ANALYSIS OF SPATIAL

ADMINISTRATIVE PATTERNS

AN APPROACH TO THE ANALYSIS OF SPATIAL ADMINISTRATIVE PATTERNS: ONTARIO HYDRO-ELECTRIC POWER COMMISSION

by

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SCOPE AND CONTENTS:

Traditional and contemporary studies of spatial administrative systems are reviewed. Economic, political and historical factors are related to patterns of administrative areas. The hypothesised relationships are tested using data for the Ontario Hydro-Electric Power Commission. Linear and quadratic models relating functional costs to workload of the administrative areas are offered. The quadratic models incorporate the concept of the long-run average cost curve. A theoretical relationship between the shape of an administrative area and the level of economic efficiency is tested. Linear programming is used to simulate administrative patterns. Four indices are used to describe and compare the patterns. One of the indices, the weighted mean, is used to operationalise Pred's Behavioural Matrix. Recommendations are made for future work.

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PREFACE

The division of politically organized areas into smaller units for administrative purposes is a long-established feature of human organization. Attempts to describe and to explain the processes which have generated the spatial administrative patterns fall within the broad framework of geographical research, and more particularly within political geography. Work thus far in political geography has largely concentrated on describing the administrative units within particular areas. Qualitative and quantitative methods have been used to provide a body of literature in the field.

With the changes in emphasis in the social sciences, particularly the search for generality using objective methodologies, some of the most recent work on spatial analysis uses quantitative techniques to test specific hypotheses. The aim of these studies is to improve the level of explanation of spatial patterns by understanding the interaction of forces which relate to the patterns.

The research presented in this thesis will attempt to formulate and test hypotheses concerning the relationships between economic, political and historical forces and the spatial administrative systems that are used by the Ontario Hydro-Electric Power Commission.

Chapter I will consist of a general introduction to the problem. A review of the most pertinent literature will be presented and the study area will be defined. An historical overview of the growth of the of the Ontario Hydro-Electric Power Commission will be offered in the second chapter. The third chapter will discuss the formulation of the hypotheses. Chapter IV will describe the data sources.

The current arrangement of administrative areas used by the Commission will be described quantitatively in Chapter V and Chapters VI, VII and VIII will be concerned with the results of the tests of the hypotheses and discussion of the methods used. Chapter IX will attempt to synthesize the research. A summary of the main conclusions will be offered, and an appraisal of the research will be complemented by suggestions for future work. Three appendices follow the last chapter.

CHAPTER I

INTRODUCTION AND REVIEW OF THE LITERATURE

The goal of contemporary human geography is to develop theories that describe, explain and predict the spatial distributions of human activities.[1] And though the focus on spatial relationships has remained unchanged throughout the history of the discipline, the purpose in examining such relationships has been under review of late, and it is the subject of debate in recent geographical literature[2].

The arguments found in this literature suggest that qualitative descriptions of unique phenomena, though often giving intuitive satisfaction, do little to enhance the level of objective understanding of reality. To achieve this objective level of understanding, which is felt to be the aim of science, there has been a shift towards the use of quantitative data to test hypotheses in as rigorous a fashion as both the data and the current state of methods will allow. All the social sciences appear to be developing this strategy. Haggett states that:

> "If the historian of geography's development looks back on the 1960's as a decade of "mathematical extravaganza" we can at least fortify ourselves with the knowledge that, without exception, all natural and social sciences went through, or are going through, such a phase."[3]

Later in his book he adds to these comments, and notes that the mathematical invasion per se, is only partially responsible for the gross trends in the subject. These trends suggest that the subject is becoming oriented towards deriving theory to explain spatial distributions, and further, that the unique study is loosing ground to the study which attempts to support or refute hypothesized relationships. Clearly, it is the search for order and the explanation of spatial patterns and processes which now forms the heart of the subject. This change in emphasis might, in part, be attributed to the change in thought in the social sciences as a whole. Specifically, it is now generally accepted that man not only relates to his immediate physical and social environment, but that his behaviour has within it certain order. It is this order which allows behaviour to be described theoretically. The intellectual climate in which this outlook developed has been examined by Bronowski[4] and Kemeny,[5] authors who have considered the development of logic and philosophy through time.

It is axiomatic to state that most of the problems in spatial analysis are multivariate. Given this, much of contemporary research is directly concerned with refining specific axioms by the systemmatic identification of variables, and the formulation and testing of hypotheses. The purpose of this procedure is to attempt to test theories and identify laws that explain the phenomena under examination. However, such a goal is frequently not realised as the subject is very youthful with respect to the theory-building philosophy[6].

The research reported in this work will attempt to test specific hypotheses. Also, an attempt will be made to provide quantitative descriptions of the spatial administrative patterns. These descriptive measures could be a basis for comparative studies, and they may assist in the future formulation of hypotheses. An historical overview of the Ontario Hydro-Electric Power Commission (hereinafter called O.H.E.P.C.) will be offered as a frame of reference for the hypotheses and the descriptions of the current administrative patterns. Finally, it is hoped that some of the methods used in this research, for constructing least-cost administrative areas, may be employed in a practical, albeit modest, way to improve the environment of man.

The Problem

The object of this research is to attempt to determine to what extent "selected"[7] economic, political and historical factors influence the three patterns of administrative areas that are used by the O.H.E.P.C. The three administrative patterns are provided by the Regions, the Rural Operating Areas (hereinafter called R.O.A.'s) and the Municipal Electrical Utilities (hereinafter called M.E.U.'s). Data for the Regions and the R.O.A.'s will be drawn from southern Ontario. For the M.E.U.'s a sample of 80 from the population of 355 for Ontario will be used.

The R.O.A.'s in southern Ontario are shown on Figure 1.1, and the Regions are marked on Figure 1.2. A list of the 80 M.E.U.'s is presented in Appendix I. The location of 75 of the M.E.U.'s is shown on Figure 1.3. The five not marked are located in northern Ontario, and are listed on this figure.

Southern Ontario is defined, for this research, as that part of the Province of Ontario to the south of the French River, Lake Nipissing and North Bay. Although less than 12% of the area of Ontario is south of the line, over 85% of the population is found here. This reflects

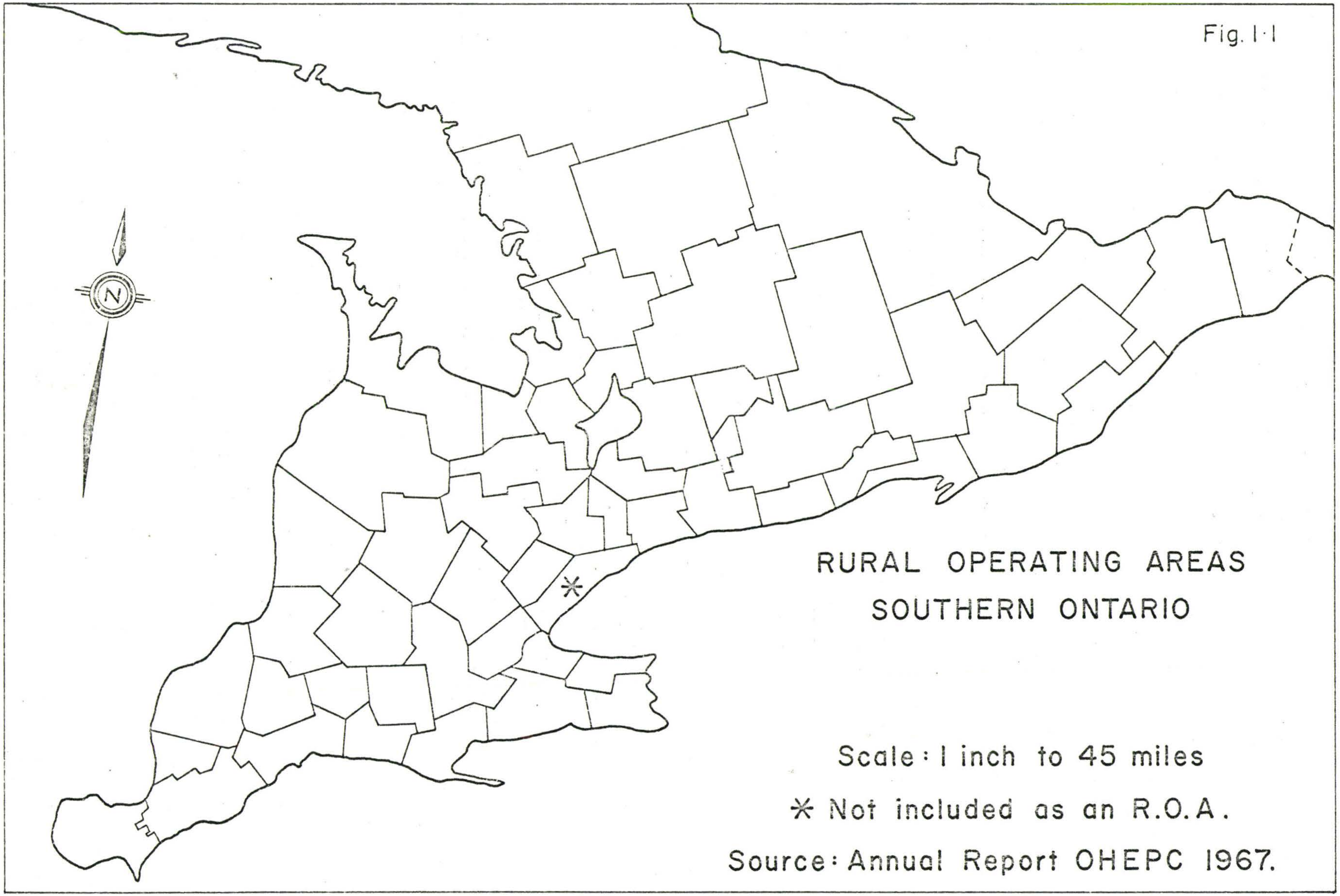
Fig. 1·1
RURAL OPERATING AREAS
SOUTHERN ONTARIO
Scale: 1 inch to 45 miles
* Not included as an R.O.A.
Source: Annual Report OHEPC 1967.

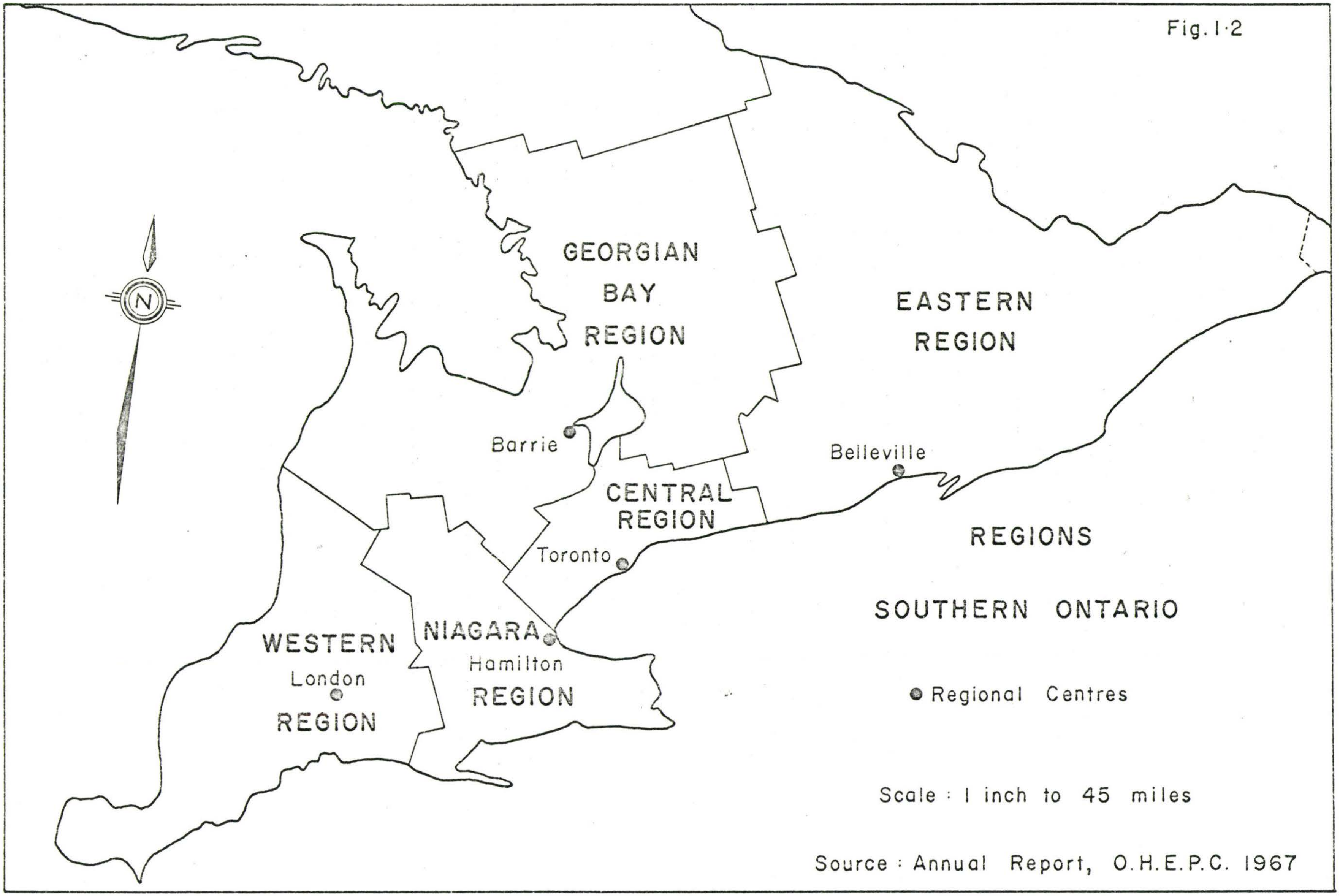

Fig. I·2

REGIONS

SOUTHERN ONTARIO

Source : Annual Report, O.H.E.P.C. 1967

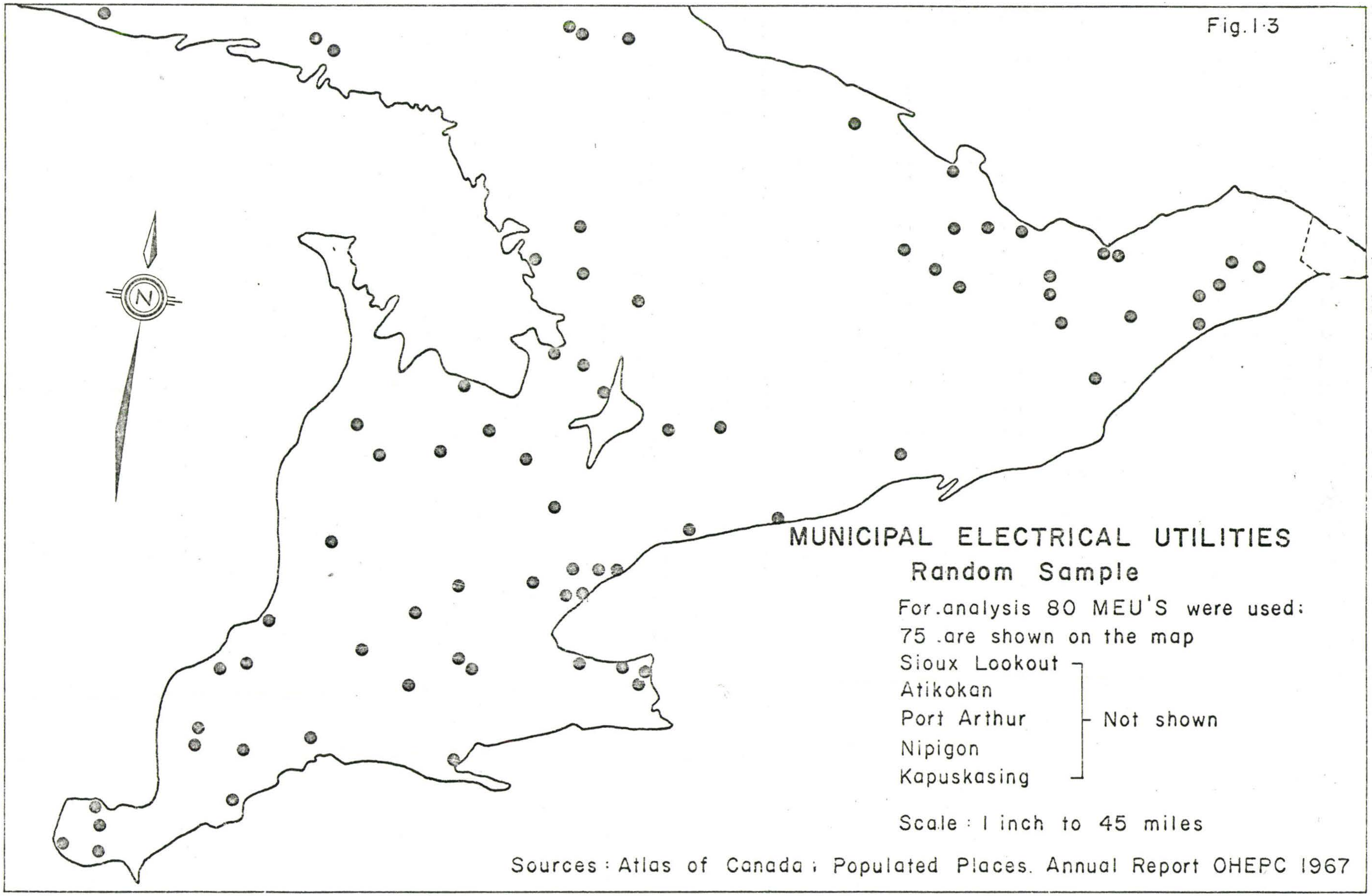
Fig. 1·3
MUNICIPAL ELECTRICAL UTILITIES
Random Sample
For analysis 80 MEU'S were used:
75 are shown on the map
Sioux Lookout
Atikokan
Port Arthur
Nipigon
Kapuskasing
Not shown
Scale : 1 inch to 45 miles
Sources : Atlas of Canada ; Populated Places. Annual Report OHEPC 1967

the high demand for administrative services. In southern Ontario, the transportation network is more highly developed, settlement is more continuous, and this area has the longest history of administration in the province. In northern Ontario, there are only two Regions and the R.O.A.'s do not cover the whole area. Further, a population data base by townships is available for southern Ontario. This is used in the analysis of the Regions.

At the outset it is recognized that the economic, the political and the historical factors are related. For analytical purposes they have been isolated. A conceptual framework for relating the factors will be discussed in Chapter III. The relative importance of the factors will be discussed in the Conclusions.

Though only one agency will be examined the author suggests that insight into the processes relating to spatial administration will be gained. It is argued that this insight will result from approaching the problem in a theoretical manner, rather than merely compiling all available data which may relate to administrative areas.

Spatial Patterns and Administrative Areas

The concept of spatial pattern is one which has attracted the attention of several geographers[8]. Hudson and Fowler state that:

> "Formal analysis of pattern is hampered by a lack of precision in its operational definitions. Pattern should not be confused with shape as they each represent geometrical or geographical properties."[9]

These two authors parallel Bunge's[10] work in shape measurement by suggesting that any closed curve has a shape, and a collection of points has a pattern. Therefore, an administrative area has shape because its boundary is a closed curve which circumscribes a two-dimensional space. The area also has a pattern if it encloses a distribution of one-dimensional objects. Points circumscribed by a boundary can be considered, as in geometry, as being one-dimensional. Thus, the shape of an administrative area deals with two dimensions; to consider a pattern of points is to deal with one dimensional objects whose pattern can be operationally determined using the relative distance or spacing of the objects with respect to one another. Therefore, pattern and shape can be separated by the relevant dimensions of the objects being studied. This research will consider both shape and pattern of administrative areas. Specifically, a pattern measure will be operationalized for the Regions, and two shape measures will be used to describe the R.O.A.'s. Conceptually, pattern is not related to the size or the area in which it occurs. However, most measures of pattern are related to the size of the area in the sense that the densities of the punctiform distributions have to be calculated. Hudson and Fowler note that:

> "Thus, pattern measures currently available do not measure pattern itself, but rather measure the configuration of the distribution in relation to the area included within a particular boundary."[11]

The Pattern of Regions

Set theory offers a convenient way of describing a pattern of points vis-à-vis a sample space[12]. Consider a sample space S of n discrete points, each having a unique location. Next consider p subsets from S, such that each subset is mutually exclusive and the sum of all subsets is the sample space S.

The subsets can be evaluated by calculating the dispersion of the points about a given point. Values for each subset can be compared. Further, values for subsets can be constructed according to some constraints regarding the allocation of points to the centrally located points. These centrally located points can be considered as the administrative centres. By constructing a spatial administrative system and defining this as an optimum arrangement of points, this can be evaluated and compared to actual systems. Using a measure of similarity it is possible to suggest if the theoretically derived pattern is similar to the actual one.

For the purposes of this study southern Ontario can be considered as the sample space, and the Regions as the subsets. Further, it is assumed that the sample is composed of a punctiform population distribution. A discussion on the nature of this distribution will be presented in Chapter V. Optimal patterns of Regions will be discussed in Chapter VIII.

The Shape of Rural Operating Areas (R.O.A.'s)

The shape of the R.O.A.'s in southern Ontario will be described using two measures developed by Haggett[13]. The first, the contact number, is a count of the number of neighbouring areas for each administrative area. The second, the shape index, relates the spatial size of the area to the long axis. The following formula will be used:

$$S = \frac{1.27\ A}{l^2} \quad \text{where} \quad \begin{array}{l} S = \text{Shape Index} \\ A = \text{Area} \\ l = \text{long axis} \end{array}$$

These measures will be discussed more fully in Chapter V.

The shape of the R.O.A.'s will be compared statistically to an optimum shape. The areas will also be compared to administrative areas in other parts of the world. Further, the shape index will be used as a measure of spatial compactness. A theoretical relationship between spatial compactness and economic efficiency of the enclosed R.O.A.'s will be tested. The results will be discussed in Chapter VII.

Review of the Literature

The study of political systems below the national level of organization has been sparsely treated in geography[14]. Further, the spatial arrangement of political systems is so distinct and conspicuous in the spatial pattern of world society that it can provide a rich source of material for inquiry.

Every political system is prominently, if not pre-eminently characterized by space. Indeed, the concept of a nation and, by extension, the concept of any other political system, is unthinkable apart from association with specific territory.

Wolfe[15] has commented that one fact appears to underlie all political events and institutions. These events and institutions always involve men interacting over distance. Ultimately political organization is spatial organization, and though it is men who organize and are organized, the terminology used is that of space. For example, the township, the county, the administrative area, the nation and the empire. In terms of sheer position and extent, politics is essentially static. The dynamics of politics requires that there be effective communication between men occupying various parts of a political entity, and between men controlling different entities. Further, it often requires that there be the possibility of physical movement among and between these entities. Within this physical network there are flows of ideas[16]. Seen together, the static and the dynamic aspects of politics, -- for example the fixed resource base and the ideology determining the use of the resources, have provided rich material for political economists and historians. In general terms politics is perhaps one of the major fields of human activity which invokes strong subjectivity. Emotive language is often the norm when discussing a political process, spirits can run high and sentimentality may abound. It is for these reasons that this research will attempt to offer objective quantitative data in support of arguments presented.

There are two general characteristics of a political system; the political process by or with which it functions, and the territory to which it is bound. Every political process has a geographical area associated with it, and no geographical area escapes some relation with a political process. The examination of the two characteristics mentioned above will form the basis of this study. The political process will be examined through a review of historical documents, together with interviews with administrators. This will be complemented by an attempt to consider such notions as "political climate" and "value systems"[17] as they influence the process of dividing space into administrative areas. The territorial aspects will be examined using data which are spatially distributed. For this research, territory will be defined in terms of specific attributes of the administrative areas, such as size of area, population, miles of road and the number of administrative personnel.

Traditionally the study of politically organized areas has been approached from two points of view. The first has been the morphological approach[18], with the emphasis resting on the description of the attributes of an area. The second has related to the study of decision-making processes and the division of responsibility among the levels of local, national and supra-national bodies[19].

Contemporary study of political systems is shared by several disciplines. On the one hand are political scientists[20], sociologists[21], and anthropologists[22]. These researchers focus their attention on the social attributes of the population as these are related to their physical, social and political environments. On the other hand some economists and regional scientists attempt to complement these studies by examining costs, benefits, methods of development, distribution and allocation of resources within and among political entities[23], Keeble has argued that:

> "... at national and sub-national scales, then, the building of models of economic development is now proceeding rapidly, stimulated by a growing realization on the part of economists and government planners of the value of this approach for practical and theoretical purposes."[24]

He continues by stating that geographers, in the light of a changing internal and external intellectual environment in their subject, now need to accept model-building in an attempt to understand more fully spatial variation and interaction in spatial economic problems[25]. Clearly, these comments apply to all geographers who are interested in trying to describe political phenomena.

Researchers have also focussed attention on assessing the viability of county units, the social and economic consequences of new administrative units, and the retention of regional myths in national politics[26]. All are pertinent to political geography. Jones[27] has suggested that the study of administrative areas could be an attractive meeting ground for political scientists and political geographers.

Within the field of political science, with the rise of the behaviourist school, there appears to be an emphasis on the study of the decision-makers, especially their actions and the way these actions relate to the on-going norm and value systems in the particular society[28]. A general decision-making model has been postulated by Agger[29], and there is a growing body of literature on community power studies[30]. All of these enhance the level of understanding of political processes.

With reference to administrative areas, the value systems that are attached to the areal division of power is a working device of an already united state. A variety of claims have been made on behalf of the areal division of governmental power, and Ylvisaker suggests that most of what has been said on the subject has been provoked in the heat of battle over whether or not to adopt or keep some variety of the system. As a result, the subject has inherited a congeries of expedient claims, supported by casual examples and fragmentary arguments chosen "on the run". These comments by Ylvisaker support the earlier remarks à propos subjectivity and political analysis.

Viewed temporally, it appears to Ylvisaker that the claims and arguments have accumulated in three distinguishable layers, deposited by passing generations of advocates and critics who have successively been concerned with the great values of liberty, in the eighteenth century, equality in the nineteenth century and welfare in the twentieth century. Since the end of the second world war one of the dominant values in North America, it seems to the author, is economic efficiency. This value per se is probably partially responsible for the many studies concerning the systems for the efficient distribution of goods and services. The many regionalization plans produced since 1945 fall into this category. In support of this notion there is a growing body of literature in business studies which is concerned with regionalization and decentralization.

Theoretical studies of the relationship between the size of a firm and the number of employees, level of efficiency and level of managerial co-operation have been offered by Adler[32], Arrow[33] and Morris[34]. Of these, Morris attempts to summarise the diverse, but "relatively modest amount of literature dealing directly with, centralization and decentralization of industrial organizations"[35], in the form of hypotheses. He states:

> "Nothing is asserted about the confirmation of these hypotheses. They indicate the need for fundamental theory that will permit them to be interrelated, and the need for making many of the concepts involved operationally defined."[36]

This study will attempt to consider the concepts with respect to the organization of the O.H.E.P.C. The concepts will be discussed in Chapter II.

With respect to the interaction and cohesion of political communities Jacob and Teune[37] have discussed the factors they feel exert integrative influence upon people. They are listed below.

1. Spatial proximity
2. Homogeneity of social group
3. Interaction or transaction among people
4. Knowledge of each other
5. Shared functional interests
6. The character or motive pattern of a group
7. The structural frame or systems power of decision-making
8. The sovereignty-dependency status of a community
9. Governmental effectiveness
10. Previous integrative experiences.

This list can be considered as a summary of the approaches that have been adopted by sociologists, anthropologists and political scientists in their attempts to analyse political processes in the context of communities. The problem of determining the influence of specific factors on the pattern of administrative areas can be viewed as a problem of defining the forces influencing human interaction within or between political entities.

Pounds, when writing about the internal spatial organization of a state notes that:

> "All states, with the exception of only the very smallest divide for purposes of internal administration into smaller units."[38]

The rationale for this statement is provided by assuming that the execution of Acts, passed by the state legislature and applicable to all parts of the state, is made easier by dividing the state into smaller units. The arguments supporting this have traditionally centred upon the grass-roots philosophy of local representation and ease of access to the decision-makers by the population at large. This tended to give rise to a proliferation of small units such as townships in Ontario. Through time two processes appear to operate. Firstly, with improved transportation and communications the small units amalgamate. Secondly, with increasing diversity of functions new regionalization structures appear.

Within the field of geography between the 1920's and the 1950's Fawcett[39], Gilbert[40], Taylor[41] and Dickinson[42] offered descriptions of the shape, size and functions of various spatial administrative systems within the United Kingdom. Of these studies Dickinson outlined some general principles for the optimum arrangement of administrative areas[43].

Writing three years earlier than Dickinson, Fesler[44] in the U.S.A., attempted to define the factors to be given the greatest weight in determining the number and size of administrative areas. The factors are:

1. The magnitude of field work
2. The localization of the objects to be administered
3. The capacity of the H.Q. to supervise the local chiefs
4. The comparative results to be expected from large-scale and small-scale administration
5. The implications of political influence on the appointment of local personnel.

Fesler also noted that the determination of the exact boundaries of the areas should be based upon a consideration of the following criteria:

1. Equalization of the work load
2. The nature and distribution of the objects to be administered
3. The administrative areas used by co-operating agencies
4. The disadvantages of changing existing boundaries.

Finally, he suggested that the location of administrative centres must take into account the following:

1. The location of the objects to be administered within the area
2. The location of the H.Q. of other agencies
3. The availability of office space
4. The need for frequent personal contacts between the headquarters and the area office.

As yet, few attempts have been made to test the relationships between the variables mentioned by Fesler in a quantitative framework. The work thus far has largely been qualitative. For example Tindal[45] has attempted to define specific factors which influence the location of field offices for various agencies in southern Ontario. His approach is qualitative, and his conclusions are based on a subjective evaluation of the evidence. One of the aims of the research presented in this report is to provide an objective analysis of the administrative areas, albeit a partial analysis, as data from only one agency will be used.

Following Dickinson in Europe and Fesler in North America, Hartshorne[46] developed the concept of "areal functional organization". He was searching for an approach that could be used to examine all spatial political phenomena. Particularly, he was interested in trying to develop a general approach and one which would move away from the morphological case study approach of his fellow political geographers. The studies by Brown[47] and Johnsrud[48] were both direct outgrowths from Hartshorne's approach.

Philbrick[49] attempted to develop the concept of areal functional organization and he suggested that it could be applied to the whole field of human geography. His ideas have neither been extensively nor intensively developed.

With specific reference to studies of intra-state boundaries, Prescott[50] reviews the many historical analyses of unique case studies. He concludes that the geographer can make a useful contribution to the planning of boundaries within the state area through more exact methods for their analysis. Further, he states that the revision of boundaries, in the light of such detailed research, could result in increased efficiency and economy. This study will attempt to make a contribution in this direction by dealing specifically with data drawn from a single agency and operationalizing a method for locating administrative boundaries and administrative centres. The constraints and assumptions for the method will be defined, and evaluation of the regionalization schemes will be presented in quantitative terms. Maps showing the location of boundaries and centres will also be presented. The results will be discussed in Chapter VIII.

With reference to Canada, it was in 1939 that Goldenburg[51] wrote that there were wide inequalities between municipalities, specifically there were differences in the relations of various municipal units to the parent provincial government, this led to lack of precision in relationships with respect to municipal government in general. The result of all this was confusion of the whole concept of the place of municipal government in the political and constitutional structure of the country. Discussion on the role of municipal governments has been forced upon all levels of the community largely as a result of the rapid urbanization in Ontario since 1945. Some of the most recent reports in Ontario include the Regional Government Plan for the Niagara Peninsula

(1969)[52], the Hamilton Wentworth Burlington Local Government Review (1968)[53] and the Peel Halton Report (1967)[54]. The complete lack of an ordered approach has been evidenced by the patchwork nature of piecemeal efforts to assist "muddling through" year after year. Recently Willbern[55] has noted this trend throughout North America. He calls it creeping adhocism.

Landon[56] has examined the evolution of local government in Ontario, and the historical chapters in Whebell's[57] thesis describe the sequence of settlement and organization in southern Ontario which led to the Baldwin Act of 1849.

Statements by Robarts[58] and McDonald[59] have drawn attention to the present inefficient arrangement of the areal division of governmental power in Ontario. Krueger[60] and Dolbey[61] offer qualitative descriptions of the current arrangement of administrative units in Ontario. They conclude that the present arrangement of administrative units is inefficient. They contest that the administrative units that were established in the past are too small to function efficiently in the present age of rapid transport and communications. The author[62] has attempted to evaluate the spatial efficiency of the location of boundaries and administrative centres for eight agencies in southern Ontario.

With regard to quantitative techniques, it is only recently that political geographers have started to employ them[63]. Undoubtedly some of these techniques will be used to test the intuitive notions that have characterized the field of political geography thus far. Examples of some recent studies are the works of Lewis[64] and Janelle[65]. They offer quantitative evidence to support the hypothesis that the size of administrative areas is related to the energy, either human or mechanical, needed to traverse the area. The energy is expressed in terms of time and cost. They have examined the concept of space-time convergence. Yeates'[66] study of school districts in Wisconsin points up the functional relationship between the size and delimitation of the school districts, and the cost of moving pupils to schools. He has used a transportation algorithm to produce a least-cost allocation of pupils to schools. An optimum location of boundaries was thus defined and this was compared to the actual locations to test for significant differences.

Finally, the frame of reference in which this research is conducted is dependent upon the assumption that the principle of rationality obtains[67]; that the pattern of administrative areas is the result of the interaction of forces through time, and that there are certain principles which underlie the way space is divided into spatial administrative systems. This study will attempt to search for some of these principles.

FOOTNOTES - CHAPTER I

1. This goal is succinctly stated in: YEATES, M.H., An Introduction to Quantitative Analysis in Economic Geography, (New York: McGraw-Hill, 1968), pp. 1-6.

2. For example: BURTON, I., "The Quantitative Revolution and Theoretical Geography", Canadian Geographer, Vol. 7, No. 4, 1963, pp. 151-162. CHORLEY, R.J. and HAGGETT, P. (Eds.), Socio-Economic Models in Geography, (London: Methuen, 1967), pp. 19-41.

   HAGGETT, P., Locational Analysis in Human Geography, (London: Arnold, 1965), pp. 1-27.

   CHORLEY, R.J., and HAGGETT, P., (Eds.), Frontiers in Geographical Teaching, (London: Methuen, 1965), pp. 3-20.

   Ad Hoc Committee on Geography, The Science of Geography, NAS/NRC 1277, (Washington, D.C.: 1965) pp. 1-6.

3. HAGGETT, P., Locational Analysis in Human Geography, op. cit., p. 1.

4. BRONOWSKI, J., The Common Sense of Science, (New York: Random House, no date).

   BRONOWSKI, J., Science and Human Values, (New York: Harper & Row, 1965).

5. KEMENY, J.G., A Philosopher Looks at Science, (New York: Van Nostrand, 1964).

6. YEATES, M.H., op. cit., p. 4, discusses the use of the scientific method in geographical research. For a discussion on methodology and research in the behavioural sciences see: KAPLAN, A., The Conduct of Inquiry, (San Francisco: Chandler, 1964), pp. 3-33.

7. These factors will be defined in Chapter III.

8. See: HARVEY, D., "Pattern, Process and the Scale Problem in Geographical Research", Transactions I.B.G., No. 45, Sept. 1968, pp. 71-8.

9. HUDSON, J.C. and FOWLER, P.M., "The Concept of Pattern in Geography", Discussion Paper Series, No. 1, Dept. Geog. Univ. of Iowa, mimeo. no date.

10. BUNGE, W., Theoretical Geography, Lund Studies in Geography, Series C, No. 1, Dept. Geog. Royal University of Lund, Sweden, (Lund: C.W.K. Glerrup, 1962) pp. 73-88.

11. HUDSON, J.C. and FOWLER, P.M., op. cit., p. 5.

12. For other examples of the use of set-theory in geography see: COLE, J.P., "Set Theory and Geography", Bulletin of Quantitative Data for Geographers, No. 2, Dept. Geog. Nottingham University, Feb. 1966.

13. HAGGETT, P., Locational Analysis and Human Geography, op. cit., pp. 48-55.

14. Ad Hoc Committee on Geography, op. cit., p. 36, support this statement.

15. WOLFE, R.I., Transportation and Politics, (New York: Van Nostrand, 1963) p. 7.

16. The analysis of flows within and between political entities is forming the basis of some contemporary research in political geography. Of about ten papers, presented at the 1967 meeting of the Association of American Geographers, in political geography, only two were of the morphological school, the others were primarily concerned with the interaction process.

17. In Chapter III an attempt will be made to define and to relate these variables to the process of regionalization evidenced by the O.H.E.P.C.

18. For a discussion of this approach, and an example see: FISHER, C.A., (Ed.), Essays in Political Geography, (London: Methuen, 1968), pp. 27-39.

19. This approach is discussed in: POUNDS, N.J.G., Political Geography, (New York: McGraw Hill, 1963), pp. 194-206.

20. JACOB, P.E. and TOSCANO, J.V., (Eds.), The Integration of Political Communities, (New York: Lippincott, 1964). DEUTSCH, K.W., The Nerves of Government, (London: MacMillan, 1966).

21. For a comprehensive list of research by sociologists see CHORLEY, R.J. and HAGGETT, P., (Eds.), Socio-Economic Models in Geography, op. cit., pp. 240-2.

22. MAIR, L., Primitive Government, (Harmondsworth: Penguin Books, 1962).

23. Much of this type of research is reported in the Papers and Proceedings of the Regional Science Association, Philadelphia, U.S.A. See also; NOURSE, H.O., Regional Economics, (New York: McGraw Hill, 1968), especially Chapter I and Chapter 10.

24. KEEBLE, D.E., in CHORLEY, R.J. and HAGGETT, P., (Eds.), Socio-Economic Models in Geography, op. cit., p. 287.

25. WRIGLEY, E.A., in CHORLEY, R.J. and HAGGETT, P., (Eds.), Frontiers in Geographical Teaching, op. cit., pp. 3-20. Wrigley's chapter considers the changes in the philosophy of geography through time.

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They state that:
"... acceptance of the ultimate existence of laws is predicated on accepting the principle of rationality or non-randomness in a universe".

CHAPTER II

HISTORY OF THE HYDRO-ELECTRIC POWER COMMISSION[1]

This chapter will describe the historical development of the Ontario Hydro-Electric Power Commission. Specifically, an attempt will be made to relate historical and political factors to the division of the Province into administrative areas. The chapter will provide an overview of the organization of the O.H.E.P.C. against which the hypotheses and the quantitative descriptions of the current administrative areas can be viewed. The hypotheses and the quantitative descriptions will be discussed in later chapters.

Before the formation of the O.H.E.P.C. the generation, and the distribution of power in Ontario was carried out by individual communities and private firms. In the early 1900's advisory commissions to the Provincial Legislature recommended that the water powers of Ontario should be conserved and developed for the benefit of the people in the Province. With Adam Beck as the driving force, on July 5th, 1905, an Order-in-Council was issued creating the Hydro-Electric Power Commission of Ontario. The Commission was created "as a corporate entity, a self-sustaining public enterprise endowed with broad powers with respect to electricity supply throughout the Province of Ontario"[2]. It was given permission to develop the generation, the transmission and the distribution of power, and the servicing of electrical installations in the

Province.

The Provincial Government advanced the initial capital of $2.5 million. By 1910 the Commission had used this to build its first transmission line and power was delivered to the eight municipalities that had voted to join the public ownership system[3]. Over the last fifty years the organization has grown, and at the end of 1967, the Commission and the associated municipalities served over two million customers. The growth of the O.H.E.P.C. is reflected in the following graphs: Number of Customers, Number of Employees, and Miles of Transmission Wire (See Figures 2.1, 2.2 and 2.3).

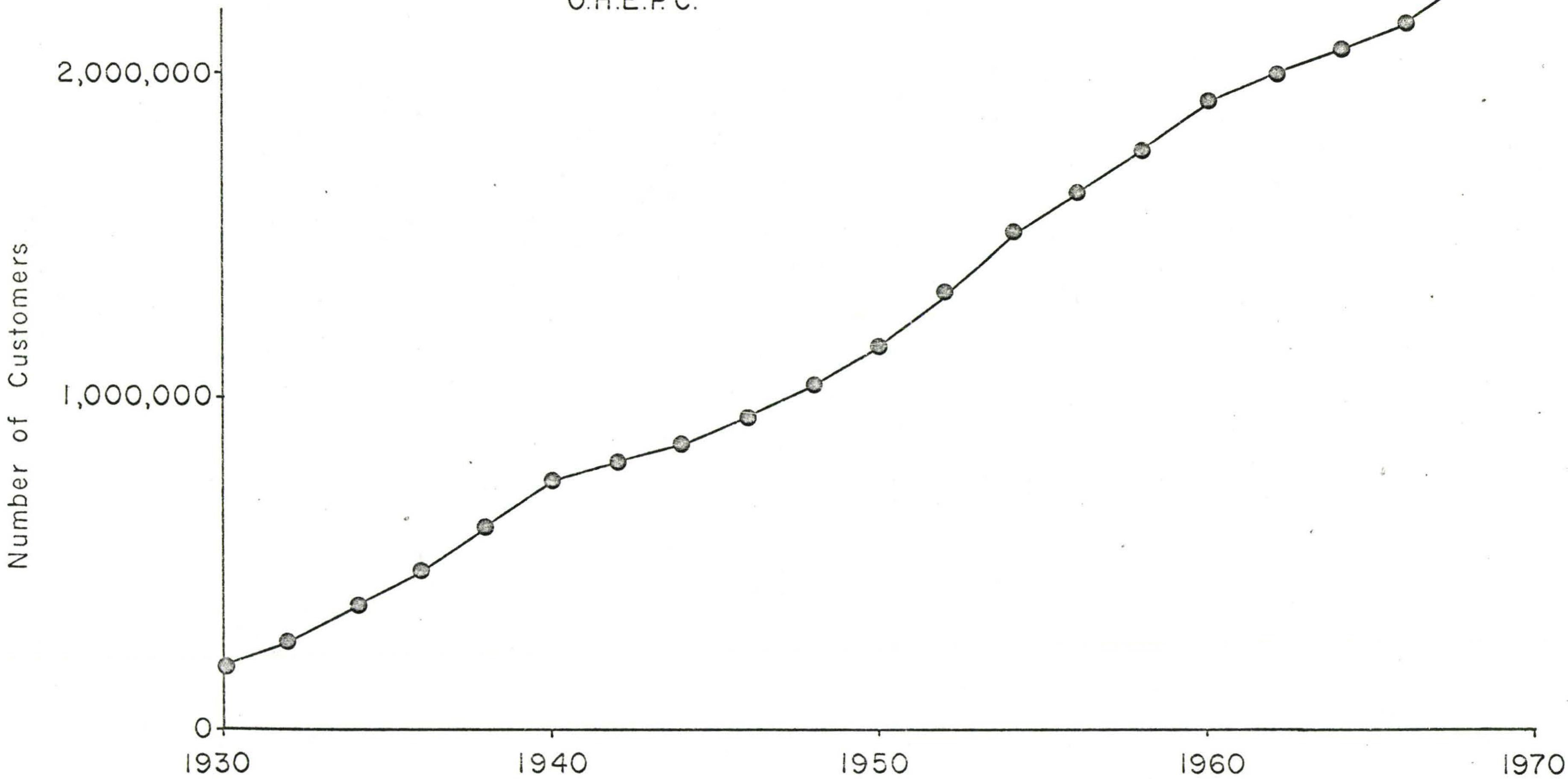
Adam Beck was appointed the first chairman of the Commission as a reward for his personal efforts in starting the organization. At that time he was Minister without Portfolio in the Conservative Government, though in effect he was Minister of Power[4].

One of the first tasks of the newly-constituted Commission was to undertake a survey of the water resources of Ontario, and at this time five power Districts were created. This represented the first attempt to amalgamate production units to gain economies of scale. The whole of the Province was not divided into Districts, and the boundaries were not clearly marked. The Districts served as groups of power generating units, and they grew month by month as generating plants were taken over by the O.H.E.P.C. The Districts were named Niagara, Trent, Georgian Bay, Eastern and Northern.

Following the Order-in-Council of 1905, on May 7th, 1906, an "Act to provide for the transmission of electrical power to municipalities"[5] was passed. The Toronto Mail and Empire reported in its editorial

Number of Customers
O.H.E.P.C.

Fig. 2·1

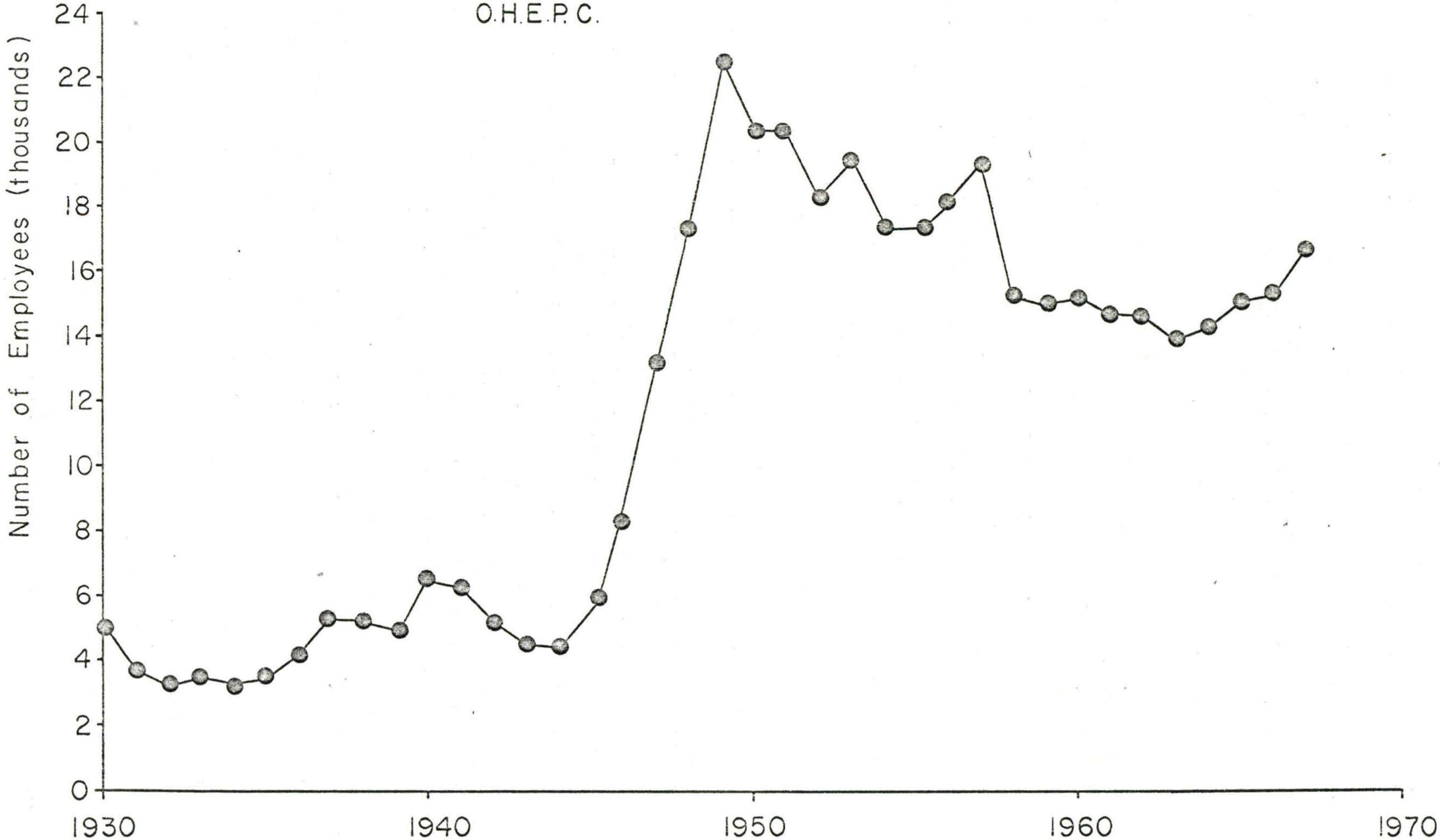


Source : Chief Statistician's Office, Toronto, O.H.E.P.C.

