A STUDY IN MARKET STRUCTURE AND COSTS IN THE DAIRY INDUSTRY IN BEIRUT

by

Victor N. Khoury

A Thesis Submitted to the Graduate Faculty of
the School of Agriculture in Partial Fulfilment of
The Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

Split Major: Agricultural Economics-General Economics

Approved:

Gordon H. Ward
In Charge of Major Work

[signature]

[signature]

[signature]

[signature]
Chairman, Graduate Committee

American University of Beirut
1959

THE DAIRY INDUSTRY IN BEIRUT

V. N. Khoury

ABSTRACT

The basic aim of this thesis is to study the relation of the costs of processing and distribution to volume and other variables in the dairy industry of Beirut, to explain this relation and to derive from it and from other sources some remarks of normative significance concerning the organization of the market, and the problem of pricing.

The cost curves found show some deviation from the expected short run cost curves of economic theory. The total cost curve is linear with respect to output indicating a constant marginal cost and an L-shaped average cost curve. Chapter IV tries to explain this discrepancy by denying the applicability of diminishing returns in the short run. It is also pointed out that the concept of a production function preassumes maximum output from a given input combination. Both principles are observationally inapplicable, in the short run.

The costs of pasteurization and bottling vary from 5.7 to 12.6 piasters per liter depending on the output of the milk plant, and since most of the plants operating in Beirut are similar in equipments their costs can be represented rather closely by one curve. The costs of processing were found to depend on volume, procurement policy, type and size of container, the method of pasteurization, product line policy, and managerial ability.

The costs of distribution vary from 4.25 to 9.1 piasters per bottle, 5 piasters being a "reasonable" average. Such factors as number of customers, route length and design, type and size of containers, location of plant, management, wholesale versus retail operations are important determinants

Unused capacity characterizes this industry and the pricing policy of the firms comprising it was shown to be responsible for this condition. "Live and let live" is the most prevalent attitude with respect to competition.

The history of the industry was also passed in review, from the early days until 1959. A note of the size and employment in this industry was made, in chapter I, where some remarks on the prospects of development were submitted based on opinion received.

The whole work of writing and formal collection of data was made from June to November 1959, while some data were available from the previous connection of the writer with this industry.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

During the last decade, the market milk industry of Beirut has grown in a more or less haphazard way. As far as can be ascertained, no study dealing with this industry has been published in any form. This was probably because of the lack of interest in such studies on the part of those in the business. It could also have been due to the state of flux arising from the rapid growth of the industry during the last few years. This paper is an attempt to fill a gap in our knowledge of the marketing of an agricultural product that enjoys a growing economic importance and a decided nutritional significance.

This paper will consist of two major sections; one dealing with the costs of processing and distribution which is basically a compilation of data on the various items of cost incurred in the collection, processing, bottling and distribution of milk and some of its by-products. These figures are subjected to an analysis aimed at bringing out the possibilities for cost reduction. The results are compared to the micro-economic models accepted to be useful for applied research.

The other major section will present a study of the market structure of the industry, with the aim of determining the degree of economic concentration, the barriers to entry, the mature and importance of the imperfections in this market, the price determining mechanism and some aspects of spatial competition in the distribution of pasteurized fluid milk.

While the above two major topics constitute the basic objective of this project, a chapter on the history of the development of the industry has been included, in order to put in their proper perspective some of the aspects of the industry that may not be easy to explain otherwise.

The methodology followed is explained in appendix A, which discussion was made necessary by the arbitrary, though apparently justifiable choice of approaches, analytical techniques, allocative coefficients, etc.

It is thought that the figures reported are too crude in their present form and accuracy to provide a detailed guide for normative use in the market milk industry of Beirut. They were never intended to be more than first approximations, and as aids to the design of more refined technical, economic and managerial studies. The study here reported could not be expanded in any of these ways due to limitations of time and finances. It is, however, clear that some important indications and trends with respect to the more significant variables have been brought out. Parallels with conceptually similar activities in other industries were also helpful in pointing out solutions to some problems, such as the route design and management problem, and the location of sub-district distribution depôts.

Dairy farming operations, in spite of the interesting production and cost function characteristics of the various alternative processes for every activity, were excluded from this study for a number of reasons, including the budgetary and time elements involved. It was felt moreover, that these do not properly fall within the scope of this industry study.

A note on the choice of subject is here called for. The writer was engaged as manager of the Hoss Dairy for the period May 1st to September 15th, 1958, and thus had some intimate contact with many of the problems discussed in this thesis. Information and data obtained while working in this capacity, provided the basis for developing the study of the milk industry of which this Dairy is a part.

The economics of receiving stations, pasteurizing equipment and bottling plants are common to the dairy, soft drinks, and the fruit juices industries. The costs of transportation and retail distribution have an even wider application. Some aspects of imperfect competition in the dairy industry and the marketing of perishable farm products have been brought out. The problems relating to spatial competition in retail distribution and to the location of distribution stations or depôts, studied in connection with the dairy industry could easily have been those of any other food industry, with appropriate reservation made for the specific aspects resulting from the nature of the product.

This thesis would have been quite different had it not been for the generous advice and editing of Professor Gordon Ward, of the Faculty of Agricultural Sciences, who has also supplied most of the sample studies quoted below. Professor Mohammed Diab of the Faculty of Arts and Sciences made many useful comments on various problems and gave freely of his time and effort - Professors Ramzi Khoury and Zakharia Sabri (Faculty of Agricultural Sciences) were extremely helpful in solving many technical problems. In addition, Prof. Khoury supplied numerous trade catalogues, specifications sheets, books and manuals.

The writer's gratitude goes to the many respondents to the numerous questions and without whose cooperation this study would have been impossible.

Chapter -I-

The Development of the Dairy Industry of Beirut

This chapter proposes to relate the history of the development of the dairy industry in Beirut, from the days preceding the introduction of pasteurized milk by Mr. Dumit early in the thirties, up to the year 1959, together with an aperçu of the current situation of the industry.

Most of the information contained in this chapter was collected as a by-product of the interviews with the owners or employees of the various plants. The writer had a first hand acquaintance only with the Hoss Dairy and Milko.

A. The Early Days:

Until a recent date, milk marketing in Beirut was a very simple operation.[1] There were mainly two forms of trade in milk. In the farming areas in the vicinity of Beirut, farmers or jobbers used to collect milk from the area and take it to town in cans. They toured the city selling fluid milk from house to house, where they would measure out the milk according to the requirements of the housewife. Such nearby farmers, were the major suppliers of milk prior to the recent developments in dairying, and are still important even now.

(1) Most of the information referring to the period prior to the extension of pasteurization, was obtained from Mr. M.M. Itani, an oldtimer in dairy production, whose farm was at the site on which the Khoury-Saadé Hospital is now built, in Maamari street, Beirut.

One can still see the remnants, due for replacement by apartment houses, of the dairy barns of that period, even in Ras Beirut. The Khoury-Saadé Hospital is built on the site of one such farm that was selling milk and vegetables to the neighbours in Maamari street until 1954. Its output was around one hundred liters daily, from seven Beiruti cows. Another farm maintained fifteen cows until about 1957, near the Church of the Rosary, also in Maamari street. The barn from a third farm can still be seen across the street from the Commodore Hotel in Ras Beirut. This latter area was a truck and dairy farming region, apparently.

The second form of trading in milk and milk products consisted in the production of cheese, laban, labneh and butter on the farms located at some distance from Beirut. These did not possess enough knowledge of milk sanitation, neither was the transportation system sufficiently developed to permit the farmers to sell fresh fluid milk in the city of Beirut.

But the Lebanon as a whole, was not self-sufficient in milk products and had to import laban, (from Aleppo), butter and cheese. Butter came principally from Denmark and Holland, and cheese from Turkey, Cyprus and Palestine. Another form of butter known as samneh was imported from Syria to supplement the Lebanese production centered in the Beka' Valley. These sources of supply for milk products gave their names to the varieties of cheese (Kopruci, Accawi, Halabi, Kashkawan, Nabulsi), of samneh (Halabi, Hamawi) and of butter (Danish butter).

The milk product known as kischek and used in cooking, was produced in the villages. It replaced fluid milk in winter, when the cows were dry.

From early times, certain shops strategically located, have concentrated their efforts on the sale of milk and milk products. Small stores of this type provide about a third of the total milk supply in Beirut, with local variations between sections of the city. Ashrafieh is the best area for such stores. Every distributor of pasteurized milk known to the writer, considers that area as a poor consumer of bottled milk.

The milk produced in Beirut in the early days was produced by goats, ewes and cows, the Beiruti cow being second only to the Shamieh in milk output. Some outstanding individuals produce up to 4000 liters per lactation.(2)

B. The Introduction of Pasteurization:

In the early thirties, the first pasteurizing plant in Beirut was installed by Mr. Dumit, in what later came to be known as the Hamra street. The innovation did not find the necessary acceptance, and for a time the output of the Dairy was not high. As the area of Ras Beirut developed and the

(2) For a description of the dairy breeds of cattle in the Lebanon, Palestine and Syria, cf. Elazari-Valcani, The Dairy Industry as a Basis for Colonization in Palestine, The Palestine Economic Society, Tel Aviv, 1928. pp. 14-37.

American University staff and foreign employees in town increased, specially after World War II, the demand for pasteurized milk expanded rapidly. After the Palestine War of 1948, Hamra street started to become an established residential area, and Dumit Bros. & Co. grew with Ras Beirut.

In 1948, Mr. William Malluk started a new milk pasteurizing plant in Furn esh-Shubbak. After about three years of unsuccessful operation Mr. Malluk sold his William's Dairy to Dumit Bros. & Co. who thus became a two-plant monopolist for pasteurized milk.

The prices of pasteurized milk were about twenty piasters higher than the price of raw milk, a difference that most consumers did not want to pay. Had it not been for the steady purchase of pasteurized milk by the American University Cafeteria, the Dumit dairy would have found it difficult to remain in business. These purchases now amount to 300 liters daily for the University and 65 liters for the American University Hospital In addition to milk, the Dumit dairy sells laban, labneh, cream and butter.

Dumit-Williams currently produce 1800-2000 liters daily of milk and milk products. It is, together with Bambi (3) the largest two sellers of milk in Beirut.

C. <u>Beverage Laban</u>: (4)

In 1949 Mr. Ibrahim Ghossoub, owner of a brick-making factory in Beirut thought that the establishment of a plant to

(3) cf. Section E.

(4) Mr. Ghossoub and his employees.

sell pasteurized rather than raw milk would be a profitable venture. He accordingly ordered equipment for the pasteurizing of 500 liters of milk per hour, at the initial cost of around 75000 pounds, which he installed in Jummeizé. His hopes did not materialize and the plant lay idle for six months since "dairy equipment does not manufacture bricks" as he put it.

While on a business trip in Aleppo, Mr. Ghossoub noted a milk product being sold in cups as a refreshment. His thoughts immediately turned to the dairy plant in Beirut, since here was a product that dairy equipment can produce. And in this way beverage laban was born. It is currently marketed by Mr. Ghossoub under the brandname MILKO, and has fully earned consumer acceptance.

Beverage laban is similar to cultured buttermilk except that its fat content is higher. It has 0.75-1.00 percent butterfat and about six percent total solids.(5)

Milko buys raw milk from the vicinity of Saidon on a contract basis, the price being inclusive of trucking to the Milko premises. This arrangement is now common in the dairy industry, prices being quoted C & F.

(5) The milk is 50% skimmed and is then cultured to produce laban. An equal volume of a 14% solution of salt in water is then added to the laban. Since the original milk has about 3-3 1/2 percent butterfat, the resulting beverage has 0.75-1.00% fat. Similarly, total solids are reduced from 12-13 to 6 percent.

Sales of beverage laban are seasonal, but there is a long term trend for increases in consumption. The trend is so pronounced that, when a Milko employee set up a new plant, KOKO, the parent dairy was not a ffected at all, and Milko's sales continued to increase. Currently, output is around 3200 quarter liter bottles daily, representing a gross income of 125,000 L.L. per year. Profits are estimated at around 35,000 L.L. annually.

D. An Integrated Operation:

In 1953, Mr. Fawzi Hoss imported a herd of French and Dutch Friesian cows for which he built a concrete stall barn in two floors. Mr. Hoss also obtained a Friesian pure-bred bull whose sone is now housed on the Hoss Farm in Sofar. Early in 1954, those of the cows that were pregnant calved and started producing milk at the then high average of seventeen liters per day. The pedigree records show an average production capacity of 14-16 liters per day per cow over the year.

Soon, total output reached 700 liters daily and in order to help in marketing the milk, Mr. Hoss imported equipment for a pasteurizing plant capable of processing 500 liters per hour. At the same time, mechanical milkers with a complete pipeline system were installed in the barn. The milkroom was connected to the pasteurizing plant by an overhead pipeline of stainless steel. The plant, a few meters from the barn, uses the high temperature short time pasteurizing system with plate heat exchangers. The equipment includes a receiving tank, a pasteurizer, a hand-operated bottle filler and copper (2-nozzles and a capacity of 600 bottles per hour), and a refrigerated store. It is now operated at 7-30 percent of capacity, with daily output varying from 200 to 890 liters daily in May and June.

Hoss Dairy used to operate two distribution routes doing mainly a retail business (home delivery). The loss of the delivery trucks during the rebellion of 1958 forced the dairy to adopt a wholesale route system, as soon as conditions returned to normal in the fall of 1958.

E. Bambi:(6)

At about the same time as Mr. Hoss was installing his pasteurizing plant, a group of entrepreneurs were forming a partnership for the purpose of selling pasteurized milk, laban and cream. Bambi, as the dairy was called, operates a 500 liters per hour plant, very similar to the Hoss plant, except that it has an automatic filler and capper whose capacity is 20 bottles per minute.

Since January 1955, this dairy has come a long way from initial sales of 200 liters per day (6 percent of capacity) to the current output of 1,850 liters, representing a capacity utilization of 46.3 percent for the pasteurizing and 32.3 percent for the filling and capping machines. Those are the highest rates of utilization of capacity in Beirut, in spite of stiff competition from Dumit Bros. & Co.

(6) Mr. Gabi Deeb and Mr. I. Bahhous of Bambi.

Bambi operates three distribution routes and has a depot in Hamra street. Its business is mainly wholesale, selling pasteurized milk, laban, chocolate milk, labneh and cream to stores and restaurants.

Bambi gets its raw milk mainly from Anjar, where a Mr. Feldman has developed an important dairy farming center as part of the program of the Karaguzian Foundation for helping the Armenian refugees.(7)

One of the original founders is now contemplating the installation of a new dairy plant to be affiliated with the ice cream plant of Lucky Cream, of which he is manager and part owner.

F. Other Innovations:

During 1956, a milk analysis project was carried out, in which the milk sold by the then operating factories of Hoss, Dumit, Bambi and Milko was tested once a week in the laboratories of the Industry Institute. The costs of the program were paid by the dairies, and the results were published in the newspapers in the form of a collective advertisement. The consumers were thus sure of the quality of the milk, since it was certified by an independent agency. Sales showed a definite increase estimated at 8 percent in three months.(8)

(7) For a description of dairy farming in Anjar see Fuleihan, J.S. and Ward, G.H., Economic Study of the Production and Marketing of Fluid Milk in the Anjar Community in the Beka'. Original typewritten draft of Mimeo. Pamphlet No.1 Rural Improvement Division, A.U.B., Aug.6, 1959.

(8) Records of the Hoss Dairy.

The program was later discontinued. The reasons given were: frictions among the distributors, considerations of costs, and the fear of every manager that the other dairies were capitalizing on his own good will. It is thought that those reasons if true, are quite trivial and should never have led to discontinuing the milk testing program. Advertizing expenditures are of the nature of investments and cannot pay-off immediately.

Another innovation in the dairy industry of Beirut, was the establishment in 1957 of the National Dairy Company S.A.L., to sell reconstituted milk and other dairy products.(9) The strength of prejudice against reconstituted milk led to the complete stoppage of the sale of bottled reconstituted milk. The company is now selling laban, beverage laban, chocolate milk (in quarter liter cartons), labneh and ice-cream.

An original idea for appealing to consumers was recently used by Dairy House, a new dairy plant established in 1958, in Jamhour, on the road to Aley. It is the first dairy in Beirut to use its own premises as a show place and to locate the plant on the main highway. Its operation and equipment do not present any other important innovations however.

G. Some Orders of Magnitude:

According to the Industrial Census,(10) there were twenty

(9) "Competitor's File" compiled by the writer while working for the Hoss Dairy.

(10) Lebanon, Industrial Census 1955, vol.2, Pp.19-22. Prepared by the Economic Research Institute, A.U.B.

establishments in Lebanon employing more than five persons each, engaged in the meat and dairy industries. The total number of persons employed was 178 receiving L.L. 332,000 annually as wages and salaries. The need for secrecy concerning individual plants resulted in the aggregation of the figures for dairy and meat products, together with the definition of an establishment adopted by the Census, it limits the usefulness of these figures for the purposes at hand, especially that some important dairies do not employ five persons.

The writer's own estimate for the pasteurizing plants (exclusive of cheese, butter, ice-cream .... and inclusive of Milco and Koko who sell only beverage laban) is as follows:

Table 1

Some Magnitudes for the Dairy Industry (11)

Number of plants	8
Number of persons employed	59
Total wages and salaries	L.L. 105,000
Gross income (Annual Sales)	L.L.1,360,000
Annual cost of raw milk (12)	L.L.1,095,000

(11) No. of persons and plants are those counted by the writer and known to the trade. Wages were estimated by applying a flat average wage of L.L. 150 per month to the employment figure. Remaining data compiled as part of "Competitor's File" for 1958 (footnote 9).

(12) 7200 liters daily at 0.415 L.L. per liter C. & F.

Table 1

Some Magnitudes for the Dairy Industry (11) (Cont'd)

Value added	L.L. 265,000
Estimated total fixed capital	L.L.4,000,000

While the dairy industry is not a major source of income, as it employs only 59 persons, an average of 7.5 per plant, about eighty percent of its sales are paid out as costs of raw milk. The costs of milk production show a high percentage of labor to total costs (about 50 percent, if forage and feed production are also included) thus enhancing the income generating capacity of the industry. Moreover, about fifteen trucks are used in distributing the pasteurized milk, and an additional unspecified number of trucks haul the 7200 liters of milk from the farms to the factories daily, for processing.

In addition, trade in non-pasteurized milk still represents a comparatively significant component of this industry with sales amounting to an estimated 6000 liters per day, (13) or 45 percent of total fluid milk sales, quite a decline from about 95 percent in 1948. The trade (and industry) of cheese and ice-cream adds considerably to the volume of milk handled

(13) The estimate is only a guess. Similar estimates by milkmen for the various zones of distribution adds up to 4500-7000 liters daily, thus corraborating the writer's own guess.

in the general area of Beirut. But such activities fall outside the scope of the present paper.

H. The Prospects:

The dairy industry of Beirut is still in its early stages of development, especially in as far as consumer acceptance is concerned. It is obvious that unless confidence is built in the cleanliness and safety of pasteurized milk, the raw milk dealers will continue to sell about half of the total volume of fluid milk. This confidence has not yet been earned.

The future of the industry is closely tied up with the growth of the city of Beirut, and with the increase in per capita income. The income elasticity of demand for milk and milk products is high even in countries as rich as the United States of America. In the past few years, the growth of the industry coincided with the influx of non-Lebanese, and the development of the "new" areas of Ras Beirut, Rue Verdun, Pigeon Rocks, and similar sections. The Jummeizeh and Ashrafieh areas are not yet converted to the benefits of pasteurized milk, in spite of a high standard of living. Sales resistance will be broken in those sections only when the prices of milk and the costs of distribution and handling have been reduced. The cost of one kilogram of protein equivalent is L.L.20 in milk,(14) and though it is a cheaper source of protein than meat and eggs (L.L. 31 and 21 respectively), pasteurized milk is still considered expensive, especially when compared with powdered milk.

It is however important to note that the farm price of milk is, inter alia dependent on the prices of animal feed. These are very high compared to milk prices, thus making dairy farming a not very attractive proposition except as part of a balanced agriculture. Basic change in the feed situation is a prerequisite to a reduction in milk prices and therefore to an extension in pasteurized milk sales. This basic change, given present technology, can arise only if more adapted concepts and techniques of feeding are utilized, including the expansion in the production of forage from both irrigated and non-irrigated farmland. It does not seem to the writer that

(14) Computed from the following table

Food	Retail Price	Protein Percent	Price/kilo Protein
Milk, fresh	0.70 LL/kg	3.5	LL. 20.-
Eggs, fresh	0.12 each	11.4	LL. 21.-
Meat, leg	5.- LL/kg	16.2	LL. 31.-
Chicken, ready to cook	4.- "	15.2	LL. 26.20

Adapted from Shepherd, G.S., Marketing Farm Products - Economic Analysis. The Iowa State College Press, Ames, Iowa. 1955 P. 355, table 24-2.

either the dairy farmers or those who propose to advise them, are moving in the direction of lower production costs. The so-called demonstration farm at Terbol[15] is a prime example of what should be avoided, but is not.[16] Those who start new dairy farms with ample capital, and little knowledge, tend to copy the attractive, but unnecessarily expensive buildings of this project.

---

(15) The reference is to the farm built by the American Point IV mission in Terbol. The dairy barn, and the cows housed in it, are, in the opinion of many experts including G.B. McLeroy (formerly acting dean of Abu Ghureib Agricultural College in Iraq and Professor of Animal Science in A.U.B. until June 1959) of a less than ideal rating.

(16) The Hoss Dairy barns were built on the Terbol Model, only more in the undesirable direction. It may seem strange, but the bull lives on the second floor, on the Hoss farm.

Chapter -II-

Processing Costs in the Dairy Industry

For the purposes of this thesis, "the dairy industry" will be taken to mean that segment of economic activity concerned with the satisfaction of the demand for pasteurized fluid milk. It is restricted to the receiving, pasteurizing, bottling and distribution of fluid milk, other derivatives of milk being important only in so far as they affect the costs, prices, output and/or quality in the pasteurized milk industry.

This chapter is concerned with the costs of receiving, pasteurizing, bottling and storage of milk collectively referred to as processing. The individual processor can control this function more readily than either the procurement or the distribution functions.

Two main objectives will be sought; one to formulate certain input-output coefficients accepted by competent authority in milk technology as representative of a good efficiency in the various processes. These standards will then be used to evaluate the operating efficiencies in the dairies studied. The second objective is to determine the costs of processing in some of the milk plants supplying the city of Beirut, with whatever accuracy is allowed by the nature of the available figures,[17] and to analyze the factors influencing these costs.

A. Description of the Processes

Milk is a potential carrier for many kinds of pathogenic bacteria, originating from persons coming in contact with it, from the atmosphere, or the cows that have produced it. "Constant vigilance to protect milk from contamination with pathogenic organisms is a moral obligation of those concerned with the market-milk business. It is also the best insurance against financial loss".[18] Some human diseases transmitted by milk are tuberculosis, typhoid and paratyphoid fevers, septic sore throat, diphtheria, dysentery, etc.... Animal diseases can also infect humans through the agency of milk and include bovine tuberculosis, anthrax, undulent fever, milk sickness, foot and mouth disease and Q-fever.[19]

(17) The data reported have been obtained by interview, actual measurement by the writer, study of the recommendations of the various dairy technologists, ... (see appendix A.) The accuracy of these figures is very variable; hence any numerical results must be taken as orders of magnitude rather than precise and final estimates for the variables concerned.

(18) Roadhouse, C.L., and Henderson, J.L., The Market Milk Industry, McGraw Hill Book Company, Inc., New York, 1950. P. 56. Ch.3-7 provide an excellent description of the relation of milk to public health, and the methods of sanitary milk production.

