UNIVERSITY OF OXFORD
AGRICULTURAL ECONOMICS RESEARCH INSTITUTE

THE DISTRIBUTION
OF MILK

A STUDY OF TOWN DELIVERY COSTS

BY

JOHN CRIPPS

Price Two Shillings and Sixpence

OXFORD
Issued by the AGRICULTURAL ECONOMICS
RESEARCH INSTITUTE
1938

THE DISTRIBUTION OF MILK

UNIVERSITY OF OXFORD
AGRICULTURAL ECONOMICS RESEARCH INSTITUTE

THE DISTRIBUTION
OF MILK

A STUDY OF TOWN DELIVERY COSTS

BY

JOHN CRIPPS

CONTENTS

LIST OF TABLES

THE FIRST TOWN

THE SECOND TOWN

THE THIRD TOWN

THE FOURTH TOWN

THE FOUR TOWNS — A COMPARISON

FOREWORD

This investigation of milk delivery costs was originally intended to be part of a wider survey of milk distribution in urban areas. It has been thought advisable, however, to publish the results of the investigation, together with certain tentative conclusions based upon them, and not to await the completion of the second part of the survey, covering mainly the problems of reorganization.

Certain changes have taken place, since the material was collected, to which brief reference may be made. Since July 1937, when the last of the four businesses collected its data, costs have risen, and, in particular, there has been a considerable increase in labour costs, which form so large a part of the total. An increase of $3s.$ per week in the minimum wage of adult roundsmen came into effect in January 1938, and represented a rise of 6 per cent in the minimum laid down for the four towns covered by the investigation. Where wages were being paid previously above the legal minimum, there has been a corresponding increase in most cases. There has also been a fairly general improvement in holiday conditions, which was reported to have increased the sectional costs of the first business under this heading by nearly 25 per cent between January 1937 and April 1938. This rise in labour costs has inevitably tended to increase the advantages of the more expensive forms of transport. But it has been offset to some extent by an increase of $0.33d.$ in the distributors' margin for the year October 1937 to September 1938 over the previous year.

The Agricultural Economics Research Institute is greatly indebted to those distributors who have provided the material for this investigation. Without their active co-operation it would have been impossible, but they must remain anonymous for obvious reasons. The writer also wishes to acknowledge the assistance and criticism of his colleagues.

<div align="right">J. S. C.</div>
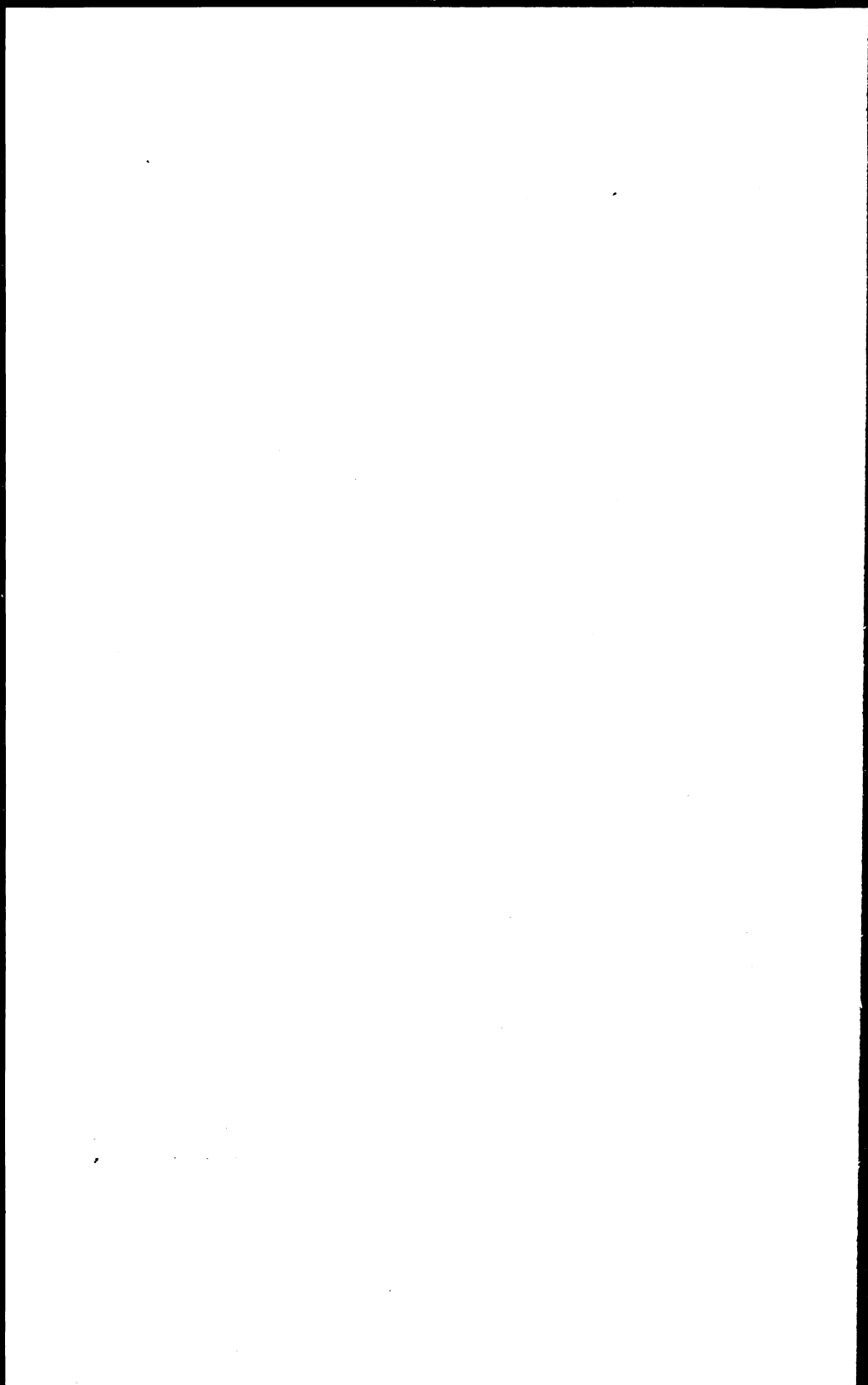
I. INTRODUCTION

THE value of milk as a protective food for all sections of the population has been increasingly appreciated in recent years. Its supply to certain categories of persons, such as expectant mothers and school children, has received special attention, but it has been recognized that such schemes cannot take the place of a general attempt to secure an all-round increase in consumption. One of the main obstacles to such an increase is the high price of milk to the ordinary consumer, and the large proportion of the total price absorbed by distributors has been the object of widespread official and unofficial comment. The high cost of distribution has led to much detailed examination and criticism of existing methods. It has also caused milk distribution to become a topic of general interest at a time when milk prices have been increased from levels already considered by the public to be much too high.

Both the urban and the rural consumer have been affected. The latter has experienced difficulties in obtaining supplies of fresh milk in producing areas, even at considerably enhanced rates, while the former has had to pay increased prices. An overhauling of the methods of supplying rural areas is no less urgent than an improvement in urban methods of distribution, but the two problems are to some extent distinct and this study deals only with the question of urban distribution. Moreover, it is concerned mainly with the retail stage of distribution, although the wholesale stage has not been wholly neglected.

The cost of distributing milk in urban areas is influenced by factors, many of which can be controlled. The services rendered to the consuming public by distributors are numerous and varied; they can be classified broadly under the headings of 'health' and 'convenience'. During the past decade there has been a very great improvement in 'health' services, resulting in a definite rise in the standard of milk distributed, both in quality and in cleanliness. Formerly, nearly all milk was sold 'loose' after little or no treatment by the distributor, whereas now much of it is properly pasteurized and bottled before

13

delivery. Unfortunately, the quality and cleanliness of milk supplies are still far from being uniformly high, but in most towns of any size it is now possible for the discriminating consumer to obtain bottled pasteurized milk at the same price as 'loose' untreated milk.

This improvement has probably tended to prevent milk prices from falling as the result of such changes in organization as have taken place. The costs of the wholesaler have increased rather than those of the retailer, where the two are distinct, but the effect of the improvement upon final prices has been the same. Pasteurization and bottling services have been introduced, in the main, by large wholesaler-retailers, and the increased processing costs must be balanced against reductions in delivery costs due to the scale upon which they operate.

There can be no doubt that these improvements in the quality and cleanliness of the urban milk supply must be welcomed, in spite of their unfavourable effect upon prices. The increase in the number of services provided under the heading of 'convenience', on the other hand, cannot be regarded in the same light. It is true that most consumers have been quick to take advantage of new services, but they have done so without being able to count the cumulative effect of their provision upon costs and prices. If their costs had been made clear at the outset, distribution methods would probably be less elaborate and less costly than at present. Ultimately, consumers will have to decide whether they are prepared to pay a high price for their milk on the basis of existing 'conveniences', or whether they will forgo certain of them in order to obtain milk at a cheaper rate.

The functions of distributors could be regulated and adjusted so as to achieve that balance between services and prices, which the majority of consumers might regard as reasonable when they were in full possession of the facts. But there are some factors affecting costs which cannot be controlled in this way; these are due principally to the physical characteristics of any given area of distribution. The topographical nature of the area and the manner in which it has been developed must be regarded as fixed. And yet they cannot be ignored in view of their influence upon comparative costs in different districts.

This study is concerned with an examination of the effect of

the provision of various services and of other factors upon milk delivery costs. The costs of pasteurizing and bottling have not been investigated. It is possible that the costs of retailing bottled milk differ from those of delivering 'loose' milk; the roundsman's load will be heavier for bottled milk at a given total gallonage, although he will not have to delay in order to measure out the amount required. But no attempt has been made to estimate whether there is, in fact, any difference in costs on this account.

Changes in costs due to differences in the 'convenience' services provided have been examined in two instances. Consumers have nearly always demanded an opportunity to choose between two or more sources of supply, and this choice has been exercised in such a way that several retailers appear daily in every street. The resultant overlapping of milk rounds has frequently been criticized, and the existence of competition of this type leads to increased costs in several other directions, notably in advertising and in the cost of giving credit on sales. These latter increases have not been investigated but the effect of the overlapping of rounds has been examined in detail.

From the point of view of the individual retailer, overlapping has the effect of reducing the proportion of the households in the delivery area served by his roundsman, who has to travel a greater distance to serve a given number of households, the lower the density of his round. Thus, the main part of the costs to the consumer of alternative sources of supply may be stated broadly as the difference between the average delivery costs of existing distributors and the delivery costs of a single distributor with a monopoly of supply in the same area, if it be assumed that hourly wage and transport costs are the same in all cases. The costs of all distributors could not be ascertained, but some idea of the increased costs due to overlapping was gained by examining the relationship between delivery costs and the density of the rounds on which those costs were incurred.

Many consumers also demand more than one daily delivery of milk, and the costs of a second delivery have been examined. But it is important to bear in mind that the additional costs do not arise merely from the duplication of effort involved on the

part of the roundsman. The practice of making two daily deliveries is closely connected with the demand for uneconomic half-pint bottles. If a single daily delivery became universal, there would be economies not only in delivery costs but also in handling and bottling costs, which have not been investigated.

Delivery costs may vary with changes in the average amount of milk and other goods delivered daily to each household, as well as with the services provided. The costs of delivery per unit of sales might be expected to fall as the average amount sold to each household increased. If this fall were reflected in a decline in retail milk prices, the amount sold to each household might increase, thus reducing costs still further. Therefore, the effect of changes in the average volume of sales per household on delivery costs has been examined.

Finally, the effects of differences in the physical characteristics of distribution areas have been investigated. The result of topographical differences has been discussed in relation to costs in various types of area. Attention has also been directed to the effect of differences in the density of buildings and the type of house predominating in the area of distribution.

II. METHODS OF INVESTIGATION AND ANALYSIS

FOUR towns were selected for the purpose of this investigation. Two of these had populations of between 50,000 and 100,000, while the third had a very much larger population, and the fourth had rather less than 15,000 inhabitants. In each town it was necessary to select distributive businesses operating a considerable number of rounds, in order to obtain groups of rounds of any size within which general conditions were fairly similar; only in this way was it possible to examine the effect of individual factors upon distribution costs. In each town, therefore, the largest concern was approached. In the smallest town there were only 9 rounds and in the two medium-sized towns the distributors selected operated 40 and 25 urban rounds respectively; all three businesses had additional rounds covering extra-urban or rural areas, but the costs of these were not obtained. The distributor in the largest town operated considerably more than 200 rounds, all within the town boundaries, but only 30 of these were examined. Thus the investigation covered 104 urban rounds.

The information was obtained between December 1936 and July 1937, and related to a given week in each case. In the first instance four questionnaires were submitted to the manager of each concern. Two related to the individual rounds and covered the following points:—

(1) the names of streets (or parts of streets) covered, and the total number of customers served; and

(2) the amount of milk and the value of dairy sundries sold; the number of deliveries daily; the number of roundsmen employed; the type of vehicle used; and the time spent on the round during the week.

The other two questionnaires related to more general facts connected with the rounds as a whole and covered:—

(3) labour costs, including wages, commissions, insurance, and the costs of holidays, sickness and accidents.

(4) transport costs, including the costs of running, maintenance, insurance and depreciation.

On the basis of this information the separate rounds were marked out on large-scale maps, where such were obtainable, so that the total length of the streets covered on each round could be measured. Where maps were not available, the length of the streets was obtained by direct measurement. In addition, the total number of houses in these streets was calculated with the aid of the town directories, or sometimes by direct inspection.

It was then possible to ascertain certain factors for each round, so that their influence upon costs might be considered. Three of these factors, the round and building densities and the average weekly delivery per household, were calculated as follows:—

(1) *The Round Density* was measured for each round by comparing the number of houses served by the roundsman with the total number of houses in the streets covered by him. Thus, if a roundsman served 50 houses in streets containing 100 houses, the round density would be 50 per cent.

(2) *The Building Density* was calculated by dividing the total number of houses in the streets covered on each round by the total length of those streets. It has been expressed as the number of houses per mile of street. For example, if the streets on any round were 2 miles in length and contained 1,000 houses, the building density would be 500 houses per mile of street.

(3) *The Average Weekly Delivery per Household* was obtained by dividing the total amount of goods delivered during the week by the number of households served on each round. In the second and fourth towns no dairy sundries were delivered, so that the average weekly delivery per household could be expressed in terms of gallons of milk. But in the other two towns, where dairy sundries were also delivered, the average weekly delivery per household has been given in terms of the total cash value of milk and sundries delivered.

The effect of these three factors was observed in relation to:—

(1) *The Number of Households Served per Hour.* This was ascertained by dividing the total number of households served by the average number of hours spent daily on each round. Thus, for a round occupying 56 hours per week, or 8 hours per day, with 320 households to be served, the number of houses served per hour would be 40.

(2) *The Weekly Delivery Costs per Household.* These were obtained by dividing the average hourly delivery costs by the number of households served per hour and multiplying the result by the number of days in the week. For example, if the average hourly delivery costs were 15*d.* and 20 households were served per hour, the daily delivery costs would be 0.75*d.* and the weekly delivery costs 5.25*d.* per household.

(3) *The Delivery Costs per Gallon of Milk.* These were measured by dividing the weekly delivery costs per household by the average number of gallons delivered per household weekly on each round. Thus, if the weekly delivery costs per household were 5.25*d.* and the average amount of milk delivered was 1.5 gallons, the delivery costs per gallon of milk would be 3.5*d.* Where dairy sundries were also delivered, no allowance was made and the delivery costs per gallon so calculated are probably too high, but this point is discussed fully at a later stage.[1]

In the first instance correlation analyses were employed to determine the nature and extent of the relationships between the three factors, the round and building densities and the average weekly delivery per household, on the one hand, and the number of households served per hour, on the other. But it seemed probable that some degree of interdependence existed between the first two factors, the product of which may be stated as the number of houses served per mile. For purposes of analysis, therefore, these two factors were combined and the effect of changes in the number of houses served per mile, and,

[1] See pp. 83-4.

where possible, in the amount of deliveries was measured in relation to the number of households served per hour. Changes in the round and building densities were then considered, each being assumed to vary in turn, while the other remained constant at the average for the group. If, for example, the average building density for a group of rounds were 300 houses per mile, and it was desired to estimate the number of households served per hour at a round density of 40 per cent, the number of houses served per mile would be 120. The number of households served per hour, when the number served per mile was 120, could be calculated from the regression equation obtained in the correlation analysis; if it were found to be 35 households per hour, this would also be the number at a round density of 40 per cent, when the building density remained constant at 300 houses per mile of street. When the number of households served per hour has been estimated in relation to given variations in the three factors, the weekly delivery costs per household and the delivery costs per gallon of milk can be calculated in the manner described above.

The results thus obtained were then utilized to eliminate, as far as possible, the effects of variations in the round and building densities and the average weekly delivery per household in determining the relationships between the physical characteristics of the delivery areas and the type of vehicle used, on the one hand, and the number of customers served per hour and the delivery costs, on the other. The rounds were grouped, where possible, according to whether they covered hilly, flat, or mixed hilly and flat areas. They were classified also according to the type of house predominant in each area into the following groups:—

(1) *Congested Areas*, where most of the houses were pre-war working-class dwellings with doors opening on to the street. Some of these areas included houses approached by three or four steps inside a gate, but this latter type of house was usually to be found in the third group.

