THE DIFFUSION OF INNOVATIONS REQUIRING COMMUNITY DECISIONS: A GEOGRAPHICAL ANALYSIS

BY

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SCOPE AND CONTENTS.

Using the concept of innovation diffusion the author examines the process of change in the central place system of Southern Ontario. The concept is formulated in terms of a decision making situation, and applied to a class of innovations which require community decisions. The analysis is organized within the framework of a queuing analogue and certain basic hypotheses are tested in relation to the phases of decision making associated with innovation diffusion. The analysis is a response to inadequacies in formulation of the concept, the lack of knowledge concerning this class of innovations and decision making in urban systems, finally, the need to understand the rate and direction of change in southern Ontario.

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CHAPTER 1

Introduction

The Problem

What is change? How does change occur in any given system, how does the system accommodate change and what are the factors which resist change? These are problems continually confronting society. One area of geographical enquiry which tries to answer some of the questions posed above lies in the study of the spatial diffusion of innovation.

Brown (1968) defines spatial diffusion according to two processes. In the first situation designated "relocation", some members of a population at time t, change their locations by time t + 1. (i.e. a frontier movement). In the second situation of "expansion", new members are added to the set of an existing population (adoption of a new practice by members of a given population). In this dissertation we are concerned with the latter type of diffusion. In the testing and elaboration of this concept, analysis and conceptualization have taken place mainly at a micro scale where individuals are the decision makers and the rate of change is small.

The purpose of this thesis is to examine the spatial diffusion of innovations which require community decisions (by municipalities

in particular) through the central place system of Southern Ontario. There are several needs for such a study, each important in its own right.

Firstly, there are certain inadequacies in the formulation of the concept of innovation diffusion, such as the nature of decision making, the character of inter-adopter influence, the role of propagators and the structure of resistance to innovation. Consequently, the concept is formulated in detail, while hypotheses related to the concept are tested within the framework of a queuing analogue.

Secondly, innovations which require group (e.g. community, municipal) decisions are an important class of innovations which have been relatively neglected. Furthermore hypotheses developed elsewhere in diffusion research have not been applied in this situation. Therefore a review of those few studies which have been made is undertaken and relevant hypotheses are tested at this scale, in particular the city size factor and the neighborhood effect. Related to this need is the underlying question of scale in geographical enquiry. Thus, any findings in this class of innovations will have a direct bearing upon the scale factor.

Thirdly, it is hoped that the analysis will contribute to an understanding of the nature of decision making in urban systems. Urban geography has mainly concentrated on the physical structures of urban systems. Only recently has attention turned to dynamic behavioral processes.

Finally, and not least of all, the thesis attempts to elucidate some aspects of the process of change in the central place system of Southern Ontario. How does change occur in this system? What are the directions of change; are there well defined routeways of change? What effect do neighboring systems have on implanting new ideas into Ontario? How does the decision making system associated with this class of innovations process these structural challenges? These are complex, intriguing and important questions which through the concept of innovation diffusion this dissertation partially attempts to answer.

CHAPTER 2

The Conceptual Framework: A Decision Making Process

In this chapter the central concept of innovation diffusion is defined and elaborated in terms of what constitutes decision making. Emphasis is placed on geographical aspects of the process and how these apply to groups arriving at a single collective decision in evaluating an innovation.

DEFINITION

The process of innovation diffusion through social systems has been defined by G. Tarde (1903), J. Schumpeter (1939), H. Barnett (1953), E. Rogers (1962). In a review of the literature E. Katz et.al. (1963) synthesize these definitions in the following statement:

> "the diffusion of innovation is the acceptance of an item or idea, over time by individual units,[1] linked by communication networks of a social structure having a value system". (p. 237)

Hägerstrand (1953) and Brown (1968) have expanded similar definitions of the process to incorporate the space dimension.[2] At the

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[1] By individual units meaning persons, or groups arriving at a single collective decision; see Katz, E. (1963), p. 244.

[2] Although previous non geographical research refers to the spatial development of innovation, eg. Chapin (1928), Wissler (1923), Edmonson (1961) no attempt is made to derive general statements concerning the process other than the general idea of concentricity or "age area" analysis.

same time Brown (1968) considers six elements basic to the process: area, time, item diffused, origin of item, destination of item and paths of movement or influence. Brown also simplifies this definition as the study of nodes (adoption units), links (communication) and messages (innovations).

According to the definition described first of all, diffusion in social systems is regarded from a behavioral standpoint where decision making is the process leading to the adoption of an innovation. Furthermore, it is also assumed that diffusion is an ordered (non random) process which can be described in terms which have general application.[3]

A fundamental assumption is that diffusion is a dynamic process where time is taken as the major independent variable, that is, the development of the process is measured as a function of certain time intervals in a definite direction.[4]

A general criticism which can be levelled at previous definitions of the process is that it has been viewed almost entirely from the viewpoint of the adopting systems that is, the groups which adopt innovations, so that the significance of the propagator's role has been diminished.[5] Consequently, in order to understand the process fully,

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[3]This non random assumption does not necessarily preclude its definition as a stochastic process.

[4]For a discussion on this point see Olsson, G. Geography 1984. Dis. Paper #7. Dept. of Geography, Bristol University (1967), p. 10 ff.

[5]For example see the review of diffusion of innovation by Katz, E. et.al. (1963) where there is hardly any mention of propagators, and their activities.

to the initial definition must be added "the acceptance of an item or idea, spread by propagators ..".

The construction of a conceptual framework draws upon material from several disparate sources of enquiry - previous diffusion research, recent studies of behavior and decision-making and studies of group behavior. The purpose of describing in detail the nature of decision making associated with innovation diffusion is twofold; firstly to provide a more specific framework for the class of innovations requiring group decisions; secondly at the same time to be sufficiently general to enable some "scale-free" statements of the process to be made.[6]

THE ADOPTING SYSTEM

Having defined the concept we can proceed to describe a decision making situation where we consider the adopting system, the propagators and contact with adopters, and how these relate to a group arriving at

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[6]Significantly only geographical research into the spatial development of innovation has considered that similar processes may operate at two scales (1) at the level of an individual in a neighbourhood system and (2) a city, in an urban system (Hägerstrand, 1966, Craine, 1966, Brown, 1967). Thus Hägerstrand (1966) states,

> "From work at the smallest scale it has been tempting to pass to the other extreme and see if the same set of concepts can be used as one tries to survey diffusion of innovation over a whole continent." p. 31.

However, Harvey (1968)(see especially pp. 92-93) queries whether we are in a position to identify scale-free theory at present. He further suggests that such discrimination is difficult using pattern analysis and that we "need direct information regarding the behavior of the population" (at. p. 93).

a single decision. Decision making by adopters is the selection of, or choice between, alternate courses of action. In the case of innovation decisions such courses of action will range between complete adoption and outright rejection. In developing a schema for describing decision-making, Kates (1962) isolates four main elements common to all other schema, namely: (1) the underlying view of man's rationality; (2) the types of decision processes involved; (3) the conditions of knowledge under which choice is made; (4) the criteria which are used to guide such choice.[7]

Since we have already stated that the innovation adoption or rejection is a decision-making situation, a schema similar to that of Kates can be employed to understand the structure of decisions made concerning innovations. Thus, we shall consider: (1) basic assumptions or the view of rationality; (2) the learning process; (3) the types of decisions involved; (4) the actual choice and evaluation criteria.[8]

(1) BASIC ASSUMPTIONS

The socio-psychological origins of diffusion research have precluded the development of normative (or deterministic) assumptions where man is presumed to act "rationally" and seek "optimal goals". The work of Griliches (1957) and Mansfield (1961) are exceptions

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[7]Kates, R. op. cit. p. 12 ff. Although applied to resource management decisions it has equal applicability here.

[8]Since decisions are the outcome of the learning process it was felt to be more appropriate to deal with them in this order.

because they assume profit maximization in the spread of innovations. The decision-making which results in an adoption or rejection of an innovation is regarded as the outcome of a learning process where successive increments of communicated information lead to a change in state of the recipient (Hägerstrand, 1952, 1966; Rogers, 1962).

Social learning is the result of contact by a propagator and also through intra-group communication. Such contact and communication is modified by both socio-economic and spatial variation in members' attributes. Thus, the underlying assumption is that diffusion in social systems is a learning process where man constructs a model of reality based on the outcome of information received and acts according to his own definition of reality.

In previous geographical analyses similar assumptions have been made in modelling the process at the scale of the individual person as the decision-maker. (Hägerstrand, 1952, 1966; Wolpert, 1964). The same assumptions can be applied to the analysis of groups as decision-makers, "group" meaning a collection of people such as a community, arriving at a single decision.[9] That is, through communication of information by propagators and other group members, the group acquires increments of information and comes to a decision.

Unlike the individual, whose goals[10] are rarely expressed let

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[9] See Katz, E. et.al. (1963), p. 244 for a discussion of this point.

[10] Hill (1968) defines goal as "an end to which a planned course of action is directed".

alone defined, group goals are often specified explicitly, since they are usually a group bond. In the case of municipal councils whose decisions concerning innovations will be examined in this thesis, the goals are also defined in political and legal terms. A group may have multiple and composite goals, that is, sub-goals related to the sub-groups within organizations (Cyert and March 1964). Consequently, in the class of innovations under consideration goal orientation can be described as the combination of the following sub-goals:

GENERAL TYPE OF GOAL	EXAMPLE
Socio-psychological	Maintaining social status of municipal councils, e.g. civic pride[11]
Political	Maintaining power
Economic	Keeping solvent or credit worthy

(2) THE LEARNING PROCESS: COMMUNICATION AND KNOWLEDGE LEVELS

If one has a decision-making group, the learning process which leads to knowledge and evaluation of an innovation on its part has been characterized as having certain phases of development over time. They are awareness and interest, evaluation, decision and trial (Rogers,

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[11] The importance of civic pride as a psychological driving power in the geographical development of towns and cities has received little attention. An important contribution to understanding its significance in the growth of 19th century cities has been the work of A. Briggs, (1963).

1962; Lionberger, 1960).[12]

Awareness and interest

Potential adopters become aware of an innovation from three sources, namely, the mass media, propagators who make direct oral contact and other members of the group. Although the mass media may produce awareness, its effect on actual adoption decisions has been shown to be largely passive,(Lazarsfeldt, 1948). At any one point in time for example, information concerning many innovations may be circulating in the mass media, making specific evaluation of any one innovation difficult. However, it has been hypothesized that at the micro-level, peers derive new ideas from the mass media and then pass them on to the rest of the group,(Lazarsfeld, P. et.al. 1942 , Katz, 1957 , Rogers, E., 1962).[13]

The role of the propagator in producing awareness of innovations is less clearly understood mainly because research has concentrated on the adopting system where it has been consistently shown that group members refer to other members, rather than propagators, for advice during evaluation. At the present time, propagators use various forms of communication, direct contact such as salesmen and the indirect methods of advertising to promote awareness,(Copp, Sill, Brown, 1958).

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[12]The phases or stages of development were recognized quite early in diffusion research (Lionberger, 1960). Problems have arisen as to their differentiation and measurement (Wilkening, 1950).

[13]This process has been hypothesized as the "two step" or multi-chain flow of information (Katz, op. cit. 1957).

Institutional propagators from governmental agencies may also be active.

A detailed analysis of the diffusion of hybrid corn by Ryan and Gross (1943) shows that information increases in the system (described as a normal curve) and precedes the normal curve of adoption. It appears that salesmen are most significant in spreading awareness during the early phases but the late adopters derive their information from neighbours.

In addition to the mass media and propagators, information is also circulated between members of the group through informal (i.e. face to face) networks, (Rogers and Beal, 1957 ; Coleman, et.al. 1957). These informal networks have been recognized as the most significant communication channels associated with the actual adoption decision, (Coleman, et. al., 1957).

Consequently, one can think of a system where group members become aware of innovations via several sources. Although previous research has been undertaken at the level of the individual it can be appreciated that a group such as a community can progress through the same learning process (Fig. 1).

Variation in knowledge levels

Through the communication of information, the adoption units learn and acquire a certain knowledge level: this knowledge level can vary according to the attributes of the adopting system.

Within certain groups it is observed that certain members act as peers and set the general pattern of behavior for the rest of the

group (Lionberger, 1960 ; Rogers, 1962). They function as senders of specialized information, processing mass media and then redirecting it to other members of the group. This sub-group's behavior is usually described as a function of higher education, income, social status and mass media exposure,(Katz, et.al., 1963).

In city systems, where central places are the adopters, similar attempts to designate "peer cities" on the basis of attributes such as city size, income and education levels are made, Crain, 1966).

Geographical variation

The geographical contribution describes spatial variation in informal information (face to face contact) flow and the subsequent learning process,(Hägerstrand, 1952 ; Wolpert, 1966). At the micro scale this is operationalized by using the Mean Information Field concept[14] while general information flow at the macro scale is described using gravity-model formulations,(Carrothers, 1956 ; Olsson, 1965 ; Porter, 1965).

A major characteristic of the spatial structure of information circulation at the macro scale is that distinct hierarchies appear to exist, (Hägerstrand, 1966) (Fig. 1). It is hypothesized that an external flow from one level to another and then an internal flow within a level explain variation in knowledge levels,(Wolpert, 1966).

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[14] A mean information field is an empirical measure of the probability of contact over space, usually at the micro level. It is based on records of telephone calls, migration, marriage partner selection and trip activity.