(19) Roadhouse and Henderson, op. cit. Pp.39-73.

Pasteurization properly carried out destroys all diseases organisms. It consists in heating the fluid milk to 143 degrees Fahrenheit for 30 minutes, or alternatively to 160 degrees F. for 20 seconds. The former temperature-time or slow process is carried out in vats by the batch process, and the latter is more suitable for the continuous pasteurization method usually referred to as HTST.(20) All the milk plants in Beirut known to the writer follow the HTST system.

The operations performed in a fluid milk plant center around the pasteurization of milk. Other operations are either preliminary to, or protective of the effects of pasteurization. Thus, the proper design of the receiving, clarifying and filtering equipment is necessary for the control of the bacterial population prior to pasteurization, which is followed immediately by cooling to a low temperature.

The batch process or holding method "shall be taken to refer to the process of heating every particle of milk to at least 143 deg. F. and holding continuously at such temperature for at least thirty minutes".(21) Vat and tank pasteurizers are by far the most common types of equipment in which milk may be

(20) High temperature short time

(21) U.S. Public Health Service, Milk Ordinance Recommended by the United States Public Health Service (Tentative Revised edition) August 1947. Section 1-L.

heated and held at the correct temperature. "The batch process of pasteurization is preferable for operations where the volume is too small to justify the use of the continuous HTST system", since at low volumes, "assembling, cleaning and other factors tend to make an HTST unit economically impractical".(22) Milk is heated in this system by spraying hot water on the walls of the container until the required temperature is shown by the thermometer. Automatic control keeps the milk at the temperature of 143 deg. F. for the required period of 30 minutes. The hot milk is cooled in a surface or plate type cooler, in order to cool it very quickly and thereby prevent any bacterial growth.

In order to hasten the heating operation, use can be made of flash heaters similar to those used in the HTST system. In this method milk is heated by first passing over surfaces in contact with hot milk. In the second stage hot water flows through the plate heat exchanger and raises the temperature of the milk to 143 deg. F. In this way heating time is reduced to 10-15 seconds. Milk at 143 deg. F. is then held in tanks for the 30 minutes recommended by competent authority. Cooling is also accomplished in the heat exchanger. This system is more easily controlled than the full holding process.(23)

The more common pasteurizer however, uses the continuous process that consists in "heating every particle of milk .... to at least 160 deg. F., and holding at such temperature for

(22) Manual for milk plant operators, Milk Industry Foundation, Wabb. D.C., U.S.A., pp.290-291

(23) Roadhouse and Henderson op. cit. pp. 317-319.

at least 15 seconds ...".[24] HTST units are built for capacities as low as 500 liters per hour[25] and up to very high capacities.

In the HTST system, milk is heated by plate heat exchangers to a temperature of 160-161 deg. F. (71-72 deg. C.) and is then held for 20 seconds in a holding tube. The more elaborate European process, the so-called flash process, consists in heating the milk to 220-260 deg. F. without holding, then dropping the temperature to 160-185 deg. F, (85 deg. C. in the Alfa Laval and Astra equipment) and holding it at that temperature for 15-20 seconds in the holding tube. Various equipment manufacturers use other time temperature combinations. Milk is then circulated in counterflow with incoming cool raw milk, with which it exchanges its heat (whence the name regenerative heat exchange). It is then further cooled by cold water.[26]

The use of regenerative heating in the plate heat exchanger results in a saving of as much as 85 percent of the

(24) U.S. Public Health Service, Milk Ordinance... (1947) sec. 1-L.

(25) Manufactured by Bergedorfer Eisenwerk A.G., Astra Works of Hamburg. Ref. to their tender No. 53.04.179. "Dairy Plant Having a Capacity of 500 liters to:American University of Beirut, Beirut, Lebanon." cf. also their tender No. 55.06.324. "Description of an Alfa Laval Standard Dairy Plant, Type S-500".

(26) Bergedorfer Eisenwrk, A.G., tenders 53.04.179 and 55.06.324. Manual for milk Plant Operators Pp. 447-450; and Roadhouse and Henderson, op. cit; Pp. 325-332.

steam required for pasteurization by the holding method. The other advantages claimed for the HTST system over the holding process are:[27]

(1) Less floor space is required because holding vats and separate coolers are not used.

(2) The original cost of the equipment is lower.

(3) The capacity of plate equipment may be easily expanded by installing additional plates and lengthening the holding tube.

(4) Bottling can start as soon as pasteurization begins, resulting in better labor time utilization. This advantage does not apply to plants with excess capacity however.

(5) HTST equipment is more easily cleaned and sanitized.

(6) Milk losses are reduced due to the smaller amount of handling in various pieces of equipment.

(7) Automation is easier to apply to a continuous than to a batch process.

(8) The shorter time of pasteurization is a definite gain to or dairy operating with a small number of workers.[28]

The operations of a dairy plant start when the milk arrives from the farms to the receiving department. In Beirut,

(27) Manual ... P. 450; Roadhouse and Henderson, op. cit, Pp. 332-333.

(28) Kay, H.D.,et al, Milk Pasteurization - Planning, Plant operation and control, Food and Agriculture Organization of the United Nations, Agric. Series No. 23. Rome, Italy, 1953. ch. 3-7.

farm to plant milk handling is done in the new standard forty-liters can. In other countries, dairies processing large volumes receive their supply of raw milk in bulk tank trucks. The latter make it possible to enjoy large economies of scale, due to a favorable investment - capacity schedule for large tanks in the receiving stations and a better labor utilization. Per thousand liters of capacity, the investment in a large receiving station must be expected to be smaller for handling in bulk than in cans,(29) especially as can storage and washing facilities, as well as additional space must be provided for cans.

Dairy plants in Beirut use the all can system in which milk is received in cans only. These are washed and returned to the collector the next day, and in smaller plants the same day. The Hoss Dairy being a producer as well as a processor of milk operates on the all-bulk pipeline method. This system consists in milking the cows by machines connected to an overhead pipe that takes the milk to a surge tank and then to the

(29) Baum, E.L., Pauls, D.E., A Comparative Analysis of Costs of Farm Collection of Milk by Can and Tank, Washington Agric. Exp. Sta., Tech. Bull. 10, Pullman, Wash. U.S.A., 1953.
______, Riley, R.D., and Weeks, E.E., Economies of Scale in the Operation of Can and Tank Milk Receiving Rooms with Special Reference to Western Washington, Washington Agric. Exp. Sta., Tech. Bull. 12. Pullman, Washington, U.S.A. 1954.
Sinclair, R.O., Economic Effects of Bulk Milk Handling in Vermont. Vermont Agric. Exp. Sta. Bulletin 581, Burlington, Vermont, U. S. A., 1955.

pasteurizing plant, when it flows into a 300-liters receiving tank prior to pasteurization.

From the receiving tank, milk is pumped to the pasteurizer which it leaves at a low temperature (10 deg. C.) on its way to an equalizing tank preceding the bottling machine. In a continuous plant, bottling may start as soon as pasteurization begins, since the latter requires only a few seconds to deliver milk to the bottling unit.

There are two main types of bottling machines, the hand operated and the mechanical. Hand operated machines may fill two to twelve bottles at a time. The bottles are fed into the machine by hand and when filled are normally capped with a machanical capping machine also operated by hand. A two nozzle hand operated filling capping machine operating in Beirut was observed to handle 500 bottles per hour.

Mechanical filling and capping machines are of various sizes. One such machine used in Beirut, can fill and cap twenty bottles per minute and requires two men to operate it, one man to feed the empty bottles, and another to remove the filled and capped bottles from the conveyor into the crates.(30)

The crates of milk bottles are then put in cold storage in order to cool them to a constant temperature of ten degrees

(30) By courtesy of Mr. Jamil Bibby who supplied the machine. The cost of the automatic filler and capper installed in the plant was L.L. 6,500, while a hand operated filler and capper would cost L.L.1000 - 1200.

centigrade until the time of distribution.

Most dairies in Beirut pasteurize early in the morning, as soon as the milk trucks bring in the raw milk from the farms, in such a way that distribution can start at 5-6 a.m. They may pasteurize again in the evening. Hoss Dairy however, because of its peculiar location in Sofar, operates the pasteurizer at 2.30 - 4.00 p.m., as their truck comes in for the Beirut bound bottled milk at 4:30-5:00 p.m.

The capacity of the pasteurizers operating in Beirut is almost identical at 4000 liters per eight-hour day. All the pasteurizing units known to the writer are HTST units manufactured in Germany by the dairy supply house of Alfa Laval. A stock description of such a machine states: "Plate pasteurizer ...... for high temperature pasteurization of 500 liters of consumption milk per hour from 5-85 deg. C. by means of steam at 0.5 atmospheres, with heat recuperation of about 70 percent.".[31] This size of pasteurizer was chosen because it is the smallest HTST unit manufactured, and because the latter system is more modern. In none of the cases was a market survey made, rather, the ruling price, minus the cost of processing and distribution at capacity output, was assumed to be the average gross profit expected per liter. At least one operator reported his dissatisfaction with his profit position, because costs proved to be higher, and profits correspondingly less than he anticipated, due to operation at 15 percent of capacity.

(31) Bergedorfer Eisenwerk, A.G.,Tender 55.06.324,item 5.

Normally the capacity of a plant is the maximum output of the smallest machine. In the dairy industry in general, the bottle filling and capping machine determines capacity. In Beirut, the filling and capping machine is generally well balanced with the remainder of the plant. The only exceptions are Milko and the B Plant.(32) In Milko, the bottling and capping machine with a capacity of 600 bottles pwe hour, is the only limitation to the expansion of output, other than market demand, since it already works 5 1/2 hours a day. Plant B has a much larger capacity automatic filling and capping machine than the pasteurizer, and it thus possesses redundant capacity.

There are two auxiliary departments in a dairy that are essential for good operation. The first is the bottle washing department, where all the bottles are washed either mechanically or by hand in a soap then a chlorine solution. In many cases steam sterilization is also used.

The second auxiliary department is the steam generator of which many kinds are available. Fuel oil firing is used exclusively in all the dairies visited because of the availability of cheap fuel oil. With an HTST pasteurizer, a 500 liters an hour dairy might use 90-120 kilograms of steam per hour depending on the design and operating conditions of the plant.(33) A European design for a similar plant provides for a boiler with a capacity of 90 kgs. of steam per hour.(34)

(32) The dairy plants from which adequate data were obtained are classified as A, B, C and D.

(33) Manual.. p. 72.

(34) Bergederfer Eisenwerk,A.G.,tender 55.66.324,Item 14.

B. The Elements of Cost in a Pasteurizing Plant:

Costs in a dairy plant are incurred in a number of cost centers, the latter being "means of collecting the costs which apply to an operation or group of operations.... The total of all center costs exactly equal total plant costs".[35] For the plants visited in Beirut, there are nine basic cost centers and a variable number of auxiliary centers, depending on the by-products handled.

These are:

(1) Raw milk receiving and storage, (where all milk is received as delivered in 40-liters cans).

(2) Can washing.

(3) Milk pasteurizing

(4) Bottle washing and filling, (where all dirty bottles are washed and sterilized, and the clean bottles are filled with products and capped).

(5) Cold room (for the storage of milk and the checking-out of the milk crates to the trucks) and refrigeration.

(6) Empty bottle receiving and storage.

(7) Steam

(8) General plant costs.

(9) Administration.

(35) Webster, F.C., Specifications and Costs for a Moderately Small Milk Pasteurizing and bottling Plant, Cornell University Agric. Exp. Sta., Bulletin A.E. 1031, Ithaca (N.Y.) U. S. A., 1956. P. 13.

Some by-product cost centers may be termed cream separating, laban, chocolate drink, labneh, etc...

The costs in these cost centers are incurred as milk, depreciation, repair and maintenance of buildings and equipment, supplies (bottles, caps, soap, chlorine, uniforms, etc..), fuel oil, labor, power, milk loss, and general expenses. These expenses are allocated to the various operations.

Costs as reported in the interviews are too sketchy to be reliable or useful. The writer has built up from engineering economic data a more reliable set of cost figures that could be used to analyse the costs of operating the dairy plants in Beirut. The basic data are those of the Hoss Dairy corrected for the special circumstances of every plant.

The "Costs" derived were then compared to the figures reported and were found to fit rather closely.(36)

C. Processing Costs in Four Dairy Plants:

Milk processing falls under a number of headings. The costs of ownership, operation and maintenance can be divided.

(36) The inadequacy of the data is a further proof of the not very efficient management in this industry. The persons interviewed had no way of estimating costs with any detail as to its physical compnents, because of the complete lack of inventory records, of cost accounting and of standards by which efficiency may be ganged. The costs as compared do not differ very much however, from the aggregated figures reported.

according to the degree of variability of their components as the rate of use of capacity is varied, into fixed and variable costs.

Depreciation, repairs and maintenance of buildings and equipment are all fixed costs, since their magnitude, at least in accounting practice is independent of changes in output, and would still be the same if no processing took place, but the plant were kept in a condition suitable for the resumption of operations.

Depreciation charges are, roughly speaking, a reflection of the useful life of the asset, but are at the same time dependent, to a certain extent on the policy decisions of management. Once the decision is made however, depreciation is fixed with respect to output.

Repairs and maintenance have fixed and variable components. The functional relationship of the variable component of repairs and maintenance charges to output was not easy to ascertain. For this reason, these costs were included in the category of fixed costs. This seems to correspond with recognized practice.

The steam required for heating the plant, general cleaning, sterilizing the pipes and the main equipment etc... is also a fixed cost. Steam is produced by burning fuel oil in the boiler, and therefore this item of cost is reported as "fuel-fixed plant requirements" in the following paragraphs.

In addition, plant overheads such as telephone, lighting, entertainment, cleaning and such other sundry costs are invarient with output, and consequently must be classed as fixed costs.

Labor presents a problem in that wages are both fixed and variable. There is first a minimum number of workers that must be kept on the payroll. They are the electricians who run the pasteurizer and maintain the equipment. By themselves, they can produce up to a certain maximum beyond which new men must be taken on.

Men are indivisible in that they are not hired by the hour, and rarely by the day (at least not in dairy plants where sanitary standards are very high), but rather on a long-term basis, usually a month. According to the expectations of production, management can take on or lay-off enough men to bring the labor force to the requisite number. In the Dairy Plant C,(37) the schedule of labor requirements shows three indivisible units. Two men are required for a production ranging from zero to one thousand liters per day. At this upper level any increase in output would necessitate an additional worker to

(37) The labor requirements schedule for plant C was computed from a job programme prepared by the writer in which the time standards for various operations were tabulated and programmed. The time standards were measured by the writer first in July 1958 and then in September 1959. cf. also appendix A.

help in bottle washing. The three men can raise output to 2500 liters daily. Five men are necessary for any output exceeding this level. Within every range, labor must be considered as a fixed cost, because of the indivisible nature of a labor contract. Figures 1 and 2 show a dudden jump in the total and average cost curves respectively, at the points at which additional men are employed.

Besides the fixed costs there are expenses such as cleaning supplies, dairy operating supplies (bottle caps, brushes, and filters) that vary in direct proportion to the number of bottles filled and/or the volume of milk processed. Fuel required to generate the steam used in operating the pasteurizer is also a variable cost, and is directly proportional to the amount of milk processed.

Table 2, giving the total daily costs of operating plant C whose capacity is 500 liters per hour, breaks the costs down into fixed plant costs, labor and variable cost.

Fixed costs, that amount to L.L.51.01 daily, include depreciation, repairs and maintenance of buildings and equipment - almost 90 percent of fixed plant costs - and six pounds of fuel and fixed plant overheads.

Labor, a semi-fixed item, varies from L.L.9.17 to L.L. 13.33 to L.L.21.67 depending on whether daily output is below 1000 liters, between 1000 and 2500 liters, or above 2500 and up to the 8-hour capacity of the plant, 4000 liters

Table 2

Costs of Operating a 500 liter/hour

Dairy Plant

	Costs Annual L.L.	Costs Daily L.L.
Building, L.L. 20,000		
Depreciation 5 pct per year	1000.-	2.78
Repairs and Maintenance (1 pct. annually)	200.-	.56
Equipment, L.L. 75000,		
Depreciation, 15 pct. annually.	11250.-	31.25
Repairs and Maintenance (5 pct. annually)	3750.-	10.42
Fuel - fixed plant requirements	360.-	1.-
Plant overheads	1800.-	5.-
Fixed plant costs	18360.-	51.01

Labor Output range	No.		
0 - 1000 l./day	2	3300	9.17
1000 - 2500 l./day	3	4800	13.33
2500 - 4000 l./day	5	7800	21.67

Variable Costs	Piasters/liter
Cleaning supplies	0.80
Dairy operating supplies (caps, brushes, filters..)	0.60

Table 2 (Cont'd)

Fuel for steam generation	0.62
Other variable costs (electricity)	0.80
Average Variable Costs=(Marginal Cost)	2.10 piasters/liter.

daily. Thus total daily costs show a "jump" at the 1000 and 2500 liter values due to the hiring of additional men. This discontinuity is reflected in the average cost (table 3).

The variable costs are assumed to bear a linear relation to output. This assumption is realistic due to the place and nature of these expenditures in the technical production relationships. Cleaning supplies used in bottle washing are use in direct proportion to the total surface of glass washed, in turn proportional to the number of bottles. In the same way dairy operating supplies consisting of such things as bottles, bottle caps, brushes etc... are also proportional to output in the sense that there is only one cap to a bottle, and a one-liter bottle to a liter of milk[(38)] irrespective of output. It is not conceivable that either diminishing or increasing returns could set in.

(38) The influence of the size of bottle is noted in section D. (q.v.)

Supplement to Table 2

Method of Determining Amount of Cost

Account	Cost per Day	Method of Determining
Payroll Expense		
Output Bracket I	L.L. 9.17	One man at LL 150/month-One man at LL 125 per month
Output Bracket II	L.L.13.133	Same as I plus a third worker at LL 125/month
Output Bracket III	L.L.21.67	Five men at LL 650/month.
Dairy Operating Expenses		
Cleaning supplies	LP. 0.80 X	Estimated from field experience, mainly
Dairy operating supplies	LP. 0.60 X	rough records from Hoss Dairy.
Fuel for steam heating the pasteurizer	LP. 0.62 X	Estimate based on engineering data (62 ccs. of fuel oil at 10 piasters/L)
Electricity	LP. 0.08 X	Estimate is average of 5 figures for monthly power consumption in the Hoss Dairy.
(X is volume in liters).		
Fixed Bldg. & Equipment Charges		
Depreciation, bldgs.	LL. 2.78	Initial cost (20,000 LL) depreciated at 5 percent annually
________, equipment	LL.31.25	Initial cost (75,000 LL) depreciated at 15 percent annually - Field experience justifies the rate chosen
Repairs and maintenance		No figures available - Estimated by engineering method - (cf. table 2).
Fuel - fixed plant requirements		Engineering data - 10 liters of fuel oil daily.

Table 3

Cost-Output Relation in a 500 l./hr.

Dairy Plant

Number of lits. per day	Percent of Capacity Output X	Total Daily Costs XX				Average Cost per liter bottle
		Fixed Plant Costs	Labor Cost	Varia-bles Cost	Total Cost per day	
	Percent	L.L.	L.L.	L.L.	L.L.	L.P. XXX
100	2.5	51.01	9.17	2.10	62.28	63.28
300	7.5	51.01	9.17	6.30	66.48	22.16
400	10.0	51.01	9.17	8.40	68.58	17.14
500	12.5	51.01	9.17	10.50	70.68	14.13
1000	25.-	51.01	9.17	21.-	81.18	8.12
1000	25.-	51.01	13.33	21.-	85.34	8.53
2000	50.-	51.01	13.33	42.-	106.34	5.31
2500	62.5	51.01	13.33	31.50	116.84	4.68
2500	62.5	51.01	21.67	31.50	125.18	5.-
3000	75.-	51.01	21.67	63.-	135.68	4.52
4000	100.-	51.01	21.67	84.-	156.68	3.91

X Based on an 8-hour day

XX From table 2

XXX Lebanese piasters

While the costs of cleaning materials and of dairy operating supplies are proportional to the number of bottles, the fuel requirements of the pasteurizer are a function of the volume of milk pasteurized. Since milk has a constant specific heat and pasteurizing temperature, then the amount of fuel used in raising the steam required in the pasteurizer unit is a linear function of the volume of milk. Hence the marginal cost of steam is constant for an additional liter of milk.

Thus the average variable cost, is also the marginal cost,[(39)] and is equal to 2.1 piasters per liter bottle.

Table 3, being a schedule of total and average costs for various outputs, is derived from table 2. The relation of total cost to volume is shown also in figure 1, where the Y-intercept of the total cost curve shows the fixed costs at zero output, and the slope of the line represents the marginal costs. The "jumps" in total cost at daily outputs of 1000 and 2500 liters are also shown.

The average cost curve in figure 2, plotting the data from table 3, stresses the two central observations in this industry. First, no evidence of increasing costs was ascertained within the institutional framework of the eight hour day, a fact graphically stated by the horizontal marginal cost line at the volume of 2.1 piasters. This only stresses the common

(39) Assuming one size of bottle (one liter).

