, has been used in a study of optimum dairy plant location in the U.S. by Kloth and Blakley (35).

The Theoretical Model

Experience with the models developed to date to solve the overall problem concerning assembly and distribution patterns and number, size and location of plants suggests, as French has pointed out, that "the best choice of method may vary with the characteristics of the individual problem" (23, page 93). Considering the scope of the proposed study and the resources available for it, it was considered that an optimum number, size and location linear programming design model for fluid milk processing plants that will show how a significant part of the fluid milk subsystem of Spain might be reorganized to reduce costs and expand output, will provide an acceptable test for the four basic hypotheses that were established in Chapter I.

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The Economic Model

The economic organization of a system concerned with processing plants involves the simultaneous consideration of three main components of total cost: (1) The costs of collection from scattered origins to the processing plants; (2) the costs of plant operation; and (3) the costs of transportation from plant to market (12, page 141). The cost minimization model underlies most plant location analyses aiming to determine an optimum pattern such that the totality of specified costs is minimized.

The problem here is the determination of an optimum number, size and location of fluid milk processing plants for Spain. In analyzing this problem, an attempt will be made to minimize the aggregate costs of assembling raw milk and transporting it to the processing plants, processing it in these plants and distributing the finished fluid milk products to the consumption centers. Figure 5 showed graphically how the minimum cost number of plants is achieved. The lowest point of the total cost curve, TC, gives the optimal solution, i.e., the optimum number of processing plants which minimizes the aggregate costs of assembly, processing and distribution.

The Mathematical Model

The mathematical model that will be applied is basically the one outlined by King and Logan (34).

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Given i cow milk production sites, each of which produces a quantity X_i of raw milk to be assembled, j potential plant locations, each of which processes a quantity Y_j, and k consumption centers, each of which consumes a quantity Z_k, the problem is one of minimizing total assembly, processing and distribution costs.

Algebraically, the transshipment model can be stated as follows:

$$\text{Min } TC = \Sigma_i \Sigma_j A_{ij} X_{ij} + \Sigma_j P_j Y_j + \Sigma_j \Sigma_k T_{jk} Z_{jk}$$

Subject to:

(1) $\Sigma_i X_{ij} = S_i$

(2) $\Sigma_i X_{ij} = \Sigma_k Z_{jk}$

(3) $\Sigma_k Z_{jk} = D_k$

(4) $X_{ij} \geq 0,\ Z_{jk} \geq 0$

Where:

TC = Total Costs.

A_{ij} = Assembly costs, in pesetas per liter, from production site i to plant j.

X_{ij} = Quantity of milk, in liters, shipped from province i to plant j.

P_j = Average processing cost, in pesetas per liter, in plant j.

Y_j = Quantity of milk, in liters, processed in plant j.

T_{jk} = Transportation cost, in pesetas per liter, from plant j to consumption center k.

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S_i = Supply of production site i, in liters.

D_k = Demand of consumption center k, in liters.

The Computer Model

The transshipment model, a special kind of transportation linear programming model, will be used in order to find the optimum number, size and location of fluid milk processing plants by minimizing the combined costs of assembly, processing and distribution. As King and Logan first described it, the basic "transportation model is modified by specifying each production and consumption area as a possible shipment or transshipment point" (34, page 97). The matrix of the transshipment model is accordingly constructed to take into account all activities involved.

The matrix to be utilized in this study consists of three distinct parts with respect to activities involved. The first part refers to raw milk assembly from the production points to the fluid milk processing plants. The number of activities (columns) of this part equals the number of supply points times the number of processing plants, m x n. The second part refers to the processing of fluid milk at all the potential fluid milk plants, and the number of activities in this part equals the number of potential fluid milk plants, n. The third part, finally, refers to the distribution of processed fluid milk products from the plants to the consumption points, and the number of activities in

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activities in this part equals the number of plants times the number of consumption points, n x p. The total number of columns, therefore, is equal to m x n + n + n x p.

With respect to the rows of the matrix, the first m rows represent the supply of raw milk to the plants from each of the m supply points. The next n rows represent milk equilibrium in the plants, i.e., the quantity received from the supply points must be equal to the quantity processed in the plants. The next 2 n rows represent the plant capacities of the n potential plants given in a range of minimum and maximum volume which can be processed in each plant. The next n rows represent the processed fluid milk equilibrium, i.e., the quantity processed in the plants must be equal to the quantity shipped to the consumption points. The remaining p rows represent the shipments of fluid milk products to the p consumption points. The total number of rows, therefore, is equal to m + 4n + p.

There is also a column showing the constraints for each row, and a row that gives the objective value (cost) for each activity (column).[22]

The most significant information to be obtained from the computer output will include: (1) The quantity of

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[22]Appendix A presents an example, based on hypothetical data, where only three supply regions, two plants and two consumption centers are considered, which gives an indication of how the matrix that will be used in the analysis looks.

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raw milk to be shipped from each production area to each processing plant; (2) the quantity of milk to be processed in each plant; (3) the quantities of fluid milk products to be shipped from each plant to each consumption point; (4) the aggregate cost of assembly, processing and distribution of the optimal solution; and (5) the marginal cost of milk processing in each plant.[23]

Because of the relatively large size of the matrices involved in the analysis, the APEX-I (18) and APEX II (17) computer programs will be utilized. The Agricultural Economics Linear Programming Package (30), which is relatively simple to utilize from the user's viewpoint, will be used to input the data and, therefore, conversion to APEX will be necessary.

The Analytical Procedure

To generate the data required in the application of the model, the following stepwise procedure will be employed.

Location and Volume of Cow Milk Production

The first step involves the designation of cow milk supply areas and of the quantities produced in each area.

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[23]That is, how much the total cost will change if the volume of fluid milk processing in one plant is increased by one unit.

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The forty-seven peninsular provinces of Spain will be considered as supply areas and the supply of milk in each of these provinces will be considered to be concentrated in one point, since the transshipment model used in the analysis is a point trading model. Each province will be represented by its capital, and milk production will be considered to be concentrated on it. Map I shows the area of study.[24]

Since the main purpose of this study is to show a more efficient alternative to the present organization, production (and consumption) in each province will be taken as they are now (production figures from the 1973-74 dairy marketing year will be used), and processing and transportation cost functions will be based on current technology and prices. Later, an effort will be made to project production and consumption of fluid milk at the national and provincial levels for 1978, with the objective of determining the optimum number, location and size of plants on the basis of the projections.

Location and Volume of Processed Fluid Milk Consumption

The second step of the analysis includes the designation of the processed fluid milk consumption regions and the

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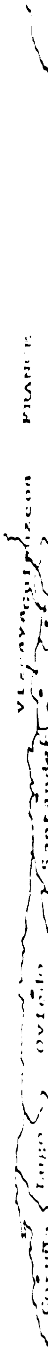
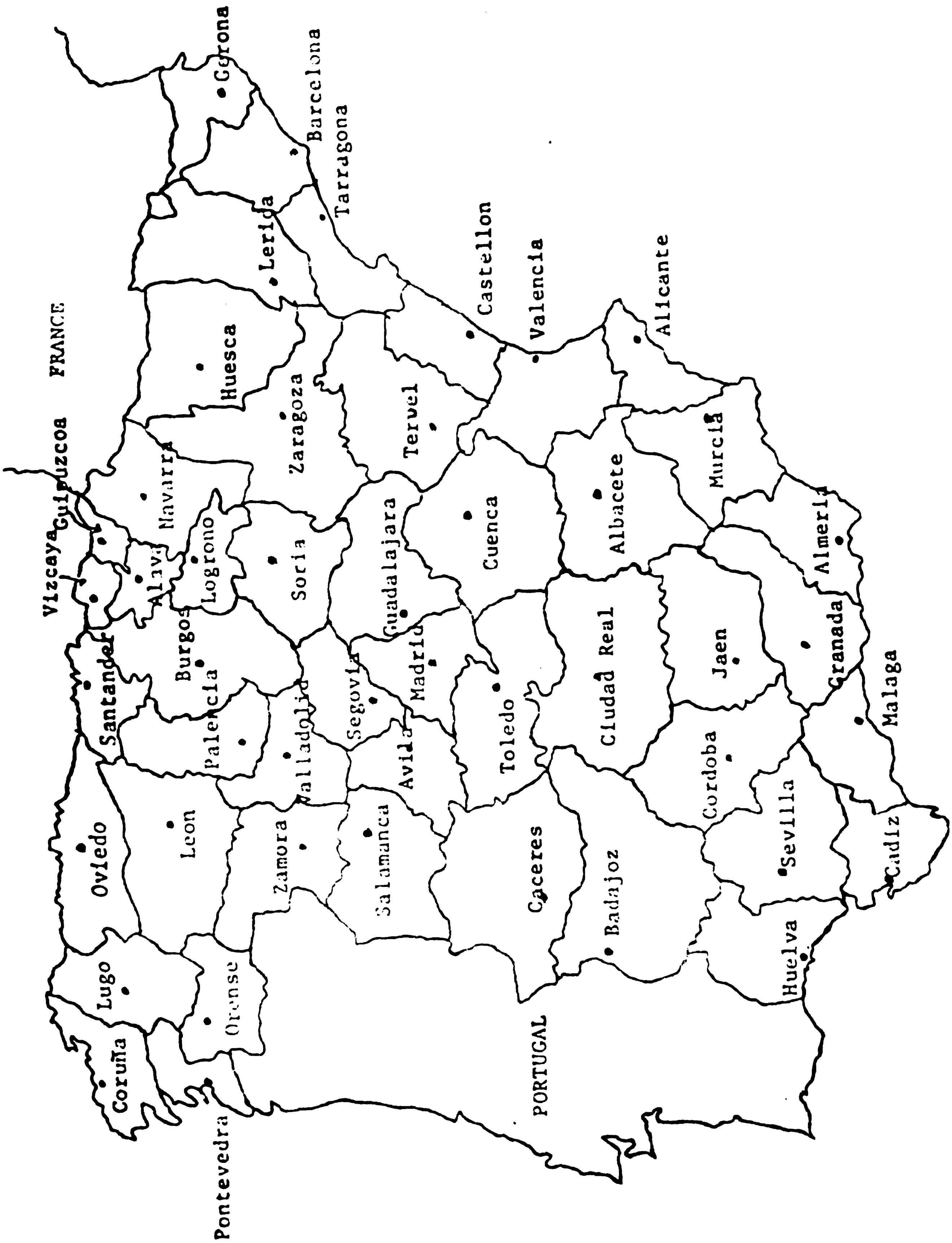
[24]The Balearic and Canary Islands and the towns of Ceuta and Melilla in North Africa will be excluded from the analysis.





Map I. Peninsular Provinces, Spain 1974.

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estimation of the quantities consumed in them. The designation is the same as that of the supply regions. Forty-seven processed fluid milk consumption regions will be considered, each of which will coincide with the forty-seven supply regions. The representative consumption point will also be the capital of each province.

The consumption figures will be computed on the assumption that per capita fluid milk consumption is homogeneous throughout the country.[25] Total production destined to fluid use in 1973-74 (plus imports and minus exports of milk destined to fluid use) divided by total population in the same period will give the average per capita consumption. Consumption in each province will then be computed by multiplying per capita consumption times the population of the province.

Designation of the Potential Fluid Milk Processing Plant Sites

Since there are no weight reductions in fluid milk processing, plants will be located close to the consumer nucleus. Theoretically, it would have made sense to consider the capital of each province and other important towns

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[25]At the present time, interprovince variations in per capita consumption of fluid milk do exist. However, per capita consumption of processed fluid milk in the areas where the system of compulsory hygienization of milk has already been established is indeed very similar and it can be expected that with the extension of this system to all the country per capita consumption of fluid milk would be more homogeneous.

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in each province as potential plant locations (as implicitly does the present regulation). However, this would not allow for plant economies of scale.

The major factors to be considered in selecting the appropriate plant locations will be potential economies of size, consumption, distances and communications among provinces, access to major highways, adequate labor supply, regional employment considerations and others.

Raw Milk Assembly and Transportation Costs

The costs of collection from scattered origins to the processing plants will be separated into two components: (1) Assembly costs, or costs involved in collecting the milk from farms to refrigeration centers; and (2) transportation costs, or costs involved in the transportation of the refrigerated milk from each origin to each destination (processing plant).

Data to estimate these costs will be those elaborated by the agencies of the Ministry of Agriculture to which the regulation of the marketing and pricing systems has been assigned.

With respect to total assembly and transportation of raw milk costs, the one-way distance between each origin and destination will be determined by road distances between the capitals of the provinces of origin and destination.

The costs will be a function of distance and the function to use will be of the form:

$$A_{ij} = a + b\ D_{ij}$$

where:

A_{ij} = Assembly cost, in pesetas per liter, from province i to plant j.

a = Average collection costs, in pesetas per liter, in province i.

b = Bulk milk transportation cost, in pesetas per liter per kilometer.

D_{ij} = Distance, in kilometers, between capital of province i and site of processing plant j.

Fluid Milk Processing Costs

To estimate the total costs and the unit costs of processing fluid milk for different plant sizes and lengths of workday, an economic engineering approach will be taken. Budgets for several synthetic plants of different size, processing both pasteurized and sterilized milk in various packages in the (constant) proportions to be specified will be elaborated. They will be presented in the next chapter.

Processed Fluid Milk Distribution Costs

The costs of transportation from plant to market will also be divided into two components: (1) Transportation from plant to consumption center (when in different location); and (2) distribution costs.

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As in the case of assembly and transportation costs for raw milk, the data to be used will be those elaborated by the Dairy Division of the Ministry of Agriculture. Costs will be, again, a function of distances and the function to be used will be of the form:

$$T_{jk} = c + d\ D_{jk}$$

where:

T_{jk} = Transportation cost, in pesetas per liter, of processed fluid milk from plant j to consumption center k.

c = Average distribution costs, in pesetas per liter, in market k.

d = Processed milk transportation cost, in pesetas per liter per kilometer.

D_{jk} = Distance, in kilometers, between plant j and capital of province k.

Determination of the Optimum Number, Size and Location of Processing Plants

The next procedural step of the analysis will be the determination of the optimum number, size and location of processing plants. To this end, the following procedure will be used:

1. The total quantity of milk to be processed will be allocated to the total number of potential fluid milk processing plants. Plants capacities will be determined within a range of minimum and maximum volume to process.

2. The unit costs of processing milk corresponding to these volumes will be calculated. The unit cost corresponding to the average quantity to be processed by each plant will be considered.
3. On the basis of these data along with the assembly and distribution costs, the first run will be undertaken. Its output will give the flow and volumes of milk which will be processed in each plant and those from plant to consumption centers.
4. Adjustments will then be made in accordance with the marginal costs of processing milk in each plant given by the output of the first run. Negative values in a plant will indicate that costs can be decreased by expanding the plant's capacity, and positive values that costs can be decreased by contracting it. Relatively small plants with large positive marginal cost values will be eliminated from the analysis.
5. The appropriate unit processing costs will be recalculated for the corresponding new volumes to be processed for each plant. The program will be run again, with the new processing data, and the second output will be obtained.

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6. This iterative procedure will be continued until the total cost (assembly, processing and distribution) stops declining.

This trial and error optimization process does not absolutely guarantee a global optimum solution but, given the purposes of this study, the result (a local minimum) will be considered satisfactory.

Determination of Optimum Price Location Differentials

From the results of the computer model, optimum interprovince differences of prices that will produce an optimum flow of milk in order to minimize total costs will be calculated.

Alternative Solution Models

Five different models will be examined in the analysis. They are the following:

1. Model I. This will be an ex-post model, designed to determine the number, sizes and locations of plants that would have supplied fluid milk at 1973-74 consumption levels to peninsular Spain at minimum cost and with all milk consumed in that year being hygienized. This model will be characterized by: (a) Provincial supplies of milk that could have been destined to fluid milk consumption in

1973-74; (b) Provincial demand for fluid milk (including processed and raw milk consumed in fluid form) in 1973-74; (c) Normal plant workday of eight hours, with plants operating 365 days a year; (d) Forty-seven supply areas, thirty-one potential plants and forty-seven demand regions. Iterations of the model will be made as needed to reach a minimum cost solution.

2. Model II. This will also be an ex-post model, designed to calculate minimum aggregate costs of assembly, processing and distribution and optimum milk flow with the present number, size and location of plants. This model will be characterized by: (a) Provincial supplies of milk actually destined to processing for fluid consumption in 1973-74; (b) Provincial demand for processed fluid milk products in 1973-74; (c) Plant workday of eight hours, 365 days a year; (d) Number, size and location of plants in 1973-74; and (e) Forty-seven supply regions, fifty-seven plants and forty-seven consumption regions. This model will be run only once, with no iteration needed.

3. Model III. This ex-post model will be similar to the previous one, with the difference that provincial supplies of milk which could have

been destined to processing for fluid use but part of which were actually destined to other uses will be considered instead of actual provincial supplies destined to fluid milk processing in 1973-74. The model will also be run only once.

4. Model IV. This will be an ex-ante model, designed to determine the number, size and location of plants that will be necessary to supply processed fluid milk to peninsular Spain at minimum cost in 1978. This model will be characterized by: (a) Provincial supplies of milk available for fluid use projected for 1978; (b) Provincial demand for processed fluid milk projected for 1978; (c) Only processed milk being consumed by 1978; and (d) All components of costs will be equally affected by inflation. Iterations of the model will be made as needed to obtain a minimum cost solution.

5. Model V. This will also be an ex-ante model, similar to Model IV, but differing from it in that the labor component of processing costs will be considered to increase by twenty percent more than all the other costs involved by 1978. Again, iterations will be made to reach a minimum cost solution.

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Feasibility Assumptions

In order to make possible the analysis to be undertaken, certain assumptions must be made. Some of these are:

1. Milk production and consumption are considered to be concentrated at one point of each production and consumption area, respectively, which of course, may lead to overestimation or underestimation of the relevant distances.
2. Assembly and distribution cost functions are assumed to be the same in all provinces and, thus, only distance is assumed to affect the unit transportation cost.
3. Processing cost functions are also assumed to be the same in all provinces. This implies that all processing plants apply similar technology and that the prices of the inputs they use are all the same. Therefore, only plant size will affect the optimum solution.
4. All milk supplied for fluid consumption is assumed to go through processing plants, i.e., no raw milk consumption is considered to take place (exception made of milk being consumed in the farms).[26]

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[26] In Models II and III, however, only milk actually processed will be considered. With consumption of raw milk, the total daily volume of processing will be lower and, therefore, the optimal solution much different. The system

5. No restrictions are imposed with respect to milk distribution, i.e., every plant can service every consumption center.[27]

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of compulsory hygienization of milk for fluid consumption was established in 1966, although it has not been extended to all the country.

[27]Actually, only plants that have been authorized for a given market can sell pasteurized milk within it. No restriction exists, however, with respect to sterilized milk, which accounts for about sixty percent of total processed (pasteurized and sterilized) fluid milk.

CHAPTER IV

ECONOMIES OF SIZE IN FLUID MILK PROCESSING: AN ECONOMIC ENGINEERING STUDY

The importance of knowing unit costs in any business cannot be overemphasized. Despite this, it often seems to be difficult to accurately determine them for the fluid milk processing operations. The primary objective of this chapter is to develop some estimates of the total and unit costs incurred in processing fluid milk by plants of different sizes and lengths of workday.

Purpose and Scope of the Study

This study is limited to an analysis of the effect of volume of production and daily length of operation upon plant processing costs incurred in pasteurizing and sterilizing milk. It will, therefore, exclude the costs of assembly from farm to plant and of distribution of processed milk from plant to market. The central purpose is to provide estimates of fluid milk processing costs that will be used, in combination with estimates of assembly and distribution costs and milk production and consumption data, to determine a least cost number, size and location pattern of fluid milk plants for peninsular Spain.

More specifically, the objectives of the study are: (1) To develop a cost analysis procedure that will be applicable to both present and future fluid milk processing facilities and systems; (2) to determine unit processing costs for the model fluid milk processing plants operating under the input-output conditions that will be specified; and (3) to provide information on cost-size relationships and other factors affecting efficiency of processing operations that will be relevant to both management of fluid milk plants and public agencies developing programs designed to improve the performance of the system.[28]

Review of Previous Studies

There are no published studies dealing specifically with economies of size in fluid milk processing in Spain.

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[28]The results of this study could be used, for example, in combination with studies of assembly and distribution costs and site costs as an aid in selecting the size and location of a new plant to minimize total costs. They could also be used to give some indication of the range in processing costs associated with reorganization of part (or all) of the fluid milk processing industry. On the other hand, a minimum processing capacity of 25,000 liters per day is required by the present regulations. Also, maximum resale prices for pasteurized and concentrated milk are established every year, with the estimation of processing costs incurred by processing plants playing an important role in the determination of these maximum prices. Thus, the study could also be used by government agencies. (Perhaps a word of caution should be said at this point, however. Since

Two cost studies dealing with the processing of fluid milk, however, were conducted recently by the Seccion de Industrias Lacteas, Ministerio de Agricultura, to aid in determining the prices of pasteurized (47) and sterilized (53) milk in different packages. The study on pasteurized milk estimated unit costs of pasteurizing milk and packaging it in one, one half and one quarter liter packages of plastic, glass and paper (including both tetraedic and prismatic packages) for a plant pasteurizing 25,000 liters of milk per day, 365 days a year, and utilizing a single type of package. The study on sterilized milk estimated unit costs of sterilizing and packaging milk in one, one half and one quarter liter packages of glass and paper (including both tetraedric and prismatic packages) and one, half, and one and one half liter plastic bottles, for a plant sterilizing 35,000 liters of milk per day, 365 days a year, and utilizing a single type of package.

Although these reports do not deal with economies of size, the method of analysis that they use could be easily modified and extended to do such studies. Furthermore, they provide a wealth of very useful and up to date

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this study is not directed at measuring industrywide average processing costs per liter actually incurred by fluid milk processing plants in Spain during some historical period, e.g., 1974, its use as a basis for price control or for determining "fair prices" would be limited. Still, it is considered that the study can provide useful information to assist in making this type of decision.)

cost information which can be used in analysis of economies of size in fluid milk processing.

In the U.S., on the contrary, a number of studies have investigated economies of size in fluid milk plants. Cobia and Babb (15) standardized the findings of studies that had been realized over a period of years and expressed costs at 1961 levels by adjusting the prices of various inputs using appropriate indexes. After standardization, observations from five of these studies (2, 75, 82, 38, and 62) formed a pattern indicating that total costs per unit dropped sharply with increasing volume up to 40,000 or 50,000 quarts per day and continued to decline, though at a slower rate, to a volume of 120,000 quarts per day, the maximum volume for which costs were tabulated.