(2) *Housing Estates*, containing, for the most part, rounds on post-war municipal housing estates, but including also some similar private estates.

(3) *Mixed Areas*, which contained considerable numbers
of both of the two types above. These areas usually
included streets with pre-war lower middle-class
houses.

In addition, there were some miscellaneous rounds which
could not be included under any of the above headings, as for
example, those in the main shopping districts and those in
residential areas with large houses.
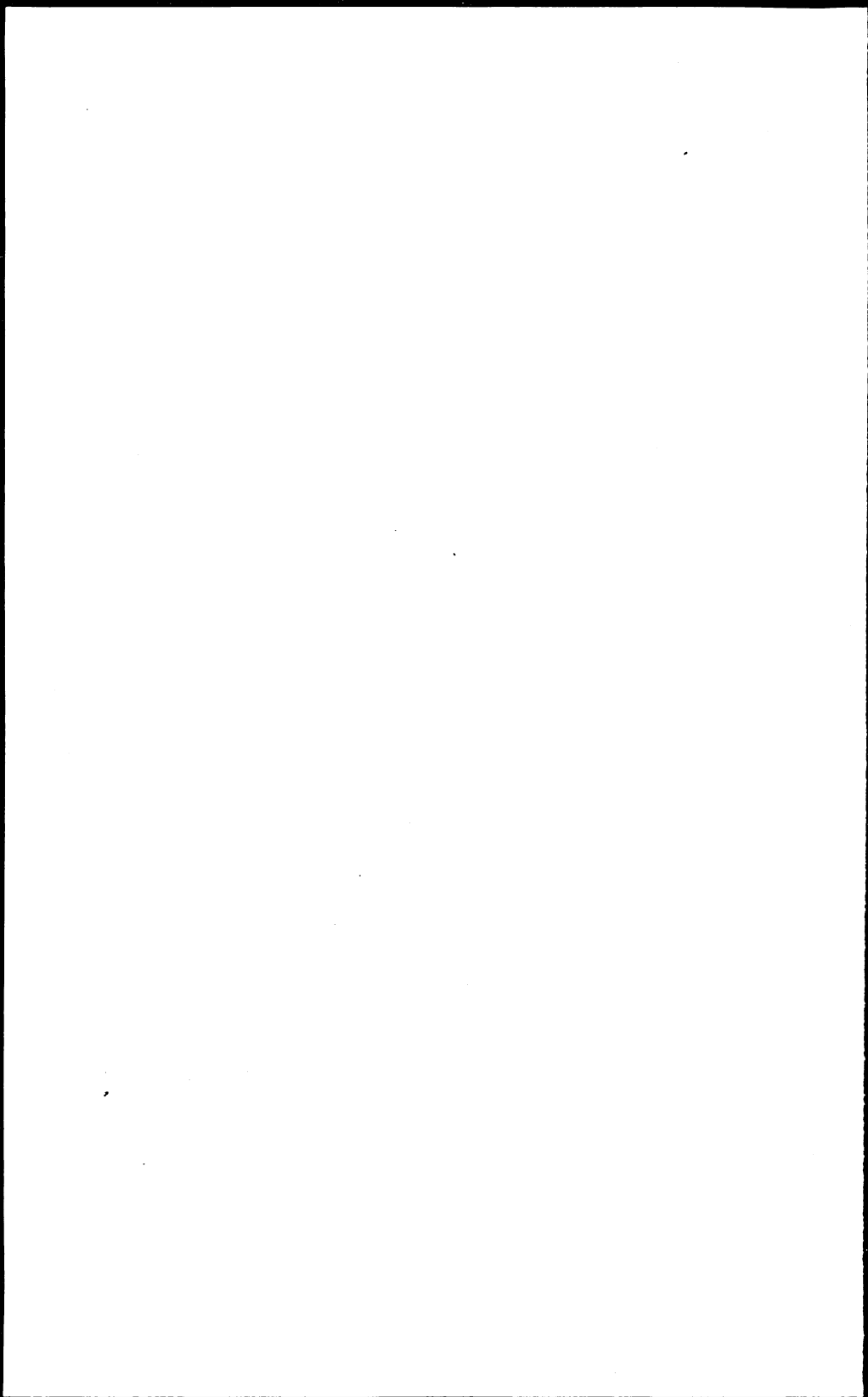
III. THE FIRST TOWN

THE first distributing business was operating under fairly favourable conditions. It covered a flat town, partly industrial and partly residential. Moreover it supplied about 40 per cent of the households, so that it was able to operate block deliveries in reasonably compact areas. But its average costs were increased to some extent by its delivery services outside the town, about 25 per cent of the milk handled being distributed in neighbouring small towns and in the rural districts within a radius of about 10 miles from the main distribution centre. The investigation was limited to the urban rounds, so that the existence of rural deliveries was important only in so far as it affected total distribution costs.

Number of Customers and Sales

Information regarding 40 rounds was collected for the week of December 5th to 12th, 1936. Six of these included a number of houses outside the town boundaries, but an additional round, for which no figures were obtained, probably covered as many houses within the town boundaries as were covered by the other six rounds outside them. The number of customers and the volume of deliveries on the 40 rounds can be regarded, therefore, as the number of customers and the volume of deliveries in the town during the week in question. They are shown in the following table, where the rounds are grouped according to the vehicles used and the types of area served.

During the week, 12,618 gallons of milk were retailed to 9,614 households in the town. In addition, some 300 gallons were sold semi-wholesale and rather less than 100 gallons as school milk. The amount of milk delivered retail to each household during the week averaged 1.31 gallons.[1]

All milk sold retail was bottled; only 169 gallons of T.T.

---

[1] This figure does not necessarily represent the average weekly milk consumption of these households, because it is probable that some, at any rate, obtain additional supplies from other sources. A consumption survey carried out during the summer of 1936, in Oxford, by Dr. K. A. H. Murray, showed that in that city no fewer than 20 per cent of the customers of one large distributor obtained additional supplies from other sources.

Table I

FIRST TOWN—TYPES OF ROUND, NUMBER OF HOUSEHOLDS
SERVED AND AMOUNT OF ·WEEKLY SALES

Type of round	Type of vehicle and area	Number of rounds	Number of households served	Weekly milk delivery	Weekly value of sundries delivered		
				gallons	£	s	d
	Barrows:						
	Congested areas	13	3,543	4,424	55	7	6½
	Housing estates	8	2,012	2,827	38	19	6
Town rounds	Miscellaneous	8	1,607	2,212	25	16	6½
		29	7,162	9,463	120	3	7
	Horse vans	3	862	1,155	30	1	7½
	Electric vans	2	260	432	8	17	3
	Total	34	8,284	11,050	159	2	5½
Rounds mainly in town	Barrows	2	397	446	5	0	9
	Electric vans	2	447	522	19	7	2
	Motor vans	2	486	600	8	12	10½
	Total	6	1,330	1,568	33	0	9½
All rounds	Total	40	9,614	12,618	192	3	3

milk were sold at 2s. 8d. per gallon; the remainder was pasteurized and sold at 2s. 4d. per gallon, the minimum price prescribed by the Milk Marketing Board for this type of area. In addition, dairy sundries were sold to the value of £192 3s. 3d. during the week, averaging 4.8d. per household. Sundries consisted of small amounts of cream and considerable quantities of eggs and butter. On a cash basis they accounted for about 11.5 per cent of the total urban sales.

Method of Distribution

This business had a central dairy, to which all milk was delivered for pasteurization and bottling. In addition, it had a number of cold-rooms about the town, where the milk was deposited from the central dairy overnight. Hand-barrows were used on 31 of the 40 rounds, the remainder being covered, 4 by electric, 3 by horse and 2 by motor vans. The latter were used mostly on rural rounds outside the town. The type of vehicle varied according to the nature of the round, and more particularly according to the distance between the delivery area and the dairy or the nearest cold-room. One roundsman was employed on each round.

All vans were able to start out with their full requirements. Hand-barrows, on the other hand, had to be serviced during the course of the rounds; empties had to be deposited and fresh supplies collected. Where the delivery area was near the central dairy or one of the cold-rooms, the roundsman could return there for fresh supplies; if it were at some distance, other arrangements had to be made. These took two forms: in some cases fresh supplies were deposited at a convenient place near the delivery area; in others a servicing van met the roundsman at a pre-arranged point on his round. Almost one-third of the hand-barrows required servicing in this way, 7 being supplied at fixed places and 6 from servicing vans.

Two deliveries were made daily to all customers requiring them, sundries being delivered usually on the second round. There was no record of the number of customers receiving two deliveries. A second delivery was not encouraged, but highly competitive conditions made its abandonment difficult.

Total Distribution Costs

The total costs of handling, processing and delivering milk in the town could not be obtained. Even if it had been possible to allocate costs in detail to the different processes and stages involved, it would still have been impossible to distinguish between the costs of urban and rural deliveries. Certain

Table II

FIRST TOWN—TOTAL DISTRIBUTION COSTS

Item	Costs per gallon	
	d	%
Wages—Outdoor staff	3.00	35
Indoor staff	1.36	16
Rolling stock (maintenance and expenses)	0.99	12
Lighting and heating	0.30	3
Rent, rates and depreciation	0.84	10
Printing and advertising*	0.11	1
Miscellaneous, trade requisites, repairs and replacements†	0.92	11
Balancing supplies and wastage	1.05	12
Total distribution costs‡	8.57	100

* Including cost of clean milk competitions
† Including national and all other insurances
‡ Excluding interest on capital and profit

general figures were available, but it must be noted that these include urban and rural deliveries, and they have been calculated on the assumption that the whole of the distribution costs were attributable to milk, no allowance being made for the costs of distributing dairy sundries. The average costs for the year July 6th 1936 to July 5th 1937 are shown in Table II.

The total costs of handling, processing and, distribution, excluding interest on capital, were 8.57*d*. per gallon, of which 1.05*d*. was incurred owing to the necessity of balancing supplies and to wastage. It was not possible from these figures to allocate costs between processing and distribution, but it may be noted that wages accounted for 51 per cent of the total costs and by far the most important single item was the wages of the outdoor staff, who were employed in connection with the delivery rounds.

Round Delivery Costs

Although no exact information regarding total delivery costs was available, certain labour and transport costs in connection with the rounds were obtained. These varied according to the type of vehicle employed. All the roundsmen worked a six-day week of 48 hours, so that a rota-roundsman was required for the remaining day of the week. Motor drivers received a wage of 58*s*. per week, whereas all other roundsmen received 56*s*. per week. The total weekly wage cost was, therefore, 67*s*. 8*d*. for motor van rounds and 65*s*. 4*d*. for all other rounds.

These earnings were augmented by a commission on sales. A weekly increase in the gallonage of milk delivered above a stated amount was paid for at the rate of $\frac{1}{2}d$. to 1*d*. per gallon according to the scale of increase, and a fixed percentage was paid on the value of sundry sales. The average weekly commission was 3*s*. 3*d*. per round. Certain deductions were also made on account of cash shortages in bookings, which had to be made good according to circumstances, but these could not be regarded as a net saving in labour costs.

The weekly cost of national insurance was approximately 1*s*. 7*d*. for each roundsman, only one or two being under 21 years of age. The average weekly employer's contribution to the superannuation fund was 1*s*. 11*d*. per roundsman. When

the insurance and superannuation contributions for rota-roundsmen had been taken into account, the total weekly cost of these two items amounted to 1s. 10d. and 2s. 3d. per round respectively. No actual figures for the costs of holidays, sickness and accidents were available, but five reserve men were employed to cover absences due to all these causes and to deal with debts and other difficulties; this was an average of one reserve man approximately to every ten rounds. If the number of reserve men proved inadequate at any time, the free day of a number of ordinary roundsmen was cancelled, overtime being paid at rate and a half for the time worked in excess of 48 hours weekly. Roundsmen were given seven, ten or fourteen days holiday with pay, the length being dependent upon the period of service. On the basis of these facts the weekly costs per round for holidays, sickness and accidents have been estimated at an average of 7s. per week.

Transport costs varied according to the type of vehicle used. For each a composite figure was obtained, covering running costs, repairs and replacements, depreciation and insurance. On this basis the weekly costs for hand-barrows were 3s. 4½d. and for horse vans 43s. 3¼d. No electric vans had been in service for a length of time sufficient to enable the actual costs to be ascertained, but the estimated weekly costs were 51s. 11d. For motor vans no estimate of the weekly costs was available.

It would appear that the costs of running hand-barrows were very small as compared with those of running vans of all types, but it must be remembered that the former had to be serviced on the rounds and could only be operated economically in several areas owing to the presence of a cold-room in the area. It was not possible to obtain details of the costs of servicing and of maintaining cold-rooms, which in their turn required supplies from the central dairy. In order that this item should not be excluded, an estimate was made of the costs of servicing hand-barrows and of maintaining and supplying cold-rooms; this amounted to 20 per cent of the labour and transport costs for barrow rounds as described above.

The costs arising from the provision of cold-rooms were divided equally among all hand-barrow rounds in order to exclude the influence of this factor upon costs, when other factors were being considered, but it is important to remember

that cold-rooms were necessary in some areas and not in others. This method of treatment tended to raise the estimated costs of delivery in the central districts of the town, where cold-rooms were not necessary, above their true level, and to depress those in districts further from the centre, where cold-rooms existed. This had important repercussions, when the comparative costs of delivery in different areas were being considered.[1]

The total weekly delivery costs for rounds operated with each type of vehicle have been summarized in the following table.

Table III

FIRST TOWN—WEEKLY DELIVERY COSTS PER ROUND

Item	Hand-barrows			Horse vans			Electric vans		
	s d	s d	%	s d	s d	%	s d	s d	%
Wages:									
Roundsman ..	56 0			56 0			56 0		
Rota roundsman ..	9 4	65 4	79†	9 4	65 4	53	9 4	65 4	50
Commission	3 3	3 3	4†	3 3	3 3	3	3 3	3 3	2
Other labour costs:									
National insurance	1 10			1 10			1 10		
Superannuation ..	2 3			2 3			2 3		
Holidays and sickness*	7 0	11 1	13†	7 0	11 1	9	7 0	11 1	8
Total labour costs ..		79 8	96†		79 8	65		79 8	60
Transport costs ..		3 4½	4†		43 3¼	35		51 11	40
Cold-room maintenance and servicing costs*		16 7	—		—			—	
Total delivery costs ..		99 7½	100†		122 11¼	100		131 7	100

* Estimated
† Excluding cold-room and servicing costs

The total weekly delivery costs for hand-barrow rounds were £4 19s. 7½d., when the costs of maintaining cold-rooms and servicing had been included. The total weekly costs for horse and electric van rounds were £6 2s. 11¼d. and £6 11s. 7d. respectively. On the basis of the above figures, when an allowance had been made for the additional costs of motor van

rounds, the average weekly delivery costs over the whole town were 4.08d. per gallon.

For all rounds labour costs averaged 85 per cent and transport costs 15 per cent of the total, if the costs of cold-room maintenance and servicing were not taken into account. But labour costs accounted for no less than 96 per cent of the total costs for hand-barrow rounds and only 65 per cent and 60 per cent respectively for horse and electric vans.

Classification of Rounds

The rounds have been grouped according to the type of vehicle used, and the hand-barrow group has been further subdivided according to the type of area covered by the rounds. Sufficient information was not available to make possible the inclusion of the two motor van rounds. Nor could any detailed conclusions be drawn from the horse and electric van groups; some material on these has been included, but their number was too limited for them to constitute a satisfactory sample.

Hand-barrow Rounds in Congested Areas

There were 13 hand-barrow rounds in the congested districts of the town, and on the average the roundsmen served 44.7 per cent of the households in these areas. The average building density was 327 houses per mile of street. The average amount of milk delivered weekly to each household was 1.25 gallons and considerable quantities of sundries were delivered in addition, so that the average weekly value of sales per household was 38.8d. The roundsmen served, on an average, 34.1 households per hour.

Changes in the number of houses served per mile and in the weekly value of sales per household accounted for 74 per cent of the observed variations in the number of households served per hour on the different rounds.[1] When the building density and the weekly value of sales were assumed to remain constant at the averages for all the rounds, changes in the round density were accompanied by the variations in the number of households served per hour and in delivery costs, shown in the following table.

[1] The regression equation was $x_1 = 45.8457 + 0.0724x_2 - 0.5777x_3$, where x_1 was the number of households served per hour, x_2 the number of houses served per mile and x_3 the weekly value of sales per household. The coefficient of multiple correlation ($\bar{R}$ 1.23) was .8575.