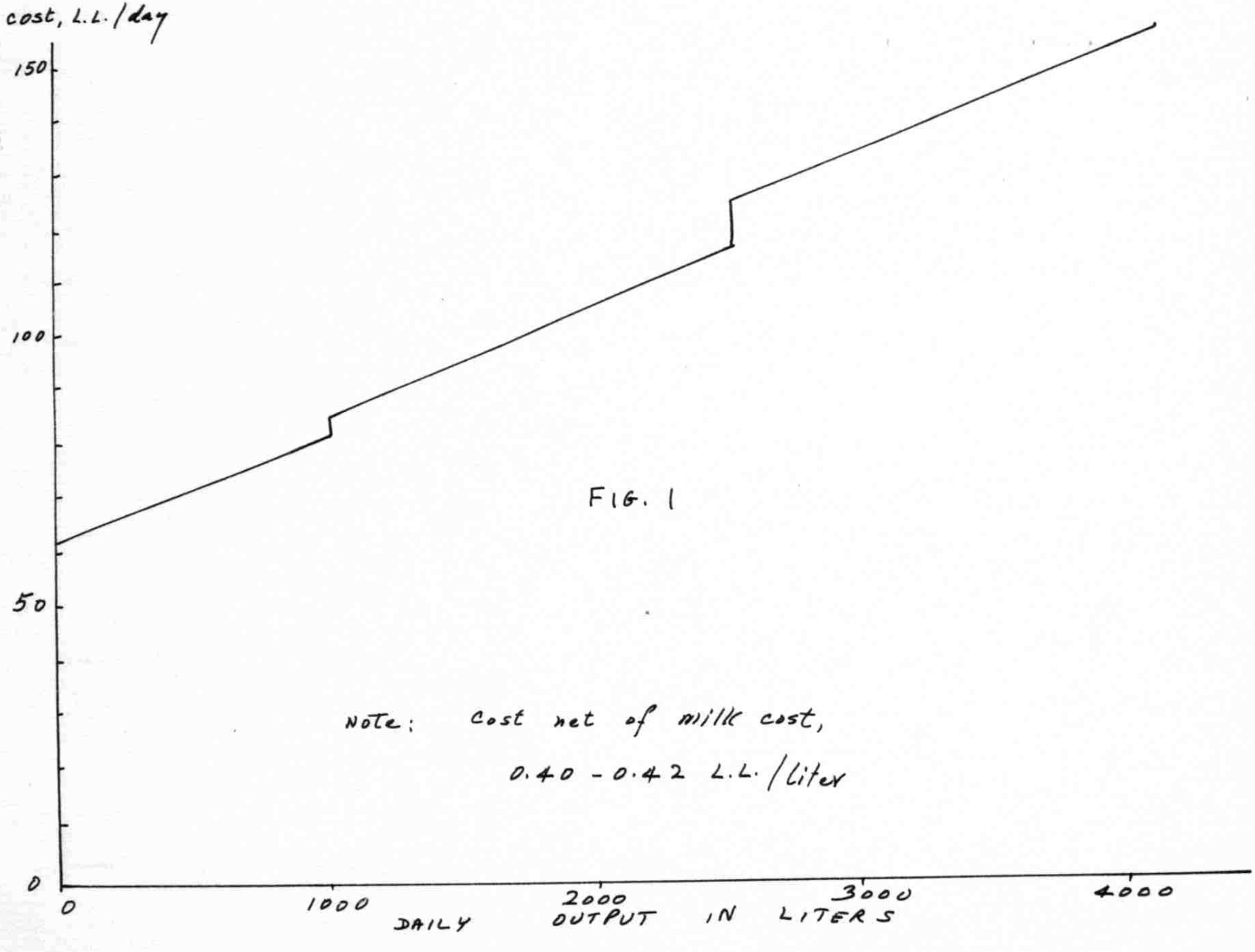
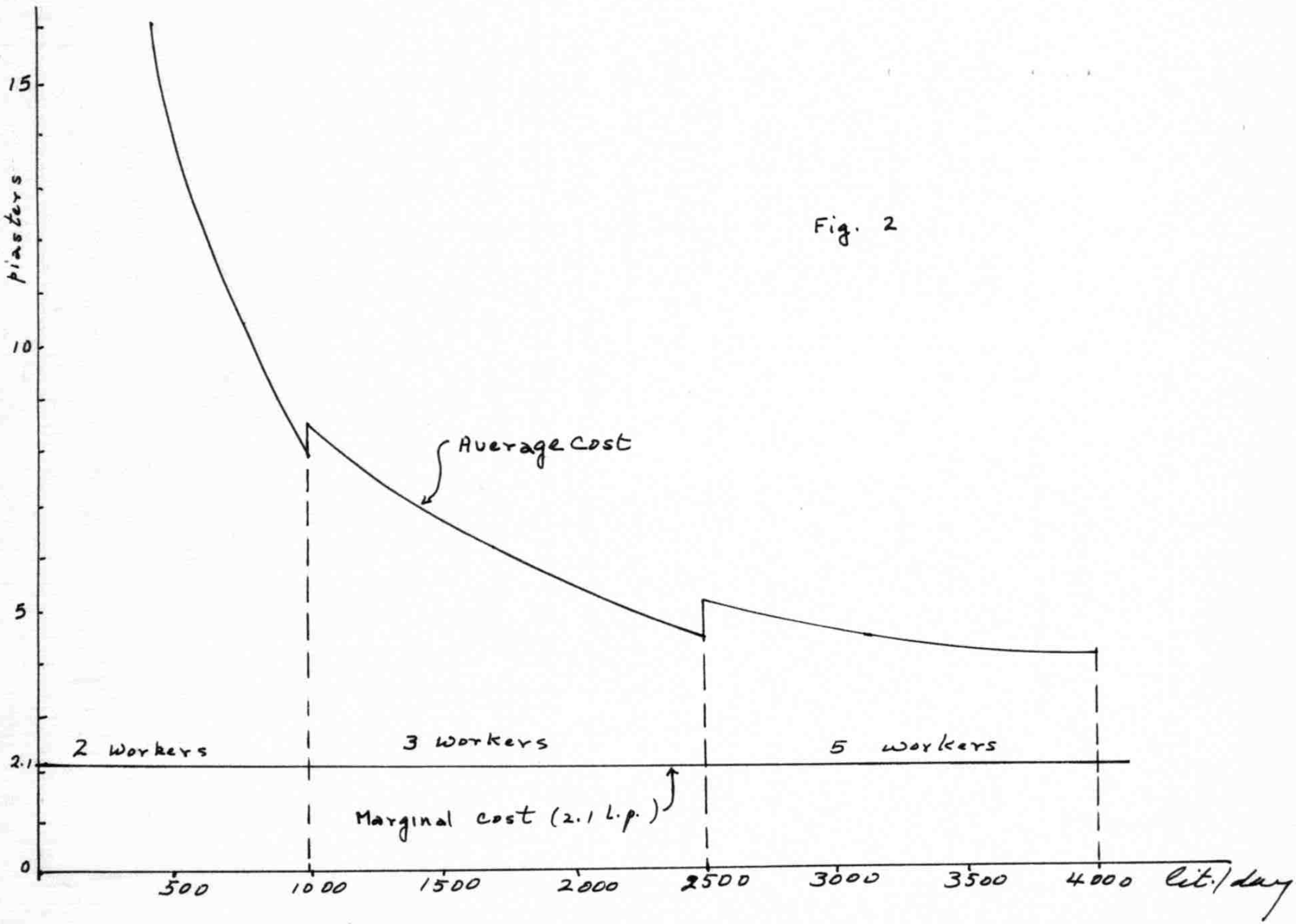

cost, L.L./day
150
100
50
0
0
1000
2000
3000
4000
DAILY OUTPUT IN LITERS
Note: Cost net of milk cost,
0.40 - 0.42 L.L./liter

FIG. 1

Fig. 2



piasters
15
10
5
2.1
0
Average cost
2 workers
3 workers
5 workers
Marginal cost (2.1 L.p.)
500
1000
1500
2000
2500
3000
3500
4000
lit./day

remark that diminishing returns do not apply to manufacturing industry.(40)

The second observation is a corollary of the first and relates to the diminishing average cost curve. The negative slope of this slope is however discontinuous. As more men are added to the labor force, the organization of the workers is changed in order to utilize the additional manpower most efficiently.

Without this increase in the payroll, the pasteurization plant would not be able to operate at capacity in all its departments. Particularly the bottling and bottle washing functions would be slowed down. In plant B where bottle filling and capping is a more mechanized operation, the first addition to the labor force becomes necessary only at the daily output of 2500 liters. The curve would however be slightly higher than for plant C, because of the higher depreciation, repairs and maintenance charges on the bottling unit, and also because of the very small additional expense on cleaning supplies and power to operate the bottling unit (table 4).

Plant A follows very closely the curve of plant C, because they both operate similar equipment. This however excludes the additional cost items incurred by A mainly in the manufacture of laban, cream and labneh. The significance of these products is noted in section D.

(40) cf.ch.4 for an elaboration of this point.

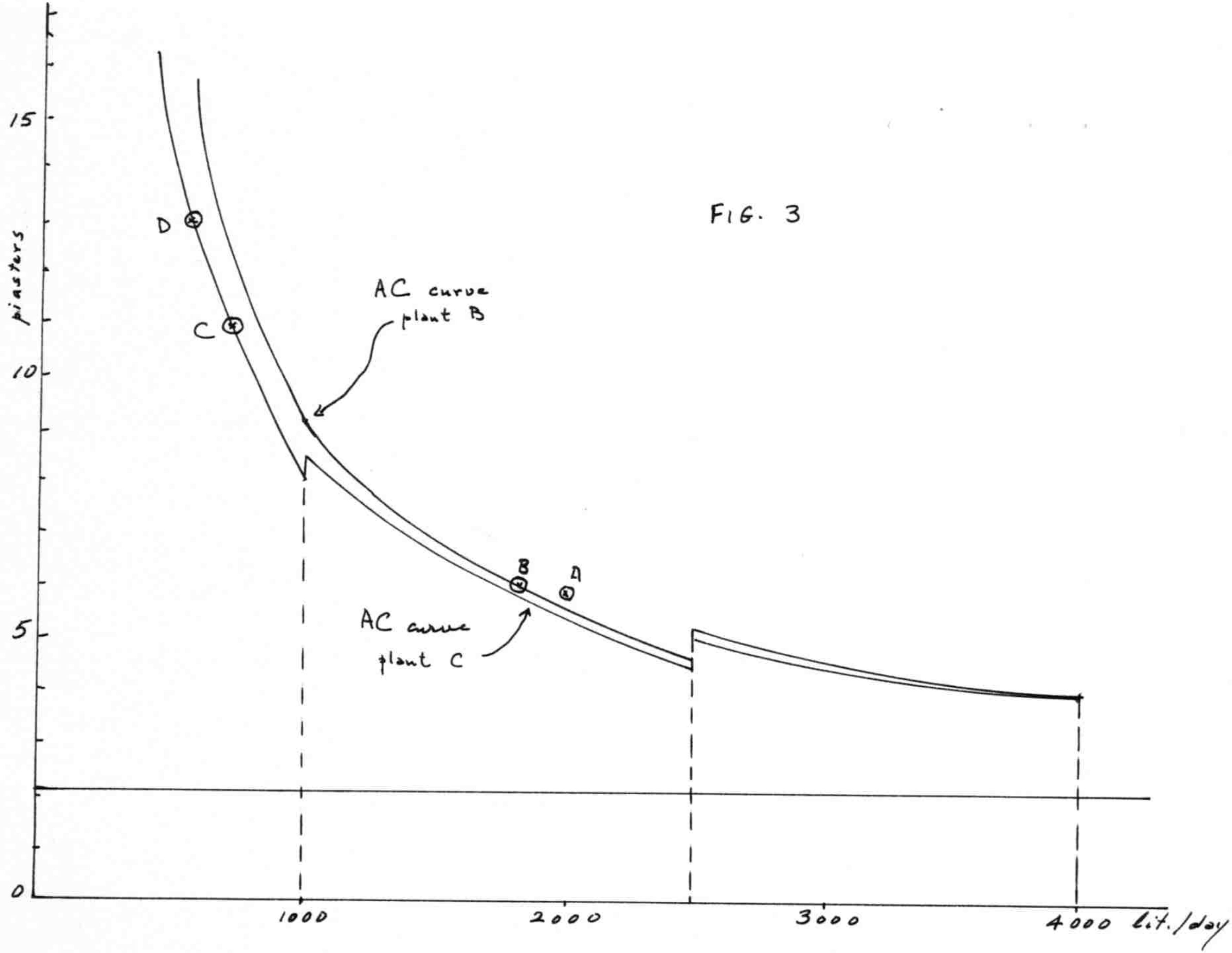
Figure 3 shows the presumed cost curve of plant B compared to that of C. Two conclusions could be made from the comparison of these curves. The first is that, in a general way, the shape of the average cost curves is the same for both plants B and C. They both fail to exhibit the U-shape expected from a study of micro-economic theory. A possible reason for this is investigated in chapter 4. The marginal cost in both plants is invariant with respect to output, so that total cost is a linear function of the rate of utilization of capacity, except for the discontinuity of the line.

The second conclusion, is that the difference between the average cost of producing any given output in either plant is not great. It could even be argued that, due to the imperfect efficiency of operation that obtain under practical conditions, a statistical cost survey would show a greater deviation from the expected average costs than the vertical differences between the average cost curves of plants B and C. Should the latter argument be valid, those differences would become insignificant.

The costs reported in the interviews are aggregate costs of processing one liter of milk, at the output levels at which the various dairies are operating. In figure 3 these costs are shown as points A(5.7 l.p./l.[41] at a daily output of 2000 liters)

(41) L.P./l is Lebanese piasters per liter.

FIG. 3



15
10
5
0
piasters
D
C
B
A
AC curve plant B
AC curve plant C
1000
2000
3000
4000 lit./day

B(6.0 l.p./l. at 1800 liters daily), C(11.0 l.p./l. at 700 liters) and D(12.6 l.p./l. at 600 liters daily). Those values corresponding to plants A, B, C and D respectively do not lie exactly on the curves for plants C and D. The reason is two-fold. One, that the reporters do not know their exact processing costs due to various reasons, inter alia the absence of cost accounting records. The second reason is that these plants should be expected to operate at less than full efficiency, because one hundred percent efficiency is humanly impossible. Even if it were, workers with free time in excess, tend not to take things as seriously as if they were working hard all day, when mistakes may upset the whole schedule. The inefficiency and lack of skill in the supervisory personnel may also be a contributing factor.

D. Some Factors Affecting Processing Costs:

The processing costs of milk reported in the previous section as applying to the dairy industry of Beirut are orders of magnitude, and apply only to milk pasteurized by the "high temperature short time" process, and bottled in one-liter bottles under the standard practices of the dairy industry. Variations from the standard procedure would induce deviations from the processing costs.

The fixed asset policy of the dairies, procurement practices, the type and size of milk container, the volume and composition of sales and the competitive structure of the economy are all important factors in modifying either the short-run cost curves or the point-cost figure.

The depreciation of building and equipment can be provided for at a more or less rapid rate depending on the policy of the dairy. The total daily cost in plant C can be represented by the set of formulae corresponding to the outputs shown:

Output range	Total Cost	=	Fixed plant Costs	+ Labor Costs	+	Variable Costs
0-1000 lit./day	T_1	=	LL. 51.01	+ 9.17	+	0.021 X
1000-2500 lit./day	T_2	=	LL. 51.01	+13.33	+	0.021 X
2500-4000 lit./day	T_3	=	LL. 51.01	+21.67	+	0.021 X

Where X is output in liters.

Should the rate of depreciation be changed from 15 to 10 percent on equipment, the fixed plant costs would be reduced from LL.51.01 to LL. 40.59. This difference can be significant in reducing average costs. As an example, the average cost formula corresponding to output 0-1000 liters daily for plant C and whose total cost is T_1 can be written

$$AT_1 = \frac{6018}{X} + 2.1 \text{ in piasters/liter.}$$

The new average cost equation corresponding to AT_1 at the 10 percent rate of depreciation would be considerably less however and can be written.

$$AT_{1,10} = \frac{4979}{X} + 2.1 \text{ in piasters/liter.}$$

The difference is more significant at the lower output levels since as output increases, the "saving" in depreciation charges is spread on a larger output.

The procurement policy of the firm is also significant in influencing the costs of processing. In particular, the handling of milk in bulk may be expected to reduce receiving and trucking expenses. This practice is however not recommended for the dairy plants in Beirut because of their relatively small size.(43)

The use of paper containers has frequently been advocated. No measurement was made by the writer concerning the costs of packaging in cartons in the city of Beirut, in spite of favourable conditions. Studies performed in the United States as to the relative merits of paper and glass containers are many. A very reliable report(44) found a slight advantage in cost in favor of cartons. This difference would be due to the savings in the cost of washing and sterilizing the empty bottles, storage of glass bottles, breakage of bottles, time spent in collecting the empties from the customers, loading and unloading of the latter, and overall cleaning for the washing department. As against all those advantages for paper containers, the cost of the paper container itself is rather high. Canadian paper containers in lots of 50,000 were offered delivered in Beirut at the following prices:(45)

(43) c.f. footnote 29.

(44) Park, C.W., (ed.) Milk Packaging For Retail Distribution. Report of a Controlled Experiment. The A.H. Pugh Printing Company, Cincinnati, 1956.

(45) By courtesy of Middle East Development Company S.A.L., July 16, 1958 (commercial offer).

Size	Price (piasters)
Liter	10.5
1/2 liter	7.2
1/4 liter	6.-

While glass bottles cost more than cartons they are returnable and thus can be used over and over again. The deposit charged to the customers is equal and in some cases exceeds the initial cost of the bottle. In this way the customers are encouraged to return the container but if they do not little loss accrues to the dairy. The costs of bottles and the deposits charged on them are:

Bottle size	Price (46)	Deposit
	Piasters	Piasters
One-liter	49	50
Half-liter	40	40
Quarter-liter	32	35

An average life for a glass bottle may be thirty trips. But some dairies achive much higher trippage on their bottles. The average depreciation per trip is therefore about one to two piasters. Packaging in paper cartons is therefore about 5 times more expensive than using glass bottles. Large economies in handling paper cartons must be realized to offset the higher container cost before paper cartons will be as economical in Beirut as glass bottles.

(46) By courtesy of Mr. Jamil Bibby, representative of Reinhold A. Averback, Inc., Easton, Pa.,USA.

The size of containers is likewise important. Bottles of various sizes require about the same time for capping, washing, handling and distribution. Cleaning materials are also approximately the same. The smaller containers account for expenses more than proportional to their size, and consequently are more expensive per liter of milk. As an illustration the capacities of bottle filling and bottle washing machines may be taken. Table 5 shows the capacity in bottles per hour of various washing and bottling machines.

Table 5

Capacity of Bottling and Washing Machines

	Bottle Size		
	Liter	Half liter	Quarter-liter
Klein Golf (Bottle soaking)(47)	400	400	400
Klein Polfram (Rinsing)(47)	400	400	400
Die Klein Seity (Bottling-capping)	400	400	400
K.A. 1 (Filling and capping)(48)	810	1320	1320
K.A. 2 (Filling and capping)(48)	1620	2640	2640

The capacity in bottles per hour is either the same for all bottle sizes, when hand operated machines are used, or the increase in number of bottles handled per hour does not compensate for the decrease in size.

(47) Bergedorfer Eisenwerk, A.G., Tender 55.06.324 (Commercial offer)

(48) Graham Enock Mfg. Co., Ltd., London.

The higher cost of filling and handling smaller size bottles was reflected in a higher price charged to the customer for a liter of milk in smaller than in larger containers. This practice was discontinued in 1958 under the pressure of competition.

The method of pasteurization, vats versus HTST, can influence the costs of pasteurization. Webster (1956), investigating the relative merits of vat and HTST systems found that vat pasteurizers are more economical at lower output levels. At the higher capacities the HTST has slightly lower costs.(49) The reasons for which only the continuous HTST system is used in Beirut, in spite of the low volume of sales remains to be investigated.

The most important single factor in determining the average cost is the level of utilization of capacity. The effect of this factor is illustrated in figure 2. As output increases, and up to capacity, unit costs decline, except at the points corresponding to outputs 1000 and 2500 liters daily, when additional labor is hired. This relationship of cost to output is central in business decision-making, since all intelligent behaviour must be backed by cost data. The drop in average costs is very quick initially, while at higher outputs the curve flattens out. Decisions regarding the product line and about price discrimination are usually based on the relation of average cost to output.

(49) Webster, F., Op.Cit. p. 26-27

E. Product Line Policy:

In as much as milk can be made into a number of products, a wide variety of milk derivatives could be marketed by a dairy plant. This is easy to do as the basic equipment can be used in the production of a number of items. Cream, laban, labne and chocolate milk, to take only a few examples, can be produced in any dairy plant, and require the addition of relatively inexpensive equipment. When their production increases total sales and volume of milk processed by the milk plant, it reduces the fixed charges allocated to the main product-pasteurized milk. Particularly in a plant with excess capacity, the broadening of the line of products should increase the efficiency of utilization of the plant, labor and managerial resources.

In theory, a dairy plant manager should select from the broad range of products available to him that which yields the greatest profit. Since marginal cost of liquid products is constant then the operationally significant criterion in the choice of products is the extent to which average fixed costs are reduced. Alternatively, the choice should go to the product in whose manufacture the greatest use is made of the fixed assets, in order to use the plant closer to capacity and thereby reduce fixed costs per unit. A competitive advantage is gained in any such new product, over a firm specializing in the production of that one product. An example in point, is beverage laban.

Bevarage laban is an apparently popular beverage in some sections of Beirut in preference to milk. The process of manufacturing involves the use of steam, refrigeration, bottling and capping machines, and occasionally (and preferably) the pasteurizer. In the hypothetical case where Bambi adds this item to his product line, some of his fixed charges will be allocated to beverage laban. Thus, the cost of processing fluid milk is decreased. Bambi may be able to sell the new product at full cost, or even at a price that will cover variable cost and a part of fixed cost, and still be better off than without beverage laban. Milko, who specializes in the production of this item has no such cost advantage, as he has to cover all costs and make a profit in order to continue in business. The full cost of a 1/4 bottle of beverage laban,[(50)] is about 7.5 piasters inclusive of distribution and is sold at ten piasters. Bambi were he producing this item could sell the bottle of beverage laban at 7.5 piasters, a price that Milko cannot match for long.

The introduction of a product such as beverage laban results in a higher labor efficiency, and consequently in lower average labor costs, especially at the beginning of a new range (such as between outputs 1000 and 2500 liters daily in figure 2).

Another advantage is where the new product can use any unsold milk. Cooking laban is such an item. Most dairies,

(50) Mr. Ibrahim Ghossoub. The bottle has a capacity of 250 cubic centimeters.

Hoss excepted, transform the milk unsold at the end of the day into cooking laban. Any cooking laban not sold after one or two days is made into labneh.

A parallel advantage, is where a byproduct is utilized, such as skimmed milk resulting from the separation of cream. Skimmed milk can be used[51] as raw material for either beverage laban or cheap labneh.

The main advantages[52] of a diversified product line for milk processing plants are:

(1) An improved break-even position. Since the fixed costs are spread on a larger value of sales, then for the dairy as a whole receipts will start to exceed costs at a lower output of the main item than in a specialized dairy.

(2) Labor efficiency is increased until additional workers have to be hired.

(3) Losses due to the wastage of products and byproducts are decreased.

(4) Per unit costs of distribution would be reduced, because the distribution channels for dairy products are the same.

---

(51) There are two classes of labneh. The cheap, sold at 1.50-2.00 L.L. per kilogram and the "full milk" labneh, usually produced on order. The price of the latter is 2.50-3.00 L.L. per kilogram.

(52) Dean, Z., Managarial Economics, Prentice Hall Inc., New York 1951. Pp. 120-133.

(5) Demand for many dairy products is cross elastic. It has been observed that many consumers prefer chocolate milk to simple pasteurized milk. The dairy can increase its sales by catering to this demand, especially as no additional equipment is required for the production of chocolate milk.

It is frequently true that the processors of dairy products consider themselves as sellers of one or another milk derivative. It would seem however that they are "selling" their own capacity to produce. In this light, any business manager who has the opportunity to exapnd into new products and who does not take the choice, is not, to that extent an efficient manager.

The problem of choosing the various items to include in a product-line is a complex one. Snyder and French (1957) have solved the problem by linear programming. Information adequate enough for the solution of the problem by linear programming is however only infrequently available.(53) Even though this method of determination cannot be used here, in the Beirut milk industry it would appear advisable to include a variety of products such as will maximize profits.

F. Vertical Integration - The Hoss Dairy:

The Hoss Dairy is a fully integrated operation. It owns a farm, a processing plant and a distribution system. The ad-

(53) Snyder, J.C., and French, C,E., "Selection of a Product Line For a Fluid Milk Plant by Activity Analysis", Journal of Farm Economics, vol. 39 (4): 914-927.

vantages derived in the case of the Hoss Dairy are not obvious to the writer. While the sanitary conditions are improved because the handling of milk prior to processing is less than where milk is produced at a distance from the plant, a whole set of diseconomies are in operatioh.

The handling costs (especially transportation) are higher, because a larger weight is trucked for a longer distance, due to the larger proportion of empties.(54)

The volume of milk produced on the farm is so low that it results in very high processing costs per unit compared to the nonintegrated dairies, who buy as much milk as they can sell. Moreover, the output of milk shows a seasonal fluctuation, and consequently the Hoss Dairy is faced with a surplus of raw milk in spring and a shortage in winter. Many stores refuse to handle Hoss Milk because of the uncertainty of its supply.

The competitive position of the dairy is impaired because should demand for its products increase the Hoss Dairy cannot supply the milk desired. The alternative of buying extra milk is vigorously rejected by Mr. F. Hoss, on the assumption that goodwill would thereby be hurt. Consequently, no advertizing or sales promotion of any kind except personal canvassing can be justified.