AGGREGATED AND SPECIFIC CONTACTS IN SOCIAL INTERACTION

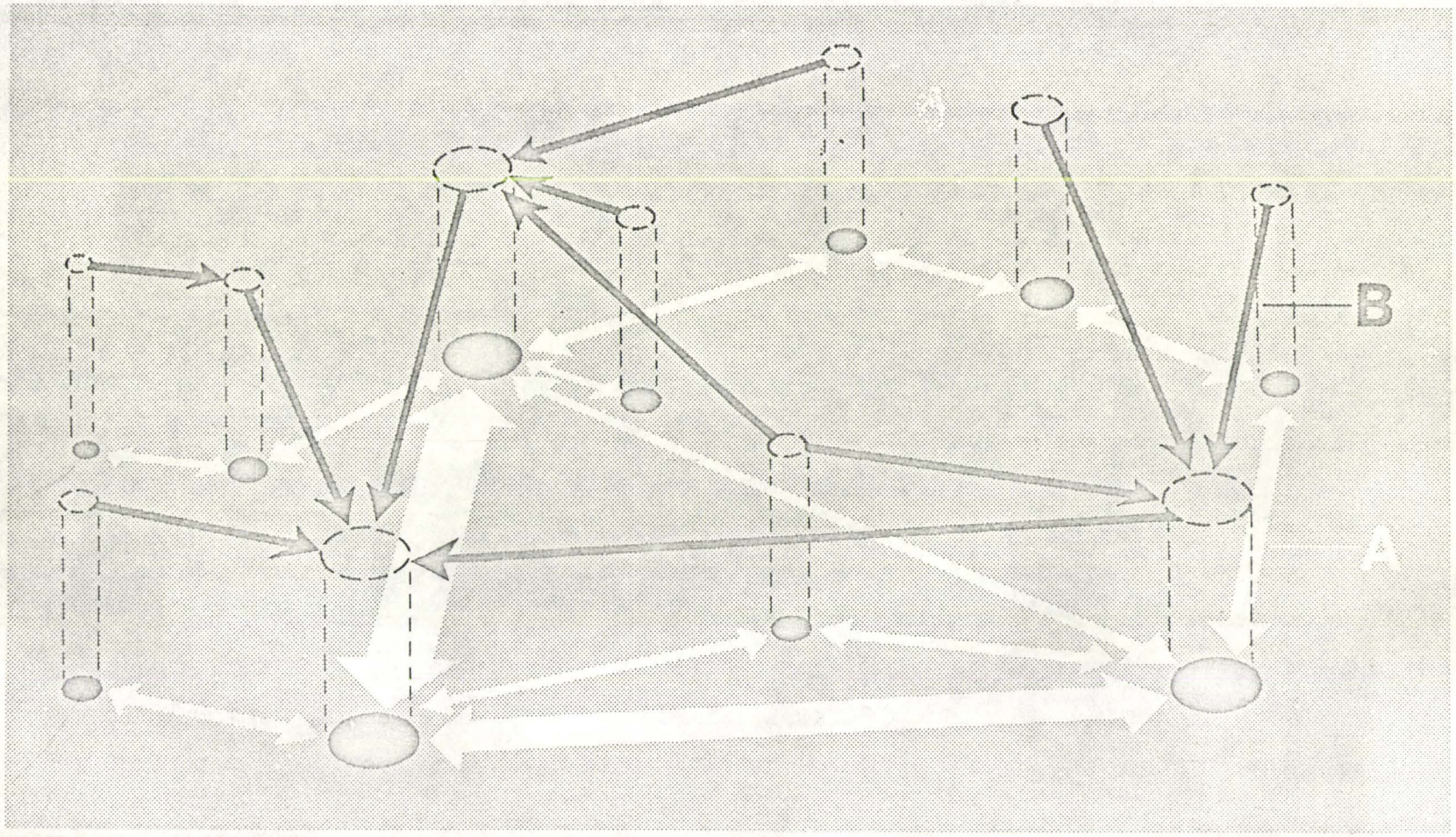

Figure. 1. Level 'A' demonstrates aggregated contacts (links) while level 'B' shows contacts for a specific problem. Both levels indicate the hierarchial effect due to variation in the attributes of systems (nodes). Nodes represent central places or individuals according to the scale of analysis.

In city systems the hierarchy effect is exhibited when innovation awareness progresses through the largest cities of different countries then large cities within countries, then regions and then finally to the smallest centres.

A modification of the city size progression of an innovation is advanced by Hägerstrand (1966) claiming that neighbours close to a previous adopter are aware sooner than many of those of a larger size (in a city system) further away, the so-called "neighbourhood effect".

Thus, in the awareness phase, information concerning an innovation is circulating through a system with several sources of communication (Fig. 1). Due to variations in attributes of adopters (e.g. city size) or location (nearer a large city) there are variations in knowledge levels. Variation in propagator's activities in contacting adopters also affects the spread of information.

It can be appreciated that an understanding of the onset of awareness and learning provides a measure of the decision-making process, assuming that the adoption date is also known. For lack of direct empirical evidence the adoption date is usually taken as a surrogate of the flow of information, however; this could give a misleading analogy of the process. Furthermore, the aggregates of social communication may not represent accurately enough the actual networks during evaluation of an innovation.[15] From a consideration

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[15]The discrepancy between the potential communication channel and the actual links has been recognized for some time. At the macro scale the effect of a provincial boundary on interaction between Ontario and Quebec was demonstrated by McKay (1958). At the micro scale similar variations may exist since the aggregative nature of mean information fields gross over them. For a discussion see A. Williams, (1968).

of information flow we must now turn to the actual decision-making.

(3) THE CONTACT SITUATION BETWEEN ADOPTERS AND PROPAGATORS

Contact by a propagator or another member of the group suggesting adoption, requires an active response on the part of the potential adopter, and sets off the evaluation processes. Where there is expenditure on the part of the adopter a market situation exists; a non-market situation would arise where a propagating group such as a new group (e.g. pro-fluoridation) contacts the adopter.

According to the assumptions underlying classical location theory, the propagator should locate where the difference between revenue and costs are at a minimum,(Losch 1939 ; Hoover, 1948). Furthermore, the market areas would be discretely divided between competing entrepreneurs.

Under "realistic" conditions the entrepreneur locates according to his interpretation of the potential market, biased according to his information. Similarly, in the development of market areas, imperfect knowledge and perceived opportunities could result in an overlapping and inter-locking of market areas,(Pred, 1967 ; Hamilton, 1967). It has also been suggested that tributary areas be delineated according to zones of maximum advantage and zones of competition,(Golledge 1968).

In marketing or spreading a new product or idea the propagator would have to search out the potential response (although he might also be acting on past responses). Under ideal conditions in the class of innovations being considered, the greatest potential for

adoption should exist in the largest cities so that the propagator should locate there and then proceed to market the product at other centres and thus down through the urban hierarchy. In reality this may be different if there are several competing propagators and if the propagator's perception of potential response is modified by distance and cultural or economic barriers.[16]

Where propagators are not motivated by profit one must assume that they seek to "convert" as many people as possible and consequently concentrate activities in areas of greater population such as the larger centres; although this is not always necessarily so, since a movement may only concentrate on say rural populations, this does appear to be the case in reform and similar socio-political movements.

The decision

Decision making can be defined as the process whereby one makes a choice between alternate courses of action in order to solve a problem, yet some decisions are clearly more important than others.[17] Consequently in recognition of this variation decisions have been classified as routine (programmed) and strategic (unprogrammed) (Simon 1965). Such a classification is somewhat arbitrary and its use would

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[16] Hamilton, op. cit., p. 376.

[17] Thus, Lundberg (1962) for example, in attempting to develop a scheme for analyzing decisions states that so far there has been a lack of uniformity in differentiating between decisions in this context.

FLOW DIAGRAM OF DECISION MAKING BY MUNICIPAL COUNCILS

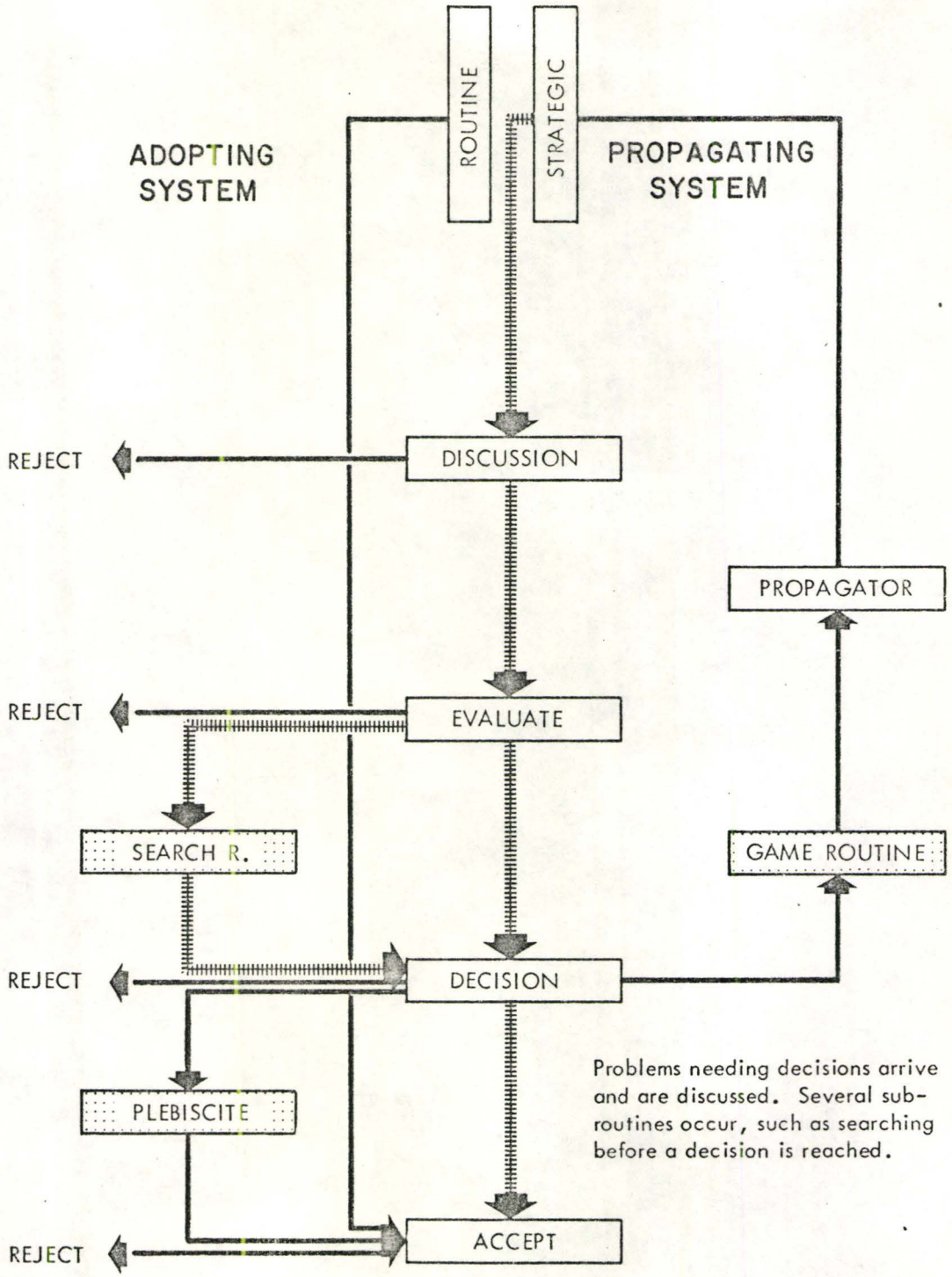

Figure . 2.

CONSIDERED IN THIS ANALYSIS SUBROUTINE

depend upon the situation under consideration. The problem is further complicated by the fact that it is difficult to deduce the processes of decision making from the overt act and thus consider whether the problem is routine or not.

Where groups arrive at a single collective decision these problems are obviated since most groups keep records of how decisions are arrived at, making them amenable to categorization and further analysis. This advantage is particularly significant when it is realized that most of the features associated with decision-making by individuals are present in the group situation (Leoni 1957).

(4) EVALUATION AND CHOICE

Assuming therefore that the decision making unit has received what it considers to be sufficient information concerning an innovation, a decision can be made (Fig. 2). In addition to either accepting or rejecting, the group may delegate the problem to a sub-group so that a looping effect may develop, with the loop being repeated many times before the actual committed decision is made. In a community situation, the decision making group may delegate the decision as a plebiscite, obviating any controversy that might ensue from their decision. These sub-routes represent risk reduction routines. Another common form of risk reduction is to adopt the innovation on a trial basis, with the possibility of reversing a previous decision (Lionberger, 1960).

Where the outcomes of the decision have a known probability distribution risk is involved; where the outcomes are unknown the assignment of probabilities is uncertain.[18] Economic risk would relate to the amount of capital required, while social risk would relate to the degree of radicalness involved in the decision with the possibility of subsequent group sanction.

To reduce the risks involved the potential adopter may employ various strategies. One common form of risk reduction is to search out more information by contacting other adopting units, to supplement the information provided by the formal channels of communication (Coleman, et. al., 1957). In a market situation it has been hypothesized that the amount of searching is related to the marginal revenue that would accrue from the process, (Cyert and March 1964).[19]

The spatial implications of intra group contact (e.g. neighbourhood effect) have already been mentioned. Recently, it has been suggested that in addition to the distance factor, the search process may be either random or operating within a certain set of rules such as

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[18]The distinction between risk and uncertainty is arbitrary. However, risk would apply to those situations where some knowledge derived from experience would enable the decision maker to expect a certain probability of an event occurring. Uncertainty would be a situation of extreme risk where any event could occur. See, Kates, R. (1962) op. cit. p. 19 for a discussion of this point.