Table IV

FIRST TOWN—ROUND DENSITY IN CONGESTED AREAS

Round density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
%		*d*	*d*
35	31.7	4.71	3.77
40	32.9	4.54	3.63
45	34.1	4.38	3.50
50	35.3	4.24	3.39
55	36.5	4.10	3.28

As the round density rose from 35 per cent to 55 per cent, the number of households served per hour increased by 4.8, from 31.7 to 36.5. The hourly delivery costs were the same in each case, so that the weekly delivery costs per household fell proportionately by 0.61*d*. and the costs per gallon of milk by 0.49*d*.

When the other two factors were held constant at the average, the number of households served per hour increased by 1.6 for every increase of 50 in the number of houses per mile of street, as shown in Table V below. There was a reduction of 0.63*d*. in the weekly delivery costs per household and of 0.5*d*. in the costs per gallon of milk, as the building density rose from 250 to 400 houses per mile of street.

Table V

FIRST TOWN—BUILDING DENSITY IN CONGESTED AREAS

Building density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
houses per mile		*d*	*d*
250	31.6	4.74	3.79
300	33.2	4.51	3.61
350	34.8	4.30	3.44
400	36.4	4.11	3.29

Finally, the results of changes in the weekly value of sales per household appear in Table VI. Here, the delivery costs per 1*s*. unit of sales have been considered instead of the costs per gallon of milk, in order to allow for sundry as well as milk sales.

Table VI

FIRST TOWN—AMOUNT OF SALES IN CONGESTED AREAS

Weekly value of sales per household	Number of households served per hour	Weekly delivery costs per household	Delivery costs per 1s. unit of sales
d		d	d
34	36.8	4.06	1.43
36	35.7	4.19	1.40
38	34.5	4.33	1.37
40	33.4	4.48	1.35
42	32.2	4.64	1.33
44	31.1	4.81	1.31

There was a decline of 5.7 in the number of households served per hour as the weekly value of sales rose by nearly 30 per cent, from 34d. to 44d. per household. Thus, the weekly delivery costs per household rose by 0.75d. But the costs per 1s. unit of sales showed comparatively little change; they fell by 0.12d. or by 8 per cent.

Hand-barrow Rounds on Housing Estates

There were only 8 hand-barrow rounds on housing estates. The average percentage of the households served was higher than that in congested areas, at 56 per cent, but the average building density was lower at 302 houses per mile of street. Variations in the weekly value of sales per household were small, no less than 5 of the rounds showing deviations of less than 1d. from the average of 44.1d. Consequently, the effect of changes in the latter factor could not be measured, but, so far as the other two factors were concerned, the same general trends were apparent as in the first group of rounds. The roundsmen served, on the average, 31.4 customers per hour on the housing estates.

Changes in the number of houses served per mile accounted for only 24 per cent of the observed variations in the number of households served per hour on the different rounds.[1] Table VII shows the effect of changes in the round density, when the building density remained constant at the average for all the rounds.

[1] The regression equation was $y = 23.9898 + 0.0444x$ where y was the number of households served per hour, and x the number of houses served per mile. The correlation coefficient ($\bar{r}_{yx}$) was .4855.

Table VII

FIRST TOWN—ROUND DENSITY ON HOUSING ESTATES

Round density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
%		d	d
50	30.7	4.87	3.45
55	31.4	4.76	3.38
60	32.1	4.66	3.30
65	32.7	4.57	3.24

An increase in the round density from 50 per cent to 65 per cent was accompanied by a rise of 2.0 in the number of households served per hour, and a consequent reduction of 0.3d. in the weekly delivery costs per household. The average amount of milk delivered weekly to each household was 1.41 gallons, so that the delivery costs per gallon fell by 0.21d.

As the building density increased there was a rise in the number of households served per hour and a corresponding fall in delivery costs as shown in Table VIII.

Table VIII

FIRST TOWN—BUILDING DENSITY ON HOUSING ESTATES

Building density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
houses per mile		d	d
250	30.2	4.95	3.51
300	31.4	4.75	3.37
350	32.7	4.57	3.24
400	33.9	4.40	3.12

The number of households served increased by 3.7 as the building density rose from 250 to 400 houses per mile of street. This led to a reduction of 0.55d. in the weekly delivery costs per household and of 0.39d. in the costs per gallon of milk delivered.

Miscellaneous Hand-barrow Rounds

The two groups already discussed were composed of rounds operating within fairly homogeneous areas, but there were 10

further hand-barrow rounds, which could not be classified so easily and formed much smaller groups. Details of these rounds appear in Table IX below.

In the first place, there were four rounds having rather more than half the households served on housing estates and rather less than half in congested areas. On these rounds an average number of 30 households were served per hour. The average weekly delivery costs per household were 4.98*d.*, and the average delivery costs per gallon 3.69*d.*, the weekly delivery of milk averaging 1.35 gallons per household.

The remaining six rounds were significant in that they were operated under somewhat exceptional conditions, such as exist, none the less, in almost every town. Four rounds covered areas in which new housing estates were in the course of construction, with rough unmade roads and difficult delivery conditions. For two of them it was not possible to ascertain the number of houses occupied at the time of the investigation, so that no average round and building density figures were ascertainable, but they would probably not have been exceptionally low. The average weekly delivery costs per household were 6.65*d.* and, as the amount of milk delivered to each household weekly was only 1.23 gallons, the average delivery costs amounted to 5.41*d.* per gallon.

The two remaining rounds showed still higher costs in relation to the number of households served and the volume of milk deliveries. These were both in the centre of the town and covered the main shopping districts, which contained, in addition to the shops, numerous public buildings; as a result the building density was very low. Only 20.3 households were served hourly on these two rounds, so that the average weekly delivery costs per household were 7.36*d.*, but the average amount of milk delivered to each customer was as high as 1.47 gallons per week, so that the delivery costs for milk averaged only 5.01*d.* per gallon.

Horse Van Rounds

Horse vans were employed on 3 rounds, all covering districts distant from the central dairy, whence they operated. The average round density of the horse van rounds was 31.9 per cent and the average building density 231 houses per mile of

C

street. The number of houses served per hour averaged 35.9, a figure considerably higher than that which would be expected for hand-barrow rounds under similar conditions. The weekly delivery costs per household averaged 5.13*d*. and the costs of delivery for milk 3.83*d*. per gallon, with an average weekly delivery of 1.34 gallons per household.

Electric Van Rounds

Electric vans were used on four rounds, one of which was quite exceptional. It covered an area with large residential houses, one or two schools, and a number of public buildings; its building density was only 134 houses per mile of street and the round density was as low as 13.1 per cent. The weekly delivery costs per household were no less than 18.36*d*., and it was only the high weekly milk delivery of 1.93 gallons per household that kept the costs down to 9.51*d*. per gallon.

The other three electric van rounds had an average round density of 37.6 per cent. and an average building density of 201 houses per mile of street. The average number of houses served per hour was only 25.9, or just 10 below the average for horse van rounds, in spite of the higher round density figure. The weekly delivery costs at 7.63*d*. per household averaged as much as 49 per cent more than on rounds served with horse vans. The amount of milk delivered per household was 1.28 gallons per week, the delivery costs averaging 5.96*d*. per gallon.

Delivery Areas

The great diversity of conditions obtaining between the different groups, particularly with regard to round and building densities, made comparisons between them difficult. But the details for each group are shown in Table IX.

The average round densities differed considerably, and it was only in considering the first two groups of rounds that the detailed effect of round density changes upon costs could be estimated. If the average round density had been 50 per cent for each of the two groups, the average number of households served per hour would have been 4.6 higher in the congested districts than on housing estates, so that weekly delivery costs per household would have been lower by 0.63*d*. in the former. This was due in part to the difference in the average building

Table IX

FIRST TOWN—AVERAGE ROUND AND BUILDING DENSITIES
AND WEEKLY SALES FOR ALL ROUNDS

Type of round	No. of r'ds	Round density	Build-ing den-sity	Weekly value of sales per house-hold	Num-ber of house-holds served per hour	Weekly deliv-ery costs per house-hold	Weekly milk deliv-ery per house-hold	Deliv-ery costs per gallon of milk
		%	houses per mile	d		d	gal-lons	d
Handbarrow rounds								
Congested areas	13	44.7	327	38.8	34.1	4.39	1.25	3.51
Housing estates	8	56.0	302	44.1	31.4	4.75	1.41	3.37
Miscellaneous areas:								
Mixed areas	4	39.3	253	42.1	30.0	4.98	1.35	3.69
Housing estates under construc-tion	4	—	—	37.5	22.5	6.65	1.23	5.41
Central business area	2	30.3	169	44.5	20.3	7.36	1.47	5.01
Horse van rounds	3	31.9	231	45.9	35.9	5.13	1.34	3.83
Electric van rounds*	3	37.6	201	45.8	25.9	7.63	1.28	5.96

* Excluding the first of these rounds referred to on p. 34.

density of the two areas, but, even when this was assumed to be 300 houses per mile of street for each, the number of house-holds served per hour was still 3.64 lower on the housing estates. The greater amount of weekly sales per household on the latter would probably account for part of this difference, but most of it must have been due to the lay-out of the estates and to the fact that the houses stand well back from the street, delivery having to be made, in many cases, at the rear of the house. At the same time, it may be noted that the difference in the number of households served per hour was 5.1 at a round density of 55 per cent, compared with 4.6 at one of 50 per cent, because the rate of increase in the number of households served per unit rise in the round density was greater for rounds in congested areas than for those on housing estates. The average amount of milk delivered weekly was 1.41 gallons per household on the housing estates, compared with 1.25 gallons in the congested

areas. Consequently the delivery costs were only 0.06*d*. per gallon higher in the former districts at a round density of 50 per cent.

However, the above comparison does not give a true idea of the difference in costs of delivery in congested areas and on housing estates. The main dairy was not centrally situated, but it was sufficiently close to the congested areas for the latter to be served from it without much difficulty. Most of the housing estate areas, on the other hand, were so far distant from the main dairy that cold-rooms had to be maintained on them, and part of the additional costs of delivery was due to the necessity of maintaining and supplying these cold-rooms. But this has not been brought out in the figures, because the costs arising out of the existence of cold-rooms were averaged out over all hand-barrow rounds in order to eliminate differences in costs due to this cause in considering the effect of other factors upon costs.[1] Thus, the actual difference in delivery costs between the two types of area must be appreciably greater than the above comparison would indicate, although the additional costs on housing estates arising from the existence of cold-rooms could not be acccurately determined.

The average number of households served per hour in the mixed areas was lower than in the congested housing districts by 4.1, but this was due entirely to the lower round and building densities in the former group. In fact, the number was approximately the same as that estimated for rounds in congested areas with similar round and building densities, and so it was substantially greater than that to be expected on housing estates under similar conditions. The average delivery costs per gallon of milk were actually lower in these mixed areas than they would have been in congested areas under similar conditions, the average weekly delivery of milk amounting to 1.35 gallons per household in the former, compared with 1.25 gallons in the latter.

The average number of households served per hour on the remaining miscellaneous hand-barrow rounds was much lower than in the other areas. This was due partly to the lower round and building densities, but also to the special conditions under which these rounds were being operated; four covered housing

[1] See p. 28.

estates under construction and two the central shopping districts. Such rounds exist in nearly every town, and their effect in raising the average delivery costs for the town as a whole cannot be ignored.

Vehicles

The number of horse and electric vans in use was so small as to prevent any detailed comparison with hand-barrows. The vans were employed on housing estates and in residential areas, mainly on the outskirts of the town. Consequently, the average building density was low, and, in the absence of cold-rooms, they had to travel considerable distances to and from the delivery areas.

Roundsmen working with horse vans served, on the average, 31.9 per cent of the households in the districts covered by their rounds, compared with 56 per cent of the households served by roundsmen with hand-barrows on housing estates. Nevertheless, they averaged 35.9 households per hour compared with 31.4 households per hour served by the latter. The total weekly costs of a horse van round were higher, however, than those of a hand-barrow round, even when the costs of servicing and maintaining the necessary cold-room were included. The average weekly delivery costs per household were 5.13*d.* for horse van rounds, compared with 4.75*d.* for hand-barrow rounds on housing estates, but it has already been explained that this latter figure does not make full allowance for the cost of cold-room maintenance and supply. When the lower round and building densities on horse van rounds were taken into account, it appeared that the delivery costs per household on these rounds compared very favourably with the costs that would probably have been incurred, if hand-barrows, working from a cold-room or from the main dairy, had been employed in the same areas.

Three electric vans were in use in areas similar to those covered by horse vans. The average density of the rounds served by the former was above that of those served by the latter, but their building density was lower. The average number of households served per hour on electric van rounds was 10 less, however, than on horse van rounds, and the running costs of electric vans were considerably greater than

those of horse vans, so that the average weekly costs per house-
hold were 7.63d. compared with 5.13d. for the latter. Thus, the
use of horse vans appeared to be more economical than that of
electric vans, and the latter did not compare at all favourably
with hand-barrows, even when the differences in the conditions
under which they operated were taken into account. The costs
of running electric vans were no more than estimates, based
upon a limited period of service, but they would have to be very
greatly reduced in order to justify the use of electric vans on
the grounds of economy in the place of horse vans or hand-
barrows.[1]

[1] Subsequent experience is reported to have shown that the use of electric
vans is more economical than was anticipated on the basis of the original
estimates.

IV. THE SECOND TOWN

THE second milk distributing business was operating under general conditions at least as favourable as those experienced by the first concern. It covered part of a large industrial centre and served about one-third of the households in its area, while in some districts the proportion was much larger. The business had between 200 and 250 rounds, on which approximately 142,000 gallons of milk were being retailed weekly. No school milk was handled, and only 350 gallons were sold on semi-wholesale terms during the week. The average weekly turnover was about £15,000.

Number of Customers and Sales

Information relating to 30 rounds was obtained for a week in July, 1937. All of these were operated within the town boundaries, and the following table shows the total number of households served and the amount of milk delivered on the rounds grouped according to the types of area served.

Table X

SECOND TOWN—TYPES OF ROUND, NUMBER OF HOUSEHOLDS SERVED AND AMOUNT OF WEEKLY SALES

Type of vehicle and area	Number of rounds	Number of households served	Weekly milk delivery
			gallons
Horse vans:			
Congested areas	8	4,321	5,639
Corporation housing estates ..	13	6,062	8,319
Middle-class housing estates ..	7	2,999	3,874
Miscellaneous	2	869	1,216
Total	30	14,251	19,048

During the week, 19,048 gallons of milk were retailed to 14,251 householders on the 30 rounds. All milk was bottled after being sterilized or pasteurized; no T.T. milk was sold. The price of pasteurized milk in July 1937 was 2s. per gallon,

39

sterilized milk being sold at an additional 2*d.* per gallon. No dairy sundries were sold apart from a very small quantity of cream, of which no account has been taken in considering costs. The average amount of milk delivered during the week to each customer was 1.34 gallons.[1]

Method of Distribution

The milk was delivered by producers to a central dairy, whence all roundsmen started out on their daily rounds.[2] Horse vans were employed on the rounds investigated, each being accompanied by a roundsman and a boy assistant. This concern operated a small number of electric vans and the view was expressed that these travelled more rapidly to and from the delivery areas, but were slower than horse vans on the actual delivery.

All four businesses referred to in this study operated block delivery systems, but none so strictly as this second concern. Under no circumstances were deliveries permitted between the dairy and the allotted delivery area. Moreover, the boundaries of the different areas had to be strictly observed so that no roundsman was permitted to serve a customer outside his area in order to make a delivery at a particular time requested by the customer, even if this merely involved crossing a street, one side of which was within his area and the other outside of it.

Only one delivery was given daily. Moreover, a charge of 1*d.* was made on each bottle delivered, a very unusual practice, which undoubtedly helped to reduce distribution costs by keeping bottle losses down to a minimum.

Total Distribution and Round Delivery Costs

No detailed figures were available to show the total distribution costs of this concern, but it was stated that the costs of handling, processing and distribution averaged about 7*d.* per gallon in July 1937; this figure did not make any allowance for profits, but included interest and depreciation on buildings, as well as the costs of repairs, renewals and maintenance of

[1] See footnote on p. 23.

[2] This was not to apply when new dairies, in course of construction at the time of the investigation, were in operation on the outskirts of the city. The new dairies were made necessary by the rapid growth of the business, but it was not anticipated that they would lead to a reduction in distribution costs; on the contrary, it was suggested that they might have an opposite effect.

plant and fixtures. The average delivery costs were estimated at about $4d.$ per gallon; in addition, rather more than $\frac{1}{2}d.$ per gallon was attributed to the costs of book-keeping and administration of the rounds. But the costs of labour and materials were rising very rapidly in the summer of 1937 and this, together with the anticipated cost increases on account of decentralization, made an increase in these figures probable in the latter part of that year.

The average delivery costs on the 30 rounds investigated were $3.36d.$ per gallon. These were lower than the average costs for all rounds owing to the favourable conditions under which these 30 rounds were being operated. None of them covered central shopping districts, high-class residential areas or housing estates still under construction, and, although a high proportion of them were concerned with housing estate areas, their average round density was well above the average for the rounds as a whole.