A similar relationship was shown by Webster et al. (79), which, in comparison with the five-studies curve, showed a somewhat more rapid drop in the lower volume ranges.

The five studies discussed by Cobia and Babb and the study by Webster et al., thus, showed a continuing reduction in the average costs per unit with increasing volume up to output levels exceeding 100,000 quarts per day. The National Commission on Food Marketing indicated that in completely automated plants unit costs decline with increasing volume up to volumes well in excess of 300,000 pounds (about 140,000 quarts) per day (56). Williams et al.

(80) also indicated that unit costs drop approximately twenty-three percent between volumes of 100,000 and 400,000 quarts per day, with much of the drop being between the 100,000 and 200,000 quart levels. The estimate indicating the largest scale requirement is the one by Devino et al. (19), whose study suggests that the maximum efficient fluid milk plant would process 800,000 quarts a day.

The Nature and Measurement of Economies of Size[29]

As a plant[30] becomes larger up to a point, the firm operating it may be able to obtain lower costs per unit of output.[31] The main factors thought to produce economies of size are: (1) The possibility of increasing efficiency through specialization of labor to specific narrow tasks; (2) the ability to use highly specialized machinery or other capital equipment;[32] and (3) the opportunity to get

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[29] It seems necessary to distinguish at the outset between economies of scale, in which the proportion of resources is held constant, and economies of size, in which it is not. What follows will generally refer to economies of size.

[30] Defined by Bain as an "aggregate of production facilities at a single location" (1).

[31] Even if lower costs are indeed obtained by larger plants unit costs cannot be expected to decline indefinitely.

[32] Or, when identical general purpose machines are used by both large and small plants, the possibility of deriving cost advantage because of longer production runs.

lower costs through the specialization of management and supervising personnel to narrower and more detailed tasks (64). An additional benefit of size, identified by E.A.G. Robinson (63) is what he called "economies of massed reserves," which arise from the fact that a firm willing to maintain continuity of production must hold equipment in reserve against machine breakdowns. A firm large enough to use only one specialized machine may be forced to double its capacity if it wants to hedge against breakdown, while the larger firm with numerous machines will obtain virtually the same degree of protection by holding only a small proportion of its capacity in reserve, and likewise with respect to the number of repairmen. Size, finally, also offers advantage in maintaining capacity sufficient to meet fluctuations in demand.

Approaches to estimating economies of size can be grouped into: (1) descriptive analysis of accounting data; (2) statistical analysis of accounting data; and (3) the economic engineering or synthetic firm approach.[33]

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[33]Two additional methods, referring mainly to economies of scale, are the Survivor Technique and the Cobb-Douglas approach. The survivor technique was presented by Stigler (72 and 73) and it necessarily applies to pecuniary and technical economies and the whole institutional framework in which the firm operates. To apply it, firms in an industry are first classified by size, the share of the industry coming from each class over time is calculated and, if the industry share from a given class has increased (decreased), the size class is considered relatively efficient (inefficient). This technique presents some advantages. It is comprehensive, avoids problems of valuation of resources, includes dynamic elements, etc. but

There are at least three definable approaches that use actual firm accounting data as the basis for constructing cost curves. These include direct analysis of non-standardized firm records, composite firm budget approach and standardized or adjusted accounting data. Descriptive analyses are relatively inexpensive and easily understood, but the results obtained from them are limited mainly because of different accounting methods used by different firms and the lack of clear identification of individual factors that influence the cost functions. Also, descriptive analyses are really snapshots which do not give functional relationships.

The statistical approach has been described by Johnston (33), and refers to a class of studies employing multiple regression analysis to identify and separate the long-run and short-run elements of average costs. Its main shortcoming is probably found in data problems, but the

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also has some obvious flaws. It shows only the borders of a range of optimal size, does not distinguish between single and multiple firms, gives only descriptive, non-normative estimates of optimality and it concludes, when distribution is constant over time, that every plant is of optimal size. It has received much criticism (see, for example, Sheperd (70)).

The Cobb-Douglas approach measures scale economies and the technique involves fitting the Cobb-Douglas production function with historical or engineering data and then examining the sum of the production elasticities. Sums of one indicate constant returns to scale, less than one decreasing returns to scale, and greater than one increasing returns to scale.

results are also clearly dependent upon the specification of the variables used and the type of function fitted to the data.

The economic engineering approach was first used in the early 1940's by R. G. Bressler, Jr.[34] It is based on engineering data relating to cost and plant designs required to achieve minimum costs. Budgets are developed and cost functions synthesized for hypothetical firms, using the best available estimates of the technical coefficients and charging market prices and opportunity costs for all resources. Synthetic firms can be constructed by budgeting techniques or linear programming.

Probably the main advantages of this technique are that it provides information about the average cost per unit of output that firms of various sizes could potentially achieve using modern technology and that it gives the differences in average cost per unit of output attributable strictly to differences in size of firm. A major disadvantage of this approach is that it is very time consuming and expensive relative to other techniques. The engineers' tendency to underemphasize the sensitivity of plant size decisions to changes in input prices can also cause problems. Finally, its applicability is restricted

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[34]The original studies are listed and summarized in the book City Milk Distribution (11). Although there have been numerous economic engineering studies since then, the classic work in the area was done by French, Sammet and Bressler (25).

to plants constructed using present technology. Nevertheless, economic engineering is emerging clearly as the most powerful, effective and widely used method and, given the objectives of this research effort, the nature of the fluid milk processing operations and the availability of appropriate cost data, it was thought to be the most appropriate and the one that will be employed in this study.

Product Specification and Operating Conditions

Certain characteristics and operating conditions that are common to each of the plants to be studied are:

1. All plants will be assumed to produce both pasteurized and sterilized milk in a proportion of forty percent of the former and sixty percent of the latter. Only packages of one liter, the most common capacity, will be considered. Pasteurized milk will be considered to be packaged in glass bottles and plastic bags, in a proportion of forty percent of the first type and sixty percent of the second. Sterilized milk will be considered to be packaged in both glass bottles and paper (tetraedric packages), in a proportion of fifty percent of each type.[35] The "unit"

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[35]This specification is very close to the actual situation in the industry, although some differences should be pointed out. Most of the smaller plants (up to a range of say, 20,000 liters per day) process only pasteurized milk, while the larger ones (those with capacity over 200,000 liters per day) usually package pasteurized milk also in paper, although in a very small proportion (about five percent of their pasteurized milk). With respect to sterilized milk, plants over 120,000-150,000 liters usually include packaging in plastic bottles in a proportion of

considered in this study, therefore, is a liter of milk. Sixteen percent of the milk will be glass-bottled pasteurized milk, 24 percent pasteurized milk packaged in plastic bag, 30 percent glass bottled sterilized milk and the remaining 30 percent will be sterilized milk in tetraedric paper packages. Pasteurized and sterilized milk, when delivered to the consumer, must have the characteristics specified by Decrees 2478/1966 (5, Article 14) and 758/1974 (8, Article 30) respectively.

2. The processing plants will be assumed to receive all their milk from regular patrons. They will receive whole milk once per day, in 40-liter cans directly from their patrons.[36] In general, there are no cooling facilities on farms, so that milk is approximately air temperature when received. The average quantity of milk received for processing for fluid use is assumed to be

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approximately twenty-five percent of their sterilized milk, at the expense of both glass bottled and paper packaged sterilized milk. Marcial Lalanda provided very useful information on this subject, though he cannot be held responsible for possible errors.

[36]At various times, however, milk is received already refrigerated and in tanks. For simplicity, however, for the purposes of this study, all plants will be assumed to receive their milk in cans.

constant over the year.[37] Quality of milk supply, fat content, etc., are also assumed to be constant over the year and from plant to plant. Raw milk, when delivered to the processing plant, must have the characteristics specified by Decree 2478/1966 (5, Article 6) as modified by Decree 758/1974 (8).

3. The plants to be studied will work eight, twelve, sixteen and twenty hours per day, 365 days per year.

4. For the purposes of this study, an annual accounting period will be used.

Cost Categories

The cost categories that will enter into unit processing costs will be cost associated with durable assets, labor, utility, and packaging material costs, and general and miscellaneous expenses. Costs associated with the ownership of durable assets are classified into site purchase, building construction, pavement and landscaping, equipment purchase and installation, and purchase of containers. These costs do not enter directly into unit processing costs, but give rise to certain annual costs. Equipment, containers, buildings and site improvements are durable

[37]Milk produced is divided into two roughly equal parts, that used for fluid purposes and that used for manufacturing. A large fraction of the manufacturing milk supply is a by-product of fluid milk use because of the need to insure adequate supplies of fluid milk.

assets which depreciate in value due to physical wear and tear while in use, deterioration associated with the passage of time and obsolescence. The annual reduction of value is a cost which is charged against annual output.[38] Repairs and maintenance costs must also be included and so are other recurrent costs associated with the ownership of durable assets during each year such as interest costs (which apply to the undepreciated balance of the initial investment), insurance premiums and property taxes.

Even though several of these costs vary from one year to another, principally in response to increasing plant age and diminishing undepreciated investment, for the purpose of estimating unit processing costs they are aggregated for the useful life of the plant and allocated uniformly to each year.

Annual labor costs include the salaries of management, office and laboratory personnel, the wages of utility, processing and shipping personnel, and the social charges to be paid by the firm.

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[38]While there is considerable disagreement over the correct way to allocate the original cost of a depreciable asset to specific accounting periods, by far the most common method is to estimate the normal useful life of the asset and the salvage value at the end of it, and allocate the difference between original installment cost and salvage value uniformly to each accounting period during the useful life of the asset (Boles, 4). For a specific plant, the application of this method results in a constant amount of depreciation cost per year.

Annual utility costs include electricity, fuel and water consumption costs.

Packaging material costs include replacement of broken bottles, metal caps (for bottles), plastic (for bags), paper, non-returnable baskets, etc.

Finally, general and miscellaneous expenses include commercial expenses (sale to thirty days), advertising, office and laboratory material, inspection and related expenses, detergents, disincrustants, clothing, shoes, etc.

Data Source

The data requirements of a synthetic firm approach to economies of size determination can be very stringent. The approach specifies optimal resource combinations which probably do not exist in many real world operations. Data for this particular study were obtained with the help of engineers specializing in fluid milk processing plants design and/or operation. Similarities between the synthetic firm approach and the engineers' process of planning were apparent. Personnel, plant designs and unpublished material in the Section de Industrias Lácteas, (Ministerio de Agricultura), plant designs in the Escuela Tecnica Superior de Ingenieros Agrónomos (Universidad Politécnica de Madrid), and several fluid milk processing firms were also extremely helpful.

Estimation of Unit Costs of Processing Fluid Milk for Plants of Different Sizes and Lengths of Workday

Unit processing costs were estimated for six hypothetical plants working eight, twelve, sixteen and twenty hours per day and 365 days a year. The selection of equipment, estimation of investment costs, labor and utility costs, etc. for the first hypothetical plant working eight hours per day is described in detail in Appendix B. The general procedure followed in this section is to summarize the results obtained from similar analyses for the remaining plants and lengths of workday. All costs are adjusted to 1974 price conditions. Budgets for the six hypothetical plants of different sizes, processing both pasteurized and sterilized milk in the packages and proportions already specified were elaborated. The daily volumes (total and by types of products) processed by each of the six hypothetical plants under the four different workday legnths are given in Table 14.

Estimation of Buildings, Equipment and Container Costs

Costs under this category include land acquisition and development, building construction costs, equipment and auxiliary installations purchase costs, and container acquisition costs.

Using data reported by the Sección de Industrias Lácteas (53), a uniform price of 1,000 pesetas per square

Table 14. Hypothetical Plants' Volumes of Operation, by Types of Package and Length of Workday, in Liters Per Day, Spain 1974.

Plant	Workday Length	Pasteurized			Sterilized			Total Volume
		Plastic	Glass	Total	Glass	Paper	Total	
I	8	10,000	6,000	16,000	12,000	12,000	24,000	40,000
I	12	15,000	9,000	24,000	18,000	18,000	36,000	60,000
I	16	20,000	12,000	32,000	24,000	24,000	48,000	80,000
I	20	25,000	15,000	40,000	30,000	30,000	60,000	100,000
II	8	15,000	10,000	25,000	17,500	17,500	35,000	60,000
II	12	22,500	15,000	37,500	26,250	26,250	52,500	90,000
II	16	30,000	20,000	50,000	35,000	35,000	70,000	120,000
II	20	37,500	25,000	62,500	43,750	43,750	87,500	150,000
III	8	21,000	15,000	36,000	27,000	27,000	54,000	90,000
III	12	31,500	22,500	54,000	40,500	40,500	81,000	135,000
III	16	42,000	30,000	72,000	54,000	54,000	108,000	180,000
III	20	52,500	37,500	90,000	67,500	67,500	135,000	225,000
IV	8	30,000	20,000	50,000	35,000	35,000	70,000	120,000
IV	12	45,000	30,000	75,000	52,500	52,500	105,000	180,000

Table 14. Continued.

Plant	Workday Length	Pasteurized			Sterilized			Total Volume
		Plastic	Glass	Total	Glass	Paper	Total	
IV	16	60,000	40,000	100,000	70,000	70,000	140,000	240,000
IV	20	75,000	50,000	125,000	87,500	87,500	175,000	300,000
V	8	60,000	40,000	100,000	70,000	70,000	140,000	240,000
V	12	90,000	60,000	150,000	105,000	105,000	210,000	360,000
V	16	120,000	80,000	200,000	140,000	140,000	280,000	480,000
V	20	150,000	100,000	250,000	175,000	175,000	350,000	600,000
VI	8	90,000	60,000	150,000	105,000	105,000	210,000	360,000
VI	12	135,000	90,000	225,000	157,500	157,500	315,000	540,000
VI	16	180,000	120,000	300,000	210,000	210,000	420,000	720,000
VI	20	225,000	150,000	375,000	262,500	262,500	525,000	900,000

meter will be charged for land acquisition. Annual economic costs for this concept consists of interest (8.5 percent per year) and taxes (0.25 percent), and are charged over total land acquisition costs.

Uniform construction costs of 8,000 pesetas, per square meter are also charged. Annual economic costs here include depreciation (1.66 percent per year), interest (8.5 percent), and taxes (0.25 percent). Interest costs are charged over average investment value (which is equivalent to charging 4.25 percent per year over total investment value), while the other costs are charged over total investment costs.

An additional cost of 555.55 pesetas per square meter, finally, is considered for pavement, landscaping, etc. of the non-constructed area. Annual economic costs for this concept are the same as in building construction above.

Land acquisition and development and building construction investment costs and annual economic costs associated with them will not vary with the length of operation. They are summarized, for the six synthetic plants in Table 15.

Equipment selection is divided into eleven sections. These include (1) receiving stage, (2) filtration, cooling and refrigeration, (3) skimming and normalization, (4) pasteurization, (5) packaging of pasteurized milk, (6) sterilization (towers), (7) sterilization (UHT),

Table 15. Land Acquisition and Development and Building Construction Costs and Annual Economic Costs Associated with Them (in pesetas), by Plants, Spain 1974.

Plant	Volume Liters/ 8 hr.day	Land Acquisition Investment Cost	Annual Costs Land Acquisition (8.75%)	Buildings Investment Costs	Pavement & Landscaping	Total External Facilities	Annual Costs External Facilities (10.00%)	Total Annual Costs
I	40,000	5,000,000	437,500	25,600,000	1,000,000	26,600,000	2,660,000	3,097,500
II	60,000	6,000,000	525,000	35,200,000	1,100,000	36,300,000	3,630,000	4,155,000
III	90,000	7,000,000	612,500	43,600,000	1,100,000	44,700,000	4,470,000	5,082,500
IV	120,000	8,000,000	700,000	52,000,000	1,200,000	53,200,000	5,320,000	6,020,000
V	240,000	10,000,000	875,000	64,000,000	1,200,000	65,200,000	6,520,000	7,395,000
VI	360,000	12,000,000	1,050,000	76,000,000	1,500,000	77,500,000	7,750,000	8,800,000

(8) complements, (9) auxiliary services, (10) laboratory and offices, and (11) others. Total equipment and auxiliary services purchase and installation costs, by plants and stages, are shown in Table 16.

Some of the annual economic costs associated with equipment purchase and installation will differ when different workday lengths are considered; thus, depreciation charges will be 12.5 percent for plants working eight hours per day, 18.75 percent for plants working 12 hours, 25.00 percent for plants working sixteen hours and 31.25 percent for plants working twenty hours per day, and repair and maintenance charges will be 10, 15, 20 and 25 percent per year for plants working eight, twelve, sixteen and twenty hours per day respectively. On the other hand, interest costs (8.5 percent per year over average investment value or 4.25 percent per year over total investment value), taxes (0.25 percent) and insurance (0.50 percent) charges will be the same regardless of the number of hours of operation per day.

Annual economic costs associated with equipment purchase and installation for the six plants and four workdays are shown in Table 17.

Container costs, finally, include cans (which are considered to be owned by the plants (47 and 53), glass bottles (for both pasteurized and sterilized milk) and returnable baskets (for bottles and plastic packages of pasteurized milk). Annual economic costs associated with

Table 16. Total Equipment and Auxiliary Services Purchase and Installation Costs (in pesetas), by Plants and Stages, Spain 1974.

Plant	Receiving	Filtration & Cooling	Skimming & Normali-zation	Pastueri-zation	Packaging Pastuerized Glass	Packaging Pasteurized Plastic	Pre-Steril-ization	Sterilization & Packaging Glass	Sterilization & Packaging (UHT)	Complements	Utilities	Laboratory	Offices	Others	Total
I	1,650,000	3,305,000	1,425,000	3,240,000	3,550,000	1,670,000	6,276,000	15,640,000	15,731,000	900,000	8,115,000	750,000	500,000	1,500,000	63,631,000
II	1,330,000	4,805,000	1,845,000	3,240,000	3,550,000	1,870,000	6,486,000	25,490,000	15,731,000	1,200,000	10,265,000	1,000,000	750,000	2,000,000	79,681,000
III	1,340,000	7,976,000	2,987,000	4,945,000	3,550,000	2,775,000	6,486,000	25,490,000	15,731,000	1,600,000	12,545,000	1,000,000	825,000	2,500,000	90,069,000
IV	2,030,000	9,110,000	4,120,000	6,345,000	3,550,000	2,775,000	6,486,000	25,490,000	15,731,000	2,000,000	14,825,000	1,250,000	900,000	3,000,000	97,106,000
V	2,870,000	18,220,000	7,870,000	12,690,000	7,100,000	5,500,000	12,882,000	50,980,000	31,157,000	3,600,000	23,945,000	2,000,000	1,200,000	5,000,000	185,064,000
VI	3,710,000	27,330,000	11,990,000	19,035,000	10,650,000	8,325,000	19,278,000	76,470,000	46,737,400	5,200,000	33,060,000	3,000,000	1,500,000	7,000,000	263,700,000

Table 17. Annual Economic Costs in Pesetas Associated with Equipment Depreciation, Repairs and Maintenance, Interest, Taxes and Insurance, by Plants and Length of Workday, Spain 1974.

Plant	Total Investment Costs	Length of Workday			
		8 hours (27.5%)	12 hours (38.75%)	16 hours (50%)	20 hours (61.25%)
I	63,631,000	17,498,525	24,657,012	31,815,500	38,973,987
II	79,681,000	22,012,275	30,876,387	39,840,000	48,804,612
III	90,069,000	24,768,975	34,901,737	45,034,500	55,167,262
IV	97,108,000	26,704,700	37,629,350	48,554,000	59,487,650
V	185,064,000	50,892,600	71,712,300	92,532,000	113,351,700
VI	263,700,000	72,517,500	106,702,000	137,680,000	168,658,000

container costs include depreciation (20 percent), interest (8.5 percent over average investment value or 4.25 percent over total investment value), taxes (0.25 percent) and insurance (0.25 percent), for a total of 24.75 percent per year over total container investment value. Table 18 gives the annual economic costs associated with containers.

Table 19 summarizes the annual economic costs associated with the durable assets considered thus far.

Table 18. Annual Economic Costs in Pesetas Associated with Container Investment Costs, by Plants and Length of Workday, Spain 1974.

	Length of Workday			
Plant	8 hours	12 hours	16 hours	20 hours
I	1,627,450	2,472,750	3,284,333	4,104,275
II	2,417,166	3,657,812	4,877,683	6,096,354
III	3,668,075	5,547,437	7,396,750	9,745,937
IV	4,892,666	7,298,125	9,754,166	12,192,708
V	9,760,333	14,631,250	19,483,333	24,385,416
VI	12,894,640	21,196,875	29,262,500	36,453,125

Table 19. Annual Economic Costs in Pesetas, Associated with Durable Assets, by Plants and Length of Workday, Spain 1974.

Plant	Length Workday	Land Acquisition & Development & Buildings	Equipment	Containers	Total
I	8	3,097,500	17,498,525	1,627,450	22,223,475
I	12	3,097,500	24,657,000	2,472,750	30,227,250
I	16	3,097,500	31,815,000	3,284,333	38,196,833
I	20	3,097,500	38,973,987	4,104,375	42,071,487
II	8	4,155,000	22,012,275	2,417,166	28,584,441
II	12	4,155,000	30,876,387	3,657,812	38,696,199
II	16	4,155,000	39,840,500	4,877,683	48,873,183
II	20	4,155,000	48,804,612	6,096,354	59,055,966
III	8	5,082,500	24,768,975	3,668,075	33,519,550
III	12	5,082,500	34,901,737	5,547,437	45,531,674
III	16	5,082,500	45,034,500	7,396,750	57,513,750
III	20	5,082,500	55,167,762	9,745,937	69,996,199

Table 19. Continued.

Plant	Length Workday	Land Acquisition & Development & Buildings	Equipment	Containers	Total
IV	8	6,020,000	26,704,700	4,892,666	37,617,366
IV	12	6,020,000	37,629,350	7,298,125	50,947,475
IV	16	6,020,000	48,554,000	9,754,166	64,328,166
IV	20	6,020,000	59,478,650	12,192,708	77,691,358
V	8	7,395,000	50,892,600	9,760,333	68,047,933
V	12	7,395,000	71,712,300	14,631,250	93,738,550
V	16	7,395,000	92,532,000	19,483,333	119,410,333
V	20	7,395,000	113,357,700	24,385,416	145,138,116
VI	8	8,800,000	72,517,500	12,894,600	94,212,100
VI	12	8,800,000	106,702,000	21,196,875	136,698,875
VI	16	8,800,000	137,680,000	29,262,500	175,742,500
VI	20	8,800,000	168,658,000	36,453,125	213,911,125

Estimation of Labor Costs

Labor costs consist of salaries of management office and laboratory personnel, wages of utility, processing and shipping personnel, and social charges to be paid by the processing firm.