[19]In a sense, the searching process can also be regarded as a delay mechanism in the face of an uncertain future - see L. Curry (1967) p. 222 for a further discussion of this point.

contacting the nearest previous adopter or one of similar status to the potential adopter (Golledge and Brown, 1967). Generally, little empirical evidence has been forthcoming upon which to base any firm empirical statements as to the nature of the spatial process other than the aggregations of social communication at the micro level concerning mean information fields.

SUMMARY

In this chapter the process of innovation diffusion in social systems is defined as a decision making situation. The concept is then elaborated in terms of a four point schema comprised of assumptions of rationality, the learning process, the contact situation and types of decisions involved and finally the choice and evaluation criteria.

In describing these basic characteristics of the decision making process as applied to innovation diffusion, particular emphasis is placed upon firstly geographical characteristics such as, the hierarchical ordering of awareness and/or adoptions, the location of propagators and the neighborhood effect in informal face to face contacts. Secondly, emphasis is also placed on the group or community as the adopting unit since this is the class of innovations being considered. Implicit in both emphases is the question of scale and whether the concept of innovation diffusion is scale-free. This point will be taken up again in the next chapter, with the review of relevant literature.

Thus, the time taken to process a decision can vary according to amount of information acquired, negotiations with propagators, searching

for more information, delegation of decisions and so on. Such variations in process times between the initial awareness of an innovation and the actual time of adoption can be tested in terms of city-size, location and their attributes. The significance of the decision-making group infrastructure is not a consideration of this thesis although it is probably an important variable to be considered (e.g. the power structures and struggles which lead to the overt decision).

From a consideration of the basic concept of decision making as applied to innovation diffusion we can examine more closely the related literature associated with decision making groups or communities arriving at a collective and single decision particularly in a central place system. Compared with the literature on the concept of innovation diffusion as a whole, previous research into innovations requiring group decisions is small.[20] Yet, from the conceptual framework and the relevant literature it should be possible firstly to develop a matrix of working hypotheses for testing aspects of the diffusion process in this class of innovations and secondly to organize the analysis in a paradigm form.

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[20] For example see the review of the literature by Katz, E. et.al. op.cit. (1963).

CHAPTER 3

A Review of Studies of Innovations Requiring Group Decisions Diffusing through Central Place Systems

It was shown in the conceptual framework that several research traditions have contributed to diffusion research, where each field of enquiry is attempting to describe and explain the process of change in the system. A similar synthesis can be made of those hypotheses which concern innovations requiring community decisions as they diffuse through central place systems.

The city as a centre of change in respect of the concept of innovation diffusion was originally the concern of sociologists. After this initial interest in urban systems they then focused attention on innovation diffusion in rural areas.[1] H. Pemberton (1937) examines the diffusion of radio sets through the central place system of western U.S.A. In an early attempt to employ the gravity concept, he hypothesizes that the frequency of culture contacts are related inversely with the time and distance from a city.[2] He concludes that

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[1] See for example, the references cited by Katz, E., et.al. op.cit. (1963). The sociological contribution is also represented in Rogers, E. (1962)

[2] Pemberton, E.H., Culture Diffusion Gradients, American Journal of Sociology, (42) p. 226.

an understanding of the communication process is fundamental to describing innovation diffusion and that it is affected by variation in the attributes of the adopting units.[3]

R. Bowers (1937) examines the diffusion of interest in radio by analyzing the ratios of amateur radio enthusiasts to the total population of towns and cities and states that the proportion of enthusiasts to the total population is a function of city size, at any given point in time.[4] He suggests that the larger cities influence the smaller ones, adopting innovations earlier because they are more "in touch" with events and are more receptive towards innovations. Finally, he states that certain innovations diffuse only so far through the system (i.e. according to a certain level of the functional hierarchy).[5]

Whereas Pemberton and Bowers examine the diffusion of innovations through urban systems which are aggregations of decisions by individual persons, E. McVoy (1940) examines those innovations requiring single community decisions, such as the city manager plan.[6] He attempts to

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[3] Ibid.

[4] Bowers, R.V. The Direction of Intra Societal Diffusion, American Sociological Review (2), p. 826-836.

[5] Ibid., p. 835.

[6] McVoy, E., Patterns of Diffusion in the United States, American Sociological Review (5), 2. p. 219-227.

test Chapin's (1928) concentric ring or ripple-pattern hypothesis but has some trouble applying it to a point pattern of central places having a hierarchical ordering.[7] The observed patterns are explained by relating them to an "index of innovativeness" based on the dating of several acts of social legislation passed by State Legislatures. He also observes that the rate of growth follows a rising S-shape curve (although not specifically described as such). The relationship between date of adoption and the size of cities is also examined and the conclusion is drawn that a complex function exists between size and acceptance date in that innovations of this type would not be adopted in the very large cities or the very small cities. Some attempt is also made to understand the regional variation in the observed patterns.[8]

K. Rose (1948) attempts to distinguish the "cultural hearths" of the United States examining the first appearance of innovations both by city and region. His empirical analysis shows that the "first use" of an innovation is not necessarily in the largest cities, although subsequent early adopters may be large centres.[9]

Ogburn and Duncan (1958) examine the relation between city size

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[7] Chapin, F.S. Cultural Change, p. 226-229. New York, (1928).

[8] McVoy, E. op.cit., p. 219.

[9] Rose, E., Innovations in American Culture, Social Forces, Vol. XXVI (225-272).

DIFFUSION PATTERN BY SIZE OF COMMUNITY

(AFTER Ogburn & Duncan)

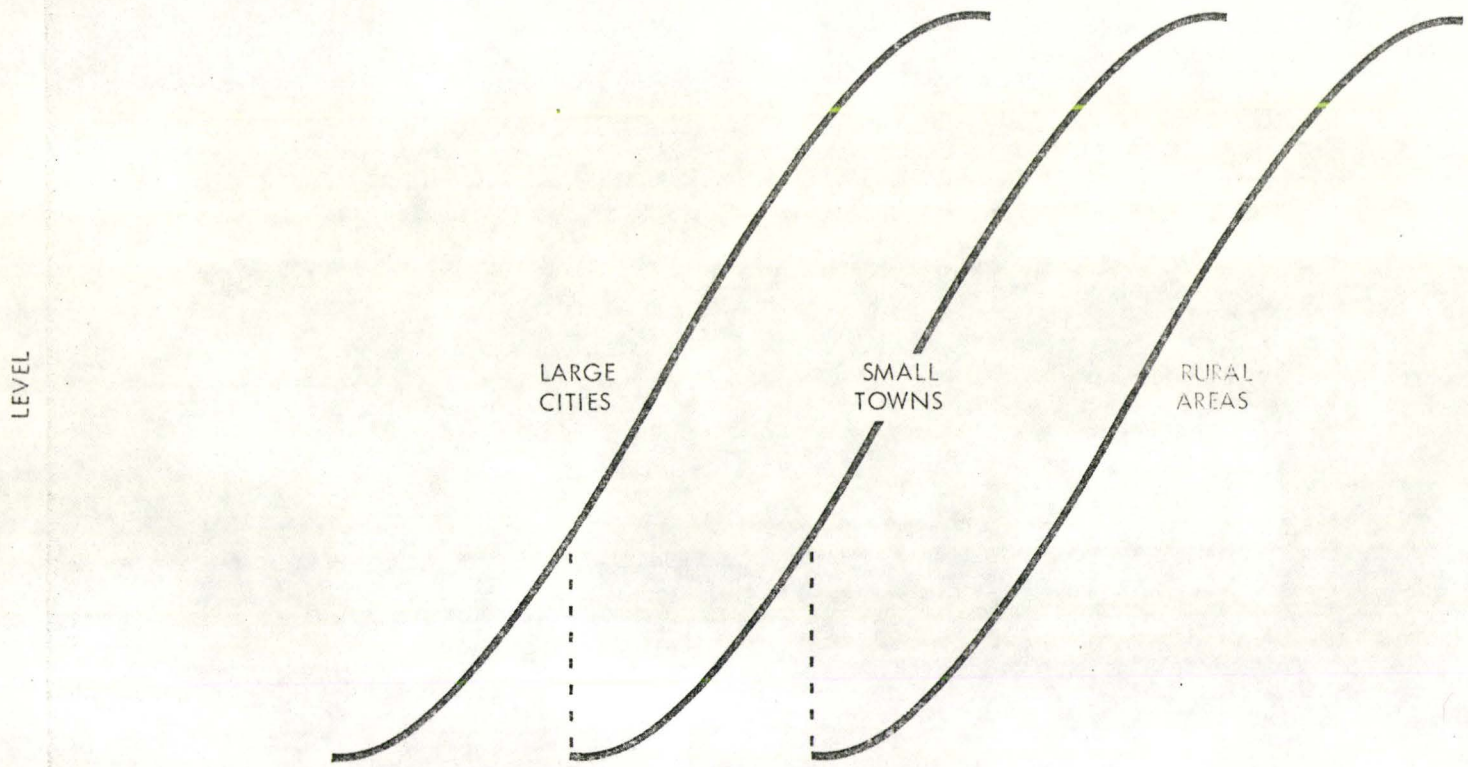

Figure. 3.

Diagram to illustrate the lag between the large centres and the small centres in terms of adopting innovations. Note the overlap between groups (dotted lines) and logistic-shaped accumulation curves.

and date of adoption and state that the smaller urban centres follow the patterns of change in the larger centres with a lag of a few years[10], again, referring to innovations requiring individuals' decisions (Figure 3). Furthermore, they attempt to explain the different growth rates in terms of the greater capital resources of the larger cities and the fact that the larger cities are more receptive to innovations.[11]

Gamson and Irons (1961) examine the relationship between the date of decision to adopt fluorides in city water systems and demographic variables such as population size, education, income and growth rates. They conclude that this type of analysis is not very useful in predicting the date or type of decision since no consistent relationships are observed.[12]

An attempt to understand the spatial variation in the community decision-making process is made by R. Crain (1966) who examines the effect of inter-city influence on community decisions concerning fluoridation. He shows that community decisions appear to be influenced by decisions made in neighbouring communities, using the three nearest

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[10] Ogburn, W.F. & Duncan, O.D. City Size as a Sociological Variable in Burgess, E.W. & Bogue, D.J. Contributions to Urban Sociology (Chicago University Press, 1964) p. 129-147.

[11] Ibid. p. 144.

[12] Gamson, W.A. and Irons, P.H., Community Characteristics and Fluoridation Outcome. Journal of Social Issues (1961) p. 66-74.

neighbours as the definition of "neighbouring".[13] His second hypothesis is that cities were less likely to have a favorable decision if their neighbour had voted against the issue.[14] From the small sample available he concludes that the hypothesis is true, although no test of significance is made. The third hypothesis is that in any pair of adopters the larger city would adopt first (cities were grouped on the basis of population size by 10-20, 20-50, 50-100, > 100, thousands). This hypothesis is substantiated in the case of very large cities in relation to smaller neighbours, but not in relation to small cities across the nation.[15] Since it is realized that there is an uneven distribution of cities among states, some attempt was made to measure the cluster effect of adoptions. It is found that where early adopters were found in these clusters, there is a decrease in adoptions after the first wave and then an increase, at a later point in time.[16] Crain interprets this as a "sheltering effect" in the early adopting areas.

Other recent research into social change and community decisions has concentrated on examining the power structure of communities.[17]

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[13] Crain, R., Fluoridation the Diffusion of An Innovation Among Cities, Social Forces (44), 4, 1966, p.

[14] Ibid. p. 4

[15] Ibid. p. 5

[16] Ibid. p. 8

[17] See for example: Paul, B.D. et. al. Community Decision Making: Fluoridation, Journal of Social Issues, 1961.

While their overt purpose appears to be the examination of the decision-making process, many are case studies and are at a preliminary stage in the development of general statements.

In general, although city size has been employed as the independent variable to explain adoption dates and some attention has been paid to inter-city influence, little attention has been focused upon the inherent spatial ramifications of the problem in studies of social change. Gamson and Irons appear to be unaware of the hypotheses developed by the earlier researchers such as McVoy; they employ product moment correlations to data that would seem to need non-parametric processing and dismiss areal variation as a minor aspect of the problem. The fact that this innovation (fluoridation) is atypical of the general class of innovations should arouse some further inquiry in itself. Crain's analysis, which is an examination of spatial aspects of the problem is hampered by the lack of a general spatial framework, as has been developed in the geographical literature, with which he could develop his ideas. However, these criticisms should not detract from the contribution of these studies in examining the process of change in city systems and realizing that certain aspects of the process can be described in general terms.

The second source of hypotheses concerning the diffusion of innovations through central place systems has been the study of urbanization (meaning the growth of urban systems). Numerous historical studies consider innovation to be an important aspect of the dynamics

of urbanization. A. Pred (1966) for example identifies the spread of innovations as a major theme in the growth process.[18] Advancing some general qualitative relationships between innovation and city size, growth rate, information circulation and migration, Pred expresses concern in the lack of interest "evinced by geographers" towards the spatial attributes of industrial innovations.[19]

The work of W. Thompson (1965) represents the recent interest of economists in the urbanization process where city size as a major independent variable is used to explain economic growth and viability[20]; an attempt is also made to consider behavioral factors such as entrepreneurial activity[21]. The hypothesis, that decision-making takes longer with increased size of cities, is also stated more clearly (c.f. McVoy's earlier statement)[22]. Generally, studies of the urbanization process have not tested the hypotheses, or extended the concepts advanced since Schumpeter's statement on entrepreneurial activity and business cycles.