Cleanliness is more difficult to maintain in the Hoss Dairy than any other dairy because of the close proximity of

(54) cf. ch. 3 section D.

the stables to the pasteurizing plant. Management is also more difficult, because of the differing requirements of skills in farming and dairy plant operation.

It does not seem that the integration of dairy farming with milk processing can be justified. The attempt at compromise in the case of the only fully integrated Lebanese operation only resulted in a mixture of the things that should be avoided for economic and technical reasons, in both dairy farming and milk plant operation.

G. Conclusion:

The Dairy industry possesses a considerable degree of excess capacity. There also exists a large potential market now supplied by the peddlers and stores who sell raw milk.

The cost curves in this industry do not exhibit the shapes expected from a study of the theory of the firm. Total cost is linearly related to output indicating a constant marginal cost within the relevant range. Consequently, the average cost curve for the short run period is in the shape of a hyperbola rather than a U. A possible explanation to this is sought in chapter 4.

The scatter of the cost data for the four firms studied indicates that the volume of output is the most important single factor in determining average processing costs. These survey figures fall on or close to the average cost curve relating to plant C (figures 2 and 3).

Considerable scope exists for cost cutting in this industry by manipulating the various factors capable of influencing costs. It may be proved that, short of aggressive price cutting in pasteurized milk, product line diversification is the most important method by which the distributers can cut their processing costs. This field has not been investigated seriously by the managers of the dairies studied, according to the information received.

Chapter -III-

The Costs of Milk Distribution

In chapter 2, the costs of milk processing in four dairy plants were analyzed and compared with the costs of operating a model plant of similar capacities.

The distribution of fluid milk to the customers is a significant cost center, and is considered by plant managers to be a very important part of their operations. Most of the competition between plants it is hoped to show, centers around a better service to the customer, in the sense of a more timely delivery of milk to his door or to the store which he patronizes. The cost of this function frequently amounts to more than half the value added to raw milk by the dairy plant operators.

This chapter proposes to study the factors influencing the costs of milk distribution, and their relevance to the cost structure and competitive behaviour of the dairy plants in Beirut, and to show the trends, technological and otherwise, in this important sector of the dairy industry.

A. The Elements of Distribution Cost:

A dairy distribution system is basically a transportation department consisting of a loading platform, trucks and dêpots, together with the attendant labor and office help. The cost of distributing one bottle of milk is the sum of the unit charges due to the fixed and variable inputs applied in the following sequence of operations:

1. Check-in the empty bottles,
    a. Unload the crates from the truck into the loading platform
    b. Count and inspect the crates,
    c. Office work (sign the receipts slip, enter the particulars in the books).
2. Check-out the bottled milk crates,
    a. Load the crates of bottled milk into the truck,
    b. Count and inspect the crates as the milk is loaded,
    c. Fill-in forms, despatch orders and other records.
3. Trip to distribution depôt
4. Unload the milk into the refrigerator in the depôt
5. Check-out the bottled milk
    a. Load into the truck
    b. Record keeping and checking.
6. Distribution to individual and wholesale customers
    a. Stop at the customer's door,
    b. Unload enough milk,
    c. Carry the bottles to the customer,
    d. Reclaim the empty bottles,
    e. Take the order for the next day,
    f. Return to the t ruck
    g. Load the empties
    h. Rearrange the load in the truck
    i. Start the truck
    j. Drive to the next customer

7. Sales and credit accounting

8. Reload the empty bottles and the returned milk

Due to the nature of these operations some of which are constant irrespective of load while the duration and supplies for others vary with the amount of sales, the costs are naturally subdivided into fixed for the day and variable costs, Loading and unloading, counting and inspection vary with the number of crates rather than with volume of milk. Thus, the labor time required to unload a given volume is dependent on the size of the bottles, the larger bottles being more economical to deliver. The relation of bottle size to volume of milk per crate is shown in table 6.

Table 6

Bottle size and liters per crate (55)

Bottle size	Number of bottles per crate	Liters of milk per crate	Total wt. of crate milk & bottles
One litre	12	12 l.	21.- kg.
Half litre	20	10 l.	20.30 kg.
Quarter litre	20	5 l.	12.50 kg.

(55) Measured by the writer. The fourth column assumes a standard all-wire basket weighing about 3 kgs., and milk bottles weighing 0.225 kilos, 0.365 kilos and 0.500 kilos for the quarter-half-and full liter bottles respectively. Milk for all commercial purposes weighs one kilogram per liter.

Distribution costs are strongly correlated with the nature of the majority of the customers along a given route. Wholesale distribution usually entails lower costs because more is delivered per customer than in retail, thus reducing the number of times the truck stops, and labor time per liter of milk delivered. Table 7 shows the average number of customers per thousand liters of sales on three representative routes, Route I is entirely wholesale, Route II is mixed and Route III a predominatly retail operation.

Table 7

Number of customers on retail and wholesale routes (56)

	Route I (wholesale)	Route II (Mixed)	Route III (Retail)
Sales volume	680	500	315
No. of customers	26	78	198
No. of customers per 1000 liters of sales	38	156	615
Liters per customer	26.1	6.4	1.59

The distance between customers influences distribution costs, but the functional relation of the influence of distance on costs and volume cannot be written down, since it would vary

(56) The data are average figures supplied by Bambi, Hoss and Milko, and do not correspond to any single distributor's route.

with the characteristics of the route itself. The design of a route would also depend on the nature of the customers (opening time of stores, schools, offices, etc. on retail routes).

There is a definite peak period of demand for milk during the day, usually between six and nine thirty in the morning. One distributor (Bambi), would hasten to dispose of his milk before 9.30 a.m., postponing payment and collection to the afternoon, when the salesman would not be rushed for time. Retail distributors (57) collect from customers at the end of the month in order to concentrate on delivering milk to customers during the preferred morning period.

The amount of office time required in a day depends more on the number of customers than on total volume sold. Wholesale routes require less office time of employees than retail or mixed routes.

The relations of route characteristics, bottle sizes, and efficiency of operation to the costs of milk distribution are more explicitly shown in section B below.

B. <u>Distribution Costs</u>:

There are three forms of cost in the distribution of milk according to their functional relation to volume. Those costs that are fixed for the day include depreciation, taxes and insurance on the truck and equipment and interest on the

(57) Hoss Dairy before July 1958 when the loss of one vehicle during the rebellion forced him out of the pasteurized milk market. The Dairy is now operating a wholesale route for pasteurized milk.

fixed investment in the distribution system. Such items as driving to the first customer, and from the last customer to the plant, loading and unloading time ... are also fixed for the day. In Beirut, as a rule, the wages of the drivers as well as the distribution employees are also fixed for the day.

During a working day, there are some additional costs incurred every time the truck stops to deliver milk to a customer. These costs are fixed for every stop. Mainly these are the costs of driving between stops, stopping and parking the truck, checking the order, waiting and talking time, sales promotion, handling the empties, rearranging the load in the truck and walking to and from the customer's premises.

There are also secondary costs incurred in any stop and these vary with the volume of sales, such as putting up the order and delivery time.

In addition to the above categories, there is the overhead cost chargeable against distribution. This component has been discussed in the previous chapter, and its effect is similar to that of the costs fixed for the day.

At this stage the problem of the fixity of labor costs arises. As in the case of plant labor, drivers are paid by the month, and since the drivers in the dairy business are also salesmen, there is an interest in creating a sense of loyalty to the dairy by an employment contract. The driver is thus entitled to compensation under the law. Most dairies follow this contract arrangement, thus reducing drivers' wages to the status of costs fixed for a month. The time spent by the driver in making each delivery is an important factor in determining the per unit cost, because of the relatively short period of time (3-4 hours) in which most of the milk must be delivered.

The costs incurred on the six milk routes for which data is available to the writer are summarized in table 7. In that table, salaries are those for the office employees engaged in the distribution of milk and including a fraction of the manager's time. Wages include payments for the drivers, assistants and occasional labor. "Trucks" includes both the fixed and the operating elements in the daily cost of the trucks. There is a total of fourteen milk routes in Beirut now, operated by eight distributors.(58) The sample of six routes studied belong to four dairies only, and were selected because of the availability of relatively detailed data.

Table 8

The Daily Costs of Milk Distribution on Six Routes in Beirut

		Route					
Cost item		A	B	C	D	E	F
Salaries	L.L.	5.33	5.33	3.61	3.61	1.27	-
Wages	L.L.	8.13	8.13	9.03	9.03	4.50	4.50
Total labor cost		13.46	13.46	12.64	12.64	5.77	4.50
Trucks	L.L.	15.25	19.75	9.47	9.82	3.85	9.80
Total Daily Costs L.L.		28.71	33.21	22.11	22.46	9.62	14.30

(58), The routes are distributed as follows: Bambi 3, Dumit 3, Hoss 2, Dairy House 2, Milko 1, Super 1, Koko 1, and other 1.

From the table 8 it can be seen that labor represents about half of total distribution costs, in the sample used, with a spread of from 30 (route F) to 60 percent (route E). In a study in the United States of America,(59) more than 80 percent of distribution costs were accounted for by labor. The difference is probably due to higher wages in that country.

Truck costs represent another fifty percent of the total cost of distribution on the six routes of table 3. These include depreciation, interest, repairs and maintenance, fuel, and lubrication, in addition to half a pound daily for miscellaneous expenses.

Table 9 gives the average cost of distributing one bottle of dairy products on the six routes. The costs per bottle show some significant variations between routes. These can be explained by the nature of the customers served. A and B were predominantly retail distributors based on a plant some fifty kilometers away from Beirut. Route A serves 198 customers distributed along a distance of 40 kilometers, while Route B distributes milk to 130 customers and extends over fifty kilometers. Being retail operations, the number of stops per day is higher and the volume of milk per stop is lower than for wholesalers such as routes C and D. Consequently, the average costs along

(59) Roadhouse C.L., and Henderson J.L., The Market Milk Industry. Pp. 492-493, second edition, McGraw Hill Book Company, Inc., New York 1950.

Table 9

The Average Costs of Distributing a Bottle of Milk in Beirut (60)

Cost item	Route A	B	C	D	E	F	4-route Average
Total bottles per day	315	420	510	470	225	3200	428.75
Number of customers	198	130	39	52	80	48	-
Distribution cost per bottle L.L.	0.091	0.079	0.0435	0.0475	0.0425	0.0045	0.066
				Use piasters			
Trucks L.L.	0.0485	0.047	0.0168	0.021	0.017	0.0031	0.036
Salaries and Wages L.L.	0.0495	0.032	0.0267	0.027	0.026	0.0014	0.030

A is 9.1 piasters per bottle as compared with 4.35 piasters for route C. The costs incurred by B are lower than in A, being 7.9 as against 9.1 piasters per bottle. The difference is due to the higher volume of sales in B than in A, but also to the smaller number of stops per working day (cf. table 9).

The two routes C and D are operated on the basis of wholesale trade. They stop mainly at stores, home delivery accounting for only three out of a total sales of fortyone cases of liter bottles in route C on the day of the writer's inter-

(60) The 4-route average shows the average costs on the routes A,B,C,D. The remaining two routes are non comparable with the first four, because of their radically different nature. Route E uses very small vehicles, based on a plant in the center of their distribution area, while route F distributes quarter liter bottles of beverage laban wholesale to shops and restaurants.

view with the driver. These routes serve 39 and 52 customers respectively, whose daily purchases average 13.1 and 9.04 liters daily. For this reason, their average distribution costs are 4.35 and 4.75 piastres per bottle respectively, The higher cost on route D can be explained by the lower average sales per customer (9.04 against 13.1 on C), in turn attributed to a larger number of customers (52 vs. 39) and a smaller volume of total sales (470 vs. 510 liters). Table 3 shows the total costs of operating route D to be higher than that of C. This can be attributed to a longer distance of daily travel by the truck of route D, (42 kms) than that of route C, (35 kms.). Since the two trucks are of the same make, size and age, and salaries and wages being identical, this can be the only main reason.

Route E is a mixed operation, that delivers milk to both houses and stores. The vehicle used consists in a small scooter-van, that carries a load of eight cases (96 liters) weighing 168 kilograms, and makes 17 kilometers per liter of fuel. In an average of 2.35 trips per day, the scooter delivers 225 liters and travels ca. 50 kilometers. Since the central plant is in the zone of distribution (Hamra Street) the use of these vans is a very cheap means of distribution. Its economy is reflected in the low average cost of delivering one bottle, 4.25 piasters, compared to the 4-route average (table 9) of 6.6 piasters.

Route F is not strictly speaking part of the milk distribution system. It is a beverage laban route, that delivers the

Table 10

Size of Sales per Customer and Costs of Distribution

	Route					
	A	B	C	D	E	F
Bottles delivered daily	315	420	510	470	225	3200
Number of customers	198	130	39	52	80	48
Sales per customer	1.59	3.-	13.1	9.04	2.76	66.67
Per bottle distribution cost piastres	9.1	7.9	4.35	4.75	4.25	0.45
Cost per customer, piastres	14.4	25.5	57.-	43.-	12.-	27.8

product to shops and restaurants at the rate of 66.67 bottles per customer, and 53.7 bottles per kilometer of route. It thus has the highest sales intensity, kilometer-wise. Since this plant has no salaried personnel, being managed by the owner on a part-time basis, its cost of operation is the lowest, per kilometer of route and in the absolute, of all the routes except E. The concentration of sales per kilometer, the low daily costs and the very high volume of 3200 bottles daily make for an extremely low cost of distribution per bottle. The general impression given by all the operations of this dairy is one of high efficiency.

Table 11 gives the relation of route length and customer and sales intensity to the costs of milk distribution. From this table the following characteristics of distribution costs

Table 11

The Intensity of Sales and Distribution Costs

	Route					
	A	B	C	D	E	F
Total Daily Cost L.L.	28.71	33.21	22.11	22.46	9.62	14.30
Kilometers in Route	40	50	35	42	50	60
Sales, bottles/km.	7.88	8.40	14.8	11.2	4.50	53.7
Customers per km.	4.95	7.00	1.12	1.24	16.0	0.80
Cost per kilometer L.L.	0.72	0.66	0.63	0.53	0.92	0.24
Cost per bottle, piastres	9.1	7.9	4.35	4.75	4.25	0.45

can be derived. First, that for similar vehicles the cost of travel per kilometer is lower the longer the trip travelled. This is shown by trucks C and D whose daily costs are very similar (22.11 and 22.46 L.L. per day) but while D covers 42 kilometers per day, C's route is only 35 kilometers long. As a result, C costs 0.63 L.L./km. and D only 0.53 L.L./km. This is due to the high ratio of costs fixed for the day (with respect to distance) to those variable with distance travelled.

Secondly, that the number of customers per kilometer, referred to in the trade as the depth of the market, is important in determining distribution costs. The deeper is the market, the lower will the costs of distribution be for any given route. On routes C and D, the effect of the depth of market is marked by the lower sales per customer on route D than on C. As a result the average cost of distributing one bottle is 9.2 percent higher on route D than on route C, when from the consideration of market depth alone, it should have been lower by twenty-five percent. The difference can be fully accounted for by the lower sales per customer on route D. This tendency is however better shown on route A and B, where in spite of a higher total daily cost of operating route B, the average cost of distribution is lower on the latter. The reason is to be found partly in the market depth of 7.0 customers per kilometer, as compared to 4.95 on route A.

Thirdly, that the intensity of sales expressed in bottles sold per kilometer of route length, being the inverse of the distance traveled per 100 bottles, is an index to one of the important fixed components of costs, the cost of traveling. The longer the distance covered per unit of sales, the more is the distribution cost. This is the reason for the surprisingly low average costs on route F, where an average of 53.7 bottles are sold per kilometer, with selling costs of 0.45 piastres per bottle, about eleven percent only of the average cost of the next lowest cost route E. Because the average cost of distributing one bottle is of the form:

$$C_a = \frac{C_t}{I \times l} = \frac{\text{Cost, daily total}}{\text{Intensity of sales x route length}}$$

any percentage increase in the intensity of sales, for a given route length and total daily costs would be reflected by a more than proportional decrease in costs per bottle. In the dairy business this is translated into the attempt by distributors one to reduce the number of stores who buy from more than one seller, and two, to deepen their market, by attracting a larger patronage along their already established routes. The third possibility, of simultaneously deepening the market and reducing mileage has never been a practical possibility in Beirut, though it theoretically could become important. Section C of the current chapter will study it in the context of location theory.

An important factor influencing the costs of dairy marketing, and of any distribution venture is the type and cost of operation of the vehicles used. The six dairy routes studied in Beirut exhibit an interesting variation in original cost, operating cost and in capacities. The original costs vary from 2700 L.L. for the tiny scooter van, to 15,000 L.L. for a 1 1/2 ton truck. Table 12 summarizes the annual costs of operating these trucks, while table 13 relates the vehicle capacity and price to the costs of distribution.

Table 11, showing the breakdown of the annual costs on the six routes is instructive in that the influence of the original cost of the vehicle, the depreciation policy of the firm and the rate of interest are brought out. In the computation of cost, depreciation by the straight line method at twenty percent annually, was adopted on all of the routes for the sake of uniformity, and also because it is a common rate

Table 12

The Yearly Costs of Vehicle Operation on Six Dairy Routes

Original Cost of Vehicle (1) L.L.	Used on route	Capacity kgs.	Deprecia- tion L.L. (2)	Interest L.L. (3)	Operation and Main- tenance (4) L.L.	Total Yearly cost L.L.
2,700	E	200	540	81	785	1,406
6,500	F	750	1,300	195	2,117	3,612
7,500	C	750	1,500	225	1,734	3,459
7,500	D	750	1,500	225	1,862	3,587
12,000	A	1,000	2,400	360	2,738	5,498
15,000	B	1,500	3,000	450	3,778	7,228

(1) Prices of new vehicles of the same brand-name and size as observed in operation on the respective routes.

(2) Based on 20 percent per year, as is current in this business in Beirut. U.S. dairies generally use 25 percent.

(3) Six percent per annum on the average investment.

(4) Computed from fuel consumption data supplied by the drivers. Repairs and maintenance were given as yearly totals at the rate of spending of the first six months of 1959.

Table 14

Effect of Depreciation Policy on Delivery Costs

Route Demomination	Original cost of vehicles	Total annual route costs (table 7)	Depreciation (20%) as a percent of total cost	Change in total cost due to a change in Depreciation from 20% to 16.67	25
	L.L.	L.L.	percent	percent	percent
E	2,700	1,406	38.5	-6.4	+9.6
F	6,500	3,612	36.0	-6.0	+9.0
C	7,500	3,459	42.5	-7.2	+10.8
D	7,500	3,587	42.0	-7.0	+10.4
A	12,000	5,598	42.8	-7.1	+10.8
B	15,000	7,228	41.5	-6.9	+10.4
Mean (arithmetical)			40.6	-6.8	+10.2

of E and F is 50 and 60 kilometers daily, while C and D operate on 35 and 42 kilometers only. Consequently, the kilometer cost is 0.16 L.L. in F and 0.25 in C and D.

Because the fraction of total cost due to depreciation is about 40 percent for all the trucks, the percentage change in total cost due to a change in the rate of depreciation is also generally similar on all six routes, with some variation accounted for above.

The influence of the rate of interest on the annual total costs of distribution is similar to that of depreciation. Interest on the cost of the truck represents an average of

Table 13

Truck Size and The Costs of Distribution

Route	E	F	C	D	A	B
Original Cost L.L. of truck	2700	6500	7500	7500	12000	15000
Capacity, kgs.	200	7500	750	750	1000	1500
Annual cost of operation L.L.	1406	3612	3459	3587	5498	7228
Kms. per year, km.	18250	21900	12775	15330	14600	18250
Cost per km. of travel L.L.	0.008	0.164	0.27	0.23	0.375	0.395

in the industry. The percentage changes from the total route costs (table 12) arising from a change in the rate of depreciation from 20 percent to 16.67 percent and 25 percent respectively are shown in table 14.

Depreciation accounts for a smaller fraction of total cost in the less expensive vehicles. For that reason, a change in depreciation policy will affect their total annual cost less, percentage-wise, than the larger vehicles. The costs of distribution per bottle were least on routes E and F, and these have a lower percentage of depreciation in the total cost than the average (38.5 and 36 percent compared to 40.6 percent on the average), indicating a more efficient utilization of equipment on those routes. As a matter of fact, the vehicles employed on routes C, D, E and F are all distribution vans specially designed for short distance hauls in urban areas, but the route length

6.1 percent of total cost with a spread of from 5.4 percent (route F) to 6.5 percent (route C). A drop in interest rate from six to five percent, would reduce total distribution costs by 1,01 percent.

The operating economy of the trucks also influences the total costs of distribution. Table 15 gives the fuel consumption (as reported by the drivers) of these vehicles, when loaded to capacity. The fuel consumption, van E excepted, of those vehicles is approximately the same, with an average of 0.144 km./lit. of fuel, or 5.03 piastres per kilometer. The truck B, being of a larger capacity (1.5 tons) has a high fuel consumption per unit distance. Its ton-kilometer consumption however is least of all the six vehicles, being 4.0 piastres only.

Table 15

Fuel Economy of the Delivery Vans

	E	F	C	D	A	B
Capacity, kg.	200	750	750	750	1000	1500
Fuel consumption						
1. kms./20 lit.	250	150	140	140	150	120
2. Lit./kms.	0.057	0.133	0.143	0.143	0.133	0.167
Cost of fuel per km.x piasters	2.0	4.66	5.0	5.0	4.66	5.85

x One liter of gasoline costs 35 Lebanese piastres.

Another important factor influencing distribution cost is the type and size of the container. There are two major types of milk containers, the glass bottles and the fiber containers commonly referred to as cartons. Both types can have any of three standard sizes, quarter-, half-, and one-liter. The influence of these six possible permutations of types and sizes on the costs of distribution is almost exclusively a result of the relative weight of milk to container, the cartons being lighter in weight. The larger the container size, the smaller is the ratio of container weight to milk. Table 16 shows the relation of type and size of container to the weight of one crate of pasteurized milk.

The saving in weight due to cartons is 21.5 percent for liters, 25 percent for half liters and 20 percent for quarter liters, assuming that the same all-wire stacking crate is used for both cartons and glass bottles. The ratio of deadweight to total load carried in a milk truck can thus be reduced by an appreciable amount, reducing as a consequence the costs of milk distribution. Only 58.- percent of the weight of a liter-crate of glass bottled milk represents milk, while in a liter crate of cartons, 72.5 percent is milk and only 27.5 percent of the load is dead weight. The percent of dead weight carried in crates of glass and carton containers are shown in table 16.

Table 16

The Weight of One Crate of Pasteurized Milk for Various Types and Sizes of Containers.

Container Size	No. of Containers	Volume of Milk	Container Type X	
			Carton	Glass
1/4 liter	20	5 l.	9.5 kgs.	12.50 kgs.
1/2 liter	20	10 l.	15.- kgs.	20.30 kgs.
1 liter	12	12 l.	16.50 kgs.	21 kgs.

X All-wire crate weighs 3 kgs; bottles 1 liter = 500 grs., 1/2 liter = 365 grs., 1/4 liter = 225 grs.; cartons, 1 liter = 125 grs., 1/2 liter = 100 grs., 1/4 liter = 75 grs. Milk has a density of one.

Table 17 shows besides the saving in dead-weight that can be made by shifting from glass to cartons, that it is also possible to save on deadweight by using the larger sizes of containers. In the U.S., the trend is to use the half gallon glass and carton container, whenever acceptable to the consumer.(61) This is an instance of economies of scale due to the size of the container.