Management for all six plants includes a general plant manager, engineer(s), office superintendent and plant superintendent(s). Office personnel include accountant, payroll clerk and clerk-typists, and laboratory personnel include laboratory technicians. Pick up and sales inspectors and custodians, finally, are also included in this group.

Utility, processing and shipping personnel are classified into six categories. These include unskilled worker (peón), skilled worker (peón especializado), specialist of third category, specialist of first category, official and stoker.

Social security and accident insurance annual charges to be paid by the processing plant, finally, include two extra-pays, one benefits pay, social security and labor mutualism and accident insurance.

Table 20 gives the total annual labor costs for the six hypothetical plants and four lengths of workday.

Table 20. Salaries, Wages, Social Charges and Total Labor Costs (in Pesetas per year) by Plants and Length of Workday, Spain 1974.

Plant	Length Workday	Salaries	Wages	Social Charges	Total Labor Costs
I	8	1,988,988	3,006,870	3,207,214	8,203,072
I	12	2,449,788	4,064,640	4,538,996	11,053,424
I	16	2,531,412	4,777,850	5,090,632	12,399,894
I	20	2,992,284	5,647,280	6,077,131	14,716,695
II	8	2,174,700	3,457,870	3,926,639	9,588,809
II	12	2,554,500	5,106,350	5,334,513	12,995,313
II	16	2,740,836	6,061,920	6,127,718	14,930,474
II	20	3,201,708	7,291,970	7,304,136	17,797,814
III	8	2,279,412	4,290,940	4,578,193	11,148,545
III	12	2,659,212	6,312,310	6,243,857	15,215,379
III	16	2,926,548	8,179,285	7,720,606	18,826,439
III	20	3,411,132	10,501,050	9,675,253	23,587,435

Table 20. Continued.

Plant	Length Workday	Salaries	Wages	Social Charges	Total Labor Costs
IV	8	2,627,124	5,238,080	5,479,754	13,345,358
IV	12	3,006,924	8,642,105	8,102,846	19,751,875
IV	16	3,402,684	11,009,860	10,021,970	24,434,514
IV	20	3,887,268	13,065,175	11,787,915	28,740,358
V	8	3,046,072	9,879,820	8,993,078	21,918,970
V	12	3,901,908	15,981,890	13,818,491	33,702,289
V	16	4,273,966	20,052,370	16,900,883	41,227,209
V	20	4,758,540	24,507,560	20,328,993	49,595,093
VI	8	3,626,970	14,905,870	12,886,987	31,419,807
VI	12	4,450,044	21,963,510	18,356,779	44,779,333
VI	16	4,645,380	28,175,445	22,791,285	55,612,110
VI	20	5,106,924	33,009,140	26,465,501	64,581,565

Estimation of Utility Costs

Utility costs include electricity, fuel and water consumption costs. Electricity is needed both for power and light. Fuel is needed to wash cans, bottles and baskets, to pasteurize and sterilize milk and for cleaning purposes. Water is needed to wash cans, bottles and baskets, to refrigerate pasteurized milk and cool sterilized milk, for steam production, refrigeration of compressors and frigorific condensers and for cleaning of plants and equipment.

Prices of 1.57 pesetas per hw.h for electricity, 3.35 pesetas per kilogram for fuel and 6.00 pesetas per cubic meter of water (53) will be applied.

Annual utility consumption costs for the six plants and four workdays are given in Table 21.

Estimation of Packaging Material Costs

Packaging material costs include replacement of broken bottles and purchase of metal caps (for glass bottles), plastic (for bags), paper and non-returnable boxes. The costs of these packaging materials in 1974 were sixty pesetas per thousand metal caps for pasteurized milk, 186.91 pesetas per thousand metal caps for sterilized milk, 0.48 pesetas per plastic package (liter), 1.56 pesetas per paper package (liter) and twelve pesetas per box. Replacement

Table 21. Annual Utility Consumption Costs (in pesetas), by Plants and Length of Workday, Spain 1974.

Plant	Length Workday	Electricity	Fuel	Water	Total
I	8	1,193,902	1,578,570	1,179,666	3,958,138
I	12	1,793,902	2,367,855	1,776,300	5,928,057
I	16	2,386,704	3,355,140	2,162,232	7,904,076
I	20	3,045,377	4,013,813	2,820,905	9,880,095
II	8	1,633,854	2,421,045	1,846,170	5,901,069
II	12	2,480,441	3,699,461	2,671,701	8,851,603
II	16	3,295,865	5,144,876	3,361,399	11,802,138
II	20	4,279,377	6,128,391	4,344,914	14,752,672
III	8	2,450,779	3,669,818	2,642,058	8,762,655
III	12	3,911,221	5,130,261	4,102,500	13,143,982
III	16	5,371,665	6,590,705	5,562,944	17,525,310
III	20	6,832,107	8,051,148	7,023,386	21,906,637

Table 21. Continued.

Plant	Length Workday	Electricity	Fuel	Water	Total
IV	8	3,267,187	5,116,200	3,504,780	11,888,167
IV	12	5,248,548	7,097,561	5,486,141	17,832,250
IV	16	7,229,909	8,978,922	7,567,503	23,776,334
IV	20	9,211,269	10,960,283	9,548,864	29,720,417
V	8	6,535,078	8,339,155	7,024,680	21,898,913
V	12	10,179,897	11,983,973	10,669,499	32,848,369
V	16	13,829,749	14,633,626	14,319,351	43,797,826
V	20	17,479,851	18,283,728	17,969,453	54,747,282
VI	8	9,802,265	14,159,495	10,477,029	34,438,730
VI	12	14,542,054	19,899,293	16,216,817	51,658,095
VI	16	20,315,179	25,572,408	21,989,942	68,977,460
VI	20	26,021,667	31,278,897	27,696,430	86,096,825

costs for broken bottles were 6 pesetas per unit for pasteurized (47) and 7.37 pesetas per unit for sterilized (53).

Packaging material costs for the six plants and four workdays are summarized in Table 22. There are no real economies of size in this category, packaging material being a function of the number of liters of milk processed by each plant.

Estimation of General and Miscellaneous Expenses

This last category includes commercial expenses, advertising, office and laboratory material, inspection and related expenses and miscellaneous expenses.

Commercial expenses result from sale to thirty days, and equal number of liters processed per daytime, the average selling price times thirty days times 7.5 percent negotiation costs. Advertising expenses represent 0.10 pesetas per liter of milk (53). Office and laboratory materials are estimated at 0.015 pesetas per liter of milk processed, inspection and related expenses at 0.075 pesetas per liter and miscellaneous expenses at 0.02 pesetas per liter.

General and miscellaneous expenses are also summarized in Table 22 for the six plants and four workday lengths.

Table 22. Packaging Materials and General and Miscellaneous Annual Costs (in pesetas) by Plants and Length of Workday, Spain 1974.

Plant	Length Workday	Packaging Material Costs	General and Miscellaneous Expenses
I	8	18,731,529	4,686,000
I	12	28,097,293	7,029,000
I	16	37,463,058	9,372,000
I	20	46,828,822	11,715,000
II	8	27,710,994	7,026,000
II	12	41,566,491	10,539,000
II	16	55,421,988	14,052,000
II	20	69,277,485	17,565,000
III	8	42,262,558	10,543,500
III	12	63,393,837	15,815,250
III	16	84,525,116	21,087,000
III	20	105,656,395	26,358,750
IV	8	55,411,989	14,058,000
IV	12	83,117,983	21,087,000
IV	16	110,823,978	28,116,000
IV	20	138,529,972	35,145,000
V	8	111,036,072	28,116,000
V	12	166,164,330	42,174,000
V	16	221,552,444	56,232,000
V	20	276,940,555	70,290,000
VI	8	164,235,967	42,174,000
VI	12	246,353,950	63,261,000
VI	16	328,471,934	84,348,000
VI	20	410,589,917	105,435,000

Total Annual Costs and Average Unit Processing Costs

Table 23 summarizes total annual costs for the six plants and four workday lengths. Dividing these total costs by the number of liters processed by each plant and workday length each year, unit costs can be obtained. These are summarized in Table 24.

Summary of Results

The first objective of this study was to develop a cost analysis procedure applicable to both present and future fluid milk plants. The procedure utilized (which is illustrated for the first plant and workday in Appendix B) was based on the synthetic plant approach, which can be modified to adjust to a variety of particular circumstances. When using this approach, the plant operations to be analyzed should be carefully defined and the operating parameters specified according to the goals of the study. Production stages and cost categories also need to be designated, adequate data must be found and resource requirements determined. Finally, factor prices must be specified and annual economic costs and unit costs computed. The basic approach used in the study is thought to have sufficient flexibility to allow cost analyses and valid economic comparisons among different systems.

The second objective was to determine unit processing costs for the model fluid milk plants operating under

Table 23. Total Annual Processing Costs (in pesetas) by Plants and Length of Workday, Spain, 1974.

Plant	Length Workday	Durable Assets	Labor	Utility	Packaging Materials	General & Miscellaneous	Total
I	8	22,223,475	8,203,072	3,952,138	18,731,529	5,486,000	57,796,214
I	12	30,227,250	11,053,424	5,928,057	28,097,293	7,029,000	82,335,024
I	16	38,196 833	12,399,894	7,904,076	37,463,058	9,372,000	105,335,861
I	20	42,071,487	14,716,695	9,880,095	46,828,822	11,715,000	125,212,099
II	8	28,584,441	9,558,809	5,901,069	27,710,994	7,026,000	78,781,313
II	12	38,696,199	12,995,363	8,851,603	41,566,491	10,539,000	112,648,656
II	16	48,873,183	14,930,474	11,802,138	55,421,988	14,052,000	145,079,783
II	20	59,055,966	17,797,814	14,752,672	69,277,485	17,565,000	178,448,937
III	8	33,519,550	11,148,545	8,762,655	42,262,558	10,543,500	106,236,808
III	12	45,531,674	15,215,379	13,143,982	63,393,837	15,815,250	153,100,082
III	16	57,513,750	18,826,439	17,525,310	84,525,116	21,087,000	199,477,615
III	20	69,996,199	23,587,435	21,906,637	105,656,395	26,358,750	247,505,416
IV	8	37,617,366	13,345,358	11,888,167	55,411,989	14,058,000	132,320,880
IV	12	50,947,475	19,751,875	17,832,250	85,117,983	21,087,000	192,736,583
IV	16	64,328,166	24,434,514	23,776,334	110,823,978	28,116,000	251,017,888
IV	20	77,691,358	28,740,358	29,720,417	138,529,972	35,145,000	368,627,538
V	8	68,047,933	21,918,910	21,898,913	111,036,072	28,116,000	251,017,888
V	12	93,738,550	33,702,289	32,848,369	166,164,330	42,174,000	368,627,538
V	16	119,410,333	41,227,209	43,797,826	221,552,444	56,232,000	482,219,812
V	20	145,138,116	40,595,093	54,747,282	276,940,555	70,290,000	592,711,046
VI	8	94,212,100	31,419,807	34,438,730	164,235,967	42,174,000	366,480,604
VI	12	136,698,875	44,779,333	51,658,095	246,353,950	63,261,000	542,751,253
VI	16	175,742,500	55,612,110	68,977,460	328,471,934	84,348,000	713,152,004
VI	20	213,911,125	64,581,565	86,096,825	410,589,917	105,435,000	880,614,432

Table 24. Average Unit Processing Costs (in pesetas per liter) by Plants and Length of Workday, Spain 1974.

Plant	Length Workday	Total Annual Costs	Total Liters Per Year	Unit Costs
I	8	57,796,214	14,600,000	3.958
I	12	82,335,024	21,900,000	3.759
I	16	105,335,861	29,200,000	3.607
I	20	125,212,099	36,500,000	3.430
II	8	78,781,313	21,900,000	3.597
II	12	112,648,656	32,850,000	3.429
II	16	145,079,783	43,800,000	3.312
II	20	178,448,937	54,750,000	3.259
III	8	106,236,808	32,850,000	3.233
III	12	153,100,082	49,275,000	3.107
III	16	199,477,615	65,700,000	3.036
III	20	247,505,416	82,125,000	3.013
IV	8	132,320,880	43,800,000	3.021
IV	12	192,736,583	65,700,000	2.933
IV	16	251,478,992	87,600,000	2.870
IV	20	309,827,105	109,500,000	2.829
V	8	251,017,888	87,600,000	2.864
V	12	388,627,538	131,400,000	2.812
V	16	482,219,812	175,200,000	2.752
V	20	592,711,046	219,000,000	2.706
VI	8	366,480,604	131,400,000	2.789
VI	12	542,751,253	197,100,000	2.753
VI	16	713,152,004	262,800,000	2.713
VI	20	880,614,432	328,500,000	2.680

the conditions that were specified. Unit processing costs were estimated for each of six hypothetical plants and four alternative workdays. The results (which were summarized in Table 24) will be used, in combination with assembly and distribution costs and supply-demand conditions, to determine the least cost number, size and location of fluid milk processing plants for Spain. For the plants analyzed, unit processing costs decreased from 3.958 pesetas per liter of fluid milk processed for plant I processing 40,000 liters daily in eight-hour workdays, to 2.680 pesetas per liter for plant VI, processing 900,000 liters daily in twenty-hour workdays, a decrease of about thirty-two percent. For the eight-hour workday, unit costs declined from 3.958 pesetas per liter for plant I processing 40,000 liters per day to 2.789 pesetas per liter for plant VI processing 360,000 liters, a decrease of almost thirty percent, with most of the drop (twenty-three percent) being in the 40,000-120,000 liters category.

The cost-volume information from Table 24 can be used to construct the four long run average cost curves of Figure 6. These four curves reflect the assumption that annual costs of other plants with intermediate capacity will behave in the same way as those of the plants which were analyzed.[39] These curves show that economies of size

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[39]The long run cost curves developed are more limited in scope than the concept of long run or planning function (operationally defined by Boles in the following way: "For each of a large number of alternative annual

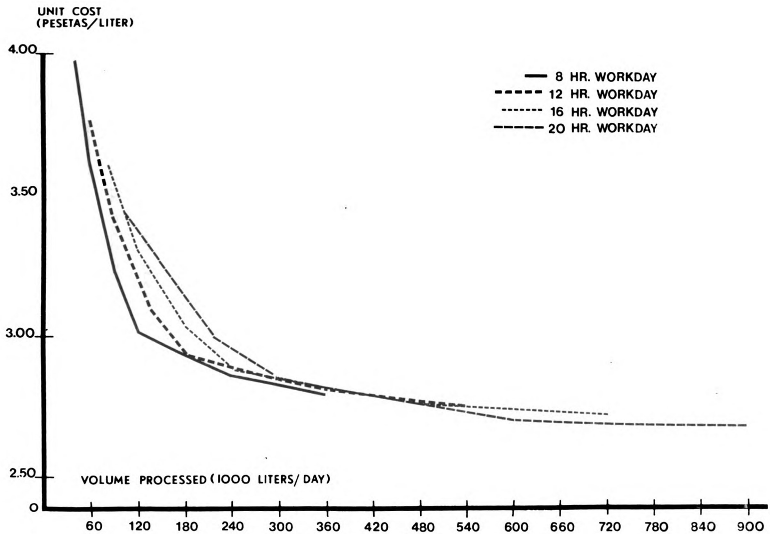

FIG. 6 LONG RUN AVERAGE COST CURVES FOR FLUID MILK
PLANTS; SPAIN 1974

in plant costs exist throughout the range of volume included in the study.

The third objective was to provide information on cost-size relationships and other factors affecting efficiency of processing operations relevant to both management of fluid milk plants and public agencies involved in the regulation of the fluid milk subsystem. While the specification of product and operating conditions made above may seem to narrow the range of potential application of the results of the study, they are considered sufficiently detailed to allow estimation of the effects of alterations on unit costs.

For most of the plants analyzed, the eight-hour workday seems to be the most efficient. The facts that there are not real economies of size with respect to packaging materials (the highest component of unit costs), the ability to install more efficient equipment in larger plants and the relatively inefficient use of some specialized personnel when working twelve or twenty-hour workdays are considered to be the main reasons for this outcome. In the long run, fluid milk processing costs can be substantially

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output rates, a particular plant is selected which processes that annual quantity at minimum average cost per unit of output. The locus of minimum cost points for all alternative annual outputs forms the long run cost function" (5, page 649). The two major limitations are the specification of plant capacities in terms of the amount of milk that can be processed in eight, twelve, sixteen and twenty hours per day, and the specification that each plant employs the same technology.

reduced by increasing the capacity of existing plants to at least 120,000 liters per day in a normal workday of eight hours, but preferably double this amount. However, the savings in processing costs associated with larger capacities might be partially offset by increases in the assembly and/or distribution costs necessary to achieve the higher volume of operation, and any conclusion on optimum size of plant at this point should be considered only preliminary. At any rate, the present minimum daily capacity of 25,000 liters per day (5) seems to be too low and should be substantially increased.

Although, as it was said at the outset, caution should be exercised when drawing implications for fair pricing, the consequences of using as guidelines for establishing maximum resale prices cost estimates obtained from relatively small plants (25,000 to 35,000 liters per day) could be better appraised with the information provided by this study.

The main factors affecting unit processing costs were packaging materials, equipment and labor. The relative importance of packaging materials expenses in unit costs for the plants analyzed increased with the number of liters processed, from about thirty-two percent for plant I working eight hours (40,000 liters) to 44.5 percent for plant VI and and eight-hour workday (360,000 liters) and more than 46 percent for plant VI and twenty hours workday (900,000 liters). Equipment costs, the second major cost item, represented almost twenty-five percent of unit processing costs for plant I and eight hour workdays, dropping to 20 percent for plant VI working eight hours per day and to 19 percent for plant VI working twenty hours per day. Labor costs, finally, were 14 percent of unit costs for plant I working eight hours, dropping to 8.5 percent for plant VI and eight-hour workdays and to 7 percent for plant VI and twenty-hour work days. These three components of unit cost made up about 71 percent of unit processing cost for plant I using an eight-hour workday, and 73 percent for plant VI with both eight and twenty-hour workdays. Utilities, building maintenance and depreciation, commercial expenses, advertising and inspection costs, in that order, accounted for most of the remaining costs.

CHAPTER V

OPTIMUM NUMBER, SIZE AND LOCATION OF FLUID MILK PROCESSING PLANTS: AN EX-POST ANALYSIS

This chapter presents the estimates of the basic data needed for the computer analysis and the empirical results obtained from Model I and compares these results with the present pattern of fluid milk plants number, size, and location (Models II and III).

Estimation of Cow Milk Supplies, Fluid Milk Consumption and Milk Assembly, Processing and Distribution Costs, and Designation of Potential Fluid Milk Plant Sites

This section presents the procedures used and the estimates obtained for cow milk production, fluid milk consumption, raw milk assembly costs, fluid milk processing costs and processed fluid milk distribution costs, and the designation of potential fluid milk processing plant sites for the 1973-74 dairy marketing year.

Estimation of Provincial Cow Milk Supplies

The main purpose of this study was to show a more efficient alternative to the present organization of the fluid milk industry. Thus, cow milk production in each province was taken basically as it is at present.[40] The provincial volumes of cow milk commercialized in 1973-74 were obtained from published data collected by the Ministry of Agriculture (44, 45, 50, and 51). Commercialized milk consumed as fluid (processed or not) plus milk of equal quality that was actually transformed into cheese, butter, condensed and powdered milk, and other dairy products in the second, third, and fourth quarters of 1973 and in the first quarter of 1974 were expressed in thousand liters per day. Table 25 gives these potential supplies of milk for fluid use for the forty-seven penisular provinces of Spain.

Estimation of Provincial Fluid Milk Consumption

Total domestic milk production consumed in fluid form, plus imports and minus exports of fresh fluid milk in 1973-74, divided by total population in the same period[41]

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[40]In the next chapter an attempt will be made to project milk production at the national and provincial levels for 1978, and estimate an optimum number, size, and location of plants on the basis of the projections.

[41]The population of Spain, calculated by the Institute Nacional de Estadistica, was 35,098,867 on July 1, 1974 (reported in [16]).

Table 25. Potential Supplies of Milk for Fluid Use, Spain, 1973-74.

	Province	Annual Commercialized Production (Million liters)	Daily Potential Supply (Thousand liters)
1.	La Coruña	214.5	588
2.	Lugo	202.0	553
3.	Orense	51.8	142
4.	Pontevedra	119.9	328
5.	Alava	26.4	72
6.	Guipuzcoa	49.4	135
7.	Oviedo	407.3	1,116
8.	Santander	307.1	841
9.	Vizcaya	83.0	227
10.	Huesca	48.6	133
11.	Logroño	18.0	49
12.	Navarra	60.5	169
13.	Teruel	16.5	45
14.	Zaragoza	33.5	92
15.	Barcelona	98.6	270
16.	Gerona	91.6	251
17.	Lerida	55.7	153
18.	Tarragona	7.7	21
19.	Avila	24.1	66
20.	Burgos	84.7	232
21.	Leon	208.1	570
22.	Palencia	43.9	120
23.	Salamanca	35.2	96
24.	Segovia	45.0	123
25.	Soria	13.0	36
26.	Valladolid	31.9	87
27.	Zamora	28.7	79
28.	Albacete	1.9	5
29.	Ciudad Real	27.9	76
30.	Cuenca	0.0	0
31.	Guadalajara	11.0	30

Table 25. Continued.

Province		Annual Commercialized Prod. (Million liters)	Daily Potential Supply (Thousand liters)
32.	Madrid	152.7	418
33.	Toledo	57.7	158
34.	Alicante	8.4	23
35.	Castellon	6.6	18
36.	Murcia	19.4	53
37.	Valencia	13.7	38
38.	Badajoz	81.8	224
39.	Caceres	99.1	272
40.	Almeria	7.0	19
41.	Granada	13.8	38
42.	Jaen	17.4	48
43.	Malaga	30.8	84
44.	Cadiz	23.3	64
45.	Cordoba	71.9	197
46.	Huelva	18.4	50
47.	Sevilla	107.4	294
Total		3,177.0	8.700

gives an average per capita consumption of 76.6 liters per year, or 0.210 liters per day.[42] Provincial consumption figures were computed on the assumption that per capita milk consumption is uniform throughout the country. Table 26 gives the provincial populations and the fluid milk needed for the forty-seven peninsular provinces of Spain.