J.A. Schumpeter (1939) regards innovation as any change in the

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[18] Pred, A., The Spatial Dynamics of United States Urban-Industrial Growth 1800-1914. (Cambridge, Mass., M.I.T. Press) 1966.

[19] Ibid.

[20] Thompson, W., A Preface to Urban Economics. (John Hopkins: Baltimore) 1965.

[21] Ibid. p. 44 ff.

[22] Ibid. p. 25.

production function (therefore distinct from invention) related to the credit mechanism, the maximization of profit and the availability of entrepreneurs.[23] Apart from the city size hypothesis economists have not considered the spatial characters of the innovation in relation to the urbanization process.

R. Meier (1962) explains urban growth as a communication process where the city/town performs an information processing function[24]; its centrality is a response to information exchange and storage. Meier introduces concepts developed in communications research applying them to urban systems stating that communications systems are analogous at different scales.[25] It can be seen that information processing would be an aspect of the community learning process and hence having great significance in the spread of information about innovations.

In the geographical literature are developed several theoretical models and considerable empirical understanding of the structure of urban systems, (Berry and Pred 1962) and interaction within the system, (Carrothers, 1957 ; Olsson, 1966); these refer to either the static

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[23] Schumpeter, J.A., Business Cycles (New York: McGraw-Hill, 1939) p. 87 ff. However, Mansfield (1963) does examine the size factor in relation to the firm and concludes that the larger organizations are able to innovate earlier with less risk involved.

[24] Meier, R.L., A Communications Theory of Urban Growth. (Cambridge, Mass., M.I.T., 1962).

[25] Ibid. p. 42.

structure or dynamic equilibrium of the system. Little empirical evidence has accrued concerning dynamic change in urban systems, Pred, (1966) apart from studies of urban growth[26] and the urban systems growth simulation models of R. Morrill (1965). Consequently, a brief review of the contribution of theoretical statements concerning innovation diffusion at the micro scale of analysis will be made, particularly as these statements assume a scale free process, followed by a review of geographical studies of diffusion in central place systems.

Geographical Contribution

The geographical contribution to describing and analyzing the diffusion of innovations through central place systems stems from both theoretical statements concerning the process in general and empirical observations of diffusion in central place systems.

In the tradition of the landscape descriptions of Carl Sauer (1925), R. Murphy (1940) examines the city as a centre of change, while D. Stanislawski (1946) describes the origin and spread of the grid pattern town.

Hägerstrand's work (1952, 1966) marks the emergence of a locational approach to the problem. Although Hägerstrand studies

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[26] For some recent examples of dynamic urban growth models and model construction in general, see - Harris, B. (Ed.) Urban Development Models: New Tools for Planning, Journal of the American Institute of Planners, Vol. XXXI (2) 1965.

diffusion mainly at the micro-level it is pertinent to review his ideas since they impute a scale-free generality or process and the transformation of the concept from one scale to another can be traced. Using data gathered from migration, mate selection, trip behavior and telephone calls, the probabilities of contact (and communication of an idea) over distance could be calculated[27] designated as the mean information field. Using this construct and a Monte Carlo generating technique, spatial patterns of information flow are generated which are visually very similar to actual diffusion patterns of adoptions. The model's assumptions are:

MODEL I

1. Innovation adopted by a receiver
2. Innovation adopted as soon as aware of it
3. Spread through private tellings
4. Takes place at constant time intervals
5. Random destination directed by Mean Information Field contact probabilities.[28]

Into the generating process is incorporated a "resistance threshold" that simulates the lag between the communication/awareness phase and the actual adoption.[29]

From the studies by Hägerstrand certain general observations are made.

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[27] Hägerstrand, T. op. cit., (1965), 263 ff.

[28] Ibid., p. 266

[29] Ibid., p. 270

(1) In any area the communication network is fairly stable over space and time.

(2) Certain innovation centres predominate.

(3) The "neighbourhood effect" is the main spatial form of development.

(4) A hierarchy of innovation centres exist.

Recently, Hägerstrand has applied these ideas to a study of the spread of Rotary Clubs through the major cities of Western Europe.[30] Two main hypotheses are considered: firstly, the relationship between adoption date and size of centre and secondly the effect of inter city influence in modifying the first hypothesis (the neighborhood effect). Consequently, we can trace the progression of the use of the concept from one scale to another and hence impute its scale-free nature.

Hägerstrand's work has since propagated a second generation of diffusion models. Karlsson (1958) modifies the Hägerstrand model with the introduction of "social distance" measures although the modified model is not subsequently tested[31]; its concepts are introduced into Wolpert's study of the communication of information about improved

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[30] Idem., Aspects of the Spatial Structure of Social Communication and the Diffusion of Information, Papers of the Regional Science Association, 16, p. 27-42 (1966).

[31] Karlsson, A., Social Mechanisms. (Free Press of Glencoe, Ill., 1958) 156 pp.

farm practices in Sweden.

In Wolpert's (1966) study, individuals are regarded as consumers of information while bias in the "knowledge" situations is introduced by developing an information potential (based upon agricultural society membership) for certain areas.[32] In this way, an attempt is made to estimate the spatial direction of knowledge situations and information flow, the two main governing rules being:-

1. A hierarchy of information situations based upon farm sizes, and society membership, the 'External relationship.
2. A matrix of compatability information transactions, the Internal relationship.[33]

In a related piece of research Wolpert attempts to show that the difference between actual farm output and potential farm output is a function of behavioral factors such as lags in information flow.[34] Brown (1966, 1967, 1968a, 1968b) has made two important contributions to the geographical study of diffusions. Firstly, by extensive reviews he has brought together several spatial models not previously employed in a geographical context and in doing so also develops a general conceptual scheme.[35] Secondly, he has extended the Hägerstrand model

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[32] Wolpert; J., A Regional Simulation Model of Information Diffusion, Public Opinion Quarterly, (1966-7, p. 597-608).

[33] Ibid., p.

[34] Idem. The Decision Process in a Spatial Context, Annals Association of American Geographers, 1964, p. 537-558.

[35] Brown, L., Diffusion Processes and Location: A Conceptual Framework and Bibliography. Regional Science Research Institute. Bibliography Series #4 (1968).

to include notions of centrality by incorporating shopping trip behavior.[36] In the scheme, Brown (1968) identifies three problem areas, firstly the description and understanding of resistance to adoption, secondly, the incorporation of the time factor in the framework and finally the identification and measurement of parameters of spatial diffusion systems which are relevant to the pattern of diffusion (e.g. removal rate in epidemiological models). Besides these operational problems Brown also states that there is also required a "formal mathematical statement of the conceptual framework"[37].

If we return to the consideration of the literature specifically concerned with diffusion in central place systems the most recent statements can be considered. Bell (1966) studies the diffusion of radio and T.V. stations through the central place system of the U.S.A. and reaffirms the earlier hypothesis that initial or "first-use" occurrences can be quite random within any system, and thereafter diffuse through the system from low to high ranks. A gravity model is developed to predict the direction of similar diffusion, but is not tested.[38]

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[36] Idem. Diffusion Dynamics. Ph.D. thesis (unpublished), Northwestern University, Illinois, 1966.

[37] Idem. op. cit. (1968) p. 87 ff.

[38] Bell, W.H., The Diffusion of Radio & T.V. Broadcasting Stations in the U.S. M.A. thesis, Pennsylvania State University (Unpublished, 1965).

Boon (1967) uses a physical analogue of energy dissipation proportional to the masses of central-places to describe the progress of information through the rank of central places,[39] which determines that the innovation can only proceed down through the system.

Eidem (1968) examines the diffusion of innovations requiring community decisions (e.g. fluoridation, swimming pools) and attempts to use adoption dates as a surrogate of information flow.[40] The analysis is based upon the measurement of adoption patterns using the nearest neighbour method.[41] It is concluded from the variation in 'R' values that community innovations can be classified into market sharing or market dividing types.

Recently, Hudson (1969) has developed a model of diffusion (of information) in a central place system. Using the dominance hierarchical structure postulated by Christaller (1966 transl.) and the model of demographic force developed by Warntz (1964), he posits that the probability that a message will first reach a town at time "t" is a binomially distributed random variable. A comparison with some of

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[39] Boon, F. A Simple Model for the Diffusion of an Innovation in an Urban System. Center for Urban Studies: Background Paper #1, Chicago, Ill., Univ. of Chicago, (1967).

[40] Eidem, R.J. Innovation Diffusion Through the Urban Structure of North Dakota, M.A. Thesis, University of N. Dakota, (1968) (Unpublished).

[41] The nearest neighbour statistic "R" gives an index of the spacing of points in a pattern where R = observed mean distance between points/(.50 (area/number of points) - ½).

the data collected by Eidem (1968) suggests a measure of similarity.[42]

Contribution of Previous Research

The contribution of previous research to the study of innovation diffusion through urban systems has been to develop useful working hypotheses, yet none of these hypotheses have been tested rigorously except in the recent geographical literature. Statements concerning the diffusion process as a whole have been made by E. Rogers (1962) based on empirical observation rather than the development and testing of hypotheses.

Theoretical statements of diffusion in social groups, (Coleman, 1966) and communication in various types of networks, (Rapaport, 1953..) have not been tested in an empirical situation.

Non-geographical studies of diffusion in central place systems have not been aware of the observations and theoretical statement of centrality and interaction developed in geography, yet on the other hand, the majority of geographers have not shown interest in the dynamic processes of central-place systems such as innovation diffusion until very recently.

The most significant contributions of geographical studies of innovation diffusion have been specifically to advance certain

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[42] Hudson, J., Diffusion in a Central Place System. Geographical Analysis, Vol. 1 (1) 1969.

hypotheses developed in analyses at the micro level, but having greater generality as being scale free, the neighbourhood effect as a spatial process, and also using qualitative methods to describe and analyse observations and generally to illustrate the significance of behavioral factors in geographical situations. However, certain unresolved problems emerge:

(i) data concerning information flow is meagre hence the use of adoption dates as surrogates of information flow; this is further reflected in assumptions such as Hägerstrand's that adoption occurs immediately after telling; consequently, it is difficult to estimate resistance thresholds.

(ii) surrogates for communication used at the micro level (the mean information field) and at the macro level (gravity models) are aggregations of many individual contacts whereas the communication of information concerning an innovation is an individual act which may be made only once. This results in a discrepancy between channel capacity and actual amount of contact (Williams, 1968); and overlooks socio/psychological aspects of choice.

(iii) The role of the propagator has generally been understated which is surprising, considering that in a majority of situations the innovation is only available if a propagator can provide it.

(iv) little research has been conducted into those innovations requiring community decisions.

Overview

The conceptual framework defines the structure of the problem area, that is, decision making and innovation diffusion while the partial review of pertinent literature illustrates previous explorations of it or problems closely related. Drawing on each section a matrix of working hypotheses can be developed.

Matrix of Hypotheses

Concerned with information flow to be tested in Chapter 5	1.	Systems are analogous: diffusion as a process is scale free.
	2.	Date of Innovation awareness is closely associated with the population size of a central place.
	3.	A hierarchy of Information Flow exists.
	4.	A neighborhood effect modifies hypothesis #2 so that small centres near large centres are aware of innovations earlier than those further away.
	5.	Propagators are the main source of initial awareness, in this class of innovations.
	6.	Propagators have spatial behavior patterns which can be described in general terms.
Concerned with adoption Tested in Chapter 6	7.	Innovation adoption is related to city size.
	8.	Hypothesis #7 modified by the neighbourhood effect.
	9.	Hypothesis #7 modified by resistance thresholds of each central place which varies according to the specific innovation and size of centre.
Concerned with decision making Tested in Chapter 7	10.	In evaluation of an innovation, decision-making groups contact other centres.
	11.	Hypothesis #10 (a) described by distance decay, (b) perceived opportunities, (c) level of hierarchy.

The concepts described earlier and the hypotheses outlined above can be examined within the framework of a paradigm of the decision making process as applied to community innovations, particularly those requiring municipal decisions.

AN HYPOTHESIZED PARADIGM OF THE DECISION MAKING PROCESS IN THE PROCESSING OF INNOVATIONS BY COMMUNITIES

The paradigm is a form of large scale model which describes the

general structure of a particular research area such as the diffusion of innovations,(Haggett and Chorley, 1967). It is particularly useful in this instance because many models have been developed for particular aspects of the diffusion of innovations so that an overall cohesion is required[43] in a description of innovation decision processing.

The adopting system

A system of central places each sufficiently large to have a legally acknowledged decision-making body is composed of inter-connected socio-economic subsystems (Fig. 2). The structure of the system may be modelled in several forms.

As a normal function of system integration, information from both mass media and informal contacts is flowing through the system in hierarchical fashion, while the total amount of information processed by central places is related to size of centre. This process may be modelled by gravity formulations with the appropriate modifications according to socio-economic attributes.

The propagators

Individuals or groups interested in the propagation of an innovation, for profit or other motives, search out potential

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[43]Thus, Chorley & Haggett (1967) define paradigms as "in a sense a large-scale model .. and are rarely specifically formulated ... and refer to patterns of searching the real world," p. 26.

respondents. They contact the large centres first as these are the system's peers, or centres nearest to them because of transfer/transportation costs (Fig. 2), and also because propagators themselves locate in the larger centres.

Contact

A contact from the propagator sets off the adopter's evaluation process which, in formal groups, usually entails a defined procedure for considering strategic decisions. This process has several routines or procedures for which specific models may be constructed. (Fig. 2).