The roundsmen were all paid the full adult wage of $66s.$ per week, even when they were under 21 years of age. Their assistants, boys of 17 years or under, were paid an average wage of $21s.$ per week. The assistants were either promoted to the position of roundsmen or dismissed after the age of 17 years, according to the degree of aptitude they had developed for work of this kind. All round employees worked a nominal 6-day week of 48 hours, although in practice most worked a shorter week and some a longer one; they were not expected to do any supplementary work in the dairy on returning from their rounds. A rota-roundsman and assistant were employed to cover the seventh day for each round, and they received wages of $75s.$ and $30s.$ per week respectively.

Two commissions were paid in addition to the standard wages. One was on sales, $1d.$ being paid for every gallon sold during the week in excess of 500 gallons. The actual average amount of milk delivered per round weekly was approximately 600 gallons, so that the average sales commission was about $8s.$ per week. A second commission was paid quarterly on the number of bottles returned by the roundsman, at the rate of $5d.$ per 1,000 bottles; if bottles were missing, they were debited against this commission at the rate of $1d.$ per bottle. In this way a roundsman and his assistant might earn an additional

14s. to 15s. per quarter. Out of every 1d. paid in commissions, the roundsman received ¾d. and his assistant ¼d.

There were also certain other charges under the heading of labour costs. National Health and Unemployment Insurance cost on the average 2s. per round, and 1s. 7d. had to be paid into the superannuation fund. Finally, the cost of holidays and sickness amounted, on the average, to 4s. 4d. and 2s. 6d. respectively for each round. Thus, the total weekly labour costs were £6 4s. 5d. per round.

The weekly transport costs for each round, on which horse vans were used, were £2 13s. 0d. The weekly costs of operating a horse van, including repairs, depreciation and insurance, were 44s. 6d., but an extra horse had to be kept for every 6 in service, adding 4s. to the costs. Motors also had to be maintained for service purposes at an average weekly cost of 4s. 6d. per round.

Table XI

SECOND TOWN—WEEKLY DELIVERY COSTS PER ROUND

Item				Weekly delivery costs per round						
				£	s	d	£	s	d	%
Wages:										
Roundsman	..	..	..	3	6	0				
Assistant	..	..	..	1	1	0				
Rota roundsman	..	..	..		12	6				
Rota assistant	..	..	..		5	0				
							5	4	6	59
Commissions:										
Sales..	..	..	..		8	0				
Bottles	..	..	..		1	6				
								9	6	5
Other labour charges:										
National insurance	..	..		2	0				
Superannuation	..	..	..		1	7				
Holidays	..	..	..		4	4				
Sickness	..	..	..		2	6				
								10	5	6
Transport:										
Horse and van	..	..	..	2	4	6				
Reserve horse	..	..	..		4	0				
Motor	..	..	..		4	6				
							2	13	0	30
Total delivery costs	..						8	17	5	100

The total weekly delivery costs per round, comprising labour and transport costs, are summarized in Table XI. The total weekly delivery costs amounted to £8 17s. 5d. per round; 70 per cent of this sum represented labour costs and the remaining 30 per cent transport costs.

Treatment of Delivery Costs

The weekly costs of each round were £8 17s. 5d., irrespective of the time spent upon it. If the average time spent on each round were assumed to be 56 hours per week, the delivery costs amounted to 38.02d. per hour. But, in practice, more than 56 hours were spent on some rounds and less on others. Now, it is customary for milk distributing concerns so to regulate the size of their rounds that each occupies the full 56 hours, where a 6-day week is in operation, or the full 48 hours, where a 7-day week exists; alternatively the roundsmen have to work in the dairy on their return when the rounds occupy a shorter period. The costs of the rounds will then be the same whether they are calculated on a weekly or on an hourly basis. Any increase in the number of households served per hour will be fully reflected in a reduction in the weekly delivery costs per household.

In the case of the second concern, however, an increase in the number of households served per hour frequently resulted in a reduction in the number of hours worked by the roundsman, because he was not required to work in the dairy on his return, nor was the number of houses to be served by him necessarily increased, in order to keep him fully occupied. For example, a rise in the round density from 25 to 50 per cent might lead to a rise in the number of households served per hour and to a reduction in the time spent in serving a given number of households. The roundsman might enjoy the benefits of this reduction, in the form of increased leisure, and so an increase in the round density would not result in a reduction in the weekly delivery costs per household. In order to emphasize the effects upon delivery costs of the factors considered, it has been assumed that changes in these factors will result in such changes in the number of households served as will keep the roundsman fully occupied for the standard number of hours each week. Costs have therefore been

calculated on an hourly basis of 38.02*d.* per hour and not on a weekly basis of £8 17*s.* 5*d.* per week.[1]

In this second town all the roundsmen started from the central dairy and the time spent by each in going to and from the delivery areas varied considerably. To eliminate the effects of these variations upon costs when other factors were being considered, the latter were examined, in the first instance, in relation to that part of the delivery costs which was incurred within the delivery areas; that is, they were calculated on the basis of the number of households served per hour spent in the delivery areas only. At a later stage, when percentage changes in delivery costs were being considered and it was still desirable to exclude the influence of differences in the distances between the main dairy and the delivery areas, the average costs incurred in travelling to and from the delivery areas for each group of rounds were added to the costs actually incurred within each area, in order to arrive at the total delivery costs. For example, where the weekly delivery costs incurred outside the delivery areas averaged 1.58*d.* per household for one group of rounds, and the estimated weekly costs incurred within the area at a round density of 50 per cent were 2.12*d.* per household, the total estimated weekly delivery costs at this round density were taken to be 3.70*d.* per household.

Classification of Rounds

The rounds were grouped according to the type of area covered by each. The first two groups consisted of congested working-class districts and corporation housing estates respectively, and the third covered recently developed middle-class estates. Two rounds covered areas with so many different types of house that they could not be included in any of the three groups.

Rounds in Congested Areas

There were 8 rounds covering districts with congested working-class houses, some of them being of the back-to-back

---

[1] The average time spent on the 30 rounds was 55.78 hours per week so that there was no appreciable difference in the average costs for all rounds, whether calculated on an hourly or weekly basis. On the former the average costs were 4.44*d.*, and on the latter, 4.45*d.* per household. But this did not apply to each of the separate groups considered. Thus, in one, the average time spent on the rounds was only 50.55 hours per week, so that the weekly delivery costs per household were 3.94*d.* when calculated on a weekly basis and only 3.56*d.* on an hourly basis.

type. The average round density was 64.2 per cent and the average building density 418 houses per mile of street. The average amount of milk delivered weekly per household varied very little between the different rounds, the average for all the rounds being 1.30 gallons, and no attempt could be made to estimate the influence of this factor upon costs. The number of households served per hour averaged 137.4, when only the time spent in the delivery areas was taken into account.

Changes in the number of houses served per mile accounted for 32 per cent of the observed variations in the average number of households served per hour.[1] When the building density was assumed to remain constant at the average for all the rounds, changes in the round density were accompanied by the variations in the number of households served per hour spent in the delivery area and in delivery costs, shown in Table XII.

Table XII

SECOND TOWN—ROUND DENSITY IN CONGESTED AREAS

Round density	Number of households served per hour spent in delivery area	Weekly delivery costs per household		Delivery costs per gallon of milk	
		Within delivery area	Total	Within delivery area	Total
%		d	d	d	d
50	125.8	2.12	3.70	1.63	2.85
55	130.0	2.05	3.63	1.58	2.80
60	134.2	1.98	3.56	1.52	2.74
65	138.5	1.92	3.50	1.48	2.70

As the round density increased from 50 per cent to 65 per cent, the number of households served per hour rose by 12.7. This resulted in a decrease of 0.20*d.* in the weekly delivery costs per household and of 0.15*d.* per gallon in the delivery costs for milk.

Changes in the building density had an equally marked effect upon delivery costs, when the round density was assumed

[1] The regression equation was $y = 83.5073 + 0.2023x$, where y was the number of households served per hour spent in the delivery area and x the number of houses served per mile in the area. The correlation coefficient ($\bar{r}_{yx}$) was .5690.

to remain constant at the average. As the building density
rose from 350 to 500 houses per mile of street, the number of

Table XIII

SECOND TOWN—BUILDING DENSITY IN CONGESTED AREAS

Building density	Number of households served per hour spent in delivery area	Weekly delivery costs per household		Delivery costs per gallon of milk	
		Within delivery area	Total	Within delivery area	Total
houses per mile		d	d	d	d
350	129.0	2.06	3.64	1.58	2.80
400	135.5	1.96	3.54	1.51	2.73
450	142.0	1.87	3.45	1.44	2.66
500	148.5	1.79	3.37	1.38	2.60

households served per hour increased by 19.5, and the weekly
delivery costs per household declined by 0.27d.; the delivery
costs for milk fell by 0.2d. per gallon.

Rounds on Corporation Housing Estates

There were 13 rounds in this group with an average round
density of 53.8 per cent and an average building density of
304 houses per mile of street. The roundsmen served, on the
average, 132.7 households per hour spent in the delivery
areas, and delivered 1.37 gallons of milk to each household
during the week.

There was no apparent connection between changes in the
average amount of milk delivered to each household and the
observed variations in the average number of households
served per hour on the different rounds. But changes in the
number of houses served per mile accounted for 34 per cent
of the observed variations,[1] and the effect of round density
changes upon the average number of households served per
hour spent in the delivery area and upon delivery costs can be
seen in the following table:

[1] The regression equation was $y = 83.8608 + 0.3027x$, where y was the number
of households served per hour spent in the delivery area and x the number
of houses served per mile in the area. The correlation coefficient $(\bar{r}_{yx})$ was
.5837.

Table XIV

SECOND TOWN—ROUND DENSITY ON CORPORATION HOUSING ESTATES

Round density	Number of households served per hour spent in delivery area	Weekly delivery costs per household		Delivery costs per gallon of milk	
		Within delivery area	Total	Within delivery area	Total
%		d	d	d	d
45	125.3	2.12	4.81	1.55	3.51
50	129.9	2.05	4.74	1.50	3.46
55	134.5	1.98	4.67	1.45	3.41
60	139.1	1.91	4.60	1.39	3.35
65	143.7	1.85	4.54	1.35	3.31

As the round density increased from 45 per cent to 65 per cent, the average number of households served per hour rose from 125.3 to 143.7. The weekly delivery costs declined by 0.27d. per household and the delivery costs for milk by 0.20d. per gallon.

Changes in the building density were accompanied by the variations in delivery costs shown in Table XV, when the round density was assumed to remain constant at the average for the group.

Table XV

SECOND TOWN—BUILDING DENSITY ON CORPORATION HOUSING ESTATES

Building density	Number of households served per hour spent in delivery area	Weekly delivery costs per household		Delivery costs per gallon of milk	
		Within delivery area	Total	Within delivery area	Total
houses per mile		d	d	d	d
250	124.6	2.29	4.98	1.56	3.52
300	132.7	2.14	4.83	1.47	3.43
350	140.9	2.01	4.70	1.38	3.34

As the building density rose from 250 to 350 houses per mile of street, there was an increase of 16.3 in the number of

households served per hour. The weekly delivery costs per household fell by 0.28*d*. and the costs per gallon of milk by 0.18*d*.

Rounds on Middle-Class Housing Estates

There were only 7 of these rounds, with an average round density of 38.3 and an average building density of 248 houses per mile of street. The number of households served per hour spent in the delivery areas averaged 119.3, but there was no apparent connection between variations in the number of households served per hour and the number of houses served per mile. The size of the group was so small as to deprive such relationships, as did at first appear to exist, of any significance, when allowance had been made for this fact.

Delivery Areas

The average round and building densities varied considerably between the three groups of rounds, and this resulted in differences in the average number of households served per hour spent in the delivery areas, as Table XVI indicates.

Table XVI

SECOND TOWN—AVERAGE ROUND AND BUILDING DENSITIES AND NUMBER OF HOUSEHOLDS SERVED PER HOUR FOR ALL ROUNDS

Type of round	*Number of rounds*	*Round density*	*Building density*	*Number of households served per hour spent in delivery area*	*Number of households served per hour at 55 per cent. round density*
		%	houses per mile		
Congested areas	8	64.2	418	137.4	130.0
Corporation estates	13	53.8	304	132.7	134.5
Middle-class estates	7	38.3	248	119.3	—

The average number of households served per hour was greatest in the congested areas, when only the time spent inside the

delivery areas was taken into account, owing to the high average round density of 64.2 per cent. At a round density of 55 per cent the number was rather lower in the congested areas than on the Corporation housing estates. The average number of households served per hour was lowest on middle-class housing estates. Here it was not possible to estimate what the number might have been at a round density of 55 per cent, but the actual number was not sufficiently low to suggest that there would have been any material difference in the number of households served per hour at this round density compared with the other two groups. In fact, so long as only the time spent within the delivery areas and the costs there incurred were being considered, there was nothing to suggest that the average number of households served per hour or the weekly delivery costs per household would differ substantially between the three groups under similar round density conditions.

Much of the roundsmen's time was spent, however, in travelling to and from their delivery areas, the average time varying considerably between the three groups of rounds. The first group in congested areas covered a district much closer to the dairy than the other two groups. In the second group, 10 rounds were on a Corporation housing estate near the north-eastern borders of the town and 2 were on a similar estate on the south-eastern edge of the town, only 1 of the 13 rounds being situated in the more central district covered mainly by the first group. Finally, the 7 rounds in the third group all operated on a middle-class housing estate in the south-eastern district at a considerable distance from the dairy.

These differences in the distances of the delivery areas from the dairy were reflected in the average amount of time spent by the roundsmen in getting to and from their delivery areas each week. The average times are shown in Table XVII to have been 33.0 and 32.9 hours per week on the Corporation and middle-class housing estates respectively; in the congested areas the average time was only 22.5 hours.

The total weekly delivery costs per household on the rounds in congested areas were 0.88d. below the average for all rounds, while the portion of these costs incurred in travelling between the dairy and the delivery areas was 0.81d. below the average. When the high round density of this group was taken into

D

Table XVII

SECOND TOWN—DELIVERY AREAS

Type of area	Dairy to dairy			Dairy to delivery area and back		
		Weekly Delivery costs per household			Weekly Delivery costs per household	
	Time spent weekly on rounds	Actual	Deviation from the average for all rounds	Time spent weekly travelling between dairy and delivery areas	Actual	Deviation from the average for all rounds
	hours	d	d	hours	d	d
Congested areas	50.6	3.56	− 0.88	22.5	1.58	− 0.81
Corporation estates	57.7	4.71	+ 0.27	33.0	2.69	+ 0.30
Middle-class estates	58.2	5.16	+ 0.72	32.9	2.92	+ 0.53
All rounds	55.8	4.44	—	30.0	2.39	—

account, it was clear that the comparatively short distances between these delivery areas and the dairy fully accounted for the difference in the total delivery costs per household between the congested areas group and the average for all groups.

On the Corporation housing estates the part of the delivery costs per household incurred in travelling to and from the delivery areas was 0.3*d*. above the average, whereas the total delivery costs per household were only 0.27*d*. higher, so that the difference in the distance between the dairy and the delivery areas again fully accounted for the difference in the total delivery costs per household between this group and the average for all the groups.

For the rounds on middle-class housing estates the position was slightly different. It has already been observed that the low round and building densities of this group increased the costs incurred within the delivery areas themselves above the average on all rounds. But it was still apparent that the deviation of the total weekly delivery costs per household from the average was mainly due to the greater distance of these rounds from the dairy. They were 0.72*d*. above the average, whereas that part of these costs incurred in travelling between the dairy and the delivery areas exceeded the average for all the rounds by 0.53*d*.