Designation of the Potential Fluid Milk Processing Plant Sites

The third procedural step of the analysis consisted in the designation of the potential plant sites. Then, distances between them and all production and consumption regions (and thus assembly and distribution costs per unit of product) could be established.

A basic model of some of the factors to take into account when selecting potential plant locations has been presented by Hamilton (27) and is reproduced in Figure 7. The elements of the second stage of the model were the major factors taken into consideration in selecting the potential plant locations. They were demand (determined by population size), plant economies and techniques (which together condition the range of production) and accessibility offered by alternative locations of supplies of raw milk, energy and

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[42] Official figures are generally higher (see Chapter II, Table 8) and apparently condensed and powdered milk are included in this category.

Table 26. Milk Needed for Fluid Consumption, by Provinces, Spain, 1973-74.

	Province	Population (Thousand people)	Daily Fluid Milk Needs (Thousand liters)
1.	La Coruña	1,072.4	225
2.	Lugo	415.4	87
3.	Orense	492.3	103
4.	Pontevedra	806.1	169
5.	Alava	236.8	50
6.	Guipuzcoa	665.0	140
7.	Oviedo	1,044.8	219
8.	Santander	477.5	100
9.	Vizcaya	1,106.0	232
10.	Huesca	214.1	45
11.	Logroño	240.7	51
12.	Navarra	492.3	103
13.	Teruel	159.8	34
14.	Zaragoza	760.7	160
15.	Barcelona	4,049.0	850
16.	Gerona	431.1	91
17.	Lerida	282.2	59
18.	Tarragona	445.9	94
19.	Avila	188.4	40
20.	Burgos	351.2	74
21.	Leon	510.1	107
22.	Palencia	193.4	41
23.	Salamanca	363.1	76
24.	Segovia	159.8	34
25.	Soria	102.6	22
26.	Valladolid	443.0	93
27.	Zamora	237.8	50
28.	Albacete	335.5	70
29.	Ciudad Real	500.2	105
30.	Cuenca	247.6	52
31.	Guadalajara	129.2	27
32.	Madrid	4,245.3	892

Table 26. Continued.

Province	Population (Thousand people)	Daily Fluid Milk Needs (Thousand liters)
33. Toledo	438.0	92
34. Alicante	940.2	197
35. Castellon	389.7	82
36. Murcia	904.7	190
37. Valencia	1,817.3	382
38. Badajoz	649.2	136
39. Caceres	445.9	94
40. Almeria	406.5	85
41. Granada	740.0	155
42. Jaen	613.6	129
43. Malaga	840.6	177
44. Cadiz	936.6	197
45. Cordoba	752.8	158
46. Huelva	393.6	64
47. Sevilla	1,558.8	327
Total	33,230.5	6,960

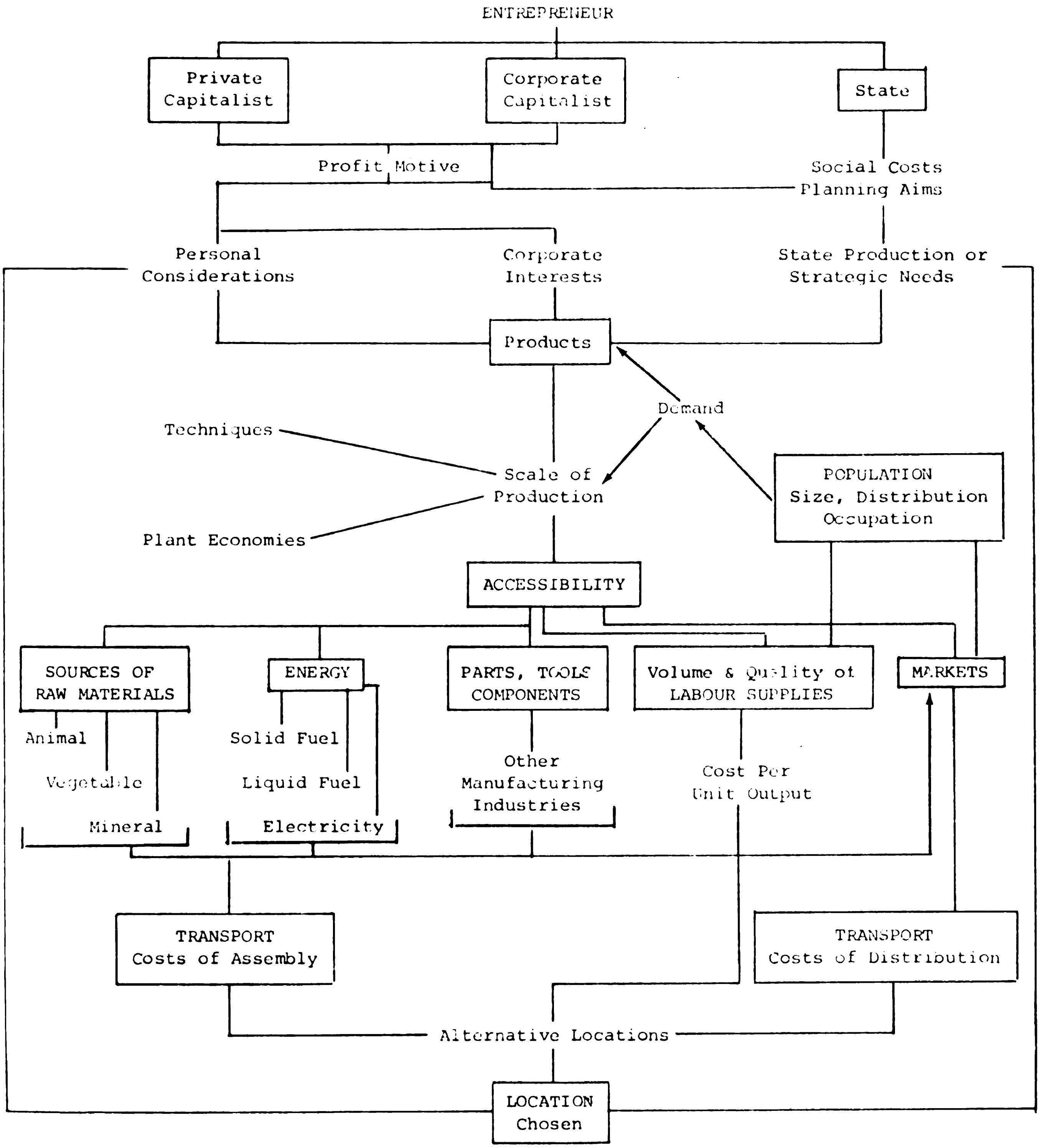

Figure 7. A Basic Model of the Factors Influencing Industrial Location Decisions.
Source: Hamilton, F.E.I. "Models of Industrial Location."

water, equipment and packaging materials, labor supplies, etc. and also to markets (access to highways, e.g.).

On the basis of these considerations, the following thirty-one locations were selected as potential plant sites: (1) La Coruña, (2) Pontevedra, (3) Oviedo, (4) Santander, (5) Bilbao, (6) San Sebastián,[43] (7) Zaragoza, (8) Gerona, (9) Barcelona I, (10) Barcelona II, (11) Lérida, (12) León, (13) Valladolid, (14) Madrid I, (20) Madrid II, (21) Madrid III, (22) Albacete, (23) Ciudad Real, (24) Badajoz, (25) Granada, (26) Jaén, (27) Almería, (28) Málaga, (29) Cádiz, (30) Córdoba, and (31) Sevilla.

Estimation of Raw Milk Assembly and Transportation Costs

Highway is the only mode of transportation used for shipping milk in Spain[44] and highway transportation costs, therefore, were the ones considered.

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[43]Bilbao is the capital of the province of Vizcaya and San Sebastián the capital of the province of Guipuzcoa.

[44]In effect, the special characteristics of raw milk reduce the options of modes of transportation practically to highway and railroad. Milk is too bulky to be economically transported by air and too perishable to be transported through pipelines (in addition to being economically unfeasible). The same can be said with respect to inland water transportation (the Guadalquivir River is the only navigable one, and only up to the city of Sevilla) and waterborne transportation (although this mode is used to ship processed milk from the peninsula to the Islands). Railroads are probably the only open alternative to exclusive highway transportation of milk. Milk tank cars could be used, and, since distances in Spain are relatively short, perishability would not be a big problem. At the present time, however, it can be said that railroads in Spain are more passenger

The average milk assembly cost from farm to refrigeration center computed by the Ministry of Agriculture is 0.60 pesetas per liter. Transportation (bulk) costs of refrigerated milk to the processing plants are estimated to be 0.001 pesetas per liter and kilometer (back-haul included). The function used to compute assembly and transportation costs of raw milk, therefore, was:

$$A_{ij} = 0.60 + 0.001 D_{ij}$$

where A_{ij} is the total assembly and transportation cost, in pesetas per liter, from producing province i to processing plant located in province j, and D_{ij} is the one-way road distance, in kilometers, between capital of province i and site of processing j.[45]

Estimation of Fluid Milk Processing Costs

The processing costs data obtained in the economies of size study reported in the previous chapter were utilized in this analysis to assign unit processing costs to each of the plants.

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than freight oriented and their relative incompleteness, inflexibility and lack of convenience have kept them away from milk transportation.

[45]Road distances were those reported in (22).

Estimation of Processed Fluid Milk Distribution Costs

Transportation costs of processed milk have been estimated by the Ministry of Agriculture to be 0.0034 pesetas per liter and kilometer for milk in returnable packages and 0.0018 pesetas per liter and kilometer for milk in non-reusable packages. The average in-market distribution costs are 0.55 pesetas per liter for milk in returnable packages and 0.31 pesetas per liter for non-returnable milk packages.

According to the specifications made in the previous chapter, forty-five percent of the processed fluid milk was considered to be packaged in returnable (glass bottles) packages, and fifty-five percent in non-reusable (plastic and paper) packages. The function used to compute transportation and distribution costs of processed fluid milk, therefore, was:

$$T_{jk} = 0.00252\ D_{jk} + 0.418$$

where T_{jk} is the total transportation and distribution cost, in pesetas per liter, from plant j to consumption center k, and D_{jk} is the one-way road distance, in kilometers, between plant j and capital of province k.

Empirical Results

This section presents the empirical results of the computer analysis undertaken on the basis of the data generated as reported in the previous section (Model I). These results include minimum aggregate cost of milk assembly, processing and distribution, least cost number, size and location of fluid milk processing plants, optimum flow of raw milk from supply areas to plants, optimum flow of processed fluid milk from plants to consumption centers and optimum price location differentials.

Minimum Aggregate Cost of Milk Assembly, Processing and Distribution

The least cost solution of Model I involved an aggregate cost of milk assembly, processing and distribution of 28,301,500 pesetas per day, or approximately 4.07 pesetas per liter. The method for determining this minimum cost was the stepwise procedure described in Chapter III. It started from all the thirty-one potential plants and ended with twenty-two. Indeed, the computer analysis showed that, as the number of plants was reduced and, therefore, the volume processed for at least some of the remaining plants increased, total costs were continuously declining. Table 27 gives the aggregate total costs with patterns of 31, 28, 24, 23, and 22 plants.

The largest share of the minimum aggregate total cost corresponded to processing costs, which represented 19,544,510 pesetas per day or 69.94 percent of total cost.

Table 27. Mimimum Aggregate Cost with Different Number of Plants, Spain, 1974.

Number of Plants	Total Cost (Pesetas per day)	Unit Cost (Pesetas per liter)
31	28,800,480	4.14
28	28,612,560	4.11
24	28,452,480	4.09
23	28,382,280	4.08
22	28,301,500	4.07

Least Cost Number, Location and Size of Fluid Milk Processing Plants

The least cost solution of this model was obtained for twenty-two plants. The optimum size of plants was simultaneously determined with the optimum number. Table 28 gives the location and sizes of these twenty-two plants which provided the pattern that minimized total assembly, processing, and distribution costs.

The largest plant processed 610,000 liters per day and the smallest one 105,000. The average processing volume was 316,316 liters per day and plant.

Optimum Flow of Raw Milk from Supply Areas to Plants

Table 29 gives the optimum flow from the forty-seven supply regions to the twenty-two plants and the total volume of raw milk supplied by each region and received by each

Table 28. Optimum Number, Size, and Location of Plants (Model I), Spain, 1973-74.

Plant Number	Location	Size (Liters/day)
1	La Coruña	312,000
2	Pontevedra	272,000
3	Oviedo	219,000
4	Santander	174,000
5	Bilbao	463,000
6	San Sebastián	135,000
7	Zaragoza	298,000
8	Barcelona I	516,000
9	Barcelona II	519,000
10	León	367,000
11	Valencia	464,000
12	Alicante	387,000
13	Madrid I	610,000
14	Madrid II	597,000
15	Ciudad Real	105,000
16	Badajoz	230,000
17	Granada	240,000
18	Jaén	129,000
19	Málaga	177,000
20	Cádiz	197,000
21	Córdoba	158,000
22	Sevilla	391,000
	Total	6,960,000

Table 29. Optimum Flow of Raw Milk From Supply Regions to Plants, in Thousand Liters Per Day (Model I), Spain, 1973-74.

Supply Regions \ Processing Plants	1. La Coruna	2. Pontevedra	3. Oviedo	4. Santander	5. Bilbao	6. San Sebastian	7. Zaragoza	8. Barcelona I	9. Barcelona II	10. Leon	11. Valencia	12. Alicante	13. Madrid I	14. Madrid II	15. Ciudad Real	16. Badajoz	17. Granada	18. Jaen	19. Malaga	20. Cadiz	21. Cordoba	22. Sevilla	Total
1. La Coruna	312																						312
2. Lugo																							0
3. Orense																							0
4. Pontevedra		272																					272
5. Alava							31	41															73
6. Guipuzcoa						135																	135
7. Oviedo			219								153	31											403
8. Santander				174	236		126				144		161										841
9. Vizcaya					227																		227
10. Huesca								133															133
11. Logrono							49																49
12. Navarra								166															166
13. Teruel											45												45
14. Zaragoza							92																92
15. Barcelona								176	94														270
16. Gerona									251														251
17. Lerida									153														153
18. Tarragona									21														21
19. Avila													66										66
20. Burgos														232									232
21. Leon										367		203											570
22. Palencia													120										120
23. Salamanca																					96		96
24. Segovia													123										123
25. Soria											36												36
26. Valladolid													87										87
27. Zamora																	79						79
28. Albacete												5											5
29. Ciudad Real															76								76
30. Cuenca																							0
31. Guadalajara											30												30
32. Madrid													53	365									418
33. Toledo												72			29			57					158
34. Alicante												23											23
35. Castellon											18												18
36. Murcia												53											53
37. Valencia											38												38
38. Badajoz																224							224
39. Caceres																6			86			180	272
40. Almeria																	19						19
41. Granada																	38						38
42. Jaen																		48					48
43. Malaga																			84				84
44. Cadiz																				64			64
45. Cordoba																	104	24	7		62		197
46. Huelva																						50	50
47. Sevilla																				133		161	294
Total	312	272	219	174	463	135	298	516	519	367	464	387	610	597	105	230	240	129	177	197	158	391	6,36[illegible]

plant which are consistent with the optimal solution of Model I.

Optimum Flow of Processed Fluid Milk from Plants to Consumption Centers

Table 30 gives the optimum flow of processed fluid milk products from the twenty-two plants to the forty-seven consumption centers, as well as the total volume of finished milk shipped by each plant and received by each consumption center.

Optimum Price Location Differentials

The dual of the above cost minimization programming model would be a problem of pricing the raw and processed milk at each of the provinces to maximize the total returns. The relative prices that would be given in the dual solution are shown in Table 31. By arbitrarily setting the price of raw milk of Province 7 (Oviedo) at the zero level, the other prices are solved relative to it. Two important relationships should be noted: (1) Trade will take place between two provinces only if the difference between their prices in isolation is greater than or equal to the total transfer costs involved, and (2) Prices in one province can differ from prices in another by an amount within the range of plus or minus transfer costs without giving rise to milk movements.

Table 30. Optimum Flow of Finished Milk From Processed Plants to Consumption Centers, in Thousand Liters Per Day (Model I), Spain, 1973-74.

Processing Plants \ Demand Regions	1. La Coruña	2. Lugo	3. Orense	4. Pontevedra	5. Alava	6. Guipuzcoa	7. Oviedo	8. Santander	9. Vizcaya	10. Huesca	11. Logroño	12. Navarra	13. Teruel	14. Zaragoza	15. Barcelona	16. Gerona	17. Lerida	18. Tarragona	19. Avila	20. Burgos	21. Leon	22. Palencia	23. Salamanca	24. Segovia
1. La Coruña	225	87																						
2. Pontevedra			103	169																				
3. Oviedo							219																	
4. Santander								100												74				
5. Bilbao					50	5			232		51	103												
6. San Sebastian						135																		
7. Zaragoza										45			34	160			59							
8. Barcelona I															425	91								
9. Barcelona II															425			94						
10. Leon																					107	41	76	
11. Valencia																								
12. Alicante																								
13. Madrid I																			40					34
14. Madrid II																								
15. Ciudad Real																								
16. Badajoz																								
17. Granada																								
18. Jaen																								
19. Malaga																								
20. Cadiz																								
21. Cordoba																								
22. Sevilla																								
Total	225	87	103	169	50	140	219	100	232	45	51	103	34	160	850	91	59	94	40	74	107	41	76	34

Table 30. Continued

Processing Plants / Demand Regions	25. Soria	26. Valladolid	27. Zamora	28. Albacete	29. Ciudad Real	30. Cuenca	31. Guadalajara	32. Madrid	33. Toledo	34. Alicante	35. Castellon	36. Murcia	37. Valencia	38. Badajoz	39. Caceres	40. Almeria	41. Granada	42. Jaen	43. Malaga	44. Cadiz	45. Cordoba	46. Huelva	47. Sevilla	Total
1. La Coruña																								312
2. Pontevedra																								272
3. Oviedo																								219
4. Santander																								174
5. Bilbao	22																							463
6. San Sebastian																								135
7. Zaragoza																								298
8. Barcelona I																								516
9. Barcelona II																								519
10. Leon		93	50																					367
11. Valencia											82		382											464
12. Alicante										190		197												387
13. Madrid I				70		52		414																610
14. Madrid II							27	478	92															597
15. Ciudad Real					105																			105
16. Badajoz														136	94									230
17. Granada																85	155							240
18. Jaen																		129						129
19. Malaga																			177					177
20. Cadiz																				197				197
21. Cordoba																					158			158
22. Sevilla																						64	327	391
Total	22	93	50	70	105	52	27	892	92	190	82	197	382	136	94	85	155	129	177	197	158	64	327	6,960

Table 31. Optimum Price Location Differentials Resulting from Solution of Dual (Model I). Spain, 1973-74.

	Province	Raw Milk (Pesetas per liter)	Processed Milk (Pesetas per liter)
1.	La Coruña	0.32	4.17
2.	Lugo	0.23	4.41
3.	Orense	0.29	4.51
4.	Pontevedra	0.38	4.25
5.	Alava	0.22	4.12
6.	Guipuzcoa	0.06	4.26
7.	Oviedo	0.00	3.92
8.	Santander	0.08	4.03
9.	Vizcaya	0.19	3.96
10.	Huesca	0.48	4.51
11.	Logroño	0.31	4.36
12.	Navarra	0.32	4.36
13.	Teruel	0.65	4.79
14.	Zaragoza	0.48	4.33
15.	Barcelona	0.76	4.53
16.	Gerona	0.66	4.78
17.	Lerida	0.60	4.69
18.	Tarragona	0.66	4.77
19.	Avila	0.37	4.51
20.	Burgos	0.21	4.42
21.	Leon	0.12	3.94
22.	Palencia	0.25	4.26
23.	Salamanca	0.04	4.44
24.	Segovia	0.39	4.47
25.	Soria	0.42	4.63
26.	Valladolid	0.30	4.27
27.	Zamora	0.15	4.28
28.	Albacete	0.68	4.86
29.	Ciudad Real	0.94	4.11
30.	Cuenca	0.57	4.65
31.	Guadalajara	0.43	4.37

Table 31. Continued.

Province	Raw Milk (Pesetas per liter)	Processed Milk (Pesetas per liter)
32. Madrid	0.48	4.23
33. Toledo	0.77	4.40
34. Alicante	0.85	4.60
35. Castellon	0.72	4.78
36. Murcia	0.77	4.81
37. Valencia	0.79	4.61
38. Badajoz	0.57	4.45
39. Caceres	0.48	4.68
40. Almeria	0.71	5.18
41. Granada	0.88	4.76
42. Jaen	1.10	5.14
43. Malaga	0.96	4.91
44. Cadiz	0.90	4.85
45. Cordoba	0.77	4.79
46. Huelva	0.66	4.78
47. Sevilla	0.75	4.54

Comparison of Proposed and Actual Location Patterns

Model I provided the optimum pattern of fluid milk processing plant numbers, locations, and sizes for 1973-74, which would have involved twenty-two plants. Actually, in 1974 there were fifty-seven plants in Peninsular Spain (see Appendix C), which were located in forty of the forty-seven peninsular provinces.[46] To compare the optimum pattern obtained from Model I with the optimum that could have been achieved with the actual number, location, and sizes of fluid milk plants existing in 1973-74, two additional models were prepared.

The present locational pattern of fluid milk processing plants in Spain was appraised under specific assumptions. In addition to the feasibility assumptions stated in the last section of Chapter III, it was considered that an optimum pattern of milk assembly, processing, and distribution existed in 1973-74.

Model II provided the minimum aggregate costs of assembly, processing, and distribution and the optimum flow of raw and finished milk with the sizes and location of plants and provincial supplies of milk which were actually used for processed fluid milk products during the 1973-74 dairy marketing year. Provincial supplies of milk destined

[46] Almost 30 percent of the plants were located in three provinces. These provinces were Madrid, Barcelona, and Valencia, with seven, six, and four processing plants respectively.

to processing for fluid consumption were obtained from published data collected by the Ministry of Agriculture (44, 45, 50, and 51). They are shown, expressed in liters per day, in Table 32. To compute provincial demand for processed fluid milk, total processed fluid milk consumed in 1973-74 in the forty-seven peninsular provinces was allocated to each of them assuming that per capita consumption of processed fluid milk products in provinces in which processing plants are established was homogeneous and that per capita consumption in provinces without milk processing facilities was 60 percent of that in the provinces with processing plants.[47] Table 32 also shows the provincial needs for processed fluid milk in 1973-74 under these assumptions. The fifty-seven processing plants operating in the 1973-74 dairy marketing year were included in the Model.