The overall structure of the process of evaluation and decision making may be modelled as a queuing analogue (Ruiz-Pala et. al. 1966).[44] Problems "arrive" and are designated "routine" or "strategic" (Fig. 2). An example of a routine problem is the annual collection of taxes in municipalities, while an example of a strategic decision would be evaluation of such innovations as the adoption of fluorides or construction of a civic mall.[45]

The first procedure is to estimate the average capacity of the system or the number of problems which can be effectively dealt with. This is a function of the number or frequency of "arrivals" or

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[44] Queuing models have been used so far to describe cars moving through tolls, critical path analyses of assemblies and similar industrial management problems - see for example A. Lee (1966).

[45] Matters requiring routine decisions occasionally develop into a problem requiring a strategic decision.

problems which require decisions and the organization of the system.

The probability distribution of arrival frequencies may be estimated from empirical observation where the time interval between successive arrivals is an independent random variable. The average arrival rate will be a reciprocal of mean time[46]

$$A = 1/T_a$$

In this instance the 'time of contact' by a propagator can be taken as the "arrival" and the innovation as the problem requiring a strategic decision.

Service time

The time interval between arrival and final strategic decision can be regarded as the "service" or process time. Process times again are independent random variables - where the average process time is[47]

$$P = 1/T_s$$

In formal groups, a form of queue discipline usually operates so that priorities are assigned to certain classes of problems. The service time is composed of three main sub-routines, (1) the actual decision-making when in the case of municipal councils members discuss the

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[46] Ruiz-Pala, E., et. al., op. cit., p.

[47] Ibid. p.

issue and come to a conclusion; (2) evaluation and searching, when contact is made with other councils or agencies for more information and finally, (3) the negotiations with the propagator.

Sub-routines

The two main sub-routines or decisions of geographical significance which together comprise the total service time are firstly the negotiations between adopter and propagator (which could be modelled with a game-theoretical approach) which is not considered in this thesis and secondly the routine of searching for more information. Hägerstrand models the latter sub-routine at the micro scale using contact probabilities based on mean information fields and Monte-Carlo simulation methods.[48] However, there are criticisms of this methodology since how this process of informal contact for information operates at the macro scale has yet to be identified and described.

The purpose of framing decision-processing as a queuing situation is to provide some general statements concerning the long-run behavior of the system, which can be used as a basis for both comparison and extrapolation and to examine in general terms those sub-routines of the decision making process which have geographical significance.

Overview

At this point it will be useful to review our progress so far prior to the actual empirical analysis. The purpose of this thesis

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[48] Hägerstrand, T., op. cit., 1963.

is to examine the process of change in a central place system using the concept of innovation diffusion and concentrating on those innovations requiring community decisions. This is undertaken in order to develop present understanding of this concept and also to examine its application in a system and at a scale hitherto neglected.

Innovation diffusion is defined in the conceptual framework as a decision making situation, a learning process having distinct sub components such as, awareness of the innovation, contact between propagator and adopter, contact between potential adopters and final decisions. Furthermore, the concept is also conceived as a spatial process where both the new idea and/or object spreads from location to location, having origins and destinations, paths of movement and influence between origins and destinations.

In the elaboration of the concept, numerous hypotheses have been advanced and tested in various situations. Consequently, a basic prerequisite to the formulation and development of these hypotheses is to specify in greater detail the characteristics of the concept, particularly, those aspects of geographical significance. Having achieved this the next step reviews the literature which is concerned with the diffusion of innovations requiring community decisions through a central place system. This is derived from sociological literature, studies of urbanization and geographical analyses of innovation diffusion. Hägerstrand's fundamental contribution is injected at this point to demonstrate how the transition of the concept from one scale to another is achieved.

From the conceptual framework and the review and assessment of previous literature a matrix of working hypotheses is developed. It specifies not only those hypotheses previously developed but indicates where the conceptual framework is weak and empirical knowledge is deficient. Two main areas of hypothesis formulation emerge which have fundamental geographical implications. Firstly, the relationship between population size of central place and the phases of the process and secondly the nature of inter-adopter influence. Thus, the analysis will attempt to develop and apply formulations of these hypotheses to data collected for the central place system of Southern Ontario.

The overall framework within which the hypotheses described above are organized, developed and applied is in the form of a queuing analogue. Thus, the decision making activity at a given location for a given innovation requiring a group decision is considered in terms of three main components, the arrival (awareness of the innovation), process time (the decision making activity), and the terminal (adoption decision). Thus, the queuing analogue seeks to organize understanding of the operative decision making process of innovation diffusion at a given location. In addition to developing the conceptual framework and hence describing it in general terms, it is hoped that an understanding of aspects of the process of change in the central place system of Southern Ontario is achieved.

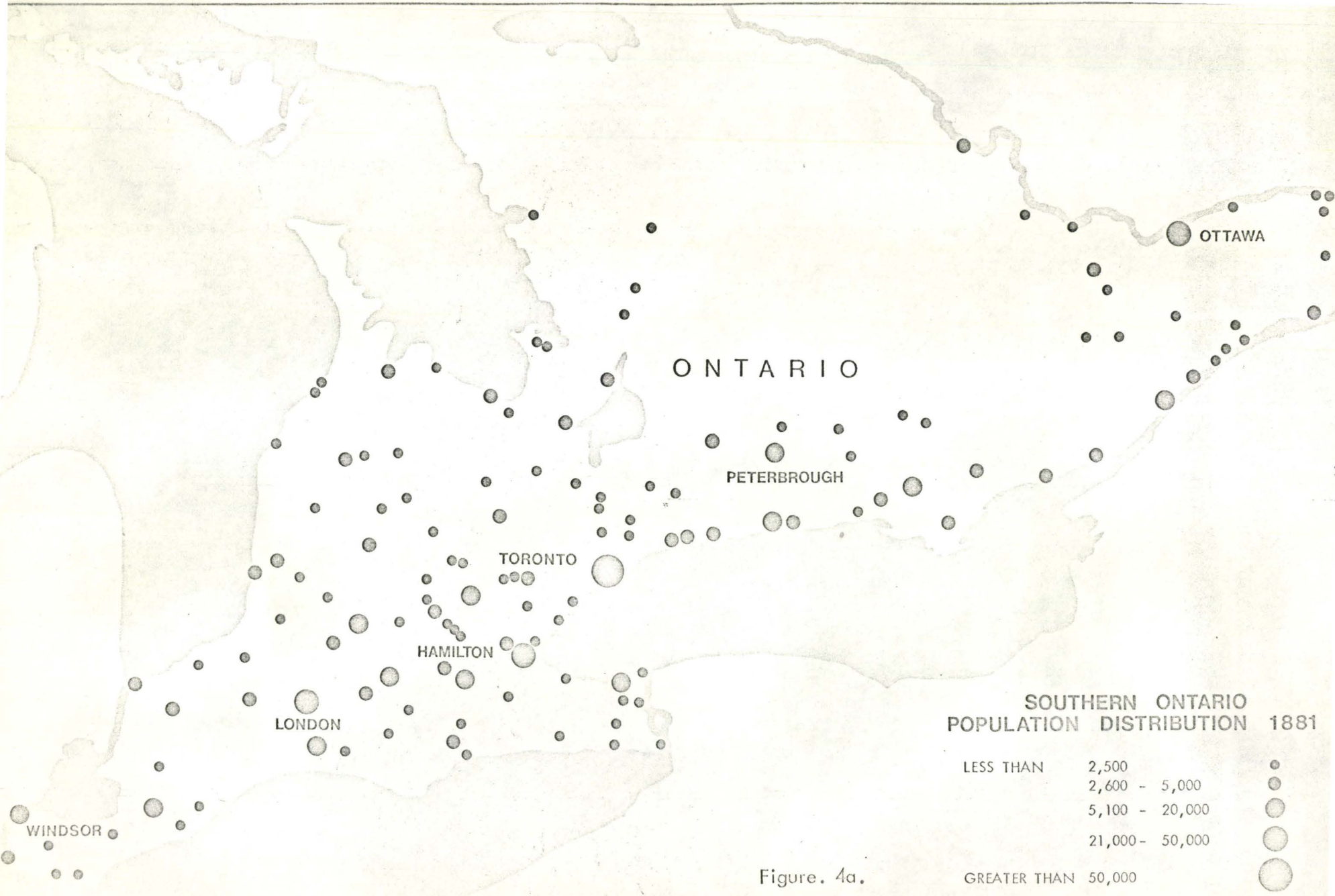
ONTARIO
OTTAWA
PETERBROUGH
TORONTO
HAMILTON
LONDON
WINDSOR
SOUTHERN ONTARIO
POPULATION DISTRIBUTION 1881
LESS THAN 2,500
2,600 - 5,000
5,100 - 20,000
21,000 - 50,000
GREATER THAN 50,000

Figure. 4a.

CHAPTER 4

The Context of Analysis

Having defined the problem, elaborated the conceptual area, explored the relevant literature and organized the analytical approach as a queuing analogue, we can now proceed to analyze the diffusion of innovations requiring community decisions through the central place system of Southern Ontario. A necessary preliminary to this, however, is to describe the nature of the system, the diffusing innovations, and the hypotheses and methods to be used.

The Spatial System.

The system of urban centres to be analyzed, (the potential adopting system) is comprised of the cities and towns of Southern Ontario which have populations greater than 1000 persons in 1881. This size is taken as the lower unit since many smaller centres experienced considerable population fluctuations during this period. Thus, 152 centres are considered. Historically, the urban frontier spread quickly through this area progressing from south to north so that large towns and cities are concentrated along the southern edge of the province (Figure 4). Centres concentrate in the South and west with an outlier cluster in the far eastern portion, avoiding the shield areas.

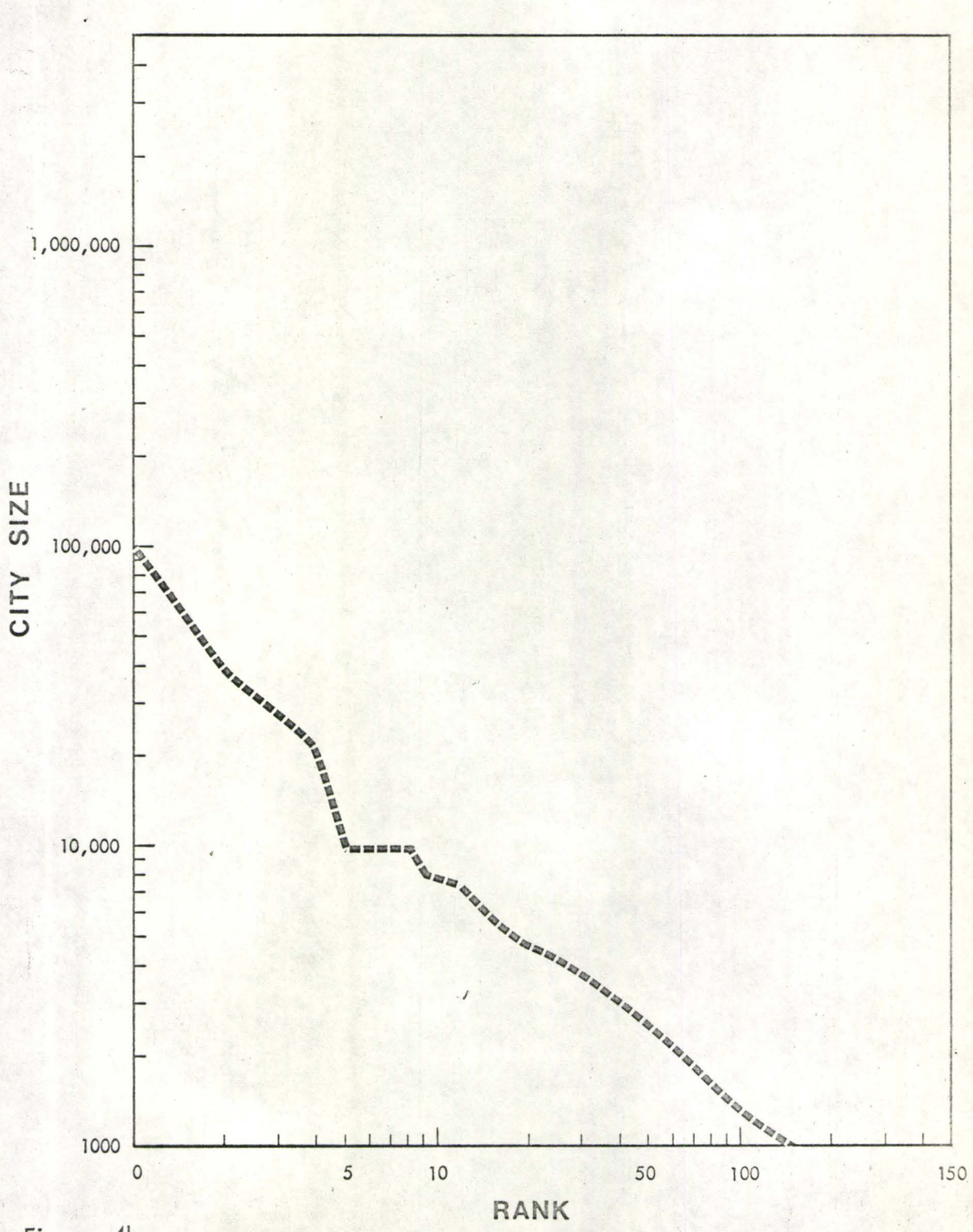
SOUTHERN ONTARIO RANKSIZE DISTRIBUTION
OF CENTRAL PLACES 1881
CITY SIZE
1,000,000
100,000
10,000
1000
0
5
10
50
100
150
RANK

Figure. 4b.

large American cities, such as Detroit and Buffalo which might influence the neighboring Canadian centres but which are not considered in this analysis.

The size distribution of centres is of the primate city type with Toronto being considerably larger than the second ranked city (Figure 4B).