The average weekly delivery costs per household were higher, therefore, on the Corporation and middle-class housing estates than in the congested areas. When the differences in the average round densities of the three groups had been taken into account, the actual costs incurred within the delivery areas were very similar, and the higher delivery costs on the housing estates appeared to be due almost wholly to their greater distance from the centre of the town and consequently from the dairy, whence all the roundsmen operated.
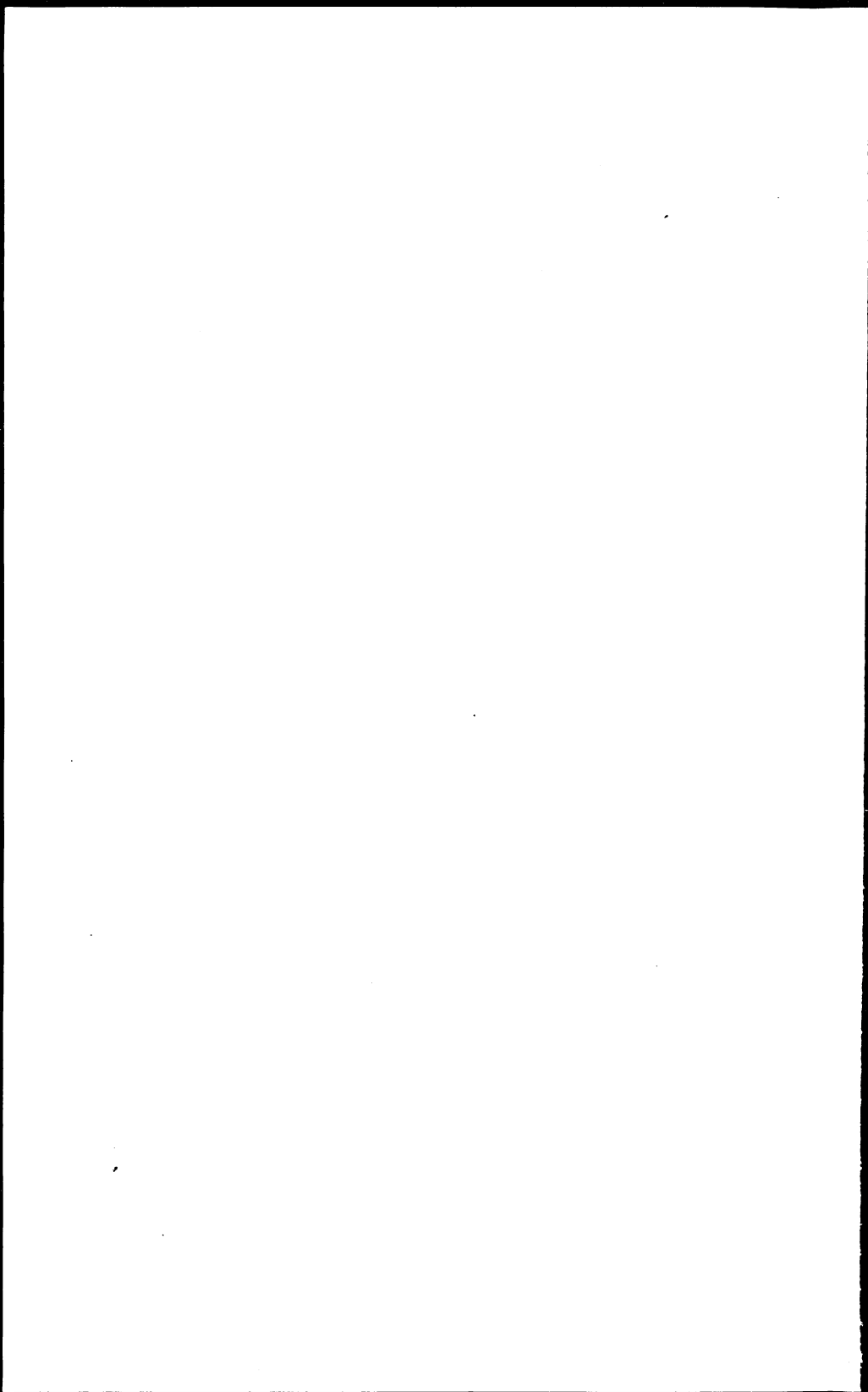
V. THE THIRD TOWN

THE third business was operating under conditions distinctly less favourable than those experienced by the first and second concerns. It covered a town which was partly residential and had few industries; it was mainly a distribution and transport centre. Many parts of it were very hilly and some contained a multiplicity of small courts and alleys, where the delivery vehicles could not penetrate. This business served almost exactly one quarter of the households in the town, but it also undertook deliveries outside, although on a smaller scale than the first concern. These out-of-town deliveries, in one or two small neighbouring towns, amounted to no more than 285 gallons per week, but a further 719 gallons were distributed on three rounds operated partly within and partly without the town boundaries. Full information relating to these rounds was not available, and they are important for this study only in so far as they tended to raise average costs above those obtaining in the town itself.

Number of Customers and Sales

Detailed information regarding the 25 rounds confined within the town boundaries was collected for the week of February 28th to March 6th, 1937. During this period, 5,224 gallons of milk were delivered to 4,544 households as is shown in Table XVIII.[1]

In addition, semi-wholesale sales during the week amounted to 318 gallons and sales of school milk to approximately 35 gallons, but this milk was not distributed on the retail rounds. The average amount delivered retail to each customer during the week was 1.15 gallons.[2]

The greater part of the milk was pasteurized and bottled, 4,383 gallons being sold at the price of 2s. 4d. a gallon, the minimum price prescribed for this type of area. Only 148 gallons of T.T. milk were sold. The remaining 693 gallons

---

[1] These figures do not include customers and deliveries within the town on the three rounds partly within and partly without the town boundaries.
[2] See footnote on p. 23.

THE THIRD TOWN

Table XVIII

THIRD TOWN—TYPES OF ROUND, NUMBER OF HOUSEHOLDS SERVED AND AMOUNT OF WEEKLY SALES

Type of vehicle and area	Number of rounds	Number of households served	Weekly milk delivery	Weekly value of sundries delivered
			gallons	£ s d
Hand-barrows:				
Congested areas ..	6	743	793	13 17 3½
Housing estates ..	2	216	257	11 19 9½
Mixed areas ..	1	163	164	7 4 9¾
Horse vans:				
Congested areas ..	7	1,541	1,840	66 10 4¼
Mixed areas ..	4	778	930	30 19 8
Tri-cars	5	1,103	1,240	59 9 7¾
Total ..	25	4,544	5,224	190 1 6¾

consisted of scald milk[1], sold 'loose' at the price of 1s. a gallon. Dairy sundries were also sold on the rounds to the value of £190 1s. 6¾d., or 10.04d. per customer, during the week. If all the milk had been retailed at 2s. 4d. a gallon, the value of sundry sales would have amounted to nearly 24 per cent of the value of all sales; but, in fact, the average price realized on milk was lower on account of the lower price of scald milk, so that sundry sales actually accounted for a rather larger percentage of the value of the total sales. Sundries consisted of cream, eggs and butter.

Method of Distribution

All milk was delivered by producers to a dairy in the centre of the town, where it was processed and prepared for distribution. Of the 25 roundsmen working on town rounds, 22 started out from and returned to the central dairy; the 3 remaining ones, serving an outlying housing estate, received their supplies at a shop, to which the milk was taken in the morning from the central dairy. Fresh supplies were taken out to the roundsman in the middle of his round in one case only, but this practice was to be developed and already empty bottles were being picked up by a motor van at certain points on some rounds.

[1] *Scald milk* is the milk from which clotted cream has been taken; it has a butter-fat content of 1 to 1.2 per cent.

Nominally, all roundsmen worked a 7-day week of 48 hours but during the week of the survey 15 roundsmen spent less than 48 hours on their rounds and 10 spent more, the maximum being 51.25 hours. The average time spent on each of the 25 rounds was 47.29 hours. One roundsman was employed on each round.

The types of vehicle used varied mainly according to the distance of the delivery area from the dairy. Three types were employed, namely hand-barrows, horse vans and tri-cars. There were 9 hand-barrows operating either in the districts round the dairy or on the outlying housing estate, to which supplies were sent in the first place by motor van. Rounds covering areas rather more distant from the dairy were served by 11 horse vans, while 5 tri-cars were employed on the outskirts of the town.

Two daily deliveries were made where required, but only 6 per cent of the households served actually received a second delivery. On 17 of the 25 rounds only one delivery was made each day.

Total Distribution Costs

The total inclusive costs of handling, processing and delivery averaged 8.59*d.* per gallon. These included interest on capital invested in buildings and plant, and were arrived at on the assumption that all costs were attributable to milk deliveries, no allowance being made for the costs of delivering dairy sundries. They included the costs of rural as well as urban deliveries.

Round Delivery Costs

No figures were available for the costs of each stage of distribution, but information obtained regarding labour and transport costs have enabled an estimate of urban delivery costs to be made. Labour costs were assumed to have been the same for all roundsmen, although in fact they varied according to age. On the 25 town rounds, 27 men were employed, two being held in reserve in case of absences. Of these, 21 were adults, receiving the full minimum wage prescribed by the Milk Distributive Trade Board for England and Wales. The 6 remaining roundsmen varied in age from 15 to 20 years and were paid at the appropriate minimum rates. The average

weekly wage was thus 48s. 1d. for a 7-day week of 48 hours. No commissions were paid.

The cost of National Health and Unemployment Insurance averaged 1s. 6d. per week for each man and the concern's weekly contribution to the superannuation fund was approximately 1s. 2½d. or 2½ per cent of the average wage. Two reserve men were employed to deal with absences due to holidays, sickness or accidents, but normally these men were employed on the indoor staff. On occasions extra assistance had to be secured from outside at the cost of about £40 a year. On the assumption that the two reserve men spent an equal amount of time working in the dairy and on the rounds, the weekly costs of holidays, sickness and accidents were estimated to average 2s. 8d. per round. Each roundsman had one week's holiday with pay during the year.

Transport costs, including running expenses, repairs and depreciation, varied with the type of vehicle used. The costs for hand-barrows averaged 3s. 6d. per week; for horse vans they were approximately 32s. 6d. per week. Tri-cars had only recently been introduced, largely owing to the difficulty in getting good horses; their estimated weekly costs were 77s., but this figure might have to be revised considerably later.

The total weekly delivery costs for each type of vehicle have been summarized in the following table:

Table XIX

THIRD TOWN—WEEKLY DELIVERY COSTS PER ROUND

Item	Hand-barrows			Horse vans			Tri-cars		
	£	s	d	£	s	d	£	s	d
Labour costs:									
Wages	2	8	1	2	8	1	2	8	1
National insurance		1	6		1	6		1	6
Superannuation		1	2½		1	2½		1	2½
Holiday, sickness, accidents* ..		2	8		2	8		2	8
Transport costs		3	6	1	12	6	3	17	0*
Total delivery costs	2	16	11½	4	5	11½	6	10	5½*
Proportion of labour to total costs (per cent)		94			62			41*	

* Estimated

The total delivery costs were £2 16s. 11½d. for hand-barrows, £4 5s. 11½d. for horse vans and £6 10s. 5½d. for tri-cars, the percentage of the total costs accounted for by labour varying from 94 per cent for hand-barrows to 41 per cent for tri-cars. The average total delivery costs for the 25 urban rounds were 4.85d. per gallon, when dairy sundries were left out of account. Labour costs averaged 63 per cent and transport costs 37 per cent of the total.

Classification of Rounds

The 25 urban rounds were operated under very varying conditions. Some had two daily deliveries and others only one; some covered very hilly districts, while others served houses in level areas; some were in congested areas, others on housing estates, and the remainder in mixed areas of no very uniform type; finally some were served with hand-barrows, some with horse vans and others with tri-cars. In fact, the diversity of conditions was such that it was impossible to select comparatively homogeneous groups of rounds large enough to measure the effect of round and building density changes upon the average number of households served per hour or upon delivery costs. In general, however, the results obtained for individual rounds pointed to conclusions similar to those obtained elsewhere. A low round or building density was usually associated with a low average number of households served per hour and, consequently, was accompanied by high delivery costs, whereas the delivery costs were lowest where the round and building densities were highest. Furthermore, the available evidence suggested that an increase in the value of weekly sales per household was not accompanied by a corresponding increase in the weekly delivery costs, so that the delivery costs per unit of sales tended to fall as the value of weekly sales increased.

The conditions under which the rounds were operated, however, were such as to make possible a more detailed examination of the influence upon costs of certain other factors, namely the number of daily deliveries, the topographical nature of the delivery areas, and the type of vehicle employed. Each of these was considered in turn, use being made of the general conclusions obtained here and elsewhere regarding the

effect of changes in the round and building densities and in the value of weekly sales per household upon costs, in order to make the comparisons more complete.

The average round density for the 25 rounds was 25.3 per cent and the average building density 254 houses per mile of street, as is shown in Table XXII below. The average number of households served per hour varied considerably according to the type of vehicle used, but the average for all the rounds amounted to 26.9 households, and weekly delivery costs averaged 5.47d. per household. Considerable quantities of sundries were delivered on all the rounds, but the whole of the delivery costs were allocated to milk and on this basis they averaged 4.76d. per gallon, the average amount delivered weekly to each household being 1.15 gallons.

Number of Daily Deliveries

In the first place, the rounds were grouped according to the number of daily deliveries on each, as shown in Table XX. Two deliveries were made on about one-third of the rounds; but only 278 households, or 6 per cent of the total number served, required a second delivery, and even on the 8 rounds with two, no less than 79 per cent of the households were content with one delivery. The area covered on the second delivery was rarely the same as that covered on the first, and was in most cases more extensive.

Of the 9 hand-barrow rounds, 6 were in congested housing areas and on 4 of these no second deliveries were necessary. The average number of households served per hour on the 4 rounds was 19.6, whereas the number was only 14.6 on the 2 two-delivery rounds. The average round density was the same in both cases, but the average building density was very much lower and the average weekly value of sales per household somewhat higher on the two-delivery rounds. This could not have accounted, however, for so large a difference as, in fact, existed between the two groups. The average weekly delivery costs per household were 1.77d. higher in the two-delivery group and at least half this difference may be attributed to the provision of a second delivery. The average delivery costs for milk were 0.63d. higher in the two-delivery than in the one-delivery group and this difference would have been

Table XX

THIRD TOWN—NUMBER OF DAILY DELIVERIES

Type of vehicle and area, and number of daily dliveries	Number of rounds	Round density *	Build-ing density *	Weekly milk delivery per house-hold	Number of house-holds served per hour	Weekly delivery costs per house-hold	Delivery costs per gallon of milk
		%	houses per mile	gallons		d	d
Hand-barrows (Congested areas)							
One delivery	4	22.4	329	1.02	19.6	5.08	4.98
Two deliveries	2	22.4	213	1.22	14.6	6.85	5.61
Horse vans (Con-gested areas):							
One delivery	4	26.6	328	1.19	35.0	4.30	3.61
Two deliveries	3	23.5	318	1.20	31.8	4.74	3.95
Tri-cars (All areas):							
One delivery	3	29.6	202	1.17	37.4	6.10	5.21
Two deliveries	2	26.0	143	1.02	27.4	8.34	8.18
All vehicles (All areas):							
One delivery	17	25.7	269	1.15	28.2	5.15	4.48
Two deliveries	8	24.5	224	1.15	24.1	6.28	5.46

* These figures refer to first deliveries only

considerably greater, had not the average weekly delivery per household been 1.22 gallons in the former, compared with 1.02 gallons in the latter.

There were 11 horse van rounds, and 7 of these covered congested housing areas in 3 of which two deliveries were made. Here, the difference in the average number of households served per hour between the one- and two-delivery groups was only 3.2, and part of this was due to the lower round density in the latter group. Where two deliveries were made, the average weekly delivery costs per household were only 0.44d. higher and the average costs for milk only 0.34d. per gallon higher than on one-delivery rounds, the average amount of milk delivered to each household being almost the same. It appeared, therefore, that the costs of a second delivery were not so great where horse vans were used as where hand-barrows were employed. This may have been due to the greater speed

of horse vans, owing to the scattered nature of the second parts of two-delivery rounds and the considerable distances between the houses served.

The 5 tri-car rounds all covered similar types of area on the outskirts of the town, and two daily deliveries were made on 2 of the rounds. When two deliveries were provided, the average number of households served per hour was 10 fewer than on the single-delivery rounds. Consequently, the average weekly delivery costs per household were higher by 2.24d.; the costs for milk averaged 2.97d. higher, but this was due partly to the considerably greater amount delivered to each household in the one-delivery group. These cost differences were accentuated by the higher average round and building densities of the rounds with a single daily delivery, and their effect would not have been offset by the very much greater average value of weekly sales per household on these rounds. Nevertheless, when allowance had been made for these other factors, it was clear that the second delivery substantially increased distribution costs on the two-delivery rounds operated with tri-cars.

Two daily deliveries were provided on 8 of the 25 rounds surveyed. The weekly delivery costs per household averaged 1.13d. more than on the remaining 17 rounds. The average amount of milk delivered weekly per household was 1.15 gallons in each case, so that there was a difference of 0.98d. in the average delivery costs per gallon of milk. There was little in the general conditions obtaining for each group to suggest that their costs would not be approximately the same, but the average round and building densities were rather lower on the 8 rounds with two deliveries, which would have tended to exaggerate the cost differences due to variations in the number of daily deliveries. When full allowance had been made for this, however, the average weekly delivery costs per household were nearly 1d. higher on two-delivery than on one-delivery rounds, and the difference in the milk delivery costs was rather more than 0.75d. per gallon.

If the provision of a second daily delivery was assumed to add 0.75d. to the delivery costs per gallon, the demand for two deliveries on the part of 6 per cent of this distributors' customers raised the average delivery costs on all the urban rounds by 0.2d. per gallon. On the other hand, it might be suggested that

the additional cost of this service should be borne by those who benefit from it, and then the households receiving two deliveries would have to bear additional costs to the extent of 3.6*d*. per gallon.

Topographical Differences in Delivery Areas

The topographical conditions under which the rounds were operated had a marked influence upon delivery costs. The tri-cars covered areas very different in other respects from those on which hand-barrows and horse vans were used, so that they have been omitted from this section. The 20 remaining rounds have been included in Table XXI below in groups covering hilly, flat or mixed areas.