Model III was similar to Model II with the difference that, as in Model I, provincial supplies that could have been destined to processing for fluid use but part of which were actually destined to other uses were considered (see Table 25) instead of provincial supplies actually processed in fluid milk plants in 1973-74.

The matrices involved in Models II and III were relatively large, involving 322 rows by 5,415 columns, and

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[47]The provinces without milk processing facilities as of March 1, 1974 were: Albacete, Almeria, Avila, Castellón, Cuenca, Huelva, and Soria.

Table 32. Provincial Supplies of Milk Destined to Processing for Fluid Consumption and Provincial Demand for Finished Fluid Milk, Spain, 1973-74.

	Province	Daily Supply (Thousand liters)	Daily Demand (Thousand liters)
1.	La Coruña	274.6	152.3
2.	Lugo	77.4	59.0
3.	Orense	77.1	69.9
4.	Pontevedra	187.5	114.5
5.	Alava	71.4	33.6
6.	Guipuzcoa	96.4	94.4
7.	Oviedo	458.6	148.3
8.	Santander	282.3	67.8
9.	Vizcaya	192.8	157.1
10.	Huesca	88.7	30.4
11.	Logroño	38.6	34.2
12.	Navarra	69.9	69.9
13.	Teruel	10.0	22.7
14.	Zaragoza	89.5	108.0
15.	Barcelona	229.3	575.0
16.	Gerona	211.3	61.8
17.	Lerida	70.1	40.1
18.	Tarragona	19.7	63.3
19.	Avila	10.0	17.3
20.	Burgos	148.0	49.9
21.	Leon	408.3	72.4
22.	Palencia	20.4	27.5
23.	Salamanca	42.9	51.6
24.	Segovia	77.1	22.7
25.	Soria	20.8	9.4
26.	Valladolid	77.2	62.9
27.	Zamora	68.5	33.8
28.	Albacete	0.0	30.9
29.	Ciudad Real	23.3	71.0
30.	Cuenca	0.0	22.7
31.	Guadalajara	20.0	18.3

Table 32. Continued.

Province	Daily Supply (Thousand liters)	Daily Demand (Thousand liters)
32. Madrid	378.3	602.8
33. Toledo	40.0	62.2
34. Alicante	11.2	133.5
35. Castellon	4.8	35.9
36. Murcia	40.1	128.5
37. Valencia	18.7	258.1
38. Badajoz	30.0	92.2
39. Caceres	104.1	63.3
40. Almeria	0.0	37.4
41. Granada	35.5	105.1
42. Jaen	36.9	87.1
43. Malaga	40.0	119.4
44. Cadiz	45.3	133.0
45. Cordoba	144.6	106.9
46. Huelva	1.3	36.
47. Sevilla	223.7	221.3
Total	4,616.6	4,615.6

the APEX-II computer program (17) had to be utilized. A program written by Professor Harsh (28) was utilized to input the A_{ij}'s and B_i's of these matrices using the Harsh-Black format (30). The objective values (C_j's) were then added and the whole set of data was coverted to APEX through a conversion program also prepared by Professor Harsh (29).

The least cost solution of Model II involved an aggregate cost of milk assembly, processing and distribution of 21,489,475 pesetas per day, or 4.61 pesetas per liter. This was 13.2 percent higher than the optimal solution of Model I and involved 33.7 percent less processed milk.

Model III involved a total cost of 21,043,627 pesetas per day, or 4.56 pesetas per liter, 12 percent higher than the optimal solution of Model I. Table 33 gives the optimal quantities to be processed by each of the existing fifty-seven plants, as obtained from Models II and III.

The optimum interprovince shipments of raw milk, in liters per day, obtained from Model II are shown in Table 34.

With respect to the distribution of processed milk, only twelve provinces had excess supplies. After satisfying their own consumption needs these provinces would have shipped processed milk to the thirty-five deficit provinces as shown in Table 35. Plants in the remaining provinces with processing facilities would have shipped all their fluid milk products to their own provinces.

Finally, the relative prices obtained from the solution of the dual of Model II are shown in Table 36.

Table 33. Optimum Quantity to be Processed by Each Fluid Milk Plant, Spain, 1973-74.

Plant Number	Location (Province)	Optimum Daily Processing Capacity (Thousand liters per day)
1	Madrid I	300,000
2	Madrid II	150,000
3	Madrid III	150,000
4	Madrid IV	70,000
5	Madrid V	60,000
6	Madrid VI	150,000
7	Madrid VII	40,000
8	Ciudad Real	40,000
9	Guadalajara	30,000
10	Toledo I	15,000
11	Toledo II	30,000
12	Burgos	30,000
13	Palencia	10,000
14	Segovia	30,000
15	Valladolid	30,000
16	Salamanca	30,000
17	Zamora	15,000
18	Leon	130,000
19	Badajoz	20,000
20	Caceres	10,000
21	Cadiz	50,000
22	Cordoba	90,000
23	Sevilla	100,000
24	Granada	100,000
25	Jaen	15,000
26	Malaga	50,000
27	Alicante	350,000
28	Valencia I	230,000
29	Valencia II	50,000
30	Valencia III	140,000
31	Valencia IV	50,000

Table 33. Continued.

Plant Number	Location (Province)	Optimum Daily Processing Capacity (Thousand liters per day)
32	Murcia	20,000
33	Barcelona I	150,000
34	Barcelona II	40,000
35	Barcelona III	220,600
36	Barcelona IV	70,000
37	Barcelona V	40,000
38	Barcelona VI	70,000
39	Gerona	15,000
40	Tarragona	15,000
41	Lerida	15,000
42	Huesca	50,000
43	Zaragoza	100,000
44	Teruel	15,000
45	Logroño	30,000
46	Navarra	60,000
47	Alava	30,000
48	Guipuzcoa	120,000
49	Vizcaya I	140,000
50	Vizcaya II	150,000
51	Oviedo I	80,000
52	Oviedo II	210,000
53	Santander	150,000
54	La Coruña	80,000
55	Lugo	20,000
56	Orense	50,000
57	Pontevedra	80,000
Total		4,615,600

Table 34. Optimum Raw Milk Interprovince Flow (Model II) in Thousand Liters Per Day, Spain, 1973-74.

	1. Madrid	2. Ciudad-Real	3. Guadalajara	4. Toledo	5. Burgos	6. Palencia	7. Segovia	8. Valladolid	9. Salamanca	10. Zamora	11. Leon	12. Badajoz	13. Caceres	14. Cadiz	15. Cordoba	16. Sevilla	17. Granada	18. Jaen	19. Malaga	20. Alicante	21. Valencia
1. La Coruña	174																				
2. Lugo																					77.4
3. Orense										15											12.1
4. Pontevedra	107.5																				
5. Alava																					
6. Guipuzcoa																					
7. Oviedo																					221.5
8. Santander																					
9. Vizcaya																					
10. Huesca																					
11. Longroño																					
12. Navarra																					
13. Teruel																					10
14. Zaragoza																					
15. Barcelona																					
16. Gerona																					
17. Lerida																					
18. Tarragona																					
19. Avila	10																				
20. Burgos					30																35.5
21. Leon	71.9		10					30			130										166.4
22. Palencia	10.4					10															
23. Salamanca									30												17.9
24. Segovia							30														
25. Soria																					
26. Valladolid	47																				30.2
27. Zamora	102.5																				
28. Ciudad Real		23.3																			
29. Guadadajara		20																			
30. Madrid	378.3																				
31. Toledo	8.3	16.7		15																	
32. Alicante																				11.2	
33. Castellon																					4.8
34. Murcia																				40.1	
35. Valencia																					18.7
36. Badajoz												20			10						
37. Caceres	64.1			30									10								
38. Granada																				35.5	
39. Jaen																		15		21.9	
40. Malaga																			40		
41. Cadiz														45.3							
42. Cordoba															80		64.6				
43. Huelva																1.3					
44. Sevilla														4.7		98.7	35.4		10	74.9	
Total	920	40	30	45	30	10	30	30	30	15	130	20	10	50	90	100	100	15	50	350	470

Table 34. Continued

	22. Murcia	23. Barcelona	24. Gerona	25. Tarragona	26. Lerida	27. Huesca	28. Zaragoza	29. Teruel	30. Logroño	31. Navarra	32. Alava	33. Guipuzcoa	34. Vizcaya	35. Oviedo	36. Santander	37. La Coruña	38. Lugo	39. Orense	40. Pontevedra	Total
1. La Coruña																80	20			274.0
2. Lugo																				77.4
3. Orense																		50		77.1
4. Pontevedra																			80	187.5
5. Alava														71.4						71.4
6. Guipuzcoa												96.4								96.4
7. Oviedo												18.5		213.6						458.6
8. Santander											30	5.1	97.2		150					282.3
9. Vizcaya													192							192.0
10. Heusca		10.5				48.2														88.7
11. Longroño							38.6													38.6
12. Navarra		8.1				1.8				60										69.9
13. Teruel																				10.0
14. Zaragoza		40		15	10.8		23.7													89.5
15. Barcelona		229.3																		229.3
16. Gerona		196.3	15																	211.3
17. Lerida		65.9			4.2															70.1
18. Tarragona		19.7																		19.7
19. Avila																				10.0
20. Burgos							37.7	15	30											148.0
21. Leon																				408.3
22. Palencia																				20.4
23. Salamanca																				47.9
24. Segovia																				77.1
25. Soria		20.8																		20.8
26. Valladolid																				77.2
27. Zamora	20																			122.5
28. Ciudad Real																				23.3
29. Guadalajara																				20.0
30. Madrid																				378.3
31. Toledo																				30.0
32. Alicante																				11.2
33. Castellon																				4.8
34. Murcia																				40.1
35. Valencia																				18.7
36. Badajoz																				30.0
37. Caceres																				104.1
38. Granada																				35.5
39. Jaen																				36.9
40. Malaga																				40.0
41. Cadiz																				45.3
42. Cordoba																				144.6
43. Huelva																				1.3
44. Sevilla																				223.7
Total	20	580.6	15	15	15	50	100	15	30	60	30	120	290	290	150	80	20	50	80	4615.6

Table 35. Optimum Processed Milk Flow from Surplus to Deficit Provinces (Model II), in Thousand Liters Per Day, Spain, 1973-74.

Surplus Provinces \ Deficit Powers	1. Avila	2. Toledo	3. Ciudad Real	4. Badajoz	5. Cadiz	6. Cordoba	7. Sevilla	8. Huelva	9. Cuenca	10. Palencia	11. Valladolid	12. Zamora	13. Teruel	14. Castellon	15. Albacete	16. Tarragona	17. Lerida	18. Malaga
1. Madrid	10	17.2	31		83	16.9	40.9	36.2										3.9
2. Guadalajara									11.7									
3. Segovia	7.3																	
4. Leon										17.5		16.1						
5. Valencia							80.4		11.0				7.7	35.9	30.9	46		
6. Alicante																		65.5
7. Barcelona																		
8. Huesca																	19.6	
9. Guipuzcoa																2.3		
10. Vizcaya				72.2													5.5	
11. Oviedo																		
12. Santander											32.9	2.7						
Total	17.3	17.2	31	72.2	83	16.9	121.3	36.2	22.7	17.5	32.9	18.8	7.7	35.9	30.9	48.3	25.1	69.4

Table 35. Continued

Surplus Provinces \ Deficit Powers	19. Oranada	20. Murcia	21. Jaen	22. Almeria	23. Gerona	24. Navarra	25. Logroño	26. Soria	27. Zaragoza	28. Burgos	29. Salamanca	30. Alava	31. Caceres	32. La Coruña	33. Lugo	34. Orense	35. Pontevedra	Total
1. Madrid			72.1										6					317.2
2. Guadalajara																		11.7
3. Segovia																		7.3
4. Leon																19.9	4.1	57.6
5. Valencia																		211.7
6. Alicante	5.1	108.5		37.4														216.5
7. Barcelona					45.5													45.5
8. Huesca																		19.6
9. Guipuzcoa					1.2	9.9	4.2		8.0									25.6
10. Vizcaya								9.4		19.9	21.6	3.6	0.7					133.5
11. Oviedo														72.5	39.0		30.4	141.7
12. Santander													46.6					83.2
Total	5.1	108.5	72.1	37.4	45.5	9.9	4.2	9.4	8.0	19.9	21.6	3.6	53.3	72.5	39.0	19.9	34.5	817.8

Table 36. Optimum Price Location Differentials Resulting from Solution of Dual (Model II), Spain, 1973-74.

Province	Raw Milk (Pesetas per liter)	Processed Milk (Pesetas per liter)
1. La Coruña	0.00	5.22
2. Lugo	0.10	4.99
3. Orense	0.16	5.38
4. Pontevedra	0.07	5.37
5. Alava	0.30	4.88
6. Guipuzcoa	0.81	4.85
7. Oviedo	0.38	4.41
8. Santander	0.58	4.62
9. Vizcaya	0.69	4.72
10. Huesca	0.84	5.64
11. Logroño	0.65	5.26
12. Navarra	0.68	5.08
13. Teruel	0.91	5.45
14. Zaragoza	0.82	5.53
15. Barcelona	1.12	5.16
16. Gerona	1.02	6.45
17. Lerida	0.96	5.99
18. Tarragona	1.02	6.03
19. Avila	0.49	5.73
20. Burgos	0.53	5.11
21. Leon	0.28	4.32
22. Palencia	0.37	4.64
23. Salamanca	0.48	5.71
24. Segovia	0.60	5.57
25. Soria	0.47	5.39
26. Valladolid	0.42	4.65
27. Zamora	0.35	5.49
28. Albacete	0.90	5.52
29. Ciudad Real	0.62	5.10
30. Cuenca	0.83	5.98
31. Guadalajara	0.65	5.62

Table 36. Continued.

Province	Raw Milk (Pesetas per liter)	Processed Milk (Pesetas per liter)
32. Madrid	0.60	4.64
33. Toledo	0.50	4.81
34. Alicante	1.07	4.88
35. Castellon	0.98	5.26
36. Murcia	0.99	5.09
37. Valencia	1.05	5.09
38. Badajoz	0.32	6.48
39. Caceres	0.25	6.25
40. Almeria	0.58	5.64
41. Granada	0.70	5.80
42. Jaen	0.65	5.49
43. Malaga	0.72	6.19
44. Cadiz	0.58	6.41
45. Cordoba	0.59	5.66
46. Huelva	0.54	6.22
47. Sevilla	0.46	6.61

The results obtained from Model III were very similar to those of Model II. The quantities to be processed in each plant and the flow from plants to consumption centers were the same in both Models and only the interprovince flow of raw milk was slightly different, as it can be seen in Table 37.

These Models indicate three possible inefficiencies in the pattern of assembly, processing, and distribution of milk in Spain in 1973-74. The first is that there are too many plants for efficient operation. With so many plants located within the Peninsula it would appear to be impossible for many of them to achieve minimum costs. It is also to be noted that the actual number of plants in Spain is increasing, thus compounding the problem.

The second possible inefficiency is the relative short distribution radius for the plants. In the actual pattern the radius is presumably even shorter, since most pasteurized milk cannot be shipped to other market areas due to existing regulations.

Finally, Model III showed that, although product-use inefficiency was relatively unimportant with the 1973-74 pattern, a better product-use allocation would have permitted a modest decrease of about 2 percent in total costs, through a decrease in assembly costs.

Table 37. Optimum Raw Milk Interprovince Flow (Model III), in Thousand Liters Per Day, Spain, 1973-74.

	1. Madrid	2. Ciudad Real	3. Guadalajara	4. Toledo	5. Burgos	6. Palencia	7. Segovia	8. Valladolid	9. Salamanca	10. Zamora	11. Leon	12. Badajoz	13. Caceres	14. Cadiz	15. Cordoba	16. Sevilla	17. Granada	18. Jaen	19. Malaga	20. Alicante	21. Valencia	22. Murcia
1. La Coruña																						
2. Lugo																						
3. Orense																						
4. Pontevedra																						
5. Alava																						
6. Guipuzcoa																						
7. Oviedo																						
8. Santander																						
9. Vizcaya																						
10. Huesca																						
11. Logroño																					19	
12. Navarra																					74	
13. Teruel																					45	
14. Zaragoza																					92	
15. Barcelona																						
16. Gerona																						
17. Lerida																					8.4	
18. Tarragona																					21	
19. Avila	66																					
20. Burgos					30																118.6	
21. Leon											130											
22. Palencia	77					10																
23. Salamanca	66								30													
24. Segovia	93						30															
25. Soria																					36	
26. Valladolid	57							30														
27. Zamora										15												20
28. Albacete																				5		
29. Ciudad Real		40																		36		
30. Guadalajara			30																			
31. Madrid	418																					
32. Toledo	143			15																		
33. Alicante																				23		
34. Castellon																					18	
35. Murcia																				53		
36. Valencia																					38	
37. Badajoz												20										
38. Caceres				30									10									
39. Almeria																				19		
40. Granada																				38		
41. Jaen																		15		33		
42. Malaga																			50	34		
43. Cadiz														50								
44. Cordoba															90		100			7		
45. Sevilla																100				102		
Total	920	40	30	45	30	10	30	30	30	15	130	20	10	50	90	100	100	15	50	350	470	20

Table 37. Continued

	23. Barcelona	24. Gerona	25. Tarragona	26. Lerida	27. Huesca	28. Zaragova	29. Teruel	30. Logroño	31. Navarra	32. Alava	33. Guipuzcoa	34. Vizcaya	35. Oviedo	36. Samander	37. La Coruña	38. Lugo	39. Orense	40. Panamora	Total
1. La Coruña															80				80
2. Lugo																20			20
3. Orense																	50		50
4. Pontevedra																		80	80
5. Alava													72						72
6. Guipuzcoa										15	120								135
7. Oviedo													218						218
8. Santander												63		150					213
9. Vizcaya												227							227
10. Huesca					50	23													133
11. Logroño								30											49
12. Navarra						17			60	15									166
13. Teruel																			45
14. Zaragoza																			92
15. Barcelona	270																		270
16. Gerona	236	15																	251
17. Lerida	114.6		15	15															153
18. Tarragona																			21
19. Avila																			66
20. Burgos							15												163.6
21. Leon																			130
22. Palencia																			87
23. Salamanca																			96
24. Segovia																			123
25. Soria																			36
26. Valladolid																			87
27. Zamora																			35
28. Albacete																			5
29. Ciudad Real																			76
30. Guadalajara																			30
31. Madrid																			418
32. Toledo																			158
33. Alicante																			23
34. Castellon																			18
35. Murcia																			53
36. Valencia																			38
37. Badajoz																			20
38. Caceres																			40
39. Almeria																			19
40. Granada																			38
41. Jaen																			48
42. Malaga																			84
43. Cadiz																			50
44. Cordoba																			197
45. Sevilla																			202
Total	620.6	15	15	15	50	100	15	30	60	30	120	290	290	150	80	20	50	80	4,615.6

CHAPTER VI

OPTIMUM NUMBER, SIZE AND LOCATION OF FLUID MILK PROCESSING PLANTS: AN EX-ANTE ANALYSIS

This chapter presents the projections of the basic data needed for the ex-ante analysis and the empirical results obtained from the application of Models IV and V.

Projections of Cow Milk Supplies and Fluid Milk Consumption and Assumptions Regarding Milk Assembly, Processing and Distribution Costs and Designation of Potential Fluid Milk Plant Sites

This section presents the procedures used (and the assumptions made) and the estimates obtained for cow milk production, fluid milk consumption, milk assembly, processing and distribution costs, and the designation of potential fluid milk plant sites for 1978.

Projection of Provincial Milk Supplies

The projections of provincial milk supplies for 1978 were developed as follows. First, national milk production in a given year was hypothesized to be a function of national

milk production in the previous year.[48] Twenty-four observations (from 1951 to 1974) were made and then least square estimates of the regression coefficients were obtained. The equation obtained was:

$$TMILKPROD_T = .0183 + 1.0314\ TMILKPROD_{T-1}$$

$$(.1304)\quad(0.0397)$$

$$R^2 = .9684,\ \bar{R}^2 = .9670$$

Total milk production at the national level was then projected for the next four years using this equation. The results are shown in Table 38.

Table 38. Projected Total Milk Production, Spain, 1975-78.

Year	Milk Production (Billion liters)	Production as a Percentage of 1975
1975	5.10	100.0
1976	5.28	103.5
1977	5.46	107.0
1978	5.65	110.7

Secondly, in order to determine the projections of total milk production which will be commercialized in 1978,

[48]Initially, it was attempted to develop a prediction model for forecasting annual production of milk in Spain, but lack of response of milk production to variables that were considered important (such as prices of milk and feed, proportion of Friesian cows, etc.) and rather poor fits made its use inadvisable. The results of this attempt are shown in Appendix D.

least square trends in percentage were established for the three main outlets of noncommercialized production (milk fed to calves, consumed in the farm in fluid form and used in the farm for home manufacturing purposes) and extended to 1978. It was projected that, in 1978, only 8.71 percent of total milk production will be fed to calves, 15.71 percent will be consumed directly in the farm and 4.43 percent will be used for home manufacturing purposes, for a total of 28.85 percent of total milk production that will not be commercialized.[49] This gives a projected commercialized production of 4.02 billion liters in 1978.

Finally, in order to project commercialized milk production at the provincial level, milk production in each province was divided by total output of Spain and a trend in percentage for each province was again established by least square regression and the trend line was extended linearly to 1978. Table 39 shows the projected daily provincial supplies of milk available for fluid consumption for the forty-seven peninsular provinces of Spain.

Projected Provincial Fluid Milk Needs

To project fluid milk consumption at the provincial level a trend in per capita fluid milk consumption was

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[49]In 1974 the percentages were 13.20, 15.92, 3.20, and 32.32 respectively for milk fed to calves, consumed as fluid in the farm, manufactured in the farm and non-commercialized.

again established by least square regression and the trend line was extended linearly to 1978. Per capita fluid milk consumption for that year was projected to be 89.2 liters, or 244.5 c.c. per day. Again, homogeneous per capita consumption throughout the country was assumed. Next, projections of provincial population for 1978 were obtained by extrapolation from the projections made by the III Plan de Desarrollo Economico y Social (60). The projections made under the assumption of indices of medium migratory behavior (1966-70 levels) were used. Provincial fluid milk needs for 1978 are also given in Table 39. These are strictly projections and should be considered as such and are only to be used as broad guidelines.