Number of Employees

O.H.E.P.C.

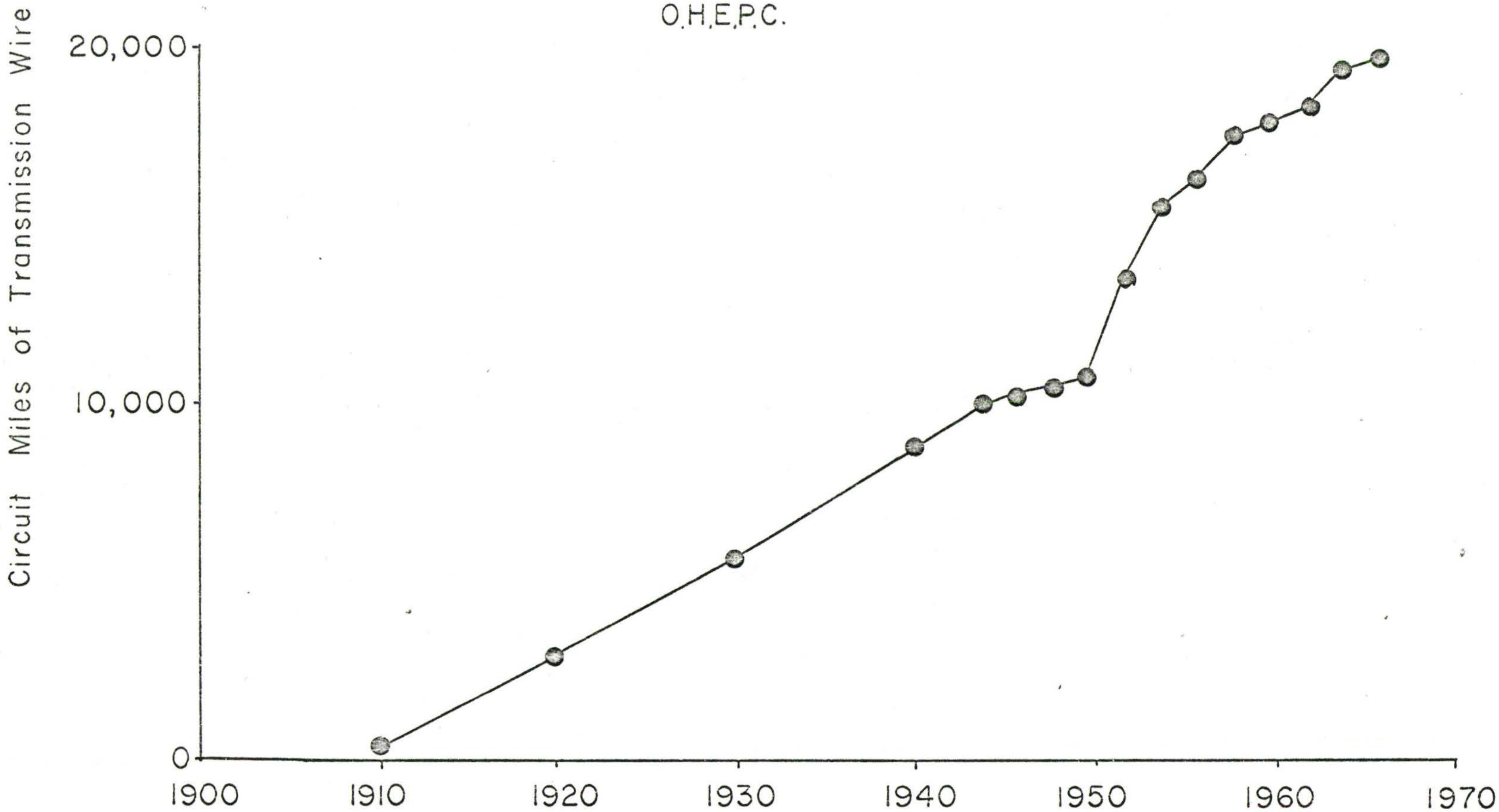
Fig. 2·2



Source : Chief Statistician's Office, Toronto, OHEPC.

Circuit Miles of Transmission Wire Fig. 2·3

O.H.E.P.C.



Source : Chief Statistician's Office, Toronto, OHEPC that:

> "It [the act] will turn out as it was designed to be, a measure of symmetrical reform-equitable towards power producers, transmitters, distributers, consumers and the Province."[6]

From the outset Ontario Hydro's organization appears to have been closely linked to provincial politics on the one hand, as evidenced by the manoeuvering by Beck in the legislature to gain funds and approval for the company, and public opinion on the other hand. The latter notion is supported by the nature of the opposition that was marshalled against Beck in the early days of Ontario Hydro. Fear of a large-scale Commission was encouraged by the investors in the companies already supplying power. The competitive claims by the Ontario Hydro were dismissed by the private entrepreneurs as unrealistic and unproven.

This suggests that politics influenced the organization of the O.H.E.P.C. Specifically, the political ethos of grass-roots and local autonomy, in this early period, appears to have slowed down the rate of growth of the Commission. A spirit of conservatism appears to have been operating at this time.

However, after the 1920's and until the 1940's the Commission expanded rapidly and overcame these forces. The O.H.E.P.C. promised cheaper costs per kilowatt as the size of the organization increased. Municipalities were encouraged to join and to help reduce the production costs. Also the Commission attempted to unify its organizational structure by equalizing the cost of power to all customers. The creed "power at cost", that had been echoed by Beck and his followers, was still present. But advanced costing and rate-fixing were difficult. In an attempt to solve the problem of rate-fixing the Commission developed the promotional rate structure. Writing in 1941 T. H. Hogg, one of the chief engineers at Ontario Hydro reported that:

> "The basic idea behind the promotional rate structure is this: the greater the load density on an electrical distribution system the greater the economy of operating and the use of material; the larger the demand for power the greater the oppportunity of developing large power resources and the greater the economies which come from generating on a large scale. These factors lower the cost of power to consumers."[7]

Clearly, notions of economies of scale were realised with respect to power generation and transmission, but no mention was made of them influencing the size or number of service or administrative units. This study will examine the relationship between the size of administrative areas and costs. The municipal electrical utilities expanded their sales, promotional schemes were operated and private companies were bought out as the Commission increased its sphere of influence. The urban dweller began to enjoy the benefits of electricity at a decreasing cost per kilowatt.

With respect to the rural dweller in the light of the "power at cost" creed, Denison posed the question, cost to whom? Consumers in outlying farms could not individually meet the prohibitive rates. On the other hand a flat overall rate was tantamount to asking the municipalities to subsidize the farmers. Both the Commission and the Provincial Government took steps to resolve this dilemma. Ontario Hydro's Rural Rate Committee studied the problem, and in a report of August 21st,1919, they recommended sweeping changes in the policy of supply to rural areas.

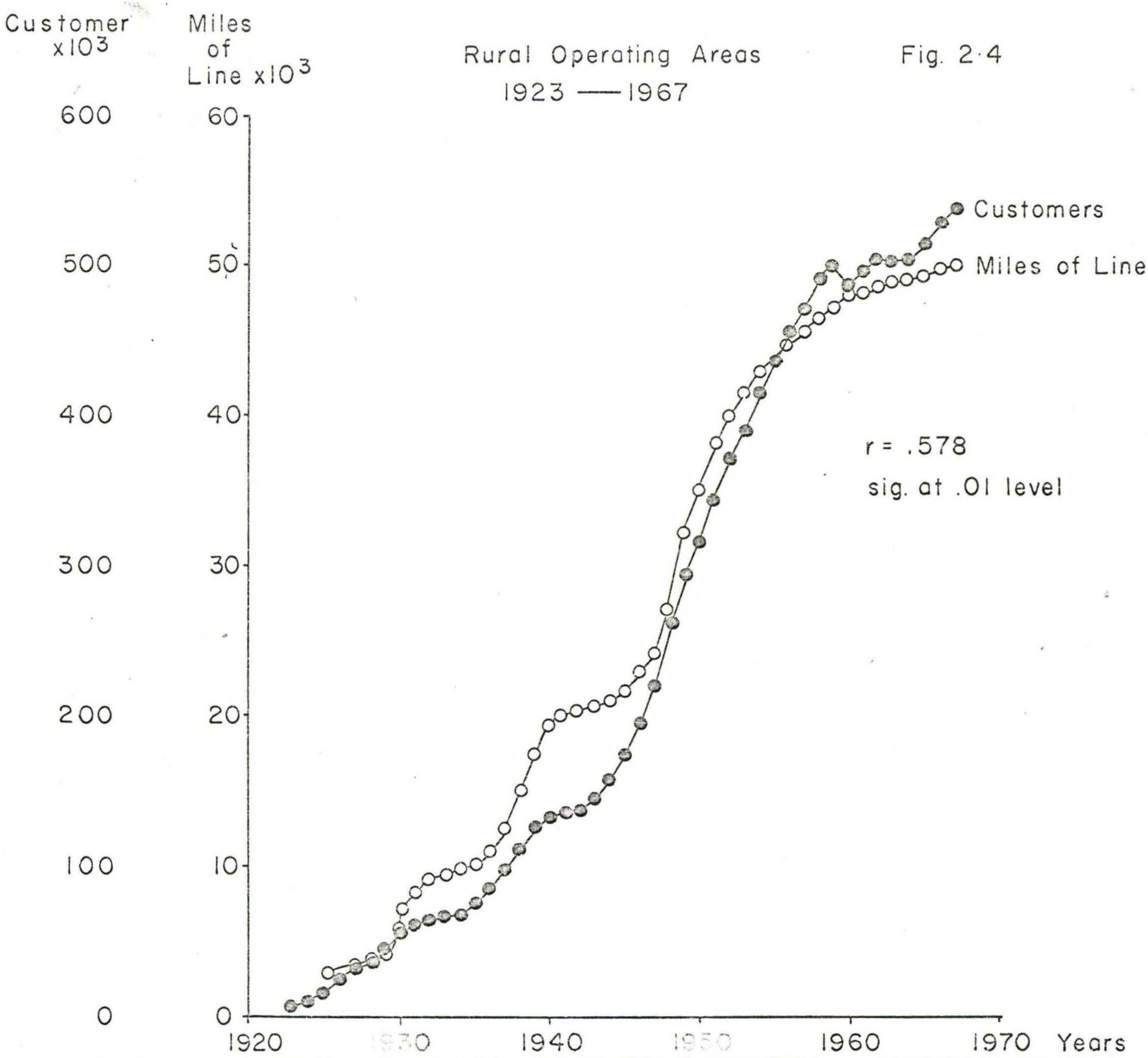
By an amendment in 1920 to the Power Commission Act of 1906 the Province was divided into Rural Districts, each consisting of about 100 square miles. These Rural Districts were to be operated by Ontario Hydro, each as a unit, with its own cost accounting and rate system. The rates were to be adjusted periodically as costs changed. The function of the Rural Districts was also to service the distribution lines. Within each Rural District a centrally located depot for equipment was chosen. The boundaries of the Rural Districts were not drawn along township lines. The boundaries were drawn through points of approximately equal time from the service centres. In the 1920's a time of about one hour by a service vehicle was used to delimit the boundary lines of the Rural Districts. It is suggested that economic distance played a greater role in influencing the location of the boundaries than any sentiment that may have been attached to townships. In some cases townships were split among Rural Districts.

Rural electrification grew steadily, in 1924 over 1,200 miles of primary line had been built. This served 20,605 customers, approximately seventeen to the mile. Four years later the comparative figures stood at 3,709 miles of line and 31,000 customers; approximately eight to the mile. In 1924 provincial grants covered 50% of the construction of rural lines and the same year the grants were extended to include transformers and secondary equipment. By 1928 Ontario Hydro was operating in 122 Rural Districts, comprising 211 townships.

In the 1920's the average Ontario farm was about 150 acres in size. This meant that usually a mile of distribution line would serve five or six farms. The Commission decided to extend service only on the basis of at least three farm contracts per mile of primary transmission line. This stipulation was later lowered to a minimum of two farms. From the inception of Ontario Hydro, rural electrification had been one of the goals of public-ownership supporters. They argued that the standard of living and social amenities would improve through electrification programmes. The provision of government subsidies greatly helped in the rural electrification programme. Denison compared the growth of rural electrification in Ontario to that in France, Germany, Holland, Sweden and New Zealand. He considered that the programme in Ontario was advancing satisfactorily, in the light of the scale of distances and the sparse population that was involved. The Commission deemed the rate of progress unsatisfactory. The meagre cash resources of many of the farmers was cited as the main factor hindering growth. In 1930 the Provincial Legislature passed the Rural Power Districts Loans Act. This Act provided the capital for wiring farm houses and barns, and installing motors and labour-saving devices. The result was an increase in the demand for power and a consequent decrease in costs per kilowatt. This trend has been maintained.

The following graph, Figure 2.4, illustrates the increase in rural electrification as evidenced by the number of rural customers, and the miles of rural primary line. The relationship between the two variables was tested using regression analysis. A correlation coefficient of .578 was calculated and this is significant at .01 level. The graphs also show the rapid post-war growth in rural electrification.

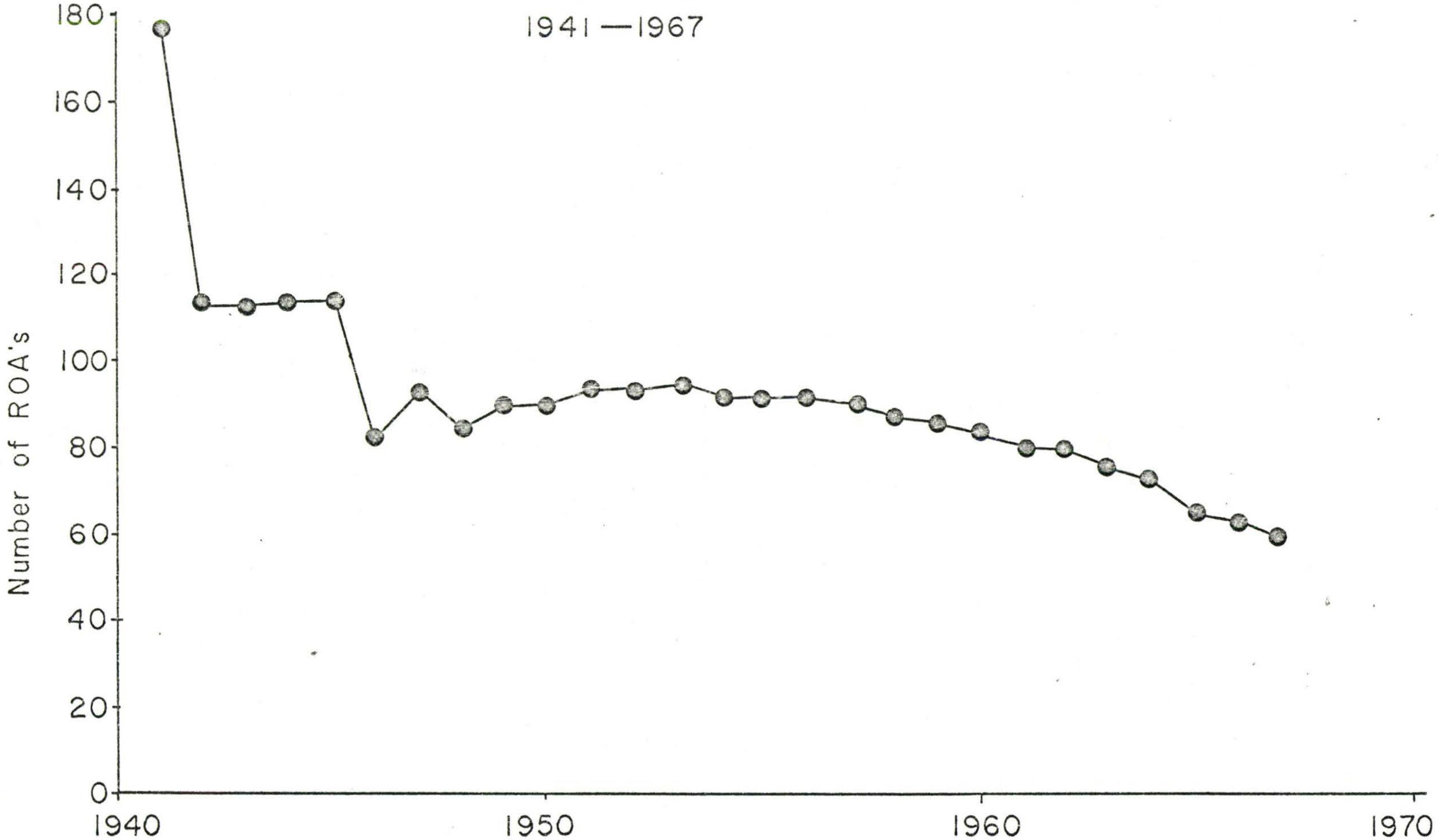
Figure 2.5 shows the number of R.O.A.'s between the years 1941 and



Customer x10³
Miles of Line x10³
Rural Operating Areas
1923 — 1967
Fig. 2·4
600
500
400
300
200
100
0
60
50
40
30
20
10
0
Customers
Miles of Line
r = .578
sig. at .01 level
1920
1930
1940
1950
1960
1970
Years

Rural Operating Areas
1941 —1967

Fig. 2·5



1967. The process of amalgamation is clearly marked especially in the period 1941 to 1947. Since 1947 the number of R.O.A.'s has declined at the rate of about two per year. It was suggested by Armour that the initiative for amalgamation had to come from the administrators of the areas, rather than as an order from the central body. This suggests that local autonomy existed and the central authority was influenced by local opinions. Armour stated that:

> "Grass-roots values seem to be holding up the amalgamation of areas, together with lack of a clear objective study of the costs of amalgamation, and the benefit to be gained."[8]

The outbreak of war in 1939, caused a rapid increase in demand for power; the Commission's power production systems were interconnected with certain municipal and privately owned local systems to help meet this demand. This involved engineering and administrative work without precedent in the history of Ontario Hydro. At the same time farmers were encouraged to consume more electricity and so release labour for war services, as well as to produce more food at lower costs. The difference in rate structures between rural areas and the M.E.U.'s was still being contested.

In 1943 the agitation for a flat rate for all Rural Districts, which in 1920 had been the subject of inquiry by the Lethbridge Committee, approached its objective. The House of Commons requested Ontario Hydro to examine the causes of differences in the cost of power to the Rural Districts and to the municipalities. The Commission reported that the basic cost of generation was the same for all, but that other costs varied with distance of transmission and distribution, load and number of users. To overcome the price differentials three proposals were made:

1. Amalgamation of all districts in southern Ontario;
2. Assistance to small municipalities with higher wholesale costs;
3. A new rural rate structure that would reduce the retail cost to 97% of the rural consumers with substantial reductions to customers in more remote districts.

This new rate structure was expected to stimulate rural electrification after the war. On January 1st, 1944, the revised rural rates were effected. All rural Power Districts were rearranged into three new units: Southern Ontario, Thunder Bay and Northern Ontario.

The local rural Power Districts were retained as administrative areas, but they were amalgamated into one division for pooling of expenses and revenues. The details of expenses for each area are not available. Therefore, in the economic analysis of R.O.A.'s a surrogate measure for costs will be used for each area. It has been stated by Preston that one of the two main costs for the Commission is salaries and wages[9]. Therefore, it is argued that the variable "employees per customer" will go some way to approximate the costs for each R.O.A.

Following the end of the war it was suggested that energy consumption would decline, yet, the decline did not materialise. In fact, by October, 1946, the demand for power had reached the highest level on record. This same year also saw some changes in the law pertaining to municipal utilities. The changes stipulated that membership of local commissions in cities of 60,000 or over be made up of the mayor, one member to be appointed by the city and one by Ontario Hydro for a term of two years. Wide-scale representation on the decision-making committees was encouraged. At this time major changes in the organization of the Commission took place. The initiation for the changes came from within the Commission, but the nature of the changes was provided by an external consulting firm. The centralized authority was gaining power and the influence of local forces seems to have been declining. Interviews with Preston, Jackson and Armour supported by the data on managerial and executive positions of the Municipal Electrical Utilities, suggest that many small M.E.U.'s persist because of attitudes of localism, and that these M.E.U.'s do not show great concern for the total organization. These points will be discussed in Chapter III.

The interviewees stated that the small municipalities were probably not operating as efficiently as possible. To amalgamate them with local R.O.A.'s and increase the size of the operation and so increase efficiency was difficult. The difficulty, they claimed, stemmed from local political values, autonomy and tradition. The municipalities with less than 1,000 customers were probably the most inefficient in terms of administrative costs.

In the mid 1940's a frequency change in the power distribution was suggested. This followed a series of technological feasibility studies. The sixty cycle frequency was to be adopted throughout the Province. This meant that those areas that were served by twenty-five cycle current, and the few served by sixty-six and two thirds cycles, had to be changed. The frequency change, together with increasingly heavy load demands and acute-power shortages, precipitated in 1947, a complete reorganization of the Ontario Hydro's administration. The Annual Report of the O.H.E.P.C. of 1947 stated:

> "When it became evident that Hydro was faced with this great expansion program the Commission late in 1946 reviewed broadly the adequacy of the existing organization to serve effectively the cooperating municipalities and its direct customers, while concurrently dealing with the multitude of technical problems involved in an expansion program."[11]

In February, 1947 the matter was further explored upon a threefold basis, comprising:

1. The general administrative organization
2. Certain engineering problems
3. Certain financial problems.

It was decided to secure the services of independent authorities to review the associated problems relating respectively to administration, engineering and finance. J. D. Woods and Gordon, Limited, industrial consultants, were retained to report upon the general administrative organization, and to make recommendations regarding an appropriate plan to provide efficient service to the consumers. A feature of the plan they recommended, and which was adopted, was the division of the Province into nine Regions, and the setting up of Regional Offices in London, Hamilton, Niagara Falls, Toronto, Barrie, Belleville, North Bay, Ottawa and Port Arthur. It was envisaged that the Regional Offices would become "nine miniature head offices"[12], and that each would be under the direction of a Regional manager charged with the responsibility of administering the day-to-day activities and policies of the Commission within his Region, excluding engineering and construction projects.

The Woods and Gordon report is not available to the public.

Preston commented that decentralization was a product of the growing workload, and diseconomies would begin to operate if all decisions had to be made through the central office in Toronto. The trend of decentralization since 1945 has been noted in the literature. Decisions made in Toronto were delegated to the Regional Managers. They became responsible for all matters pertaining to consumers. The 1947 Annual Report stated that:

> "... it is believed that the adoption of a decentralized type of administration will afford many advantages to the municipal and other customers."[12]

The advantages were not defined. One year later the following statement appeared in the Annual Report:

> "The decentralized type of administration has already proved successful, and beneficial - both to the Commission and to the Consumer."[13]

According to Preston this comment is "an unsubstantiated piece of conjecture". In 1948, McHenry[14] discussed Regional organization. He suggested that because the Commission operated over such a large area, a decentralized type or organization was necessary to ensure a much more rapid and advantageous day-to-day service to the municipalities and consumers generally. McHenry also commented that the re-organization was taking time and that it was difficult to break up an existing organization, put it together again and expect efficient operation immediately. He claims that the re-organization was showing "marvellous improvements" in the time it had been operating.

Finally, he noted that it was the very definite aim and object of the Commission to render to municipalities the maximum of service with the least possible delay. However, in that connection:

> "... let me point out that it takes two parties to effect complete co-operation, and the co-operation and service the municipalities obtain from the regions depends on the degree the municipal systems avail themselves of the regional organization and consult with the regional offices in carrying out their work."[15]

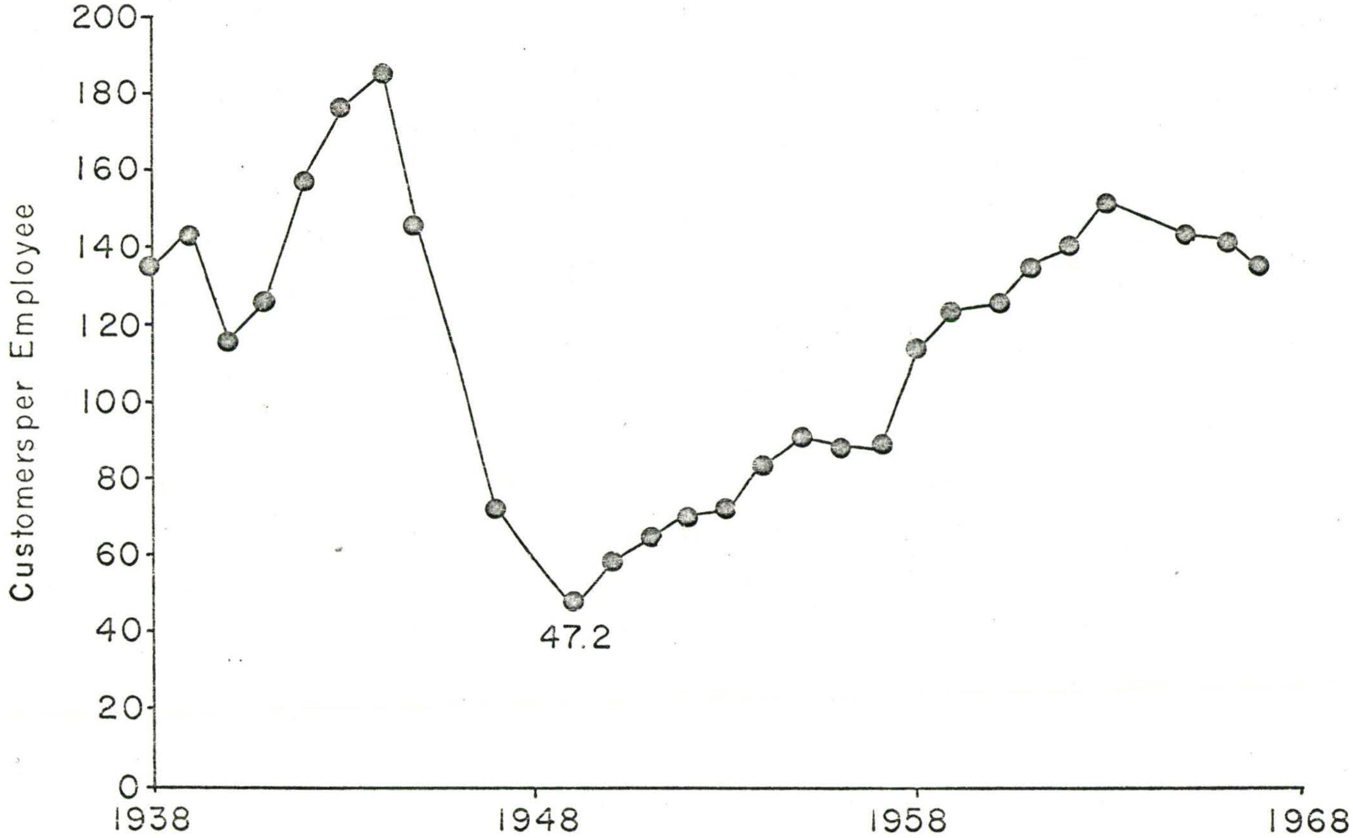
McHenry was referring to local Commissioners who resented the new organization structure. Such Commissioners probably realised that if the centralized organizational structure could be radically changed, then their links to very small units were possibly tenuous.

According to Preston the critical factor in the plan to decentralise was the cycle conversion programme. The customers needed to have access to local offices to obtain the new equipment; more offices were necessary and employees made more frequent trips between customers and centres. The cycle conversion programme began on January 19th, 1949. During the period of the cycle conversion programme the feeling of local autonomy reappeared. Fear of the "large-scale impersonal organization" and fear of "lower safety standards through larger organizations" were cited as forces which reinforced local sentiment at that time.

In 1953, the Commission described its "all-out effort to keep abreast of the mounting power demands" and this, according to Denison, reflected the growing level of prosperity in the Province, the large-scale expansion of industry and the increased farm output. By July 1959, the cycle conversion programme was completed. Figure 2.2 shows the influence of this programme on the number of employees, and Figure 2.6 shows the decrease in the number of customers per employee as the

Customers per Employees 1938 —— 1967

Fig. 2·6



programme began to operate. This trend was reversed after a low-point of 47.2 customers per employee was reached in 1949.

In 1960 the East Central Region was amalgamated with the Central Region. Ottawa ceased to serve as a location for a Regional headquarters. The enlarged Central Region was served by Belleville[16]. Two years later the West Central Region was allocated to the Niagara Region, and the Regional office was located in Hamilton[17]. Niagara Falls ceased to be used as a Regional centre. Knights[18], the editorial officer of Ontario Hydro, stated that these changes followed improvements in the mobility of service equipment and transportation in general. He stated that consideration has been given to reducing the number of Regions in Ontario by six.

In summary, the O.H.E.P.C., now operates two generating systems which cover the Province; the East System and the West System. Power is sold either to municipal electrical utilities who distribute it to their customers and deal with all local services, or it is sold directly to customers by the Commission. The servicing of these customers is carried out through the R.O.A.'s.

The Regions operate as autonomous units with respect to all matters relating to servicing and administration. They do not control power generation or transmission.

FOOTNOTES - CHAPTER II

1. Data for this chapter were drawn from the following sources.

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   PLEWMAN, W.R., Adam Beck and the Ontario Hydro, (Toronto: Ryerson Press, 1947)

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   SMITH, H.A., "Present and Future Development for Bulk Supply of Electricity in Ontario", The Engineering Journal, July, 1965, pp. 1-6

   M.E.U. Executive and Managerial Positions, document prepared by the Chief Statistician's Office, O.H.E.P.C., Toronto, Dec. 1968

   Newspaper reports in Appendix III. These documents were supplemented by unstructured interviews with W. S. Preston, Chief Statistician, Finance Branch, O.H.E.P.C., Toronto; W. T. Jackson, Niagara Region Manager and A. O. Armour, Dundas Rural Operating Area Manager

2. Annual Report, Toronto, O.H.E.P.C. 1967 p. 1

3. DENISON, M., *op. cit.*, for a discussion on the methods that were used to encourage municipalities to join the Commission.

4. DENISON, M., *ibid*. p.47

5. Ontario Legislature, Edward VII, Ch. 13

6. Toronto Mail and Empire, May 11, 1906

7. DENISON, M., *op. cit.*, p. 103

8. Interview

9. Interview; the other main cost is the interest on monies borrowed. Ontario Hydro is a capital intensive industry.

10. Interview with Preston; it is interesting to note that Denison, M., op. cit., p. 228 states:

    "Following the end of the war it was felt by the Hydro Commission that there must be a tremendous upsurge of new industrial activities, and there would be comparable acute shortages of power."

11. Annual Report, Toronto, O.H.E.P.C. 1947, p. vii

12. Annual Report, ibid. p. ix

13. Annual Report, Toronto, O.H.E.P.C. 1948

14. McHENRY, M.J., "Regional Organization", Hydro News, vol. 36, 1949

15. McHENRY, M.J., ibid.

16. The availability of office space in Belleville was cited as the reason for its choice over Ottawa, see DOLBEY, S.J., op. cit., Tindal suggests that the move away from Ottawa represents an attempt to withdraw the Commission from the political influence of the capital, see TINDAL, C.R., op. cit.

17. Preston suggested that Hamilton's central spatial location influenced its selection over Niagara Falls. The latter represents an eccentric spatial location in the Niagara Region.

18. Knights, J.J., Editorial Officer, O.H.E.P.C. correspondence with author, Nov. 1966.

CHAPTER III

FORMULATION OF THE HYPOTHESES

> "Research is the attempt to improve the level of objective description. And scientific inquiry is an understanding geared to the solution of the problems. The first step in the formulation of research is to make the problem concrete and explicit."[1]

The problem that this research is concerned with is to determine the influence of selected factors on the shape, pattern, size and arrangement of the administrative areas that are used by the Ontario Hydro-Electric Power Commission. This chapter will define the factors and defend their choice. Further, hypotheses concerning the possible connection between these factors and the administrative areas will be erected. The role of an hypothesis in scientific enquiry can be stated thus:

> "it is to suggest explanations for certain facts and to guide in the investigation of others."[2]

This research will also offer quantitative descriptions of the administrative areas. It is hoped that these descriptions will point out some of the factors which influence the configuration of the administrative areas. Cohen and Nagel define this type of approach. They say that:

> "We cannot take a single step forward in any inquiry unless we begin with a suggested explanation. Such tentative explanations are suggested to us by something in the subject matter and by our previous knowledge. When they are formulated as propositions, they are called hypotheses."[3]

From the outset it is postulated that administrative services are distributed according to some general principles. And that the division of territory into administrative areas is the outcome of a decision-making process. For the purposes of analysis it is argued that the process is influenced by consideration of three groups of factors. These factors are defined as economic, political and historical. The next three sections of this chapter will offer hypothesised relationships between the factors and the administrative areas.

The final section in this chapter will discuss a conceptual framework for relating the factors.

Economic Factors

Underlying the postulate that economic factors influence the pattern of administrative areas is the notion that regionalization represents an attempt to optimize a cost function. The optimizing of cost functions formed the basis of classical economic theory on the organization of activities; particularly optimization as represented by least-cost models or maximum-profit models. For an actual organization to achieve an optimum arrangement it is necessary to assume that all alternatives open to the decision-maker are known, and that the arrangement will change at any time to gain marginal utility. Optimum models of human behaviour have been used by researchers to establish normative patterns of behaviour or organization. The investigation of deviations from a defined norm offers a research strategy that is widely used in the social sciences[4]. A normative model of Regions will be defined, such that the distance between consumers and administrative centres is minimized. The boundaries of the Regions will be located to satisfy this objective. Further, each Regional centre will be located at the point of minimum aggregate travel within the Region. It is argued that the cost of administering a Region is a function of the linear distance between the centre and the consumers. A minimum-distance model of Regions will also be a least-cost model under these conditions.

Hart[5] has suggested that the point of minimum aggregate travel represents an optimal location for an administrative centre as it represents the most accessible point to all consumers. When the Regions were established the rationale was to decentralise the organization and make each Region,

> "... responsible for all matters pertaining to customer relations within their respective Regions, and it is believed that the adoption of a decentralised type of administration will afford many advantages to the consumers."[6]

Presumably one of the main advantages that this type of organization would afford was easier access between centres and consumers than was possible under the centralised system.

The concept of minimum-distance and minimum-effort, in models of human organization, has been discussed by Zipf[7] who suggested that the notion of least-effort strongly influences human behaviour and organization patterns.

Least-distance models will be constructed under the constraints that firstly, each Region serves an equal number of people and secondly, that each Region serves the same number of people as in reality. A least-cost model whereby the population is assigned to the nearest Regional centre will also be constructed. In this case no constraint is placed upon the number of people served by each Region.

Finally, a series of least-distance iteration models, whereby the centres and the boundaries of Regions are successively relocated under defined constraints, will be constructed.

In the case of the normative models of Regions it is argued that distance is related to effort and that the models represent least-effort patterns. Information gained from the interviews[8] suggested that the pattern of Regions was influenced by considerations of the work load and this was related to the population distribution. Further, that notions of accessibility influenced the location of boundaries and centres. Explicit definitions of accessibility were not provided.

All the normative models and the actual pattern of Regions will be evaluated quantitatively. The hypothesis that the actual pattern is not significantly different from each of the normative patterns will be tested. The results will be discussed in Chapter VIII. The differences between the actual pattern and the normative patterns will also be discussed.

Turning to the smaller administrative areas that cover southern Ontario, the R.O.A.'s, the next part of this chapter will attempt to offer a theoretical explanation for their shape and arrangement.

Retaining the notion of least-distance as a dominant force in determining the location of administrative boundaries it can be shown that hexagon-shaped administrative areas offer the most compact shape under the following assumptions:[9]

1. Homogeneous population distribution

2. Finite number of evenly spaced administrative centres

3. Infinite isotropic transportation surface

4. Linear transportation rate for distributing the service from the centres to the population.

The regular hexagon satisfies the least-distance constraint.

Haggett[10] has postulated that if administrative areas are packed in such a way as to have contact with six adjacent areas, (contact number equal to six), they will approximate to the shape of hexagons. Thus they will exhibit a high level of compactness. He tested the null hypothesis that the contact number is not significantly different from six for a sample of counties in Brazil, and therefore that the principle of compactness appears to influence the pattern of administrative areas. He found that although the number of contacts varied from two to fourteen, nearly one in three counties had exactly six neighbours. The mean contact number was 6.21. This rather striking approximation to the hexagonal number proposed by Losch[11] and Christaller[12] suggests that criticism of the hexagonal system as over-theoretical may have been too hasty.

Haggett also reported that preliminary counts on administrative areas in France and China suggested that the Brazilian figure was not exceptional. He concluded:

> "... further investigation is necessary before we can be sure we have isolated a regularity in territorial organization."[13]

In the light of these comments the following hypothesis will be tested. That the shape of the R.O.A.'s in the study area approximate hexagons and that there is no significant difference between the number of contacts they exhibit and the number of contacts they would exhibit if they were hexagons, that is six. The test of this hypothesis and a discussion on the assumptions noted above will be presented in Chapter VII.

This research will also examine the shape of the R.O.A.'s using the shape index that was defined in Chapter I. This index theoretically varies from 0.0 to 1.0 as the shape approaches a circle. A regular hexagon has a value of .83. The relationship between the contact number and the shape index will be examined to test for any regularity in shape among the R.O.A.'s. When these areas were established the O.H.E.P.C. stated that they should be approximately equal in size and as compact as possible. This research will offer a measure of compactness, the shape index, and test the hypothesis that the R.O.A.'s are regular hexagons, and therefore exhibit maximum spatial compactness. The reasons for deviations from regular hexagons will be discussed, with the test of the hypothesis, in Chapter VII.

With respect to the size of administrative areas, economic theory concerning the relationship between the cost per unit output and the quantity of a good produced, will be used. For administrative areas the cost per unit output will be defined in terms of costs per consumer or number of employees per consumer; it is argued that these two variables, like cost per unit output, measure economic efficiency. The quantity of the good produced will be defined in terms of the variables which reflect the size of the work load, - for example, size of area, number of customers, miles of wire, and miles of road. Economic theory suggests that the relationship between these two variables is described by the long-run average cost (LAC) curve[14]. This is the envelope curve of short-run average cost (SAC) curves. It is assumed that if firms operate at the lowest point on their respective SAC curve the shape of the LAC curve is U-shaped. This is the case if the scales of operations become successively more efficient up to some particular scale then become successively less efficient as the range of the operation scales from very small to very large. Increasing efficiency, associated with larger and larger scales of operation, is reflected by SAC curves lying successively at lower levels and further to the right. SAC curves lying successively higher and to the right réflect decreasing efficiency. The SAC curves and the LAC curves are shown in Figure 3.1. The LAC curve suggests that as the size of an operation increases it becomes increasingly efficient, until a point is reached when diseconomies begin to operate. Economies of scale contribute to this relationship. Leftwich suggests two economies of scale:

1. Increasing possibility of using advanced technological developments and larger machinery.

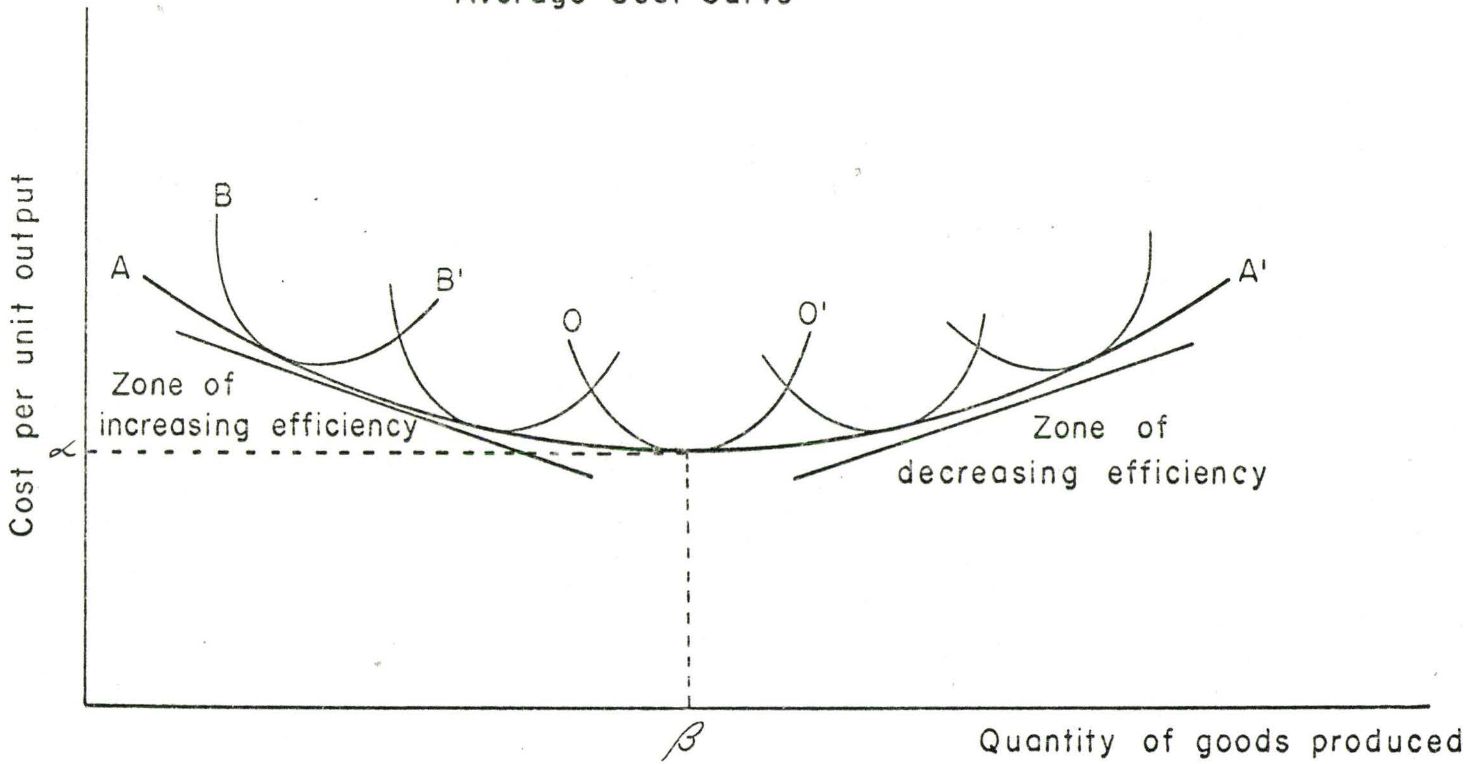
2. Increasing possibility of division and specialization of labour.

Theoretically it is argued that the economic efficiency of an administrative area is related to the size of the area. The relationship is described by a U-shaped curve, this assumed that economies of scale operate and that all administrative areas operate at the minimum point on their respective SAC curve.

Data for the sample of M.E.U.'s and the the R.O.A.'s will be used

Theoretical Short-Run Average Cost Curves and Long-Run Average Cost Curve

Fig. 3·1



B–B' Short-Run Average Cost Curve (SAC)

A–A' Long-Run Average Cost Curve (LAC)

O–O' SAC containing optimum point of production

At β production level, minimum cost per unit output obtains, to test the relationship between measures of the economic efficiency of each administrative area and the measures of the size of the areas. The results will be discussed in Chapters VI and VII. For the M.E.U.'s the ranges of the variables that will be used in the analysis are shown on Table I.

TABLE I

VARIABLES	MAXIMUM	MINIMUM
Total costs per customer	$148.81	$73.19
Administrative costs per customer	$ 29.09	$ 7.37
Size of area	69,272 (acres)	345 (acres)
Miles of road	707 (miles)	4 (miles)
Number of customers	231,898	134

For the R.O.A.'s the ranges of the variables are shown in Table II.

TABLE II

VARIABLES	MAXIMUM	MINIMUM
Employees per customer	5.98×10^{-3}	4.62×10^{-4}
Number of employees	83	16
Number of customers	17,951	2,674
Size of area	2,469 (sq. miles)	189 (sq. miles)
Miles of wire	1,742 (miles	294 (miles)

Intuitively these ranges seem quite large, and it is suggested that if a relationship between the economic efficiency and the size of the administrative area exists, it should be reflected by these data.

For the R.O.A.'s a measure of economic efficiency, the number of employees per customer, will be related to a measure of spatial compactness of the area. Theoretically it is argued that as the area becomes more compact the level of economic efficiency increases. The compactness describes the spatial distribution of the workload, and it is assumed that as the workload becomes more concentrated so the level of economic efficiency increases. Particularly, travel time between the area depot and the consumer will decline as the area becomes more compact. This relationship will be discussed in Chapter VII.

Finally, it is argued that through time with improved transportation and communications, the size of administrative areas increases through an amalgamation process. This process complements the growing diversity of the total organization as the workload increases through time. The two processes operate simultaneously, they have been recognized and are reported in the literature by Morris[15]. With respect to the O.H.E.P.C. these processes were discussed in Chapter II.

The introduction of political and historical factors into the normative economic models of administrative areas should improve the level of explanation of the current arrangement of areas. The next two sections will attempt to isolate the dominant political and historical factors which appear to have influenced the arrangement of administrative areas used by the O.H.E.P.C. An attempt will be made to formulate the relationships into hypotheses.

Political Factors

Chapter II offered a general introduction to some of the political factors which influenced the development of the O.H.E.P.C. This section will complement Chapter II by defining two particular sets of political factors and relating them to administrative areas. The first set concerns the large scale political values which have been generally discussed by Ylvisaker[16]. The second set considers the values of individual decision-makers. Data were drawn from a review of the Annual Reports of the O.H.E.P.C., particularly, the letter of Transmittal from the Chairman of the O.H.E.P.C. to the Lieutenant-Governor of Ontario together with a review of the works by Denison and Plewman[17]. Denison's study of the O.H.E.P.C. was completed in 1960. To gain information about the organization since this date, a survey of newpaper reports was conducted. The press files of the Hamilton Spectator were examined. A list of the newspaper articles appears in Appendix III. Interviews with administrators were also conducted[17].

Since 1910 there appear to have been three main periods each with a characteristic political climate which influenced the organization of the O.H.E.P.C. They are summarized in Table III. The political climate appears to be related to the economic and social life in the Province, and both these elements influence the regionalization process. The most radical changes in organization appeared after 1945. The period 1939 to 1945 also saw the greatest changes in the political climate. Following the end of the second world war an increase in industrial development, urbanization and the demand for electricity manifest itself in a new arrangement of administrative areas; the Regions.