Table XXI

THIRD TOWN—TOPOGRAPHICAL DIFFERENCES IN DELIVERY AREAS

Type of area	Number of rounds	Round density *	Building density *	Weekly milk delivery per household	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
		%	houses per mile	gallons		d	d
Hilly ..	7	23.5	281	1.16	22.1	5.83	5.03
Flat ..	6	24.7	344	1.16	29.1	4.26	3.67
Mixed	7	25.2	259	1.15	25.6	5.04	4.38
All areas	20	24.5	290	1.16	25.4	5.02	4.33

* These figures refer to first deliveries only

In the hilly and flat groups the proportion of rounds in congested, mixed and housing estate districts and the proportion served with hand-barrows and horse vans was very similar. But two deliveries were provided on 3 hilly rounds and on only 1 flat round, which would have raised the costs of the hilly group above the average. Moreover, the hilly rounds had a slightly lower average round density and a considerably lower average building density, which would again have tended to increase their relative costs. But these differences could not have accounted for the fact that the average number of households served per hour on hilly rounds was 7 below the average

number on flat rounds. In the former group the average weekly delivery costs per household were 5.83*d*. and .the costs of delivering milk 5.03*d*. per gallon, whereas, in the latter, they averaged 4.26*d*. and 3.67*d*. respectively, the average amount of milk delivered weekly to each household being 1.16 gallons for both groups. When full allowance had been made for the more favourable conditions obtaining in the group of flat rounds, it appeared that the weekly delivery costs averaged at least 1*d*. per household lower, and the average delivery costs for milk not less than 0.85*d*. per gallon lower on the flat rounds than on those in hilly districts. In the mixed areas costs were midway between those in hilly and in flat districts.

Vehicles

Finally, all the rounds were grouped according to the type of vehicle used on each, as shown in Table XXII. But it must be remembered that, although one type of vehicle might at first

Table XXII

THIRD TOWN—VEHICLES

Type of vehicle	Number of rounds	Round density *	Build-ing density *	Weekly milk delivery per house-hold	Number of house-holds served per hour	Weekly delivery costs per house-hold	deliv-ery costs per gallon of milk
		%	houses per mile	gallons		*d*	*d*
All rounds:							
Hand-barrows	9	23.9	283	1.09	18.2	5.48	5.03
Horse vans	11	24.8	293	1.20	31.3	4.80	4.00
Tri-cars	5	28.3	176	1.12	33.4	6.85	6.12
All vehicles	25	25.3	254	1.15	26.9	5.47	4.76
Rounds in conges-gested areas only:							
One Delivery:							
Hand-barrows	4	22.4	329	1.02	19.6	5.08	4.98
Horse vans	4	26.6	328	1.19	35.0	4.30	3.61
Two Deliveries:							
Hand-barrows	2	22.4	213	1.22	14.6	6.85	5.61
Horse vans	3	23.5	318	1.20	31.8	4.74	3.95

* These figures refer to first deliveries only

sight have appeared to have been more economical than another, it did not necessarily follow that it would have paid to have substituted that type for all others. The conditions under which each vehicle was operated had to be considered.

There was little difference in the average round and building densities of the hand-barrow and horse-van groups. Moreover, the geographical conditions and the proportion of rounds with two deliveries were very similar in each case. There were 2 hand-barrow rounds on housing estates, but 4 horse-van rounds covered mixed areas compared with only 1 hand-barrow round. The delivery areas served by horse-vans were farther from the central dairy than those covered by hand-barrows, but the greater speed of the former probably rendered this of little importance. Thus, conditions generally were such as to suggest the probability of fairly equal costs between the two groups. But the average number of households served per hour was only 18.2 on hand-barrow rounds, compared with 31.3 on those covered by horse vans.

The weekly running costs of horse vans were 32s. 6d. compared with 3s. 6d. for hand-barrows, but the superior performance of the former more than counteracted the effect of this difference in running costs. The average weekly delivery costs per household were 5.48d. for hand-barrow rounds and only 4.80d. for those covered by horse vans. The difference was even greater for the delivery costs per gallon of milk owing to the greater amount of milk delivered weekly to each household on horse-van rounds; for the latter they averaged 4d., compared with 5.03d. per gallon. The horse-van rounds were considerably less costly, therefore, than the hand-barrow rounds, and while this did not mean that it would have paid the business to replace all its hand-barrows with horse vans, it would almost certainly have been uneconomical to extend their use, especially as the new hand-barrow rounds would have been further from the central dairy than the existing ones. And it would probably have paid to substitute horse vans for hand-barrows on certain of the rounds.

There was some difficulty, however, in obtaining suitable horses and good horse-men, and it was partly for this reason that tri-cars were introduced. Costs on the five rounds, where they were employed, would in any case have been high owing

to the distances between the delivery areas and the central dairy and to the very low building density for the group, although the rather high average round density would have offset the effect of the latter to some extent. Tri-cars were able to travel to and from the delivery areas more rapidly than the other types of vehicle, and the average number of households served per hour was highest where they were in use, but their running costs were more than twice as great as those of horse vans.[1] The average weekly delivery costs per household were 6.85d. for the tri-car rounds, or 2.05d. higher than those for horse-van rounds, and the difference in the delivery costs per gallon of milk was slightly larger, owing to the greater average milk delivery per household on the latter. If horse vans had been used on the five tri-car rounds, the costs would have been considerably above the average costs for the existing horse van rounds for reasons already indicated, but they would probably still have been substantially below existing costs on the five rounds. On the other hand, hand-barrows could hardly have been used here in the absence of cold-rooms or sub-depots, owing to the distance of the delivery areas from the central dairy.

[1] The running costs of tri-cars could only be estimated owing to their short period of service and this fact must be borne in mind, when they are being compared with the running costs of other vehicles.

VI. THE FOURTH TOWN

THE fourth distributing concern was situated in an important market town with a population not exceeding 15,000. But it served a neighbouring town, some 20 miles distant, and several surrounding villages. In the market town its roundsmen served 47 per cent of the households.

Number of Customers and Sales

In the main town there were 9 rounds, one of which extended outside the town boundaries. Information regarding these was obtained for the week May 20th to 26th, 1937. During this period 2,082 gallons of milk were delivered to 1,900 households, the amount delivered weekly to each household averaging 1.10 gallons.[1]

All milk was pasteurized and bottled, no T.T. milk being handled. In May 1937 it was being sold at 2s. per gallon, the minimum price prescribed by the Milk Marketing Board for towns of this size. Small quantities of cream were also delivered, but their total cash value was only 16s. 9d. during the week.

Method of Distribution

The concern had a central dairy, to which producers delivered all milk. The 9 roundsmen working in the town operated from these central premises with hand-barrows; 2 returned there for fresh supplies during their rounds, but the remainder had supplies brought to them by a motor van, which also collected their empty bottles. One roundsman was employed on each round and there was only one daily delivery.

Total Distribution and Round Delivery Costs

The total average distribution costs of the business had little bearing upon the costs incurred within the town itself, because rather more than half the milk was delivered outside of it. But the town delivery costs were estimated on the basis of such information as was available as to labour and transport costs.

All roundsmen worked a 7-day week of 48 hours; 40 hours

---

[1] See footnote on p. 23.

were spent on the rounds and 8 in the dairy. The majority of the roundsmen were under 21 years of age and they were paid the appropriate minimum rates. There were no commissions. The ages of the roundsmen, together with their weekly wages and the cost to the concern of National Health and Unemployment Insurance, are shown in the following table.

Table XXIII

FOURTH TOWN—AVERAGE WEEKLY LABOUR COSTS

Age of roundsman	Number of roundsmen	Average weekly wage		Average weekly cost of national insurance	
		s	d	s	d
21 or over	2	52	0	1	7
19	3	40	6	1	6
18	1	35	0	1	6
16	3	19	0	1	3
Total average		35	$3\frac{1}{3}$	1	$5\frac{1}{3}$

The average weekly wage was 35s. $3\frac{1}{3}d$.; with an additional 1s. $5\frac{1}{3}d$. for insurance and 8d. for the superannuation fund, the total weekly cost per roundsman averaged 37s. $4\frac{2}{3}d$.

No figures were available for the average weekly cost of holidays, sickness and accidents, but this has been estimated at 3s. per roundsman. Thus, the average weekly labour costs per roundsman amounted to 40s. $4\frac{2}{3}d$., but part was chargeable to work in the dairy, where each man spent one-sixth of his time each week. The weekly labour costs, therefore, averaged 33s. $7\frac{3}{4}d$. per round.

The hand-barrows cost £26 when new and their estimated length of service was 6 years. During this period the cost of minor repairs averaged approximately £7, and the average running costs were about 5s. per annum. When allowance had been made for major repairs and insurance, weekly transport costs averaged about 3s. per round.

It was not possible to arrive at an exact figure for the costs of servicing hand-barrows in the middle of the rounds, but these have been charged on the basis of 10 per cent of the total

delivery costs and have been estimated, therefore, at 3s. 8d. per round weekly. Thus, the average weekly delivery costs amounted to 40s. 3¾d. per round for the 9 town rounds, equivalent to 12.09d. per hour. The weekly delivery costs for milk averaged 2.09d. per gallon over the whole town, 92 per cent of which represented labour costs and only 8 per cent transport costs.

Town Rounds

The round and building densities of the round, which lay partly outside the urban boundaries, could not be ascertained, but these were measured for the 8 remaining rounds. There were no considerable variations in the average amounts of milk delivered weekly per household and the building density was very similar on 5 of the 8 rounds, so that only round density changes were examined in relation to the average number of households served per hour and delivery costs.

The round density averaged 47.3 per cent for the 8 rounds and changes in the number of houses served per mile accounted for 24 per cent of the observed variations in the average number of households served per hour on the different rounds.[1] The effect of round density changes is shown in the following table.

Table XXIV

FOURTH TOWN—ROUND DENSITY

Round density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
%		d	d
40	35.6	2.37	2.17
45	36.6	2.31	2.11
50	37.5	2.26	2.07
55	38.5	2.20	2.01
60	39.4	2.15	1.97

As the round density increased from 40 per cent to 60 per cent, the number of households served per hour rose by 3.8, and the

[1] The regression equation was $y = 28.0919 + 0.0626x$, where y was the number of households served per hour and x the number of houses served per mile. The correlation coefficient ($\bar{r}_{yx}$) was .4941.

weekly delivery costs fell by 0.22*d.* per household. Owing to
the low average weekly milk delivery of 1.10 gallons per house-
hold, the delivery costs for milk were little below the weekly
costs per household; they declined by 0.20*d.* per gallon.

Delivery Areas

The areas covered by these rounds were not of a uniform
type as is indicated in the following table:

Table XXV

FOURTH TOWN—DELIVERY AREAS

Type of area	Number of rounds	Round density	Number of households served per hour	Weekly delivery costs per household	Delivery costs per gallon of milk
		%		d	d
Congested areas:					
Without shops	2	47.2	41.1	2.06	1.88
With shops	1	44.6	35.7	2.37	2.17
Mixed areas	3	48.1	35.6	2.38	2.18
Housing estates	2	52.7	35.7	2.37	2.17

On housing estates the average round density was as high as
52.7 per cent, compared with 47.2 per cent in congested areas
without shops, but the average number of households served per
hour was nevertheless 5.4 higher in the latter, and the average
weekly delivery costs were lower by 0.31*d.* per household. This
was reflected in a difference of 0.29*d.* per gallon in the delivery
costs for milk. When the effect of round density differences
were taken into account, the costs in the shopping district and
in mixed areas were between those in congested areas and on
housing estates. It was clear that, even in a comparatively
small town where distances were not great, there were marked
differences in delivery costs in the different types of delivery
area.

VII. THE FOUR TOWNS — A COMPARISON

Total Distribution and Round Delivery Costs

The four milk distributing firms were operating under such different conditions that no close comparison between them was possible. The total distribution costs, excluding interest on capital and profits, were highest in the first town at 8.57*d.* per gallon. This was due to the extent to which the firm undertook the distribution of milk and dairy sundries in neighbouring small towns and rural areas, which together accounted for about 25 per cent of its total sales. Its urban delivery costs were only 4.08*d.* per gallon, and there was no reason to suppose that its wholesaling and processing costs were above the average.

The relatively high costs of extra-urban deliveries also served to raise the average distribution costs of the third distributor. The costs obtained included interest on capital, but not profits, and amounted to 8.59*d.* per gallon. If interest on capital were excluded, they would be slightly below those of the first concern. The proportion of rural to urban sales was much lower than in the previous case and urban delivery costs were substantially higher at 4.85*d.* per gallon, partly owing to the lower average weekly delivery of 1.15 gallons, compared with 1.31 gallons per household.

The total distribution costs of the second business were estimated at 7*d.* per gallon before provision had been made for profits. This was about 1½*d.* lower than those of the other two concerns, but no rural deliveries were undertaken. The urban delivery costs were estimated at 4*d.* per gallon, but they averaged only 3.36*d.* per gallon on the 30 rounds investigated, with an average weekly delivery of 1.34 gallons per household.

No figure for the total costs of distribution of the fourth business was available, but round delivery costs were very much lower than elsewhere; they averaged only 2.09*d.* per gallon, or little more than half the average for the second concern, which had the next lowest costs. This was due mainly to the employment of juvenile labour and to lower average wage rates as indicated below, but the size of the town was

partly responsible. None of the delivery areas was very far from the central dairy, so that hand-barrows, with low weekly costs, could be employed on all rounds without the necessity of incurring additional costs for the maintenance of sub-depots in the delivery areas. A motor van serviced the hand-barrows on the majority of the rounds, but here again the costs were probably lower than they would have been in a larger town owing to the smaller distances to be covered. Thus, the size of the fourth town favoured low delivery costs and, in addition, the average round density was higher here than elsewhere, the roundsmen serving, on the average, every second household in the town. Moreover, no dairy sundries were delivered and no second deliveries were made.

Delivery costs were next lowest in the second town, which was very much larger than any of the others, the average distance between the delivery areas and the dairy being, as a result, much greater. It is impossible to state how far this difficulty could have been overcome by decentralization, but the view was expressed that decentralization would not reduce delivery costs, owing to the expense of maintaining and supplying a number of depots scattered over the town. Thus, the size of the town appeared to be unfavourable to low delivery costs while, on the average, only about one-third of the households were served, compared with rather more than 40 per cent served by the first distributor. On the other hand, milk was only delivered once daily to each household, no sundries were distributed apart from very small quantities of cream, and a charge was made on all bottles. The wages and commissions paid to adult roundsmen were very much higher than those paid elsewhere, but each adult had a boy assistant, and the average wage and commission per man or boy was lower than the average paid to adult roundsmen employed in the first town.

The first business had delivery costs very little higher than those of the second, although two deliveries were made to a large number of households and dairy sundries were distributed, amounting in value to 11.5 per cent of the total value of sales. But the density of the rounds was greater and the town itself was smaller. Under ordinary circumstances a centralized system of distribution would have been preferred in a town of

this size, but decentralization was adopted owing to the straggling and extended nature of the town and to the difficulty of finding a central site for a dairy with accommodation adequate to avoid congestion.

Delivery costs were highest for the third distributor. This was due partly to the topography of the town, which was very hilly in some districts. Two deliveries were made only to a small proportion of the households served, but the number was sufficient to raise the average delivery costs over the whole town. Moreover, the proportion of the total number of households served was lower than that of the other concerns and more than twice as many dairy sundries were distributed weekly to each household as were distributed in the first town; the value of sundry sales was about 25 per cent of the value of all sales. On the other hand, the third town was rather smaller than the first and very much smaller than the second; and the average weekly wage was substantially lower than that paid elsewhere, except in the fourth town, nor were any commissions paid.

Labour Costs

The importance of labour costs varied according to the type of vehicle employed on the rounds. Where hand-barrows were used, labour accounted for 96 per cent of the round delivery costs, excluding those incurred in maintaining and servicing cold-rooms or other depots, in the first, 94 per cent in the third, and 92 per cent in the fourth town. When horse vans were operated by one roundsman only, labour costs amounted to 65 per cent and 62 per cent of the delivery costs; but they accounted for 70 per cent of the latter, when both a roundsman and an assistant were employed on each round. Where electric vans and tri-cars were in use, labour costs amounted to 60 per cent and 41 per cent of the delivery costs respectively.

It has been seen already that the business operating in the fourth town had average delivery costs very much below those obtaining in the other three, and this was due mainly to differences in average labour costs. The fourth distributor paid no commissions to his roundsmen, only two of whom were 21 years of age or over. If no juvenile labour had been employed, the average wage would have been 13*d*. instead of 8.76*d*. per hour, an increase of 48 per cent. It is reasonable,

however, to expect a certain proportion of the employees to be under 21 years of age, and the average hourly wage of 1s., paid by the third concern, may be regarded as the normal minimum; this was still 37 per cent above the average for the fourth concern.

The first and second firms paid wages considerably above the required minima and gave commissions on sales in addition, although the second employed one juvenile to every adult roundsman. The first concern, using mainly hand-barrows, incurred average labour costs per employee at the rate of 17.07d. per hour, compared with 10.09d. per hour incurred by the fourth business. Thus the average hourly labour costs of the latter were 41 per cent lower and the lower average weekly delivery costs were due very largely to this difference. Results somewhat similar appeared from a comparison between the fourth business, on the one hand, and the second and third businesses on the other, when the different types of vehicle used were taken into account.