The Diffusing Innovations

The innovations which diffuse through this system are: mechanics institutes, waterworks systems, electric power systems, filter systems, municipally controlled power systems, telephone systems, community centres/arenas, fluoridation, clubs, and credit unions. The first eight innovations required municipal decisions, while the remaining two innovations are associated with non-municipal sub-groups within the urban centres and are included for comparison. Thus, information concerning the ten innovations is available, however this information is not complete for all centres for all stages of the decision making process. This can be clarified by considering the three main stages of decision making.

The Decision Making Process

(1) The Awareness Phase: Arrival

From an examination of municipal records, the date of awareness of three of the innovations mentioned namely,

power systems	(18%)
municipally operated power systems	(32%)
fluoridation	(14%)

can be ascertained for a sample of the central places in the system. Sample size is parenthesized. While this sample is representative of all sizes of centre, a spatial bias is present. By virtue of the accessibility of municipal records, centres in the western half of the province are represented more than those in the eastern section.

From several sources information concerning the behavior of propagators in spreading awareness is available for a sample of centres, for the same innovations and in addition credit unions.

The Adoption Decision: The Terminal

From several sources the adoption date can be ascertained. For all innovations the sample is over 80% and in some cases 100%. The terminal decision is discussed prior to the analysis of decision making in order to make comparison of the two phases easier. The samples of adoption dates are much larger since definite decisions to adopt innovations are usually recorded in several sources. This contrasts therefore with the awareness phase where the flow of ideas in a system is only recorded in obscure places. However, records for awareness do exist in group situations as opposed to the micro level studies where recourse has to be made to "recall" methods.

The Decision Making Activity: The Process Time

From the examination of municipal records described above a sample of approximately 25% of the centres provides information concerning (1) inter centre contacts
(2) inter centre contacts (innovations)
(3) frequency of arrivals.

Again, different sized centres are represented in the sample, but the spatial bias mentioned above is present.

Hypotheses

It can be seen that data is available for the three main components of the queuing paradigm, the arrival, the processing and the terminal. The samples are limited and biased in certain ways. It is for this reason that the hypotheses tested are elementary in conception. However they are tested repeatedly for the different phases of the process. Yet at the same time, their validation is fundamental to understanding the process.

The first main hypothesis which is tested attempts to describe the relationship between the population size of centre and the ordering in time of phases of the process. In other words a simple demographic relationship.

The second main hypothesis attempts to describe the nature of the spread of phases of the process in terms of the behavior of propagators, and secondly inter adopter influence and whether these modify the first hypothesis. From this it should be possible to derive some statement of the scale-free nature of the process.

Methods

The approach adopted is to describe in graph and map form the spread of phases of the process through the system. Simple statistical methods (linear and areal) are used to test the developed hypotheses, while a measure of spatial ordering is also formulated.

These are discussed in more detail as they are applied, at various stages of the analysis.

CHAPTER 5

Analysis of the Awareness of Innovation: the Arrival

Introduction

It is shown in the conceptualization of the problem that awareness and the associated flow of information is the first phase of the decision making process. However, it is also shown that our understanding of this phase and subsequent decision making is relatively underdeveloped. This is borne out by the common assumption in model formulation that adoption occurs as soon as knowing occurs.

Consequently, in this chapter we attempt to describe aspects of the flow of information, in terms of the city size factor and the spatial development of awareness. Furthermore to understand the associated processes involved in the testing of these hypotheses a preliminary examination of the source of awareness, the propagator, is also undertaken.

People become aware of innovations through information received through the mass media and also through informal personal contacts.[1] Tarde (1905) is the first to differentiate between the circulation of new ideas and the actual object itself. However, it is not until Ryan and Gross (1943) demonstrate the existence of a normal distribution of innovation awareness (of new knowers) followed at a

later period in time by a normal distribution of adoptions, that Tarde's hypothesis is confirmed. The learning/adoption process has since been refined whereby sub-phases of awareness, interest, evaluation, trial and adoption are distinguished,(Rogers 1962). However, there has been little corresponding empirical research to determine the variation which occurs during these phases. However, differentiation between information circulation and adoption decisions in terms of resistance thresholds described by geographical attributes is a fundamental feature of Hägerstrand's models. (1952, 1966).[2]

The Sources of Information and the Growth of Awareness

Communities become aware of innovations through the mass media and through the specific contacts made when a propagator interested in spreading the innovation contacts a municipal council.[3] While it has been shown conclusively that personal contacts are more important in influencing strategic decisions than the mass media [4] during evaluation, an examination of the latter information system might give a preliminary indication of information processing by communities.

An examination is made of newspaper references to the innovation of electric power systems in Southern Ontario during the period 1880-1890. Figure 5 shows the frequency of lines of information

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[2]Other recent studies have concentrated on adoption decisions. only. See especially the studies of fluoridation decisions.

[3]This type of information flow as modelled by Hudson, J. op. cit. (1969), is different from the flow of information during evaluation.

[4]Lazarsfield, P. op. cit. (1948)

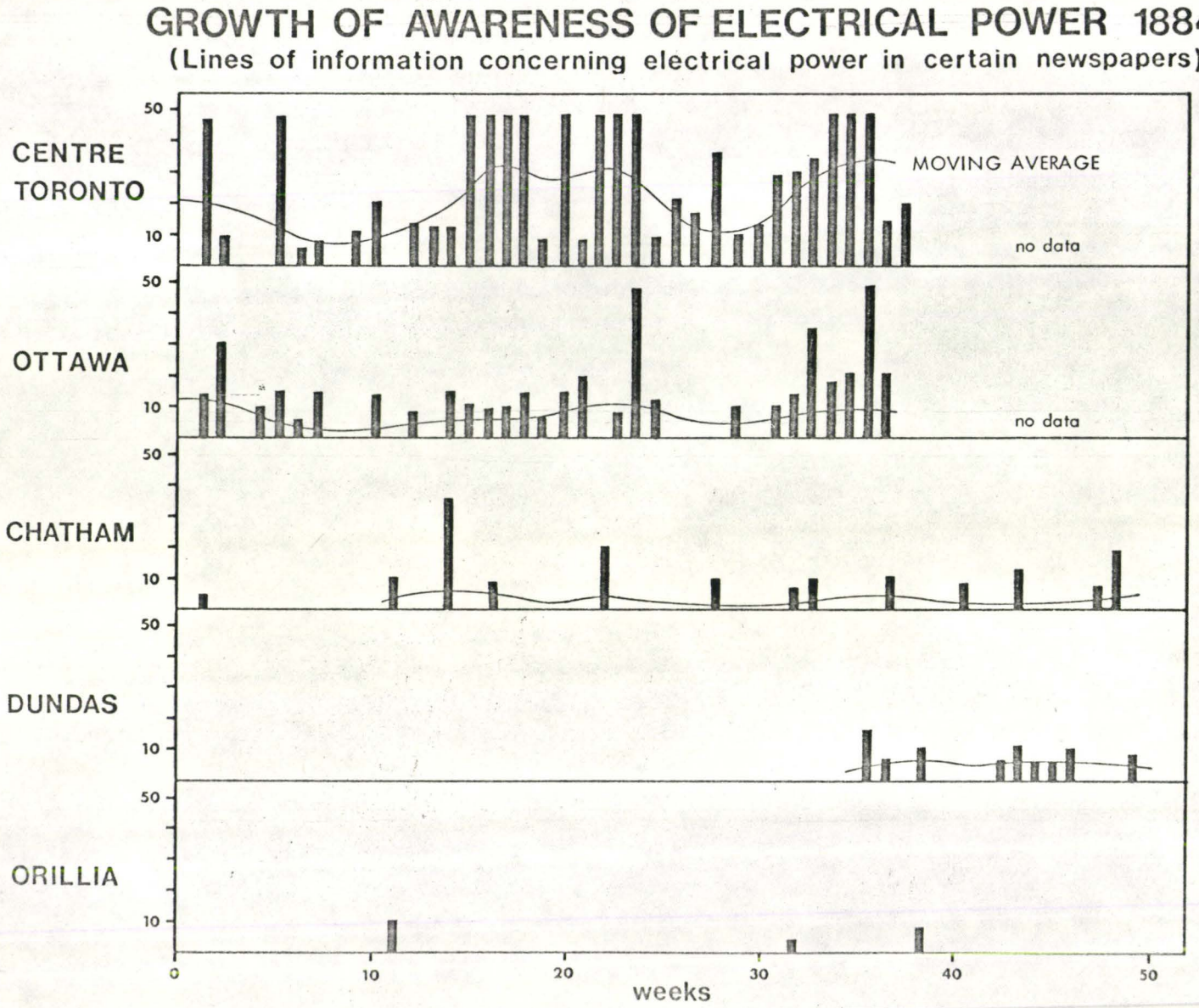
GROWTH OF AWARENESS OF ELECTRICAL POWER 1884.
(Lines of information concerning electrical power in certain newspapers)
CENTRE TORONTO
MOVING AVERAGE
no data
OTTAWA
no data
CHATHAM
DUNDAS
ORILLIA
50
10
0
10
20
30
40
50
weeks

Figure. 5.

about electric power in certain newspapers representative of various sized centres in Southern Ontario. Ideally, it would be better to have such information on several innovations but the problems of collection are considerable.

However, certain observations can be made concerning the distributions of different amounts of information about this innovation.

1. The total amount of information processed by the system gradually increases through time; the system is gradually learning.

2. The total amount of information processed by the different communities appears to have a positive relationship with the size of centre concerned.

3. Larger centres appear to have been aware of the innovation before the smaller centres.

4. Information transmitted through the system appears to have a characteristic wave form with irregular surges of information occurring.[5]

Despite the fact that this preliminary examination of mass media information refers to one innovation only and that it is for one form of mass media, certain time trends and city size associations are indicated. For a more precise indication of the occurrence of

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[5]For an interesting analysis of wavelet composition of time series see Robinson, E.A., in Wold, H.A. Econometric Model Building p. 37-105 (North-Holland, Amsterdam, 1964).

ORIGINS OF INITIAL CONTACTS CONCERNING INNOVATION REQUIRING MUNICIPAL COUNCIL DECISION

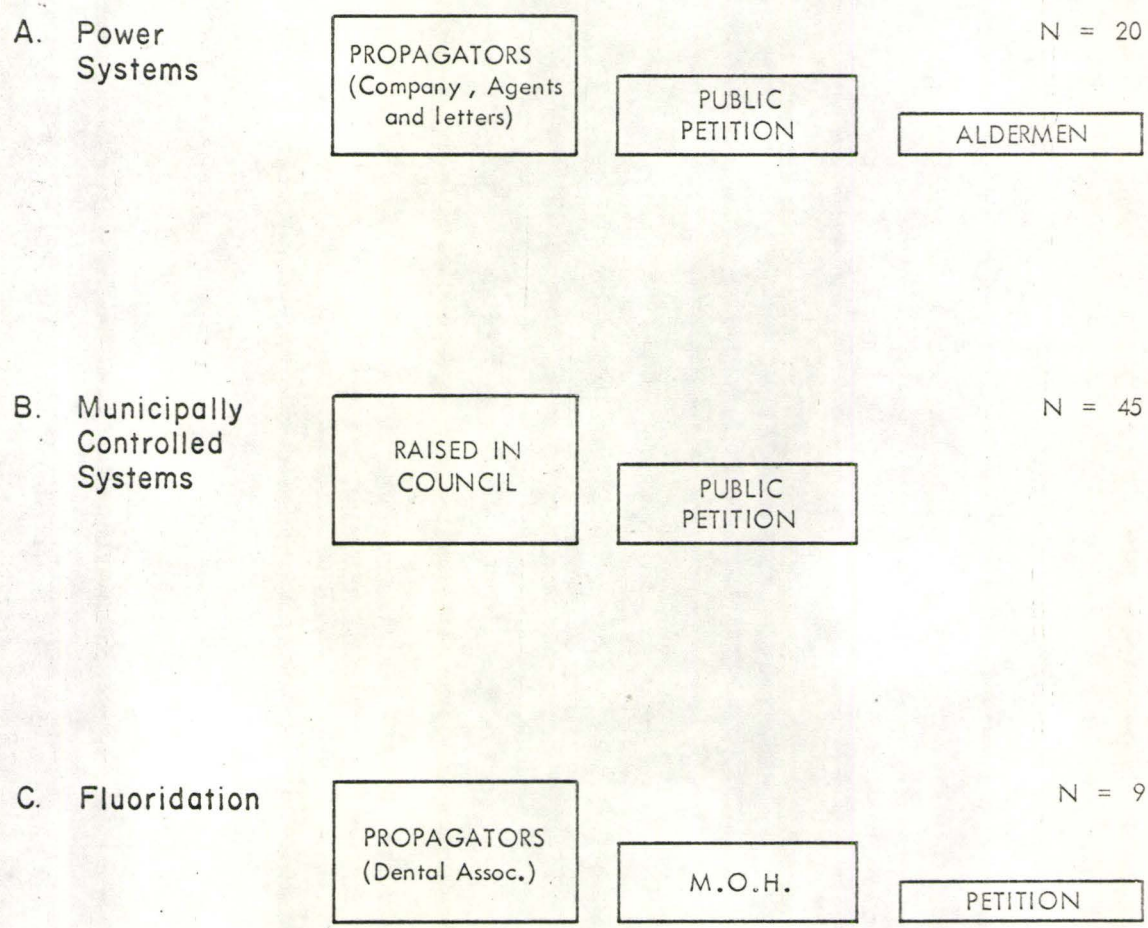

Figure. 6.