Future research could compare the regionalization process of the O.H.E.P.C. to that of other agencies in Ontario for the same period. An attempt could be made to formulate specific hypotheses as more empirical

TABLE III

POLITICAL CLIMATES IN ONTARIO - 1900-1967[20]

PERIOD	CHARACTERISTICS OF THE POLITICAL CLIMATE	ECONOMIC AND SOCIAL LIFE IN ONTARIO	RELATIONSHIPS TO THE PROCESS OF REGIONALIZATION
1900 1939	Grass-roots politics, local autonomy, fear of large-scale organizations.	Territorial expansions; primary economic growth; rural settlement.	Ad hoc small administrative areas, local control decentralized decision-making.
1945 Early 1960's	Tradition and local sentiment less dominant than in first period. Planning more acceptable, delegation of responsibility to higher authorities	Urbanization; expansion of tertiary sector in the economy; industrialization; development of transportation facilities.	Amalgamation of areas, with increasing demands new regional structures, central decision-making and local decision-making.
Early 1960's 1968	Period of appraisal of plans, tradition and local sentiment becoming decreasingly, important.	Continued urbanization; industrialization; high demand for services and economical prosperous period.	Systemmatic appraisal of regionalization. Transfer of decision-making to most efficient level. Decentralization with high demand and diversity of functions.

data becomes available.

With reference to the individual values of decision-makers it has been reported in the literature that personal goals and values influence decisions[18]. Also that socio-economic parameters of the decision-makers influence their decision. In the field of community power studies empirical evidence suggests several relationships between variables describing individuals and their decisions. However, operational definitions of decisions are lacking and this makes it very difficult to search for some general principles in the process of decision-making at this level. Because data were impossible to obtain concerning the characteristics of the decision-makers of the O.H.E.P.C. only superficial relationships can be suggested. The evidence for these relationships is based on interviews with Preston, Jackson and Armour[19].

They suggested that individual personalities exerted influence on the organization of the O.H.E.P.C. And that this type of influence had decreased considerably from the time of Beck. He was the person who exerted the most profound influence. Individual influence was probably exerted by Commissions on the organization of M.E.U.'s particularly the small ones, - for example, those with less than 1000 customers. The most common type of influence, at this level,was probably to perpetuate the ethos of local control and autonomy, and to fight against amalgamation. The interviewees could not give specific examples. At this time the relationships between political factors and administrative areas can only be formulated as propositions. More data and precise operational definitions are needed to advance the understanding of the relationship of political factors to spatial administrative systems.

This could form the basis of a future research project.

Historical Factors

This section will discuss and apply some of the concepts in the literature concerning the relationship between historical factors and the arrangement of spatial administrative systems to the areas used by the O.H.E.P.C. The literature suggests that the location of new administrative boundaries is determined by currently existing administrative lines, and that the arrangement of new administrative areas follows the arrangement of currently existing administrative areas[21].

This research examined the relationship between township lines and county lines, as examples of existing administrative boundaries, and the boundaries of the Regions and the R.O.A.'s. For the most part the Regional boundaries follow the township lines. The townships appear to be the basic spatial unit for the Regions in southern Ontario. In northern Ontario the boundary between the Northwestern Region and the Northeastern Region follows the Albany River and then follows a north-south line which is approximately equidistant from the Provincial boundaries with Manitoba and Quebec. The boundaries of the R.O.A.'s sometimes divide townships; their location was not influenced by either the location of township lines or the location of county lines.

With respect to the influence of previous administrative areas on the arrangement of areas used by the O.H.E.P.C. Table IV summarizes the relationships. It is only the smallest administrative units, the townships and the municipal areas, that have influenced the current

TABLE IV

THE INFLUENCE OF EXISTING ADMINISTRATIVE
AREAS ON THE ARRANGEMENT OF REGIONS,
R.O.A.'s AND M.E.U.'s

	Existing administrative areas which influenced the arrangement
REGION	Groups of townships (This point is discussed more fully in Chapter V
R.O.A.'s	Nil
M.E.U.'s	1. Municipal boundaries 2. Townships

arrangement of Regions and M.E.U.'s. The counties and the regions of other agencies do not appear to have played a role in this respect. Data on the functions of regionalization schemes of other agencies and the counties is needed before they can be compared to the regionalization schemes of the O.H.E.P.C.

The economic, the political and the historical factors have been discussed individually. In all cases they have been related to the current arrangement of Regions, R.O.A.'s and M.E.U.'s. The final section of this chapter will make some further comments on factors which influence spatial organization. Also, a discussion on Pred's behavioural matrix, as a framework in which to incorporate all the factors, will be presented.

Pred's Behavioural Matrix[22]

Pred has recognized that spatial organization is a produce of decision-making. This, he claims, is influenced by two elements; the level of information possessed by the decision-maker and the ability of the decision-maker to use the information. This Behavioural Matrix is an attempt to relate these two elements to actual and theoretical patterns of spatial organization or behaviour. The matrix will be discussed more fully in Chapter VIII when it will be used to describe the simulated and the actual pattern of Regions.

The concept of optimum spatial organization, as argued in the first section in this chapter, presents a limited framework in which to view reality[23]. It is a useful analytical tool, but the models produced under the severe assumptions and constraints are often very different from reality. In an attempt to improve the level of description of the models of administrative areas the following could be included.

1. Satisficer levels of utility[24]

2. Limited range of alternatives for the decision-maker[25]

3. Limited ability of the decision-maker to use information[26]

as well as the political and historical factors discussed above.

Future research could attempt to relate the economic, the political and the historical factors and the three factors listed above to the two elements in Pred's Matrix. If this could be done then a powerful descriptive model of spatial administrative systems should result.

FOOTNOTES - CHAPTER III

1. SELLITZ, C., et. al. Research Methods in Social Relations, (Toronto: Holt, Rinehart and Winston, 1964), p. 31.

2. SELLITZ,C., ibid, p. 35

3. SEELITZ, C., ibid, p. 35

4. For a discussion on some uses of residual mapping in hypotheses testing in human geography see: McCARTY, H.H., & LINDBERG, J.B., A Preface to Economic Geography, (New Jersey: Prentice Hall, 1966) pp. 78-79 and for a general review of some of the most recent literature on residual analysis see: ROBINSON, G., & FAIRBAIRN, K.J., "An Application of Trend Surface Mapping to the Distribution of Residuals from Regression", Annal Assoc. Amer. Geog., Vol. 59, No. 1, March, 1969, pp. 138-170.

5. HART, J.F., "Central Tendency in Areal Distributions", Econ. Geog. Vol. 30, No. 1, Jan., 1954, pp. 48-59.

6. DENNISON, J.F., op. cit.

7. ZIPF, G.K., Human Behaviour and the Principle of Least Effort, (London: Hafner Publishing Co., 1965)

8. PRESTON, see footnote 1, Chapter II.

9. For a proof see: LOSCH, P., The Economics of Location, (New York: John Wiley, 1967), pp. 109-123. For a discussion on the relationships between hexagnol areas and spatial interaction see: WOLDENBURG, M.J., "Energy Flow and Spatial Order", The Geog. Review, Vol. LVIII, No. 4, 1968, pp. 557-574.

10. HAGGETT, P., op. cit., p. 48

11. LOSCH, A., op. cit., pp. 108-123

12. CHRISTALLER, W., Central Places in Southern Germany, (Trans. from Die Zentralen Orte in Süddeutschland, C.W. Baskin), (New Jersey: Prentice-Hall, 1966) pp. 77-90.

13. HAGGETT, P., op. cit., p. 51

14. For a discussion on SAC and LAC see: LEFTWICH, R.H., The Price System and Resource Allocation, (Toronto: Holt, Rinehart and Winston, 1965), pp. 131-148.

15. MORRIS, W.T., Decentralization in Management Systems, (Ohio: State Univ. Press, 1963), pp. 1-24

16. YLVISAKER, P., op. cit.

17. See Footnote 1, Chapter II.

18. For a summary of some contemporary research on decision-making see: EDWARDS, W. & TVERSKY, A., (Eds.) Decision-Making, (Bungay, Suffolk: The Chancer Press, 1967) SIMON, H.A., Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization, (New York: McMillan, 1957). A review of this book is provided by BANFIELD, E.C., "The Decision-Making Schema", Public Admin. Review, Vol. 17, 1957, pp. 278-285.

    Katona develops an inter-disciplinary approach to the study of decision-making in KATONA, G., Psychological Analysis of Economic Behaviour, (Toronto: McGraw-Hill, 1951).

19. See Footnote 1, Chapter II.

20. Whebell stresses the importance of understanding the political climate to explain local government areas. See: WHEBELL, C.F.J., op. cit., p. 100.

21. For a summary of the influence of historical factors on boundary locations see: PRESCOTT, J.R.V., op. cit., p. 174.

22. PRED, A., Behaviour and Location, (Lund, Sweden: C.W.K. Gleerup, 1967). See pages 21 to 64 for a discussion on the Behavioural Matrix. A review of literature on behaviour and location theory occurs in this book.

23. This point is discussed by PRED. A., op. cit.,

24. SIMON, H.A., Models of Man,(New York: John Wiley, 1957).

25. SIMON, H.A., ibid. p. 198.

26. KATONA, G., op. cit., and PRED, A. op. cit.

CHAPTER IV

DATA SOURCES

This chapter will present the data sources that will be used to provide quantitative descriptions of the current spatial arrangement of M.E.U.'s, R.O.A.'s and Regions. The data that will be used for testing the hypotheses, relating the economic factors to the arrangement of administrative areas, will be included. The sources of information that were used for Chapter II, and in the formulation of the hypotheses concerning the political and historical factors have been noted earlier.

Municipal Electrical Utilities: Data

	DATA	SOURCE
1.	A random sample of 80 M.E.U.'s	Annual Report, 1967, O.H.E.P.C., Toronto

The 355 M.E.U.'s in Ontario were arranged alphabetically and numbered 1 to 355. Using a random number table eighty were selected.[1] It is suggested that a random sample of size 80 from a population of 355 will provide an unbiased and representative cross-section of the body of data. For each M.E.U. the following data were collected.

2.	Number of customers	as above
3.	Administrative costs ($) Total costs ($) Power purchased ($) Depreciation ($)	as above
4.	Miles of road	Municipal Directory, 1963. Department of Municipal Affairs, Toronto.

The miles of road recorded in the 1963 Municipal Directory were increased by 6%, in an attempt to provide data for 1967. The increase was based on 1.5%. This figure was derived from statistics provided in Appendices 10 and 12 of the Annual Reports of the Department of Highway, Ontario.[2]

5.	Area (acres)	as above

Boundary changes were considered from the Annual Reports of the O.H.E.P.C. to bring the data to a 1967 base. The figures were adjusted where boundary changes had taken place.

Rural Operating Areas: Data

	DATA	SOURCE
1.	Base map of R.O.A.'s	Annual Report, 1967, O.H.E.P.C., Toronto

For each R.O.A. the following data were collected.

2.	Area (sq. miles)	Chief Statistician's Office, O.H.E.P.C., Toronto
3.	Long axes (miles)[3]	Calculated from 1 above
4.	Number of customers	Annual Report, 1967, O.H.E.P.C., Toronto
5.	Miles of wire	as above
6.	Number of employees	Chief Statistician's Office,).H.E.P.C., Toronto, Regional Employment Sheets

Regions: Data

	DATA	SOURCE
1.	Base Map of Regions	Annual Report, 1967, O.H.E.P.C., Toronto
2.	Base map of Townships in Southern Ontario	Department of Mines & Tech. Surveys, Ottawa, 1965, Ontario South, Counties and Geographical Townships[4]

3.	Population of Townships	Municipal Directory, 1967, Dept. Municipal Affairs, Toronto
4.	Co-ordinates of the centre of each township	Map of townships of Southern Ontario, centres located by hand at the intersection of the long axes[5]
5.	Co-ordinates of Regional Centres	Map of Southern Ontario, above; located by hand near the estimated actual location
6.	Population served by each Region	Calculated from 3 & 4 above.

The co-ordinates of the Township Centres and the Regional centres were recorded using a Benson-Lehner analog-digital converter. The accuracy in location is half a mile on the east-west axis and one quarter mile on the north-south axis.

For the analysis of the Regions, it is assumed that all the Regions are composed of complete townships, and that the Regional boundaries are coterminious with the township boundaries. of the 590 townships in Southern Ontario, only about 2% are split between Regions. The population distribution used in the study of the Regions is punctiform; the inhabitants of each township is assumed to be located at the centre of the township. It is suggested that there are two factors which minimize this approximation. Firstly, the boundaries produced in the least cost models[6] run across townships, yet, in the real system 98% must follow township boundaries. The divergence from optimality resulting from relocation along township lines outweighs the divergence due to the approximation of the population distribution. Secondly, in the algorithm used in allocation, decisions are made on an ordinal scale of distance. The probability that a small error in population location would result in a boundary revision is therefore low.

Histograms of all the variables used in the economic analyses will be included in Chapter V. The maximum value, the minimum value, the mean and the standard deviation will be marked on each histogram. All the data were stored on I.B.M. data cards.

FOOTNOTES - CHAPTER IV

1. Random Sampling Numbers, Table XIV, GREGORY, S., Statistical Methods and the Geographer, (London: Longmans, 1968) p. 101.

2. The Annual Reports for the period 1963 to 1967 were examined.

3. This was measured by hand.

4. The scale of this map was 1 inch to 16 miles. The projection was not marked.

5. A transparent map of Southern Ontario at a scale of 1 inch to 30 miles was used. The projection was not marked. It is assumed that linear distances calculated on this map are not significantly distorted by the projection.

6. See Chapter VIII.

CHAPTER V

QUANTITATIVE DESCRIPTIONS OF THE SPATIAL ARRANGEMENT OF M.E.U.'S, R.O.A.'S AND REGIONS

This chapter will offer some quantitative descriptions of the three spatial administrative systems currently used by the O.H.E.P.C. The descriptions will be considered under the headings, Municipal Electrical Utilities, Rural Operating Areas and Regions.

Municipal Electrical Utilities (M.E.U.'s)

For each of the sample of eighty M.E.U.'s the following data were collected:[1]

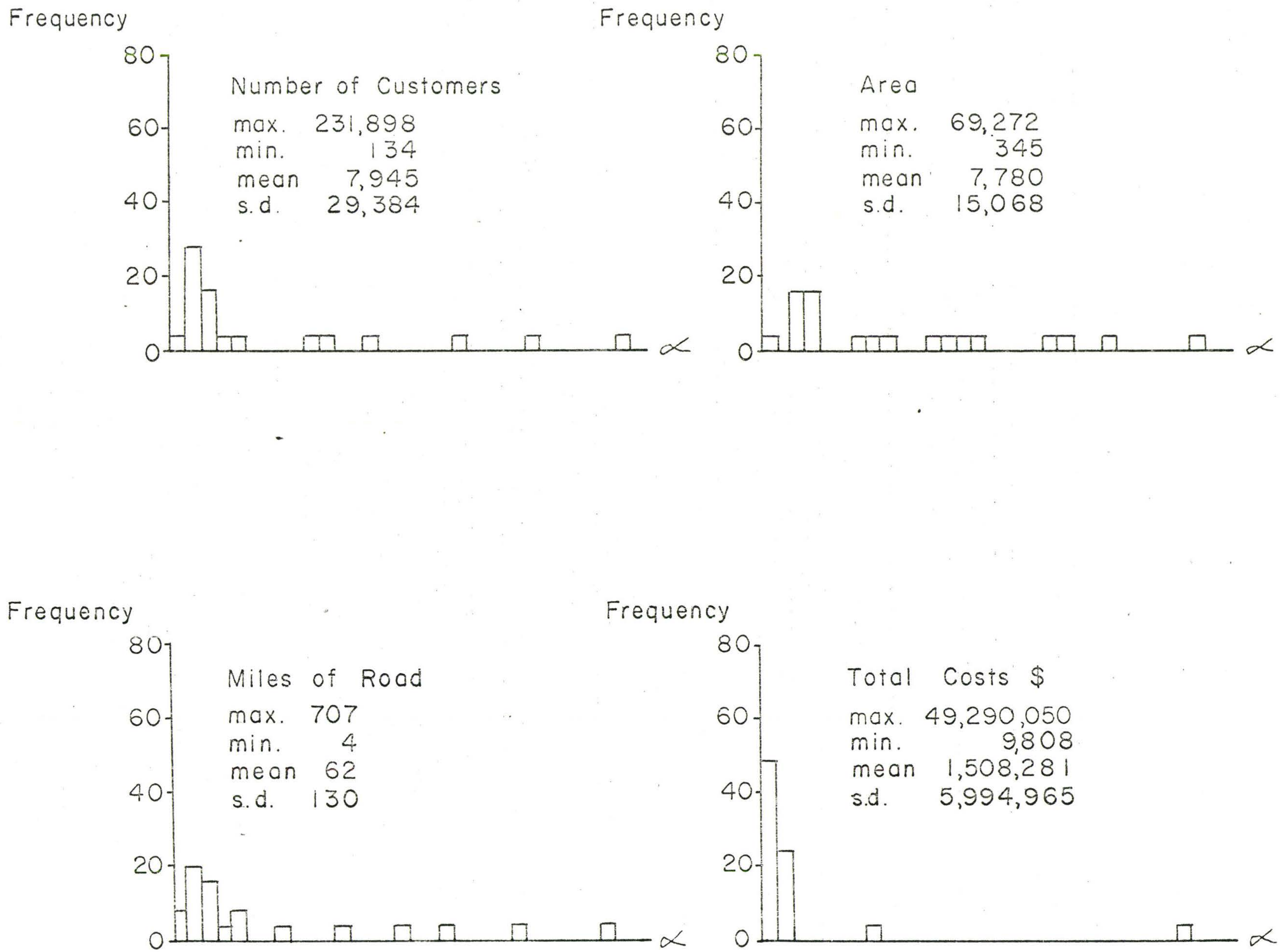
1. Number of customers
2. Area (acres)
3. Miles of road
4. Total cost ($)
5. Administrative cost ($)
6. Power purchased ($)
7. Operation and maintenance ($)
8. Depreciation ($)

From these variables the following were calculated:

9. Customers per acre
10. Customers per mile of road
11. Acres per mile of road
12. Total costs per customer
13. Administrative costs per customer.

Figures 5.1 to 5.4 show histograms of the thirteen variables. The mean, the standard deviation, the maximum and the minimum values are

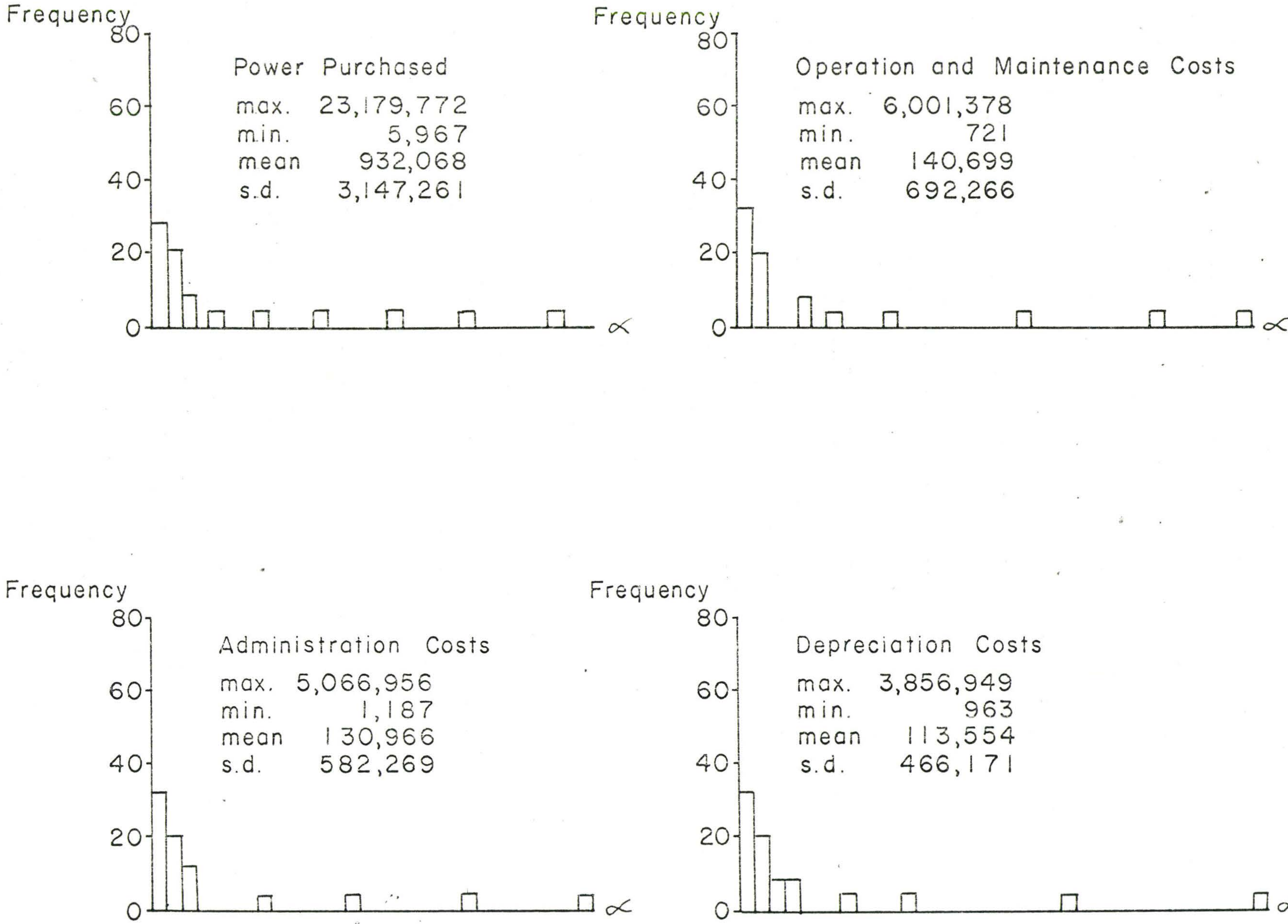
HISTOGRAMS OF M.E.U. VARIABLES Fig. 5·1



∝ max. value (Horizontal axes not to scale)

HISTOGRAMS OF MEU VARIABLES

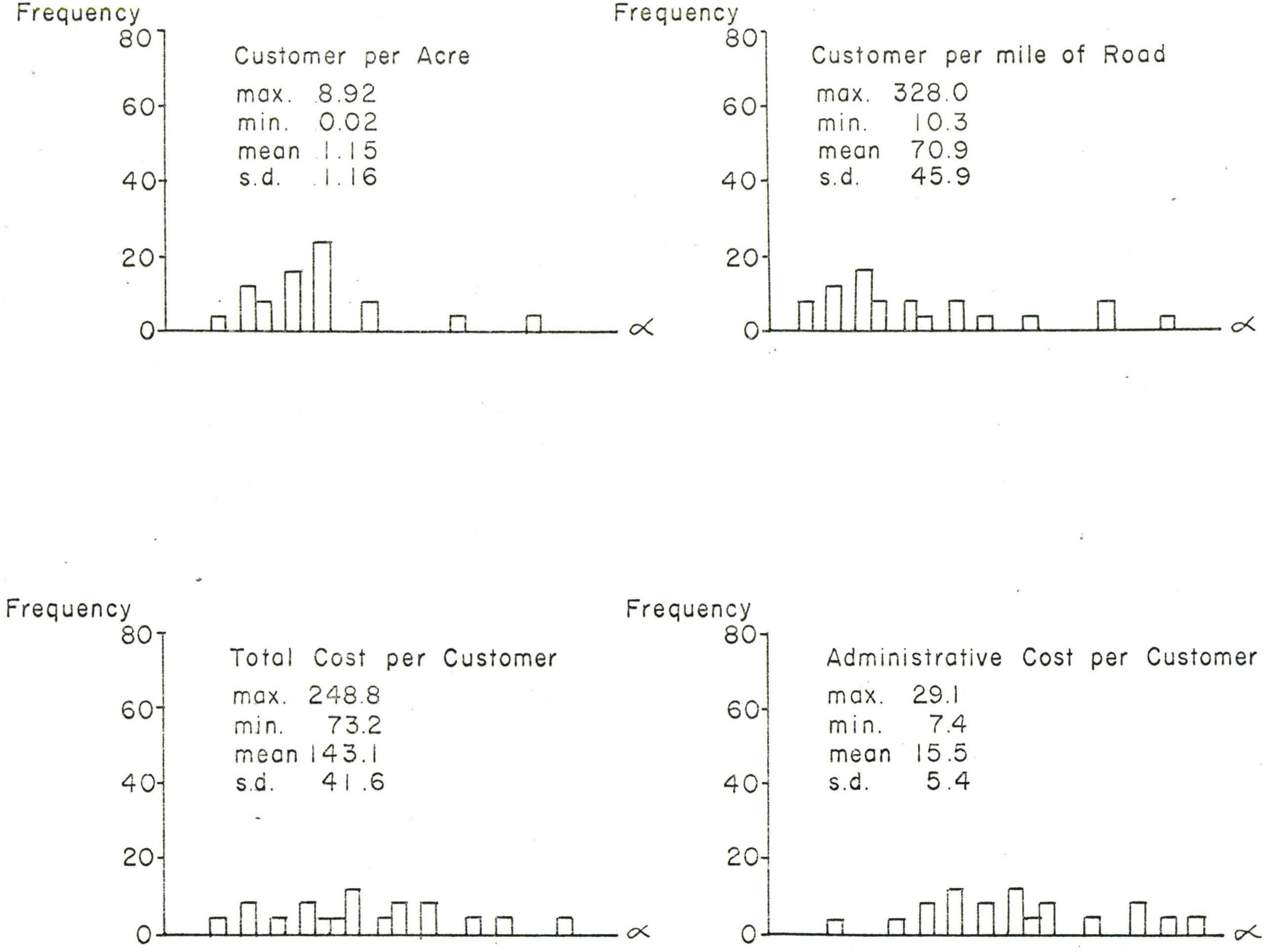
Fig. 5·2



∝ maximum values (Horizontal axes not to scale)

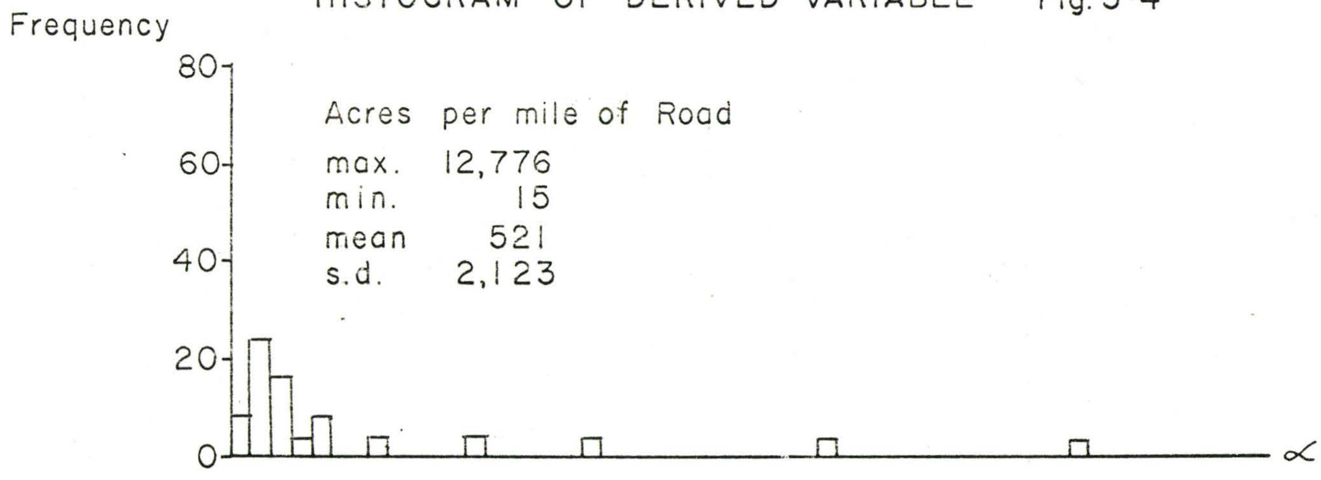
HISTOGRAMS OF DERIVED VARIABLES

Fig. 5·3



∝ maximum values (Horizontal axes not to scale)

HISTOGRAM OF DERIVED VARIABLE Fig. 5·4



∝ max. value (Horizontal axis not to scale) marked on the diagrams. The x axes have not been drawn to scale; the histograms have been drawn to show the general characteristics of the distributions. These histograms show that the variables 1 - 8 are positively skewed. The derived variables 9 - 13 with the exception of the variable "acres per mile of road", are more normally distributed. The two variables "total costs per customer" and "administrative costs per customer" appear to be the most normally distributed.

Intuitively it was felt by the author that some if not all of the variables are inter-related. To test this hypothesis the variables were correlated against each other. The correlation coefficients are shown on the correlation matrix, Table I. Significance levels have not been assigned to these values, because of the nature of their distributions. This matrix suggests that there is a very close relationship among the first four variables; power purchased, operation and maintenance costs, administration costs and depreciation costs. Of the second set of variables, that is, those variables in the set 1 - 8, which are not shown above, the variables "acres per mile of road" and "total costs per customer" appear to have a very low relationship to the other variables.

To allow significance levels to be assigned to the correlations coefficients it is necessary to have normally distributed data[2]. An attempt was made to transform the data and approximate it to normal. A logarithmic transformation to the base 10 was used. It was assumed that the variables "customers per acre", "customers per mile of road" and "total costs per customer", were normally distributed. To test for normality the Kolmogorov-Smirnov test was used[3]. The cumulative percentage frequency was plotted on probability paper and the maximum deviation from

TABLE I

CORRELATION MATRIX

(UNTRANSFORMED DATA)

	1	2	3	4	5	6	7	8
1	1.0							
2	.93	1.0						
3	.93	.99	1.0					
4	.97	.98	.98	1.0				
5	.78	.81	.80	.81	1.0			
6	.74	.73	.72	.75	.87	1.0		
7	- .06	- .04	- .05	- .05	- .22	- .12	1.0	
8	.36	.26	.29	.30	.36	.45	- .18	1.0

(Product Moment Correlation Coefficient)

1. Power purchased ($)
2. Operation & maintenance costs ($)
3. Administration Costs ($)
4. Depreciation costs ($)
5. Customers per acre
6. Customers per mile of road
7. Acres per mile of road
8. Total costs per customer ($)

an estimated least-squares line was measured. At the .01 level of confidence the data are not significantly different from a normal distribution. The correlation matrix using the transformed data is shown in Table II. A correlation coefficient of .295 or greater is significant at the .01 level.[4] The set of transformed variables "power purchased", "operation and maintenance costs", "administration costs" and "depreciation costs" are closely correlated. The lowest value for r is .964. Among the rest of the variables the logarithm "acres per mile of road" is only significantly correlated with the "customers per acre". This suggests that the population density and the density of roads is related.

The variable "total costs per customer" is significantly correlated to all the other variables, with the exception of the logarithm of "acres per mile". This suggests that the size of the area, in relation to the miles of road in the area, has insignificant influence on the cost of supplying services to the population. The low correlation .360 between the variables "total cost per customer" and "customers per acre" lends weight to the argument that the spatial set of variables have a low explanatory contribution in the total set of variables which explains total costs per customer.

The variable "total cost per customer" (Y) was plotted against the variables "power purchased" (X_1), "number of customers" (X_2), "miles of road" (X_3) and "customer per mile" (X_4).

The independent variables X_1, X_2 and X_3 were normalized using a logarithmic transformation. The dependent variable, Y, and the independent variable X_4 were assumed to be normally distributed. The following linear equations of the least squares regression lines were calculated.

TABLE II

CORRELATION MATRIX

(INCLUDING TRANSFORMED DATA)

	1	2	3	4	5	6	7	8
1	1.0							
2	.968	1.0						
3	.972	.971	1.0					
4	.978	.964	.976	1.0				
5	.608	.654	.626	.624	1.0			
6	.701	.726	.700	.714	.873	1.0		
7	- .237	- .276	- .247	- .230	- .435	- .245	1.0	
8	.773	.700	.725	.734	.360	.446	- .09	1.0

1. Log_{10} power purchases ($)
2. Log_{10} operation maintenance ($)
3. Log_{10} administration ($)
4. Log_{10} depreciation ($)
5. Customers per acre
6. Customers per mile
7. Log_{10} acres per mile
8. Total cost/customer($)

$$Y = -10.63 + 8.26 \log X_1 \quad (5.1)$$

$$r = .796$$

$$Y = 14.58 + 41.22 \log X_2 \quad (5.2)$$

$$r = .675$$

$$Y = 134.2 + .143 \log X_3 \quad (5.3)$$

$$r = .448$$

$$Y = 114.4 + .401 \log X_4 \quad (5.4)$$

$$r = .198$$

The correlation coefficient of equations 5.1, 5.2 and 5.3 are significant at the 0.01 level. The correlation coefficient of equation 5.4 is not significant at the 0.05 level.

The largest amount of variation in the dependent variable is explained by X_1. The distribution of consumers, in relation to the road network, offers no significant explanation in the dependent variable. The mileage of roads in each area and the number of customers are significantly related to the total costs per customer.

Attempts to construct quadratic models which incorporate the notions of changing scale of the organization and their effects on the total costs per customer, will be discussed in Chapter VI. These models will be used to test the specific hypothesis regarding economies of scale, and as descriptive models of the M.E.U.'s.

Rural Operating Areas (R.O.A.'s)

In southern Ontario, as defined in Chapter I, there are fifty-four R.O.A.'s. For each R.O.A. the following data were collected.

1. Number of customers
2. Miles of wire
3. Size of area
4. Number of employees.

The number of employees per customer, for each area, was calculated. Histograms of the variables are shown in Figure 5.5 and Figure 5.6. The distribution of the variable "size of area" appears to be positively skewed. The other variables are assumed to be normally distributed. The mean, the standard deviation, the maximum and the minimum values are marked on the graphs. A correlation matrix of the variables is presented in Table III. A logarithmic transformation of the "size of area" was used to normalize these data.

Among all the correlations there are only two which are not statistically significantly related at the 0.01 level. They are the "number of customers" and the logarithm "size of the area" (r = .244)[5].

TABLE III

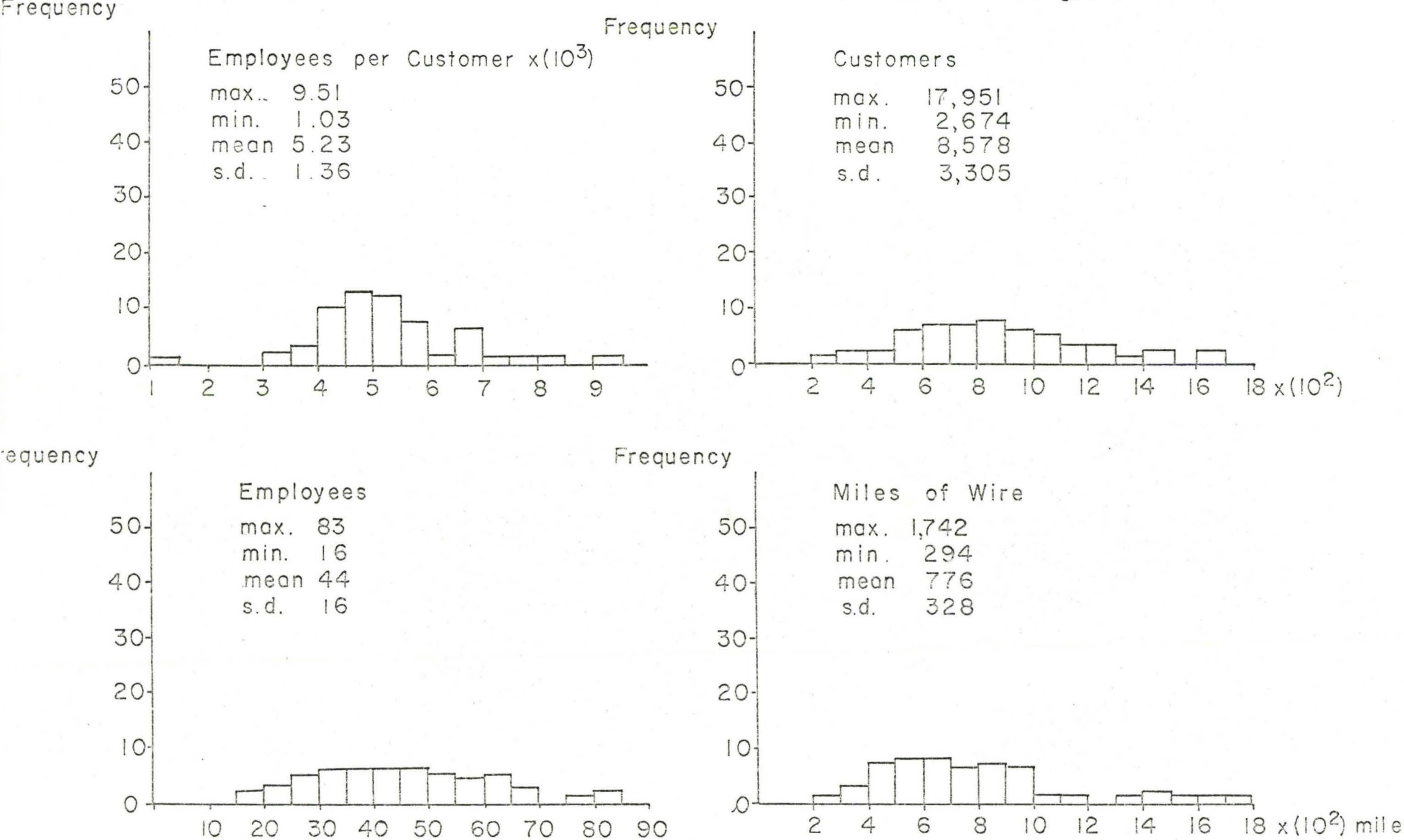
RURAL OPERATING AREAS - (SOUTHERN ONTARIO)

CORRELATION MATRIX[6]

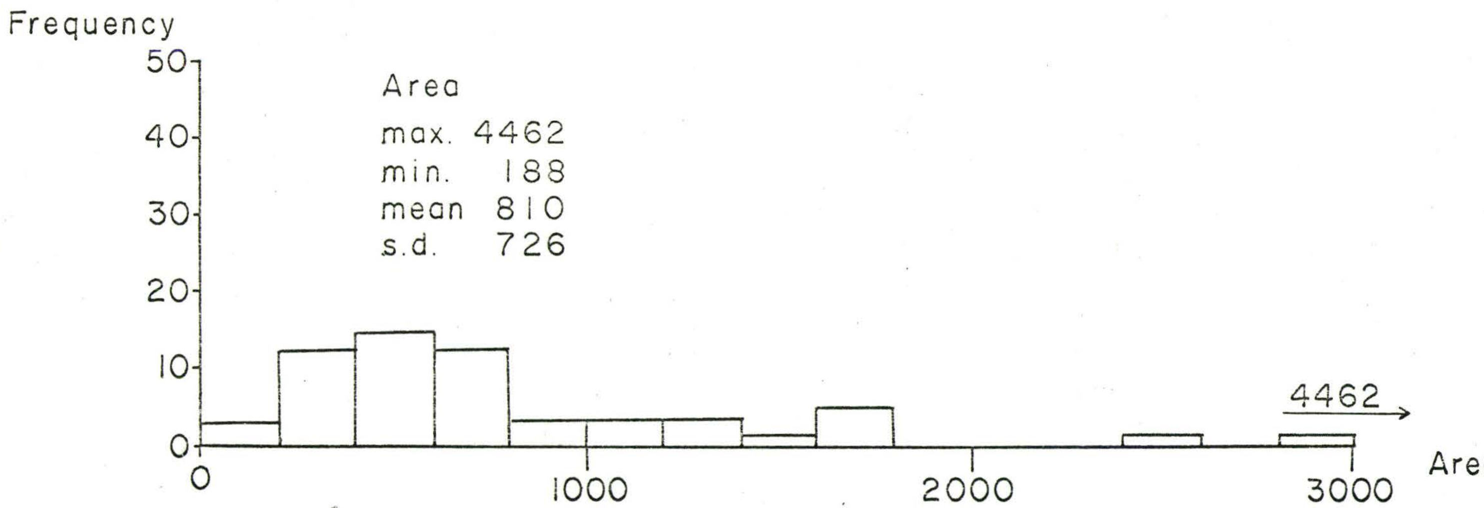
	1	2	3	4
1	1.0			
2	.579	1.0		
3	.244	.730	1.0	
4	.822	.526	.189	1.0

1. Number of customers
2. Miles of wire
3. Log size of area
4. Number of employees

HISTOGRAMS OF RURAL OPERATING AREAS DATA. Fig. 5·5



HISTOGRAM OF RURAL OPERATING AREA DATA Fig. 5·6



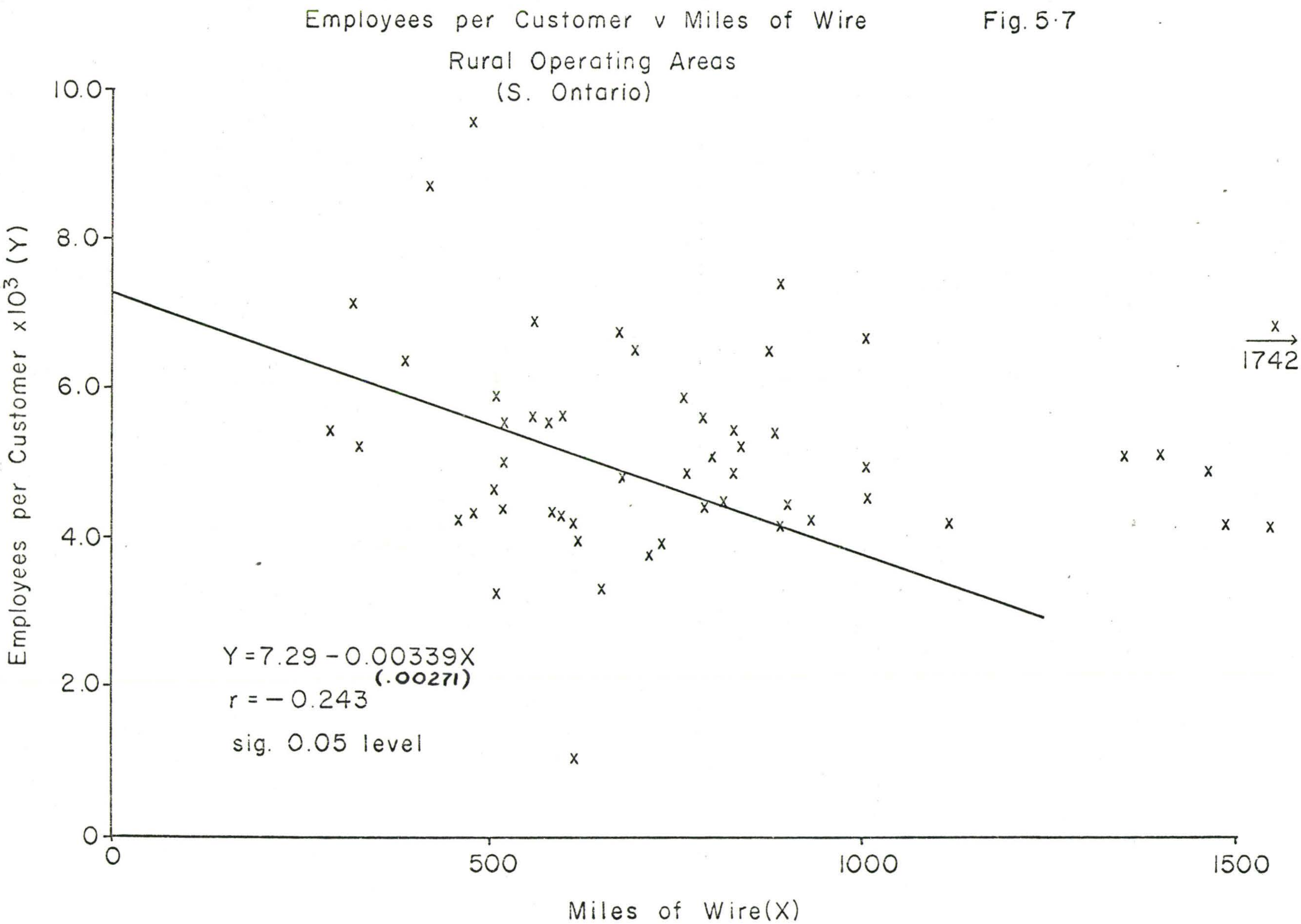
The lowest correlation appears to be between "number of employees" and the logarithm "size of area", (r = .189)[7]. The variable which has the highest correlation with all the other variables is "miles of wire"; the two variables which are most closely related are "number of employees" and "number of customers". A linear model of this relationship is suggested. The following linear equation of the least squares regression line was calculated.

$$Y = 10.15 + 0.00405\ X \qquad (5.5)$$

Where Y is the number of employees and X is the number of customers. A regression coefficient of .822, which is significant at the 0.01 level, was calculated. Figure 5.7 shows the scatter diagram and the regression line.

It was assumed that the variable "employees per customer" is normally distributed and this was correlated against the variables "miles of wire" and the logarithm "size of area". Correlation coefficients of -.243 and -.071 were derived respectively. The former value of r is significant at the 0.05 level. The scatter diagram and the regression line is shown on Figure 5.8. The negative slope suggests that as the miles of wire increase, that is the scale of the operation increases, the cost of the operation per unit, as represented by the variable employees per customer, decreases. This evidence supports the hypothesis that economies of scale operate with respect to these two variables.