Another saving in distribution costs that could be

(61) Spencer, Leland, A Half-Century of Significant Developments in the Distribution and Pricing of Market Milk. Dept. of Agric. Econ., Cornell University Agric. Exp. Sta., Bull. 1039, Ithaca, New York, 1956. P. 7. Monroe, W.J., Multiquart Containers, U.S. Dept. of Agric., General Report 54, January 1959.

achieved by shifting from glass to cartons is due to elimination of the collection of empty glass bottles. A maximum of efficiency in the dairy business requires "that all vehicles return a full load of empties to the processing depôt rather than return unloaded".(62) Since it takes time to claim the empties, collect and arrange them in the truck, then to unload t them at the depôt or central plant, the shift to cartons would make this much more time available for actual distribution. No reliable estimate as to the magnitude of this potential saving in time is available, but on the basis of observation in the Hoss Dairy, the writer ventures to propose the figure of ten percent of the peak distribution time. At the Hoss Dairy, this saving would have been significant, especially as it

Table 17

Deadweight in Milk Crates X

	Glass	Cartons
1 liter	42.- percent	27.5 percent
1/2 liter	49.5 percent	33.3 percent
1/4 liter	60.- percent	47.5 percent

X Computed from table 16.

(62) Davis, J.G., A Dictionary of Dairying, 2nd ed. (revised), Leonard Hill Ltd., London 1955. P. 313.

occurs during the peak distribution period between 6:30 and 9:- a.m.(63)

C. <u>The Locational Significance of Distribution Costs</u>:

The Dairy Industry, together with most industries, deviates from the mainstream of classical economic theory, in that its operations are spread out in space, and that the costs of procurement of its raw materials, of the processing of milk and of its distribution, are functions of the location of the various components of the industry, namely, the supply of raw materials, and the centers of consumption for pasteurized milk.

This section proposes to note the possible significance of transportation costs in the distribution of pasteurized milk, to the location of the central processing plant, the distribution depôts and the zone of distribution of the milk products. The data on hand can only be useful in hinting at some of the problems involved, and thus, more shall be derived by the use of a combination of economic theory and the intimate knowledge of the writer concerning the dairy industry, than by reference to any figures that are available.

The costs of distribution include the costs of all the <u>operations involved in transferring the bottled milk from the</u>

(63) The only complete scientific appraisal of cartons as compared to bottles in milk packaging is the report commonly known as The Controlled Experiment: Park, C. W., (ed.), <u>Milk Packaging for Retail Distribution - Report of a Controlled Experiment</u>. The A.H. Pugh Printing Company, Cincinnati, 1956.

plant to the consumer and of trucking back the empty bottles to the plant. The weight carried by the vehicles per hundred liters of milk varies between 137 and 250 kilograms depending on the type and size of the milk packages.(64)

Raw milk from the farms usually comes in forty liter cans.(65) The hectoliter of milk in cans weighs an average of 112.5-137.5 kilograms, depending on the material from which the cans are made.

Table 18, showing the relative bulk of milk in various types and sizes of containers brings out an important fact about the localization of the dairy industry. Assuming the same cost of transporting a ton-kilometer of all forms of containers, it would seem that the pasteurization of milk is a "market-oriented" industry. Thus, if the industry were located at the sources of supply of milk, the aggregate costs of transferring the milk from the pasteurizing plants to the centers of consumption in Beirut would have been higher than if the plants were located nearer to Beirut, as they currently are, with the exception of the Hoss Dairy. This latter dairy, on account of the very large bulk transported from the pasteurizing plant in Sofar, is incurring presently the highest trans-

(64) Computed from table 16.

(65) 30 and 60 liter cans are also used in Lebanon, "Barmil", the Arabic word for can, is fast becoming equivalent to forty liters of milk, however - steel barrels weigh 15 and aluminium 5 kilograms approximately.

Table 18
Average Weight per hectoliter of Milk in Various Containers

Container Size	Container Type: Glass[x]	Container Type: Cartons	Cans[xx]: Aluminum	Cans[xx]: Steel
Quarter-liter	250 kgs	190 kgs	-	-
Half-liter	203 kgs	150 kgs	-	-
One-liter	175 kgs	137 kgs	-	-
Two-liters[=]	151 kgs	-	-	-
Forty-liters	-	-	112.5 kgs	137.5 kgs.

x Computed from table 16.

xx Based on the weight of one steel can of fifteen kilos, and five kilos for the aluminum can.

= Two liter glass assumed to weigh 650 grammes.

port costs in the industry, not to mention the increased breakage of empty bottles on the return trip.

The introduction of the two-liter bottle and of carton packages has reduced the advantages of a location nearer the market, due to the reduced bulkiness of any given load of milk. Aluminum cans, with a gross weight of 112.5 kgs. per can of milk restored the advantage of location to the city rather than the supply area.

It was pointed out in chapter I, that the production of Samneh, butter, cheese and labne used to be centered in the more distant locations, such as the Beka'. The considerations of relative transport cost of raw milk and of those much more concentrated products, must explain the localization of these manufactures in the dairy farming regions. The lower prices of milk in Zahle and Shtaura, are a further reason for (and result of) this "specialization" of the farther regions in the bulk reducing processes.(66)

It is noted however, that the late comers in the dairy industry of Beirut are not located in the center of their zones of distribution but rather in the suburbs of Beirut. Dumit Bros. & Co., and Milko being the oldest, are located in the new residential areas (Hamra street and Jummeizeh respectively),

(66) Hoover, E.M., The Location of Economic Activity, McGraw Hill Book Company, Inc., New York, 1948, Ch. 3. passim.

while Bambi, Dairy House, and the National Dairy Company S.A.L., are all located outside of town. The reason for this being that the relative transportation costs of procurement and distribution are not the only determinants of industrial location. High rents, land prices, municipal charges, congestion of traffic in town and zoning regulations in the municipal area of Beirut are so many arguments for an out-of-town location. In fact when Dumit Bros. & Co., was started, Ras Beirut was considered a suburban area.

Milk pasteurizing plants operate their distribution routes in either of two ways. The routes can be based on the main plant, in which case larger vans are required, or they can operate a series of distribution depôts in the various areas of Beirut. In the latter case a number of scooter vans such as that described for Route E in tables 8-15, would be required. The former method is typified by Routes A and B, while Routes C and D represent the latter method.(67)

In a general way, the fact that a dairy is operating a depôt in a residential area, would seem to give that dairy a considerable competitive advantage, due to the increased convenience of customers, both stores and households in making their daily purchases of milk. In addition, the depôt could be used as a tool in advertizing the brand name of the dairy.(68)

(67) Route codes refer to the routes described in section B.

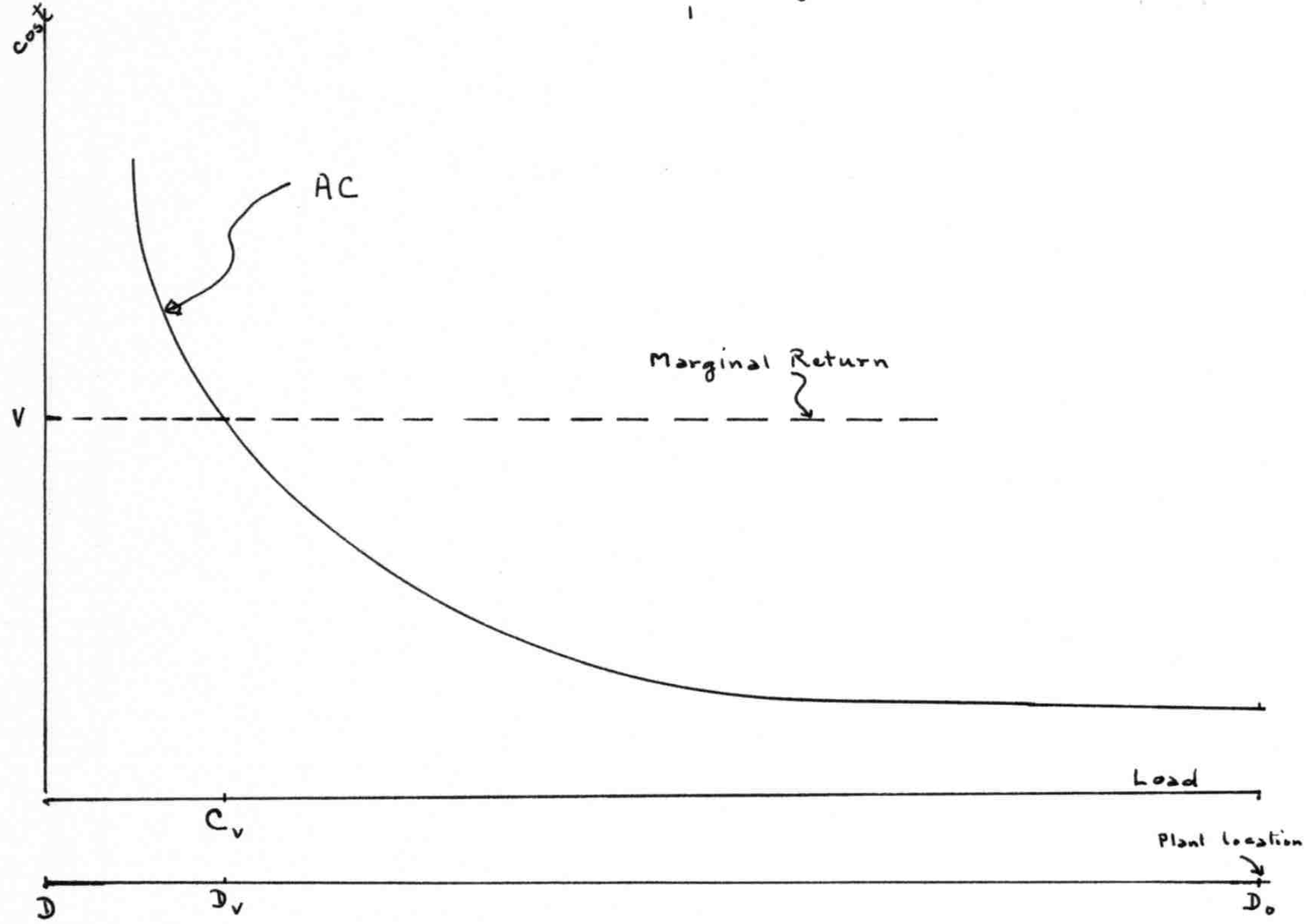
(68) This and the following paragraphs is a recasting of notes made by the writer in the spring of 1958, as part of a study of the feasibility of establishing distribution depôts for the Hoss Dairy.

load. The radius of operations of the particular vehicle employed on a route, and consequently the length of the route, would depend on the load capacity of the vehicle and the intensity of sales in the area. In turn the net capacity of a truck is a function of container size and type. Thus fiber packages and/or the larger sized containers tend to lengthen the routes. The same effect is to be expected from retail sales as compared with delivery to stores and hotels.

An important aspect of distribution costs arises in connection with the cost actually incurred by a given milk container. As the vehicle proceeds along its route, the cost of distribution per kilometer of distance varies only slightly, while at every stop, the number of packages remaining is a little less than before. The average cost of transporting the next bottle is consequently an increasing function of distance. After a certain point, the average addition to total cost due to the distribution of one extra package equals or exceeds the revenue to the dairy from the sale of that extra unit. At that point, it is not profitable to extend the route any longer.

The situation may be diagrammatically shown by figure (4), where AC is the average cost of distributing a liter-kilometer of milk, V is the marginal revenue, and Cv is the critical number of packages at which the truck should start going towards its base. The number of packages in the truck is a function of the instantaneous distance of the vehicle from

Fig. 4



its base, and for this reason, the figure could be redrawn to show the cost of distribution per liter-kilometer as a function of distance traveled. The addition of axis DD^1 however, achieves this purpose.

On a radial route, the truck would therefore travel the distance D^1D_v away from the plant, and then, loaded with empty bottles make the return trip back to the plant. The distance actually covered on such a route is $2.D^1D_v$, of which only 50 percent represented an inescapable task - the trip away from the plant. The other half must be allocated to the cost of returning the empty bottles, a non-productive activity.

With a circular distribution route, the allocation of cost to the returning of the empty bottles need not arise at all.

The van starting with a full load from the plant, would travel away from the plant for a distance shorter than D^1C_v and then returns by another route to its base. Its remaining load is distributed on this new route. As the van proceeds, there is an increased proportion of empty bottles in the van. But transportation costs start being allocated to those empties only after distribution is finished, i.e., at D_v for a radial route, so that on a circular route no cost is allocated to empties.

Circular routes in the congested areas are best operated with the smaller vehicles, such as scooter-vans whose operating expenses are low. The capacity of such vans however, is small and for this reason a distribution depôt on which to base the network of circular routes becomes necessary. The Bambi Depôt in Hamra Street is now used as a base for three bicycle and two motor van routes.

It is an observed fact that dairy routes deviate from the model expounded above, the reason being the large excess capacity at the central plants. It would therefore appear, that the dairy plants in Beirut are using the technique of dumping their distributive services on the market, by extending their routes a distance longer than expected from the model above, and consequently accepting a loss on the additional route length in order to expand sales and thus reduce the average costs of processing.

While this practice is justified, the establishment of distribution depôts in the areas not tapped before, has a cumulative effect on sales, and would achieve the purpose of decreasing the costs of processing to a larger extent than the dumping of distributive services. The depôt or store is an advertising medium to the brand, seen by all the passers-by because it is always there, while the truck that passes only once daily cannot enjoy this advantage. Moreover, the choice of a store-man from the "target area" to run the depôt would have an undoubted effect on sales.

The yearly costs of operating a depôt as reported by a successful dairy are:

Wages and Salaries	4800 L.L.
General expenses	1100 L.L.
Rent	2700 L.L.
	8600 L.L. annually

The volume of sales from this depôt was reported as 288,000 liters per year, an average of around three piastres per liter. In less expensive areas rent and salaries would be less. These costs should be partly allocated to advertizing expenses.

The area immediately surrounding a distribution depôt, usually patronizes that store to the exclusion of all competitors. This almost guaranteed sales volume especially in an area of large apartment houses and could by itself justify the establishment of a distribution depôt.

D. Conclusions:

The costs of milk distribution in Beirut vary greatly from one dairy to another. This variation is due to greater efficiency of operation, greater sales, and/or more wholesale customers on a route.

The effect of such factors as container types and sizes, market depth, length of route and location were investigated.

A representative dairyman in Beirut operates one or two routes, and distributes four hundred liters per route at a cost of five piastres per liter delivered.

The Dairy industry, has a bulk reducing component i.e., cheese, butter etc.... that is material oriented and a main component, i.e., the fluid processes of pasteurization,and laban and chocolate making that is market oriented.

It would seem, on the basis of theory alone, unsubstantiated by quantitative data, that dairy companies may improve their sales by extending their use of distributive depôts, because of the advertizing value of such stores.

Chapter IV

Some Aspects of Cost Functions

In cahpter 2, the cost structure of the pasteurized milk industry was investigated. The cost curves obtained do not exhibit the shape expected from economic theory. In particular, the short-run cost curve does not have the traditional U-shape. It is the purpose of this chapter to point out the general application in numerous industries of the L shaped hyperbola of the cost curve found in the Beirut milk plants, and to attempt to explain this empirical shape in the light of production function analysis.

Examples will be drawn from studies undertaken in other industries and that have been accepted as irreproachably correct from a methodological point of view. In particular, the studies of Joel Dean enjoy this general acceptability and at the same time exhibit the mathematical properties of the cost curves found in chapter 2. While the approach may be a theoretical digression, it is thought that the subject of statistical cost functions is important, as well as relevent enough to warrant such a digression.

A. Production and Cost Functions:

"Production from the point of view of the firm, is a form of internal exchange, whereby certain assets such as raw materials and money are transformed into finished goods...

The production or physical cost function, describing what kinds and quantities of assets must be sacrificed in order to produce various quantities of product is, of course, a many-dimensional affair... However, these relationships can be summed up in a total cost curve".(69)

If we denote by q the quantity of output derived from combining inputs $x_1, x_2, \ldots, x_n$, then the expression

$$q = f(x_1, x_2, \ldots, x_n)$$

is a production fucntion.(70) Some of the x's may represent fixed factors, in the sense that the production function states the output due to the application of one or more variable inputs on a set of fixed inputs or plant. The variable inputs may be combined in one or more ratios, and every such combination is known as a process of production. Processes can be used in various amounts in conjuction with the fixed plant to produce outputs that vary <u>pari passu</u> with the variable inputs. The law of variable proportions only expresses the fact that there is more than one process for the production of a given output. Marginal analysis assume an infinity of processes, the assumption being implied in the continuity of the production function. Thus, when iso-product curves convex to the origin

(69) Boulding, K., <u>A Reconstruction in Economics</u>, P. 95, John Wiley and Sons, Inc., New York. 1950.

(70) Carlson, Sune, <u>A Study of the Pure Theory of Production</u>, The University of Chicago Libraries, Chicago, Pp. 14-15.

are drawn, as in figure 5-A the continuity of the curves I and II implies an infinite number of possible combinations of the inputs x_1 and x_2. The ratio of x_2 to x_1, represents the slope of a line such as P_1 (figure 5-A) known as a process line, and since there is an infinity of points such as A on curve I, and B on curve II, the number of such process lines is infinite, and the production problem reduces to a choice of a level of output and of a combination of inputs. In agriculture, the application of different amounts of fertilizers and water gives rise to continuous production functions, and therefore, to an infinite number of processes, in the sense that there is an infinite number of ways in which the three basic fertilizer elements and water can be combined or "dosed" and still yield the same given output.

There are cases, however, and they are becoming numerous with the development of mechanized industry[(71)] in which management is not free to vary the combination of inputs: The marginal rate of substitution between inputs does not exist under those conditions. Such inputs as hours of use of pasteurizing equipment and bottling machine can be combined only in fixed proportions to each other depending solely on the hourly capacity of these two machines. The fact that milk can be bottled in quarter-,half- and liter bottles and that the rate of production of the bottling unit is slightly different for every bottle size,

(71) Veblen, Th., The Theory of the Business Enterprise. Mentor Books, New York, 1958. Pp. 9-16.

Figure 5. A

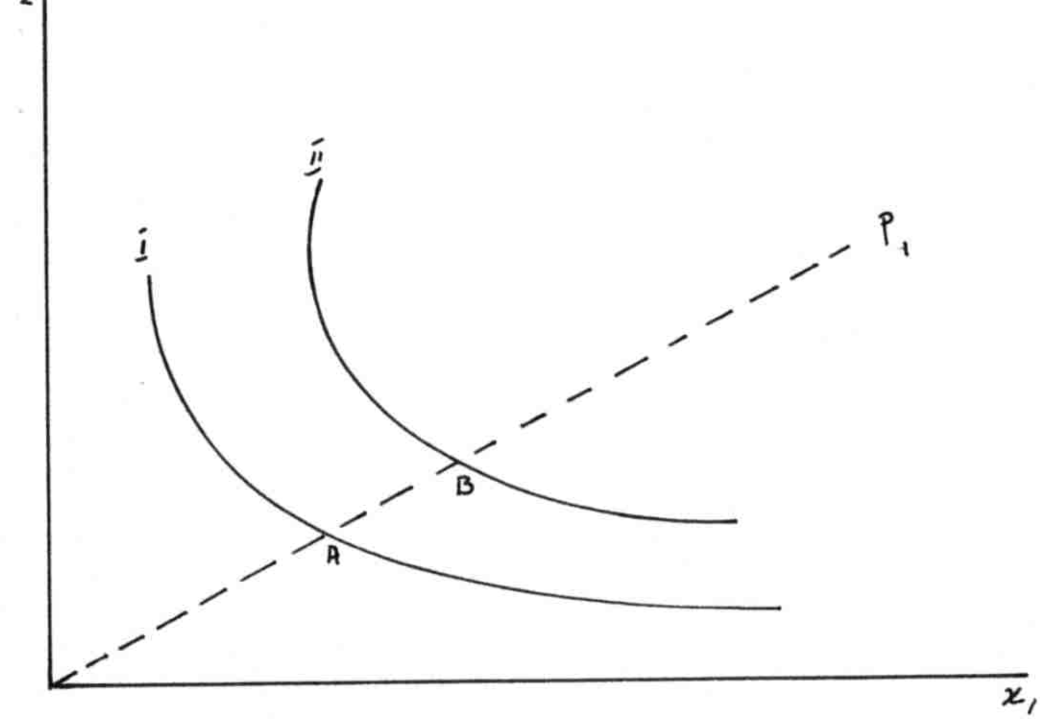
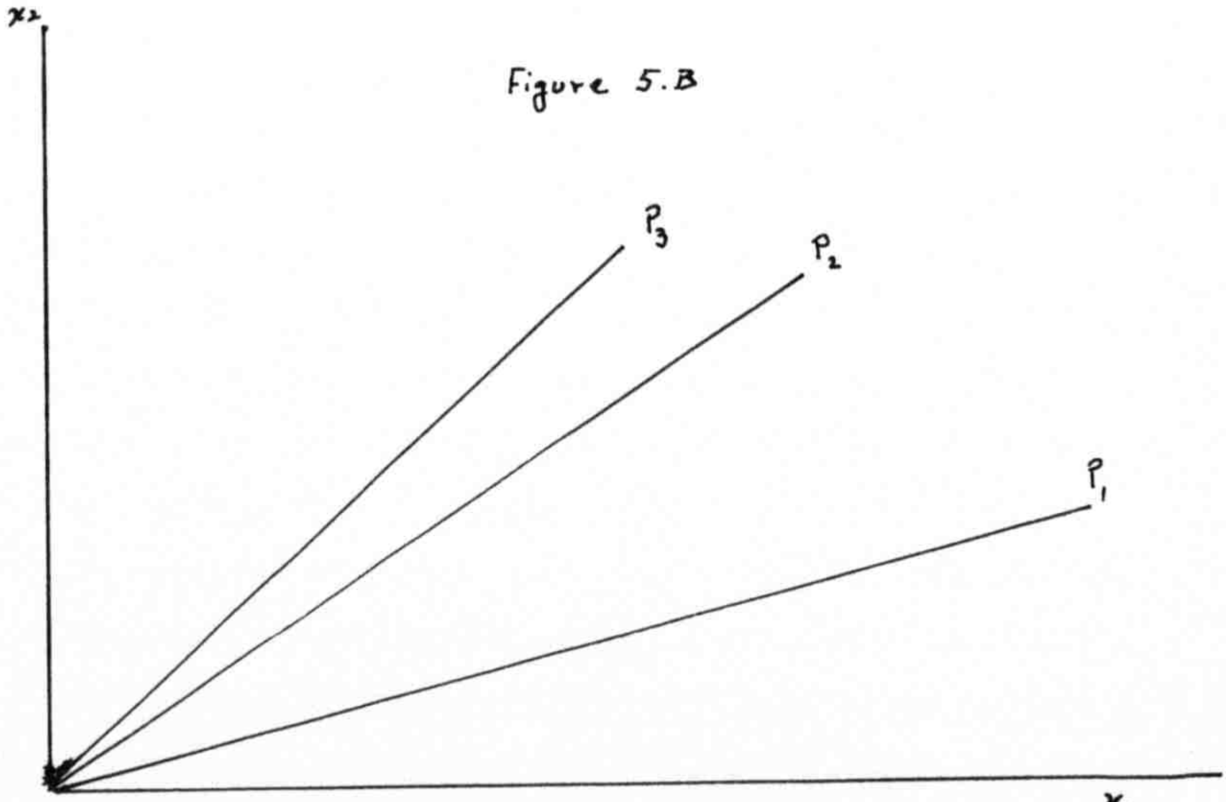


Figure 5.B



results in three capacities of the bottling unit, and therefore in three processes of production representing all the possible combinations of bottling and pasteurizing equipment time. This situation is represented in figure 5-B. The lines P_1, P_2, P_3, represent the combinations of pasteurizer with bottling machine time for quarter-, half- and one-liter bottles.