Contacts are the outcome of contact by a propagator, public petition, or interest groups. In the case of municipally controlled systems public agitation was probably more significant than indicated since council action was usually the result of local discussion in the community.

awareness we must turn to an examination of the specific contacts by propagators received by municipalities concerning power systems, municipally controlled power systems, and fluoridation.

The Growth of Awareness

The dates at which municipal councils become aware of innovations can be ascertained from the minutes and records of city council meetings. Thus, although information may be circulating in the mass media prior to the first mention in the city records (as indicated in the observations above) this information does not impinge upon the role of the decision makers which is to process current problems. The awareness is the result of contact by various propagators interested, financially or otherwise, in the spread of the innovation. (Figure 6). In the case of power systems, awareness spreads during the 1880's; company agents are the most significant source of initial awareness. This is understandable in that they are directly concerned with spreading a technological innovation. However, public petition is also significant representing perhaps the effects of the mass media in spreading information. Where municipally controlled power systems are concerned, awareness spreads during the late 1880's and 1890's; this represents a change in municipal responsibilities, therefore the councils themselves would be particularly aware of this innovation. Finally, in the case of fluoridation of water systems where awareness spreads during the 1950's and 1960's, although their motives are not financial, the dental and medical associations are similar to the

CITY SIZE AND AWARENESS OF POWER SYSTEMS 1883 — 1890

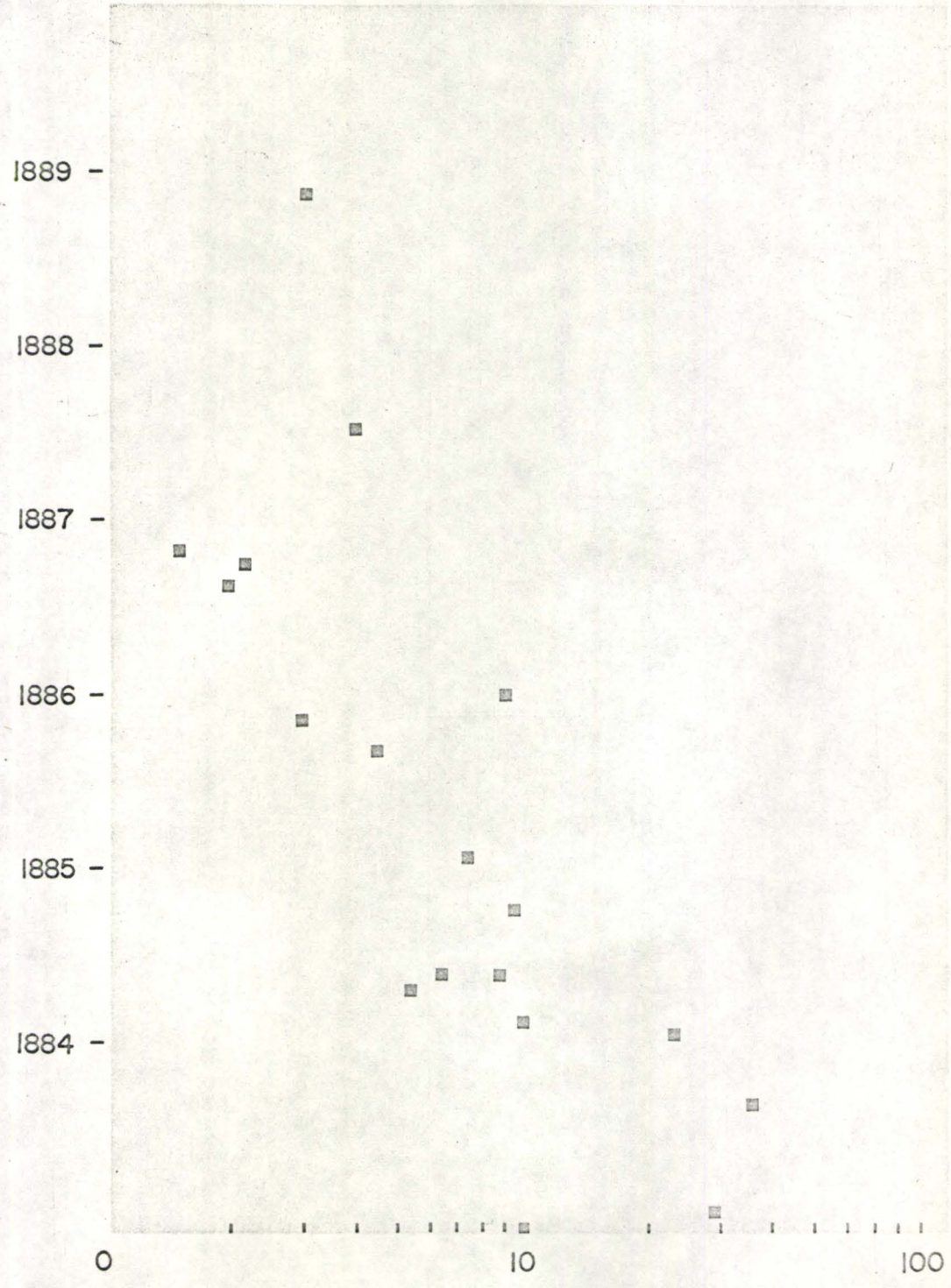

Figure. 7.

agents of the power companies, in that they are professional interest groups, concerned with the spread of the innovation.

Awareness and Size of Centre

The first hypothesis which can be tested, is that the date of innovation awareness is related to the population size of central place in that large centres are aware earlier than smaller centres, since there were strong indications from the variation in mass media information (described above) that such an association is present. The relationship between date of awareness of electric power systems and size of central place is shown in Figure 7. It can be seen from Figure 7 that if the date of awareness is taken as the dependent variable, and the size of central place is taken as the independent variable, a negative relationship appears to exist. The null hypothesis can be framed as follows:

"There is no relationship between awareness date and population size of centre."

A suitable measure of correlation between the two variables may be obtained using Spearman's Rank correlation coefficient r.[6] A significant correlation between the awareness date of electric power systems (operated by private companies) and population size of centre appears to exist where, r = .68; with 18 degrees of freedom this

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[6] Gregory, S. Statistical Methods and the Geographer (1964). p. 181. Spearman's coefficient "r" has a power of about 91 % of a comparable parametric test.

CITY SIZE
AND AWARENESS OF POWER SYSTEMS
1890 – 1905

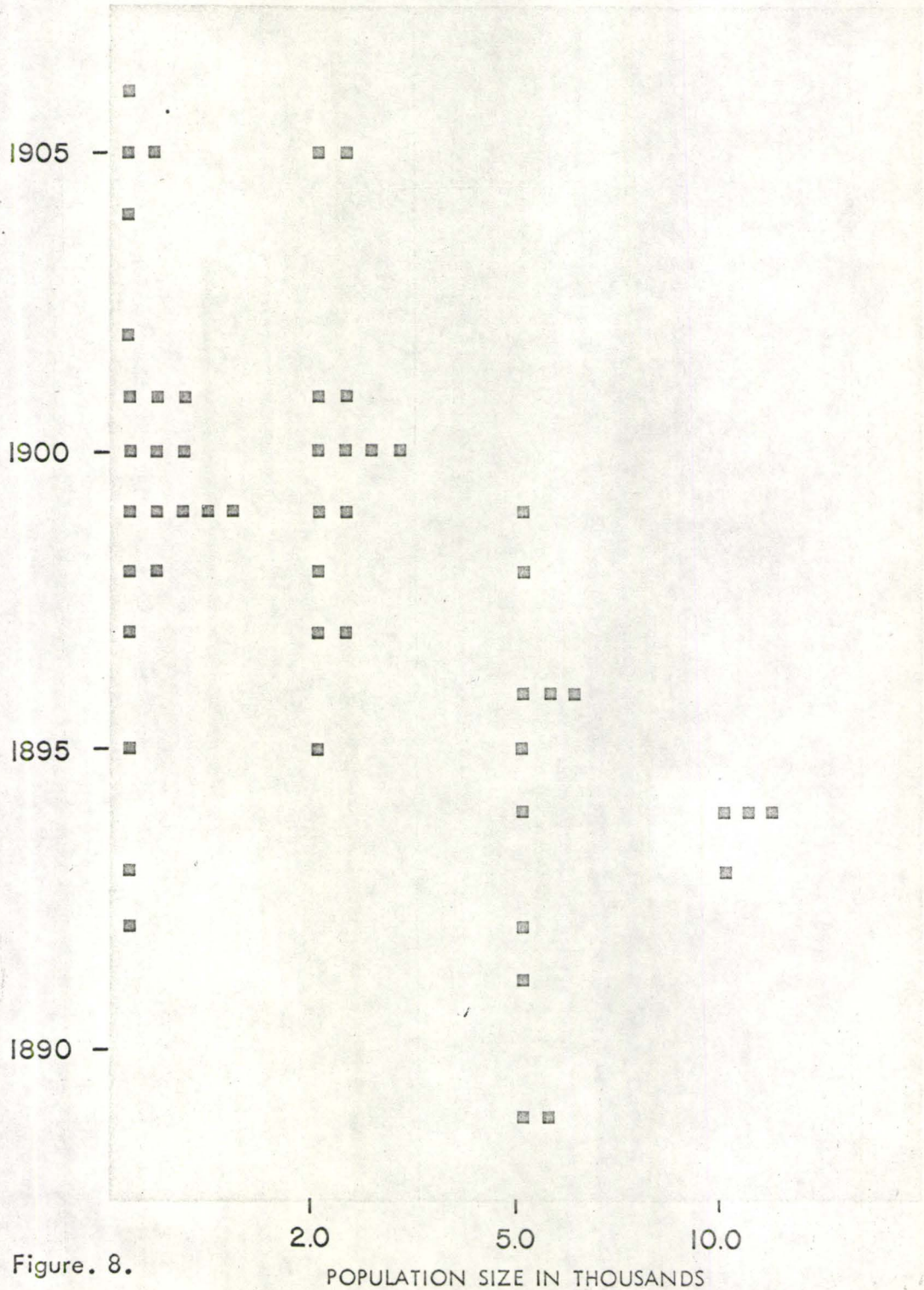

Figure. 8.

coefficient is significant at the 1% level; i.e. the probability of this type of arrangement being due to chance is .01 - based on the student's t distribution.[7] Therefore the null hypothesis may be rejected.

Turning to the awareness of municipally owned power systems, Figure 8 shows the relationship between the corresponding awareness dates and population size of centres, suggesting that a similar correlation should exist. Using the Spearman Rank correlation method, a correlation coefficient of $r = .54$ is obtained.

With 50 degrees of freedom this value is significant at the 1% level, based on the student's t distribution. Finally, an examination of the awareness dates of the fluoridation of municipal water systems suggests that a similar correlation between the two variables exists. The same method of correlation is applied. However, the correlation coefficient of $r = .49$ is not significant even at the 5% level, consequently one would have to accept the null hypothesis that no relationship exists.

However, an important consideration here might be the number of sample points involved, since the coefficient value is clearly in the right direction and the distribution of points is similar to the distributions shown in Figures 7 and 8. However, there might be a real difference in the spread of information through city systems

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[7] Idem. p. 181

CITY SIZE AND AWARENESS OF FLUORIDATION 1944 – 1966

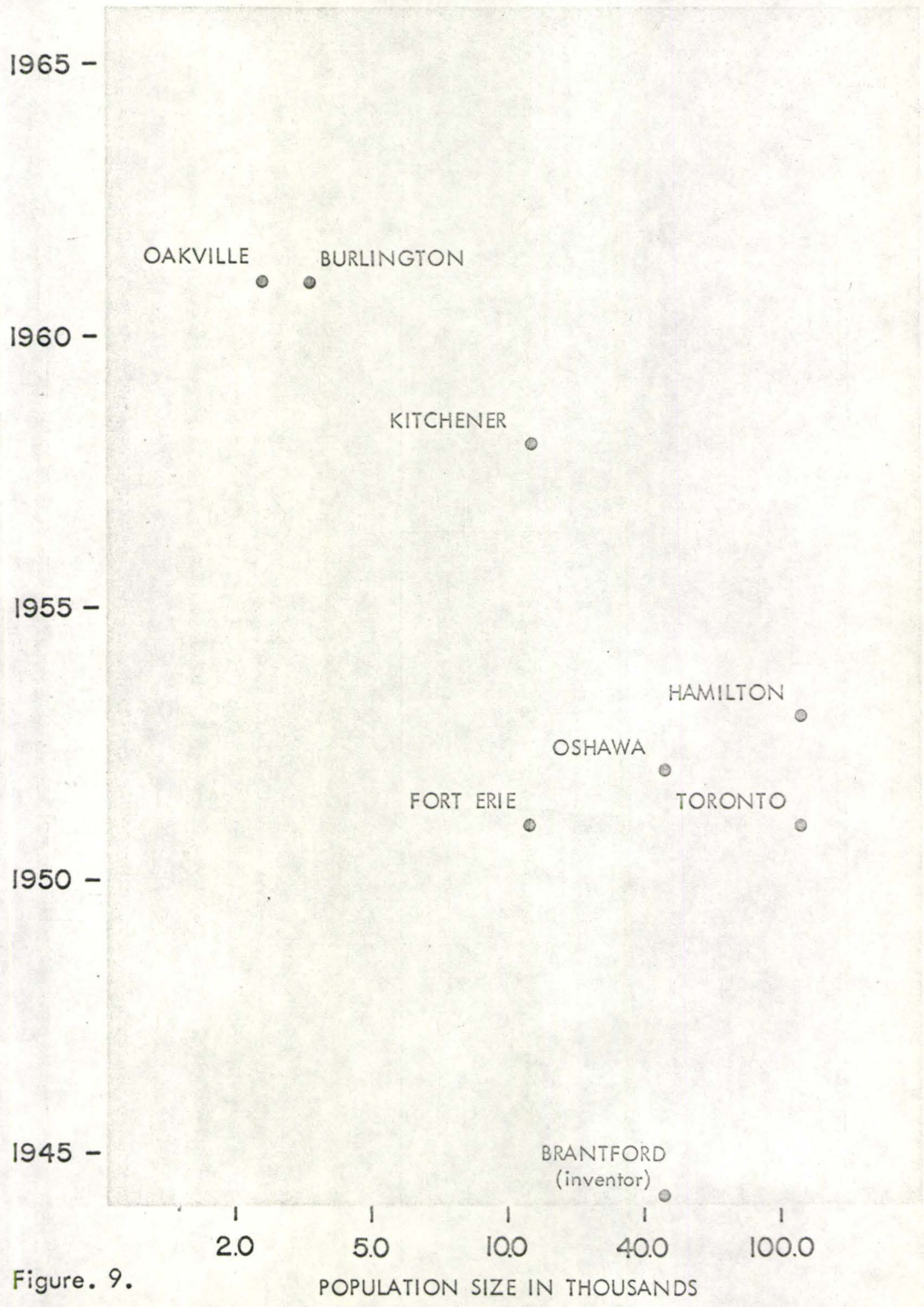

Figure. 9.

between the three innovations considered. Clearly, a more detailed examination of this process is required. Tentatively it can be concluded that a correlation between dates of awareness of innovations and size of central place occurs.