The correlations presented here are an attempt to relate these characteristics of the R.O.A.'s. The characteristics are the points,

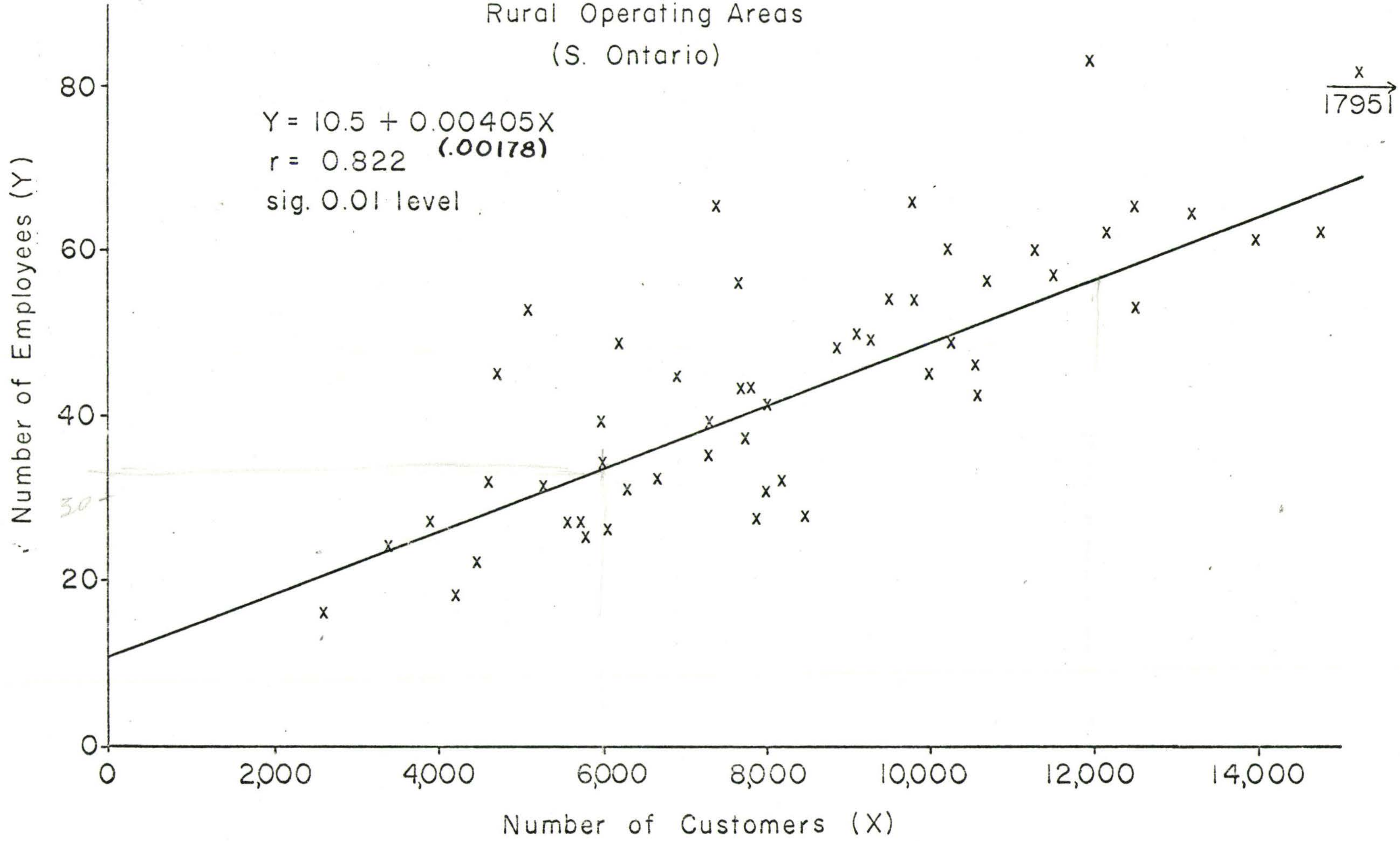


Employees per Customer v Miles of Wire
Fig. 5·7
Rural Operating Areas
(S. Ontario)
Employees per Customer x10³ (Y)
Miles of Wire(X)
10.0
8.0
6.0
4.0
2.0
0
0
500
1000
1500
1742
Y = 7.29 − 0.00339X
(.00271)
r = − 0.243
sig. 0.05 level

Number of Employees v Number of Customers Fig. 5·8

Rural Operating Areas

(S. Ontario)



lines and areas as represented by the number of customers and the number of employees, the miles of wire and the size of the areas respectively. Further, a relationship between the economic efficiency of the R.O.A.'s and the spatial size of the R.O.A.'s was posited. The economic efficiency was defined by the variable "number of employees per customer", this was related to the size of the R.O.A.'s. The relationship was tested for the R.O.A.'s in southern Ontario, it was found that the size of the area is not significantly related to the economic efficiency of the area, as defined above. This relationship will be tested again using a quadratic model to incorporate the concept of economies of scale. This test will be discussed in Chapter VII.

The next part of this section will describe the shape of the R.O.A.'s using the measures, contact number and shape index that were discussed in Chapter I and III. The two measures were originally used by Haggett[8] to describe the spatial arrangement of administrative areas in Brazil. It was found that as the contact number approached six the value of the shape index approached .83. This suggested that the areas were fairly regular in shape and tended toward hexagons. It has been shown that regular hexagons are the optimum shape for packing into an infinitely large area, as they minimize the distance between centrally located administrative centres and an evenly distributed population.[9] The regular hexagon represents a least cost division of space, where cost is directly related to the linear distance separating the population and the centre.

The twenty-six enclosed R.O.A.'s were tested for the shape regularity that Haggett found in Brazil and that has been noted in other parts of the world. To overcome the influence of the configuration of the Provincial boundary only the R.O.A.'s that were enclosed by other R.O.A.'s were examined.[10] For these areas the shape indices and the contact numbers were calculated. The mean value of the contact number was found to be 5.85. The hypothesis that there is no statistically significant difference between the actual number of contacts and six contacts was tested using the chi-square[11] test at the .05 level of confidence. The hypothesis cannot be rejected. The histogram of the contact numbers is shown in Figure 5.9. The mean of this measure and the statistical test suggest that the enclosed areas tend towards hexagons, though in fact only six areas have exactly six contacts. The mode of the distribution is five, seven areas have seven contacts, and the remaining two areas have four and eight contacts respectively.

The area (A-square miles) and the long axis (L-miles) of each R.O.A. were used to calculate the <u>shape index</u> (S). The formula $S = 1.27 (A/L^2)$ was used. The histogram of the values is shown on Figure 5.10. For the fifty-four R.O.A.'s the value of S varies from .960 to .235. The mean value is .516. For the twenty-six enclosed R.O.A.'s the mean value of S is .533.

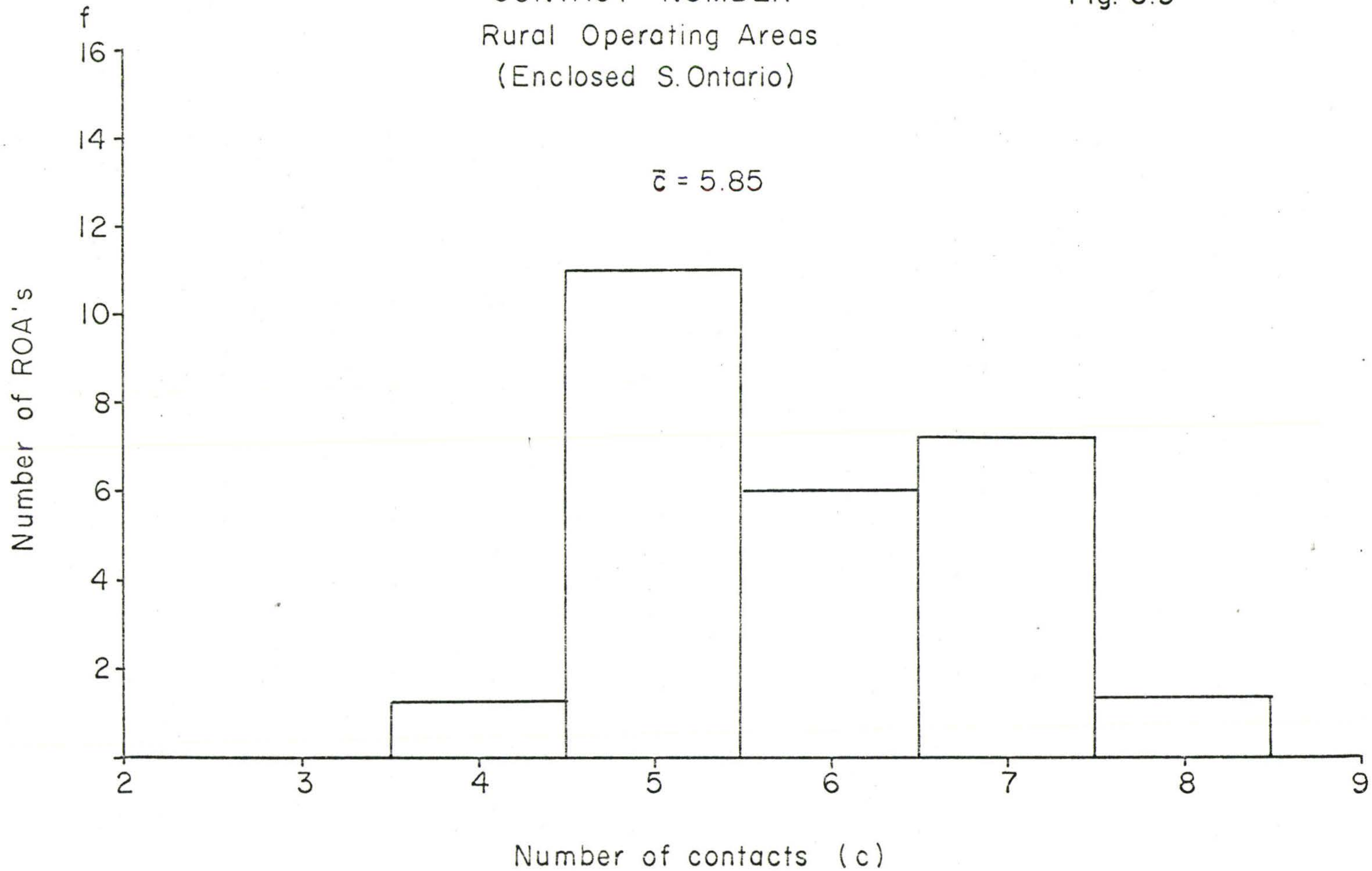
Given that regular polygons have unique values for S, and distinct values for the contact number the next task was to attempt to describe the relationship between the two indices. The mean value of the number of contacts, 5.85, suggests that the polygons are hexagonal in shape. Therefore, if they are regular the mean value for S should approach .83. In fact, the mean value is .533. This suggests that the R.O.A.'s are irregular hexagons.

CONTACT NUMBER

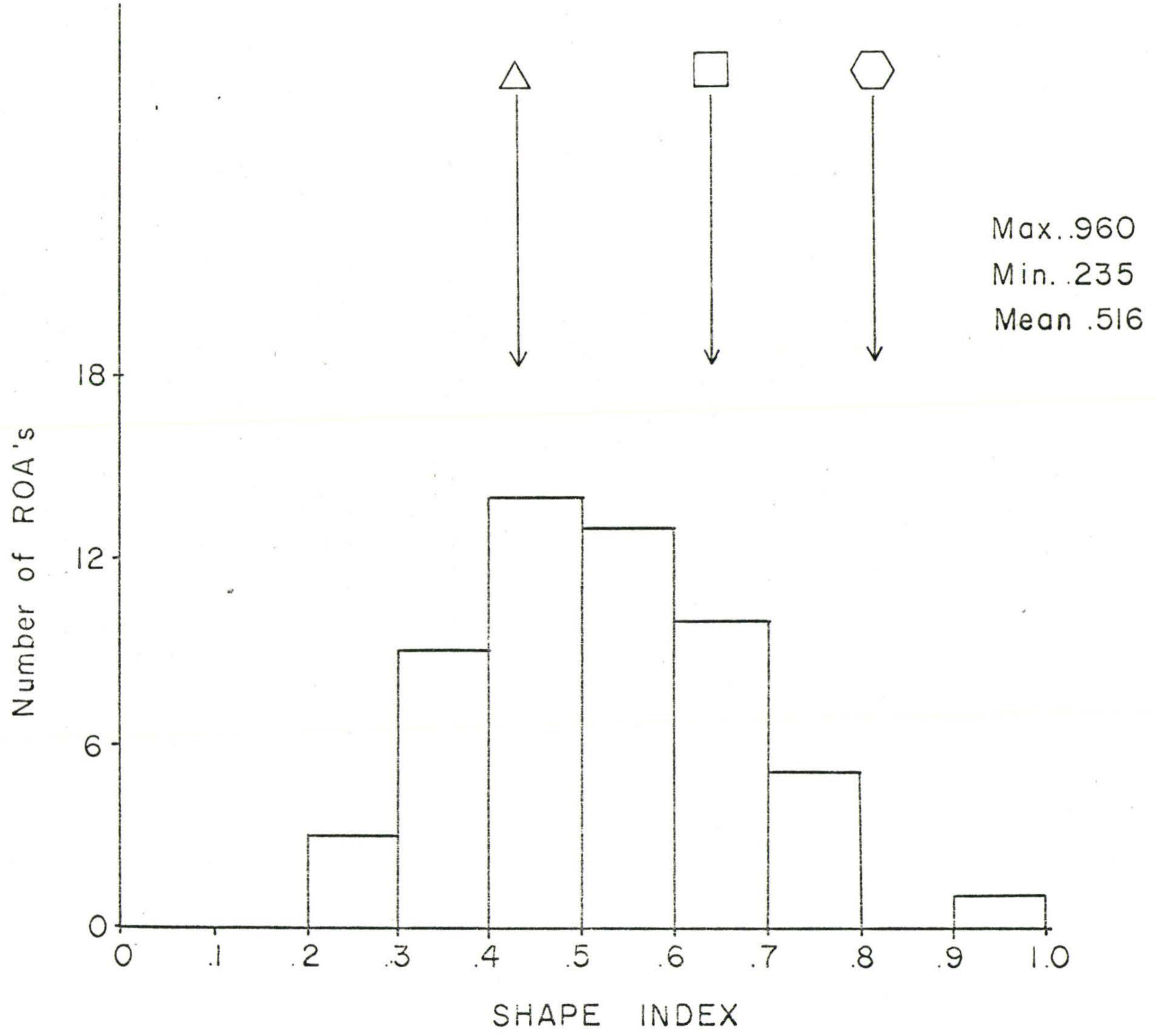
Rural Operating Areas

(Enclosed S. Ontario)

Fig. 5.9



HISTOGRAM OF SHAPE INDEX Fig. 5·10
Rural Operating Areas
(S. Ontario)



For the enclosed R.O.A.'s the contact number and the shape index were correlated. On the scatter diagram, Figure 5.11, the least squares regression line is shown. The equation of this line is,

$$Y = .669 - .024 X \qquad (5.6)$$

where Y is the shape index and X is the contact number. The regression coefficient is 0.214, this is not significant at the 0.05 level. On the same graph the curve for regular polygons has been plotted.

In summary, the shape of the R.O.A.'s has been examined; the mean contact number suggests that the areas are hexagons and the shape indices suggest that they exhibit a mean deviation of 0.306 from regular hexagons.

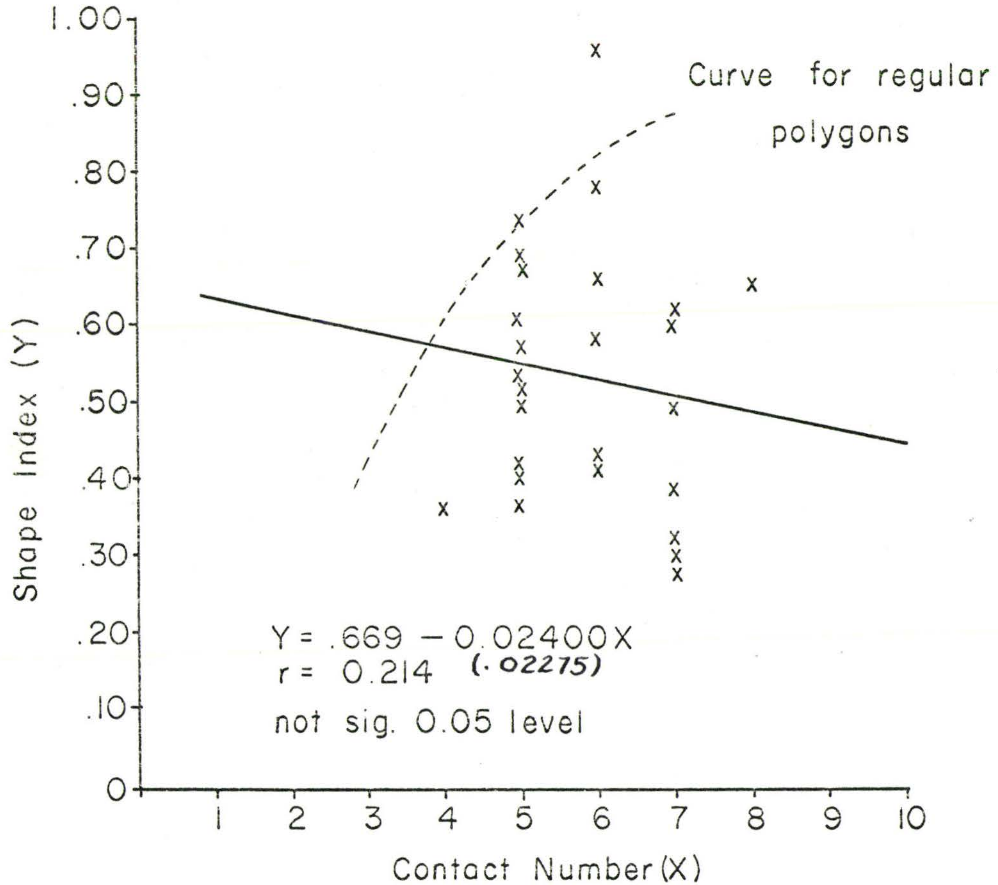
It has already been noted in Chapter II that the number of R.O.A.'s has decreased through time. Future research could test the hypothesis that the R.O.A.'s tend to increase in spatial efficiency through time and this may be the result of a learning process which operates in the decision-making procedure. The notion of a learning process operating through time, and manifesting itself in changing spatial patterns or organization has attracted the attention of some geographers[12]. Morris also draws attention to the concept of learning and organization. He states:

> "In the majority of cases organizational change might better be described as evolutionary rather than revolutionary. That is, if one takes the long view, the changes in organization appear more as small, gradual modifications ... a good deal of inertia may be present. The process or organizational learning seems inadequate for a stable evolutionary development and instead, a sort of vacillation or "hunting" takes place."[13]

Shape Index v Contact Number

Fig. 5·11

Rural Operating Areas
(Enclosed S. Ontario)



Clearly, operational definitions of learning need to be clarified before the relationships can be formulated into hypotheses. Also it will be necessary to examine the nature of the population distribution vis-à-vis the location of the centres of the R.O.A.'s, before either the contact number or the shape index can be used as perfect measures of the spatial efficiency of the areas.

Regions

In this section a technique for describing the spatial pattern of Regions will be discussed. The technique will use the population distribution and relate this to the actual location of the Regional centres and theoretically located Regional centres. A simple functional relationship to describe the cost of servicing a Region will be suggested. This relationship will be used in an attempt to describe the spatial pattern of the five Regions in the study area.

The fundamental spatial administrative building block for the Regions is the township. There are 590 townships in the study area, and 504 are occupied. The population distribution used is punctiform, the inhabitants of each township being assumed to be located at the geometrical centre of the township. The factors which minimize the effect of this approximation were discussed in Chapter II. The set of points, the centres of townships, were weighted according to the population assigned to each township. In the case of a town falling on the boundary of two or more townships, the population of the town was assigned equally among the adjacent townships. The total population of the study area was assigned among the 504 townships. The townships were grouped under the centre currently serving them. The data were stored on I.B.M. cards.

It is postulated that the cost of a region is a function of the number of people served and the distance between the consumer of the service and the administrative centre[14]. It is hypothesised that the cost C_{ij} of administering a township i from a centre j is a function of the distance d_{ij}, and the population of the township M_i[15]. A simple linear functional relationship is suggested; $C_{ij} = M_i \cdot d_{ij}$.

This relationship is open to criticism. Studies by Chernick and Schneider[16] on the cost of providing hospital services in relation to distance suggest exponents of 1 or 2 for d_{ij}. Most empirical work on this parameter suggests that d_{ij} can take exponents from one half to three, though other studies favour logarithmic or exponential functions of distance. Malm[17] and MacKay[18] discuss functions of M and d in a gravity model context. Olsson[19] provides a summary of distance and cost relationships in his book, Distance and Human Interaction.

Airline distances, computed from cartesian co-ordinates, have been used throughout this study. However, the methods used are not restricted to the relationship expressed in the above equation. Other functional relationships may be used in these models, and no restrictions are placed on the determination of d_{ij}. All distances were computed over-land; however, routes which would have crossed major embayments, such as western Lake Ontario, were redefined on a longer path confined to the land area.

For each subset of weighted points, that is, each Region, the actual administrative centre is known. Two other locations were computed. These theoretical locations are firstly, at the centre of gravity of the distribution and, secondly, at the point of minimum aggregate travel. In the literature both of these points have been suggested as providing optimal locations for centres where the demand is spatially distributed.[20]

For cost defined as $M_i\ (d_{ij})^2$, the optimum location is at the centre of gravity. This is analogous to the location of the least squares line on a scatter diagram. The points which are furthest from the centre carry a disproportionately higher weighting due to the exponent of two for d. The centre of gravity can be readily calculated and the exact and unique solution obtained. With cost defined on a linear basis, the point of minimum travel must be located by a lengthy iterative procedure. Kuhn and Kuenne[21] devised an algorithm for the solution of this problem which has been applied by Chernick and Schneider[22] in their analysis of hospital locations. Gould and Leinbach[23] have also used the method to analyse hospital locations in Guatemala. In the study of Regions a method developed by Cooper[24] was used. His method uses less computer time than earlier methods.

The following indices were derived to describe the current arrangement of Regions with respect to a punctiform population distribution and point locations for the actual Regional centres and the theoretical Regional centres. The first index of efficiency, I_j of an area j is defined by the ratio of first moments about the theoretical and the actual locations of the centre. It is calculated from the formula

$$I_j = \frac{\sum_i M_i\ Z_{ij}}{\sum_i M_i\ d_{ij}},$$

where Z_{ij} is used to denote the distance between the township location and the point of minimum aggregate travel. Further, an index of efficiency I_j^1 of an area j is defined by the ratio of second moments about the theoretical and the actual locations of the centre. It is calculated from the formula

$$I_j^1 = \frac{\sum_i M_i Z_{ij}^2}{\sum_i M_i d_{ij}^2} .$$

These indices can vary between 0.0 when the centre is located at infinity, and 1.0 when the actual centre and the theoretical centre are located at the same point. The indices are shown in Table III.

TABLE IV

INDICES OF EFFICIENCY OF REGIONS: SOUTHERN ONTARIO

Actual Centres	Regions	I_j	I_j^1	Ranking
Barrie	Georgian Bay	.603	.409	5
Belleville	Eastern	.663	.472	4
Hamilton	Niagara	.928	.928	1
London	Western	.860	.583	3
Toronto	Central	.863	.722	2

On the basis of these indices it appears that the centre that is currently used by the Hamilton area has the lowest cost. The area served by Barrie appears to have the highest cost and this is closely followed by Belleville. Toronto and London have similar values and they appear to have slightly higher costs than Hamilton. The ranking of the centres is identical using I_j and I_j^1.

A further index was developed. For each Region the mean distance between the population and the Regional centre was calculated. Linear distances were used, they were calculated from the cartesian co-ordinates that were used to describe the weighted point set. Table IV shows the values that were computed.

TABLE V

MEAN DISTANCE: REGIONS, SOUTHERN ONTARIO

Region	Centre	Mean Distance (miles)
Georgian Bay	Barrie	63.7
Eastern	Belleville	79.3
Niagara	Hamilton	23.4
Western	London	48.2
Central	Toronto	48.2

The results presented in this table suggest that because consumers in the Region served by Hamilton have the lowest distance value, the functional costs for this Region are lower than any other. This supports the findings evidenced by the first two indices. The table also suggests that the population in the Regions served by London and Toronto appear to be similar. However, on the basis of the population distribution among the Regions, there are 2.4 million people in the Central Region (Toronto) and less than 1 million in the Western Region (London). The population served by each Region is shown below:

Region	Centre	Population
Georgian Bay	Barrie	344,433
Eastern	Belleville	1,062,212
Niagara	Hamilton	1,145,606
Western	London	966,847
Central	Toronto	2,421,246

Finally, for the total set of Regions the percentage of the population that is served by the nearest[25] Regional centre was calculated. For the current arrangement of centres and boundaries 54.6 percent of the total population is served by its nearest Regional centre.

The centres of gravity, the points of minimum aggregate travel, the two indices of efficiency, the mean distance indices and the percentage of the population served by the nearest centre were calculated on an I.B.M. 7040 computer at McMaster University.

Summary

This chapter has attempted to apply some quantitative methods to describe the current arrangement of administrative areas used by the O.H.E.P.C. Attempts have been made to interpret the equations and the indices that were derived. The descriptions and interpretations offered could form a basis for comparative studies. To improve the level of understanding of spatial administrative systems, future research could incorporate such elements as time and learning processing to the static descriptive models presented in this chapter.

FOOTNOTES - CHAPTER V

1. The data sources were discussed in Chapter IV.

2. For a discussion on testing data for normality see: GREGORY, S., op. cit., pp. 45-56.

3. This test is discussed in SIEGEL, S., Non-Parametric Statistics, (Toronto: McGraw Hill, 1956), pp. 127-136.

4. Taken from the graph of significance levels for correlation coefficients using student's t distribution in GREGORY, S., op. cit., p. 181.

5. The correlation between the "number of customers" and the "size of the area" is .239; the log transformation only slightly improves the value of r.

6. A value for r of .350 or greater is significant at the .01 level.

7. The correlation between the "size of the area" and the "number of employees" is .236; the log transformation significantly influences the value of r.

8. HAGGETT, P., op. cit., pp. 48-55.

9. See footnote 9, Chapter III.

10. Twenty-three R.O.A.'s are completely enclosed; the three bordering on Lake Simcoe were included in the twenty-six. Their boundaries were extended by straight lines into the lake.

11. See: GREGORY, S., op. cit., pp. 163-179. Because only three of the groups satisfy the condition of the test, i.e. they have frequency values of five or more, this test is not very powerful in this case.

12. See for example: GOLLEDGE, R., "Learning Theories in Geography", paper read at annual meeting of the Assoc. of Amer. Geog., Washington, 1968, mimeo.

13. MORRIS, W.T., op. cit., p. 11.

14. The work load of the Regions was defined by Tindal as a function of distance and the number of customer, see footnote 45, Chapter I.

15. It is hypothesised that the number of customers is directly related to the population.

16. CHERNIACK, H.D. and SCHNEIDER, J.B., "A New Approach to the Delineation of Hospital Service Areas", Discussion Paper, No. 16, Regional Science Research Institute, Philadelphia, August, 1967.

17. MALM, R., et. al., "Approaches to Simulations of Urban Growth", Geografiska Annaler, No. 1, 48 B, 1966, pp. 9-22.

18. MACKAY, J.R., "The Interactance Hypothesis and Boundaries in Canada", The Canadian Geographer, Vol. 4, No. 1, 1960, pp. 1-8.

19. OLSSON, G., Distance and Human Interaction, (Philadelphia: Regional Science Research Institute, 1965).

20. For a full discussion on this see Chapter VIII, also see: MASSAM, B.H., op. cit., Appendix C, pp. 94-95.

21. KUHN, H.W. and KUENNE, R.E., "An Efficient Algorithm for the Numerical Solution of the Generalised Weber Problem in Spatial Economics", Journal of Regional Science, Vol. 4, No. 2, 1962, pp. 21-33.

22. CHERNIACK, H.D. and SCHNEIDER, J.B., op. cit.

23. GOULD, P.R. and LEINBACH, T.R., "An Approach to the Geographic Assignment of Hospital Services", Tijdschrift voor Econ. en Soc. Geografie, 57, Sept./Oct., 1966, pp. 203-206.

24. COOPER, L., "Solutions of Generalized Locational Equilibrium Models", Journal of Regional Science, Vol. 7, No. 1, 1967, pp. 1-8.

25. Nearest is defined as air-line distance calculated from the cartesian co-ordinates.

CHAPTER VI

MUNICIPAL ELECTRICAL UTILITIES;
DISCUSSION OF THE TESTS OF THE HYPOTHESES

This chapter will attempt to discover if the concept of economies of scale applies to a sample of 80 Municipal Electrical Utilities. Specifically, the relationship between a cost per unit output variable and variables acting as surrogates for the spatial size of the organization, will be examined. The notion of economies of scale is now firmly established in the literature of economics and location theory.[1] With respect to the organization of firms, relationships between size, decision-making and efficiency have been discussed in the review of the literature in Chapter I. With specific reference to the O.H.E.P.C. the relationships were discussed in Chapters II and III. In general terms it is suggested that as the size of an organization increases the efficiency tends to increase and the cost per unit of output decreases. Once a low point has been reached in the average cost curve, the cost per unit output tends to increase as the size of the organization increases.

In the short-run, that is with no changes in the fixed costs or size of an organization, the theoretical average cost curve is U-shaped. In the long-run, that is with changes in the fixed costs, the variable costs and the size of the organization, the average cost curve is the envelope curve of the series of short-run average cost curves. The theory which suggests that this situation obtains was discussed in Chapter III.

The specific hypotheses that will be tested in this chapter were postulated in Chapter III, they concern the relationship between cost per unit output variables and variables which describe the spatial size of the organization. The two variables that will be used as measures of the cost per unit output are "total cost per customer" (Y_1), and "administrative costs per customer" (Y_2). The surrogate variables which measure the spatial size of the organization are "number of customers" (X_1), "miles of road" (X_2) and "area" (X_3).

The general quadratic model

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_1^2$$

is suggested by the theory as providing a description of the U-shaped long-run average cost curve.[2]

A step-wise multiple regression procedure was used to calculate the values of α, β_1 and β_2 for the following equations.

$$Y_1 = \alpha + \beta_1 X_1 + \beta_2 X_1^2$$

$$Y_1 = \alpha + \beta_1 X_2 + \beta_2 X_2^2$$

$$Y_1 = \alpha + \beta_1 X_3 + \beta_2 X_3^2$$

$$Y_2 = \alpha + \beta_1 X_1 + \beta_2 X_1^2$$

$$Y_2 = \alpha + \beta_1 X_2 + \beta_2 X_2^2$$

$$Y_2 = \alpha + \beta_1 X_3 + \beta_2 X_3^2$$

The Fortran IV Multiple Regression programme[3], using the I.B.M. 360 S.S.P., was modified to calculate the quadratic variable as the second independent variable. Using data for the sample of 80 M.E.U.'s the following equations were derived. An I.B.M. 7040 computer was used to make the calculations.

$$Y_1 = 136.29 + 0.00140X_1 \quad (6.1)$$

$$Y_1 = 127.05 + 0.43118X_2 - 0.00050X_2^2 \quad (6.2)$$

$$Y_1 = 132.73 + 0.00260X_3 \quad (6.3)$$

$$Y_2 = 15.33 + 0.00013X_1 \quad (6.4)$$

$$Y_2 = 15.17 + 0.01130X_2 - 0.00002X_2^2 \quad (6.5)$$

$$Y_2 = 14.86 + 0.00023X_3 \quad (6.6)$$

Equations 6.2 and 6.5 were the only ones where the β_2 coefficient appeared to be significant. Scatter diagrams and the least squares lines are shown in Figures 6.1 to 6.6.

In the case of equation 6.2 the quadratic least squares line yields a correlationcoefficient of .529. This value is higher than that offered by the least squares linear equation. In the latter case r has a value of .448. This suggests that the quadratic equation offers a better description of the scatter of points. For equation 6.5 the correlation coefficient is .085, this is insignificantly higher than the r value .049, provided by the linear equation. Confidence limits have not been assigned to the regression values because the independent variables are positively skewed in all cases. Histograms of the variables were presented in

Total Cost per Customer v Number of Customers — Fig. 6·1

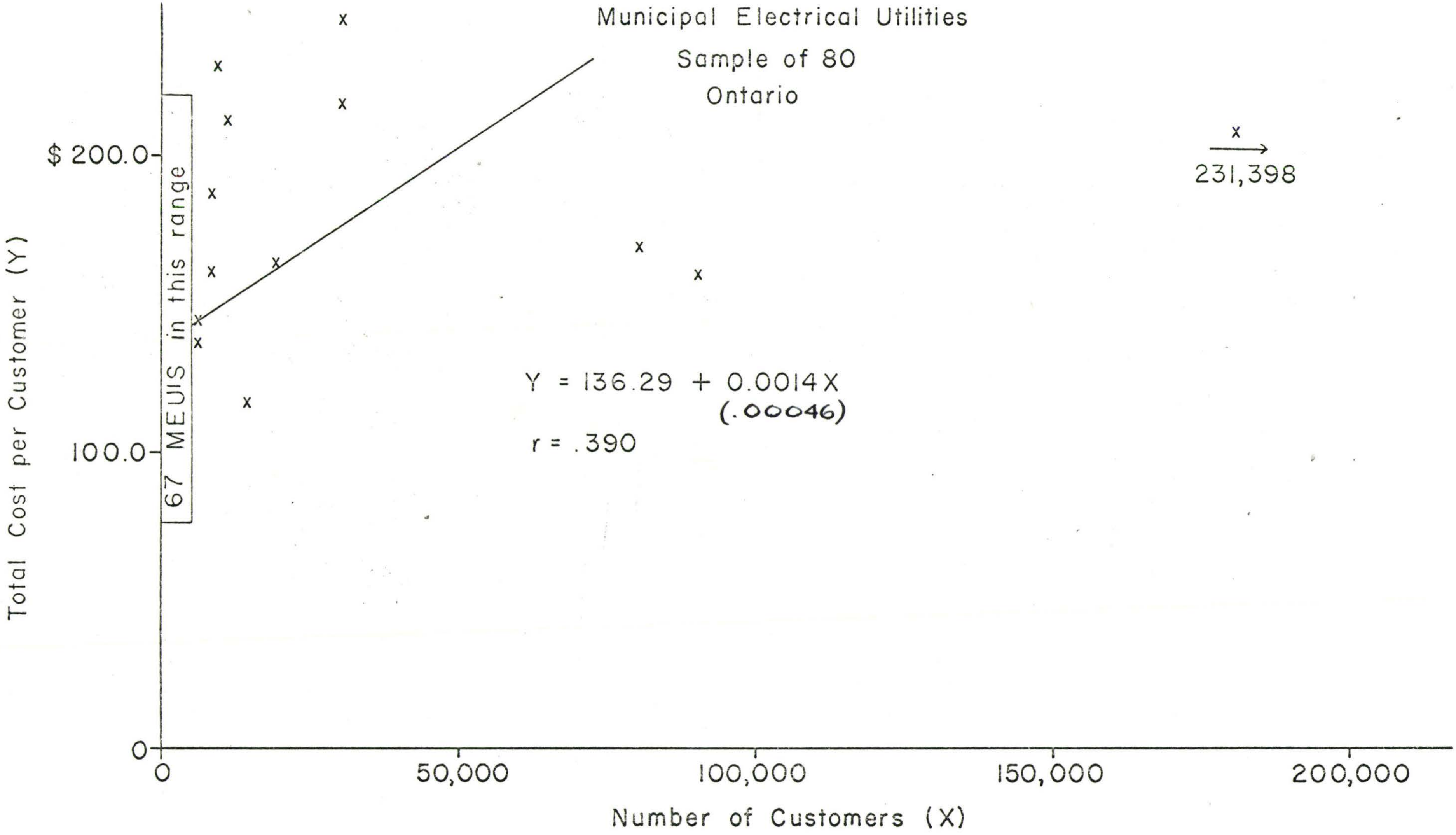


Fig. 6·2

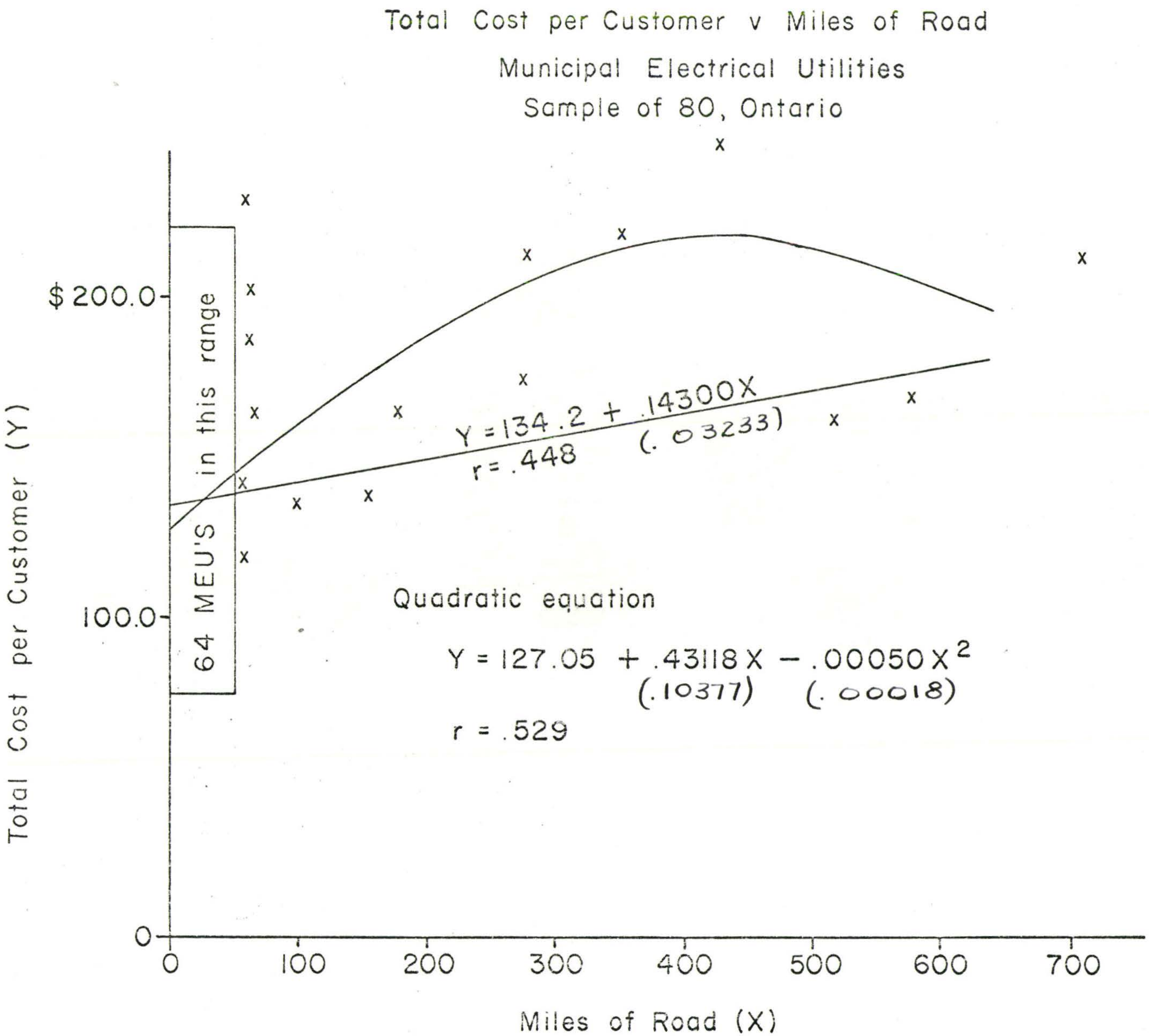
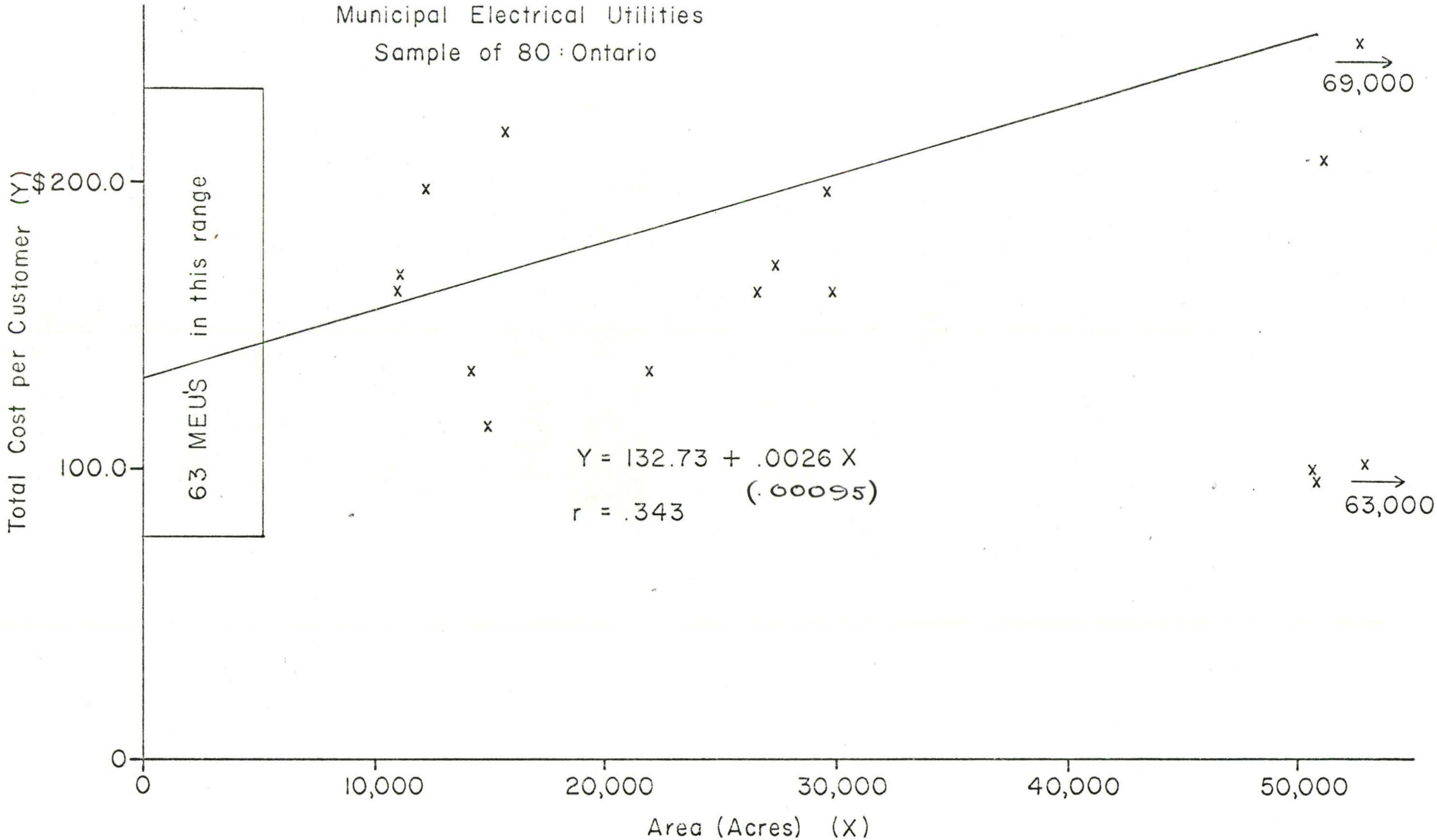

Total Cost per Customer v Miles of Road
Municipal Electrical Utilities
Sample of 80, Ontario
Total Cost per Customer (Y)
$ 200.0
100.0
0
0
100
200
300
400
500
600
700
Miles of Road (X)
64 MEU'S in this range
Y = 134.2 + .14300X
(.03233)
r = .448
Quadratic equation
Y = 127.05 + .43118 X − .00050 X 2
(.10377)
(.00018)
r = .529

Fig. 6·3

Total Cost per Customer v. Area
Municipal Electrical Utilities
Sample of 80 : Ontario

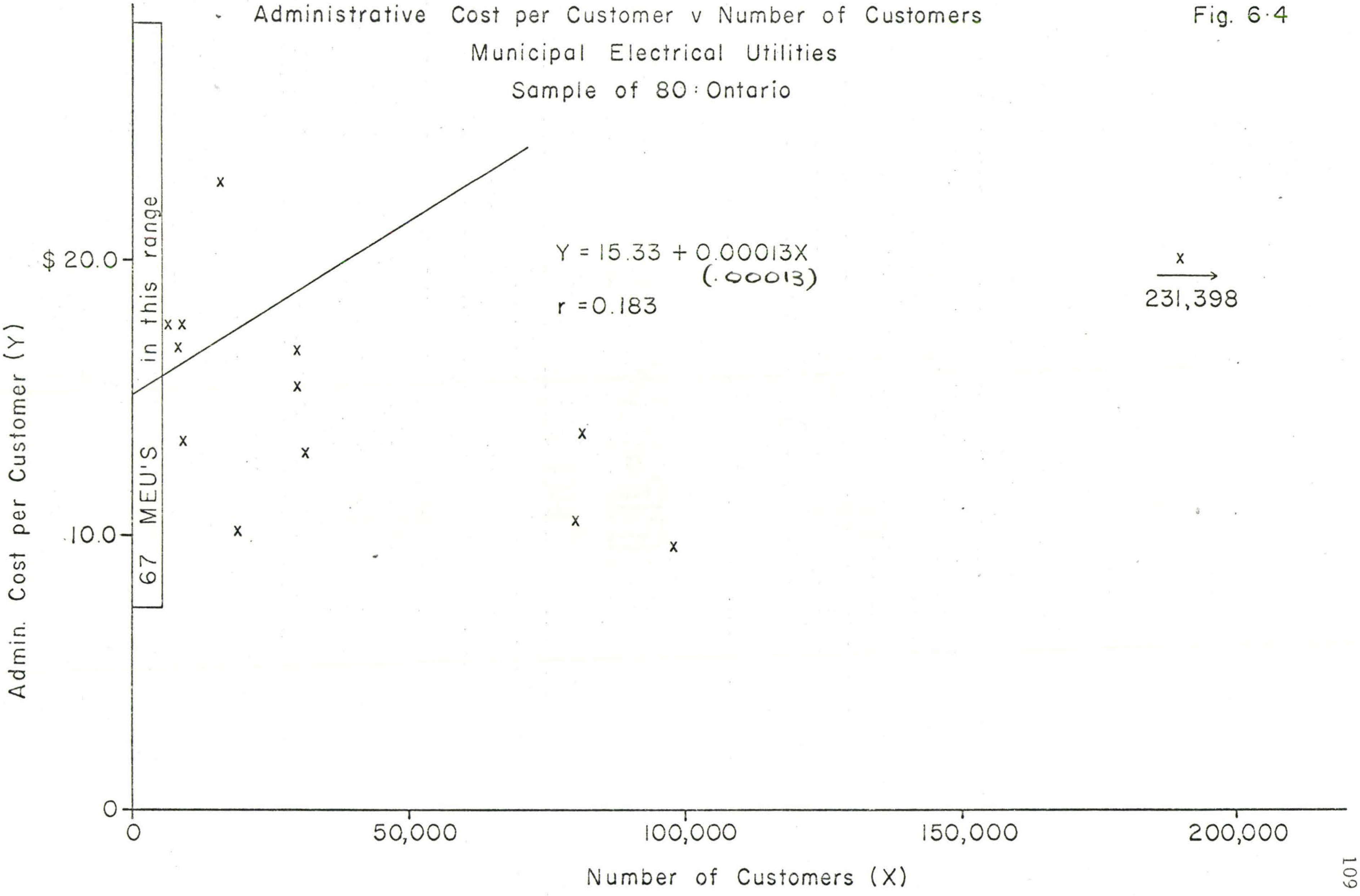


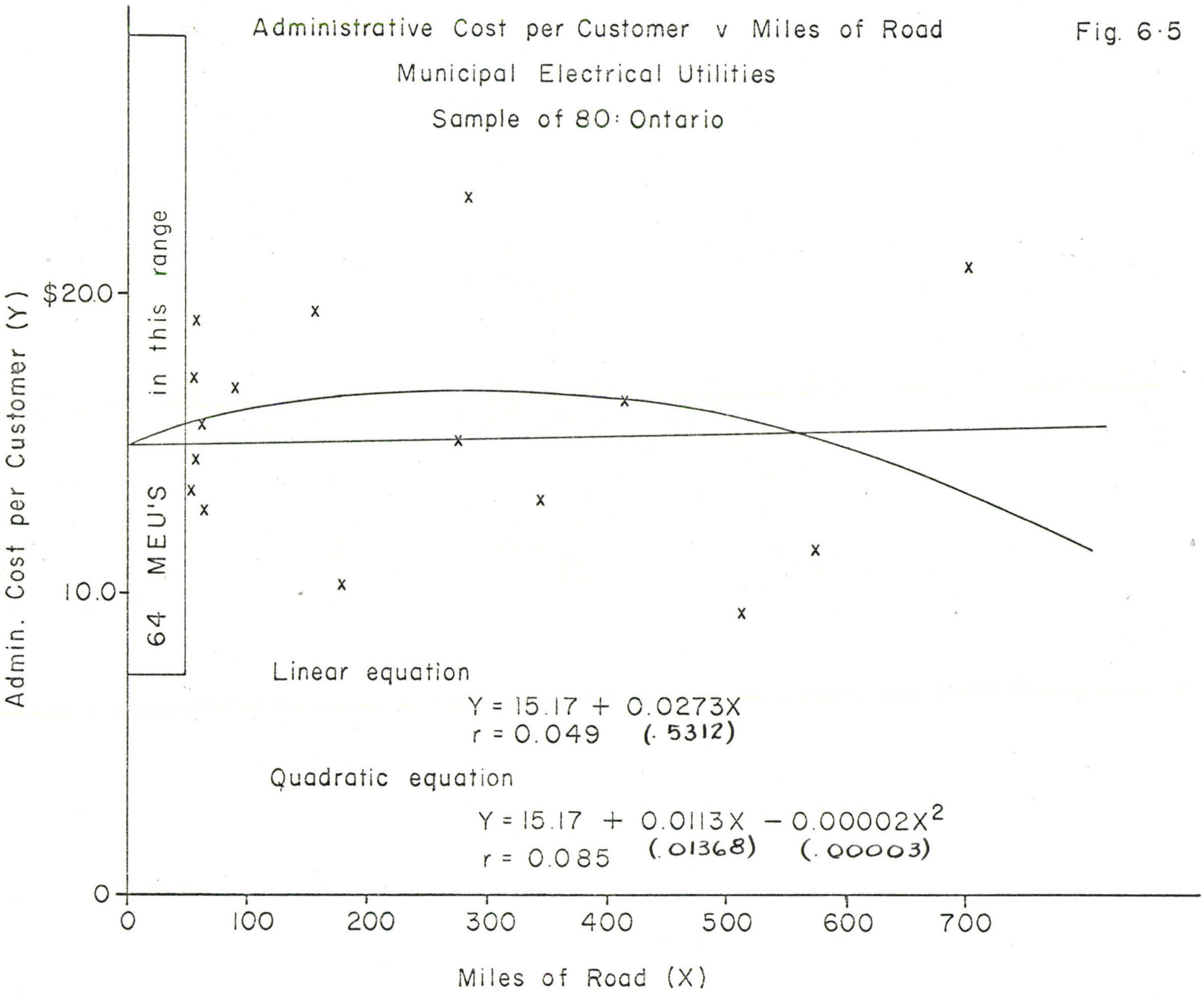
Administrative Cost per Customer v Number of Customers

Municipal Electrical Utilities

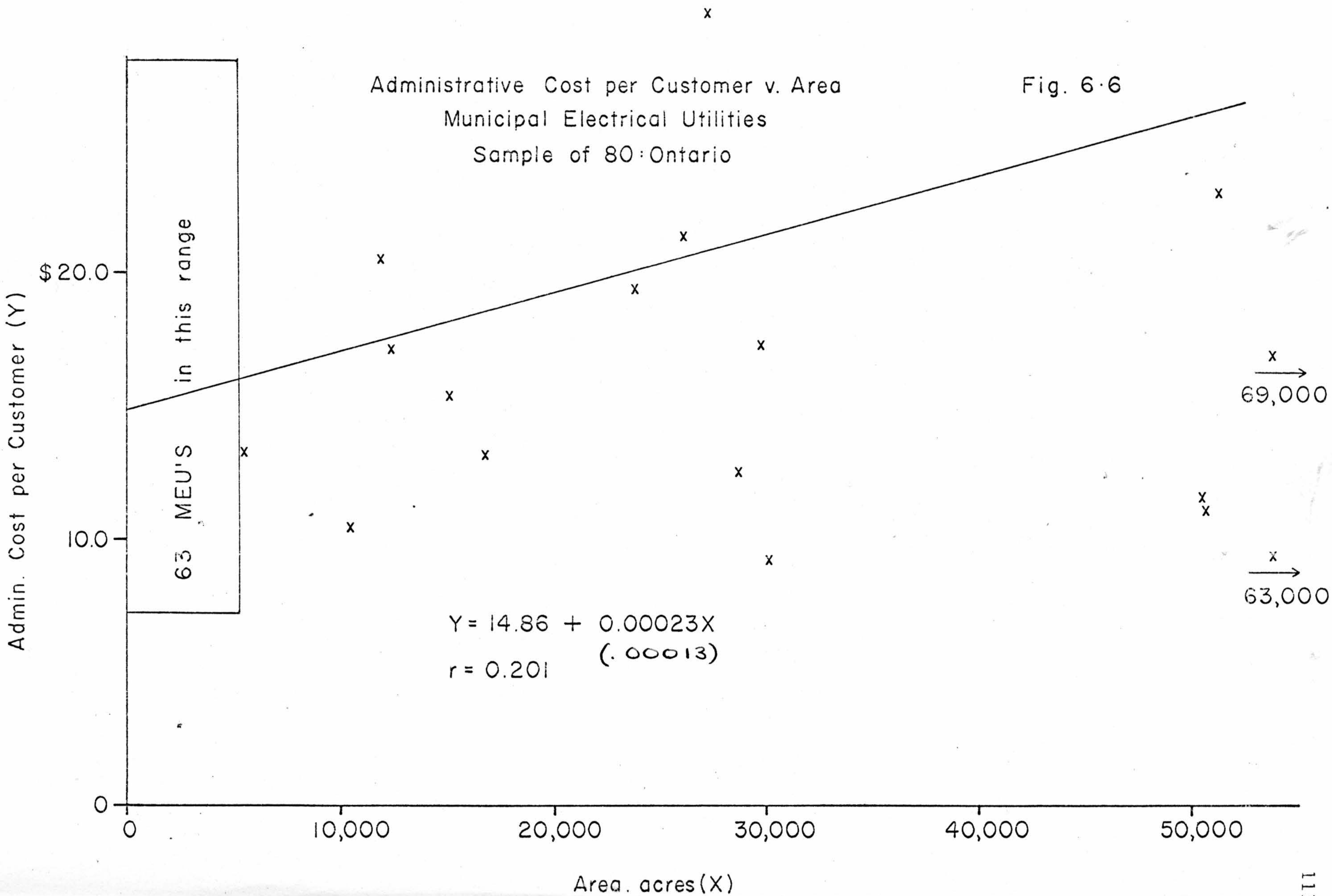
Sample of 80 : Ontario

Fig. 6·4





Administrative Cost per Customer v Miles of Road
Fig. 6·5
Municipal Electrical Utilities
Sample of 80: Ontario
64 MEU'S in this range
Linear equation
Y = 15.17 + 0.0273X
r = 0.049 (.5312)
Quadratic equation
Y = 15.17 + 0.0113X − 0.00002X2
r = 0.085 (.01368) (.00003)
Admin. Cost per Customer (Y)
$20.0
10.0
0
0
100
200
300
400
500
600
700
Miles of Road (X)



Administrative Cost per Customer v. Area
Municipal Electrical Utilities
Sample of 80 : Ontario
Fig. 6·6

Chapter V.