The production function is then the set of plane curves whose orthogonal projections on the plane X_1 X_2 are P_1, P_2 and P_3. The characteristic feature of this case being a finite number of processes, as contrasted with the infinite combination ratios assumed in the continuous production function.

The laws of return apply in both continuous and discontinuous production functions. Once a process has been chosen, the "basket of inputs" can be considered as one since its various components bear a fixed proportion to one another. After a certain point, diminishing marginal productivity due to the application of additional levels of the process set in. The curve representing output as a function of activity or process level lies on a plane perpendicular to the plane of the figure, along the process or activity line, and is similar to the production function with one input.

Alternatively, production can be studied with reference to costs, rather than physical inputs. At given input prices, the combination of inputs resulting in a minimum cost for a given output, or a maximum output for a given outlay, can be computed. A production function in two inputs x_1 and x_2 and one output q, may be written

$$q = f(x_1, x_2)$$

Let P_1 be the price of x_1, and P_2 the price of x_2, and let C_t represent the expression $P_1x_1 + P_2x_2 = C_t$ or the total cost of acquiring inputs x_1 and x_2. Then,

$$q = f(x_1, x_2) = g(P_1x_1 + P_2x_2) = g(C_t)$$

The inverse function expressing total cost C_t as a function of output q can be written symbolically (72)

$$C_t = c(q) + F$$

where F is the cost of the fixed input to which x_1 and x_2 were applied.

It must be noted that P_1 and P_2 may be fixed factor prices or may be functions of x_1 and x_2 respectively, where the factor markets are not perfectly competitive. Average and marginal costs can be readily derived from the total cost equation. Their respective expressions are symbolically

$$C_a = \frac{C_t}{q} = \frac{c(q) + F}{q}$$

for average cost, and

(72), Samuelson, Paul, Foundations of Economic Analysis, Harvard University Press, Cambridge, 1948. Pp. 57-89.

$$\frac{dC_t}{dq} = C'(q) \text{ for marginal cost.}$$

Two aspects of production and cost function analysis call for comment. It is assumed, in the case of a continuous production function that a given output q can be obtained from the utilization of any one of an infinity of possible input combinations. The statement is represented by an iso-product curve for output q. To this iso-product curve, there corresponds a cost function such that the total cost of producing output q depends upon the ratio in which the variable inputs are combined, and alternatively on the choice of a process of production, it being understood that an enterpreneur would try to minimize the cost of producing any given output. The mathematical expression of this problem enunciated by Samuelson in 1948 in the guise of a constrained minimum,[73] reconciles the activity analysis approach to the continuous production function analysis and at the same time provides the framework of a development of production theory along the traditional marginalist lines. The problem is seen as one of minimizing the total cost function, subject to the constraint imposed by the iso-product curve. The optimal solution to the production problem so stated, is the point at which " the marginal productivity of the last pound is equal in every use",or alternatively,"that the physical productivity of any factor must be proportional to the price at

(73) Samuelson, P., op. cit. P. 60.

which it can be hired, the factor of proportionality being ... equal to marginal cost."(74)

The above formulation, assumes that in order to define a cost function, a set of least cost combinations for given outputs has been determined, and the function is therefore a list of minimum costs of producing various levels of output. Thus a cost function "cannot even be written down until a programming problem has been solved".(75)

The second aspect of production and cost function analysis is concerned with the choice of a production function and the use made of a process once chosen. The writing down of a production function assumes that some experimentation has taken place, using various combinations of the variable inputs and various amounts of every combination, and applying these to the fixed factor. "The same combination of productive services gives varied amounts of output, depending on how efficiently the productive services are organized".(76) In order to obtain the maximum obtainable output from any "combination of productive services", given current technology, a problem of choice arises, as between various ways of organizing the productive services or variable inputs, so as to obtain the maximum output or the upper bound to the production

(74) Samuelson, P., _op_. _cit_. P. 61

(75) Dorfman, R., Samuelson P., and Solow, R.M., _Linear Programming and Economic Analysis_. ARAND Croporation research study. McGraw Hill Book Company Inc., New York, 1958 P. 202.

(76) _Ibid_., P. 15

function. In Carlson's words[77] "the purely technical maximization problem may be said to be solved by the very definition of our production function," in such a way that "the use of production functions presumes that a large proportion of the problem of allocation has been solved before analysis begins ... we see thus that the production function as conventionally defined summarizes the solutions to the underlying programming problems for various values of the variable factors. The numerous restraints and the inequality signs that clutter up a programming problem, are absent from the conventional formulations, not because they are inapplicable but because it is assumed that they have already been handled".[78]

Assuming that those programming problems have been solved, and a production surface determined, then the relevance of this surface to an industrialist should be examined, especially in an ever more mechanized mode of production.

It is maintained that in manufacturing industry the production surface for any particular product is relevant only to those firms that produce the machines destined to manufacture that product. This is so because the capital goods firm is the only one of the chain of producers in the roundabout production methods characteristic of the use of machines in industry, that is free to "vary the combination of inputs." It takes the

(77) Carlson, S., *op. cit.* Pp. 14-15.

(78) Dorfman, Samuelson and Solow, *op. cit.* Pp.202-203.

initial decisions concerning the processes that it considers "desirable" in the production of goods nearer to the consumer, in the chain of production, than its own goods. It then chooses from this finite number of processes, a finite number of "sizes" or outputs. The resulting ratios and amounts of the inputs are embodied in machines, and the attendant specifications and instruction sheets.

In this way, an entrepreneur contemplating the purchase of a piece of equipment is faced with a "skeleton" production function, reduced to only a finite number of disconnected points, each point representing one size and process of a line of machines available for sale.

The purchase of one from among those few pieces of equipment removes from the production function, what little remains in it that is of any normative significance for that particular firm. All the factors of production become fixed, their amounts, ratios and organization being described in the "Specifications and Data" sheet.

The above is graphically shown in figure (6), where the intersection of the production surface with a process plane determines a space curve. This curve is cut by an output (horizontal) plane whose height above the origin measures the size or capacity of the machine. Point S, and its projection on the iso-product map, represent the selection of one choice from the permutation of processes and sizes of equipment embodied in capital goods, and is therefore "fixed" in terms of all inputs and of output . The fixity of output is a direct result of the definition of a production function, as a set of maximum outputs corresponding to particular input combinations.

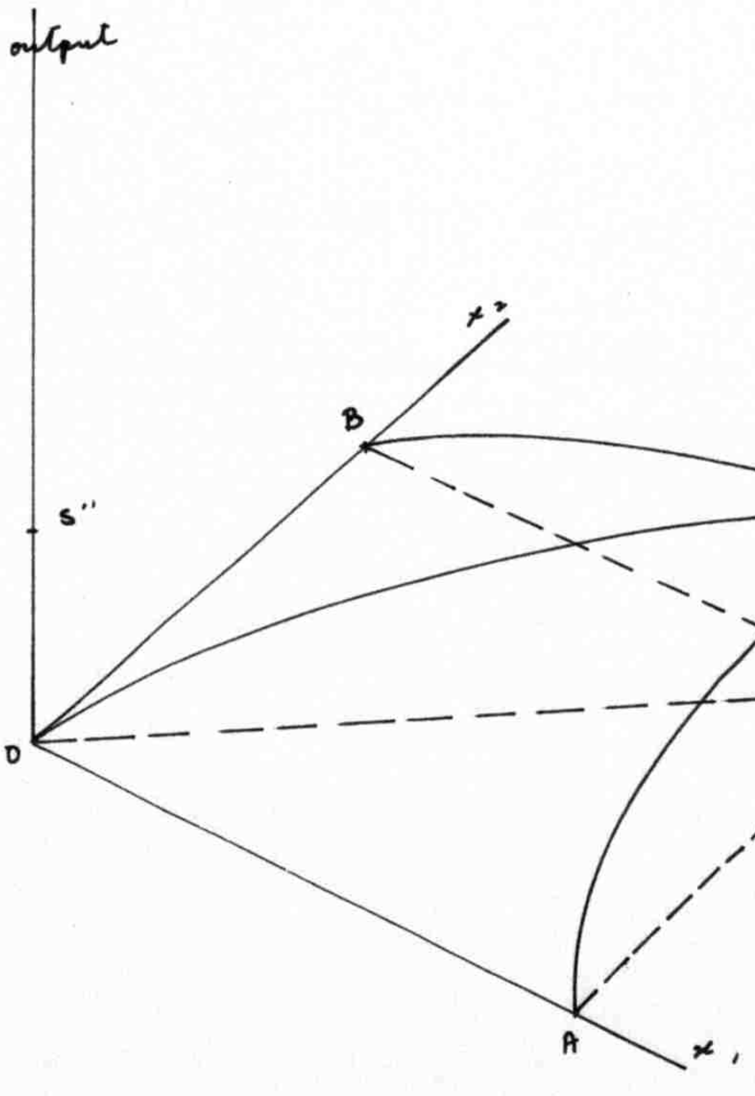
Point S, being a point on the production function, must be taken as an upper limit to the output obtainable from combination S', and therefore a smaller output could be obtained if, and only if a certain level of under-employment of capacity is tolerated. This possibility entails higher unit costs of production.

With this conception of a production function, the average cost curves of individual pieces of equipment can be only continuously declining with increased utilization of capacity and up to the limit of technical capacity S. Beyond this limit- i.e., the production surface - output cannot increase. Thus, part of the production cost is incurred as a penalty for not producing at point S (the production surface), but rather somewhere on SS', below S, the maximum attainable output for the combination $\bar{x}_1$, $\bar{x}_2$. This conclusion is also derivable from the identity of the horizontal coordinate of the average cost-output curve, in cost curve analysis, and the segment SS', where S' represents zero output and S is the capacity of the plant.

The findings of the present study, as well as those of Joel Dean, Yentema and others (79) are explained by the above hypothesis since the investigators mentioned report average cost curves in the shape of a hyperbola signifying that as the fixed costs are spread on a larger output, unit costs of production

(79) cf. infra. section B.

Figure 6



are correspondingly decreased; that the fixed elements of costs are more important that variations in the variable costs, and that those latter ar nearly constant and identifiable with the asymptote to the average cost hyperbola that it raises by its own value. Thus the expression for the average cost would have the form

$$C_a = \frac{F}{q} + B$$

x where C_a = average cost; F = fixed cost; B = marginal cost or $\frac{dC}{dq}$ and q = output.

Figure 7 shows this relation in a graphical way. The vertical cost line at S refers to the infinite rate of increase of cost at that point, and that, therefore, production cannot take place beyond capacity. This is a definitional proposition.

The question as to the mechanism by which average cost curves could approximate the theoretical U shape, is easily explained. The cost curve of Fig. 8, represents the costs of operating a given fixed plant according to a fixed input combination or process for a period of time fixed by law or custom, but usually eight hours a day. Should more than one process be embodied in equipment owned by the firm, it is only rational to employ this equipment in the order of increasing unit cost. As one machine reaches capacity output, an additional machine having a higher unit cost is employed, resulting in another constant marginal cost higher than the previous one. The extra equipment may have been old, absolete, or standby equipment of

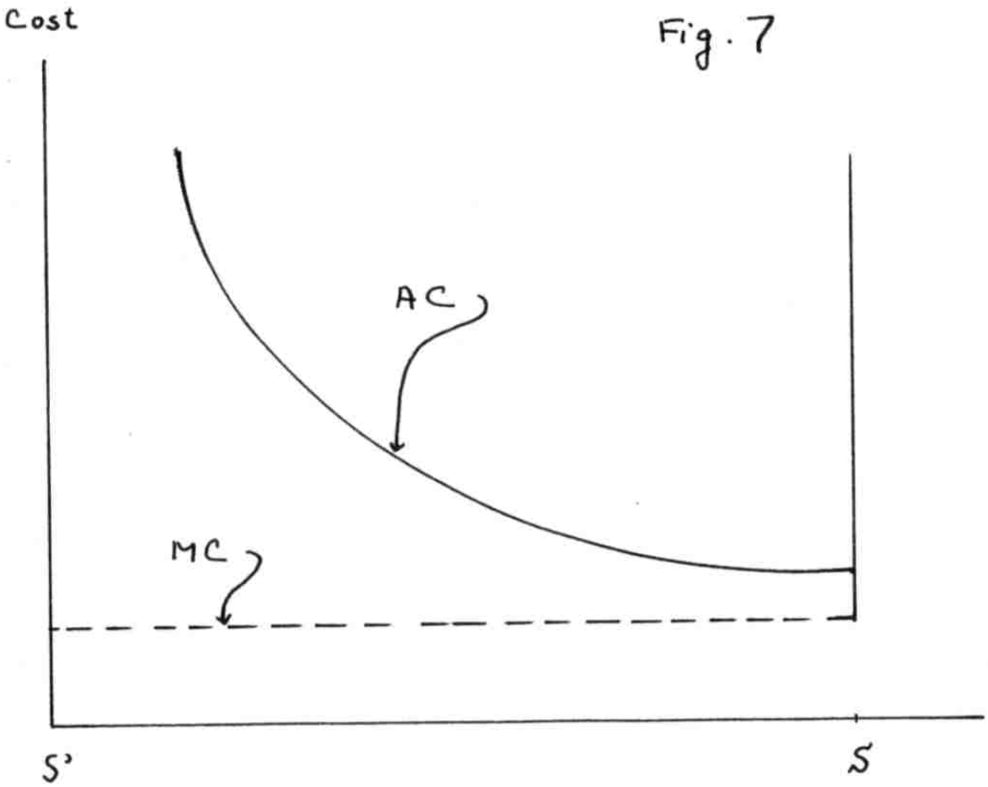
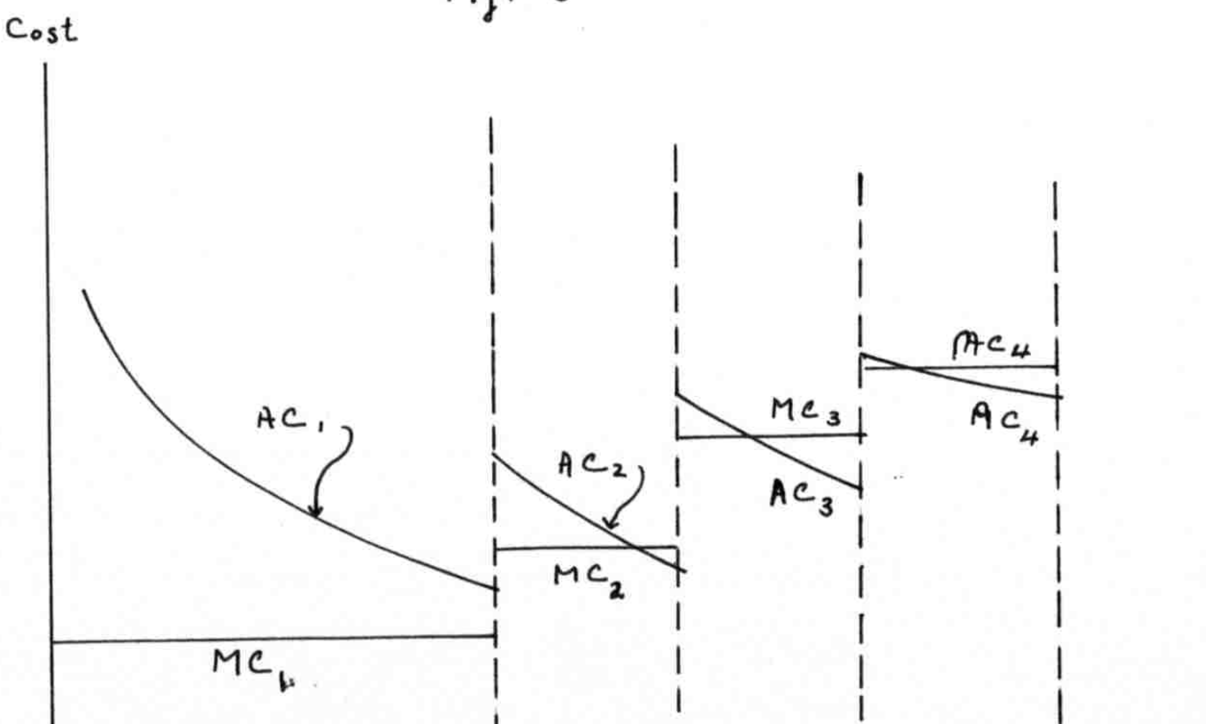


Fig. 7

Fig. 8



smaller capacity. It is assumed that these machines have been included in the fixed costs so that no additional expenses results from employing them. Figure 8 shows the case of four pieces of equipment, embodying different processes but capable of producing the same product, used in an order of increasing average cost.(80) It is clear that while increasing cost is possible in a firm, it is not possible where individual machine costs are concerned. This result seems to conferm to actual conditions rather closely, and even though it may be "conceptually unwieldy", its operational and normative significance should not be denied. It is not realistic in the case of processes embodied in a machine to assume a continuous function for the marginal cost of the firm since marginal cost is a horizontal line for any machine, and at different levels from that of other machines.

Some firms exhibit the U-shaped average cost curves in neither the smooth nor the step function form. The milk plants described in this study, synthetic or realistic, exhibit the cost curve characteristics of a single process. This must be ascribed to the fact that the particular firmsare organized to operate with equipment homogeneous with respect to their cost functions, and that standby equipment is either not available because the firm does not expect to operate at or beyond the installed capacity, or that the standby machines embody the same process

(80) Adapted from Dorfman, Samuelson and Solow, op.cit, P. 140.

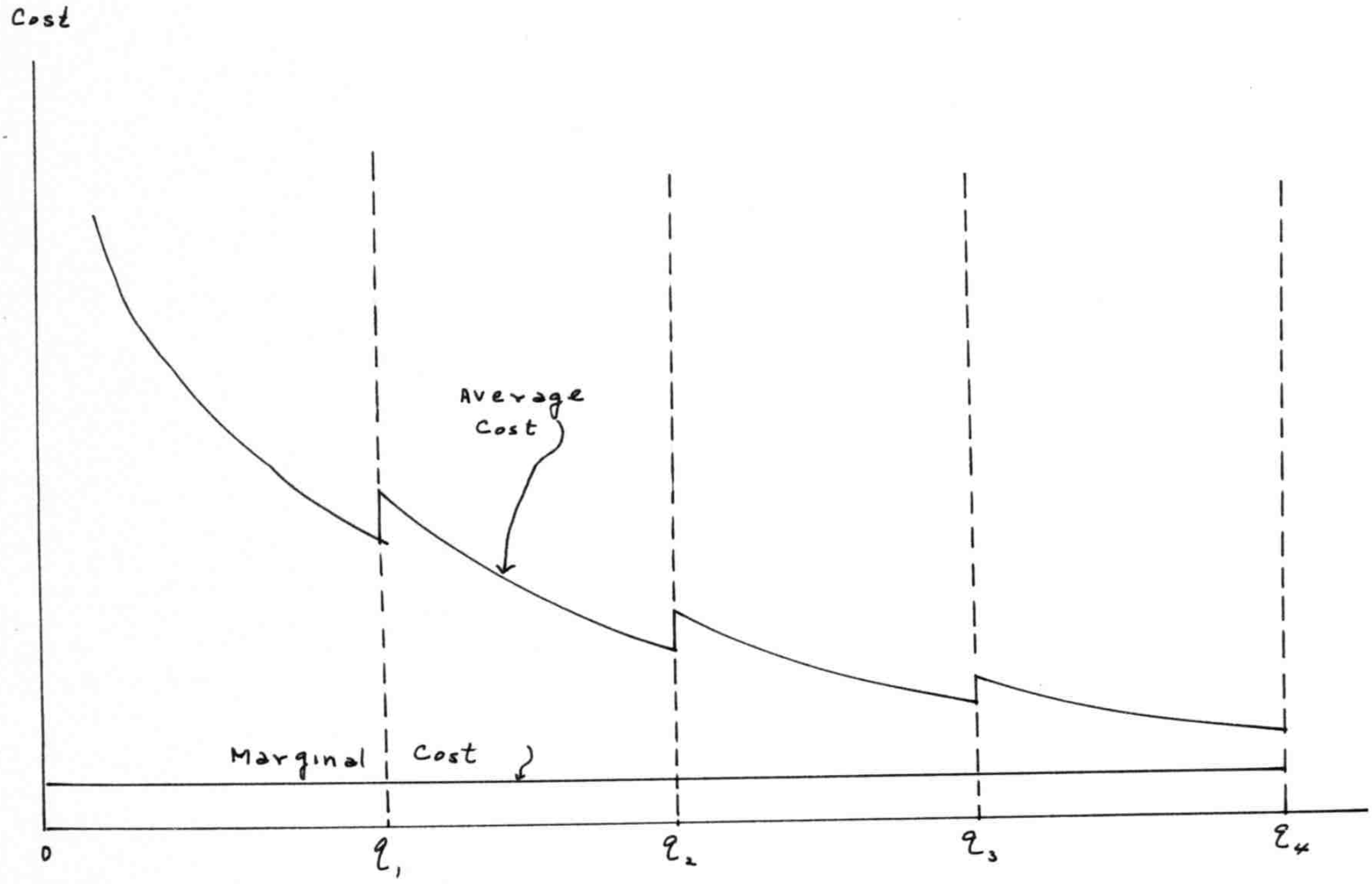
and have the same rated capacity as the original plant. In this second case[81] the average cost of the firm would be as in fig. 9-(a), and the total cost as in fig. 9-(B) representing the cost structure of a firm engaged in the pasteurization of milk by the batch process. One batch pasteurizer is fully utilized at output q_1, so that pasteurizer II is employed until output q_2 is reached. Outputs q_3 and q_4, as well as regions III and IV in the figure, should be similarly interpreted, keeping in mind the equivalence of the four pieces of equipment in size and specifications. The corollary to this is shown in fig. 5(B) in the identical marginal costs of all four pasteurizers, marginal costs being obviously represented by the identical slope of the sections I through IV of the total cost curve. These sections are consequently parallel. The jump in cost whenever an additional unit is employed is due to the increased labour requirements that go with the utilization of the equipment.

B. <u>Cost Functions in Micro-economic Theory - A Study in Relevance -:</u>

It was pointed out earlier in this chapter, that the average cost curve has the form of a rectangular hyperbola, where output q, the independent variable, is allowed to vary from zero (S^1) to technical capacity (S). The average cost

(81) Henry et al., Efficiency of Milk Marketing in Connecticut, Economies of Scale in Specialized Pasteurizing and Bottling Plants. Storrs Agric. Exp. Sta. Bull. 259. Connecticut, 1948. P. 140.