Designation of Potential Fluid Milk Plant Sites

The following twenty-two locations (optimal solution for 1973-74) were selected as potential plant sites for the 1978 models: (1) La Coruña, (2) Pontevedra, (3) Oviedo, (4) Santander, (5) Bilbao, (6) San Sebastián, (7) Zaragoza, (8) Barcelona I, (9) Barcelona II, (10) León, (11) Valencia, (12) Alicante, (13) Madrid I, (14) Madrid II, (15) Ciudad Real, (16) Badajoz, (17) Granada, (18) Jaen, (19) Malaga, (20) Cadiz, (21) Córdoba, and (22) Sevilla.

Table 39. Provincial Supplies of Milk Available for Fluid Consumption and Provincial Fluid Milk Needs, Spain, 1978 (Projected).

Province		Daily Potential Supply (Thousand liters)	Daily Fluid Milk Needs (Thousand liters)
1.	La Coruña	1,472	271
2.	Lugo	1,036	100
3.	Orense	61	104
4.	Pontevedra	374	206
5.	Alava	47	65
6.	Guipuzcoa	188	173
7.	Oviedo	1,533	262
8.	Santander	618	121
9.	Vizcaya	426	291
10.	Huesca	139	52
11.	Logroño	56	60
12.	Navarra	187	127
13.	Teruel	37	37
14.	Zaragoza	83	193
15.	Barcelona	285	1,063
16.	Gerona	216	112
17.	Lerida	272	67
18.	Tarragona	8	114
19.	Avila	224	45
20.	Burgos	184	87
21.	Leon	431	122
22.	Palencia	151	47
23.	Salamanca	145	89
24.	Segovia	134	38
25.	Soria	63	24
26.	Valladolid	128	116
27.	Zamora	112	57
28.	Albacete	17	82
29.	Ciudad Real	73	121
30.	Cuenca	0	60

Table 39. Continued.

Province	Daily Potential Supply (Thousand liters)	Daily Fluid Milk Needs (Thousand liters)
31. Guadalajara	8	30
32. Madrid	258	1,149
33. Toledo	208	106
34. Alicante	26	244
35. Castellon	18	99
36. Murcia	41	230
37. Valencia	47	470
38. Badajoz	279	154
39. Caceres	369	107
40. Almeria	20	103
41. Granada	37	183
42. Jaen	42	147
43. Malaga	87	211
44. Cadiz	62	237
45. Cordoba	275	185
46. Huelva	83	97
47. Sevilla	302	403
Total	10,852	8,460

Milk Assembly, Processing and Distribution Costs

Two alternative assumptions with respect to the components of total costs were made. In Model IV all costs were considered to be equally affected by inflation, while in Model V the labor component of processing costs was considered to increase by 20 percent more than the other costs involved by 1978.[50]

Empirical Results

This section presents the empirical results obtained from the application of Models IV and V.

Model IV

The least cost solution of this model was obtained for twenty-one plants, one less than in the 1973-74 solution with respect to which the plant in Jaen was dropped. Table 40 gives the location and sizes of those twenty-one plants. The largest plant will process 750,000 liters per day and the smallest one 121,000. The average processing volume will be 402,857 liters per day and plant. In comparison with the 1973-74 results (Model I), all plants

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[50] Wage costs in Spain have been generally low (one-half to two-thirds those of France and one-third those of the U.S.). In 1974 wage increases averaged 25 percent over the preceding year. Meanwhile inflation was about 20 percent. It will be assumed that this trend will continue for the next four years.

Table 40. Optimum Number, Location and Size of Fluid Milk Plants, Spain, 1978 (Projected).

Plant Number	Location	Size (Liters per day)
1	La Coruña	371,000
2	Pontevedra	310,000
3	Oviedo	262,000
4	Santander	121,000
5	Bilbao	639,000
6	San Sebastian	188,000
7	Zaragoza	349,000
8	Barcelona I	644,000
9	Barcelona II	645,000
10	Leon	430,000
11	Valencia	569,000
12	Alicante	474,000
13	Madrid I	755,000
14	Madrid II	755,000
15	Ciudad Real	121,000
16	Badajoz	261,000
17	Granada	433,000
18	Malaga	211,000
19	Cadiz	237,000
20	Cordoba	185,000
21	Sevilla	500,000
	Total	8,460,000

except the one in Santander increased their processing volume.

The twenty-one plants least cost solution involved an aggregate cost of milk assembly, processing and distribution of 34,381,040 pesetas per day or 4.06 pesetas per liter at 1974 prices, a drop of 0.1 percent in unit costs with respect to 1973-74, but with an 18.2 percent increase in output. Again, processing costs were the highest component of total costs with 23,471,400 pesetas per day or 68.26 percent of total costs.

By dropping either of the two smallest plants, those in Ciudad Real and Santander, total daily costs would increase by 30,830 or 27,830 pesetas per day, at 1974 levels, respectively.

Table 41 gives the optimum flow from the forty-seven supply regions to the twenty-one plants, as well as the total volume of raw milk supplied by each region and received by each plant, while Table 42 shows the optimum flow of processed products from the twenty-one plants to the forty-seven consumption regions as well as the total volume of milk products shipped by each plant and received by each consumption region.

Model V

This last model differed from the previous one in the assumption that the labor component of processing costs

Table 41. Optimum Flow of Raw Milk from Supply Regions to Processing Plants (Model IV), in Thousand Liters Per Day, Spain, 1978.

Supply Regions \ Processing Plants	1. La Coruña	2. Pontevedra	3. Oviedo	4. Santander	5. Bilbao	6. San Sebastian	7. Zaragoza	8. Barcelona I	9. Barcelona II	10. Leon	11. Valencia	12. Alicante	13. Madrid I	14. Madrid II	15. Ciudad Real	16. Badajoz	17. Granada	18. Malaga	19. Cadiz	20. Cordoba	21. Sevilla	Total
1. La Coruña	371																					371
2. Lugo																						0
3. Orense																						0
4. Pontevedra		310																				310
5. Alava								47														47
6. Guipuzcoa						188																188
7. Oviedo			262		39					430	234	389	39									1,393
8. Santander				121	174		323															618
9. Vizcaya					426																	426
10. Huesca								139														139
11. Logroño							26		30													56
12. Navarra								187														187
13. Teruel											37											37
14. Zaragoza									83													83
15. Barcelona								271	14													285
16. Gerona									216													216
17. Lerida									272													272
18. Tarragona									8													8
19. Avila														224								224
20. Burgos											184											184
21. Leon													431									431
22. Palencia														151								151
23. Salamanca													145									145
24. Segovia														134								134
25. Soria									22		41											63
26. Valladolid														128								128
27. Zamora																	112					112
28. Albacete												17										17
29. Ciudad Real															73							73
30. Cuenca																						0
31. Guadalajara											8											8
32. Madrid													140	118								258
33. Toledo												1			48		159					208
34. Alicante												26										26
35. Castellon											18											18
36. Murcia												41										41
37. Valencia											47											47
38. Badajoz																261					18	279
39. Caceres																		97			272	369
40. Almeria																	20					20
41. Granada																	37					37
42. Jaen																	42					42
43. Malaga																		87				87
44. Cadiz																			62			62
45. Cordoba																	63	27		185		275
46. Huelva																					83	83
47. Sevilla																			175		127	302
Total	371	310	262	121	639	188	349	644	645	430	569	474	755	755	121	261	433	211	237	185	500	8,460

Table 42. Optimum Flow of Finished Milk From Processing Plants to Consumption Centers (Model IV) in Thousand Liters Per Day, *Spain, 1978.*

	1. La Coruña	2. Lugo	3. Orense	4. Pontevedra	5. Alava	6. Guipuzcoa	7. Oviedo	8. Santander	9. Vizcaya	10. Huesca	11. Logroño	12. Navarra	13. Teruel	14. Zaragoza	15. Barcelona	16. Gerona	17. Lerida	18. Tarragona	19. Avila	20. Burgos	21. Leon	22. Palencia
1. La Coruña	271	100																				
2. Pontevedra			104	206																		
3. Oviedo							262															
4. Santander								121														
5. Bilbao					65				291		60	112								87		
6. San Sebastian						173						5										
7. Zaragoza										52			37	193			67					
8. Barcelona I															532	112						
9. Barcelona II															531			114				
10. Leon																					122	47
11. Valencia																						
12. Alicante																						
13. Madrid I																						
14. Madrid II																			45			
15. Ciudad Real																						
16. Badajoz																						
17. Granada																						
18. Malaga																						
19. Cadiz																						
20. Cordoba																						
21. Sevilla																						
Total	271	100	104	206	65	173	262	121	291	52	60	127	37	193	1063	112	67	114	45	87	122	47

Table 42. Continued

	23. Salamanca	24. Segovia	25. Soria	26. Valladolid	27. Zamora	28. Albacete	29. Ciudad Real	30. Cuenca	31. Guadalajara	32. Madrid	33. Toledo	34. Alicante	35. Castellon	36. Murcia	37. Valencia	38. Badajoz	39. Caceres	40. Almeria	41. Granada	42. Jaen	43. Malaga	44. Cadiz	45. Cordoba	46. Huelva	47. Sevilla	Total
1. La Coruña																										371
2. Pontevedra																										310
3. Oviedo																										262
4. Santander																										121
5. Bilbao			24																							639
6. San Sebastian																										188
7. Zaragoza																										349
8. Barcelona I																										644
9. Barcelona II																										645
10. Leon	89			116	56																					430
11. Valencia													99		470											569
12. Alicante												244		230												474
13. Madrid I		38						60		657																755
14. Madrid II						82			30	492	100															755
15. Ciudad Real							121																			121
16. Badajoz																154	107									261
17. Ganada																		103	183	147						433
18. Malaga																					211					211
19. Cadiz																						237				237
20. Cordoba																							185			185
21. Sevilla																								97	403	500
Total	89	38	24	116	56	82	121	60	30	1140	100	244	99	230	470	154	107	103	183	147	211	237	185	97	403	8,460

will increase 20 percent more than all other components of aggregate total costs by 1978.

The least cost solution of this model was also obtained for twenty-one plants, but this time, instead of the plant in Jaen the one in Ciudad Real was dropped from the optimal solution with respect to Model I. Its volume was absorbed by the two largest plants located in Madrid. Table 43 gives the optimum number, location, and sizes of plants obtained from Model V. The largest plant will now process 816,000 liters per day. The average processing volume will also be 402,857 liters per day and plant. This twenty-one plants least cost solution will involve an aggregate cost, at 1974 prices, of 34,711,830 pesetas per day or 4.10 pesetas per liter. The minimum cost with twenty-two plants was 34,754,220 pesetas per day.

With respect to the optimum flow of raw milk from supply regions to plants, there were only minor changes with respect to the optimal solution of Model IV (Table 41). Toledo will now ship 121,000 liters per day to Madrid, 32,000 liters to Jaen, and only 54,000 liters to Granada, in addition to 1,000 liters per day to Alicante whereas in Model IV it shipped 48,000 liters to Ciudad Real, 159,000 liters to Granada and 1,000 liters to Alicante. Ciudad Real will ship 73,000 liters of raw milk per day to Jaen and Jaen, finally, will send its 42,000 liters daily supply to its own plant.

Table 43. Optimum Number, Location and Sizes of Plants (Model IV), Spain, 1978 (Projected).

Plant Number	Location	Size (Liters per day)
1	La Coruña	371,000
2	Pontevedra	310,000
3	Oviedo	262,000
4	Santander	121,000
5	Bilbao	639,000
6	San Sebastian	188,000
7	Zaragoza	349,000
8	Barcelona I	644,000
9	Barcelona II	645,000
10	Leon	430,000
11	Valencia	569,000
12	Alicante	474,000
13	Madrid I	816,000
14	Madrid II	815,000
15	Badajoz	261,000
16	Granada	286,000
17	Jaen	147,000
18	Malaga	211,000
19	Cadiz	237,000
20	Cordoba	185,000
21	Sevilla	500,000
	Total	8,460,000

The optimum flow of processed fluid milk products will also be similar to the one for Model IV (Table 42) with only two differences. The two plants in Madrid will supply 121,000 liters of processed fluid milk per day to Ciudad Real and the plant at Jaen will supply its own province with 147,000 liters per day (Granada, of course, will not supply Jaen, but only its own needs and those of Almeria).

Sensitivity Analysis

As the results from Model V have indicated, a 20 percent increase in the labor component of processing cost would change the optimal solution of Model IV. Although it will not be attempted here to explicitly test the sensitivity of the optimal solutions obtained for the models that have been applied, an effort will be made to give a range of stability for the optimal solution of Ex-Ante Model IV with respect to processing costs, the largest component of total costs.

Raw milk transportation costs equal 0.001 pesetas per liter and kilometer, while finished milk transportation costs are 0.00252 pesetas per liter and kilometer, for a combined transportation cost of 0.00325 pesetas per liter and kilometer. The two closest plants[51] in the optimal

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[51]The two plants in Madrid and the two in Barcelona are excluded. Combination of these would result in one plant of 1,510,000 liters per day in Madrid and one of 1,289,000 liters per day in Barcelona. It is considered that no cost reductions can be achieved by combination (partial or total) of these four plants.

solution of Model IV, those of Santander and Bilbao, are separated by a distance of 110 kilometers. The plant in Santander and the one in Ciudad Real were the smallest ones in this optimal solution. If the two plants of Santander and Bilbao were to be combined in one located in Bilbao and processing 760,000 liters per day at a unit cost of 2.74 pesetas per liter of milk, there would be a decrease in processing costs of 33,880 pesetas per day and an increase in transportation costs of 46,851.2 pesetas per day, a net cost increase of 12,971.2 pesetas per day. For this change in the optimal solution to take place, an increase in processing costs of more than 7 percent will be needed.[52] Slightly more than a 7 percent increase in processing costs will be necessary to drop the plant in Ciudad Real (188 kilometers from Madrid), and similarly for those of San Sebastian (119 kilometers from Bilbao), Pontevedra (122 kilometers from La Coruña), Malaga (133 kilometers from Granada), etc.

On the other hand, to have one more plant in the optimal solution (the one of Jaen will be the first to enter), a reduction in processing costs would be necessary. The activation of the Jaen plant would represent an increase in processing costs of 56,690 pesetas per day with respect to the optimal solution of Model IV and a decrease in transportation costs of 50,760 pesetas per day. A reduction

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[52]Or a reduction of about 7.1 percent in transportation costs.

in processing costs of slightly more than 9.5 percent would be needed to make the plant in Jaen viable.

The optimal solution of Model IV, therefore, would be stable even with reductions in processing costs up to 9.5 percent or increases up to 7 percent. Of course, changes in the components of processing costs would also modify the optimal solution.

CHAPTER VII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the results of the study and presents the main conclusions drawn from it as well as some recommendations that could lead to improved efficiency in the fluid milk subsystem of Spain. Some of the limitations of the study and possible areas in which further research is needed are also identified.

Summary

The first objective of this research was to analyze the present organization of the fluid milk subsystem of Spain. After defining the dairy subsector and fluid milk subsystem of Spain, trends in milk production, consumption and import-export activities were presented and both the structure and government role in the fluid milk market were described. A preliminary evaluation of the performance of the fluid milk subsystem suggested that, although the subsystem has been fairly progressive in recent years, there seems to be substantial room for improvement with respect to other performance dimensions, such as product suitability, adequate output levels and consumer information, and absence of misregulation. The later analysis also showed that the subsystem is relatively inefficient, with indications of both suboptimal use of resources within firms and of inefficient allocation of resources between them.

The second objective of this study was to determine the effects of volume of production in individual plants upon the cost of processing fluid milk. An economic engineering study was undertaken to this end. A cost analysis procedure was developed and applied to each of six synthetic plants and four alternative workday lengths in order to estimate unit processing costs. For the plants analyzed, it was found that unit costs decreased from 3.958 pesetas per liter of fluid milk processed for a plant processing 40,000 liters per day for an eight-hour workday to 2.789 pesetas per liter for a plant processing 360,000 liters per day for an eight-hour workday.[53] This was a decrease of almost 30 percent, with most of the drop (76.6 percent) being in the 40,000-120,000 liters category in which cost decreased by 22 percent. The main factors affecting unit processing costs were packaging materials, equipment and labor costs. For most of the plants analyzed, the eight-hour workday was most efficient.

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[53]Unit costs for this plant operating twenty hours per day and processing 900,000 liters would be 2.680 pesetas per liter.

The third and fourth objectives included the determination of least costs numbers, locations and sizes of fluid milk processing plants for Peninsular Spain and of interprovince price differentials for both raw and finished milk that would be consistent with this optimum. The basic analytical tool used was the transshipment model. The main purpose of this analysis was to determine whether adjustments in sizes and numbers of plants would provide a more efficient pattern for milk assembly, processing, and distribution than the prsent one which, furthermore, would allow for expansion of the present fluid milk processing industry to provide hygienized milk to all consumers.

The data used for this analysis were provincial raw milk supplies available for fluid milk processing, provincial fluid milk consumption data, raw milk unit assembly costs between all supply regions and potential plant sites, fluid milk unit processing costs at each potential plant, and finished milk unit distribution costs between all potential plants and consumption centers. Provincial raw milk supplies were obtained from published data elaborated by the Ministry of Agriculture. Provincial fluid milk consumption figures were calculated on the basis of total supplies and population figures and assuming that per capita consumption of fluid milk products was uniform throughout the country. Raw milk assembly costs and fluid milk distribution costs were also obtained from secondary data elaborated by the Ministry of Agriculture. Finally, fluid milk processing costs were obtained from the study of economies of size conducted as part of this research.

Three ex-post (1973-74 dairy marketing year) and two ex-ante (1978 calendar year) models were solved. According to the least cost pattern obtained for 1973-74, twenty-two plants, processing a daily average volume of 316,316 liters of milk per plant would have provided processed milk to all consumers at that year's consumption levels at an average cost of 4.07 pesetas per liter. Processing costs represented almost 70 percent of unit costs. Optimum location and sizes of plants and optimum flow of raw and processed milk were also obtained. Optimum provincial price location differentials for raw and finished milk consistent with the minimum cost solution were obtained from the solution of the dual.

The actual pattern of fifty-seven plants, processing a daily average of 80,975 liters per plant and providing an amount of processed milk which was less than two-thirds of the total milk consumed in fluid form in 1973-74, could have attained a minimum average unit cost of 4.61 pesetas per liter of processed milk. The actual cost was equal to or, presumably, greater than this amount. Optimum flow of raw and finished milk and optimum provincial price location differentials to achieve this minimum aggregate cost under the present pattern of plant numbers and locations were also obtained.

A more efficient product-use allocation of milk would have permitted the attainment, under 1973-74 conditions, of a unit cost of 4.56 pesetas per liter, as obtained from Model III, in which provincial supplies of milk that could have been destined to processing for fluid use but part of which were destined to other uses were considered instead of provincial supplies actually processed for fluid consumption in 1973-74.

For 1978, it was projected that 8,460,000 liters of milk per day, a 21.5 percent increase with respect to 1974, will be needed for fluid consumption. The least cost pattern for 1978 would involve twenty-one plants, processing a daily average of 402,855 liters per plant at a unit cost, in 1974 prices, of 4.06 pesetas per liter, if all costs are assumed to be equally affected by inflation. Processing costs would represent more than 68 percent of unit costs. The optimal solution was found to be stable even with reductions in processing costs up to 9.5 percent or increases up to 7 percent.

If the labor component of processing costs is assumed to increase by 20 percent more than all the other components of aggregate total costs by 1978, the optimal solution would also involve twenty-one plants, although one of them will be different from the optimal solution under the previous alternative assumption.

Optimum locations and sizes of plants and optimum flow of raw and processed milk products were also obtained for 1978.

On the basis of these findings, the four hypotheses established in Chapter I seemed to be confirmed. Most of the existing plants are of suboptimal size, there are too many plants and the system of hygienization of milk could be extended to all the country with a reduction in unit costs through adjustments in the number, location and size of processing plants. In addition, price location differentials as presently computed do not guarantee optimum milk movements.

Conclusions

The major conclusions drawn from this study can be summarized as follows:

1. Relative inefficiency, inadequate output levels, lack of sufficient consumer information, inadequate fluid milk product mix offered and elements of misregulation seem to be the main barriers to improved performance in the fluid milk subsystem of Spain.
2. Milk prices received by producers have deteriorated considerably during the last few years relative to the prices paid by farmers for their inputs, placing them at 1971 levels.

3. Total fluid milk processing costs per unit drop sharply with increased volume up to 120,000 liters per day and continue to decline, although at a slower rate, to a volume of 360,000 liters per day for an eight-hour workday, the most efficient workday length.

4. Packaging materials, equipment and labor costs, in this order, are the main factors affecting unit milk processing costs and, together, make up more than 70 percent of processing costs per unit.

5. When considering assembly, processing and distribution costs and demand and supply conditions, the minimum efficient plant would have processed 105.000 liters per day in 1973-74. In 1978 the minimum efficient size will be 121,000 liters per day.

6. An optimum pattern of twenty-two plants would have provided hygienized milk to all consumers of fluid milk (50.7 percent more than the actual quantity provided) in 1973-74 at a cost per unit 13.2 percent lower than the minimum cost that could have been attained with the actual pattern of fifty-seven plants.[54]

7. An improved product-use allocation, with milk available in each province being destined to processing for fluid consumption as the first priority would

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[54]Existing regulations, however, would not have permitted the attainment of this optimum pattern.

permit a slight decrease in unit costs through a decrease in assembly costs.

8. Twenty-one and one-half percent more milk will be needed for fluid consumption in 1978 than in 1974. If all the milk to be consumed in fluid form by 1978 were to be hygienized in processing plants, the increase in processed milk needed with respect to the quantity supplied in 1973-74 would be 83.3 percent. An optimum pattern of twenty-one plants could provide the needed amount of hygienized milk at a minimum cost in 1978.

Taken as a whole, the research has demonstrated relative economic advantages for moving towards a fluid milk processing industry both more concentrated and with an expanded capacity. While it would be very difficult to expect the dismissal of nearly 60 percent of the plants existing in 1974 some alternative will be needed to keep the subsystem from further deterioration with the present organization.

Recommendations

This study has focused almost exclusively on the design aspect of efficient area organization. While the general value of the information provided by this type of studies in formulating both private and public goals is widely recognized, "free-market" economists such as French have argued that their results are apt to be "rather sterile

in the absence of some central planning authority" (24, page 94). The basis for such planning authority in the fluid milk subsystem is already present in Spain under current regulations, in whose context this study was undertaken. Most of the recommendations to be drawn from this research which, for the most part, come directly from the conclusions outlined in the previous section, are directed to the public agencies to which the development of programs to improve the performance of the fluid milk subsystem is currently assigned, although it is considered that some of them would also be valid under a different arrangement and will also be relevant to management of fluid milk plants and other participants.