The range of values for the independent variables and the dependent variables is summarized in Table I.

TABLE I

RANGE OF VALUES - DEPENDENT AND INDEPENDENT VARIABLES

VARIABLE	MINIMUM	MAXIMUM	MEAN	S.D.
Number of customers	134	231,898	7,949	29,384
Miles of road	4	704	62	130
Area (acres)	7,780	69,272	7,780	15,068
Total cost per customer ($)	73.2	248.8	143.1	41.6
Administrative cost per customer ($)	74	29.1	15.5	5.4

Of the six quadratic models proposed, only two yield significant coefficients for the quadratic term using empirical data. The shape of these two curves is convex sloping downwards. This is the inverse of the theoretical long-run average cost curve. There appears to be at least four reasons why a U-shaped curve was not derived.

1. Perhaps the range of values is not large enough to exhibit significant differences among the size of the operations in the sample of M.E.U.'s.

2. Perhaps the choice of the dependent and the independent variables does not reflect the notions of cost per unit output or the size of the operation, as required by the theory.

3. The independent variables are positively skewed and the data do not include the same number of M.E.U.'s in all size classes.

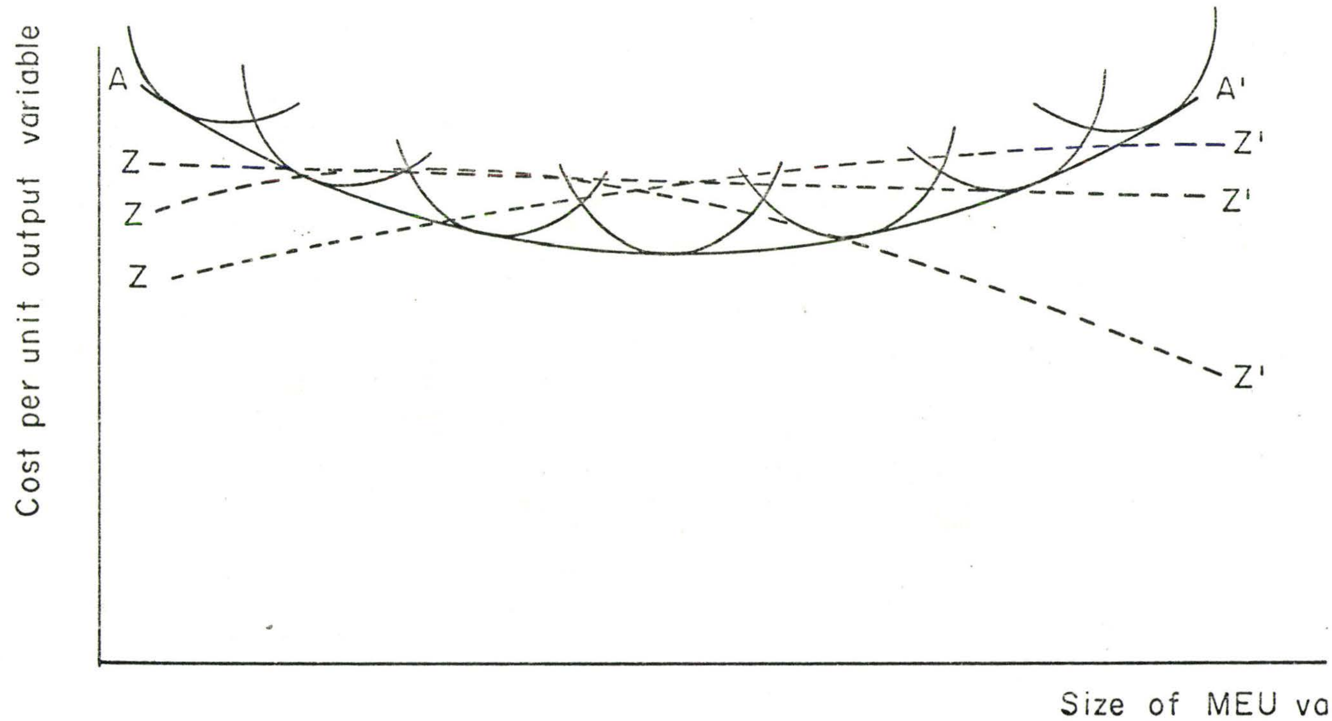
4. The assumptions on which the theory is based do not operate in reality.

Of these reasons 1 and 2 seem intuitively to be satisfied. The range of variables appears to be quite large and the choice of variables seems to satisfy the constraints of the theory. However, with respect to 3, the independent variables are positively skewed and though the range may look large, in fact most of the values are less than the mean. The shape of the resultant curves will therefore be strongly influenced by the distribution of the data below the mean. With respect to 4, the theory assumed that firms operate at the lowest point of their short-run average cost curve; this may not obtain in reality. Further, that the long-run average cost curve can be represented by a continuous function; this may be either a step-function or a non-continuous function in reality, as a discrete number of sizes of firms occur. Future research could examine the nature of the function and the efficiency of each M.E.U. with respect to its particular short-run average cost curve. The empirically derived curves can be explained if it assumed that each M.E.U. does not operate at the low point on its particular short-run average cost curve. Figure 6.7 illustrates this case.

The two quadratic equations, 6.2 and 6.5 will be examined next.

$$Y_1 = 127.05 + 0.43118X_2 - 0.00050X_2^2 \qquad (6.2)$$

Empirical and Theoretical Long-run Average Cost Curve   Fig. 6·7



A–A' Theoretical LAC


Theoretical SAC

Z–Z' Empirically derived LAC'S

Intersection of SAC and Z–Z' indicates the level of efficiency of each MEU

$$Y_2 = 15.17 + 0.1130X_2 - 0.00002X_2^2 \qquad (6.5)$$

Equation 6.2 suggests that as the miles of road in the M.E.U.'s increases the total cost per consumer increases until a maximum total cost of $219.00 is reached. The actual maximum is $248.8. The part of the curve to the left of the maximum suggests that economies of scale do not operate. However, to the right of the maximum, that is, as the miles of road increase from about 430, the total costs per consumer decrease. In this part of the curve, it is suggested that economies of scale operate. For equation 6.5 a similar shaped curve results. A maximum is reached in this case, when the miles of road in the municipality are about 280.[4] To the right of this point, the administrative costs per customer tend to decrease. The maximum administrative costs per customer are about $17.0 as derived from the curve. This compares with an actual value of $29.1. To the right of the maximum value of the dependent variable, it appears that economies of scale operate.

In the case of the four linear models the coefficient of the linear independent variable is, in all cases, positive. This suggests that as the size of the operation increases the cost per customer increases. The graphs indicate the least-squares line for each set of data. However, in the two cases where the number of customers is the independent variable, over 75% of all the data are contained in the extreme left-hand side of the distribution. This may have distorted the slope of the line, and the relatively few data points on the right may have almost no influence on the final shape of the curve. Therefore, in this case the positively skewed distribution makes it difficult to draw conclusions about the notion of economies of scale as they relate to the number of customers in an area. An attempt was made to normalise the variable "number of customers". A logarithmic transformation to the base ten was used.[5] The cumulative percentage frequency is presented in Table II.

TABLE II

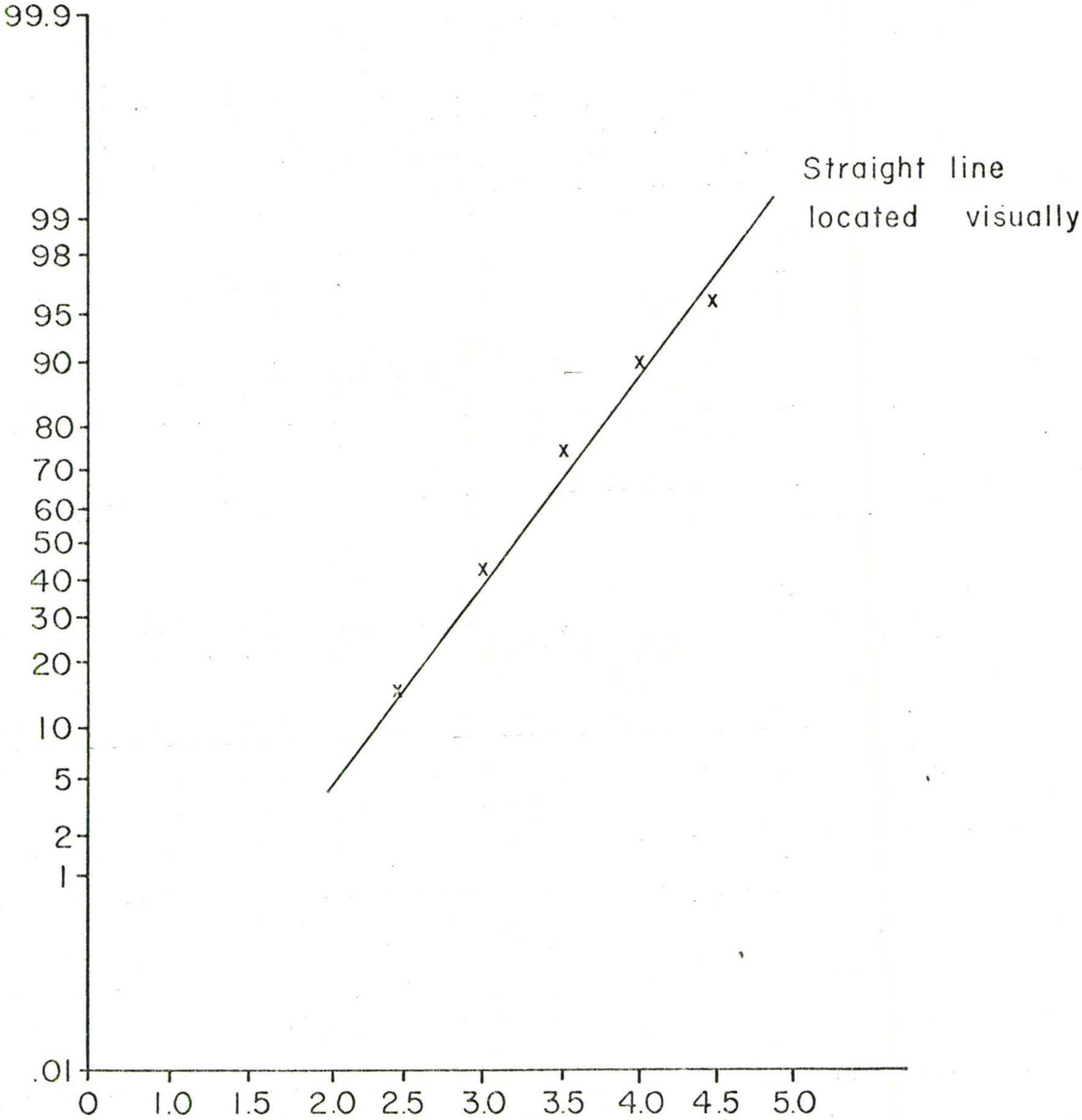
CUMULATIVE PERCENTAGE FREQUENCY LOG NUMBER OF CUSTOMERS

LESS THAN	PERCENTAGE OF VALUES
2.0	0
2.5	16
3.0	47
3.5	75
4.0	90
4.5	96
5.0	100

The values were plotted on arithmetic probability paper, this is shown in Figure 6.8. The values approximate to a straight line and thus the transformed data were assumed to be normally distributed. The logarithm "number of customers" (X_1) was plotted against "total cost per customer" (Y_1), the scatter diagram is shown in Figure 6.9. The least squares line is also shown. The equation of this time is given by the equation:

Test for Normal Distribution of Variable Log. Number of Customers Using Arithmetic Probability Paper

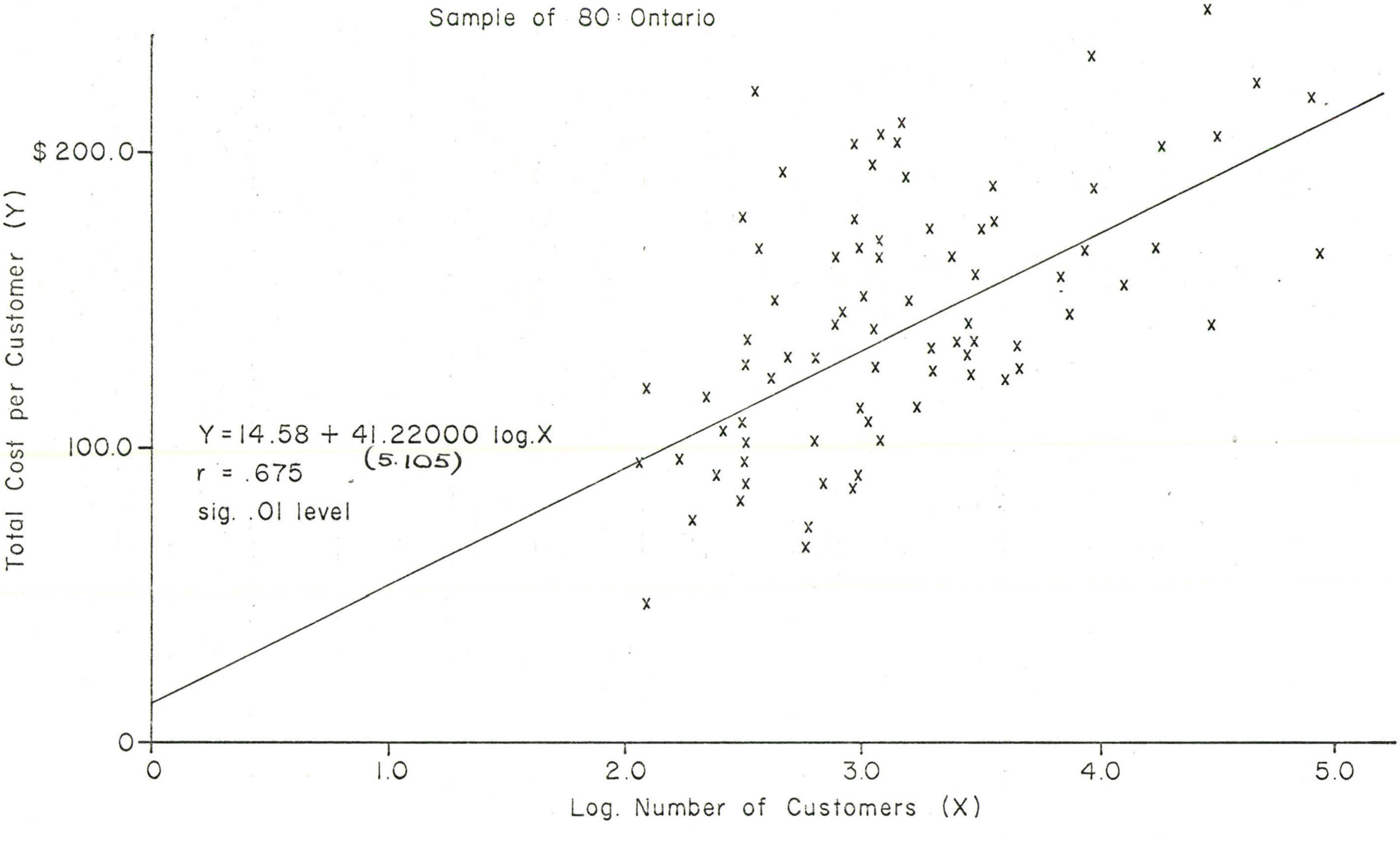
Fig. 6·8



Total Cost per Customer v. Log. Number of Customers — Fig. 6·9

Municipal Electrical Utilities

Sample of 80: Ontario



$$Y_1 = 14.58 + 41.22 \log X_1 \qquad (6.7)$$

with a correlation coefficient of .675. This is significant at the 0.01 level. Equation 6.7 suggests that the total cost per customer is directly related to the number of customers. Economies of scale do not appear to be operating in this case. The data for the total costs per customer and the number of customers were analysed further. The variable "number of customers" was divided into two groups. The first group is made up of M.E.U.'s with less than 4,000 customers. From the sample of eighty there are sixty-four M.E.U.'s in this group. The second group, that is the M.E.U.'s with more than 4,000 customers, contained sixteen M.E.U.'s. Using a stepwise multiple regression procedure an attempt was made to calculate the values for α, β_1 and β_2 for the model

$$Y = \alpha + \beta_1 X + \beta_2 X^2 .$$

For the data in the first group the following equation was derived.

$$Y = 111.22 + 0.00488X \qquad (6.8)$$

where Y is the "total costs per customer" and X is the "number of customers". A correlation value of .473 was calculated. For the second group of data the following equation was derived

$$Y = 184.71 + 0.00008X \qquad (6.9)$$

Y and X are the same variables as in equation 6.8. A correlation value of .148 was calculated. Confidence limits were not assigned to the regression values because the data are positively skewed. For both the equations the value of the coefficient β_2 was not significant. The scatter diagrams and the regression lines are shown in Figure 6.10 and Figure 6.11. The graphs suggest that the total costs per customer are directly related to the number of customers. Economies of scale do not appear to be operating in this case, thus supporting the findings presented above.

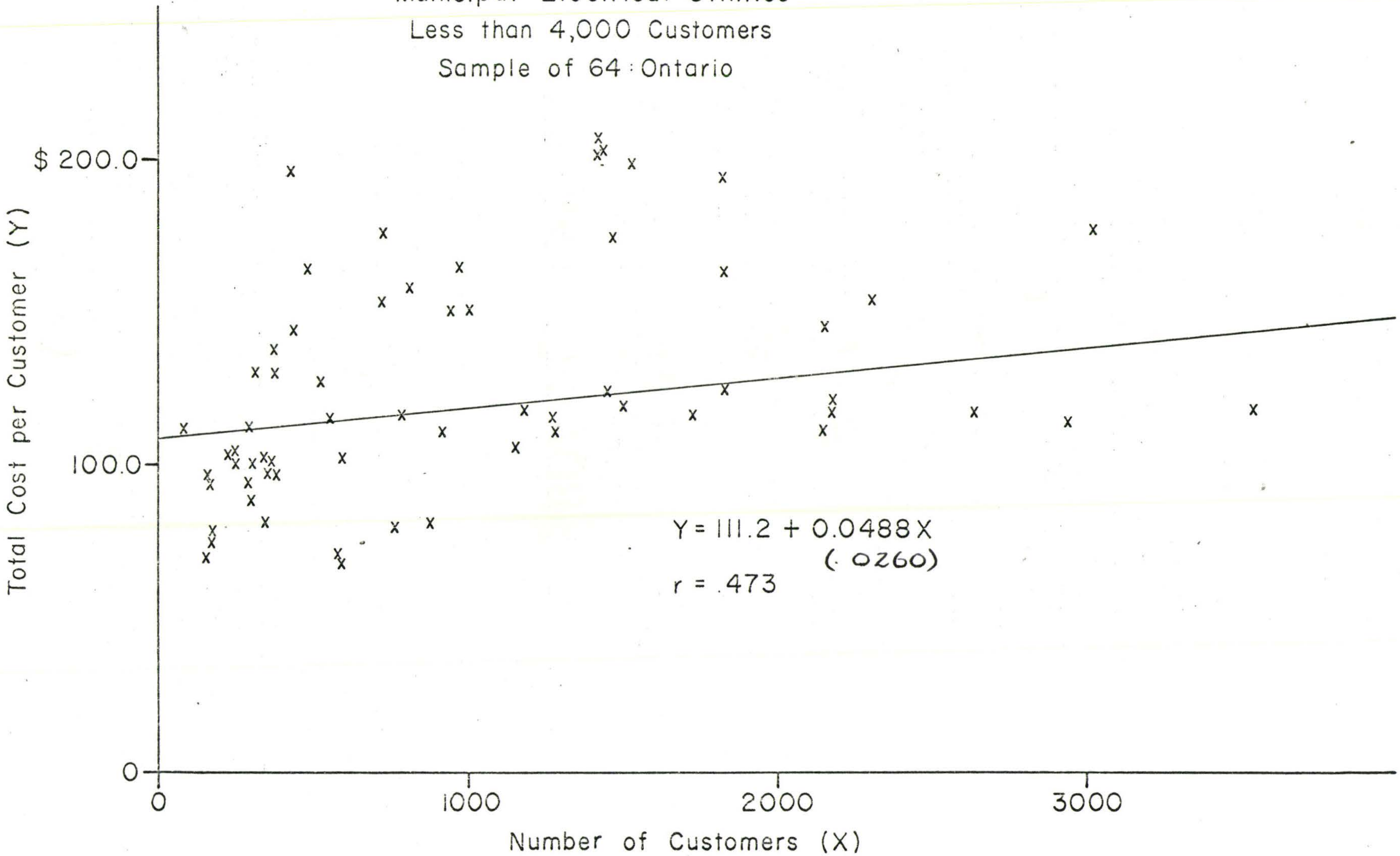
Finally, an attempt was made to examine the relationships between the total costs per customer and the customer and transportation densities. Theoretically, as the number of customers per mile of road increases the total costs per customer should decrease. This assumed that the cost to consumers is related to their spatial distribution in relation to the miles of road. The interview with Preston[6] suggested that in the densest areas of population per mile of road the total costs per customer were lower than in the areas where the population was more widely dispersed along the roads.

To test the hypothesis that the total cost per customer is inversely related to the number of customers per mile of road, a simple regression analysis was conducted. Both variables were assumed to be normally distributed.

The least squares regression line is represented by the equation

$$Y = 114.4 + 0.410X \qquad (6.10)$$

Total Cost per Customer v. Number of Customers Fig. 6·10
Municipal Electrical Utilities
Less than 4,000 Customers
Sample of 64 : Ontario

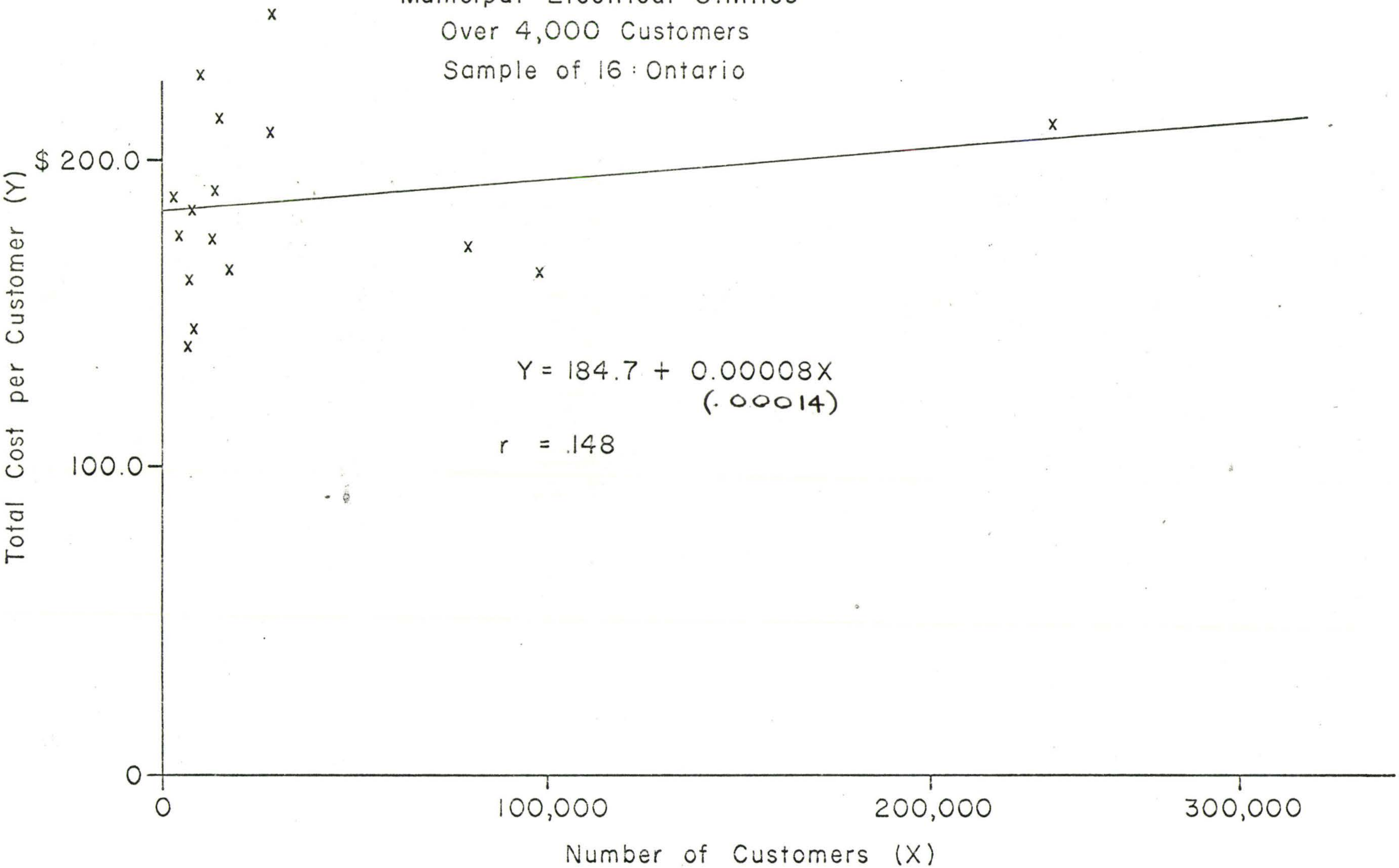


Total Cost per Customer v. Number of Customers — Fig. 6·11

Municipal Electrical Utilities

Over 4,000 Customers

Sample of 16 : Ontario

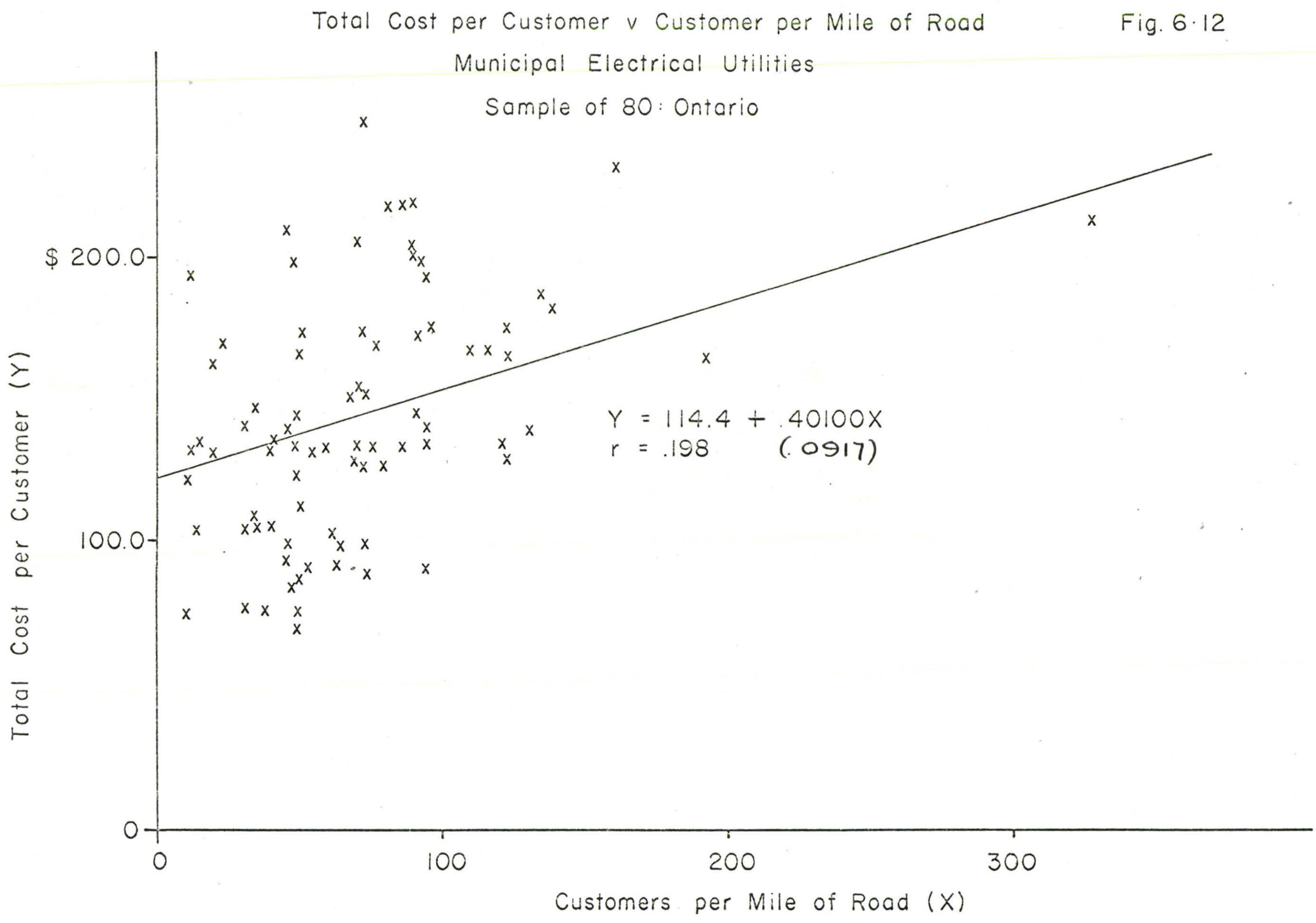


where Y is the total cost per customer and X is the number of customers per mile. A correlationcoefficient of .198 was calculated. The scatter diagram and the least squares line is shown in Figure 6.12. The correlation coefficient is not significant at the 0.05 level. At the 0.10 level of significance the graph appears to represent a positive relationship between the two variables, and on this evidence the hypothesis cannot be accepted.

The relationship between the administrative costs per customer and the number of customers per mile was also examined. Theoretically, following the same argument as offered above, the variables should be inversely related. The two variables were assumed to be normally distributed; a simple linear regression gave a correlation coefficient of .067 which is not significant at the 0.05 level.

In summary, the variation in costs among the sample of Municipal Electrical Utilities, has been analysed in the light of economies of scale. The variables, "number of customers", "size of area" and "miles of road" have been used as measures of the spatial size of the operation. The analysis suggests that the variation in total costs per customer and administrative costs per customer can only partially be explained by the spatial variables. Further, economies of scale with respect to these spatial variables do not appear to play a major role in explaining the variation in costs. Only in the case of miles of road did the concept appear to have some explanatory value.

The positively skewed independent variables indicate that a range of different size operations, with approximately equal numbers at all



Total Cost per Customer v Customer per Mile of Road
Fig. 6·12
Municipal Electrical Utilities
Sample of 80: Ontario
$ 200.0
100.0
0
Total Cost per Customer (Y)
Y = 114.4 + .40100X
r = .198 (.0917)
0
100
200
300
Customers per Mile of Road (X)

levels, does not obtain. The problem of obtaining good data to determine the shape of the long-run cost curve remains. For the data used in this study, the general trend between the costs and the spatial size of the operation, appears to be linear and positive. Further examination of the efficiency of each M.E.U. is required to determine the point of operation on the respective short-run average cost curve. This may help to elucidate the findings presented in this chapter.

FOOTNOTES - CHAPTER VI

1. See: LEFTWICH, R.H., <u>op. cit.</u>, pp. 143-148 and NOURSE, H.O., <u>op. cit.</u>, pp. 87-92.

2. α is the intercept on the Y axis and β_1 and β_2 are the coefficients of the linear and quadratic terms respectively. The coefficients were calculated to five decimal places.

3. INGRAM, D.R., "Multiple Regression Programme", Departmental Note No. 1, Department of Geography, McMaster University, Mimeo. No date.

4. It appears that approximately 50% of the M.E.U.'s enjoy economies of scale because they have more than 280 miles of road.

5. For a discussion on testing for normal distributions see GREGORY, S., <u>op. cit.</u>, pp. 45-56.

6. See footnote 1, Chapter II.

CHAPTER VII

RURAL OPERATING AREAS:

DISCUSSION OF THE TESTS OF THE HYPOTHESES

This chapter will attempt to analyse the relationships between spatial variables and cost variables for the R.O.A.'s in southern Ontario. In Chapter III it was hypothesised that the spatial size and the economic efficiency of the R.O.A.'s is related, and that the relationship could be described by a U-shaped long-run average cost curve. The hypothesis will be tested in this chapter. Also, an attempt will be made to improve the level of description of the linear models of the R.O.A.'s discussed in Chapter V. Quadratic terms will be introduced into the equations to incorporate non-linear relationships. Such relationships are suggested by the economic theory pertaining to average cost curves.

For this analysis the cost variable is defined as the "number of employees per customer". This is a measure of economic efficiency. The spatial variables are defined as the "size of the area", the "miles of wire" and the "number of employees". Empirical data for the fifty-four R.O.A.'s in southern Ontario were used to test the hypothesis that the relationships between the "number of employees per customer" and the three spatial variables are described by a U-shaped quadratic curve. The general quadratic model of the form:

$$Y = \alpha + \beta_1 X + \beta_2 X^2$$

was suggested by the theory[1]. A step-wise multiple regression procedure[2] was used to calculate the values of α, β_1 and β_2. The following equations were calculated.

$$Y = 7.01 - 0.00026X_1 \quad (7.1)$$

$$Y = 5.39 - 0.00030X_2 \quad (7.2)$$

$$Y = 7.29 - 0.00474X_3 \quad (7.3)$$

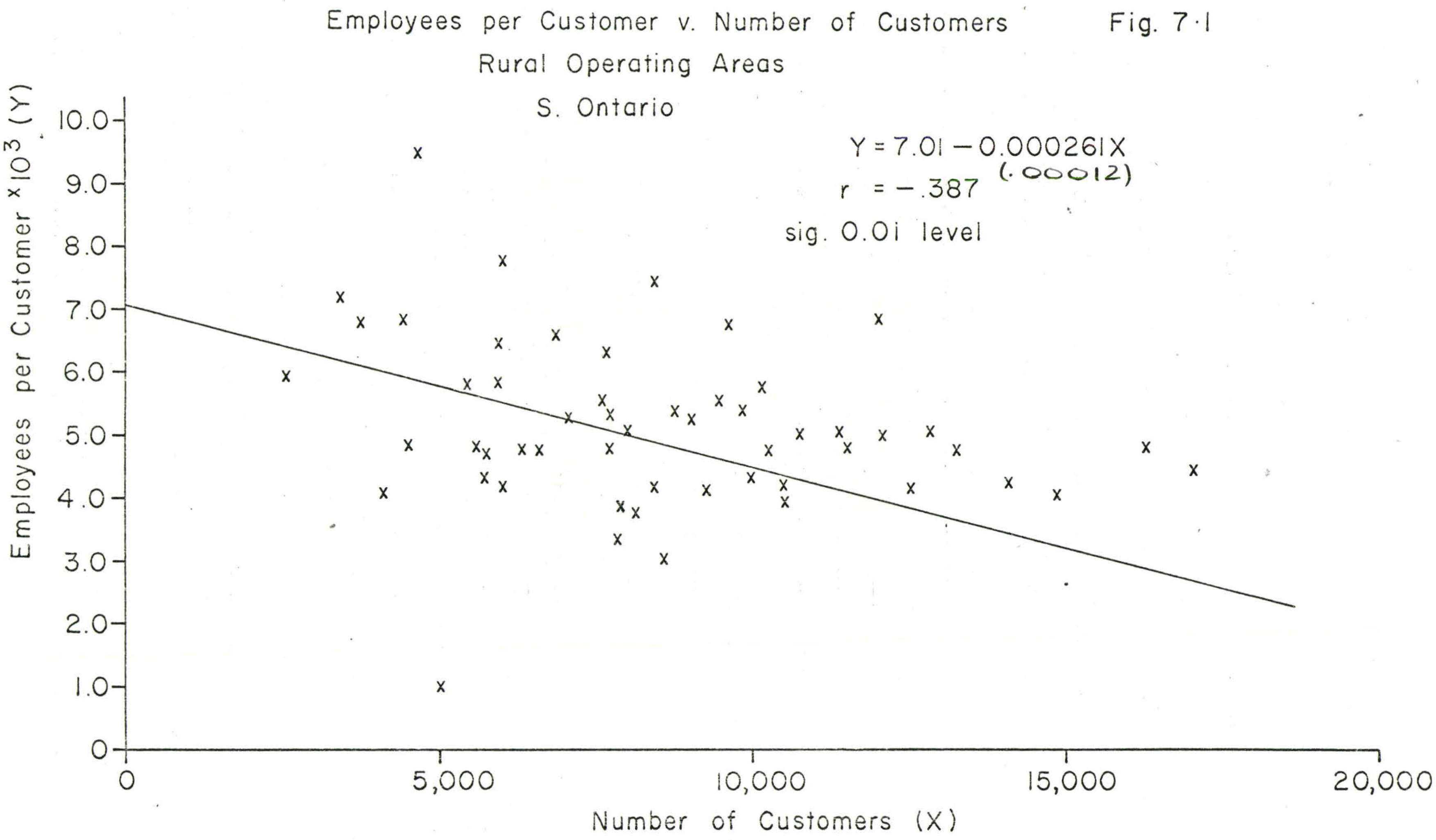
where Y is the number of employees per customer, and X_1 is the number of customers, X_2 is the size of area and X_3 is the miles of wire. In all cases the value of β_2 was so low that it did not significantly improve the level of explanation provided by the linear part of the equation.

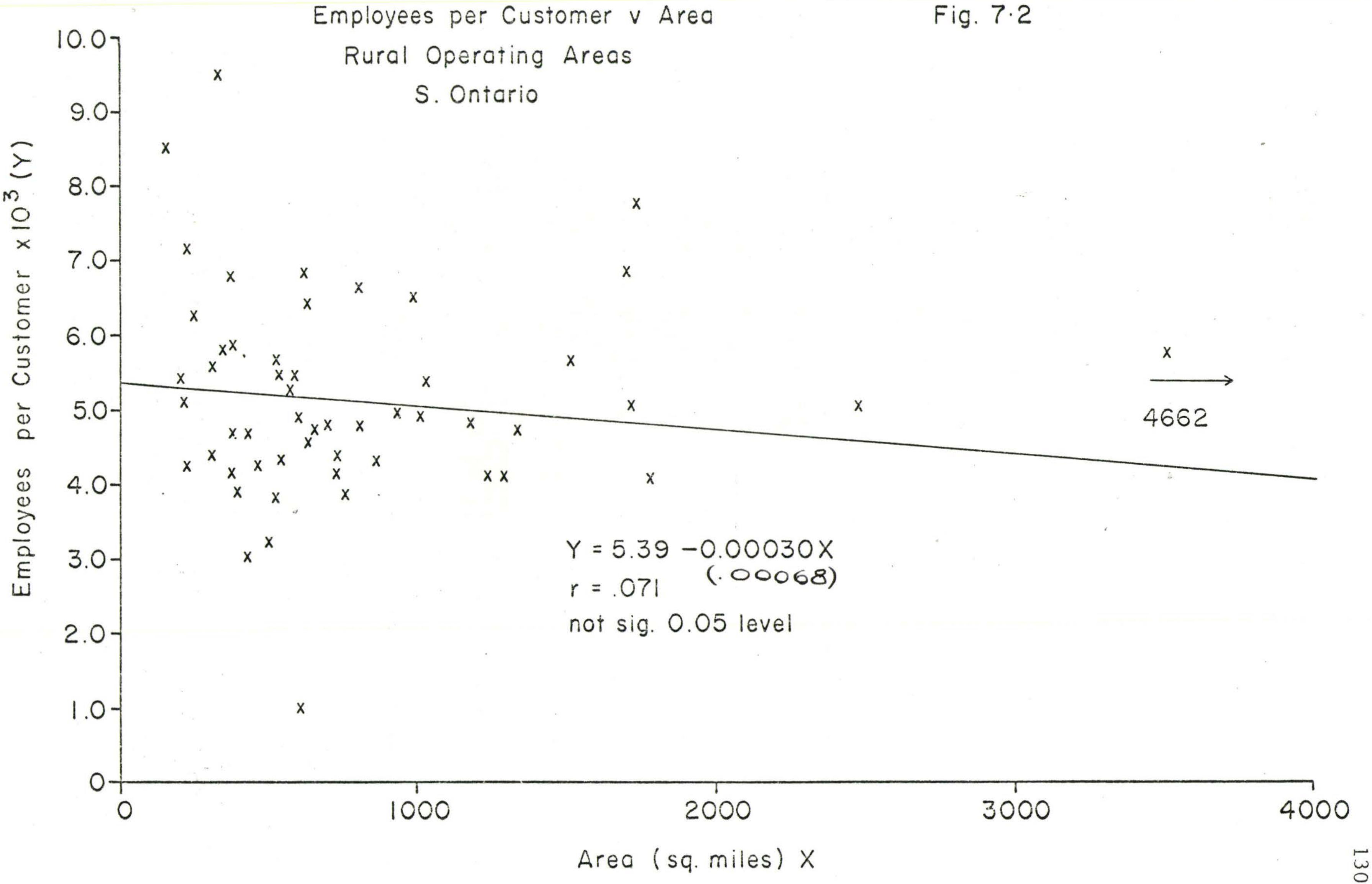
The scatter diagrams and the least squares lines are shown in Figures 7.1, 7.2 and 7.3. In all cases, as the size of the operation increases the number of employees per customer tends to decrease. Even without the part of the curve which should slope upwards and to the right, the data suggest that the three spatial variables examined influence the efficiency of the R.O.A.'s in a fashion which supports the hypothesis formulated above.