Figure 9-A



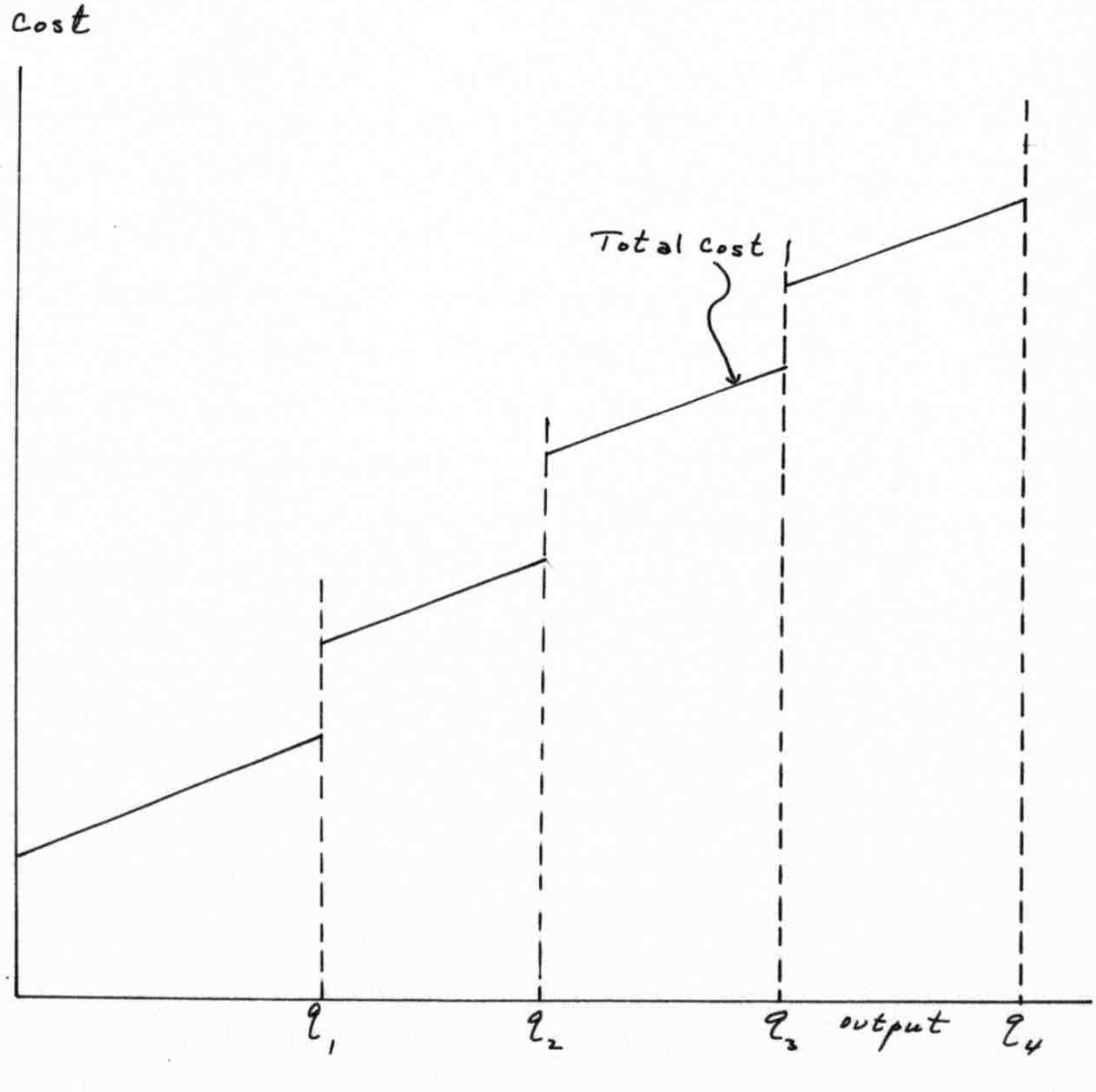


Figure 9 - B

curves of micro-economics theory however, exhibit a certain minimum cost point at an output $\bar{q}$, and higher costs as output deviates from $\bar{q}$ in either direction. This minimum cost output is referred to as the economic capacity of the plant.

Most empirical measurements of cost functions in mechanized industry seem to contradict the theoretical curves, at least to the extent of not showing a minimum cost output. This section will attempt to provide a theoretical framework to explain this discrepancy between the theoretical and the empirical functions. The relevance of the theoretical functions to some groups of industries and the normative usefulness of these functions will then be examined.

A production function, it has been shown above, is not a unique predetermined function of input quantities and ratios, but is rather one of a large number of possibilities. A given permutation of inputs may yield a large number of possible outputs depending on the method by which the inputs are organized. The maximum value of these outputs is a point on the production surface. A point on the production function, such as S in fig. 6 may be looked upon as the technical productive capacity of the machine embodying the process C_1S' and whose size OS'', is a function of the amounts of the inputs represented by the coordinates of point S'. Machine processes are the physical expressions of such points as S. The rate of capacity utilization in a factory employing a machine process is a measure of the position of the plant along the line segment SS^1. As explained above, the average cost curve showing the relation of unit cost to output is a hyperbola, since all costs other than raw materials and fuel are fixed. Marginal cost is a constant because raw materials bear a linear relation to output. This is in line with results obtained by a number of econometricians and other researchers into the cost structure of industry.

"Statistical demand, cost and other functions might enable us to check the validity of abstract theoretical predictions (so far as these have objective content), and if theory is verified, to make objective and quantitative predictions of behaviour"(82). As it turns out, theory is not verified, if by theory the U-shaped average cost curves are meant. But economic theory was not refuted by the empirical cost functions either, as it is shown below.

The most important statistical cost studies were performed(83) by Wilhelm Von Noerdling (1886), Ehrke and Schneider(1933),

(82) Bain, J.S., Price and Production Policies, Pp. 129-173 of A Survey of Contemporary Economics, Ellis, H.S., (editor), The American Economic Association, The Blackiston Company - Toronto. 1949. P. 138.

(83) Cited by Staeble Hans, The Measurement of Statistical Cost Functions: An Appraisal of Some Recent Contributions, The American Economic Review, vol. XXXII (1942) Pp. 321-333, Reprinted by the American Economic Association in "Readings in Price Theory" Allen and Unwin 1956.

Yntema T.O. (1940), Ezekiel, M. and Wylie, K.H. (1940) and Joel Dean's various studies starting in 1936 - Yntema's and Dean's results are now to be discussed.

Joel Dean studied the relation of cost to output in a leather belt shop, and a hosiery mill.(84) The Hosiery mill study was based on monthly data of cost and output extending over a period of five years (1935-1939), and the curve was fitted by the method of least squares to give

$$C_t = 2935.59 + 1.998\ q$$

where C_t = total cost and q = output in dozens.

"The statistical distribution of cost observations was examined by graphic multiple regression analysis .... Here the linear relationship of first differences ... combined with the lack of any evidence of rising per unit cost at extreme output.... substantiated the hypothesis that the relationship of total cost was linear ... It is enough to note that for practical purposes straight line cost functions apparently have more usefulness than theory would lead us to believe."(85) The leather belt shop study gave essentially the same linear relation of total cost to output.

(84) Dean J., The Relation of Cost to Output for a Leather Belt Shop, Technical Paper 2, National Bureau of Economic Research, New York 1941.
___, Statistical Cost Functions of Hosiery Mill, Studies in Business Administration, School of Business, University of Chicago, vol. 11 No. 4, Chicago 1941

(85) Dean, Joel, Managerial Economics, P. 291-292 Prentice-Hall, Inc., New York 1951.

T.O. Yntema (1940) studied the relation of the total costs of production to output in the United States Steel Corporation.[86] The data used is the yearly figures of cost and output for the period 1927-38 to which a straight line was fitted by least squares, and the line

$$C_t = 182.1 + 55.734\ q$$

(where C_t = Cost in mu. dollars and q = output in mu. tons), was found to show a better fit than any other curve.

The marginal costs in the Dean and Yntema equations are 1.998 dollars per additional dozen and 55.734 dollars per additional ton of output. These marginal costs are constant, in line with the general belief of most business-men, at least over the range of outputs within their experience. But then, this is the range relevant to price policy.

The "one striking finding" ... of these studies, namely the constancy of marginal costs was dismissed by Bain[87] as "hardly revolutionary in its implications" not for any inherent weakness but because "the bulk of the firms in question operate in concentrated industries where the tendency to extend output is fully checked either by the decline of price with increasing output or by increasing marginal selling costs as more is sold at given prices".[88]

(86) Yntema, T.O., "Steel Prices, Volume and Costs", in United States Steel Corporation, T.N.E.C. Papers, vol.1, New York 1940.

(87) Bain, Joe, op.cit. in "Survey of Contemporary Economics" Pp.140-141.

(88) Loc. cit. P. 141

Tintner "finds it very interesting that the investigations of Dean do not seem to verify the a priori notion of the economists about short-run costs"(89) and advances three hypotheses to explain the apparent contradiction:(90)

(1) The range of data was not great enough to cover the sections of the cost curve where increasing marginal costs appear, and thus what was measured by Dean and Yutema would be the values around the bottom of the average cost curve.

(2) "The assumptions of the economists are wrong, and we have actually in the economy constant marginal cost, at least over the relevant section of the cost curve .... there are no discernible economies or diseconomies of large scale production".(91)

(3) The linearity of total cost is due to the dynamism of the market as contrasted with the static nature of the theoretical cost curves. The concepts of adaptability and flexibility developed by Stigler(92) are invoked as a partial explanation.

But before discussing Tintner's hypotheses, it is proposed to look into the nature of the empirical cost functions and try to determine in the light of the model of section A, whether

(89) Tintner, Gerhard, Econometrics. P. 48, John Wiley and Sons, Inc., 1952.

(90) Tintner - op.cit. P.50

(91) Loc. cit.

(92) Stigler, G. "Production and Distribution in the Short Run" Journal of Political Economy, vol. 47 (1939) M. 308 ff., Reprinted in A.E.A.'s Readings in the Theory of Income Distribution" Allen and Unwin 1950.

the theoretical cost functions and the functions developed by Dean and Yutema propose to refer to the same phenomena. It is the position of the writer that if the empirical cost functions were based on different premises from those of the cost functions of micro economic theory, then the comparability of the two sets of curves should be first studied.

The cost curves of economic theory are based on the law of diminishing returns, and on the production function of which the former principle is but one aspect. The latter is taken as the maximum output obtainable from any given combination of factors. Any point below the production surface represents a contradiction to rational behaviour.(93)

The law of diminishing returns states a mathematical property of the production surface. The convex nature of this surface with respect to the origin, is mathematically expressed by a negative second partial derivative, or a diminishing first partial derivative. Historically, this law was derived from agricultural research, that seeks the relation between the

(93) Viner, J., "Cost Curves and Supply Curves", Zeitschreft fuer Nationaloekonomie, vol.III (1931) Pp. 23-46, Reprinted in American Economic Association's Readings in Price Theory Pp. 198-232.
Cassel, J.M., "On the Law of Variable Proportions", Explorations in Economics, 1936, Pp. 223-236, Reprinted in AEA's Readings in the Theory of Income Distribution, Pp. 103-118, Allen & Unwin 1950, London.

output of some crop and the intensity of fertilizer and water applications. Given the ratio of fertilizer to water, i.e. the process of production, and the intensity of irrigation and fertilization, then the maximum possible output will determine a point on the production surface. The set of such maxima constitutes the production function.

As the proportion of variable to fixed factors is increased, diminishing returns set in. "Decreasing returns arise from the scarcity of some factor of production and the consequent necessity of using greater and greater proportions of the others along with it."(94) Viner (1931) assumes "that within the useful range of observation, the law of diminishing returns is operative, and the average direct cost is therefore drawn possitive throughout".(95)

There are therefore two factors involved. One is the assumption of maximum utilization inherent in the production function, the other is the "dosing" or varying of the proportions of the variable to the fixed inputs. Both are open to question on grounds of the observed behaviour of business.

"Dosing" is open to only a few industries as a matter of routine, and then only as a mental process rather than as a method of production. The production function is a planning function, and is thus not available to those firms who buy ready-

(94) Cassel, J.M., op. cit. p. 104

(95) Viner, loc. cit. p. 203

made equipment. The number of such firms is growing with the increase in the roundabout nature of production. Capital goods industries however, do deal with production functions; not those functions relating to their own products but to the activities of the firms who will buy the resulting capital goods - Once such an equipment manufacturer has "chosen" the input combinations, these are embodied in machines, and thus become fixed. Their costs, at constant prices are consequently fixed, to the client firm, once the latter buys the machine and starts it operating.

There remain labor, raw material and fuel costs. Labor is employed, in industry at least, in a very restricted number of combinations with machines, according to the instructions of the manufacturer of these machines. Institutional arrangements may contribute to this same result. The only really variable costs remaining are raw material and fuel costs. These, it may be noted bear a linear relation to output, by the technical nature of production. Diminishing returns cannot possibly exist. Total cost is therefore directly proportional to output - a result in agreement with the findings of Dean, Yutema and chapter 2 of this paper.

The second factor is the maximum utilization assumption. Variations in output can arise in this case only from a less than maximum utilization of the capacity of the machine, representing a degree of inefficiency compared to the production function. In figure 6, the attainable output according to the production surface is S, but due to the deficiency of market demand, an output Q between S and S' is produced. Since marginal cost, is constant, then the "inefficient" production function containing Q is parallel to the main production surface at point S.

That a firm should choose to produce below capacity is not necessarily contrary to rational behaviour, since rationality dictates also that production and sales activities be coordinated. Should demand fail to absorb all that a firm can produce, then production is bound to be below plant capacity over a period of time.(96) Production at capacity for a long time, is consistent only with perfect competition.

One conclusion is that the "short run" and the "long run" cost curves of theory are much in common. In fact all that was shown is that the assumptions of the short run cost curve can exist only for the long run curve, since by changing the proportions of the factors, the plant is being changed and therefore a new "short run" curve, in the sense of the empirical functions, must be substituted for it.

Tintner's three hypotheses (supra) can now be fitted into the argument. To dispose first of the economies and diseconomies of scale.(97) There does not seem to be in Dean's or Yutema's figures any reference to a change in scale. Since "the size of

(96) Intermittent operation at capacity output may also be resoted to, in case the saving in cost from operation at capacity area not absorbed in inventory charges. This situation however is still a case of less than maximum output.

(97) <u>cf</u>. <u>supra</u>, Tintner's 2nd point, p. 96

the group of factors which are fixed in amount in the short run"[98] have remained fixed, it is not clear how economies or diseconomies of scale could arise. The Marginal Cost in the short run is a measure of the "cost of producing the last unit of output, and its constancy cannot be relevant to scale.

That the range of data is not great enough to show the increase in marginal cost is entirely possible. Added to Bain's questioning of the validity of Dean's and Yntema's results on the ground that there exists in accounting and statistical techniques a bias towards linearity,[99] the argument becomes formidable. In fact, the increase in maintenance and depreciation costs due to a higher rate of use at or near capacity could conceivably raise the average cost curve. The extent of the bias could be important. Johnston, J., however disagrees with the "linearity bias" theory[100] and proves that the techniques used cannot impart such a bias except in the case of "the accounting treatment of the cost of the capital equipment and the difficulty of ascertaining the user cost of capital assets"[101].

(98) Viner, J., op. cit. p. 202

(99) Bain, J.S., op. cit. in A Survey..... , P. 140

(100) Johnston, J., "Statistical Cost Functions-A Reappraisal", The Review of Economics and Statistics, XL:4. Pp. 339-351 - November 1958.

(101) loc. cit. p. 350

Stigler[102] has emphasized that the traditional U-shaped cost curves are based on the assumption that capital equipment is indivisible but completely adaptable to the cooperating factors. "The Empirical results suggest that divisible equipment possessing varying degrees of adaptability to the cooperating factors is more typical of modern industrial processes"[103], since in the short run, the existence of the fixed costs precludes adaptability to the changing conditions of the variable factor. Furthermore, Stigler asserts that under the modern conditions of production diminishing returns need not hold at all; "Numerous writers have been too hasty in asserting that increases in output necessarily entail rising marginal costs"[104], when on the contrary, marginal costs are "very probably" constant, especially in the case of a divisible plant.

Thus, Stigler's divisible non-adaptable plant, as well as the scheme of section A may explain the linearity of total cost.

The cost curves of theory are based on the least cost method of production, because of the assumptions of maximum profit in the short run, and of perfect knowledge relating to the methods of production.

It is seldom true that a firm maximizes profit in the short run. The influence of uncertainty, of non-economic

(102) Stigler, G., op. cit. (passim.)

(103) Johnston, J., op. cit. P. 350.

(104) Stigler, op. cit. P. 136

factors (public relations, politics, etc...) reduces substantially from the assumed drive for efficiency being always sufficient to reduce costs to the minimum for a given output. This urge for efficiency in fact varies over the business cycle and is also dependent on market structure.

It is moreover true that, especially in the smaller firms, the least cost methods are not known, and in stagnant markets not even sought. The human element in this respect, is fully as important as the strictly economic determinants of the system. It expresses its importance in higher costs than those indicated by the cost curves of theory. Alternatively it may be said that the firm is operating at less than capacity, even though it may be producing the maximum output obtainable with their human material. In this sense the costs of training the labor force, management consultancy and extension work represent investments in the same way as the addition of control devices is an investment, since both reduce the cost of production.

The cost curves of theory therefore exhibit certain limitations for applied research, and for normative use. These derive from the two assumptions of diminishing returns, and of maximum output for a given factor combination. Both assumptions may be contested under certain conditions. While the latter is very probably inaccurate especially in underdeveloped countries, where the ecological conditions taken for granted in a developed economy do not exist and thus the whole level of costs would be raised.

Chapter -V-

The Market Structure of the Milk Industry of Beirut

This chapter proposes to note some of the peculiarities of the market for pasteurized milk in Beirut. Only three aspects are discussed, namely concentration of sales, the problem of entry and competitive behaviour.

The inadequate treatment given these three topics, as well as the exclusion of other equally important and interesting lines of investigation must be explained by the reluctance of entrepreneurs and managers to give information concerning their reactions to competition. The writer's short experience in the industry was too short, and occurred during the non representative spring and summer of 1958.

A. Concentration in The Dairy Industry:

The application of such a resounding phrase as "the concentration of economic power" to the tiny dairy industry of Beirut would seem ridiculous, especially when the "poetic ambiquity" attached to this phrase is considered. It is the concern of the next few paragraphs to investigate the more interesting aspect of "economic power" in the dairy industry, namely the power to limit the independence of customers and competitors in making their decisions concerning pasteurized milk. To the extent that such an influence may be applied, there exists a certain degree of insultation of the firm against competition. The discussion of the tactics by which the milk distributors make use of this power to limit competition is relegated to section C.

For lack of a better measure of the monopolistic elements in the market, the volume of sales is taken as a first approximation, leaving the further elaboration of the points raised by the sales data to the discussion of section C., below. Some interesting remarks are called for by table 18.

Table 18

Annual Fluid Milk Sales in Beirut(X)

Firm code	Sales(liters)	Percent of total
A	700,000	40.78
B	630,000	36.69
C	245,000	14.26
D	142,000	8.27
Total pasteurized milk	1,717,000	100.-
Non-pasteurized milk	2,100,000	122.-
Total	3,817,000	222.-

X Estimated from information presented elsewhere, by multiplying average daily output, as reported, by 360.

The number of firms selling pasteurized milk is not what would have been expected from the many names mentioned in the industry. Only four out of eight dairies maintain milk routes, the rest are mainly producers of such items as laban, beverage laban, labneh and cream.

Another characteristic refers to the extreme concentration of sales, firms A and B controlling 77.47 percent of the total market, while C and D - a new comer, account for only 22.53 percent. This situation is not expected to change due to the policy of the Hoss Dairy of processing and selling only milk produced on their own farm. The other minor plant, while selling its own milk, does not limit its growth potential, by refusing to process purchased milk. It is also a new plant, and as is often the case with foods sold under a brand name, it takes a long time to develop a market, especially when no advertizing or other large scale sales promotion is practiced. For this reason, this plant is expected to grow with the market, presumably at the same rate as A or B, but would preserve its present share of 8.27 percent of the market.

Non-pasteurized milk, a closely substitutable product for pasteurized milk, especially in such areas as Ashrafieh and Jummeizeh where it is preferred to bottled milk at the current prices, presently accounts for more than half of the fluid milk sales. The influence of this unorganized market on the pricing policy of the "dairies" would appear to be limited however. The "dairies", on the other hand, look at the demand for 2.1 million liters catered to by the milk peddlers, as a potential market to be conquered. It must be added that they are not doing much to conquer it, but are relying on the rising standards of living and the spread of education to convince people of the advantages of pasteurized milk. While this attitude may be justified, their other polities, inter alia their pricing policy, are not designed to insure that any increase in total consumption of pasteurized milk would accrue to them rather than to new entrants. The ease of entry may be ganged by the share of the market already enjoyed by plant D, after about a year of operation only.

B. Pricing, Entry and Excess Capacity:

The plants A, B, C and D above each have the capacity to process 1,4 million liters annually. The industry is therefore operating at 30.55 percent of capacity. Had the whole fluid milk sales of Beirut been handled by the four dairies alone, the rate of utilization of capacity would rise to 68 percent. Even then, there would exist a considerable degree of surplus capacity in this industry.

There have been many attempts at explaining the existence of this excess capacity, by entrepreneurs, managers and people otherwise connected with the industry. The jist of all such explanations is that somebody else, usually the consumers and/or the government are to blame. The consumers are blamed for not appreciating the relative value from a sanitary as well as nutritional points of view, of pasteurized milk as compared to the raw product. The government is responsible, as the argument goes, to probibit the sale of non-pasteurized milk in order to protect the health of its nationals. It should also prohibit the importation of powdered milk so that consumers would buy pasteurized whole milk. An argument is also heard in the industry, though rather infrequently, to the effect that the government should raise obstacles to the entry of new dairies to the industry in order not to aggravate an already "unsatisfactory" situation.

While such arguments may be justified, to an investigator, there seem to exist some reasons from within the industry for the perpetuation of excess capacity. These may be classified into two categories: one, those arising from the particular market structure, and two, those due to the attitudes of the entrepreneurs vis à vis their cost structure on the one hand, and the ease of entry on the other.

There is no doubt as to the existence of an oligopolistic market in the dairy industry, especially as the two biggest firms control more than three quarters of the market. Every one of the three biggest firms, A, B and C is conscious of the influence of its pricing and service and product policies, on the competitors, as well as on the position of the "equilibrium points", so much so that equilibrium has ended by meaning both a status quo and a modus vivendi, rather than a point endowed with a certain amount of dynamic stability. This stability would have been due to the nature of the supply curve in relation to a market demand schedule. The "stability" of this oligopolistic market is not of this nature, as it arises from the fear of a "price war". Such a price war may arise, but it would seem that the prices of pasteurized milk could be considerably reduced, and still yield a reasonable return, with the non-negligible probable result, that non-pasteurized fluid milk sales would be reduced to a very low figure. The gains from the increased output, in the form of lower unit costs can be very significant. For plant C, an increased output from the current 14.26 percent of capacity to a 50 percent utilization of the plant would reduce the unit processing cost from 10.62 to 4.60 piastres per liter, a drop of 60 percent. Thus, this plant could increase its net profit by reducing the sellingprice of milk by 5 piastres per liter, provided this reduction in price would stimulate the increase in consumption to raise sales to 50 percent or more of capacity.

The existence of excess capacity is due partly to a historical reason. The first dairy to start operation set a new traditional retail price of 75 piastres per liter. This price has been consistently maintained and has been paid by the customers ever since. The competition of the William's Dairy in the early fifties was not stiff enough, neither could it be effective enough due to the locational advantage enjoyed by Dumit Bros. & Co., to break the leadership of the latter. With the merger of the duopolists in a two-plant monopolist firm, the position of the new dairy was finally established. In 1953-4, the two firms, Bambi and Hoss Dairy, started operations. At first they had no interest in reducing their prices from the ruling 75 piastres. Hoss Dairy started a retail route, distributing bottled milk to the houses of the customers - a disquised price cut. Its sales policy was very successful, especially as the home delivery was coupled with an extensive advertizing campaign. Home delivery, it was shown earlier is an expensive operation, in which the cost of a liter delivered on the doorstep may cost up to 9.1 piastres over and above plant and raw material charges. It may be argued that five piastres could have been diverted as a retail price cut (from 75 to 70 piastres), leaving around four piastres for distribution to stores. This latter alternative was modified by the other entrant, Bambi, who started a wholesale route, and gave the storemen an additional reduction of five piastres, instead of reducing retail prices.