1. The minimum price to milk producers should be increased to correct the progressive deterioration in the relative position of dairymen during the last three years, in which real milk prices received by farmers have dropped almost 11 percent, placing them at 1971 levels. Slack existing in the subsystem could allow some increase in producer prices to be absorbed without a drastic increase in consumer prices. At any rate, higher producer prices seem to be necessary if the country is to become self-sufficient in milk, given the increased needs projected for the near future. On the other hand, if prices are allowed to deteriorate further it is very likely that future supplies will not be

sufficient to cover the expected increased demand.

2. The minimum daily processing capacity for an eight-hour workday should be increased up to at least 105,000 liters for plants seeking authorization to enter the processing industry. Although smaller plants could still be exceptionally authorized in special cases as it is presently done, unless special conditions not reflected by the models in this study prevail the construction of such new small plants should be discouraged. If relatively small plants continue to be authorized at the present rate, this would result in greater inefficiency in the fluid milk industry, making it increasingly unable to supply high quality, processed milk to all the country at reasonable prices.

3. Existing firms operating below the 105,000 liters per day level should be provided incentives for consolidation of both plants and markets in order to accelerate the movement towards a more efficient organization of the fluid milk subsystem.[55]

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[55]Since optimization of the efficiency of the total subsystem does not necessarily guarantee that the efficiency of each of the component parts or participants will be optimized, additional programs might be necessary to avoid adverse economic impact on some participants if the subsystem is to move toward increased concentration. Such programs might include selective subsidies to affected

4. No restrictions should be imposed with respect to the geographical area in which a processing firm is allowed to sell its product. The elimination of present restrictions on the sale of pasteurized milk, it is thought, would contribute to a more efficient flow of finished products. Even if no reduction in the number of plants is achieved but optimum flow of both raw and processed milk are allowed to take place, cost per unit will be only 13.2 percent higher than those to be obtained under an optimum pattern of twenty-two plants. Furthermore, elimination of the existing restrictions would very likely bring about a decrease in the proportion of sterilized milk that is being produced, which would result in an improved efficiency of the subsystem.
5. The system of compulsory hygienization of milk should be extended to all the country. Existing plants should be able to provide processed milk to all consumers, either through longer workdays or expansion, once present restrictions are eliminated.
6. Maximum resale prices should be established for both pasteurized and sterilized milk or for neither of them. This would eliminate another incentive to produce sterilized milk beyond the amount that would

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participants, increased participation of public companies in the subsystems, etc.

be necessary and would contribute to improved efficiency. In the light of the results of this study, the present system of establishing maximum resale prices, in which costs incurred by plants processing from 25,000 to 35,000 liters per day are used for guidelines, seems to work to the advantage of the larger plants, which is consistent with the need for a more concentrated industry revealed by this research. However, the implications of the present system should be fully understood to avoid inconsistency between this part of the present regulations and other parts which tend to encourage the building of relatively small plants.

7. Interprovince price differentials for both raw and processed fluid milk should be established in such a way as to minimize aggregate costs involved in milk assembly, processing and distribution. This would also contribute to a more efficient product-use allocation. Failure to do so will contribute to the continuation of a relatively inefficient system and could deprive some consumption areas of adequate supplies.

Limitations and Needed Research

Some of the limitations of this study have been suggested throughout its development. However, it is considered necessary to reemphasize some of them and to

to suggest additional areas of research to overcome some of these limitations.

This study was undertaken considering the existing decision-making framework and was designed to propose changes in the present regulations that could lead to an improved performance. The evaluation of other alternatives (including the absence of any government intervention, the creation of marketing orders or marketing boards or even the total ownership and/or control of the subsystem by the government) to the present system of partial government intervention was beyond the scope of the study. However, it is important that additional alternatives of organizing the fluid milk subsystem be examined and research in this area should be placed high on the list of priorities.

Individual research projects such as this particular study are also obviously limited by the abilities of existing procedures and the capability of the researcher to include all the relevant variables. This was true in this study, which focused on estimating the numbers, locations, and sizes of fluid milk processing plants that would minimize aggregate costs of assembly, processing and distribution. No consideration was given to the costs that would be involved in making the changes suggested by the models. Additional work to estimate the actual savings that would occur with respect to the present situation by shifting to the new organization would be an important addition to the results of the study.

Analysis in terms of a single commodity is, on the other hand, oversimplified and important relations existing among commodities are ignored. A more comprehensive sub-sector study which could incorporate the present subsystem study should follow.

The quality of the data used may also be considered a limitation. The secondary data utilized to estimate provincial supplies and demand may not be entirely reliable. Inaccurate data, of course, would make questionable the validity of the results obtained. The projected supplies and demand, which were based on past trends may also be of a crude nature. Although more elaborate econometric models might be used to improve the projections, there is no reason to believe that more sophisticated models would improve the quality of the data. A dramatic improvement in the quality of the data system is fundamental if meaningful research is to be conducted in Spain.

Improvement of the results obtained from the models utilized should be straightforward once more accurate supply and demand data are obtained. Additional work could be done by using available computer options which could make it possible to include differences in provincial demand and supply functions as a part of the models.

The study, moreover, was obviously a static analysis of a subsystem which is evidently dynamic. While the consideration of ex-ante models alleviates to some extent the problem, it does not solve it. Further work, both at the conceptual and applied level is suggested.

The extent to which milk production is responsive to producer prices could not be adequately determined with the econometric models used. Given the commitment of the Spanish government to increased milk production and the system of minimum producer prices, information with respect to the expected output with a given level of prices is badly needed. Parametric linear programming, for example, could be used to determine normative supply responses both at the national and provincial levels as an alternative to econometric models. Different supply responses in different agricultural regions under an optimum pricing system could very likely change the geographical distribution of milk production. A different supply pattern could require a pattern of fluid milk plant numbers, sizes and locations different from the one indicated in this study.

Similarly, an alternative to the assumption of uniform provincial fluid milk consumption should be found. Household consumption surveys to obtain cross-sectional data for estimating provincial fluid milk demand would be extremely important since time-series data, even if available, would probably be inadequate.

These dynamic adjustments should be simultaneously determined through analyses that incorporate supply and demand functions together with assembly, processing and distribution costs. The supply and demand functions were not estimated in this study whose results, therefore, must be viewed more as an indication of direction of change rather than a precise specification of an equilibrium position. Information about both the fluid milk subsystem and the dairy subsector should be accumulated over time. In this sense, this study represents only a beginning contribution to the accumulation of research results that are increasingly needed.

APPENDICES

APPENDIX A

MATRIX FORMAT OF THE TRANSSHIPMENT MODEL UNDER THE LINEAR PROGRAMMING FORMULATION

MATRIX FORMAT OF THE TRANSSHIPMENT MODEL UNDER THE LINEAR PROGRAMMING FORMULATION

Table A-1, based on hypothetical data, gives an indication of how the matrix used in the analysis looks. Three supply regions, two plants, and three demand regions are considered. They make up a matrix of fourteen rows by fourteen columns.

A, B, and C represent supply areas, D and E processing plants, and F, G, and H demand regions. Row 1, for example, shows that region A can ship the total amount she produces (in this case, less than or equal to 1,000 units, as shown in the columns of restraints) to both processing plants D and E, as figures of one indicate in columns 1 and 2. Exactly which quantity, if any, will be shipped from supply region A to potential processing plants D and E will depend on the relevant costs. Ones also appear in rows four and five (milk equilibrium) under the same columns 1 and 2. Similarly for supply regions B and C.

The intersections of columns 7 and 8 with rows 4 and 5, respectively, shows the total amount of milk to be processed in each plant, which should be equal to the sum of the corresponding quantities shipped to each plant from each

Table A-1. Matrix Format of the Transshipment Model Under the Linear Programming Formulation.

Location		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Constraints		
		D	E	D	E	D	E	D	E	F	G	H	F	G	H	Type	Level	
Supply Regions	1.A	1	1													≤	1,000	Quantities Supplied
	2.B			1	1											≤	750	
	3.C					1	1									≤	250	
Processing Plants	4.D	1		1		1		-1								=	0	Milk Equilibrium
	5.E		1		1		1		-1							=	0	
	6.D							1								≥	750	Plant Capacities
	7.D							1								≤	1,250	
	8.E								1							≥	600	
	9.E								1							≤	900	
	10.D							-1		1	1	1				=	0	Processed Milk Equilibrium
	11.E								-1				1	1	1	=	0	
Consumption Regions	12.F									1			1			≥	900	Quantity Demanded
	13.G										1			1		≥	700	
	14.H											1			1	≥	400	
Unit Costs		-2	-3	-1	-3	-1	-2	-4	-5	-1	-2	-3	-3	-2	-4			

of the supply regions and, thus, a zero balance milk equilibrium appears in the corresponding column of constraints.

Rows 6 and 7 show the plant capacity of processing facility D in a range of greater than or equal to and lesser than or equal to given minimum and maximum plant capacities, as shown in the column of constraints. Similarly rows 8 and 9 for plant E. The intersections with columns 7 and 8 give the amount of milk processed in each plant.

The intersections of columns 7 and 8 with rows 10 and 11, respectively, show the total amount of fluid milk products shipped out from each of the plants D and E, which should be equal to the sum of the corresponding quantities shipped to the consumption centers and, thus, a zero balance processed fluid milk equilibrium appears in the column of restraints, with respect to the processing plants.

Row 10 and columns 9, 10, and 11 show the amounts of processed fluid milk products which can be shipped from plant D to each of the consumption regions F, G, and H. Again, the quantities that will be actually shipped from D to F, G, and H will depend on the relevant cost figures. Similarly for row 11 and the same columns 9, 10, and 11 relative to plant E.

Rows 12, 13, and 14 under columns 9, 10, and 11 show the fluid milk products received by consumption regions F, G. and H, respectively, from plant D. Similarly, rows 12, 13, and 14 under columns 12, 13, and 14 for plant E.

The quantities of fluid milk products which should be received by these consumption regions should be greater than or equal to the quantities appearing in the column of constraints for the corresponding row (12, 13, or 14 for F, G, and H, respectively).

The last, not numbered, row shows the unit costs of assembly (columns 1 to 6), processing (columns 7 and 8) and distribution (columns 9 to 14). They are expressed as negative numbers, which permits solving the cost minimization problem as a maximization problem.

APPENDIX B

ESTIMATION OF UNIT COSTS OF PROCESSING FLUID MILK: APPLICATION OF THE BUDGETING PROCEDURE TO PLANT I WORKING EIGHT HOURS PER DAY

ESTIMATION OF UNIT COSTS OF PROCESSED FLUID MILK: APPLICATION OF THE BUDGETING PROCEDURE TO PLANT I WORKING EIGHT HOURS PER DAY

Plant I processes 40,000 liters per day working eight hours. Sixteen thousand liters are pasteurized, 10,000 being packaged in plastic bags and 6,000 in glass bottles. Twenty-four thousand liters are sterilized, 12,000 being packaged in tetraedric paper and another 12,000 in glass bottles.

Building Costs

After observing actual plants and designs of plants of similar capacity, it is estimated that 5,000 square meters of land are needed for plant I. Total investment costs for this concept are:

$$5{,}000 \text{ m}^2 \times 1{,}000 \text{ pts/m}^2 = 5{,}000{,}000 \text{ pts.}$$

And annual economic costs 8.75 percent of this figure, that is, 437,500 pesetas.

Of the total land purchased, 3,200 m^2 will be actually build (350 for factory, 150 for receiving room, 200 for laboratory and offices, 150 for the boiler and

2,350 for warehouses and the refrigeration chamber). Total investment costs are:

$$3{,}200 \text{ m}^2 \times 8{,}000 \text{ pts/m}^2 = 25{,}600{,}000 \text{ pesetas}$$

And annual economic costs are 10 percent of this figure, i.e., 2,560,000 pesetas.

The non-constructed area, finally has to be paved, landscaped, etc. Total investment costs for this concept are:

$$(5{,}000 - 3{,}200) \times 555.55 = 1{,}000{,}000 \text{ pesetas}$$

An annual economic costs represent 100,000 pesetas.

Total annual economic costs associated with buildings and land acquisition and development for plant I, therefore, are 3,097,500 pesetas (or 0.21 pesetas per liter).

Equipment Costs

The selection of equipment and the associated investment costs for plant I are as follows:

Receiving Stage

Chain conveyor (for cans).	300,000 pts.	
Drainer.	45,000 pts.	
Automatic can washer (250 cans/ hour	450,000 pts.	
Scale (250 kilograms).	185,000 pts.	
Receiving Vat (1,000 liters) . . .	70,000 pts.	
TOTAL RECEIVING STAGE.		1,050,000 pts.

Filtration, Cooling, and Storage

Pump (10,000 liters/hour).	80,000 pts.
Purifier (10,000 liters/hour). . .	500,000 pts.

Cooling cabinet (10,000 liters/ hour)	225,000 pts.
Five storage tanks (8,000 liters each)	2,500,000 pts.
TOTAL FILTRATION & REFRIGERATION STAGE	3,305,000 pts.

Skimming and Normalization

Deposit (500 liters)	65,000 pts.
Pump (5,000 liters/hour)	50,000 pts.
Heater-cooler (5,000 liters/ hour)	250,000 pts.
Skimmer (5,000 liters/hour)	560,000 pts.
Skimmed milk deposit (8,000 liters)	500,000 pts.
TOTAL SKIMMING & NORMALIZATION STAGE	1,425,000 pts.

Pasteurization

Pasteurizer (5,000 liters/hour) . .	1,100,000 pts.
Compressor	40,000 pts.
Homogenizer (5,000 liter/hour) . .	1,750,000 pts.
Tank pasteurized milk (5,000 liters)	500,000 pts.
Pump (5,000 liters/hour)	50,000 pts.
TOTAL PASTEURIZATION STAGE	3,240,000 pts.

Packaging of pasteurized milk

Baskets conveyor	100,000 pts.
Baskets washer (420 units/hour) . .	250,000 pts.
Bottles washer (5,200 units/ hour)	1,200,000 pts.
Bottles conveyor	200,000 pts.
Filler-closer (5,000 bottles/ hour)	1,800,000 pts.
Plastic filler (two units, 1600 liters/hour each)	1,550,000 pts.
Compressor (5.5 C.V.)	45,000 pts.
Conveyor	75,000 pts.
TOTAL PACKAGING PASTEURIZED MILK	5,220,000 pts.

Sterilization by towers

Pump (10,000 liters/hour)	80,000 pts.
Sterilizer (6,000 liters/hour) . .	5,896,000 pts.
Intermediate deposit (5,000 liters)	300,000 pts.

Baskets chain conveyor.	120,000 pts.
Baskets washer (500 units/ hour)	350,000 pts.
Bottles washer (3,000 units/ hour)	1,500,000 pts.
Filler-closer (3,000 units/ hour)	1,800,000 pts.
Bottles conveyor.	300,000 pts.
Automatic inspector	1,500,000 pts.
Continuous sterilizer (3,000 bottles/hour)	10,000,000 pts.
Exit chain conveyor	120,000 pts.
TOTAL STERILIZATION TOWERS. . . .	22,366,000 pts.

<u>Sterilization (UHT System)</u>

UHT Equipment, complete (3,600 liters/hour).	6,500,000 pts.
Filler machine (3,600 liters/ hour)	875,000 pts.
Exit conveyor	75,000 pts.
Packer Machine.	100,000 pts.
Boxes' conveyor	300,000 pts.
Compressor (10 C.V.).	65,000 pts.
TOTAL STERLIZATION UHT.	7,915,000 pts.

<u>Complements</u>

Cleaning Equipment.	140,000 pts.
Pipes and Valves.	760,000 pts.
TOTAL COMPLEMENTS	900,000 pts.

<u>Auxiliary Services Installations</u>

Steam production and distribution.	3,000,000 pts.
Fuel.	500,000 pts.
Frigorific.	2,000,000 pts.
Water	350,000 pts.
Electricity	2,200,000 pts.
Compressor.	65,000 pts.
TOTAL AUXILIARY SERVICES.	8,115,000 pts.

<u>Laboratory and Offices</u>

Laboratory.	750,000 pts.
Office.	500,000 pts.
TOTAL LABORATORY AND OFFICES. . .	1,250,000 pts.

Others

Equipment transportation, insurance, installation, etc.	1,500,000 pts.
TOTAL OTHERS.	1,500,000 pts.
TOTAL EQUIPMENT INVESTMENT COSTS	63,631,000 pts.

Annual economic costs are 27.5 percent of these investment costs, that is, 17,498,525 pesetas per year (or 1.19 pesetas per liter).

Container Costs

The number of cans needed for plant I processing 40,000 liters of milk per day are:

$$\frac{40{,}000 \times 2 \times 1.3}{40} = 2{,}600 \text{ cans}$$

And, at 1,000 pesetas per can, investment costs for cans are 2,600,000 pesetas.

The number of glass bottles for pasteurized milk for plant I bottling 6,000 liters of pasteurized milk per day are: 6,000 x 3.5 = 21,000 bottles. The cost per bottle is 6 pesetas, and investment costs for glass bottles for pasteurized milk, thus, are 126,000 pesetas.

Glass bottles for sterilized milk cost 7.40 pesetas per unit and the number needed by plant I is 12,000 x 20 = 240,000, for a total cost of 1,776,000 pts.

Returnable baskets for glass bottles cost 80 pesetas/unit. Each basket holds twelve bottles and the number of baskets needed, therefore, is 21,750. Investment costs for this concept are 1,740,000 pesetas.

Returnable baskets for plastic packaged pasteurized milk, finally, cost 150 pesetas per unit and plant I needs $\frac{26,000}{12}$ = 2,166. Total cost is, then, 363,000 pts.

Total container investment costs for plant I and an eight-hour workday, therefore, are 6,509,800 pesetas, and economic annual costs associated with them, which represent 24.25 percent of this figure, are 1,627,470 pesetas (or 0.11 pesetas per liter).

Durable Asset Costs

Annual economic costs associated with the durable assets considered thus far for plant I for an eight-hour workday are 22,223,475 pesetas or 1.51 pesetas per liter.

Labor Costs

Plant I working an eight-hour workday, requires one plant manager, one engineer, one plant superintendent, one office supervisor, one accountant, one payroll clerk, five clerk typists, two laboratory technicians, two custodians, nineteen unskilled workers (three for the receiving stage, one for pasteurization, four for packaging of pasterized milk, one for presterilization and bottling, one for UHT system, four for boxes, labels, etc. and five for shipping, warehouses, vacation and sick leaves, etc.), four skilled workers (for cooling and filtration stage, presterilization and bottling, boiler, and frigorific installation, respectively), two specialists of third category (one for the receiving stage and another for shipping, warehouses, leaves, etc.), eight specialists of first category (one for cooling and filtration, one for pasteurization, one for packaging of pasteurized milk, two for presterilization and bottling, one for UHT system, and two for packaging of aseptic milk), one official (frigorific installation) and one stoker (boiler).

Tables B-1 and B-2 give the salaries (wages), tariff and complementary basis and accident insurance rates for management, office and laboratory personnel, and for utility, processing and shipping personnel, respectively. For Plant I and an eight-hour workday, total salaries are 165,749 x 12 = 1.988,988 pesetas per year and total wages are 8,238 x 365 = 3,006,870 pesetas per year.

Social security and accident insurance charges include: (1) two months (or sixty days) of total (take-home) pay (two extra pays), (2) one month of base salary (or thirty days of base wage)--benefits pay, (3) 41.47 percent of tariff basis, plus 17.47 percent of complementary basis plus 17.47 percent of benefits pay (social security and labor mutualism), and (4) fifteen months (or 455 days) times total amount accident insurance (Accident Insurance). Total social security charges for plant I for an eight hour workday are 3,207,214 pesetas per year, and total labor costs are 8,203,072 pesetas per year or 0.56 pesetas per liter.

Table B-1. Salaries, Tariff, and Complementary Basis and Work Accident Insurance Rates for Plant I and Eight-hour Workday, in Pesetas/Month, Spain, 1974.

Number	Category	Base Salary	Total Month	Tariffed Basis	Complementary Basis	Accident Insurance		
						Epig.	Percent	Amount
1	Director	12,570	15,474	13,620	2.904	488	1.7	263.05
1	Engineer	12,570	13,383	13,620	813	488	1.7	227.51
2	Lab Technician	13,500	13,500	14,640	---	393	3.0	405.00
4	Inspector	29,640	34,904	32,024	5,267	393	3.0	1047.12
1	Plant Superv.	7,950	9,547	8,610	1,597	393	3.0	286.41
1	Office Superv.	9,060	11,254	9,840	2,194	487	1.0	112.54
1	Accountant	9,060	10,999	9,840	1,939	487	1.0	109.99
1	Payroll clerk	7,410	9,334	8,010	1,924	487	1.0	93.34
5	Clerk Typist	33,750	33,750	36,600	---	487	1.0	337.50
2	Custodian	13,500	13,604	14,460	104	483	3.0	204.06
19	Total	149,010	165,749	161,460	16,739	---	---	3290.58

Source: Ministerio de Agricultura, Spain. Escandallos para la determinacion del precio de la leche esterilizada en distintos envases.

Table B-2. Wages, Tariff, and Complementary Basis and Accident Insurance for Plant I and Eight-Hour Workday, in Pesetas/Day, Spain, 1974.

Number	Category	Base Wage	Total Day	Tariffed Basis	Complementary Basis	Accident Insurance		
						Epig.	Percent	Amount
20	Unskilled	4,500	4,500	4,880	---	393	3	135.00
3	Skilled	708	708	767	---	393	3	14.16
2	Specialist 3rd	472	472	512	---	393	3	7.08
8	Specialist 1st	1,888	2,064	2,048	176	393	3	61.92
1	Official	242	258	262	16	393	3	7.74
1	Stoker	236	236	256	---	393	3	7.08
35	Total	8,048	8,238	8,725	192	---	-	232.98

Source: Ministerio de Agricultura, Spain. Escandallos para la determinacion del precio de la leche esterilizada en distintos envases.

Utility Costs

Utility costs include electricity (for power and light), fuel and water consumption costs.

Electricity Costs

The procedure used to calculate electricity needs for power consists of listing processing and auxiliary equipment consuming electric energy, their power (in C.V.) and working hours per day, and converting this to kw.h through the formula Σ(CV x hours) x 0.736 = Total kw.h

For Plant I and an eight-hour workday, these are found on page 204.