It is difficult to exaggerate the importance of labour costs in relation to total delivery costs, especially where hand-barrows and, to a lesser extent, where horse-vans are employed. Moreover, labour appeared also to be much the most important single item in total distribution costs. For the first business, wage costs, excluding national insurance and superannuation payments, amounted to 50 per cent of the total costs; the practice of this concern of employing hand-barrows on a large scale tended to maximize the importance of labour costs, but there was no reason to suppose that the proportion would have been substantially lower in the other towns.

Transport Costs

While labour costs were responsible for the greater part of total delivery costs, transport costs were of great importance in some instances. Electric vans and tri-cars had not been operated long enough for more than tentative estimates of their running costs to be made. They were both used on out-lying rounds, where costs would, at any rate, have been well above the average. Undoubtedly they had the advantage of greater speed in travelling to and from the delivery areas, and tri-cars compared favourably with horse vans and hand-

barrows in the third town in terms of the number of households served per hour by the roundsmen operating them, although electric vans did not have any advantage in this respect over the other types of vehicle used by the first distributor. But, unless the estimates of costs of running electric vans[1] and tri-cars should prove to be excessive, there is no reason to suppose that they will be more economical in use than horse vans, even on the rounds farthest from the dairy. Tri-cars were, in fact, introduced into the third town mainly owing to the difficulty of getting suitable horses.

Adequate information for a comparison between horse vans and hand-barrows was available only in the third town. Here the horse-van rounds were considerably less costly than the hand-barrow rounds although both types of vehicle were operated from the same centre and the hand-barrows were used in the areas adjoining the centre, while the horse vans covered those farther afield. The town contained several very hilly districts and it is possible that these conditions favoured the use of horse vans. At any rate the latter appeared to be more economical than hand-barrows, when all distribution was undertaken from a central dairy, except possibly on those rounds immediately adjacent to the dairy itself.

In the first town the machinery of distribution was decentralized and there were no hilly districts. Under such circumstances hand-barrows were the most economical form of transport. In one section of the town, however, the number of customers was insufficient to justify the maintenance of a separate cold-room, and the cost of operating rounds with horse vans was considerably less than it would have been if hand-barrows had been employed.

Again, in the fourth and smallest town, hand-barrows were the most economical, especially for a business which served a high proportion of the households in the town.

Round Density

The proportion of the households served to the total number of households in the town varied from about 25 per cent for

---

[1] Subsequent experience is reported to have shown electric vans in a more favourable light. The original estimate for running and maintenance costs appears to have been too high.

the third to rather more than 47 per cent for the fourth distributor. The first served about 40 per cent of the households and the second about 33 per cent in the area covered by its operations, but the proportion served by the second was 51 per cent on the 30 rounds investigated.

The effect of changes in the density of the rounds was measured in five groups, two in the first, two in the second and one in the fourth town. In the first two towns one group was made up of rounds in congested areas and the other of those on housing estates; in the fourth town the rounds covered various types of area. The effects of variations in the building density and the average amount of milk and sundries delivered weekly per household within each group were eliminated, where such variations existed to any marked extent and appeared to have some direct bearing upon costs.

The influence of changes in round density upon the total weekly delivery costs per household and upon the costs of delivery per gallon of milk are shown in the following table:

Table XXVI

ALL TOWNS—ROUND DENSITY

Town	Round density (%)	45	50	55	60	65
		d	d	d	d	d
	Weekly delivery costs per household					
I	Congested areas ..	4.38	4.24	4.10	—	—
	Housing estates ..	—	4.87	4.76	4.66	4.57
II	Congested areas ..	—	3.70	3.63	3.56	3.50
	Housing estates ..	4.81	4.74	4.67	4.60	4.54
IV	All areas	2.31	2.26	2.20	2.15	—
	Delivery costs per gallon of milk					
I	Congested areas ..	3.50	3.39	3.28	—	—
	Housing estates ..	—	3.45	3.38	3.30	3.24
II	Congested areas ..	—	2.85	2.80	2.74	2.70
	Housing estates ..	3.51	3.46	3.41	3.35	3.31
IV	All areas	2.11	2.07	2.01	1.97	—

In all five groups costs fell as the round density increased, but the extent of the reduction differed in each group. In the first two towns the percentage decline was greater in congested areas than on housing estates over a given round density range,

but, in the second town, the rate of fall was greater on the housing estates. As the round density increased from 50 per cent to 55 per cent, the weekly costs per household fell by 3.3 per cent in congested areas and by 2.3 per cent on housing estates in the first town; in the second, the reductions amounted to 1.9 per cent and 1.5 per cent respectively.

The difference in the percentage fall was more marked as between the groups of rounds in each town. In the first, where distribution was decentralized and hand-barrows were used, one roundsman being employed on each round, the cost fell comparatively rapidly as the round density increased. In the fourth town, also, the weekly cost per household fell by 2.7 per cent as the round density rose from 50 per cent to 55 per cent, hand-barrows being used on all the rounds. In the second town, on the other hand, the fall was less pronounced; here distribution was centralized and the rounds were operated with horse vans, two persons being employed on each. The fall in the costs of delivery per gallon of milk was in each case proportionate to the fall in the weekly costs per household. No results were obtained in the third town owing to the diversity of the conditions under which the rounds were operated, but, in general, there was the same downward trend in costs as the round density increased.

Building Density

The density of buildings was measured in terms of the number of houses per mile of street. As in the case of round density the percentage decline in costs was somewhat greater in congested areas than on housing estates. In the first town, as the building density rose from 250 to 350 houses per mile of street, there was a fall in the weekly delivery costs per household of 9.3 per cent in congested areas and of 7.7 per cent on housing estates. In the second town the fall was not so marked, amounting only to 5.6 per cent over the same building density range on housing estates; in congested areas the average building density was considerably higher, and the percentage decline was very similar to that on the housing estates. In the other two towns there appeared to be a general downward trend in costs as the building density increased, but no detailed results were obtainable.

Table XXVII

ALL TOWNS—BUILDING DENSITY

Town	Building density (houses per mile)	250	300	350	400	450
	Weekly delivery costs per household					
I	Congested areas ..	4.74	4.51	4.50	4.11	—
	Housing estates ..	4.95	4.75	4.57	4.40	—
II	Congested areas ..	—	—	3.64	3.54	3.45
	Housing estates ..	4.98	4.83	4.70	—	—
	Delivery costs per gallon of milk					
I	Congested areas ..	3.79	3.61	3.44	3.29	—
	Housing estates ..	3.57	3.37	3.24	3.12	—
II	Congested areas ..	—	—	2.80	2.73	2.66
	Housing estates ..	3.52	3.43	3.34	—	—

Weekly Sales

Variations in the amount of milk and sundries delivered to each household were so small in three groups that their influence could not be examined, while the results obtained for the remaining two groups were to some extent contradictory. In the second town, no sundries were delivered apart from negligible quantities of cream, and there was no apparent relationship between the amount of milk sold and the weekly delivery costs per household on housing estates, when the influence of round and building density changes had been excluded. The actual amount of milk delivered weekly per household averaged between 1.25 gallons and 1.45 gallons, the latter representing an increase of 16 per cent over the lower figure. It appeared, therefore, that, where only milk was delivered and no more than one daily delivery was made, the weekly costs per household were unaffected by such an increase. Thus, the delivery costs per gallon of milk fell considerably as the amount sold to each customer increased.

The first firm delivered sundries as well as milk and it made two deliveries to a large number of households, sundries being sold usually on the second delivery. There was a marked increase in the weekly costs per household in congested areas as the average value of weekly sales per household increased; but the increase was not sufficient to prevent a small decline in the delivery costs per unit value of sales, although this was by

no means so great as on the housing estate rounds in the second town.

Again, no detailed evidence was available from the rounds operated by the third firm, which distributed sundries on a much larger scale than the first, but made a smaller number of second deliveries. In general, however, the results indicated a downward trend in the delivery costs per unit value of sales as the value of weekly sales per household increased, more marked than that obtaining in the first town. The fourth firm only delivered milk, but the variations between the rounds were so small that their effect upon costs could not be determined.

Number of Daily Deliveries

A single daily delivery of milk was made by the second and fourth distributors. The first, on the other hand, gave two deliveries to a large, but unknown number of households. Undoubtedly the demand for a second delivery reacted unfavourably upon the delivery costs of the latter and great efforts were being made to cut down the number of second deliveries to a minimum. But the conditions under which the two firms operated were so different, that it was impossible to compare their costs with reference to a single factor of this nature. In the third town, on the other hand, the number of second deliveries was ascertained, and it was possible to make a comparison between the rounds on which one delivery was given and those on which a certain number of households received two deliveries.

Two deliveries were given daily to 6 per cent of the customers of the third firm. These took place on 8 of the 25 urban rounds, and 21 per cent of the households received two deliveries. When other factors affecting costs had been taken into account, it appeared that the average delivery costs per gallon of milk were at least 0.75*d*. higher on the rounds with two daily deliveries than on those with only one daily delivery. The net result was an increase of 0.2*d*. per gallon in the average delivery costs over the whole town. If the households demanding two deliveries had had to bear the full costs of the second delivery themselves, their milk would have cost them 3.6*d*. per gallon more than it cost households which were satisfied with the single daily delivery.

Topographical Differences

There was very little difference in the topographical charac-
teristics of the first, second and fourth towns; all covered areas
predominantly flat with no gradients of any importance. But
there were several very hilly districts in the third town, in
addition to those that were either wholly or partly flat. It was
possible, therefore, to estimate the effect of topographical
differences upon delivery costs in this town. The average
weekly delivery costs appeared to be at least 1*d.* per household
greater in the hilly than in the flat districts, and this was
equivalent to a difference of about 0.85*d.* per gallon in the
average milk delivery costs. In mixed districts the average
delivery costs were approximately midway between those of
the other two groups.

Delivery Areas

Some comparison between the costs of delivery in districts
with different types of development was possible in each town.
In most instances the new housing estates were at some distance
from the centre, so that costs on them were bound to be greater
than those in the older and more central congested areas. But
the exact nature and extent of the difference depended to a
large extent upon the methods of distribution adopted.

The first distributor maintained a number of cold rooms or
sub-depots in different districts, to serve as bases from which
the roundsmen could operate. The main dairy itself was not
centrally situated, but it was sufficiently close to the congested
areas for them to be served from it without much difficulty,
although on some rounds servicing arrangements had to be
made as it was uneconomical for the roundsman to return to
the dairy to pick up new supplies in the middle of his round.
Thus, the costs of servicing were by no means confined to
rounds on housing estates. On the other hand, the latter were
all at some distance from the dairy and additional costs arose
from the necessity for maintaining cold-rooms on or near the
estates, if hand-barrows were still to be employed for distribu-
tion there.

A centralized system of distribution existed in the second
town. The rounds in congested areas were comparatively close
to the central dairy, whereas those on housing estates were at

considerable distances from it. The differences in delivery costs between the two types of area was represented by the differences in those parts of the total delivery costs, that were incurred in travelling to and from the delivery areas. Thus, the average weekly costs per household incurred outside the delivery areas were 1.58*d*. for rounds in congested areas and 2.69*d*. for those on housing estates, an increase of 70 per cent. for the latter group. For a third group of rounds, covering a recently-constructed middle-class estate with some high-class residential houses, the costs incurred in travelling between the dairy and the delivery areas each week averaged as much as 2.92*d*. per household, and were 89 per cent higher than those incurred for rounds in congested areas.

The third town was much smaller than the second, so that the distance of new housing estates from the centre was not so great. A large number of houses in such areas were served by tri-cars, the running costs of which were very high, but these rounds would have been more costly than the average, even if horse vans had been used on them. Two rounds on housing estates were served by hand-barrows and for each part of the extra costs involved were due to the necessity of maintaining a depot and supplying it by a motor van from the central dairy.

The fourth town was so small that the housing estates were not at any great distance from the dairy and could be served from it with hand-barrows. There was no question of maintaining sub-depots, but the roundsmen on housing estate rounds had to cover greater distances than those operating in the centre of the town, and servicing arrangements had to be made for them. Thus, although the distance between the dairy and delivery areas was in all cases limited, some part of the additional costs on housing estates were still due to this factor.

The costs of delivering milk on housing estates were, in most cases, therefore, bound to be higher than those incurred in congested areas, either on account of the extra time spent by the roundsmen in travelling to and from the delivery areas, or of the necessity of maintaining and supplying cold-rooms or sub-depots on the estates. But costs in these areas were sometimes higher for other reasons. The effect of variations in the building density upon delivery costs has already been discussed and, as the building density was always lower on housing

estates than in congested areas, this alone tended to raise costs.

In the first town the average weekly delivery costs per household at a round density of 50 per cent were 4.24d. in congested areas and 4.87d. on housing estates. The average building density was 327 houses per mile in the first town, and 302 houses per mile in the second, while the average value of weekly sales per household was 38.8d. and 44.1d. respectively. These differences alone would not have accounted for the whole of the difference in delivery costs between the two types of area.

The first firm employed hand-barrows on all the rounds in the two groups discussed above, and a somewhat similar variation in costs in different areas occurred in the fourth town, where hand-barrows were used. The second firm, on the other hand, used horse vans, and each of these was attended by a roundsman and an assistant. Under these circumstances there appeared to be little difference in delivery costs between the rounds in congested areas and those on housing estates, apart from the difference due to distance from the dairy to which reference has already been made, although the building density was 418 houses per mile in congested areas and only 304 houses per mile on housing estates.

No comparison could be made between the costs of delivering milk in congested areas and on housing estates in the third town owing to the diversity of vehicles employed and to the topography of the areas, but it was possible to compare rounds in congested and mixed areas, where horse vans were employed with one roundsman on each. There was little difference in the distances between the central dairy and the delivery areas, nor were the distances great, so that they would have been quickly covered by horse vans. The average round density was higher on the four rounds in congested areas than for a similar number of rounds in mixed areas, but this would have accounted for only a small part of the difference of 1.12d. in the weekly costs per household in the two areas. Part of the difference was due undoubtedly to the lower building density of 249 houses per mile in the mixed areas as compared with 328 houses per mile in the congested areas.

In all four towns the costs of delivering milk were considerably

greater on housing estates than in congested areas. This was partly due to the fact that the former were further from the town centres than the latter, a fact that was of greatest importance in the second town owing to its size. The extra costs were reflected, in the first town, in the costs of maintaining and supplying cold-rooms on housing estates. In the second they were apparent in the differences in the delivery costs incurred in travelling between the dairy and the delivery areas. In the third they were due partly to the greater time spent in travelling to and from the delivery areas, and partly to the necessity of maintaining and supplying a sub-depot on one of the estates. And in the fourth town they were due both to the greater time spent in travelling between the dairy and the delivery areas and to the necessity for servicing the hand-barrows in the middle of the rounds. When horse vans were operated by two persons, as in the second town, the costs incurred within the delivery areas themselves were approximately the same in congested areas and on housing estates. Where hand-barrows were employed in the first and fourth towns, however, delivery costs on housing estates were higher than those in congested areas, owing partly to the lower building density and partly to other causes. The same was true in the third town, where each horse van was operated by a single roundsman without an assistant.