Assuming that all the variables are normally distributed, the correlation coefficients are as follows:

Y against X_1 $\quad r = -.387$

Y against X_2 $\quad r = -.071$

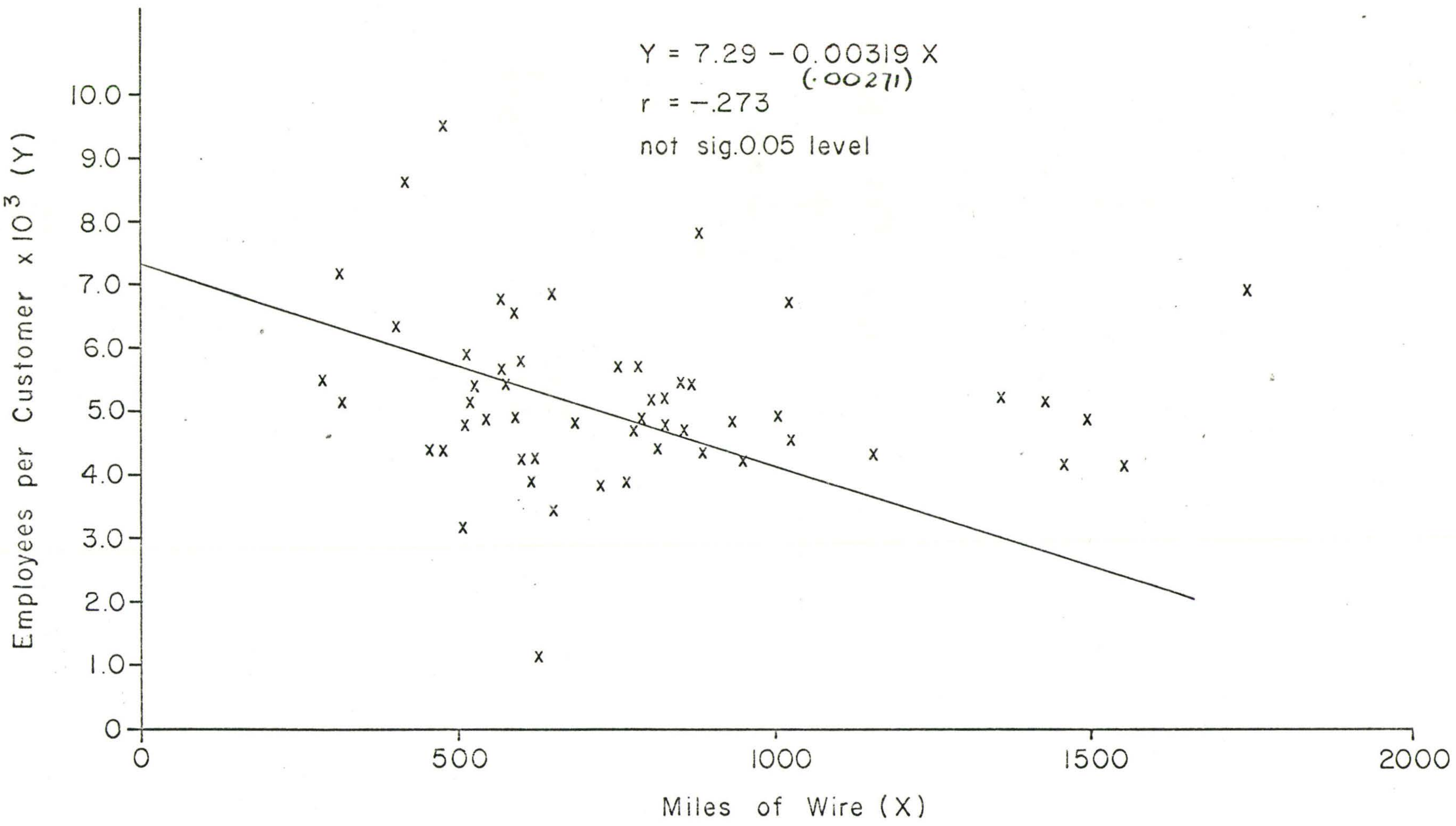

Employees per Customer v. Number of Customers
Fig. 7·1
Rural Operating Areas
S. Ontario
Y = 7.01 − 0.000261X
(.00012)
r = −.387
sig. 0.01 level
Employees per Customer x10³ (Y)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
0
5,000
10,000
15,000
20,000
Number of Customers (X)



Employees per Customer v Area
Rural Operating Areas
S. Ontario
Fig. 7·2
Employees per Customer x10³ (Y)
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1000
2000
3000
4000
Area (sq. miles) X
4662
Y = 5.39 −0.00030X
(.00068)
r = .071
not sig. 0.05 level

Fig. 7·3

Employees per Customer v. Miles of Wire



Y against X_3 $\quad r = -.243$

The correlation between Y and X_1 is significant at the 0.05level. Since the sign of all the correlationcoefficients is negative, an inverse relationship is suggested. Thus the hypothesis cannot be rejected by the statistical test.

It is argued that if economies of scale obtain then the relationships between the number of employees and the three spatial variables of the R.O.A.'s will be non-linear. Further, quadratic models of these relationships should offer a higher degree of explanation in the dependent variable than was offered by the linear models discussed in Chapter V. It is hypothesised that quadratic models of the relationships will yield higher regression coefficients than those of the linear models. The general quadratic model of the form:

$$Y = \alpha + \beta_1 X + \beta_2 X^2$$

was suggested by the theory. Using a step-wise multiple regression procedure the following equations were calculated.

$$Y_1 = 10.16 + 0.00389X_1 \qquad (7.4)$$

$$Y_1 = 38.66 + 0.00921X_2 \qquad (7.5)$$

$$Y_1 = 47.73 - 0.03087X_3 + 0.00003X_3^{\,2} \qquad (7.6)$$

where Y_1 is the number of employees and X_1 is the number of customers, X_2 is the size of area and X_3 is the miles of wire. Equation 7.6 was the only one in which the coefficient β_2 improved the level of explanation provided in the linear part of the equation. The scatter diagrams and the least squares lines are shown in Figures 7.4, 7.5 and 7.6. The variables are assumed to be normally distributed. The following correlation coefficients were calculated.

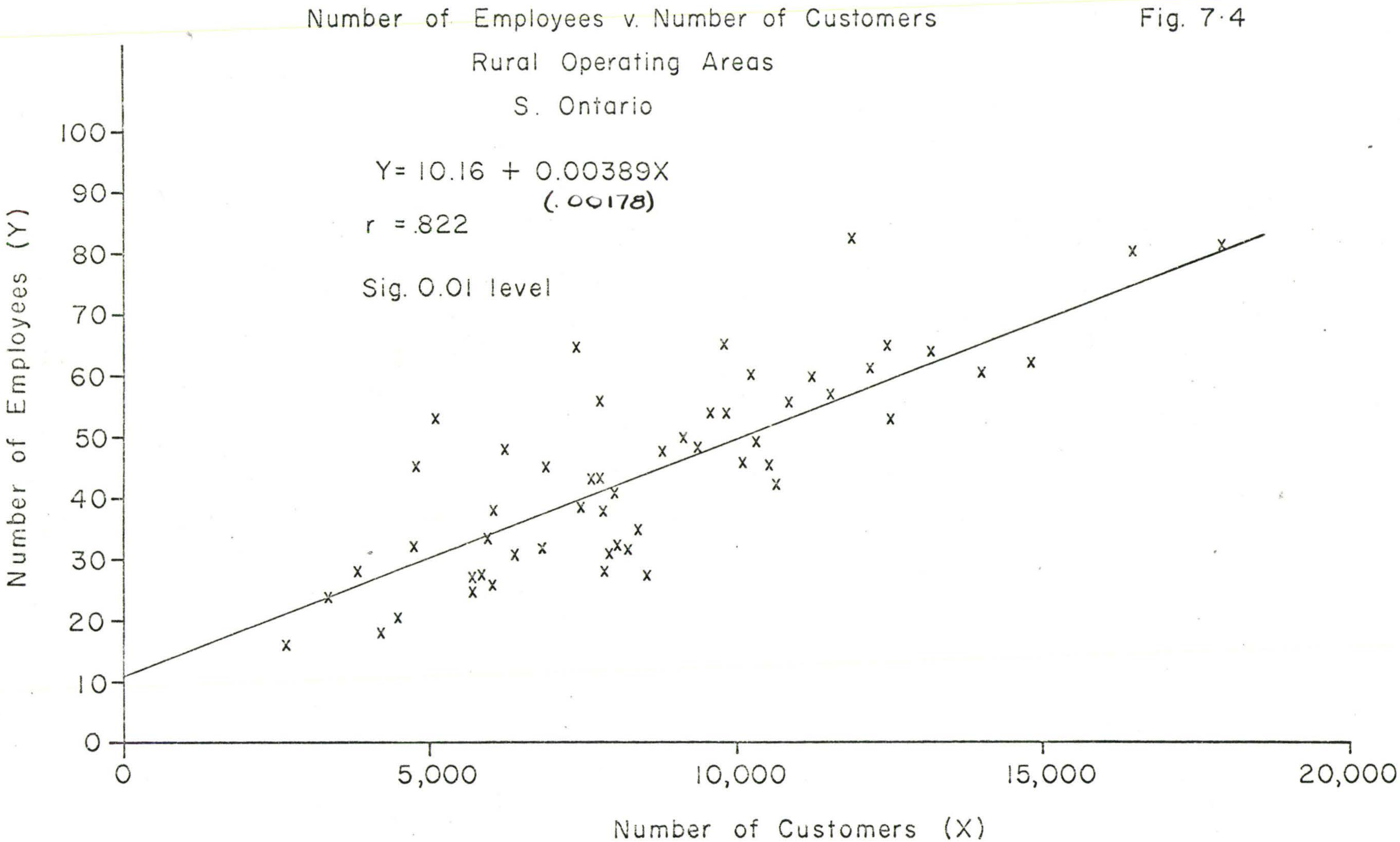
Y_1 against X_1	r = .822 significant	0.01
Y_1 against X_2	r = .247 not significant	0.05
Y_1 against X_3	r = .581 significant	0.01

The correlation coefficients can be compared to those derived from the linear models, they are shown below.

Relationships Y_1 against	Linear Model r	Quadratic Model r
X_1	.822	.822
X_2	.239	.247
X_3	.578	.581

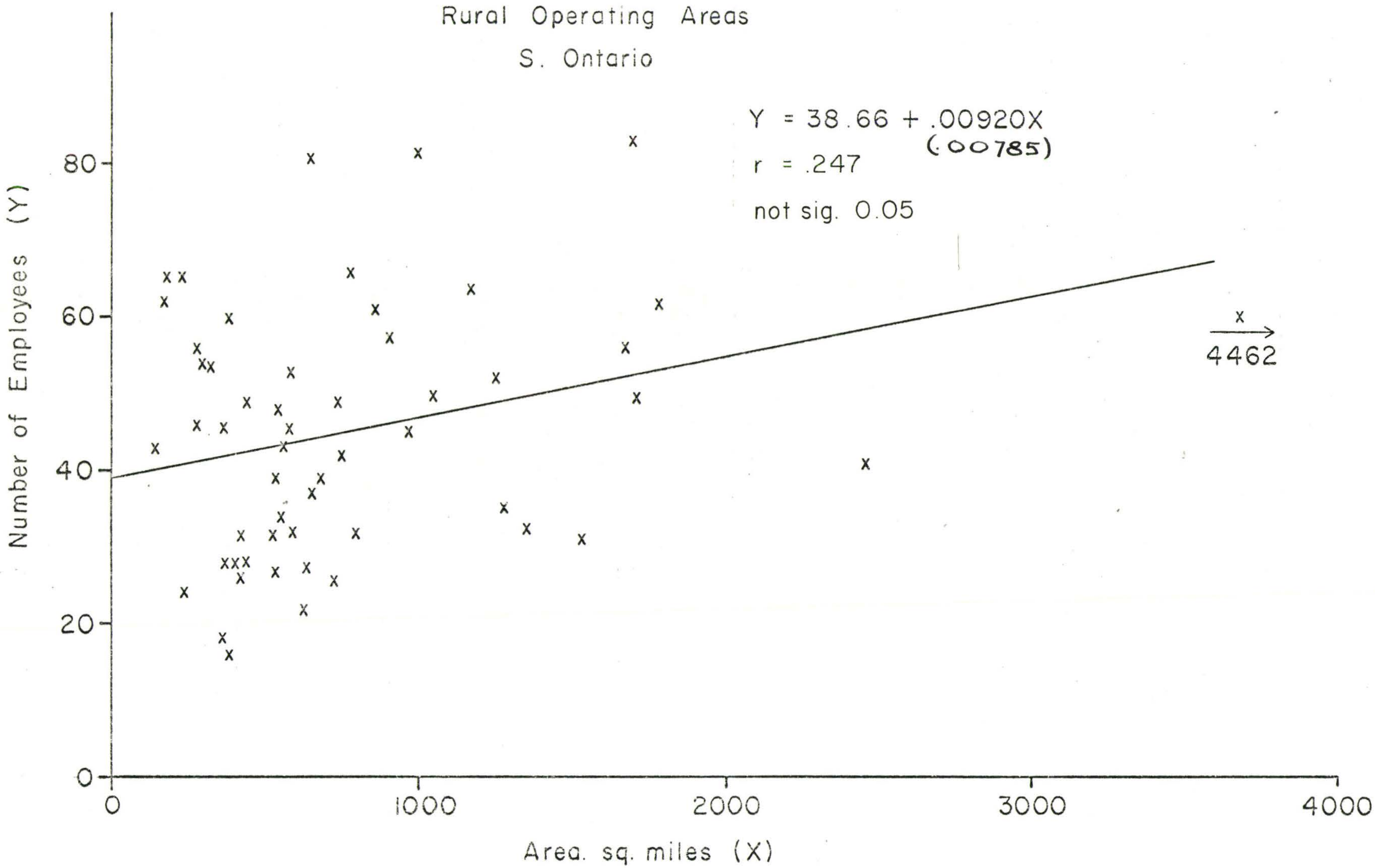
In the case of Y_1 against X_1, the quadratic models offer no improvement in the level of explanation. In the other two relationships only slight improvement, in the levels of correlation, is provided by the quadratic models. For the R.O.A.'s examined it can be concluded that the relationships between the number of employees and the three spatial variables are linear and positive. Quadratic models do not significantly improve the level of explanation.

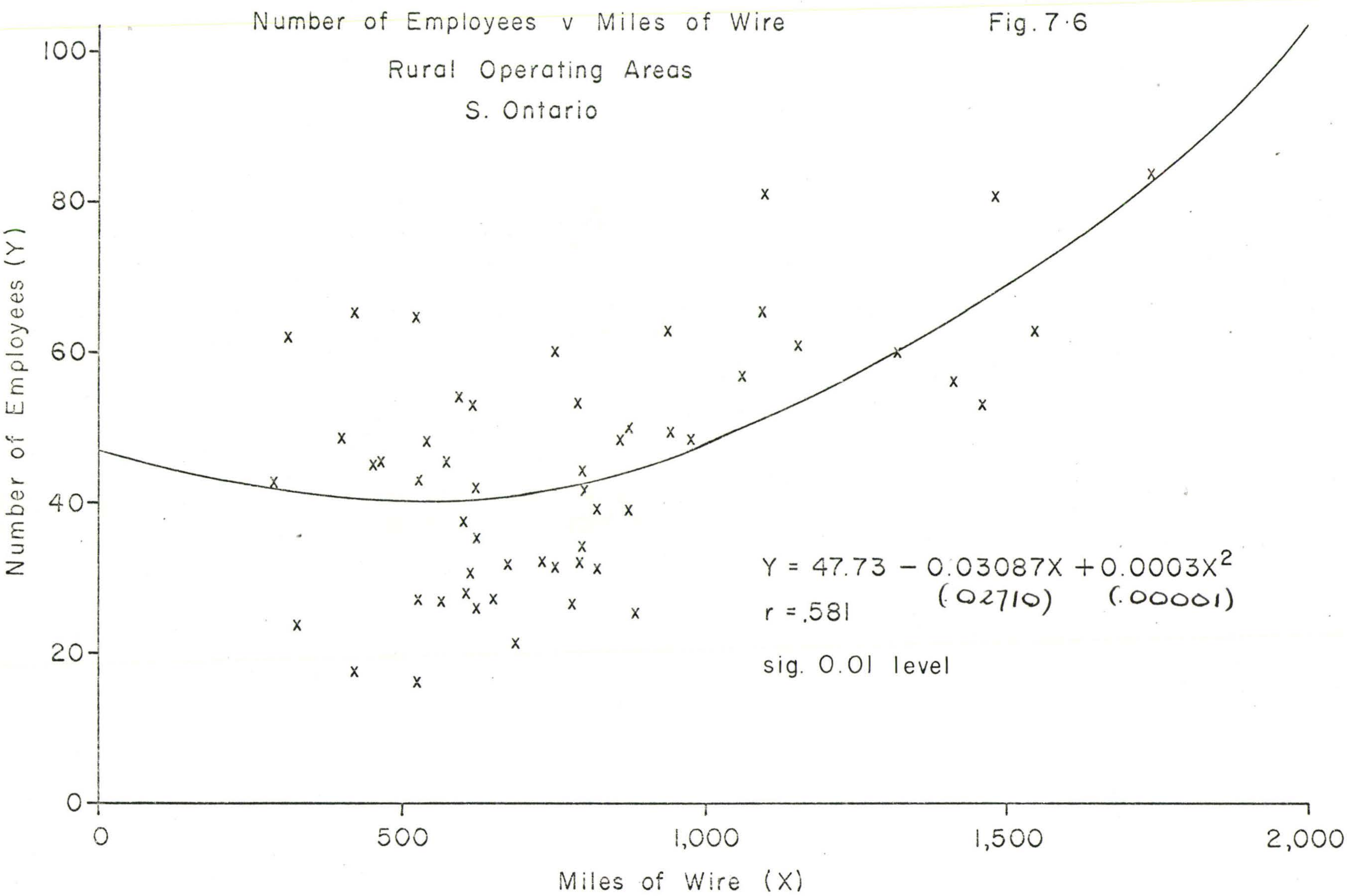
Fig. 7·4



Number of Employees v. Number of Customers
Rural Operating Areas
S. Ontario
Y= 10.16 + 0.00389X
(.00178)
r = .822
Sig. 0.01 level
Number of Employees (Y)
100
90
80
70
60
50
40
30
20
10
0
0
5,000
10,000
15,000
20,000
Number of Customers (X)

Number of Employees v Area Fig. 7·5




Number of Employees v Miles of Wire
Fig. 7·6
Rural Operating Areas
S. Ontario
Number of Employees (Y)
Miles of Wire (X)
100
80
60
40
20
0
500
1,000
1,500
2,000
Y = 47.73 − 0.03087X + 0.0003X²
(.02710)
(.00001)
r = .581
sig. 0.01 level

The next part of this chapter will attempt to examine the relationships between the shape of each enclosed R.O.A. and the level of economic efficiency. If the areas were distributed over a homogeneous population density surface, and the administrative centres were located at the point of minimum aggregate travel in each area, then as the shape of the areas approached regular hexagons the aggregate linear distance between the population and the centres would decrease. It follows that the more spatially compact is the area, the more economically efficient it is for supplying a good or a service from a central point to a spatially distributed demand.

It is recognized that in reality a homogeneous population surface is an ideal. Further, that the configuration of the bounding edge will influence the optimum shape of the constituent areas. Also, that the location of the actual centres will influence the shape of the optimum pattern of areas. For the twenty-six enclosed R.O.A.'s, it is assumed that the bounding edge does not influence the shape of the constituent units. Also, that the administrative centre is at the point of minimum aggregate travel of each area. On the basis of these assumptions and the arguement presented above the following hypothesis was formulated. That as the shape of the area approaches a regular hexagon the economic efficiency increases.

The hypothesis was tested for the enclosed R.O.A.'s. The variable "employees per customer" was used to measure the economic efficiency and the shape of the areas was defined according to the shape index discussed in Chapter V. The variables were assumed to be normally distributed. Using a linear regression procedure the following least-squares regression line was determined.

$$Y = 3.63 + 3.64733X \qquad (7.7)$$

where Y is the number of employees per customer and X is the shape index. A correlation coefficient of .433 was calculated. This is significant at the 0.05 level. The scatter diagrams and the least squares line are shown in Figure 7.7. The sign of the coefficient of X is positive, thus a direct relationship between Y and X is suggested. The hypothesis is not supported using this type of analysis and these data.

From Figure 7.7 three residuals stand out, they have values for the number of employees per customer which are much higher than predicted by equation 7.7. The three residuals are London R.O.A., Brampton R.O.A. and Tweed R.O.A. In an attempt to rationalize why they have such high values the following is suggested. Firstly, these areas have a less than average number of customers. This is shown in Table I.

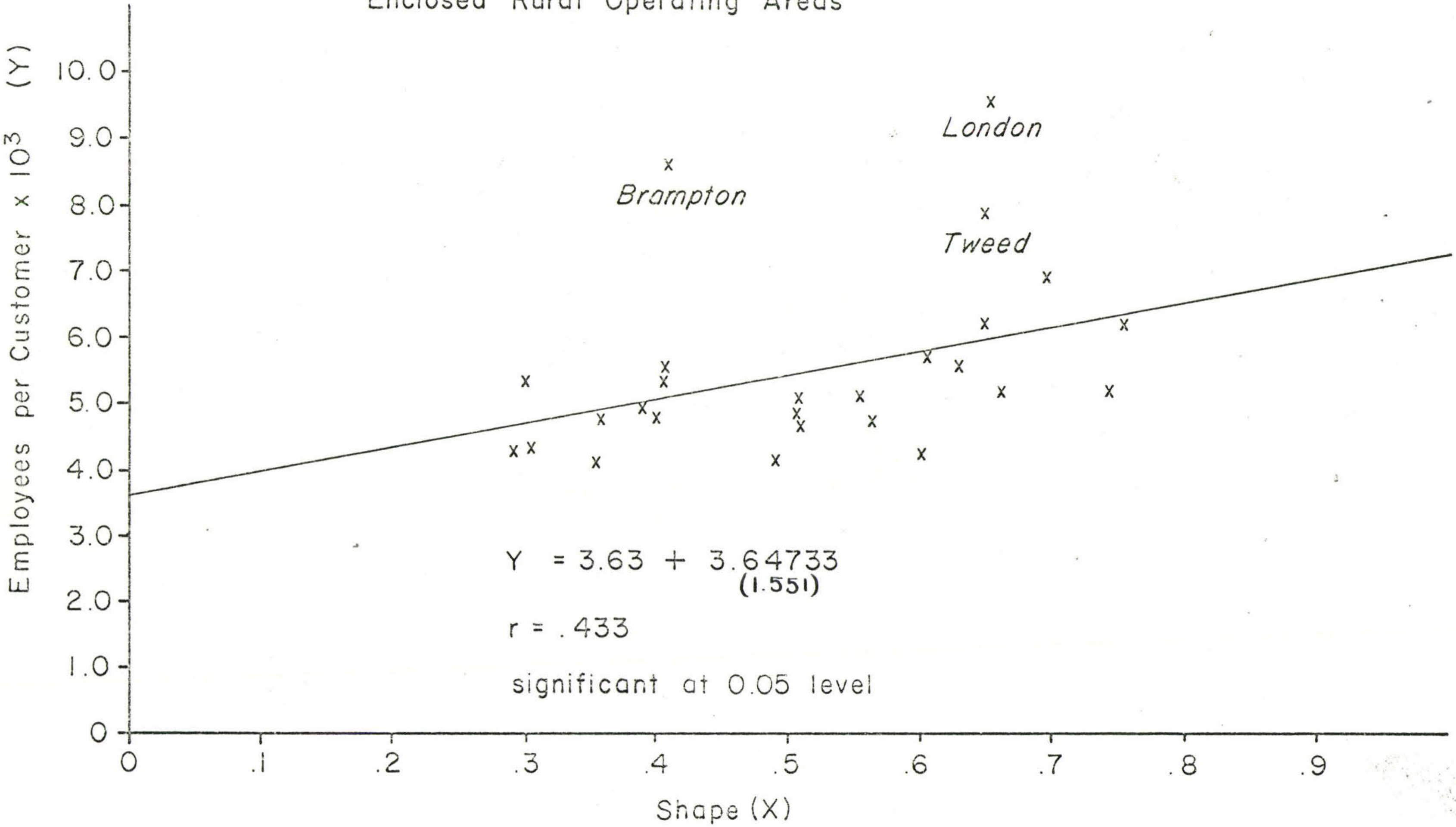
TABLE I

NUMBER OF CUSTOMERS

Brampton R.O.A.	7,482 Customers
London R.O.A.	4,730 Customers
Tweed R.O.A.	6,238 Customers

The mean for the fifty-four R.O.A.'s in southern Ontario is 8,579 customers. This suggests that any economies of scale relating to the number of customers will probably not be enjoyed by these three areas. Further, Employees per Customer v. Shape of Areas Fig. 7·7

Enclosed Rural Operating Areas



Tweed R.O.A. is the largest of all the areas and this, together with the low number of customers, produces a widely dispersed demand for administrative services. This serves to increase the number of employees per customer. Brampton R.O.A. and London R.O.A. have below average miles of wire. This is shown in Table II.

TABLE II

MILES OF WIRE

Brampton R.O.A.	421 miles
London R.O.A.	482 miles

The mean to all the fifty-four areas in southern Ontario is 776 miles. Therefore, Brampton and London probably do not enjoy any economies of scale to be gained by having a large mileage of wire to be serviced. Finally, the three areas have disproportionately higher values for the number of employees per customer, for reasons which may not be related to economic efficiency. This illustrates the way in which this variable is not a perfect surrogate for economic efficiency.

If the three areas discussed above were eliminated from the analysis, then the least-squares regression line would be represented by the following equation:

$$Y = 3.52 + 3.13979X \qquad (7.8)$$

where Y is the number of employees per customer and X is the shape index. A regression coefficient of .664 was calculated, this is significant at the 0.01 level. The scatter diagram and the least-squares line are shown in Figure 7.8.

By visual examination of the graph it is suggested that variation in the level of economic efficiency among the areas may not be sufficiently large to exhibit the theoretical relationship hypothesised above. For the fifty-four R.O.A.'s the number of employees per 1000 customers varies from 9.6 to 4.1; for the twenty-six enclosed R.O.A.'s it varies from 7.6 to 4.1. For these areas, the maximum time to reach the furthest point in the area, from the mid-point of the long axis, is about one hour; the minimum time is about twenty minutes and the average time is about forty-five minutes. This assumes a car speed of about fifty miles per hour.

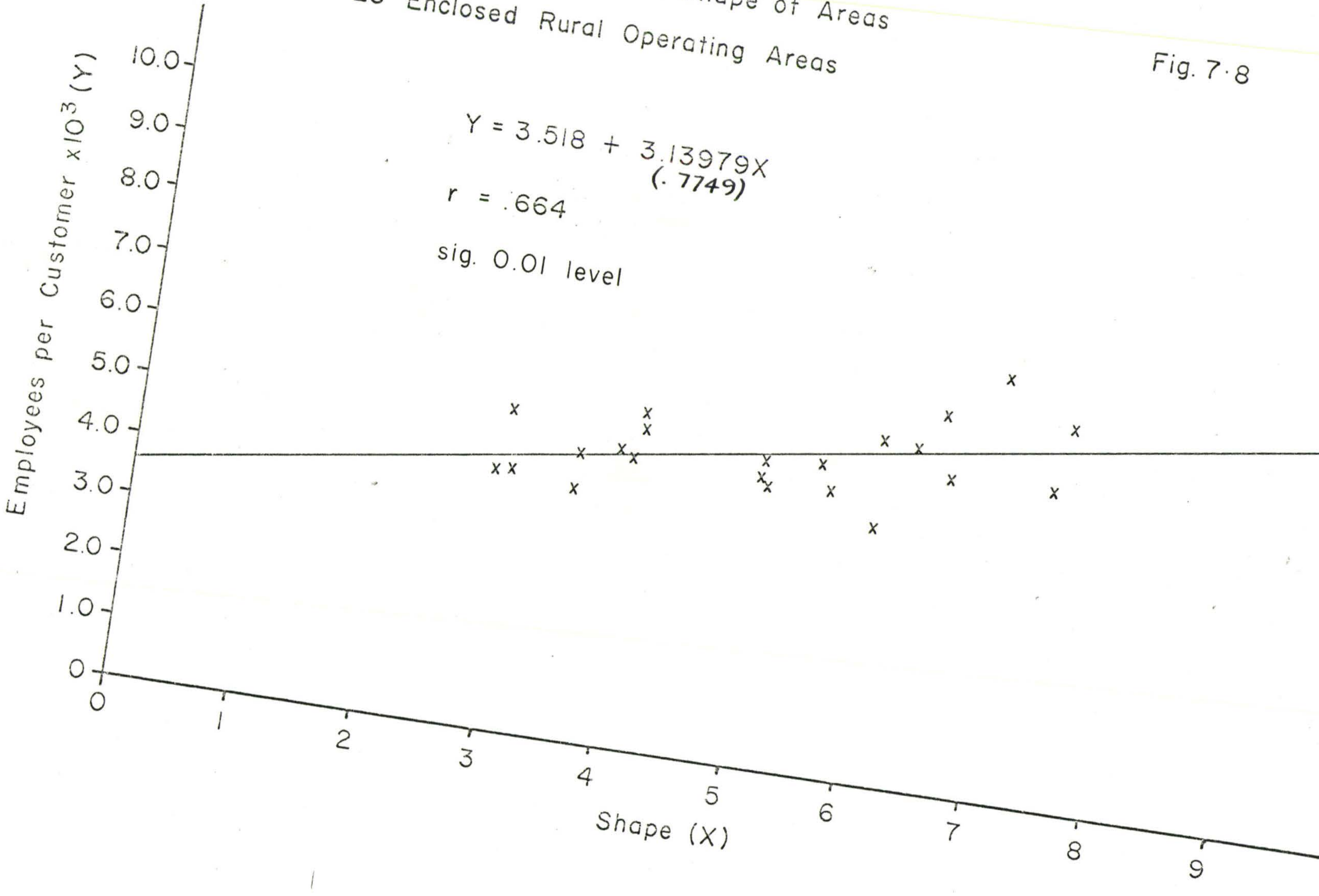
Armour[3] suggested that the level of service varied slightly among the R.O.A.'s, and that a variation in times as presented here was tolerable within the current framework. Further, he suggested that a tolerable deviation from a mean of forty minutes, was about thirty minutes, thus suggesting that the areas could be larger than at present with no substantial loss in economic efficiency.

In summary, this chapter offers a discussion on the analysis of R.O.A.'s. Specifically, an attempt was made to test hypotheses concerning economies of scale. The first part of the analysis, using the quadratic models, suggested that as the areas increase in number of customers, miles of wire or size, the number of employees per customer tends to decrease. The hypothesis that economies of scale operate, within the range of defined variables, cannot be rejected. In the second part of the analysis

Employees per Customer v. Shape of Areas

23 Enclosed Rural Operating Areas

Fig. 7·8



using quadratic models to describe the relationship between the number of employees and the three sizes-of-operation variables, it was found that these models do not significantly improve the level of explanation over the linear models. Therefore, it is questionable whether economies of scale manifest themselves in terms of the number of employees in each area.

The final part of the analysis attempted to construct and test a theoretical relationship between a measure of compactness of R.O.A.'s and a measure of economic efficiency. The analysis suggested that a positive relationship obtains. Future research could develop other measures to test the relationship. Clearly, a greater range in size of areas, together with cost data to measure the economic efficiency of the areas, is needed to test the hypotheses more rigorously.

FOOTNOTES - CHAPTER VII

1. See footnote 2, Chapter VI

2. See footnote 3, Chapter VI

3. See footnote 1, Chapter II

CHAPTER VIII

REGIONS: DISCUSSION OF THE TESTS OF THE HYPOTHESES

This chapter will analyse some of the spatial characteristics of the five Regions currently used by the Ontario Hydro Commission in southern Ontario. The current pattern of Regions will be compared to eight simulated patterns in an attempt to understand the processes underlying regionalization. Two of the patterns will be produced by a random process and six of the patterns will be produced using least-cost considerations. Four measures of each pattern will be made operational. The hypotheses that the current pattern is not a random pattern and that some notions of least-cost influence the actual location of regional boundaries and administrative centres will be tested.

For the purposes of this analysis it is assumed that the study area shown in Figure 8.1 can be considered as a weighted set of discrete points. This notion has already been discussed in Chapter V, with respect to southern Ontario. The data used in the present analysis are the same as were used to provide descriptions of the current pattern of Regions in Chapter V.

Finally, an attempt will be made to compare the patterns of Regions using Pred's Behavioural Matrix. It is argued that fuller understanding of the processes underlying regionalization should ensue as more precise methods are developed for operationalizing the Behavioural

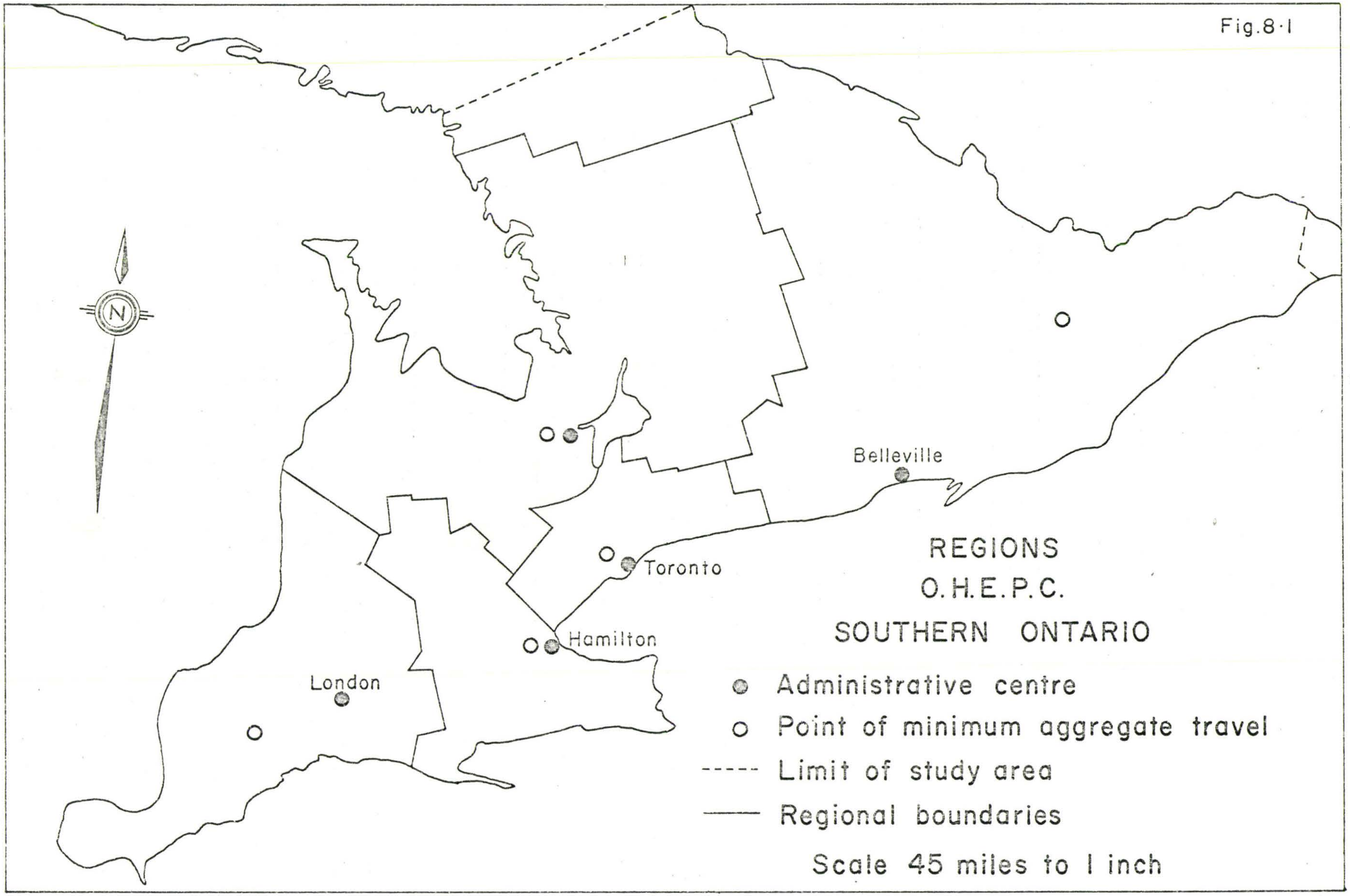


Fig.8·1
Belleville
Toronto
Hamilton
London
REGIONS
O.H.E.P.C.
SOUTHERN ONTARIO
Administrative centre
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

Matrix. This could form the basis of a future research project.

The Regionalization Processes

The agglomeration of points, in order to satisfy agreed objectives is a regionalization process[1]. The delimitation of regions, so as to minimize the internal variation among selected parameters, and to maximize the between-region variation, is a traditional problem in geography. The problem has been treated quantitatively as well as qualitatively[2].

In a mathematical sense, the problem of spatial division is extremely complex. Socio-economic parameters are usually discretely distributed over space, and though the mathematical analysis of large discrete systems has improved in the last decade, the methods are still cumbersome. Iterative numerical methods involving large quantities of computational time are typical of this area of study.

Central Place Theory provides an example where postulates about human behaviour are used to derive patterns of human location. Haggett[3] has considered some developments of this theory in the light of "field theory", "territoriality" and "packing". He has attempted to formulate hypotheses relating the size and shape of organizational units to population density. The hypotheses have been formulated with the aim of helping researchers understand a little more about the processes which appear to operate when man divides space into functional units.

The next task in this chapter is to illustrate the relationship between the requirements of the system formulated by decision-makers and the actual location of boundaries drawn on the map. It is assumed that a number of cities have been classified as administrative centres, and a population which requires a service that is provided by a centre is distributed around these cities. Further, that it is found desirable to draw the boundaries between administrative areas to minimize the aggregate distance between individuals and their administrative centre. If there are no constraints placed upon the number of persons served by each administrative centre, then to achieve the declared objective, clearly, individuals are assigned to their nearest centre. This initial allocation model of individuals to their nearest centre is called a proximal solution. Geometrically, the administrative areas appear as irregular polygons whose segments are the perpendicular bisectors of lines joining the centres. In the general case all polygon corners are also junctions of three separate areas.

In the case of southern Ontario and the data base discussed earlier in this chapter, and given that London, Hamilton, Toronto, Barrie, and Belleville are to be used as administrative centres, then the proximal regions are shown in Figure 8.2[4]. The map was constructed geometrically.

Following the proximal regions, five simulated regional patterns were produced using a defined cost function. Specifically, the cost function is the same as the one that was defined in Chapter V, i.e.

$$C_{ij} = M_i \, d_{ij} \qquad \text{where}$$

C_{ij} = cost of administering a township i from an administrative centre j

M_i = population of township i

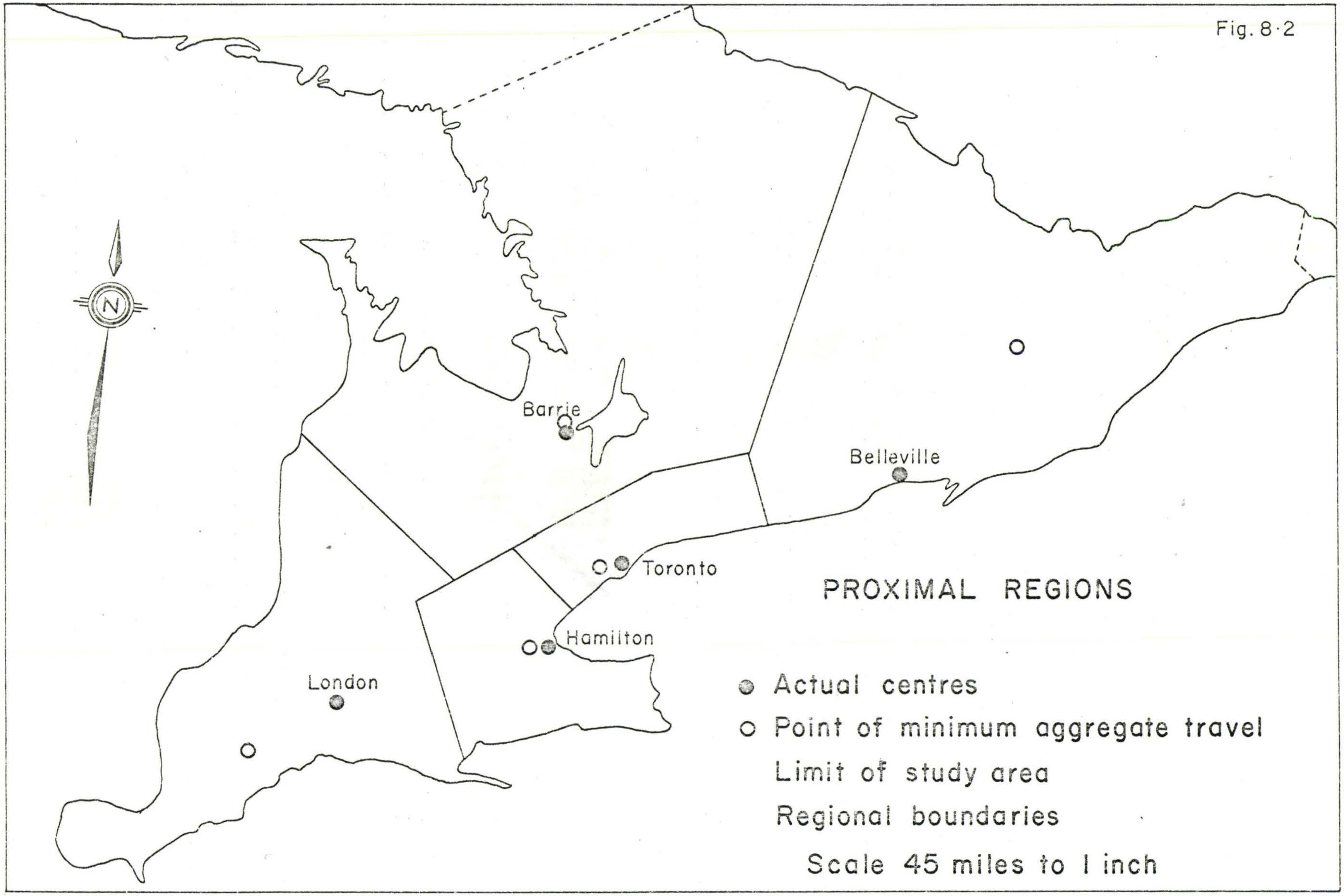


Fig. 8·2
Barrie
Belleville
Toronto
Hamilton
London
PROXIMAL REGIONS
Actual centres
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

d_{ij} = linear distance between township i and centre j.

The main criticisms of this simplistic functional relationship have been discussed in Chapter V. However, it is felt that the two parameters d_{ij} and M_i significantly relate to cost, and thus the equation was used in this form at this time.

The problem of regionalization can be expressed as one in which goods (people) are allocated from sources (townships) to destinations (administrative centres). Given that the cost of transportation is a linear function of d_{ij}, then if a set of constraints regarding the number of people to be served by each centre is known, the transportation method of linear programming can be used to examine feasible solutions. A least-cost allocation can be determined. This is the solution which minimizes the objective function, - that is the total cost of the system.

A recent study by Mills[5] and earlier studies by a group of the Yale Law School[6] considered delineation of political constituencies using linear programming. Bunge[7] and Silva[8] also draw attention to its use in regionalization. Yeates[9] has considered a similar problem, using an algorithm to allocate children to schools.

For the models presented in this chapter the Vogel Approximation Method[10] was used to provide an initial solution. Empirically, it has been found that this method approaches the optimum allocation to a greater degree than the north-west corner method, or the mutually-preferred-routes-method. Iterations to an exact optimum were by the MODI algorithm. An I.B.M. 7040 computer was used and output was presented on an incremental plotter. The procedure for solving the transportation problem is summarized in Figure 8.3.

At the outset it is recognized that for the five given centres the proximal solution will provide the overall least-cost solution; that is under the constraint equation $C_{ij} = M_i d_{ij}$.

Any imposition of constraints upon the volume of service to be handled by the centres, as represented by number of people, will increase the overall cost of the system. Under these conditions some of the population will be compelled to travel to more distant centres. This condition appears to occur in reality[11].

Following the model of proximal regions, the constraint that each centre serves an equal number of people, was introduced. The transportation problem was solved, and the least-cost regions are shown in Figure 8.4.

Next the equal population constraint was relaxed and a population demand equal to that of the current system was introduced. The table below summarises the percentage of the total population served by each centre.

CENTRE	%
Barrie	5.79
Belleville	17.91
Hamilton	19.32
London	16.28
Toronto	40.69

DATA MATRIX Fig. 8·3

Administrative centres →

Townships ↓

	1	2	3	. . . .	j	m	
1	d_{11}	d_{12}	d_{13}		d_{1j}	d_{1m}	a_1
2	d_{21}						a_2
3	d_{31}						a_3
.							
.							
i	d_{i1}				d_{ij}		a_i
.							
n	d_{n1}					d_{nm}	a_n
	b_1	b_2	b_3	. . . .	b_j	b_m	

Given that d_{ij} is the distance between the township i and the administrative centre j.

The rim requirements, a and b, indicate

i) a_1 to a_n the number of people in each township

ii) b_1 to b_n the number of people served by each centre.

The variable X_{ij} is the number of people in the i^{th} township assigned to the j^{th} centre.