Daily needs of electricity for light are estimated in 40 kw.h. Total annual electricity needs for Plant I for an eight-hour workday are 760,447.3 kw.h., and total annual electricity costs are 1,193,902 pesetas or 0.08 pesetas/ liter.

Fuel Cost

One kilogram of fuel supplies twelve kilograms of steam. Steam needs for washing of cans, bottles and baskets are 1.5 kgs. of steam per can, 0.3 kgs. per bottle and 0.5 kgs. per basket (20), i.e., 1500 kgs. of steam/day for cans, 5,400 kgs. for bottles and 1,167 kgs. for baskets, for a total of 8,067 kgs. steam/day for washing of bottles, cans, and baskets.

Stage	Equipment	C.V.	Hours/day	C.V. hours/day
Receiving	Cans conveyor	2	4	8
Receiving	Cans Washer	8	4	32
Filtration & Cooling	Pump	8	4	32
Filtration & Cooling	Purifier	3	4	12
Filtration & Cooling	Cooling Cabinet	9	4	36
Filtration & Cooling	5 Tank Agitators	2.5	8	20
Skimming & Normalization	Pump	5	8	40
Skimming & Normalization	Heater-cooler	9	8	72
Skimming & Normalization	Skimmer	6	8	48
Skimming & Normalization	Deposit agitator	0.5	8	4
Pasteurization	Pump	5	3.2	16
Pasteurization	Pasteurizer	50	3.2	160
Pasteurization	Homogenizer	12	3.2	38.4
Packaging Pasteurized Milk	Baskets conveyor	2	4.4	8.8
Packaging Pasteurized Milk	Baskets washer	2	2.2	4.4
Packaging Pasteurized Milk	Bottles washer	2	1.2	2.4
Packaging Pasteurized Milk	Filler-closer (glass)	5	1.2	6
Packaging Pasteurized Milk	Filler-closer (plastic)	6	3.2	19.2
Sterilization (Towers)	Pump	8	1.2	9.6
Sterilization (Towers)	Sterilizer	55	1.2	66
Sterilization (Towers)	Baskets conveyor	2	1.2	2.4
Sterilization (Towers)	Baskets washer	2	0.6	1.2
Sterilization (Towers)	Bottles conveyor	2	1.2	2.4
Sterilization (Towers)	Bottles washer	2	1.2	2.4
Sterilization (Towers)	Filler-closer	5	1.2	6
Sterilization (UHT)	UHT System	44	3.33	146.66
Sterilization (UHT)	Filler machine	5	3.33	16.66
Sterilization (UHT)	Boxes' conveyor	2	3.33	6.66
Sterilization (UHT)	Packer machine	3	3.33	9.99
Sterilization (UHT)	Exit conveyor	2	3.33	6.66

Stage	Equipment	C.V.	Hours/day	C.V. Hours/day
Cleaning	General	5	3	15
Cleaning	UHT System	5	3	15
Refrigeration Production	Two compressors (60,000 frig)	54	16	864
Refrigeration Production	Compressor (20,000 frig)	9	16	144
Refrigeration Production	Two pumps	30	4	120
Refrigeration Production	Fans	3	24	72
Refrigeration Production	Air Extractor	3	24	72
Refrigeration Production	Agitator tank	3	16	48
Refrigeration Production	Air curtains door (Frigorific chambers)	1	24	24
Water elevation	Pump	50	8	400
Steam Production	Thermic installation (Complete)	14	10	140
Compressors	Plastic fillers	5.5	3.2	17
Compressors	UHT sterilized filler	10	3.33	33.3
Compressors	Pasteurization	5	4	20
Total (Power).				2,870.73 C.V. Hour/day

Steam needs for pasteurization and sterilization are two kilograms of steam per centigrade degree and 1,000 liters (20). Milk is pasteurized at 76°C, but reaches 50°C in recuperating sections; therefore, steam needs for pasteurizing milk are:

$$\frac{16{,}000 \text{ liters/day} \times 2 \text{ kgs/°C and } 1{,}000 \text{ liters} \times (76-50)}{1{,}000 \text{ liters}}$$

= 832 kgs./day. Steam needs for sterilizing milk are:

$$24 \times 2 \times (140-105) = 1{,}680 \text{ kg/day}$$

With respect to cleaning, steam consumption for general cleaning are 350 kgs/hour (or 1,050 kgs/day), for cleaning of the UHT system they are the same as when sterilizing and, for cleaning of the plant, steam needs are 1,000 kgs/day, for a total of 2,890 kgs. steam per day for cleaning purposes.

Total steam consumption, therefore, is 13,469 kgs/day and, adding an additional 15 percent for losses, 15,488 kgs/day and 5,653,485 kgs/year. Annual needs of fuel, therefore, are 471,215 kgs. and total annual fuel costs are 1,578,570 pesetas or 0.10 pesetas per liter.

Water Costs

Water needs for washing of cans, bottles, and baskets are 10 liters per can, 2 liters per bottle, and 3 liters per basket (20). Total water needs for washing containers are: 1,000 cans x 10 l/can + 18,000 bottles x 2 l/bottle + 2,334 baskets x 3 l/basket = 43,002 liters/day.

Water needs for refrigeration of pasteurized milk and cooling of sterilized milk are 3 liters of water per liter of processed milk (20). Total water needs for refrigeration and cooling of processed milk, therefore, are 120,000 liters/day.

Water needs for steam production are 15,689 liters/day (amount of steam produced per day).

The needs of water for refrigeration of compressors and frigorific condensors are given by the formula:

$$L \text{ liters of water} = \frac{1.3\ F}{T_2 - T_1}$$

where F is the number of frigories and $T_2 - T_1 = 6°C$ is the difference between temperatures of the refrigeration water at exit and entry.

Frigorific needs are divided into two parts, indirect refrigeration (tank of iced water) and direct refrigeration (0°C frigorific chamber). Frigorific needs for indirect refrigeration include refrigeration of raw milk (receiving stage) and of pasteurized milk, plus losses. To refrigerate milk in the receiving stage the number of frigories needed per day are: 40,000 liters x 1.032 x 0.93 x (25-4) = 806,400 frigories/day (where 1.032 is the density of milk, 0.93 its specific heat and 25 and 4°C the temperature of milk before and after refrigeration, respectively). To refrigerate pasteurized milk the number of frigories needed per day are: 16,000 x 1.032 x 0.93 x (20-4) =

245,760 frig/day. Adding 10 percent for losses, frigorific needs for indirect refrigeration are 1,158,376 frig/day.

Frigorific needs for direct refrigeration, on the other hand, include: entry of products in the frigorific chamber, air cooling, water condensation, losses through paraments and others (light, losses, etc.). Six centigrade degrees is the maximum allowable temperature of entry of products (pasteurized milk) and the frigorific needs for this concept are: 16,000 x 1.032 x 0.93 x (6-0) = 92,137 frig/day. For air cooling, the frigorific needs are: 200 x 0.31 x 30 = 1,526 frig/day (200 cubic meters is the interior volume of the chamber, 0.31 the specific heat of air and 30°C the maximum exterior temperature). Frigorific needs for water condensation are: $200 \times 17.96 \times \frac{610}{1000} =$ 2,191 frig/day (17.96 are the grams of water to condense for cubic meter of air, and 610 kilocalories/kg is the vaporization heat of water). Losses through paraments represent 220 x 6 x 30 = 39,600 frig/day (220 square meters is the exterior surface of the chamber), and others (light, losses, etc.) represent 27,091 (or 20 percent) additional frigories/day, for a total need for the frigorific chamber of 162,545 frigories/day, and total frigorific needs of 1,320.924 frigories/day.

Water needs for refrigeration of compressors and frigorific condensors, therefore, are:

$$\frac{1{,}320{,}924 \times 1.3}{6} = 286{,}200 \text{ liters/day}$$

Finally, 7,000 liters of water per day are needed for cleaning the general equipment and the UHT system, and 200 liters per 1,000 liters of milk processed (or 8.000 liters per day) for cleaning the plant.

Including an additional 10 percent for losses, total water needs for Plant I for an eight-hour workday are 536,652 liters/day or 196,611 cubic meters/year, and annual costs are 196,611 x 6 = 639,666 pesetas or 0.03 pesetas/liter.

Packaging Material Costs

Replacement of broken bottles represent: $\frac{3}{100}$ x 6,000 x 3.5 x 6.00 = 1.379,700 pesetas for glass-bottled pasteurized milk and $\frac{3}{100}$ x 12,000 x 3.5 x 365 x 7.37 = 3,389,460 pesetas, for sterilized milk.

Metal caps costs are $\frac{105}{100} \times \frac{6,000 \times 60}{1,000} \times 365 =$ 137,970 for pasteurized milk and $\frac{105}{100} \times \frac{12,000 \times 186.91}{1,000}$ x 365 = 859,599 pesetas for sterilized milk (5 percent added for broken, defective, etc.)

Plastic (for bags) costs are: 10,000 x 365 x 0.48 = 1.752,000 pesetas.

Paper costs are 12,000 x 265 x 1.56 = 6,832,800 pesetas.

Costs for non-returnable boxes, finally, are $\frac{12,000}{12}$ x 365 x 12 = 4,380,000 pts.

Annual packaging materials costs for Plant I for an eight-hour workday, therefore, are 18,731,529 pesetas or 1.28 pesetas per liter.

General and Miscellaneous Expenses

Commercial expenses result from sale to thirty days and equal $40,000 \times 18.00 \times 30 \times \frac{7.5}{100} = 1,620,000$ pesetas/year. Advertising expenses, office and laboratory materials costs, inspection and related expenses and miscellaneous (including detergents, disincrustants, clothing, shoes, etc.) for plant I are, respectively, 1,460,000 pesetas, 219,000 pesetas, 1,095,000 pesetas, and 292,000 pesetas per year. Total annual general and miscellaneous expenses, therefore, are 4,686,000 pesetas or 0.32 pesetas per liter.

Total Annual Costs and Average Unit Processing Costs

Total annual costs for Plant I for an eight-hour workday, therefore, are 57,796,214 pesetas and unit costs are $\frac{57,796,214}{14,600,000} = 3.958$ pesetas per liter.

APPENDIX C

NAME AND LOCATION OF FLUID MILK PROCESSING PLANTS, SPAIN, 1974

NAME AND LOCATION OF FLUID MILK

PROCESSING PLANTS, SPAIN, 1974

Plant Number	Name	Location
1	Centrales Lecheras Españolas S.A. (CLESA)	Madrid
2	Central Lechera Ganadera S.A. (CALEM)	Madrid
3	Industrias Lácteas Madrileñas S.A. (ILMASA)	Madrid
4	Central Lechera de Burgos S.A. (CELEBUSA)	Madrid
5	Lechera de Alcala S.A.	Alcala de Henares (Madrid)
6	Industrias Lácteas Agrupadas S.A. (ILASA)	Coslada (Madrid)
7	Lácteas Reunidas S.A.	Alcorcon (Madrid)
8	Lácteas Montañesas S.A.	Ciudad Real
9	Cooperativa Lechera Alcarreña	Guadalajara
10	Lácteas San Servando S.A.	Toledo
11	Industrias Lácteas Talavera (ILTA)	Talavera de la Reina (Toledo)
12	Central Lechera de Burgos S.A. (CELEBUSA)	Burgos
13	Central Lechera Palentina S.A. (CELEPASA)	Palencia
14	Cooperativa Central Lechera Segoviana (CELESE)	Segovia
15	Central Lechera de Valladolid S.A.	Valladolid
16	LEDESA	Salamanca

17	Grupo Sindical de Colonización 3905 (GAZA)	Zamora
18	Lácteas Montañesas S.A.	Leon
19	Central Lechera Agropecuaria Pacense (CLAPSA)	Badajoz
20	Industrias Lácteas Cacereñas S.A. (ILCASA)	Caceres
21	Cooperativa Ganadera La Merced	Jerez de la Frontera (Cadiz)
22	Cooperativa de Productores de Leche	Cordoba
23	Grupo Sindical de Cononización 1434	Sevilla
24	Unión Industrial y Agro-Ganadera S.A. (UNIASA)	Granada
25	Cooperativa Provincial Agricola de Jaén	Jaen
26	Cooperativa Lechera Malagueña (COLEMA)	Malaga
27	Lácteas Levantinas S.A.	Alicante
28	Central Lechera del Prado S.A.	Valencia
29	Granja Fúster	Valencia
30	Industrias Lácteas Cervera S.A.	Valencia
31	Granja Alarcó S.A.	Valencia
32	Central Lechera Murciana S.A.	Murcia
33	La Lactaria Española S.A.	Barcelona
34	Productos Lácteos Freixas S.A.	Barcelona
35	Sociedad Anonima Letona	Barcelona
36	Esplotaciones Agrícolas Marsal S.L.	Barcelona
37	Centro Lácteo Balcells S.A.	Barcelona
38	Granja Vila	Barcelona
39	Central Lechera Municipal	Gerona
40	Cooperativa Central Lechera de Tortosa	Tortosa (Tarragona)
41	Grupo Sindical de Colonizacion 4250	Lerida

42	Cooperativa Lechera OSCA	Huesca
43	Centrales Lecheras Unidas de Zaragoza S.A. (CLUZASA)	Zaragoza
44	Cooperativa Lechera Los Amantes	Teruel
45	Central Lechera Vizcaína S.A.	Logroño
46	Cooperativa de Productores de Leche de Navarra (COPELECHE)	Pamplona (Navarra)
47	Central Lechera Alavesa S.A.	Vitoria (Alava)
48	Centrales Lecheras Reunidas de Guipúzcoa S.A. (GURELESA)	San Sebastian (Guipuzcoa)
49	Central Lechera Vizcaína S.A. (ONA)	Bilbao (Vizcaya)
50	Cooperativa Lechera Beyena	Bilbao (Vizcaya)
51	Central Lechera de Gijon S.A. (LAGISA)	Gijon (Oviedo)
52	Grupo Sindical de Colonizacion de Integración Superior 9608 (CLAS)	Siero (Oviedo)
53	Cooperativa Lechera SAM	Santander
54	Unión Territorial de Cooperativas del Campo (UTECO) de La Coruña	La Coruña
55	Complejo de Industrias Lácteas de Lugo S.A. (COMPLESA)	Lugo
56	Unión Territorial de Cooperativas del Campo (UTECO) de Orense	Orense
57	Lacto-Agricola Rodríguez S.A. (LARSA)	Vigo (Pontevedra)

Source: Ministerio de Agricultura, Spain. Relación de Centrales Lecheras

APPENDIX D

MILK SUPPLY EQUATIONS

MILK SUPPLY EQUATIONS

Two different prediction models were developed to attempt the forecasting of annual milk production in Spain. In the first model, total milk production was expressed as the output of the number of productive cows times the average milk output per cow. The supply equations (number of exclusive dairy cows, number of dual purpose cows that are milked and milk output per cow) were considered as part of a recursive system and treated without specifying the other equations in the model. Initially, the supply equation for milk was represented as follows:

$$TMP_T = (NEDC_T) \times MOC_T$$

with:

EQ.1. $NEDC_T = f(NEDC_{T-1}, DPM_{T-1}, DPF_{T-1}, DPB_{T-1})$

EQ.2. $NDPC_T = g(NDPC_{T-1}, DPM_{T-1}, DPF_{T-1}, DPB_{T-1})$

EQ.3. $MOC_T = h(PERFRC_T, FMPR_T, T)$

where

TMP = Total milk production, in million liters.

NEDC = Number of exclusive dairy cows, in thousand.

NDPC = Number of dual purpose cows that are milked, in thousand.

MOC = Average milk output per cow, in liters per year.

DPM = Average price of milk, in pesetas per liter, divided by the index of prices paid by farmers (1965 = 100).

DPF = Average dairy ration cost, in pesetas per kilogram, divided by the index of prices paid by farmers (1965 = 100)

DPB = Average price of beef, in pesetas per kilogram divided by the index of prices paid by farmers (1965 = 100).

PERFRC = Percentage of Friesian cows over total (exclusive and dual purpose) dairy cows.

FMPR = Feed-milk price ratio.

T = Time

Eleven observations (from 1964 to 1974) were made (see Table C-1) and then least square estimators of the regression co-efficients were obtained. The supply equations were as follows:

EQ.1.
$$NEDC_T = \underset{(1,648.98)}{1,186.70} + \underset{(0.14)}{0.62}\ NEDC_{T-1} + \underset{(60.21)}{123.86}\ DPM_{T-1}$$

$$- \underset{(54.47)}{213.72}\ DPF_{T-1} - 6.42\ DPB_{T-1}$$

$$R^2 = 0.9528$$

R^2 describes how well the sample regression line fits the observed data. The coefficients were significantly different from zero, the one for the number of dairy cows in the previous year being least significantly different from zero.

Table D-1. Factors Affecting Milk Production, Spain, 1964-74.

Year	Exclusive Dairy Cows (Thousand)	Dual Purpose Cows (Thousand)	Deflated Price of Milk (Pts/Kgr.)	Deflated Price of Feed (Pts/Kg.)	Deflated Price of Beef (Pts/Kgr.)	Feed-Milk Price Ratio	Percentage Friesian Cows (Over Total)
1964	810	682	5.76	6.74	26.34	1.168	37.48
1965	828	680	6.27	6.77	32.65	1.079	38.12
1966	841	742	6.33	6.86	30.71	1.084	36.89
1967	864	789	6.39	6.98	28.84	1.092	36.23
1968	929	773	6.34	6.99	29.82	1.102	38.62
1969	1,029	759	6.25	6.89	32.07	1.102	40.90
1970	1,020	807	6.52	6.88	29.08	1.055	39.80
1971	1,144	719	6.91	6.97	29.63	1.008	44.56
1972	1,149	721	7.75	7.08	34.21	0.922	45.25
1973	1,285	650	6.98	7.07	31.16	1.113	48.30
1974	1,311	667	6.91	7.41	30.62	1.072	49.30

Sources: Ministerio de Agricultura, Spain. Anuario de Estadistica Agraria 1972, and Boletin Mensual de Estadistica (several Issues).

A second formulation of this equation, with deflated price of milk lagged two years instead of one was also estimated, but the wrong sign appeared on the feed price coefficient; the R^2 was 0.9069.

$$\text{EQ.2.}\quad NDPC_T = \underset{(1979.08)}{-405.80} + \underset{(0.41)}{0.26}\ NDPC_{T-1} - \underset{(68.05)}{4.50}\ DPM_{T-1}$$

$$+ \underset{(291.93)}{176.50}\ DPF_{T-1} - \underset{(14.12)}{7.73}\ DPB_{T-1}$$

$$R^2 = 0.3839$$

Although the negative sign on the coefficent of milk prices could mean a shift to exclusive dairy cows when favorable prices exist and the positive sign on the coefficient of feed prices could show a preference for dual purpose, more rustic, dairy cows when feed prices are high, the slight annual variations of real milk prices (with a minimum producer price set by the government every year) and feed prices (with most of the cereals having also regulated prices) do not seem to support this. Two alternative formulations of EQ. 2 were estimated with similar results. They were:

$$NDPC_T = \underset{(936.61)}{-613.33} + \underset{(0.32)}{0.62}\ NDPC_{T-1} + \underset{(40.29)}{11.47}\ DMP_{T-2}$$

$$+ \underset{(109.04)}{42.88}\ DFP_{T-2} + \underset{(10.52)}{16.84}\ DPB_{T-2}$$

$$R^2 = 0.6852$$

and

$$NDPC_T = \underset{(1193.23)}{-304.01} + \underset{(0.37)}{0.38}\ NDPC_{T-1} + \underset{(35.00)}{41.89}\ DPM_{T-2}$$

$$+ \underset{(159.67)}{94.14}\ DPF_{T-1} - \underset{(10.25)}{5.59}\ DPB_{T-1}$$

$$R^2 = 0.5502$$

Finally, with respect to milk output per cow the following equation was estimated:

$$\text{EQ.3.}\quad MOC_T = \underset{(88{,}901.28)}{-24{,}168.08} + \underset{(79.81)}{45.64}\ PERFRC_T + \underset{(1016.59)}{441.58}\ FMPR_T$$

$$+ \underset{(47.44)}{11.56}\ T$$

$$R^2 = 0.4615$$

Wrong sign appeared on the coefficient of feed-milk price ratio, besides a poor fit. A second equation for milk output per cow was estimated:

$$MOC_T = \underset{(113{,}500.21)}{-10{,}912.64} + \underset{(97.36)}{54.06}\ PERFRC_T - \underset{(168.93)}{71.19}\ DPM_T$$

$$+ \underset{(782.60)}{164.70}\ DPF_T + \underset{(62.04)}{4.42}\ T$$

$$R^2 = 0.4649$$

Again, wrong signs appeared in the coefficients of prices of milk and feed.

When testing this first model for 1974, a year not included in the data series, to project milk production, the estimated supply was 4.60 billion liters, 6.5 percent less than the actual production of 4.93 billion liters. When fitting the equations with the observed data, they consistently failed to adequately predict the turning points.

In the second model, total milk production in a given year was hypothesized to be a function of the prices of milk, feed, and beef and the percentage of friesian cows in that year and total milk production in the previous year. The following equation was estimated:

$$TMP_T = \underset{(3.71)}{-2.80} - \underset{(0.21)}{0.11}\ DPM_T + \underset{(0.55)}{0.34}\ DPF_T + \underset{(0.6)}{0.06}\ DPB_T$$

$$- \underset{(0.003)}{0.003}\ PERFRC_T + \underset{(0.306)}{0.932}\ TMP_{T-1}$$

$$R^2 = 0.9458$$

with wrong signs appearing in the coefficients of the four main variables. A second analysis gave the equation:

$$TMP_T = \underset{(1.284)}{-0.596} - \underset{(1.309)}{0.972}\ MFPR_T + \underset{(0.51)}{0.58}\ DPB_T + \underset{(0.029)}{0.001}\ PERFRC_T$$

$$+ \underset{(0.270)}{0.967}\ TMP_{T-1}$$

$$R^2 = 0.9434$$

Again, wrong signs appeared in the coefficients of milk-feed price ratio and price of beef.

The deficiencies of both models are apparent. Lack of response to important variables, such as prices of milk and feed, (probably because of government regulation of prices of milk and most cereals and because of lack of off-farm employment opportunities); the existence of two types of dairy cows (roughly two-thirds of them being exclusive dairy cows and one-third being dual purpose cows) which, furthermore, are not always consistently defined in different years, the wide differences in milk output per cow between these two groups and the endemically poor time-series data gathered in the country make inadvisable the use of these models to forecast annual milk production.

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