As the market expanded, due to the product and service competition of Dumit, Bambi and Hoss, and also because of the rising standards of living as well as the establishment of whole new sections of town, the price-cost structure in the milk industry continued to present a bait to prospective dairymen. A characteristic statement was made by an entrepreneur now contemplating the establishment of a new fluid milk plant. He thought that, if he could operate at 35 percent of capacity, at the current prices, his gross profits would amount to 40-50 percent on an investment of 100,000 L.L. His entry into this market, with a non-aggressive attitude toward competitors would add to the excess capacity already present. The culprit must be found in the pricing of pasteurized milk.

At the present moment, the wholesale price of a liter of pasteurized milk is 60 and the retail 75 piastres. The general belief being that the retailer is performing a service in promoting the sale of milk, and in reducing the costs of distribution. The spread that the processor is charging for his services between the price paid for the raw milk (L.L.0.40-0.415) and the wholesale price is not designed to prevent new entry, neither does it enable the present processors to acquire the potentially large market in Ashrafieh and Jummeizeh. The writer interviewed about a dozen retailers in Ashrafieh in 1958 with a view to investigate the possibilities of developing sales of pasteurized milk in that section. The concensus of opinion was that the consumers "do not think that pasteurization is worth twentyfive piastres". The general impression was that a retail price of 65 piastres of pasteurized milk might induce an important shift in consumption pattern from raw to pasteurized milk.(105) The writer is of the opinion that a change in the pricing structure designed to capture the Ashrafieh and Jummeizeh milk purchases while at the same time discouraging entry, would be worth considering. The fear of a price war can be allayed by an agreement of non-aggression. Such an agreement may be designed to avoid a price war and to achieve the price

---

(105) No record was kept of those interviews, as they were not intended to be used for academic work. At the time, raw milk was sold at 0.50 L.L. per kg. in retail, and bottled milk at 0.75 L.L.

cut simultaneously for the whole industry. Price discrimination favoring the "target areas" may also be tried, failing which, a general retail price of 0.65 L.L. per liter all over Beirut can only increase fluid milk consumption and thereby reduce unit processing costs. As a by-product of the proposed policy, the dairy industry should appear less attractive to a potential entrant, since the latter would find that his breakeven point corresponds to a larger output than previously, at the 0.75 L.L. price.

But in order to adopt such a policy of discouraging entry and capturing the raw milk market, the milk processors must have a set of, average costs corresponding to various outputs, and must be possessed of a desire to maximize their profits. While the latter desire may be among the driving forces in the market, there should be no illusion about the existence of the former condition. Not one of the dairies keeps cost accounting records, and they only have a vaguest idea that larger outputs, were they possible, would bring greater profits. Their attitude to competition can be summarized by the phrase "live and let live" so characteristic of many digopolistic situations. This attitude carries over to cover new entrants as well as the established competitors, and as a result they do not make use of the reserve competitive power at their disposal in the form of excess capacity, the presence of which should theoretically have helped to discourage entry. Their policy should be to set their price low enough to make it unattractive to a prospective entrant.

Such a price need not be the same as average cost at capacity plus a reasonable profit, because the knowledge, which must be broadcast, of the existence of excess cpacity and therefore of reserve competitive power, in itself a deterrent, would raise the critical price at which a potential entrant would hesitate to go into pasteurized milk. This critical price is surely less than 0.75 L.L. per liter. Collusive pricing may prove to be a good way of achieving this reduction in price without the danger of a price war. The latter danger is not great however, due to the professed attitudes, and previous behaviour when retailer margins were increased. In the autumn of 1958, retailer margins were raised from ten to fifteen piastres per liter. Bambi was the first to charge retailers 0.60 instead of 0.65 L.L. per liter, the previous wholesale price, and Dumit, Hoss and Dairy House tamely matched Bambi's move. A potential belligerent would have behaved more aggressively.

The presence of excess capacity must therefore be laid at the door of the dairy plants, whose pricing policy encourages entry and therefore makes it more difficult to achieve full utilization of capacity. The arguments as to consumer ignorance and the non-interference of the government cannot be taken seriously.

C. Competition in Dairy:

This section consists in only a few remarks relevent to a study of competition in the market milk industry. An extended discussion does not seem justified because of the lack of price competition at the retail level, as well as the absence of reliable data concerning the attitudes of businessmen toward competition. A study of price policy during the years 1958-59 can be attempted.

Retail prices, have been stable at L.L. 0.75 per liter for as long as most buyers can remember. A general attitude concerning changes in the retail price is that they tend to "ruin the market". Two things are implied in this statement. One, is that price changes at the consumer level would lead the latter to expect a drop in the price of a liter of milk, and consequently to start asking for this price cut. Some competitor or other might be encouraged to comply by the hope of larger sales at the expense of the dairies who have kept their price constant. These would then have to follow and reduce their prices to a lower level in order to recapture their customers. This kind of price war can only reduce profits in the short-run. Moreover, the price-elasticity of milk is, in the opinion of the distributros, less than unity in their areas of distribution. The writer does not subscribe to this latter opinion, and has proved for a duration of at least one week in August of 1958 - when a retail price cut of five piasters, raised sales by about ten percent in Sabra street - that the price elasticity of demand for pasteurized milk is higher than unity in the "poorer" sections of town. Consequently, the increase in sales is larger, percentage-wise than the cut in price, since new patronage is built up.

This retail price has become, with time, a customary price. For any particular firm, there remains only output as a variable. Consequently, most dairies concentrate on creating the conditions that will cause a greater volume of sales. Such conditions, all center around the promotion of such monopolistic elements in the market, as will on the one hand, insulate the relevant firm from corresponding measures by other firms while, on the other hand, trying to exapnd its own sales.

The most important single action in competition is the acquisition of the patronage of the retailers. This can be done by offering the retailer a price differential greater than that offered by the other dairies. This is a move that the latter are sure to match, with the result that the discount to stores is increased. This explains the increase from 10 piastres to the present price differential that the retailer gets of fifteen piasters per liter. It was shown in Chapter 3 that the saving in distribution cost arising from wholesale as against retail distribution is nowhere near this figure. The willingness of the dairy-men to grant this differential must therefore be explained on other grounds.

It is believed that retailers cause a saving to the distributors in the form of reduced selling hedaches and expenses, "fully worth fifteen piasters". This is probably very true. These retailers have their own clientèle on whom they hold a certain degree of monopoly power, and can consequently sell them any brand of milk they happen to stock. The cost of acquiring a comparable patronage of individual consumers is deemed too great by many people in this business, though no figures have ever been shown the writer to substantiate this belief. This cost appears larger than the gain resulting from selling more milk at the higher consumer price.

A further advantage of the retailer over the individual customers is that the former pay cash, while credit must be extended to householders. An additional cost is thus created in the form of interest on operating capital, as well as increased office work and credit losses.

The main disadvantage of stores is the ease with which they shift from one dairy to another, causing continuous upsets in production and sales planning.

A device used to induce stores to handle only the milk of one distributor is full line forcing, in which the storekeeper is required to buy all his requirements of dairy products from one firm, otherwise the latter would stop dealing with that store. This device is aimed at insulating the dairy from the actions of rivals and is often very successful in milk, where milk, laban, labneh, cream and chocolate milk are forced on the retailer and he has to buy all or none. This is particularly detrimental to the one-product dairies. It is effective where a distributor has some inducement to offer the store to buy the dairy products he desires only from him.

No advertizing of any magnitude is carried out in this industry. The personal relations of the driver-salesman are however stressed. This applies to both wholesale and retail operations.

In a general way however, there does not seem to be much competition in milk distribution in Beirut, neither within the pasteurized milk industry nor between the latter and raw milk. The distributors have a strong reserve of competitive power that they are not using which is represented by the large excess capacity. Commenting on this point, one businessman remarked that it would probably be profitable for Bambi to buy up the Hoss Dairy at the capitalized value of its earnings, in order to put it out of business and acquire its 400 odd customers. This would increase Bambi's rate of capacity utilization, and increase his long time profits by much more than he paid for the Hoss Dairy. This is probably a true assessment of the situation, and serves to give a good picture of the large potential competitive power, that the dairy industry is keeping uselessly in reserve.

D. <u>Conclusion</u>:

The dairy industry in Beirut operates under oligopolistic competition. This is due to the very uneven distribution of sales as between the four firms. In addition, there is a large excess of capacity that explains partly the high processing costs in the industry. The high prices of pasteurized as compared to raw milk have encouraged entry and are consequently reponsible for the presence of excess capacity. There has been no price cutting to consumers as a means to attract customers and increase volume. New entrants have used other devices to attract enough customers to develop a profitable business.

Competition in this industry is very tame and the attitude of the distributors is well described by the phrase "live and let live". While it is true that "there is a place for everybody" in this industry, there is no reason why one dairy man should not try to do everything possible to secure and protect as large and as prosperous "a place" as possible.

Appendix A.

A Note on Methodology

This appendix relates to some problems that arose during the preliminary period when the data were being collected. This appendix was made necessary by the special circumstances that put the writer in a position to observe the dairy industry from within, as manager of the Hoss Dairy. There is, consequently, an inevitable personal touch to some of the opinions and the choice of the supporting data.

To the extent that there exists what may be called "the problem" of the dairy industry in Beirut, consisting in a vicious circle of poor management, weak finances, small sales and weak management, one should not expect accurate data to be had easily. One dairyman could not tell the capacity of the various pieces of equipment that he owns. Only one owner-manager could give detailed answers to all questions concerning his operations, that proved to be correct when double checked against actual measurement. It is not surprising that the cost structure of this firm indicates a superlative efficiency by any standard; Route F of chapter 3 is operated by this manager.

As a consequence of the lack of knowledge reliance had to be made on other sources such as inference, actual measurements of the variables, projections of data from one firm to another, questioning directed at the plant employees who possess a surprising amount of data obtainable by the technically trained investigator. Comparisons with the Hoss Dairy were continuously made, especially when it was discovered that all the dairy plants operate about the same type and sizes of equipment and follow about the same routine. In addition, specification and data sheets were used, and were used previously by the writer in preparing a budget and a break-even chart for the Hoss Dairy based on engineering economic techniques.

Without going into details, the information in this thesis can be classified as originating in the ways outlined below.

1. Information Based on the Hoss Dairy:

The writer, during May - September of 1958, while managing this dairy, had occasion to make working estimates of most of the important variables, especially the fixed items of plant cost, and the operating costs of the distribution system. Job programs for various outputs were made and tested on a "blank". Run the test consisted in pasteurizing various quantities of tap water and bottling them without the actual application of the caps, since the tube of the capping machine was left empty. Bottle washing was simulated by washing the equivalent number of dirty bottles obtained from the store-room. The test was run for the purpose of keeping equipment in working order, and was exploited for the two auxiliary ends of testing the labor requirements schedule used in preparing the tables of chapter II, and in training an extra worker in operating the pasteurizer.

In preparing this paper, fixed distribution costs were estimated by economic engineering techniques. On the other hand the figures used in preparing the financial budget at Hoss Dairy were simple projections of the previous month's expenses.

During my work in that firm, volume of significant data was entered in a notebook labelled "competitor's file". This information was collected from drivers, managers and owners of the various dairy plants, as well as my own notes gleaned from visits to these dairies or observation of their routes. Because of the non-uniform accuracy of such data, reference was made in the body of the thesis to this file, whenever used.

2. <u>The Interview</u>:

To facilitate collection of data from the various distributors of pasteurized milk a comprehensive questionnaire was prepared. However it was not used in its original form. Its length, as well as the ignorance of the distributors as to the technical aspects of their businesses, added to their natural resistance to answering questions of so intimate a nature, resulted in the failure of the interview method. The writer filled in whatever answers he already knew, sought (and obtained) permission to observe the plant in operation. Later only those questions were asked of the managers that could not be filled in by observation or other means. These referred to the attitudes towards sales, advertizing, competition, pricing etc.... The major finding being that these entrepreneurs have not thought along really aggressive lines. "Live and let live" seems to be the prevalent attitude, a conclusion that I had expected from their tame behaviour as "dear competitors" during 1958.

In only one case, Milko - a beverage laban distributor, were there any clear and accurate answers given, with no inhibitions or false secrets. Every bit of information, when measured, was found accurate, even to the time requirements for various jobs and the costs in the various centers of cost. The data on the variable costs of cleaning supplies, dairy operating supplies and "other variable costs (electricity)" in table 2 and its supplement, are derived from the Hoss Dairy records, corrected by comparison with the data from Milko.

A large amount of information referring to the costs of distribution, is due to drivers and co-drivers, who apparently possess a surprising amount of very useful data, and have a not so surprising insight into the factors influencing the costs of distribution. An unknown number of ideas in chapter III came from these employees.

Any unsubstantiated opinion, or unacknowledged figure must be taken as arising from the short experience of the writer with the Hoss Dairy.

Literature Cited

Andrew, P.W.S., "Industrial Analysis in Economics" in Wilson, T. and Andrews, P.W.S., Oxford Studies in The Price Mechanism, Pp. 139-173. Clarendon Press, Oxford. 1952.

Associazone Italiana Lattiero Casearia (Assolatte), ed., Le Lait et les Produits Laitiers Italiens, Comitato Italiano, Latte e Derivati - Milano. 1959

Babb, E.M., and Butz, W.T., Improving Fluid Milk Distribution Practices through Economic Engineering Techniques. The Pennsylvania State University, College of Agriculture, Agric. Exp. Sta., Bulletin 622, University Park, Penns. U.S.A., June 1957.

Bain, J.S., "Price and Production Policies". Pp. 129-174, cf Ellis, H.S. 1 ed. A Survey of Comtemporary Economics, The American Economic Association - The Blackiston Company Philadelphia, 1949.

Baum, B.L. and Pauls, D.E., A Comparative Analysis of Costs of Farm Collection of Milk by Can and Tank in Western Washington, 1952. Washington Agric. Exp. Sta., Institute of Agric. Sc., State College of Washington, Technical Boulletin 10. Pullman, U.S.A., 1953.

_____, E.L., Riley, R.D., and Weeks, E.E., Economies of Scale in the Operation of Can and Tank Milk Receiving Rooms, with Special Reference to Western Washington. Washington Agric. Exp. Sta., Institute of Agric. Sc., State College of Washington, Technical Bulletin 12, May 1954.

Bartlett, R.W., and Gothard F.T., Measuring Efficiency of Milk Plant Operation, University of Illinois, Agric. Exp. Sta., Bulletin 560, Urbana, Ill., U.S.A., 1952.

Boulding, K.E., A Reconstruction of Economics, John Wiley & Sons, Inc., New York, 1950.

Branton, N., Administration of Business Enterprise. Sir Issac Pitman & Sons, Ltd., 1948.

Cassels, J.M., "On the Law of Variable Proportions". Explorations in Economics 1936. Reprinted by The American Economic Association, Readings in the Theory of Income Distribution, George Allen and Unwin, Ltd., London 1950. Pp. 103-119.

Chamberlain, E.H., The Theory of Monopolistic Competition. 7th ed. The Harvard University Press, Cambridge, 1956.

__________, ___ , Towards a More General Theory of Value, Oxford University Press, New York, 1957.

Clarke, J.M., Studies in the Ecomomics of Overhead Costs, The University of Chicago Press, Chicago, Illinois. 1947.

______, D.A., Jr., Milk Delivery Costs and Volume Pricing Procedures in California. University of California, Calif. Agric. Exp. Sta. Bulletin 757. Amshurst, U.S.A., 1956.

Coase, R.H., "The Nature of the Firm", reprinted from Economica (1937) by The American Economic Association, Readings in Price Theory, George Allen and Unwin, Ltd., London 1956. Pp. 331-352.

Cochrane, William, "The Market as a Unit of Inquiry in Agricultural Economics Research", Journal of Farm Economics, vol. 39:1, Pp. 21-40. February 1957.

Cook, H.L., Paper Packaged Milk in Wisconsin - Its Part in Expanding Distribution Areas. University of Wisconsin Agric. Exp. Sta., Research Bulletin 179. Madison, Wis., U.S.A., 1953.

____, ___ , Halvorson, H.W., and Robinson, R.W., Costs and Efficiency of Wholesale Milk Distribution in Milwakes. University of Wisconsin, Agric. Exp. Sta., Research Bulletin 196. Madison, Wis., U.S.A., May 1956.

Crossley, E.D. ed., The United Kingdon Dairy Industry XV International Dairy Congress, on behalf of United Kingdom Dairy Association, London, 1959.

Davis, J.G., A Dictionary of Dairying. 2nd ed., Leonard Hill Ltd., London, 1955.

Dean, Joel, Managerial Economics. Prentice-Hall, Inc., New York, 1951.

Eiteman, W.J., Price Determination - Business Practice Versus Economic Theory. Bureau of Business Research, School of Business Administration, University of Michigan, Report No. 16. Ann. Arbor, Mich., U.S.A., 1949.

Hall, R.L., and Hitch, C.J., "Price Theory and Business Behaviour" in Wilson, T. and Andrews, P.W.S., Oxford Studies in The Price Mechanism, Pp. 107-139. Clarendon Press, Oxford. 1952.

Henry, W.F., Bressler, R.G., Jr., and Freck, G.E., Efficiency of Milk Marketing in Connecticut. 11. Economics of Scale in Specialized Pasteurizing and Bottling Plants. Storrs Agric. Exp. Sta., Coll. of Agric., University of Connecticut, Bulletin 259, June 1948.

Hermann, L.F., and Whatley, T.J., Costs and Mrgins of Milk Distributors in Memphis, Tenn., Pin. 1948. U.S. Dept. of Agric., Bureau of Agric. Economics, Washington, D.C., 1950.

Hiroch, D.E., Milk Distribution Costs of Georgia Cooperatives. Farmer Cooperative Service, U.S.Dept. of Agric., General Report 16, Washington D.C., 1955.

Hoover, E.M., The Location of Economic Activity, McGraw Hill Book Company, Inc., New York, 1948.

Hottelling, H., "Stability in Competition", Reprinted from The Economic Journal (1929) by The American Economic Association, Readings in Price Theory. George Allen and Unwin, Ltd., 1956. Pp. 467-485.

Ireson, W.G., Factory Planning and Plant Layout. Prentice Hall, Inc. , New York, 1954.

Isard, W., Location and Space - Economy. The Technology Press and John Wiley & Sons. Inc., New York. 1956.

Kabbarah, T., Project: Milk Pasteurization Plant. School of Engineering, American University of Beirut,(Senior Project. Typewritten.) 1956.

Kay, H.D.; Cuttel, J.R.; Hall, H.S., Mattrek, A.T.R. and Rowlands, A., Milk Pasteurization - Planning, Plant, Operation and Control. Food and Agric. Organization of the U.N., Rome, Italy, 1953.

Knudtson, A.C., "Estimating Economies of Scale," Journal of Farm Economics, vol. 40:3, PP. 750-756. August 1958.

Lefeber, L. Allocation in Space, Production, Transport and Industrial Location. North-Holland Publishing Company, Amsterdam, 1958.

Lovell, A.H., Generating Stations, Economic Elements of Electrical Design. 4th ed., McGraw Hill Book Co., Inc., New York 1951.

Muchlup, Fritz, "On the Meaning of the Marginal Product". Reprinted from Explorations in Economics (1936) by The American Economic Association, Readings in the Theory of Income Distribution, George Allen and Unwin, 1950. Pp. 158-175.

Manual for Milk Plant Operators. Milk Industry Foundation, Washington, D.C., U.S.A., 1957.

Monroe, W.J., Multiquart Containers - Their Significance In Dairy Cooperatives. Farmer Cooperative Service, U.S. Dept. of Agriculture, General Report 54. Washington D.C. 1959.

Mueller, W.F., "A Comment on the FTC's Report On Mergers with Special Reference to Dairy Mergers". Journal of Farm Economics, vol. 39:1, Pp. 140-152.

Needlham, R.T., Modern Farm Dairy Equipment, Leonard Hill Ltd. London 1952.

Nicholls, W.H., A Theoretical Analysis of Imperfect Competition with Special Application to the Agricultural Industries. The Iowa State College Press, Ames, Iowa, U.S.A., 1947.

Owens, T.R., and Poutz, W.T., Specifications and Costs for Processing Operations in Small Market Milk Plants. The Pennsylvania State University, Coll. of Agric., Agric. Exp. Sta., Bull. 625, University Park, Penna., U.S.A., August 1957.

Park, C.W., Milk Packaging for Retail Distribution, Report of a Controlled Experiment. The A.H. Pugh Printing Company, Cincinnati, 1956.

Pritchard, N.T., and Cope, W.H., Milk Assembly in the Fort Wayne Milkshed. Purdue University, Agric. Exp. Sta., Station Bulletin 559, Lafayette, Indiana, February 1951.

Rautentranch, W., and Villers, R., The Economics of Industrial Management. Funk and Wagnalls Company, New York, 1949.

Roadhouse, C.L. and Henderson, J.L., The Market Milk Industry. 2nd ed., McGraw Hill Book Co., Inc., New York, 1950.

__________, ___. and Hubbell, B.E., Manual for Employees of Dairy Plants. The Olsen Publishing Co., Milwankee, Wisconsin, U.S.A., 1957.

Rotschild, K.W., "Price Theory and Oligopoly", reprinted from The Econimic Journal (1947) by The American Economic Association, Readings in Price Theory, George Allen and Unwin, London 1956. Pp. 440-467.

Samuelson, P.A., Foundations of Economic Analysis. Harvard University Press, Cambridge, 1948. Pp. 57-90.

Shephard, R., Cost and Production Functions. Princeton University Press, Princeton, New Jersey, U.S.A., 1953.

Smithies, A., "Optimum Location in Spatial Competition", reprinted from The Journal of Political Economy. 1941, by The American Economic Association, Readings in Price Theory, George Allen and Unwin, Ltd., 1956. Pp. 485-505.

Snyder, J.C., and French, C.E., "Selection of Product Line for a Milk Plant by Activity Analysis", Journal of Farm Economics, vol. 39:4 Pp. 914-927. November 1957.

Spindler, H.G., Labor Costs on Wholesale Milk Routes in Springfield, Mass. Unicersity of Massachusetts, College of Agric., Exp. Sta. Bull. No. 498. Amherst, U.S.A.

Stachle, Hans, "The Measurement of Statistical Cost Functions: An Appraisal of Some Recent Contributions." Reprinted from the American Economic Review, 1942 by The American Economic Association, Readings in Price Theory, George Allen and Unwin, Ltd., London, 1956. Pp. 264-383.

Stigler, G., "Production and Distribution in the Short run", reprinted from the Journal of Political Economy (1959) by The American Economic Association, Readings in The Theory of Income Distribution, George Allen and Unwin, Ltd., London 1950. Pp. 119-143.

Taylor, J.C. and Brow, R.W., Fluid Milk Plants in the Sotheast, Methods, Equipment and Layout. United States Dept. of Agric., Marketing Research Report No. 232., Washington, D.C. 1958.

Tracy, P.H., Armenerding, G.D., and Hannah, H.D., Dairy Plant Management. McGraw Hill Book Company, Inc., New York, 1958.

Triffin, R., Monopolistic Competition and General Equilibrium Theory. Harvard University Press, Cambridge, 1940.

Webster, Fred C., Specifications and Costs for a Moderately Small Milk Pasteurizing and Bottling Plant. Dept. of Agric. Economics, New York State College of Agric., Bulletin A.E. 1031. Ithaca, N.Y., U.S.A., 1956.