The object function Φ is to minimise

$$\Phi = \sum_{i=1}^{n} \sum_{j=1}^{m} d_{ij} X_{ij}$$

<u>The following constraints must be satisfied.</u>

1. The supply of people must equal the demand for people by the administrative centres

$$\sum_{i=1}^{n} a_i = \sum_{j=1}^{m} b_j$$

2. A negative assignment is not allowed.

$$X_{ij} \geqslant 0$$

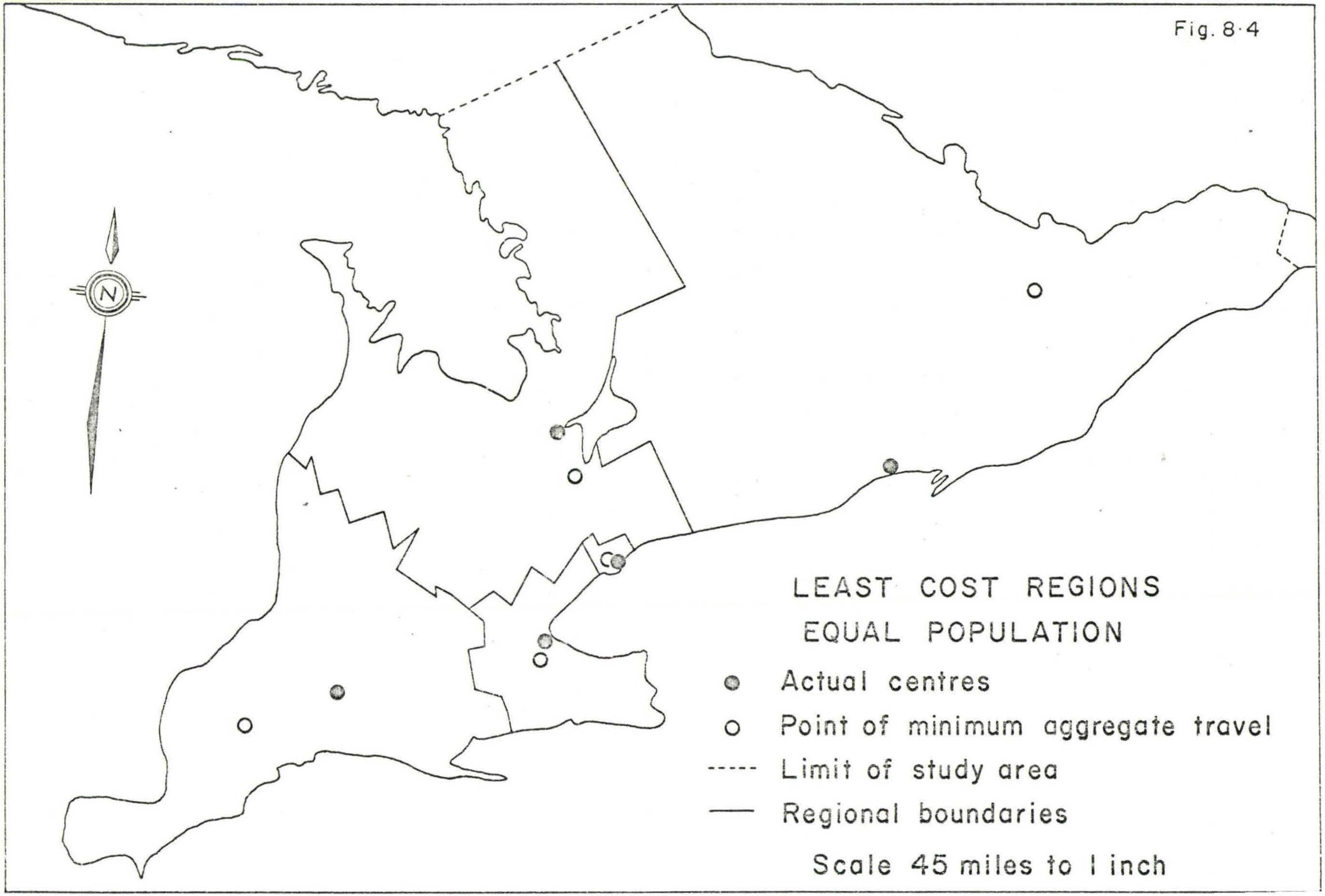


Fig. 8·4
N
LEAST COST REGIONS
EQUAL POPULATION
Actual centres
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

The transportation problem was again solved, and the least-cost regions, under the constraint of a scaled demand for population, are shown in Figure 8.5.

For each model regions were constructed around five actual administrative centres. However, within each region, a new location for an administrative centre was calculated. This is the point of minimum aggregate travel[12]. The algorithm developed by Cooper was used to locate this point[13].

On the maps presented in this chapter the points of minimum aggregate travel for each region are shown as open circles. Accordingly, Figures 8.6, 8.7 and 8.8 are the result of taking the new centres at the optimum points and modifying the boundaries by resolving the transportation problem under the constraints of a scaled population demand.

Finally, two models were produced by randomly allocating points to the five actual centres; in the first model the only constraint was that each centre should serve an equal population, and in the second model the centres had to serve the same number of people as in reality. The random models were generated by using two sets of numbers, one for the centres of the townships and one for the administrative centres. For the township centres there were P numbers. This is the sum of weights of the 504 points. For the equal-population random model the second set of numbers was calculated so that there were (P/5) number for each centre. Numbers were selected randomly from each set and this defined the allocation of people to centres. For the ranked population model the second set of numbers was calculated so that the five centres had defined percentages of the total P. The percentages are listed earlier in this

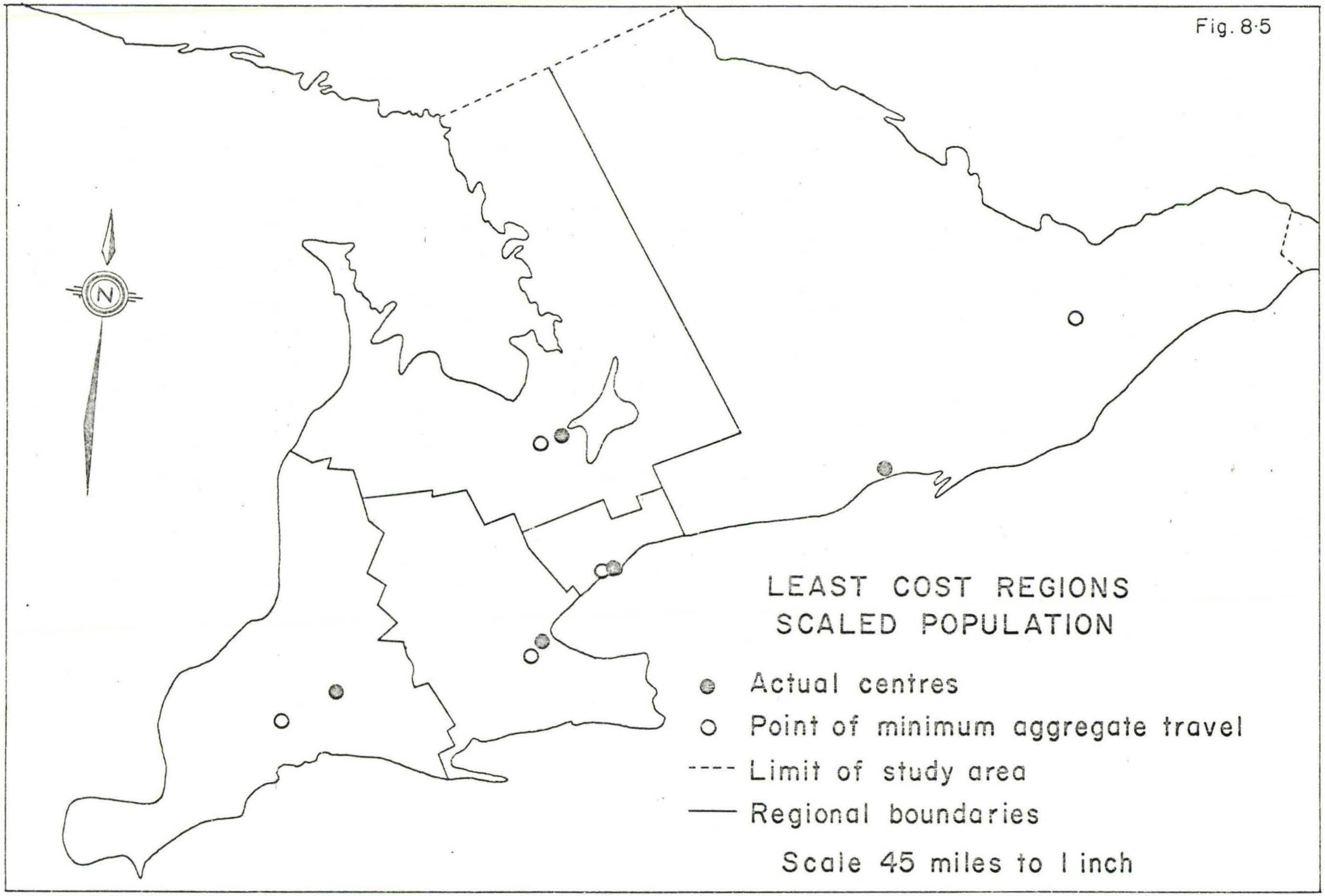


Fig. 8·5
LEAST COST REGIONS
SCALED POPULATION
Actual centres
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

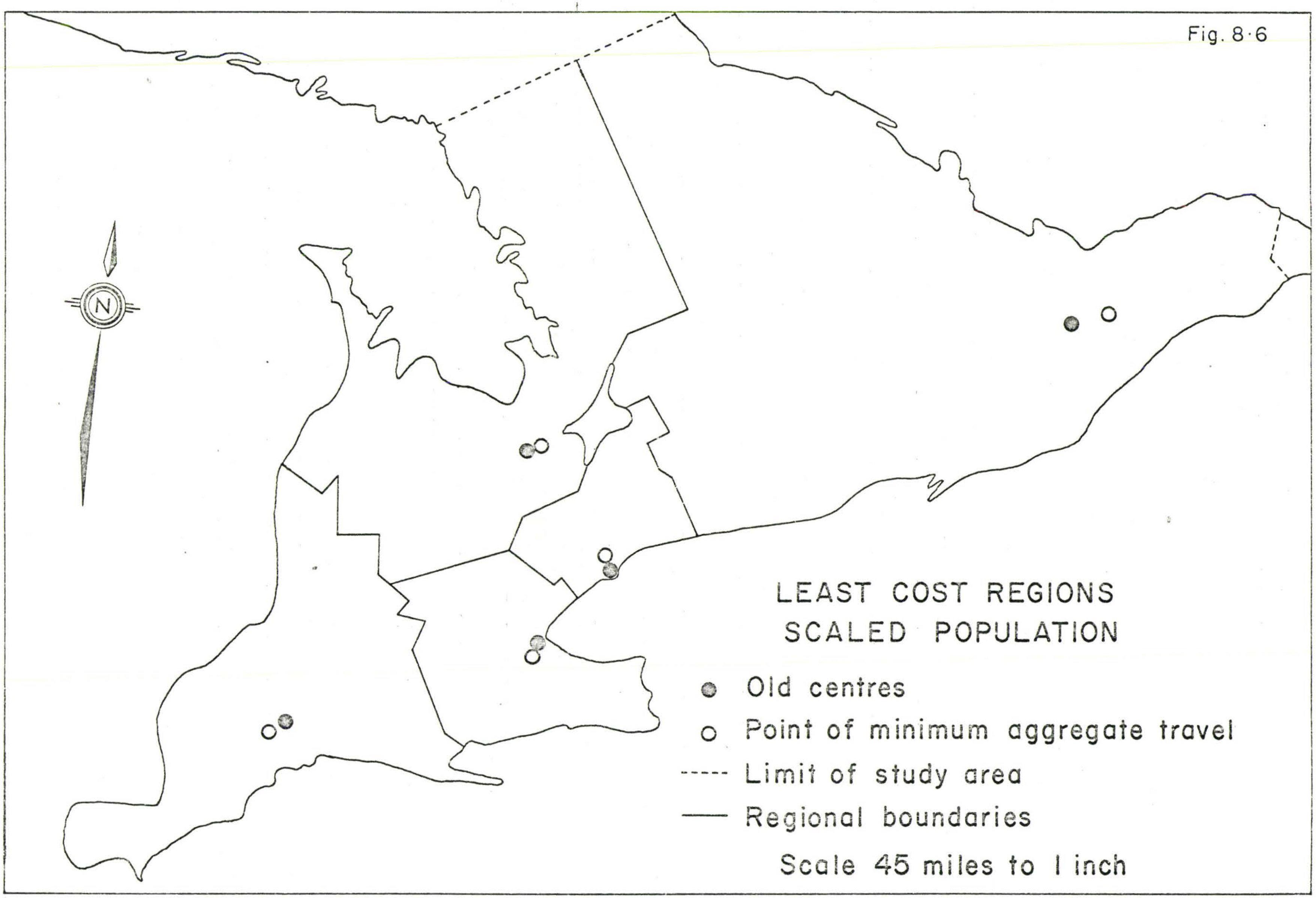


Fig. 8·6
N
LEAST COST REGIONS
SCALED POPULATION
Old centres
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

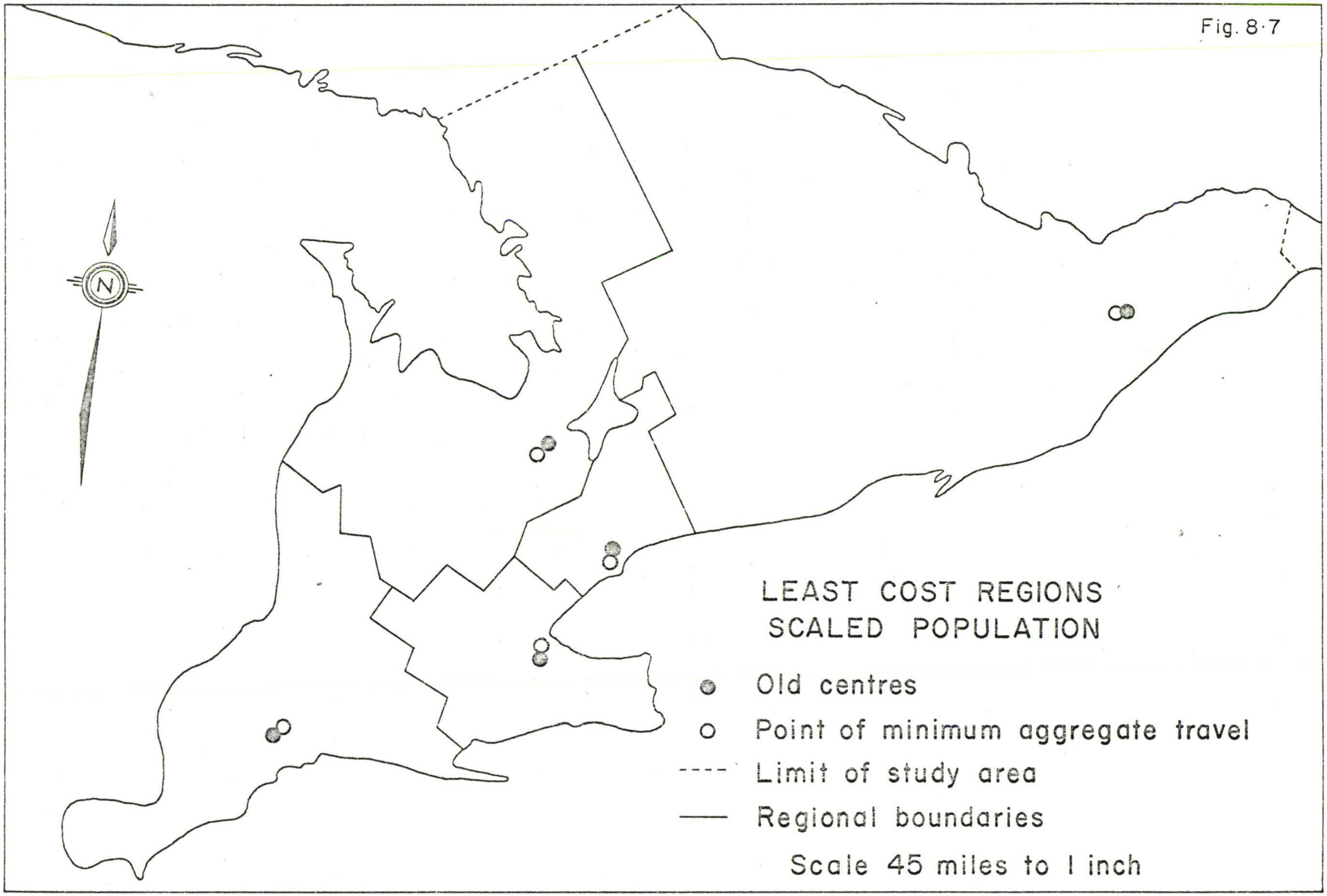


Fig. 8·7
N
LEAST COST REGIONS
SCALED POPULATION
Old centres
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch

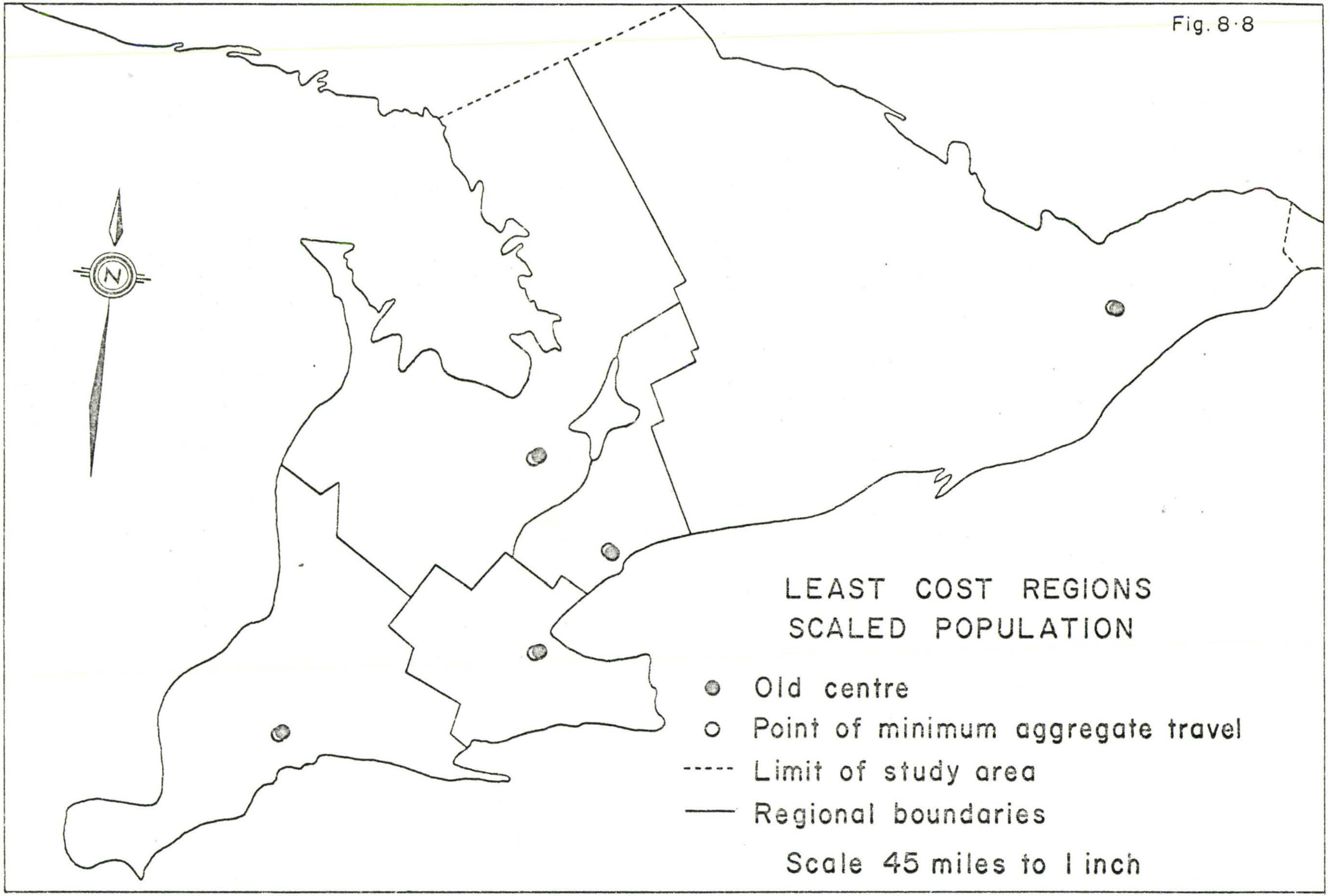


Fig. 8·8
LEAST COST REGIONS
SCALED POPULATION
Old centre
Point of minimum aggregate travel
Limit of study area
Regional boundaries
Scale 45 miles to 1 inch
N

chapter. The allocation of people to centres was defined by randomly selecting numbers from each set.

Because such allocation schemes would not necessarily produce continuous regions, maps were not prepared. However, the models were evaluated in order to allow them to be compared to those produced earlier, and the actual system. The random patterns were not constrained by any consideration of distance.

Evaluation of the Models

Four indices were used in the evaluation of the models, all based on an average over the entire population. The first index is provided by calculation of the proportion of all persons served by the nearest administrative centre. A second index, the mean distance, obtained from the average distance separating an individual and his administrative centre. Thirdly, an index of efficiency was derived for each area and its associated centre. This latter index measures the extent to which the position of the centre deviates from the defined optimum point within the area. In this work the defined optimum point is at the point of minimum aggregate travel.

The index of efficiency I_j is defined by the ratio of the first moments about the actual and the optimal locations of the centre. The fourth index is provided by calculating the number of people served by each centre.

The indices of efficiency are shown in Table I. The second and third indices are shown in Table II. Table III summarises the fourth

TABLE I

INDICES OF EFFICIENCY

CENTRE	1	2	3	4	5	6	7	8	9
Barrie	.603	.964	.651	.947	1.0	1.0	.999	.744	.703
Belleville	.663	.639	.794	.647	1.0	1.0	.999	.439	.447
Hamilton	.928	.984	.989	.989	1.0	1.0	.999	.754	.865
London	.860	.913	.984	.884	1.0	1.0	.999	.731	.805
Toronto	.853	.909	.752	.926	1.0	1.0	.999	.988	.995
Mean I_j*	.781	.876	.834	.879	1.0	1.0	.999	.727	.763
Fig. #	8.1	8.2	8.4	8.5	8.6	8.7	8.8		

1. System currently used by the Commission
2. Proximal solution
3. Least-cost solution with equal population constraints
4. Least-cost solution with scaled population constraints
5. Scaled populations: first iteration of centre locations
6. Second iteration of centre locations
7. Final iteration of centre locations
8. Random allocation of townships to centres, equal population constraints
9. Random allocation, scaled population constraints

*See Chapter V for calculation of I_j

TABLE II

MEAN DISTANCE INDEX

REGIONALIZATION SCHEMES

CENTRE	1	2	3	4	5	6	7	8	9 *
Barrie	63.7	42.0	42.2	44.4	37.4	36.7	37.1	87.9	81.9
Belleville	79.3	78.8	80.2	81.3	52.9	53.2	53.2	139.7	121.4
Hamilton	23.4	21.0	21.6	21.2	19.6	20.2	19.2	71.4	70.3
London	48.2	47.1	47.3	47.3	41.8	41.8	41.7	159.1	106.9
Toronto	48.2	8.9	3.3	10.9	10.9	10.4	11.1	41.2	75.0
Weighted Mean	49.7	32.6	38.1	33.2	26.6	26.5	26.5	98.1	88.8
% Population served by nearest centre	54.6	100.0	79.0	94.7	90.2	94.5	90.2	19.6	22.4

*See Key on Table I

TABLE III

POPULATION SERVED

	1	2	3	4	5	6	7	8	9 *
Barrie	344,433	378,663	1,110,426	345,024	346,375	338,529	344,918	1,162,815	409,601
Belleville	1,062,212	1,058,499	1,189,050	1,066,269	1,065,850	1,068,352	1,068,352	1,190,508	1,407,372
Hamilton	1,145,606	1,337,688	1,157,939	1,149,982	1,085,875	1,131,311	1,072,384	1,025,413	1,032,332
London	966,847	1,014,407	1,192,607	969,113	971,998	971,998	971,184	1,161,045	519,707
Toronto	2,421,246	2,173,779	1,131,323	2,422,472	2,492,938	2,452,846	2,506,198	1,423,255	2,594,024
Barrie	5.79	6.35	19.21	5.79	5.80	5.68	6.15	19.50	6.87
Belleville	17.88	17.75	20.57	17.91	17.87	17.92	17.92	19.96	23.60
Hamilton	19.28	22.43	20.03	19.32	18.21	18.97	17.98	17.20	17.31
London	16.29	17.01	20.61	16.27	16.30	16.30	16.29	19.47	8.72
Toronto	40.76	36.46	19.58	40.71	41.82	41.13	41.66	23.87	43.50
	Fig. 8.1	Fig. 8.2	Fig. 8.4	Fig. 8.5	Fig. 8.6	Fig. 8.7	Fig. 8.8		

*See Key on Table I

index. The index I_j is dimensionless. The distance measure is in miles, and the percentage index represents a proportion of the total population. The population served is expressed in actual figures and as a percentage.

The means were calculated in the following way. For each region the M_i's were multiplied by their respective d_{ij} and summed; i.e.

$$\sum_i M_i d_{ij} .$$

This quantity was divided by the total population of the region, that is $\sum M_i$.

The mean distance travelled by an individual for a region is represented by $\bar{d}$. Symbolically this can be expressed as

$$\bar{d} = \sum M_i d_{ij} . \quad (\sum M_i)^{-1} .$$

To calculate the overall mean for a regionalization system, referred to as the weighted mean in Table II, the following method was used.

For each region

$\bar{d} \times \sum M_i$ was calculated and summed for the five regions, yielding

$$\sum_{k=1}^{5} (\bar{d} \cdot \sum M_i)_k .$$

This quantity was divided by the total population $\sum_{k=1}^{5} M_k$, where M is the population of each area. The weighted mean can be expressed symbolically as

$$\bar{wd} = \sum_{k=1}^{5} (\bar{d} \cdot \sum M_i)_k \cdot (\sum_{k=1}^{5} M_k)^{-1}$$

This method allows the means of each of the five regions to be weighted according to the number of people in the region. Each person is equally important in the calculation of the distance to the administrative centre.

If a mean is calculated by summing the $\bar{d}$'s and dividing by five, for each regionalization scheme, a biased value results. The two sets of means are shown below in Table IV.

TABLE IV

REGIONALIZATION SCHEME	WEIGHTED MEAN	MEAN
Actual	49.7	52.5
Proximal	32.6	39.6
Equal Least Cost	38.1	38.9
Scaled Least Cost	33.2	41.0
Scaled Iteration 1	26.6	32.5
Scaled Iteration 2	26.5	32.4
Scaled Iteration 3	26.5	32.5
Equal Random	98.1	99.8
Scaled Random	88.8	91.3

The four indices are presented graphically.

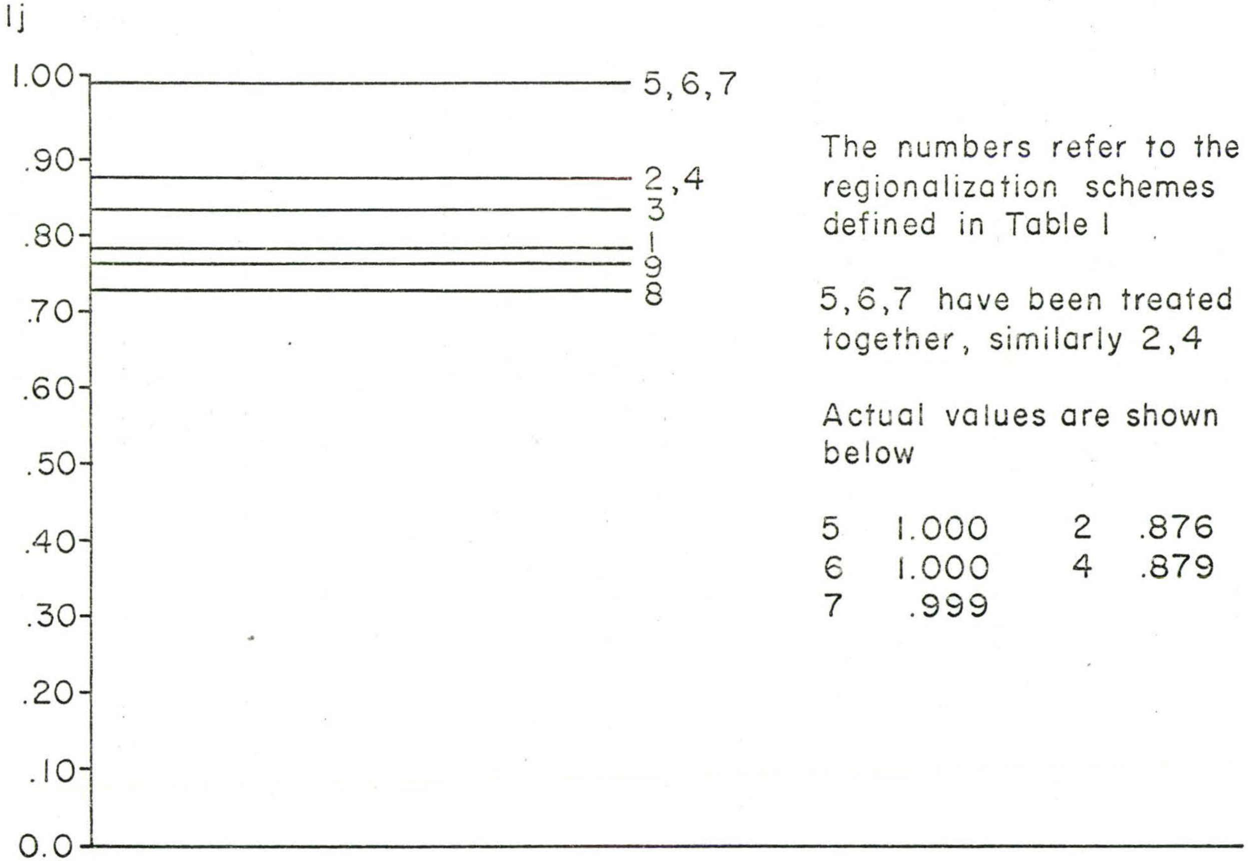
Figure 8.9 shows the mean index of efficiency for each regionalization scheme and Figure 8.10 shows the index of efficiency for six regionalization schemes for each of the five centres. The values for schemes 5, 6 and 7 have been omitted, as the values for all these schemes approach 1.0 (See Table I). The two random allocation systems have been included to show the values that would be obtained if no organizational principles are imposed upon the allocation routines. This excludes the constraints of equal population or scaled population.

The mean I_j index for the actual system suggests that the current arrangement of centres and boundaries is more efficient than that produced by a random system, but less efficient than any of the other six systems. It is acknowledged that the random system would probably not produce continuous administrative regions, yet the value for the mean I_j of the random systems only appears to be marginally lower than that for the actual systems.

The three systems produced by relocation of centres, followed by redefinition of boundaries, have mean I_j indices of 1.0[14]. The scaled population least-cost model, number 4, has a higher mean I_j than the equal population least-cost model, number 3. This suggests that a scaled division of the total population among the centres produces a spatially more efficient arrangement of centres and boundaries.

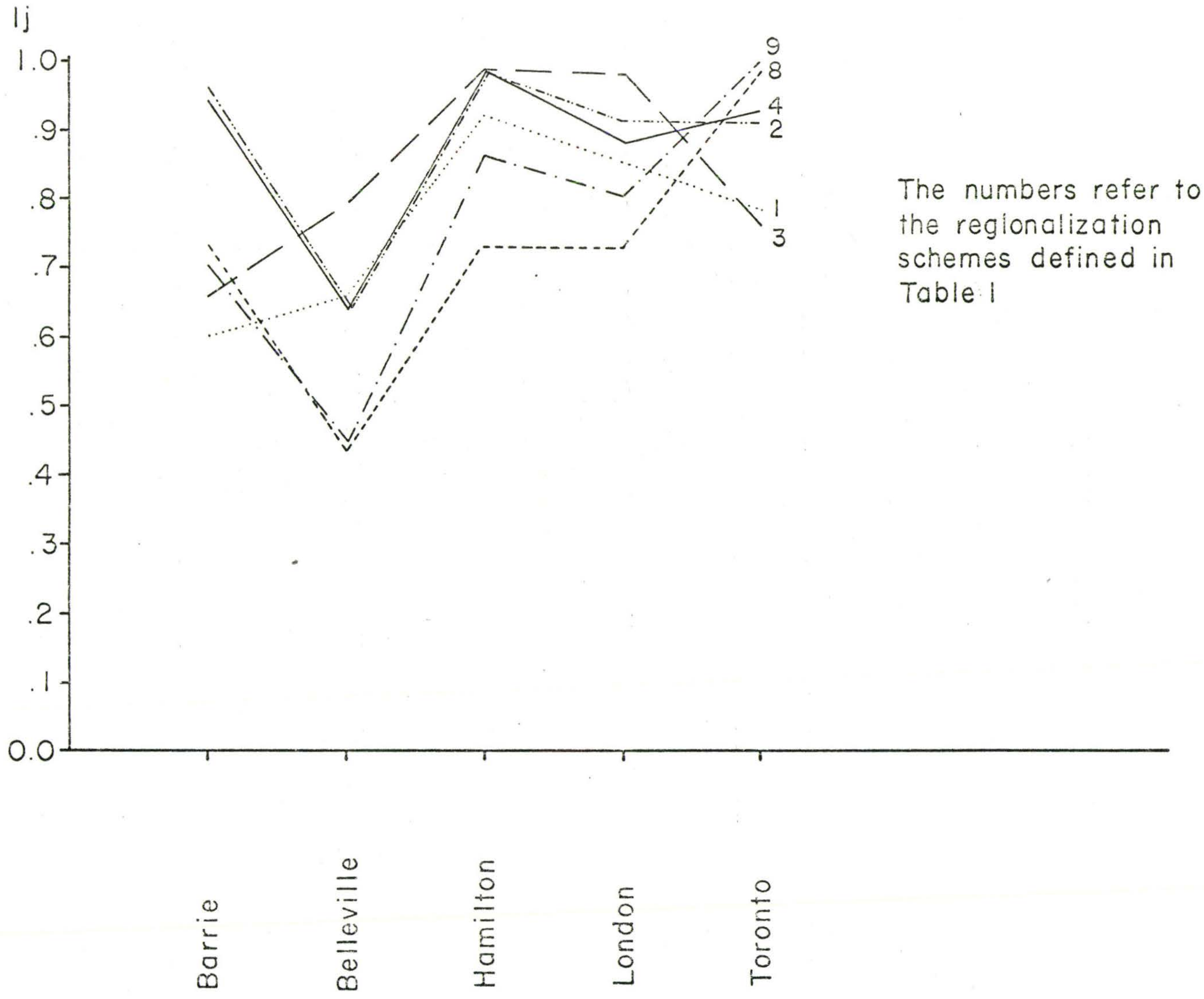
Considering Figure 8.10, it is clear that Belleville has the lowest index, and this reflects its eccentric spatial location in the eastern region. The current centre is removed from the main demand

Indicies of Efficiency — Mean Ij Fig. 8·9



Indices of Efficiency, Ij

Fig. 8·10



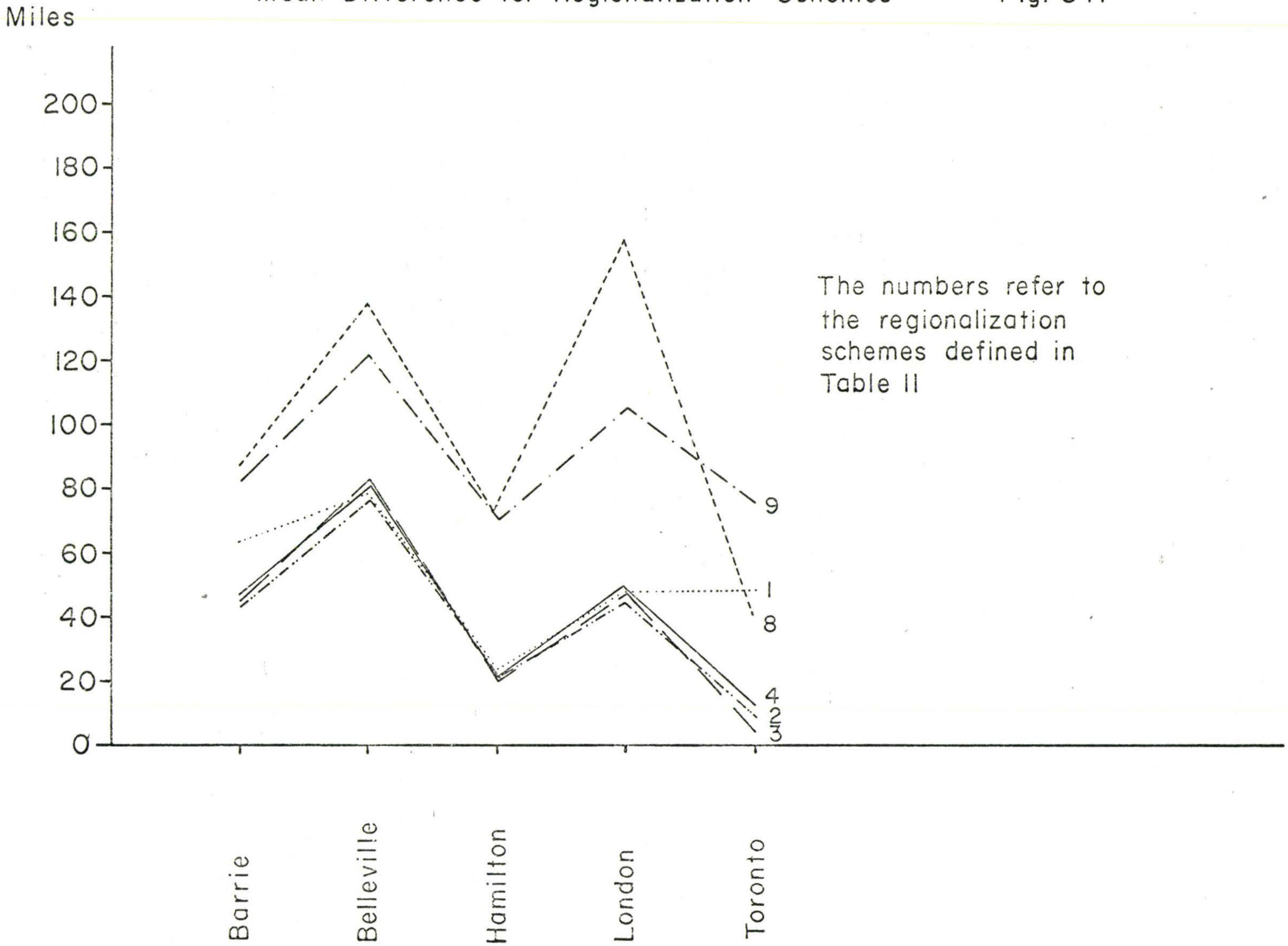
which lies towards Ottawa and the north-east of Belleville. This point is clarified by noting the position of the point of minimum aggregate travel on Figure 8.1.

Considering all the values of I_j the lowest value is provided by Belleville for the equal population random system. Apart from the consistently high values provided by systems 5, 6 and 7, the highest value is provided by Hamilton. This centre records a value of .959 for systems 3 and 4. The maps of the latter two systems, Figure 8.4 and 8.5, indicate the proximity of the point of minimum aggregate travel to Hamilton.

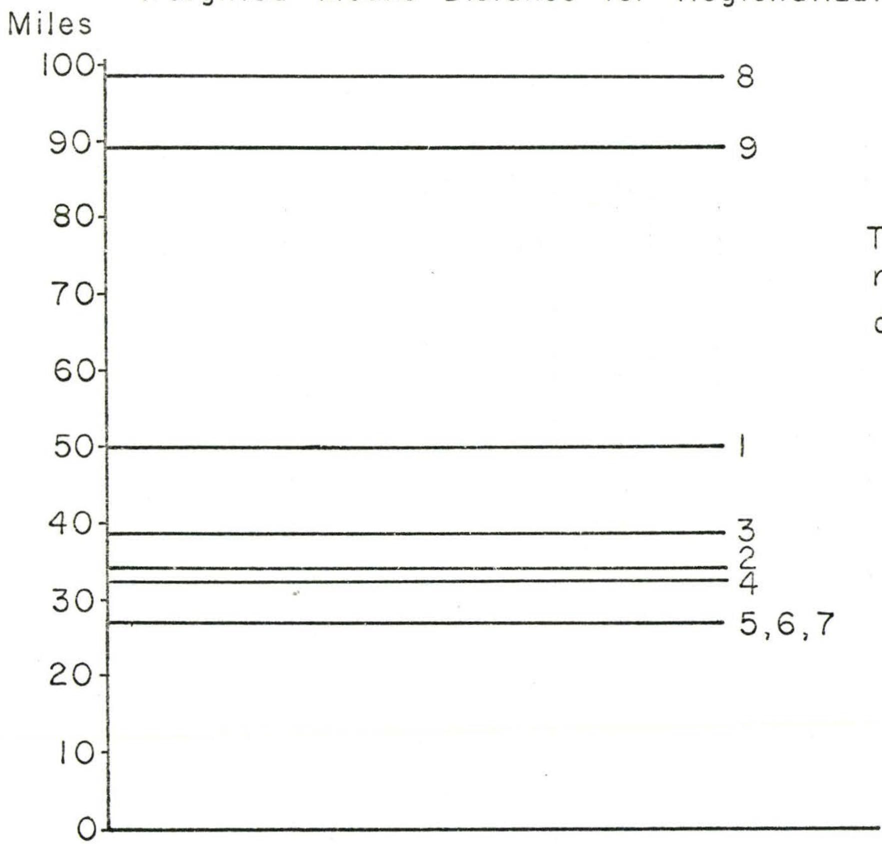
The maps of systems 5, 6 and 7, Figures 8.6 and 8.8, clearly indicate the successive moves of the point of minimum aggregate travel towards the old centres. Even if the two centres are not coincident a value of 1.0 is recorded.

Figure 8.11 illustrates the mean distance for regionalization systems 1, 2, 3, 4, 8 and 9. The last two systems, the random systems, have been included to show that the current system offers a lower value than was provided by a random generated system. Figure 8.12[15] shows this very clearly. Specifically, models 8 and 9 have values for the weighted mean of 98.1 miles and 88.8 miles successively. The value for the actual system is 49.7 miles. The hypothesis that the current regionalization system is the product of an organizational procedure with an attempt to reduce the functional costs, appears to be supported by this evidence. With respect to the actual system, the proximal system, the equal and the scaled least-cost and the two random systems the following null hypotheses were formulated.

Mean Difference for Regionalization Schemes Fig. 8·11



Weighted Means Distance for Regionalization Schemes Fig. 8·12



The numbers refer to the regionalization schemes defined in Table II

These values have been treated as a single line.

5 26.6 miles
6 26.5 miles
7 26.5 miles

1. That the mean distance for the actual system is not significantly different from the mean distance for the equal population random system.

2. That the mean distance for the actual system is not significantly different from the mean distance for the scaled population random system.

3. That the mean distance for the actual system is not significantly different from the mean distance for the proximal system.

4. That the mean distance for the actual system is not significantly different from the mean distance for the equal population least-cost system.

5. That the mean distance for the actual system is not significantly different from the mean distance for the scaled population least-cost model.

Using the weighted mean distance for the regionalization schemes shown in Table V, the following ranking of similarity between the simulated patterns and the actual pattern results (See Table VI).

TABLE V

WEIGHTED MEAN DISTANCES (Wd.)

REGIONALIZATION SCHEME	Wd. (MILES)
Actual	49.7
Equal-population least cost (EPLC)	38.1
Scaled-population least cost (SPLC)	33.2
Proximal	32.6
Equal-population random (EPR)	98.1
Scaled-population random (SPR)	88.8

TABLE VI

RANKING OF SIMILARITY

Most Similar	1	EPLC
	2	SPLC
	3	PROXIMAL
	4	SPR
Least Similar	5	EPR

It appears that the equal-population least-cost pattern is most similar to the current pattern, and that the equal-population random pattern is least similar. Using the Spearman Rank Correlation[16] an attempt was made to evaluate the ranking of the mean distances for the regionalization schemes. The results are summarized below.

	Correlation Coefficient ρ
Actual vs EPR	.34
Actual vs SPR	.75
Actual vs Proximal	.64
Actual vs EPLC	.64
Actual vs SPLC	.64

Because the sample is small and the values of ρ are relatively low, the significance levels are less than .1 and they have not been recorded.

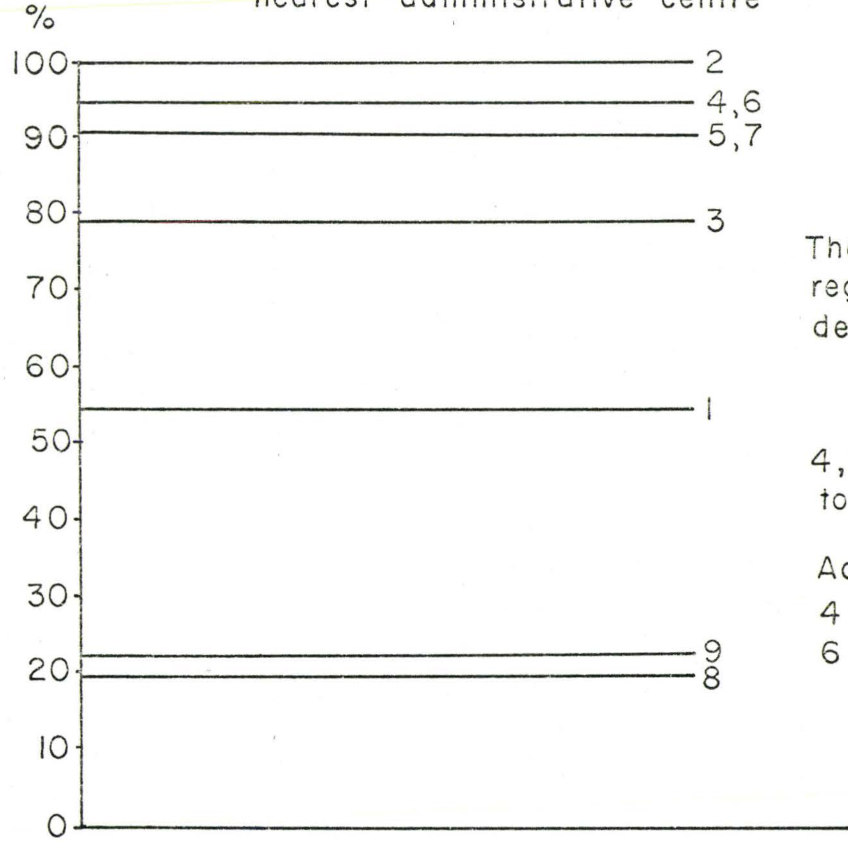
Figure 8.13 shows the percentage of the population served by the nearest administrative centre, for the nine regionalization systems. The two random-generated systems show that the probability of a person being served by his nearest centre is approximately 0.2. That is almost 20% of the total population is served by the nearest centre. This can be considered as representing one end of an organization continuum. The other end being represented by the proximal system where the probability of a person being served by his nearest centre is 1.0. The actual system falls between these extremes. This system represents some kind of equilibrium position between cost minimization on the one hand and control of the volume of service handled by a centre on the other hand. Clearly, the proximal and the random systems represent extremes in the payoff between cost and volume of service. The scaled population least-cost system is represented by a value similar to systems 5, 6 and 7 and suggests a more efficient spatial arrangement than either the actual system or the equal population least-cost system.

Figure 8.14 shows the population served by each centre for regionalization schemes 1, 2, 3, 4, 8 and 9. In all cases the 5 actual centres have been used as the administrative centres. In the schemes 5, 6 and 7, represented in Figure 8.15, the centres used have been generated. The centres are the points of minimum aggregate travel within each region.