F
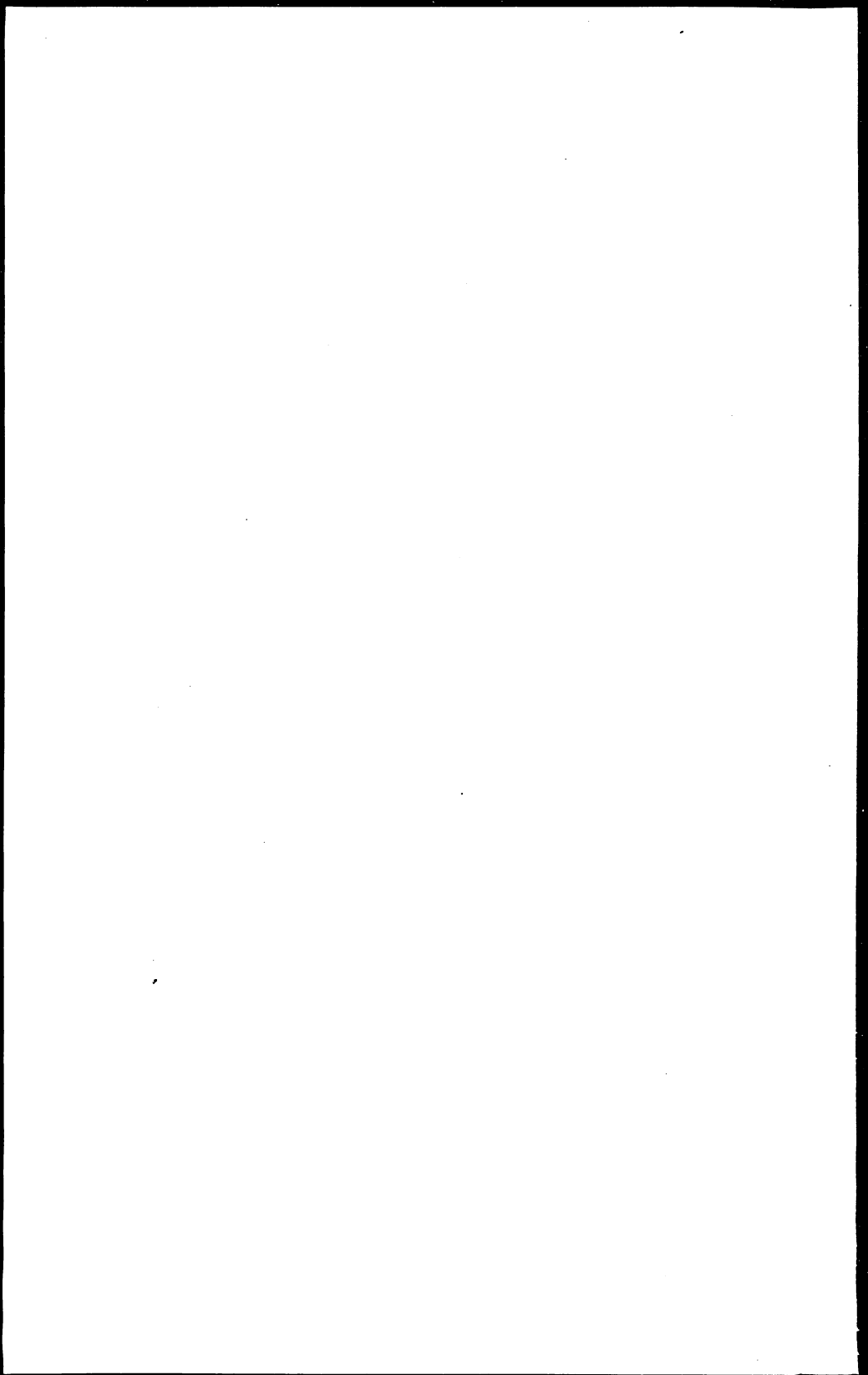
VIII. CONCLUSION

IT is hardly possible to arrive at any definite figure for the average costs of distributing milk in any town owing to the absence of complete and comparable records, and to the widespread reluctance of distributors to disclose the necessary information. No attempt was made to estimate average distribution costs in the four towns, but there can be little doubt that they would have been considerably above the averages for the firms investigated.

All the businesses sold very little or no T.T. milk. The proportion of T.T. to total milk sales was highest in the third town at 2.9 per cent, while the second and fourth concerns sold no T.T. milk at all. But the milk provided by all these distributors was of a very high quality. The third pasteurized and bottled 83.9 per cent of the milk sold retail and only 13.2 per cent was sold 'loose' as scald milk; the first pasteurized and bottled all milk not sold as T.T. milk, while the second and fourth concerns bottled all milk after it had been pasteurized or sterilized.

Processing and bottling costs form part of the wholesale costs of distributors and in this respect these firms had little or no advantage over their competitors, except over those few who carried out the same operations on a smaller scale. Their total distribution costs, on the other hand, were probably below those of their rivals owing to their lower round delivery costs. In each town the largest distributive concern was selected, and the four businesses operated on a scale which made block deliveries possible. The rounds, therefore, covered fairly compact areas, within which each roundsman served a comparatively high proportion of the total number of households.

In the second and fourth towns no dairy sundries were delivered, so that the full costs of the rounds could be charged to the distribution of milk. In the first and third towns, on the other hand, dairy sundries were delivered in considerable quantities, and part of the round costs should have been allocated to them. But no satisfactory method of allocating delivery costs between milk and sundries has yet been devised

and so the whole costs were, in fact, allocated to milk. This inevitably raised the estimated delivery costs per gallon of milk above the actual costs, although it was impossible to determine the extent of the error. In the first town, where milk and sundries were delivered, the delivery costs per household rose with an increase in the total value of weekly sales per household, although the rise was not sufficient to prevent a fall in the delivery costs per unit value of sales when such an increase occurred. Consequently, the delivery costs per gallon of milk given above not only left out of account possible reductions in overhead costs due to the sale of sundries, but also included the additional costs incurred in their distribution. In the third town there was no evidence as to the effect of increased sales upon delivery costs, but the firm operating there had taken to delivering sundries with the expressed purpose of reducing the overhead costs per gallon of milk delivered on its rounds. The effect of sales of dairy sundries in lowering the costs of delivery per gallon of milk may well be exaggerated, if no account be taken of the increased delivery costs per household involved in their distribution. But the allocation of all delivery costs to milk exaggerated the costs per gallon, where sundries were also delivered on the rounds.

The unweighted average margin obtained by distributors is the difference between the monthly wholesale milk prices and the minimum retail prices prescribed by the Milk Marketing Board. In each of the first three towns the margin, during the year October 1936 to September 1937, averaged 10.74d. per gallon; in the fourth town it averaged 9.74d. per gallon. But the actual margin obtained by each firm was below this level owing to semi-wholesale sales, and the margin obtained by the third firm was also affected by sales of scald milk at a lower price than ordinary milk. Since the total distribution costs obtained covered all sales, they could not rightly be compared with the unweighted average margin to obtain figures for net profits. On the other hand, the total distribution costs quoted were above the actual total distribution costs incurred by the first and third concerns for urban deliveries as no allowance was made for the distribution of dairy sundries or for extra-urban deliveries, which were more costly than those within the towns themselves.

It was not possible to ascertain the actual average margin obtained by each distributor, nor to estimate the precise extent to which costs were affected by the above considerations. There was no doubt, however, that all four concerns were making very satisfactory profits from the distribution of good quality milk within their respective towns, owing to the efficiency of their distributive machinery and to the scale upon which they operated. If urban distribution alone were considered and an allowance made for the costs of delivering dairy sundries, it seemed probable that the first firm was making profits, after payment of interest on plant and buildings, in excess of 2d. per gallon of milk sold, and that the second was making not less than 3d. per gallon; the third probably obtained between 1d. and 2d. per gallon on urban deliveries, the lower return being due to the more difficult conditions under which it had to operate. No estimate was possible for the fourth concern owing to the absence of any figure for total distribution costs.

An attempt was made at the outset to distinguish between the 'health' and 'convenience' services provided by milk distributors. Some of the latter have been shown by these investigations to have a direct bearing upon delivery costs. One of the most important 'conveniences' demanded by most consumers is the right to choose between alternative sources of supply, and the choice is exercised so that no single distributor can command the custom of more than a limited proportion of all householders. The proportion of households supplied by the businesses investigated was very much above the average; for none was it lower than 25 per cent and it exceeded 47 per cent in the last of the four towns. But it was found that, as the proportion of houses served in any given area increased, the average delivery costs per household and per gallon were reduced. The percentage decline was somewhat greater in congested areas than on housing estates, and it was more marked where hand-barrows were operated by a single roundsman than where horse vans were attended by a roundsman together with a boy assistant. On all rounds, however, there was a reduction in delivery costs as the proportion of houses served increased. There was no means of telling whether the rate of fall would have been the same at round densities of less than 35 per cent. or whether it

would have been maintained as the percentage of houses served approached the maximum, but there was only a slight decrease in the rate of fall up to a round density of 65 per cent and there was no reason to suppose that the decline would not have continued to take place until a round density of 100 per cent was reached.

The total number of retailers was about 25 in the fourth town, 125 in the first and third towns, and very much larger in the second town. This does not mean that each consumer was able to exercise an effective choice between this number of retailers, and, in fact, it was probably limited to less than one-fifth of the number in any particular district. But every consumer had a wide choice, any limitation of which would tend to reduce average delivery costs, because, as the number of retailers declined, the proportion of houses served by those remaining in business would increase.

It would undoubtedly be advantageous, therefore, to secure any restriction in the number of distributors, but, even if 3 or 4 remained in competition with each other in a district, the proportion of houses served by each would necessarily be very much below the maximum. Delivery costs could be reduced to the lowest level only if a single retailer were left to serve all the houses in his area. This does not necessarily mean that delivery costs will be lowest, when the whole of a town's supply is under the control of one firm. But it is essential to concentrate the supply of any one district of a town in the hands of a single distributor, if the greatest possible economies are to be realized.

Thus, part of the costs to the consumer of the right to choose between several sources of supply can be measured by comparing the average delivery costs at present obtaining in any area with the delivery costs to be anticipated at a round density of 100 per cent, that is, when a single retailer distributes all the milk required in the area. Some idea of the potential economies may be gained by reciting the results obtained in the present investigations. In the first town, where delivery was undertaken by hand-barrows, the weekly delivery costs per household fell by 13 per cent in congested areas as the round density rose from 35 per cent to 55 per cent; on housing estates they declined by 6.2 per cent as the round density increased from 50 per cent to 65 per cent. In the second town, where two

persons were employed on each round operating a horse van, the weekly delivery costs per household declined by 5.4 per cent in congested areas as the round density rose from 50 per cent to 65 per cent; on housing estates they fell by 5.6 per cent as the round density rose from 45 per cent to 65 per cent. And in the fourth town the weekly delivery costs per household declined by 9.3 per cent in all areas, as the round density increased from 40 per cent to 60 per cent.

The waste entailed in the existence of a number of distributors in each area arises from the resultant overlapping of retail routes. A similar type of waste is involved in the provision of more than one daily delivery, because it means that the rounds-men have to cover at least parts of their routes on two or more occasions in the same day. In the third town it was observed that a demand for a second daily delivery by 6 per cent of the households served by the firm investigated led to an increase of 0.2d. in the average delivery costs per gallon over the whole of the town; a larger demand for two deliveries would have resulted in a still further increase in average delivery costs. Nor does this give a true indication of the total costs involved in a second delivery. When milk is delivered twice daily, the amount delivered on each occasion is less than it would be if the full day's supply were delivered at one time. This must tend to increase the demand for half-pint bottles, because it appears that the demand for a second delivery does not come only from households requiring exceptionally large amounts of milk each day; and the extra cost of handling bottles of this size is generally recognized to be considerable. The second firm, which made one delivery daily, only supplied 1-pint bottles to its customers.

Two of the main 'convenience' services have been investi-gated, but others exist to a varying extent in different distribu-tion centres. Sometimes the cost of giving extensive credit facilities to customers is considerable, although the firms investigated gave little credit and this may help to account for their low distribution costs. Again, the provision of an un-limited number of bottles to customers who fail to return those provided, contributes towards increased costs; this difficulty was overcome by the second distributor by charging a deposit on all bottles. This firm also refused to make special deliveries

to particular customers at times not convenient to the ordinary roundsmen, a practice which is by no means universal, although costs tend to be increased, if it is not adopted.

The rapid growth in the number of services is partly the result of the highly competitive conditions existing in the trade. The expansion of 'health' services has been very beneficial, although there is no reason why the highest standards should not now be secured by legislative and administrative action, which would have the advantage of making universal the standards at present attained only by the more progressive businesses. But the increase in the number of 'convenience' services is of less certain value. Many of these are not required by the majority of consumers, and a still greater number of householders would undoubtedly be prepared to forgo them, if the costs of their provision were more fully appreciated. Some may demand that all existing services should be retained. There is no reason, however, why the majority should be deprived of the opportunity of obtaining cheaper milk with an acceptable minimum of service, in order to satisfy the less reasonable demands of their more exacting neighbours.

Competitive conditions prevent distributors from reducing the number of services offered to their customers without running a grave risk of loss of custom. The first business covered by this study, for example, has recently been attempting to reduce the number of second deliveries and has suffered at least a temporary loss of business as a result. No doubt it could have accomplished this reduction more successfully if it had been able to offer a reduction in price to those requiring only one delivery, but the Milk Marketing Board's practice of prescribing minimum retail prices has made this impossible. The fixing of minimum prices has tended, in fact, to intensify competition in services by excluding the possibility of competition in prices.

It has been suggested that the licensing of distributors might enable many of the obstacles in the way of price reductions to be overcome. But any restriction of numbers envisaged by the advocates of such a policy would fail to achieve the benefits to be derived from the complete elimination of competition in milk distribution. In so far as a reduction in numbers enables retailers to combine more successfully, it

may lead to improved organization and a corresponding increase in the dangers of profiteering at the expense of consumers. But, so long as competition exists, even in a restricted form, it will still be very difficult to secure a reduction in the number of services offered, nor will it be possible to avoid the expense of advertising and canvassing for new customers, which now forms an important item on the balance sheets of many firms. Moreover, it has already been shown that nothing short of the establishment of local monopolies of supply will put an end to the wastes of overlapping on delivery rounds.

There are certain difficulties in the way of establishing local monopolies which must not be ignored. It would involve an absence of choice between alternative sources of supply, which the majority of consumers may not be prepared to accept, even if it would lead to a reduction in retail prices and if high standards of quality and cleanliness were laid down by law. It would also raise problems of administration, difficult of solution. If private monopolies were set up, the costs of distribution might be very substantially reduced, but, without adequate safeguards, there would be no guarantee that the fall in costs would be fully reflected in price reductions to the consumer.

The strict regulation of prices by an independent authority might provide, in theory, a means of securing these benefits to the consumer, but, in practice, it would be unlikely to achieve the desired result. These investigations have shown that milk delivery costs vary very considerably with the type of area in which distribution takes place. In the third town the effect of topographical differences was observed, delivery costs being between $0.75d.$ and $1d.$ per gallon higher in hilly than in flat districts. Moreover, in all four towns the type of housing development affected costs to a very marked extent. In all cases delivery costs were higher on housing estates than in congested areas, while in mixed districts they were, in general, higher than in congested areas, but lower than on housing estates. In three of the towns costs were higher on housing estates partly owing to the lower building density in newly-developed areas and to other factors not examined, such as the greater distance of the houses from the street and the practice

of back-door delivery on housing estates. But the difference in costs between these two types of area was due mainly to the distance of the housing estates from the centre of the town. The size of a town, measured not only by its population, but also by the area within its boundaries, clearly has a direct bearing upon delivery costs and it was not surprising to find that the difference in costs between congested areas and housing estates was greatest in the second and largest town.

The prescription of minimum retail prices by the Milk Marketing Board has been criticized frequently by official and unofficial bodies and attention has been drawn to the arbitrary nature of the area classifications adopted. But any attempt to fix prices over a wide area or for a limited number of types of area is bound to be arbitrary in view of the multiplicity of factors affecting costs. At present minimum prices are inevitably fixed at levels sufficiently high to cover costs in high-cost areas. They are also high enough to give a margin of profit to the less efficient distributor providing the widest possible range of services. As a result, efficient businesses providing a reasonable minimum of service in low-cost areas are able to make unduly large profits.

It would be possible to fix minimum retail prices at a level which would discourage elaborate services and yield no more than a reasonable return to efficient distributors in low-cost districts. There would then be nothing to prevent firms less favourably situated from charging prices above the prescribed minimum, as they do in some places at the present time. But the control of monopolist distributors would require the fixation of maximum prices, and, if such prices were fixed at a level high enough to permit a reasonable return to distributors in high-cost areas, they would give ample opportunity for excessive profit-making elsewhere; if, on the other hand, maximum prices were fixed at a level sufficiently low to prevent excessive profits in all areas, the continuity of supply in high-cost districts would immediately be endangered. It is difficult to see, therefore, how the full effect of reductions in delivery costs, resulting from the establishment of local monopolies, could be passed on to the consumer by price control, unless prices were fixed separately for each town or part of a town, in which a single distributor was operating. But this would

scarcely be practicable, and, even if it were attempted, it could only follow a detailed study of costs in each centre.

The difficulty of controlling private monopolies suggests that co-operative or municipal distribution might provide a better alternative. The distributive concern would then be controlled by consumers, either as members of their co-operative organization or as citizens electing their municipal authority. In either case the necessity for price control would be avoided, the conflict of interest that exists between a private distributor and the consumer being no longer present.

The final choice must remain with the majority of consumers themselves. They may exercise it in a positive manner by consciously directing their custom along certain channels, or by demanding that action be taken to reorganize distribution by their local government bodies or by the central government; or they may exercise it in a negative way and thus permit existing conditions to continue unchanged. If positive action be taken, the price of milk to the consumer can be reduced, and this would pave the way to still further reductions, because these investigations have shown that an increase in the volume of sales per household, such as would follow reductions in prices, would, in itself, lead to reductions in the delivery costs per gallon of milk sold.

There is no means of measuring accurately the possible reductions in costs to be achieved by the reorganization of milk distribution. It is clear from these investigations, however, that large distributors are able already to operate at costs well below the minimum margins allowed by the Milk Marketing Board. If no more than one delivery were made in all districts and only one distributor were permitted to operate in each, retail prices might be reduced by about 4d. per gallon, or 1d. per quart, over the year. In some towns where topographical conditions or methods of development are unfavourable to low delivery costs, so large a reduction might not be possible; but there are others where it could be achieved without undue difficulty, provided that reorganization was carried through to its logical conclusion.