At the outset it is recognized that the population served by the actual centres is not significantly different from that served by the same centres in the following systems; scaled population least-cost and scaled population random. Also, the three systems with generated centres, shown

Percentage of the population served by the nearest administrative centre

Fig. 8·13



The number refer to the regionalization schemes defined in Table II

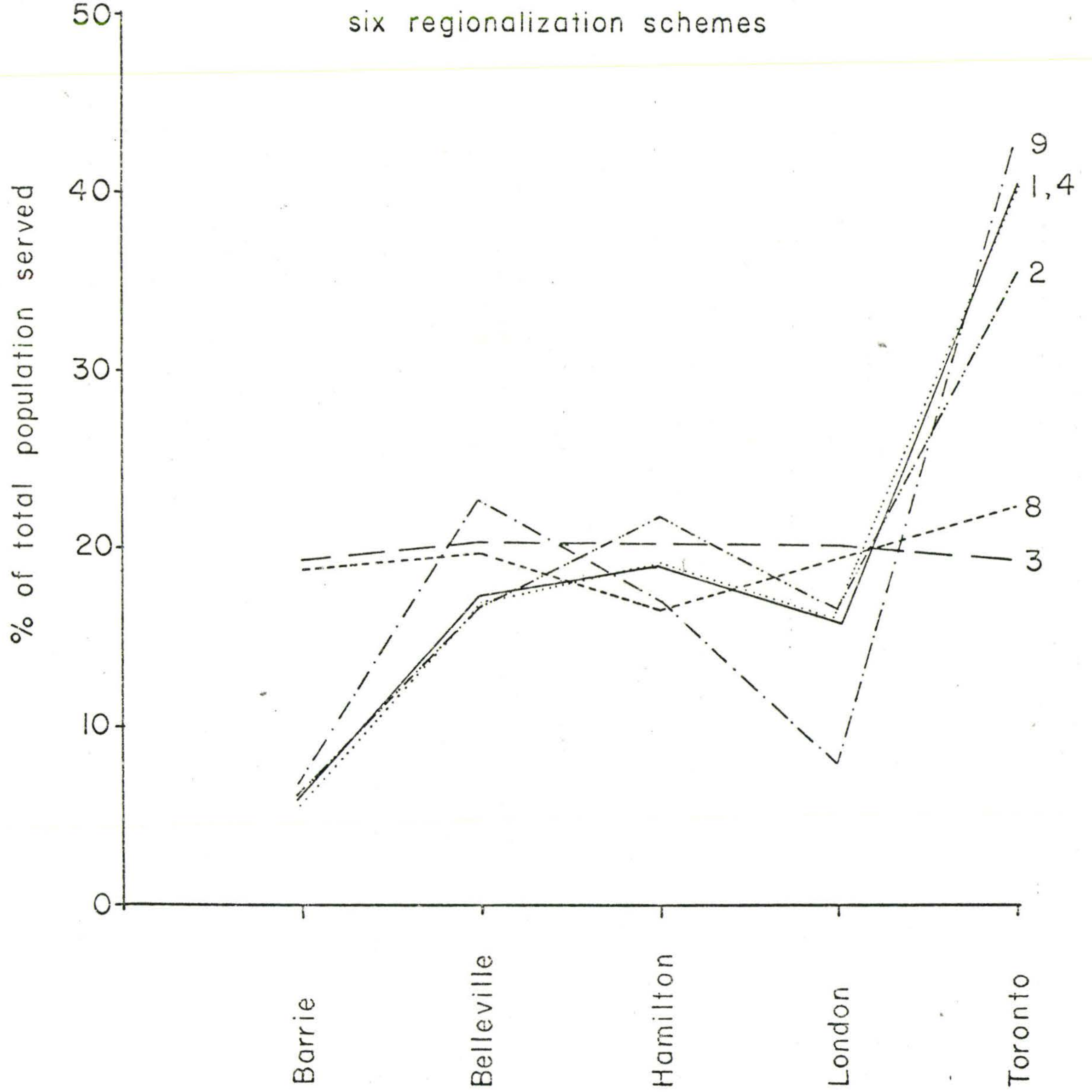
4,6 have been treated together, similarly 5,7

Actual values are shown below

4	94.7 %	5	90.2 %
6	94.5 %	7	90.2 %

Population served by each centre for six regionalization schemes

Fig. 8·14



The numbers refer to the regionalization schemes defined in Table III in Figure 8.15 have populations which are not significantly different.

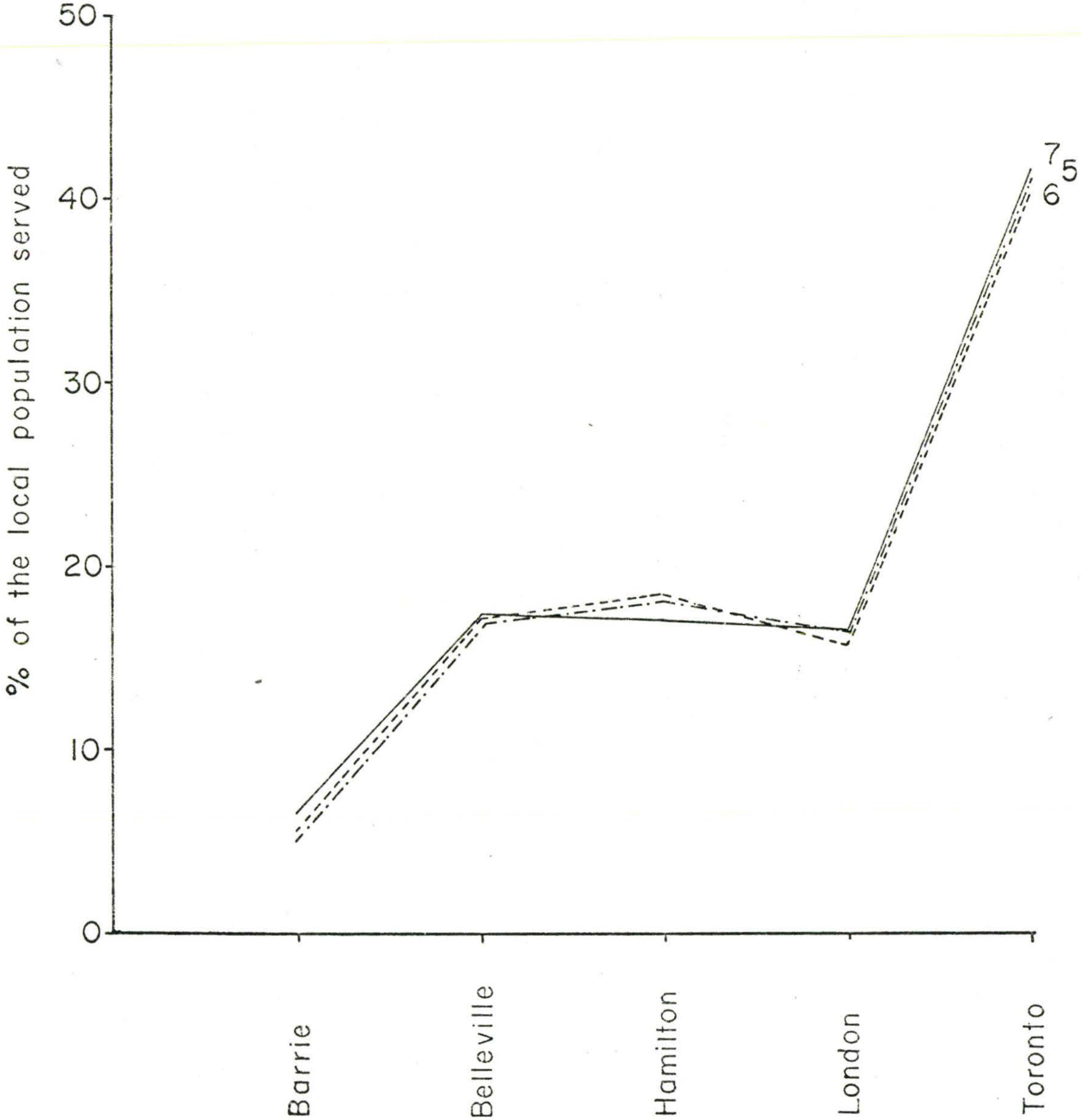
The two equal population systems, the random one and the least-cost one, are also not significantly different in terms of the population served by each centre. Clearly, all this is to be expected as the input constraints were similar in systems 1, 4, 5, 6, 7 and 9. Also they were similar for systems 3 and 8. However, in the case of the proximal model no constraint was placed on the population to be served by each centre. With respect to this system the following null hypothesis was formulated. That the population served by the five centres in the proximal system is not significantly different in ranking from the population served by the same centres in the actual system. The value of ρ was calculated to be +1.0. The hypothesis cannot be rejected. On the basis of ranked mean distance the actual and the proximal systems appear to be different, ρ is .64. The ranking coefficients do not consider the magnitude of the values, and therefore they only give a partial comparison of the regionalization systems.

On the basis of the population served the actual system is similar to the proximal system, and as such the actual system will enjoy some of the cost benefits of an arrangement whereby there is a high probability (.54) that the population will be serviced by the nearest administrative centre. This supports the hypothesis that the actual system appears to have been arranged in an attempt to minimize the functional costs[17].

The three systems with new centres (shown in Figures 8.6, 8.7 and 8.8) indicate the marginal advantages to be gained by relocation of centres and boundaries. With the notable exception of Belleville the other actual

Population served by each centre for three regionalization schemes

Fig. 8·15

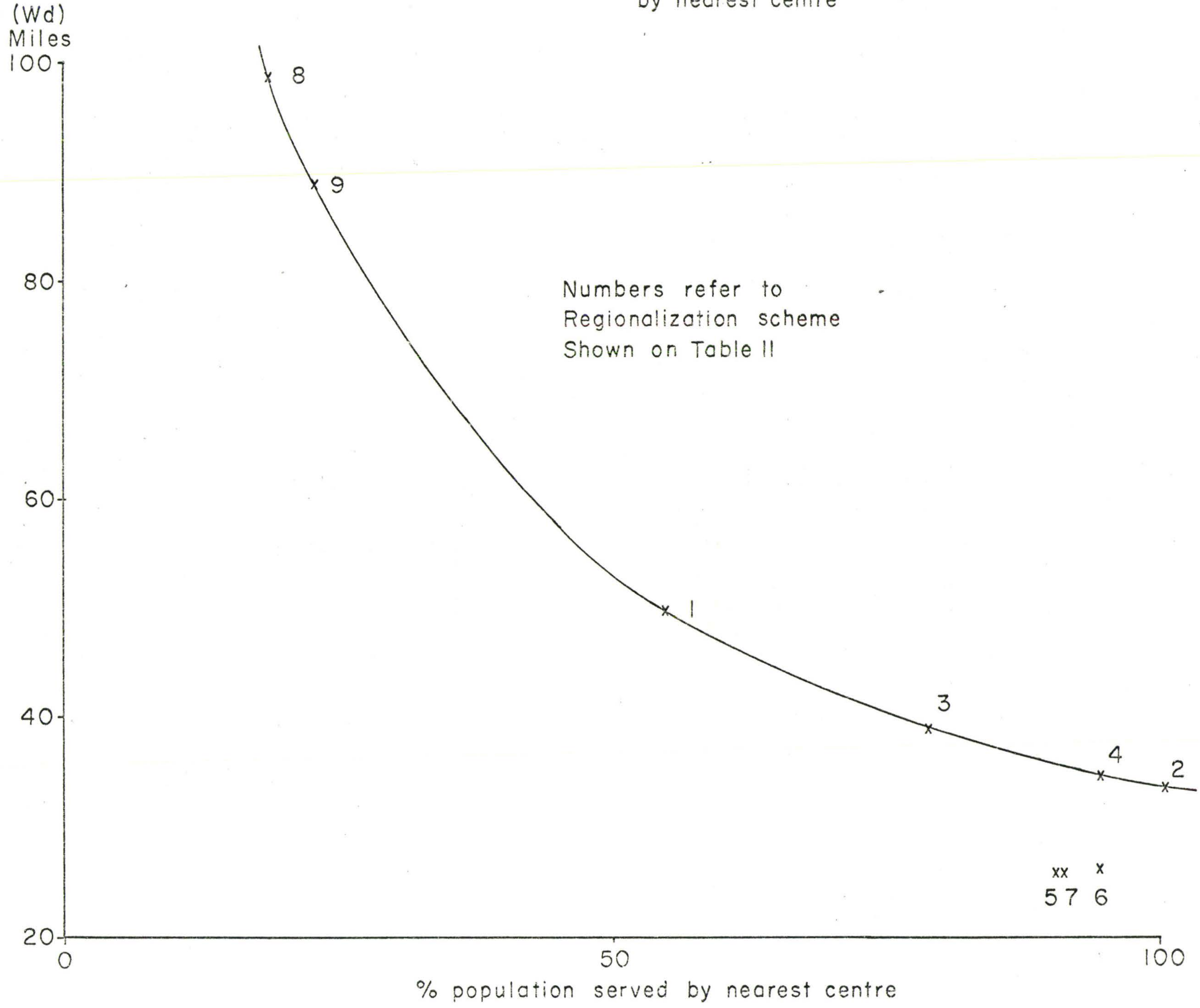


The numbers refer to the regionalization scheme defined in Table III centres are fairly close to the optimal ones as shown in Figure 8.8. Using the weighted mean distance for the actual system and the final iteration system an attempt was made to indicate possible financial advantages to be gained by relocation. The actual system has a weighted mean distance of 49.7 miles and the iteration system has a value of 26.5. For every 200 trips made between the centre and the consumer the comparative distances are approximately 9,900 miles and 4,500 miles under the present system and the new system respectively. These distances can be converted into a gasoline saving of over $100. Savings in travelling time would also serve to improve the efficiency of the organization.

By relating the two indices which appear to influence the administrative costs of a region it can be shown that as the weighted mean distance of the system decreased the percentage of the population served by the nearest centre increases. Figure 8.16 illustrates this. Clearly, the random systems are the most expensive to administer and under the constraint of using the five actual centres, the proximal system represents the cheapest system. On the graph the actual system appears to be more expensive to administer than either the equal or scaled population least-cost systems. Further, the advantages to be gained by relocating the centres is shown diagrammatically. Any cost savings in this direction will be gained because the weighted mean distance of the systems decreased by about ten miles. The percentage of the population served by the nearest centre, for these systems, is less than one hundred. Throughout this study the functional cost of a Region has been expressed in terms of population and distance. Clearly, for a more complete analysis of

Fig. 8·16

Weighted Mean Distance (Wd) v Percentage total population served by nearest centre



functional costs consideration of labour charges, capital expenditure and depreciation should be included.

In an attempt to compare the regionalization schemes discussed above Pred's conceptual Behavioural Matrix will be made operational. Further, an evaluation of this conceptual matrix, as a method for organizing data and making meaningful statements about spatial organization, will be offered.

Pred's Behavioural Matrix

Pred[18] suggests that spatial behaviour or spatial organization is functionally related to the amount of information and the ability to use this information that is possessed by decision-making units. Specifically, he formalises this notion into the conceptual matrix shown in Figure 8.17[19].

He claims that:

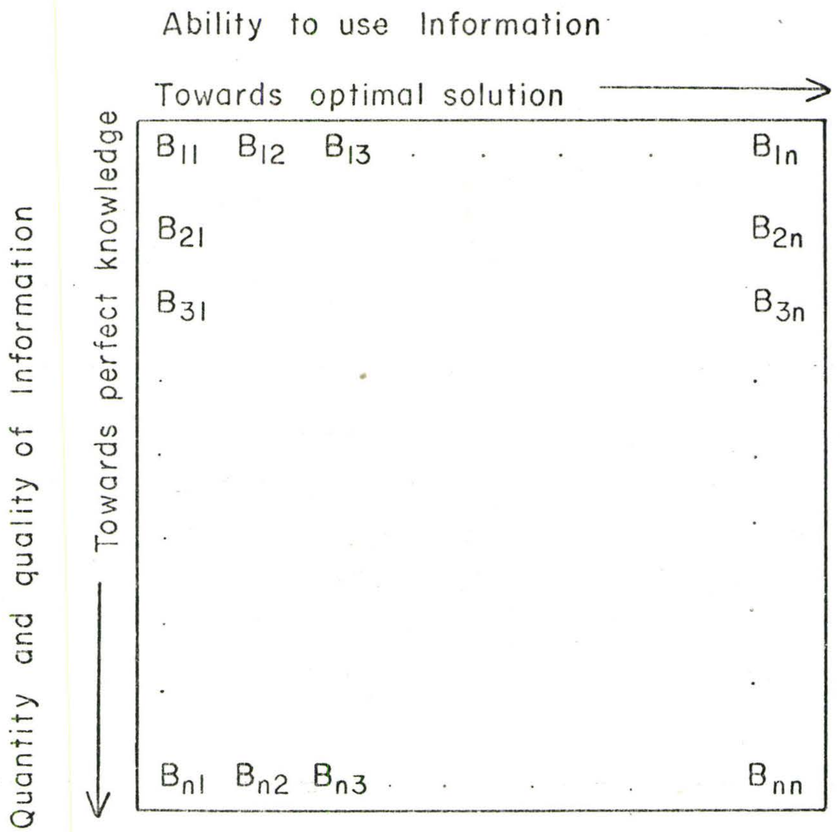
> "... any economic-geographic distribution, any array of spatial interaction, is an aggregate manifestation of individual decisional acts made at the personal, group and/or firm level".

and further that:

> "... the gulf between observable economic-geographic phenomena and the neat optimal solutions of economic location theory is the product of imperfect knowledge and non-optimizing behavior on the part of the decision-making units, the problem becomes one of systemmatizing its contents for analytical purposes."[20]

All alternative types of behaviour or spatial organization, within a particular class, can be assigned specific locations within the matrix. Deviations from theoretical norms are explained in terms of the two variables along the two axes. Clearly, this assumption is simplistic. For

The Behavioural Matrix (after Pred) Fig. 8·17



Source: Pred, A., op. cit. p. 25

example, no mention is made of goal definition or value systems.

Pred does not show clearly how to determine which of the variables influence non-optimum patterns of behaviour or organization. Yet he attempts to explain these patterns by locating them in a particular quadrat of the matrix, thus implying either a lack of information or an inability to use the information to its best advantage.

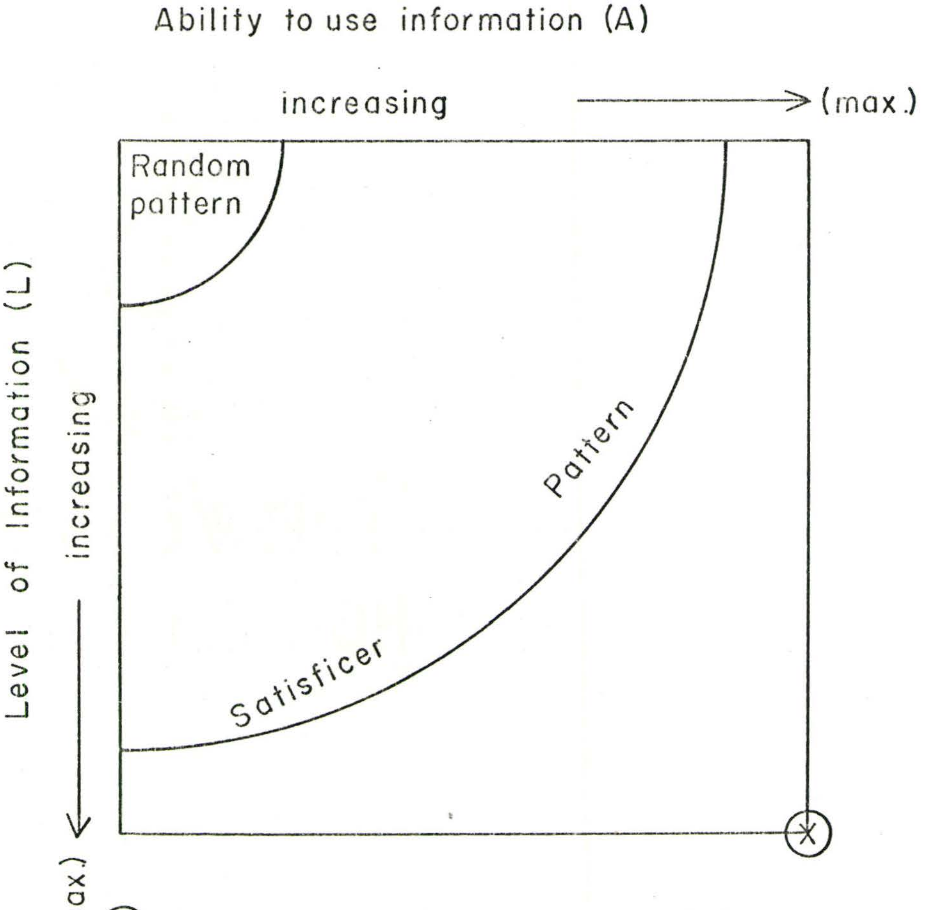
His discussion on the "randomness of spatial distributions"[21] is followed by the suggestion that random patterns should be located in the top left quadrat of the matrix. With respect to the rest of the matrix,[22] if it cannot be determined which of the two variables causes a spatial pattern to deviate from an optimum pattern, then the following conceptual diagram is suggested in Figure 8.18.

By using this type of conceptual diagram it is argued that a particular pattern can be caused by a continuous substitution function between A and L. The rationale for suggesting that A and L are related is dependent upon the assumption that actual patterns of spatial behaviour or spatial organization are satisficer solutions[23]. If satisficer patterns obtain in reality then intuitively it is felt that either of the two variables or one of many combinations of the, would produce such a solution. The optimal solution appears to demand total information and the highest level of usage.

With respect to the pattern of regions in the study area and using the weighted mean distance as a descriptive index of each regionalization pattern, an attempt has been made to graduate the conceptual diagram presented above. The reciprocal of the weighted mean distance was used to

Modified Behavioural Matrix (Conceptual)

Fig. 8·18



(X) Theoretical optimum pattern defined by max. L and max. A produce data that were consistent with the conceptual matrix. The data are shown in Table VII.

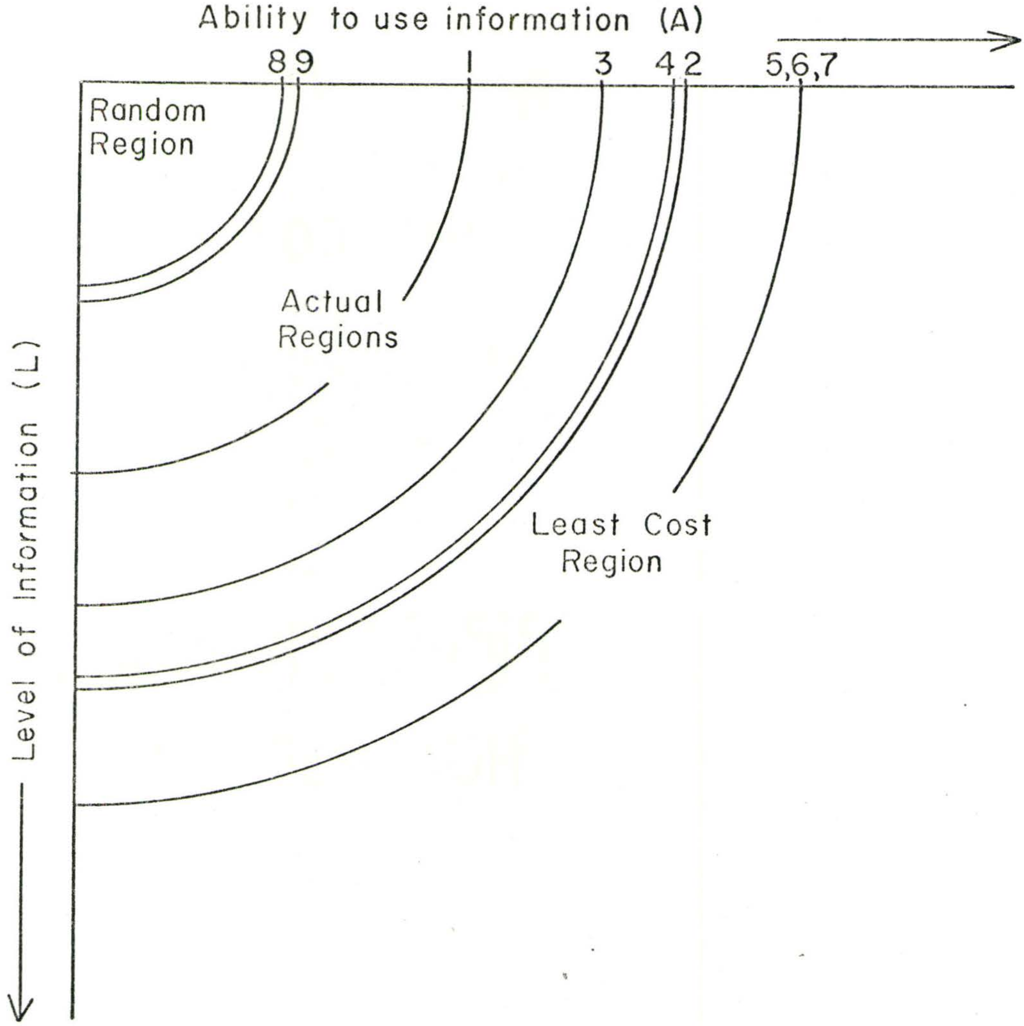
TABLE VII

REGIONALIZATION SCHEME	WEIGHTED MEAN MILES (Wd.)	$10^2 \cdot (\text{Wd.})^{-1}$
System currently used by the Commission	49.7	2.01
Proximal solution	32.6	3.07
Least-cost solution with equal population constraints	38.1	2.62
Least-cost solution with scaled population constraints	33.2	3.01
Scaled populations: first iteration of centre locations	26.6	3.76
Second iteration of centre locations	26.5	3.77
Final iteration of centre locations	26.5	3.77
Random allocation of townships to centres, equal population constraints	98.1	1.02
Random allocation, scaled population constraints	88.8	1.13

Figure 8.19 shows the graduated modified behavioural matrix. The randomly generated patterns suggest either low level of information and/or low ability to use information, whereas the least-cost optimal patterns suggest high level of information and ability to use same. The actual pattern of regions is located between these two extremes.

Modified Behavioural Matrix (Applied)

Fig. 8·19



The reciprocals of the weighted means were multiplied by 10^2 to provide a linear scale for this diagram, see Table VII.

It is suggested that this graduated diagram supports the arguement that the actual patterns of regions appears to be a satisficer solution.

At this time data are not available to attempt an empirical substitution between variables A and L for various spatial patterns of organization. This could form the basis for future research.

It is hoped that the research presented here has pointed a way in which Pred's matrix may be used as the basis for objective comparative studies of spatial regionalization systems. For only when consistent methods for operationalizing the matrix are available will it be possible to make full use of the concepts he presents.

In summary, the analysis reported in this chapter suggests that the current pattern of regional boundaries and centres that are used by the Ontario Hydro-Electric Power Commission, has been arranged in an attempt to minimize the linear distance between the centres and the population. In general terms it is suggested that the notion of least-cost influences the pattern of administrative units. Four indices were used to describe the actual pattern of regions and the eight simulated patterns. The simulated patterns and the actual pattern were compared. The marginal utility to be gained by relocating the administrative centres and boundaries was shown diagrammatically. Finally, an attempt was made to modify Pred's behavioural matrix, in order to incorporate the notions of satisficer patterns of spatial organization and substition between the two variables "ability to use information" and "level of information". The nine regionalization schemes were located in the matrix using the weighted mean distance index.

FOOTNOTES - CHAPTER VIII

1. This process was described using set-theory in Chapter I.

2. For a recent review see: LANKFORD, P.M., "Regionalization: Theory and Alternative Algorithms", <u>Geographical Analysis</u>, Vol. 1, No. 2, April, 1969, pp. 196-212.

3. HAGGETT, P., <u>op. cit.</u>, p. 40.

4. The point of minimum aggregate travel marked by an open circle will be discussed later in this chapter.

5. MILLS, G., "The Determination of Local Government Electoral Boundaries", <u>Operational Research Quarterly</u>, Vol. 18, No. 3, 1967, pp. 243-55.

6. WEAVER, J.B. & HESS, S.W., "A Procedure for Non-Partisan Districting: Development of Computer Techniques", <u>The Yale Law Journal</u>, Vol. 73, Dec. 1963, pp. 288-303.

7. BUNGE, W., "Gerrymandering, Geography & Grouping", <u>Geog. Review</u>, Vol. 56, No. 2, 1966, pp. 256-63.

8. SILVA, R., "Reapportionment and Redistricting", <u>Scientific American</u>, Vol. 213, No. 5, Nov. 1965, pp. 20-27.

9. YEATES, M., "Hinterland Delimitation - A Distance Minimizing Approach", <u>The Professional Geographer</u>, Vol. XV, No. 6, 1963, pp. 7-10. See also: KOENIGSBERG, E., "Mathematical Analysis Applied to School Attendance Areas", <u>Socio-Economic Planning Sciences</u>, Vol. 1, No. 4, Aug. 1968, pp. 465-475.

10. For a discussion of the Vogel Approximation Method, and the MODI method see: REINFELD, N.V., & VOGEL, W.R., <u>Mathematical Programming</u>, (New Jersey: Prentice-Hall, 1958) Chapter IV.

11. See for example; GOLLEDGE, R.G. <u>et. al.</u>, "Some Spatial Characteristics of Iowa's Dispersed Farm Population and their Implications for the Grouping of Central Place Functions", <u>Economic Geography</u>, Vol. 47, No. 3, July, 1966, pp. 261-272.

    The paper discusses the movement of consumers to retail outlets.

12. The rationale for using this point was discussed in Chapter V.

13. Cooper, L., <u>op. cit.</u>

14. This index was calculated to one decimal place.

15. For the regionalization scheme that is used by the Ontario Hospital Services Commission (O.H.S.C.) souther Ontario is divided into five regions. The weighted mean distance is 35.35 miles. This compares with a value of 49.70 for the O.H.E.P.C. The O.H.S.C. regions were delimited more recently than those of the O.H.E.P.C.

16. For a discussion on this see; COLE, J.P. & KING, C.A.N., op. cit., pp. 136-138.

17. Given that the functional costs are directly related to M_i and d_{ij}.

18. PRED, A., op. cit., pp. 21-64.

19. PRED, A., ibid., p. 25.

20. PRED, A., ibid., p. 21.

21. PRED, A., ibid., pp. 30-32.

22. Excluding the bottom right of the matrix, B_{nn} in Figure 8.17, which is reserved for the optimal pattern.

23. The concept of the satisficer model of human behaviour has been discussed by Simon. See SIMON, H., op. cit., p. 198, for his comments on bounded rationality.

CHAPTER IX

SUMMARY AND CONCLUSIONS

The aim of this study has been to examine relationships between selected economic, political and historical factors and patterns of administrative areas. The relationships were formulated into hypotheses and they were tested using data from the Ontario Hydro-Electric Power Commission. Both qualitative and quantitative data were used.

Following an introductory chapter, which included a definition of the problem and a review of the literature, the second chapter offered an overview of the growth of the O.H.E.P.C. In the third chapter the hypothetical relationships were quantitative descriptions of the current arrangement of administrative areas that are used by the O.H.E.P.C.

The principal conclusions of the analyses have already been set out at various stages in the study, particularly in Chapters VI, VII and VIII where the results of the tests of the hypotheses were presented. This chapter serves to provide an overview of these conclusions, and it will also indicate future lines of research that might prove profitable.

Throughout the study an attempt has been made to use explicit objective tests to support or refute the hypotheses. It is argued that this strategy will allow comparative studies to be undertaken; and that in the long-run the ability to explain spatial administrative systems using general statements should improve. The data used to test the economic relationships were readily available in ratio form. Data for the political and historical variables were less easy to quantify, and some of them especially those associated with the "political climate" and "value systems", tend to be highly subjective.

The principal philosophy underlying this study is that spatial administrative areas can be examined in a systemmatic, objective way, and that the explanation of the patterns of the areas can provide a fruitful field of research for geographers. Such research can make use of some of the contemporary techniques for pattern description. This approach is suggested as a long-run strategy for the construction of predictive models of spatial administrative systems. The earlier approaches in geography, and especially in political geography, relied heavily on using qualitative data to examine unique areal administrative systems. Contemporary research is searching for generality.

The specific conclusions resulting from the testing of the hypotheses will be discussed next. The precise details of the conclusions are available in the body of the text; they will not be repeated here.

For the eighty M.E.U.'s examined it was found that there is a direct relationship between the total cost per consumer and the number of customers, the spatial size of the M.E.U.'s and the miles of wire in the M.E.U.'s. Similarly there is a direct relationship between the administrative costs per customer and the three variables mentioned above. Variation in total cost per customer and administrative costs per customer are not completely explained by these variables and economies of scale with respect to these spatial variables do not appear to play a major role in describing the variation in costs. Only in the case of miles of road in the M.E.U.'s did economies of scale have some explanatory value.

Data for a wide range of sizes of operations were not completely available. Most of the M.E.U.'s are in fact in the lower range of values for all the spatial variables. This results in positively skewed distributions. The regression coefficients yielded by the quadratic models of the M.E.U.'s were not significantly higher than those of the linear models. This suggests that consideration of a U-shaped long-run average cost curve does not help to describe the relationship between the cost per unit output variable and the three surrogate variables for the size of the workload. The M.E.U.'s are the longest established administrative units of the O.H.E.P.C. It is suggested that inertia has prevented them from expanding their workloads to gain any advantages through scale. The Commissioners still wish to operate each M.E.U. as an independent unit and perpetuate historical ties to local municipalities. The administrator of the O.H.E.P.C. in Toronto suggests that the M.E.U.'s with less than 1000 customers are the least efficient, yet because of the political values operating in the organization it is not possible for the central body to force amalgamation or expansion onto the M.E.U.'s. The political values relate to both local personalities and to the general political ethos in Ontario. At the current time local ties and grass-roots politics appear to be declining, but the M.E.U.'s persist for the most part, in their original form. They are confined by municipal boundaries. Future research could attempt to explain why the variation in efficiency among the M.E.U.'s is not completely described by the variables used in this study.

With respect to the R.O.A.'s in southern Ontario the analysis suggests that there is an inverse relationship between the number of customers and the miles of wire. These findings support the hypotheses that economies of scale manifest themselves on the organization of the R.O.A.'s. However, in the second part of the analysis, using quadratic models to describe the relationship between the number of employees and the three size of operation variables, it was found that these models do not significantly improve the level of explanation over the linear models.

A measure of the spatial compactness of each R.O.A. was theoretically related to a measure of economic efficiency. The former measure is the shape index, and the latter measure is the number of employees per customer. The data suggest a significant direct relationship. This is contrary to the theory. It is argued that the assumptions on which the compactness index is based are too limited, and therefore to test the theoretical relationship more rigorously the index needs to be modified.

Another measure of shape, the contact index, suggests that the R.O.A.'s approximate hexagons. Though this supports the findings of other researchers who have attempted to find a territorial regularity among spatial administrative units, the author suggests that the index should be related to the function of the areal unit in an attempt to move beyond simplistic isolated geometric measures of shape, and to understand the processes which generate the particular shape.

The number of R.O.A.'s has declined steadily over the last twenty years, and it appears that they have been amalgamated to enjoy some of the economic advantages of scale. When the R.O.A.'s were initially established the administrative boundaries of the townships and the counties were not used to delimit the areas. Consequently, it is argued that local political ties and tradition have not hindered amalgamation and expansion.

For the five Regions in southern Ontario it was suggested that the cost of administration of each Region was directly related to the distance between the population and the Regional centre, and the number of people in the Region.

The analysis suggests that the current pattern of Regional boundaries and centres has been arranged in an attempt to minimize the defined cost function. Six simulation models of regions were constructed under defined cost constraints. Two randomly generated spatial administrative systems were produced for comparative purposes. Four indices were developed for describing each model and for comparing the models with the actual pattern of regions. Using the mean distance index the actual pattern appears to be most similar to the equal population least-cost simulation model. On the basis of the population served the actual system of regions is similar to the proximal simulated system of regions. The probability that the population will be serviced by the nearest centre is .54 for the actual system. This is a considerable improvement over the two randomly-generated systems where the probability is only .2. This supports the hypothesis that the current set of Regions approaches a level of spatial efficiency which demands some organizational principles.

Three models were produced by relocating the Regional centres. With the notable exception of Belleville, the four other actual centres are physically close to the defined optimal locations. For the Western Region the optimum centre is about thirty miles from the actual centre. The other centres, Hamilton, Barrie and Toronto are about ten miles from the optimum location for the administrative centres. Belleville is over sixty miles from the optimum location for the administrative centre for the Eastern Region.

The marginal utility to be gained by relocating the Regional boundaries and centres is shown diagrammatically. An attempt was made, using the weighted mean of the nine regionalization schemes, to classify the models within a modified behavioural matrix that was originally designed by Pred. The notion of a satisficer level of spatial organization was also included. Minimization of distance between centres and consumers of administrative services appears to be an important element in the determination of actual centres and boundaries. The notion of minimum-effort seems to influence spatial administrative organization. Future work could examine other measures of distance, such as time and cost. Also, attempts could be made to improve the cost definition of effort that was used in this study.

The Regional boundaries follow the township boundaries. Because the Regions are so large in comparison to the townships it is argued that the populations of townships do not feel any attachment to particular Regions. It follows that adjustments to the pattern of Regions have not been restricted by local political values; rather the Regions have been arranged in order to satisfy economic goals. Further, the Regions have only existed for twenty years and tradition or historical inertia have not hindered the amalgamations.

The research was not able to provide data concerning the influence of individuals in the decision-making process on regionalization. The interviewees suggested that this factor should be considered. Clearly, this relationship and one between political values and regionalization schemes needs to be examined more intensively before specific hypothesis can be tested.

At this time the three administrative systems appear to operate independently. The M.E.U.'s and the R.O.A.'s offer similar services to the public, but the former are organized as autonomous units whereas the latter form part of an integrated system. The M.E.U.'s, unlike the R.O.A.'s, do not appear to enjoy advantages through economies of scale. It is suggested that future research could examine the feasibility of a single regionalization scheme to service all consumers in both municipalities and rural areas. Perhaps the largest single barrier to this idea would be the local political values and historical inertia which is currently attached to the M.E.U.'s. Before recommendations on the least-cost size of workload and the optimum size of administrative areas could be made, more empirical data on the cost of administration in relation to the scale of the operation and the spatial aspects of the workload are required.

The Regions are currently the largest of the administrative units. An hierarchy of spatial administrative systems operates for the O.H.E.P.C.

with respect to the R.O.A.'s and the Regions. The fifty-four R.O.A.'s in southern Ontario are divided among the five Regions. The functions of the two systems are separate. If the R.O.A.'s and the M.E.U.'s were reorganized into a new spatial administrative system, an attempt could be made to fit this into the pattern of Regions in order for both the spatial patterns to use some common boundaries. This may help in data collection, and economic forecasting and planning.

Finally, it appears to the author, that one of the main problems which needs to be solved with respect to the influence of economic, political and historical factors on the pattern of administrative areas, is to find a way of integrating the various factors, and weighting them against each other. Multivariate models thus far developed in geography are largely of the linear type; deterministic and dependent upon ratio data. Probabilistic non-linear models which allow ordinal data to be used will possibly offer much for the future researcher who is attempting to construct powerful predictive models of spatial administrative systems.

This study has attempted to analyse some of the variables which explain the pattern of administrative areas. In isolation the variables which describe the spatial size, the economic efficiency, the value system, or the level of organization only partially describe the actual patterns of administrative areas. And though it is suggested that more systemmatic, objective analytical studies be undertaken, it should be noted that a synthesis stage is also necessary in the long-run research strategy.

To provide such a framework it might prove useful to focus on the decision-making process of the administrators; the type and level of information they receive, their learning patterns and their definitions of goals and incentives.

Clearly, much inter-disciplinary research is necessary before powerful descriptive models of spatial administrative systems can be built. It is hoped that the research reported here is a step in this direction.

APPENDIX 1

This contains a list of the eighty Municipal Electrical Utilities that were used in the analysis. The list is taken from the Annual Report, O.H.E.P.C., Toronto, 1967.

Acton	Alexandria	Almonte
Amherstburg	Apple Hill	Arkona
Athens	*Atikokan Township	Barry's Bay
Beachburg	Beeton	Blyth
Bolton	Brampton	Brantford
Cache Bay	Caledonia	Cannington
Carleton Place	Chalk River	Chesterville
Coldwater	Collingwood	Creemore
Deep River	Dundalk	Eganville
Elmira	Espanola	Essex
Finch	Forest	Grand Bend
Hanover	Harrow	Huntsville
*Kapuskasing	Lindsay	Merlin
Merrickville	Milton	Mitchell
Morrisburg	Nepean Township	Niagara
*Nipigon	Oil Springs	Orillia
Ottawa	Paisley	Paris
Parry Sound	Pembroke	Perth
Petrolia	Plantagenet	Port Arthur
Port Hope	Port Rowan	Renfrew
Rosseau	St. Catharines	St. Thomas
Scarborough	*Sioux Lookout	S. Grimsby Township
Stirling	Sturgeon Falls	Tecumseh

Thessalon	Thorold	Toronto
Toronto Township	Victoria Harbour	Webbwood
Wellesley	W. Ferris Township	Whitby
Woodstock		

*Not marked on Figure 1.3

APPENDIX 2

This contains a summary of the Ontario Municipal Electrical Utilities Executive and Managerial Positions.[1]

Municipalities	355
Chairmen	353[2]
Vice-Chairmen	11
Commissioners	702
General Managers	26
Chief Engineers	2
Councillors	130
Trustees	86
Superintendents	15
Secretaries	142
Treasurers	2
Secretary-treasurers	194
Clerks (e.g. Town clerk)	309
Managers	192

Total number of executive positions	2164
Total number of executives	1967[3]

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[1] From a report of the same name prepared by W. S. Preston, Chief Statistician's Office, O.H.E.P.C., Toronto, 1968.

[2] At the time of the survey West Ferris Township and Widdifield Township did not have Chairmen.

[3] Some municipalities have one person in more than one executive position.

APPENDIX 3

This contains a list of newspaper references concerning the organization of the O.H.E.P.C. from Feb. 1, 1961 to April 11, 1969. They were taken from the file entitled:

Ontario Hydro-Electric Power Commission 1961-69.

which is available in the library, Hamilton Spectator Office, Hamilton, Ontario.

The following abbreviations will be used:

HS	Hamilton Spectator
GM	The Globe and Mail
TT	Toronto Telegram
TDS	Toronto Daily Star
FP	Financial Post

SOURCE	DATE	TITLE OF ARTICLE
GM	Feb. 1 1961	Involuntary Exports Cost Hydro $400,000 tax
GM	Feb. 27 1961	Wants No Government in Hydro
TT	March 4 1961	Hydro Out of Politics
GM	March 29 1961	Liberals Want Hydro Bound to Legislation
HS	April 7 1961	Hydro Taxes First Steps to Combine Two Areas
GM	April 7 1961	Hydro's Peculiar Autonomy
GM	May 11 1961	1960 Hydro Demand Climbs 3.4 Percent, Reaches Peak Level

SOURCE	DATE	TITLE OF ARTICLE
GM	May 31 1961	Grass Roots Man is Boss
GM	Nov. 9 1961	Value of Standards Proved by Hydro: Vast Field Waits
GM	Nov. 20 1961	Hydro Research Station Opens
GM	Nov. 23 1961	Power Merger Won't Raise Costs: Macauley
GM	Dec. 7 1961	N.D.P. Liberals Assail Operations of Hydro
GM	Dec. 27 1961	After Hard Sell '61 Hydro Enters Atomic Era
HS	Feb. 2 1962	B.C. Eyes Ontario Hydro Project
HS	March 8 1962	Fear Amendment to Hydro Act
HS	March 8 1962	Electrical Group Fears Ontario Hydro Take Over
GM	Jan. 2 1963	Increase in Power Consumption Expected to Reach 6.5% in 1963
HS	March 5 1963	Political Interference in Ontario Hydro Feared
HS	March 6 1963	Hydro Asked to Sell Bonds to Employees
GM	Nov. 4 1963	Power Delicately Juggled for Ontario Needs
HS	April 2 1964	Re-Inspection of O.H. Commission
GM	April 22 1964	Future Hydro Power Assured in Ontario Legislature
GM	April 22 1964	2,042,000 Hares & Tortoises in Ontario Hydro's Menagerie
HS	May 6 1964	Hydro Sends W. J. Jackson
GM	May 29 1964	Per Capita Consumption Tops Average in U.S.

SOURCE	DATE	TITLE OF ARTICLE
HS	Sept. 24 1964	Proposals to Abolish PUC's Runs into Sharp Criticism
GM	July 20 1965	Ontario Hydro Urges One Whole-sale Price
HS	Oct. 23 1965	Line in Sky Ready by Christmas
HS	Nov. 12 1965	Says Hydro May Withdraw from U.S. Grid
GM	Nov. 12 1965	Association Opposes Placing Hydro Affairs Under Council Control
GM	Nov. 13 1965	Power Ties May be Cut, Robarts Says
GM	Mar. 3 1966	Municipal Elec. Body Assails New Hydro Costing Procedure
GM	Mar. 4 1966	Ontario Hydro Denies Intent to Dissolve Municipal Boards
HS	Mar. 26 1966	New Top Man for Ontario Hydro
GM	April 16 1966	Hydro Chief Sees 4 Province Grid Within 3 Years
GM	June 2 1966	Single Ontario Grid is Planned By Hydro
HS	June 2 1966	Provincial Power Grid Planned
GM	July 22 1966	Plan to Aid Poor Areas Irks Robarts
HS	July 22 1966	Tax Plan Blamed for Loss of Plant
TDS	Aug. 31 1966	Hydro to Lend Up to $2,000 for Rewiring Private Homes
FP	Oct. 1 1966	Hydro Doubles Capacity
GM	Oct. 29 1966	Crucial OMB Ruling to Set Policy on Who's to Pay for Hydro Moves
GM	Nov. 9 1966	Hydro Throws Light on Economics of Buying Bulbs for Homes

SOURCE	DATE	TITLE OF ARTICLE
HS	Nov. 28 1966	Hydro to Give Loans
FP	Feb. 18 1967	Seven Ontario Hydro Plants Under Way
HS	Mar. 7 1967	Hydro Keeps Pace with High Demand
HS	Mar. 9 1967	No More Black Outs Hydro's Objective
HS	April 19 1967	Farmers Hear Hydro Plan
HS	April 19 1967	3 Power Projects Approved
GM	May 2 1967	Ont. Hydro's Latest Plan for Expansion
HS	May 16 1967	Industrial Climate Urged for Counties
GM	June 2 1967	Linemen in the Sky
HS	July 4 1967	New Hydro Manager Has African Experience
GM	Oct. 19 1967	Board Halts Hydro Debate as Court Affair
GM	Dec. 11 1967	Bad Year for the Utility
HS	Jan. 24 1968	Hydro Plans 23% Expansion
GM	Mar. 6 1968	Ontario Hydro Plans Increase in Capability
TDS	April 22 1968	Ontario See End to Power Shortages
HS	May 15 1968	Hydro Line Gobbles up Farmland
HS	July 8 1968	Hydro Reports Record Income During 1967
HS	July 19 1968	Hydro Tax Under Fire
GM	July 19 1968	Hydro Must Be Asked to Justify Tax Set Up

SOURCE	DATE	TITLE OF ARTICLE
HS	Aug. 10 1968	Hydro Bass Raps Tax Suggestions
HS	Aug. 17 1968	To Service Hydro Plant
GM	Oct. 10 1968	Robarts Believes Ontario Must Double Power in 10 Years
HS	Oct. 10 1968	Angry Demand For Levy Share to Aid Hydro Installation
HS	Nov. 23 1968	Hydro Building No Decision by Hydro
HS	Dec. 13 1968	Partial Black Out Possible
HS	Jan. 7 1969	Hydro Buys Farms for Right of Way
GM	Feb. 13 1969	Ontario Signs Power Deal with Quebec
HS	Feb. 13 1969	Ontario to Purchase Quebec Power Bloc
HS	March 15 1969	Science Study Aided by Hydro
HS	April 11 1969	Keep Separate Hydros

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