Variance

If Figure 8 is examined closely it can be seen that variance in awareness dates increases considerably as the size of centre decreases. This in itself is not totally unexpected.[8] However, the fact that some members of the class of smallest centres are aware early is contrary to the concept of information flow in an hierarchical system; consequently, it was decided to check the historical circumstances associated with the diffusion of this innovation.

At St. Catharines, the feasibility of a municipal power system was raised in 1887 and a committee visited other places to gain further information.[9] However, no action was taken. The issue was raised again in 1895 which is in keeping with the flow of information concept, shown in Figure 8 when the main phase of awareness occurs. At Windsor, the local power company began operations in 1884, but, by 1885 the town was dissatisfied with the service. The company continued to experience trouble so that by 1887, they were offering to

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[8] Thompson, W. (1965) op. cit. p. 27.

[9] Minutes of Council Meetings, St. Catharines. Provincial Archives of Ontario, Toronto. (unpublished).

sell out to the town.[10] Consequently, it can be seen that in the case of some centres, local conditions lead to them being aware of the innovation long before the majority of centres and even centres that are larger than themselves. The main period of information flow spreads during the 1890's associated with the attempts to reform city government.

However, even in the main period of awareness during the 1890's it is apparent that certain small centres are aware earlier than others for no readily discernible historical reasons. Consequently, to account for these variations in the development of awareness dates we turn to an examination of the spatial patterns of awareness, since spatial variation in the flow of information would modify the city size hypothesis.

Patterns of Awareness

It is shown that an association appears to exist between date of innovation awareness and the population size of central place. It is also apparent that a considerable variation exists in the awareness dates of the smaller central places.

The neighbourhood hypothesis

It is hypothesised that in the spatial development of information potential knowers close to a previous knower have a higher probability of becoming new knowers than those further away. The concept has

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[10] Minutes of Council Meetings, Chatham. Provincial Archives of Ontario, Toronto. (unpublished).

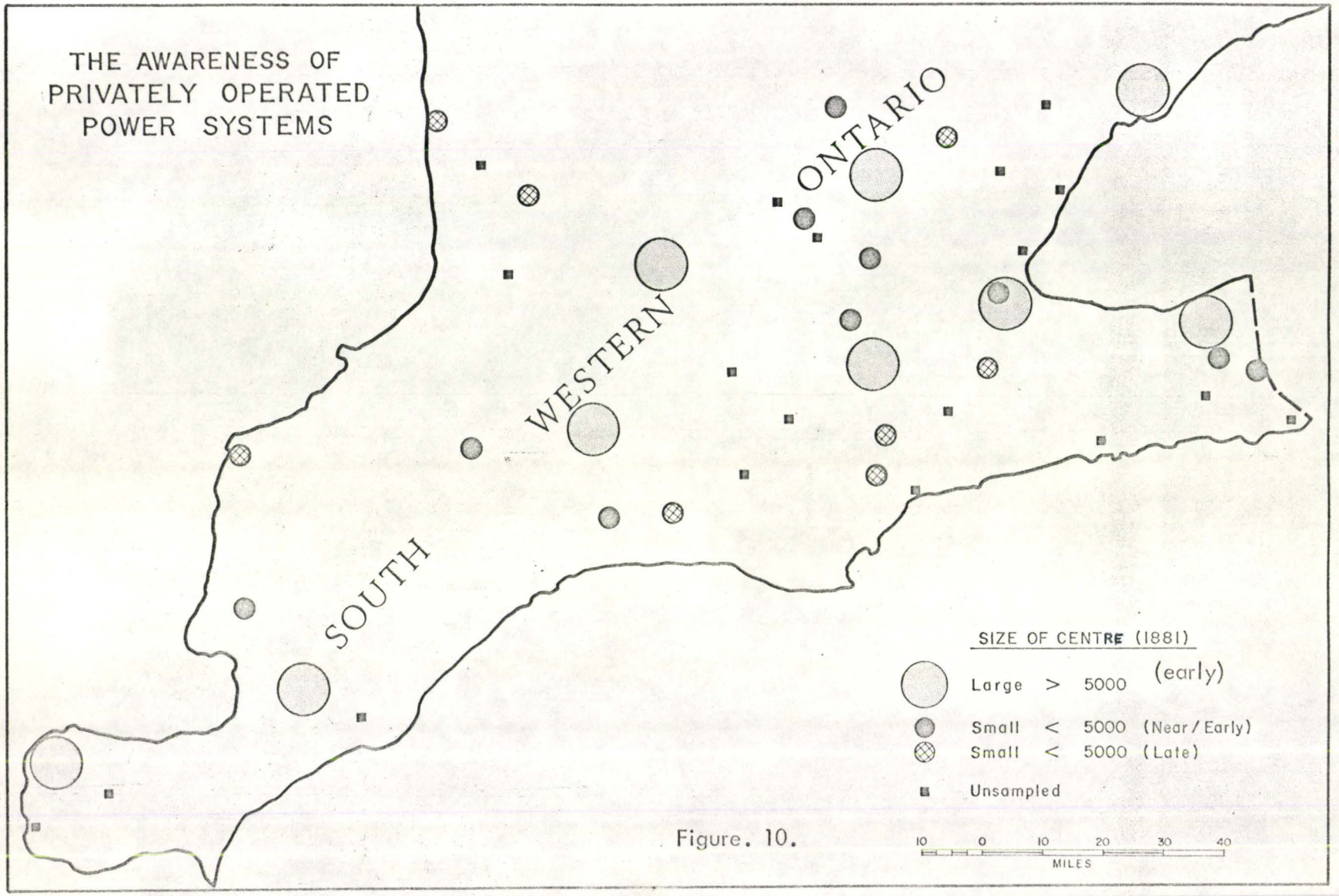
THE AWARENESS OF
PRIVATELY OPERATED
POWER SYSTEMS
ONTARIO
WESTERN
SOUTH
SIZE OF CENTRE (1881)
Large > 5000 (early)
Small < 5000 (Near / Early)
Small < 5000 (Late)
Unsampled
10 0 10 20 30 40
MILES

Figure. 10.

mainly been applied to individuals although recently Hägerstrand (1966) also applied the concept to a central place system. Thus, in the latter case if the hypothesis is true, one would expect small centres close to large centres which were knowers, to become aware earlier than those further away even if the latter were larger, thus disturbing the awareness date city-size association. However, the analyses have been applied to adoption dates rather than awareness dates, with the assumption that adoption occurs as soon as awareness.[11] Recent applications of statistical tests to adoption dates throw doubt upon the validity of the "neighbourhood effect" (Cliff, 1968) at the micro scale suggesting that the spatial development is not significantly different from random. Consequently, the next step is to analyse the spatial development of awareness for evidence of a "neighbourhood effect".

The spatial development of awareness of electrical power systems in South West Ontario is shown in Figure 10. It is apparent first of all that the larger centres are aware before all the smaller centres. There is some indication that the small centres close to the larger centres become aware earlier than those further away, however there are insufficient points to test the hypothesis effectively.

Figure 11 shows the spatial development of awareness of municipally controlled power systems during the 1890's. It once again appears that there is a suggestion of a neighbourhood effect in that certain

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[11] Hägerstrand, T. op. cit. (1965), p. 267.

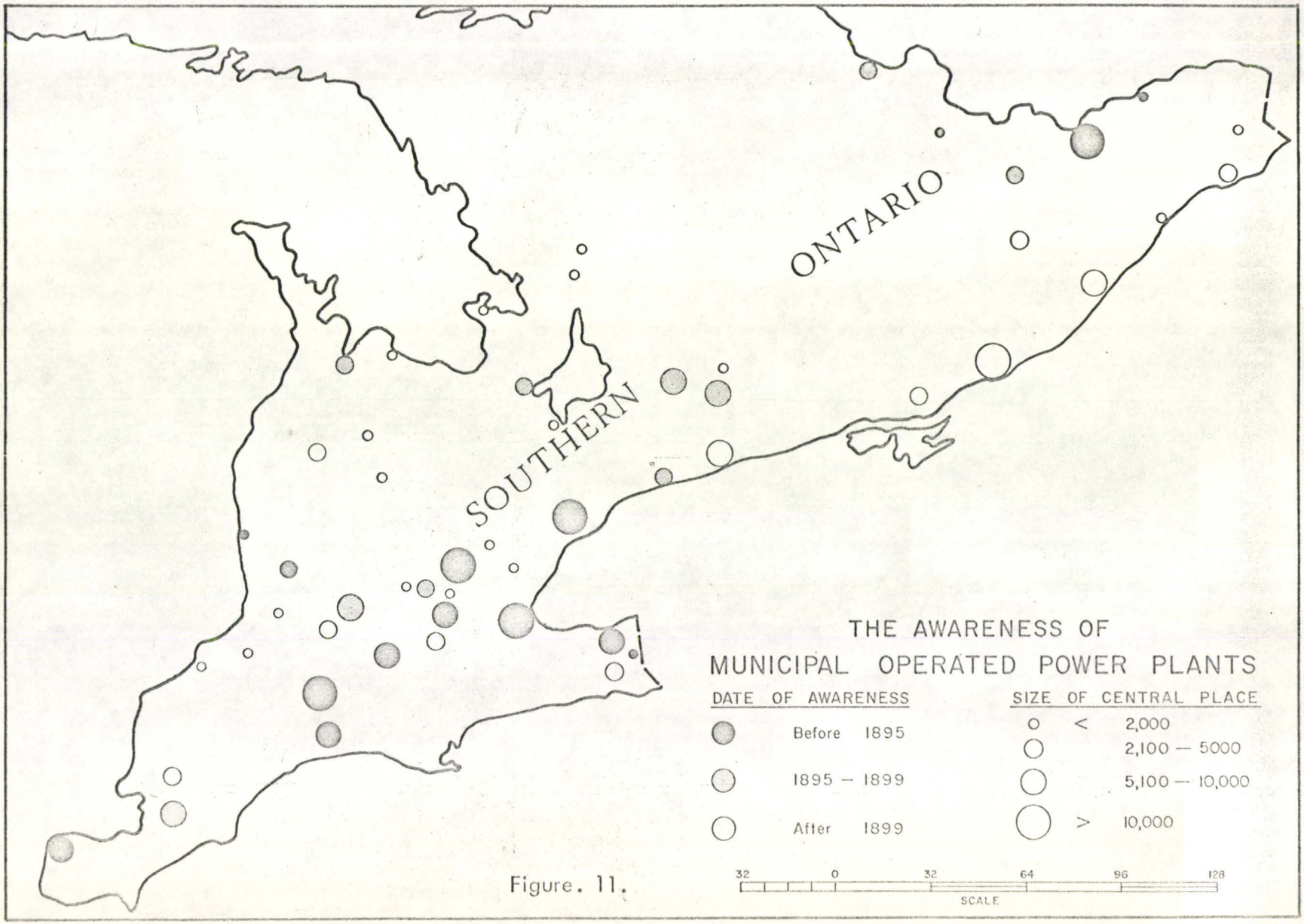
ONTARIO
SOUTHERN
THE AWARENESS OF
MUNICIPAL OPERATED POWER PLANTS
DATE OF AWARENESS
Before 1895
1895 — 1899
After 1899
SIZE OF CENTRAL PLACE
< 2,000
2,100 — 5000
5,100 — 10,000
> 10,000
32 0 32 64 96 128
SCALE

Figure. 11.

small centres close to the larger centres are aware before those small centres further away. The effect seems to be more apparent in the case of the latter innovation than the former.

Clearly a more rigorous test of the neighbourhood effect is required. Several methods have been developed to describe the relative location of points in pattern arrangements. The methods can be classed into two main groups, quadrant counting and order neighbor distance measures. From these measurements an index of the degree of clustering can be ascertained; if successive patterns are examined for a certain area over time one can estimate whether the process was ordered or random. In view of the problems associated with these methods (they will be discussed in greater detail in the analysis of the spatial development of adoption dates) coupled with the restrictions of this set of data (the small number of sample points) a comparatively simple test was developed to determine whether the neighbourhood effect was present.

The method employed is as follows: -

1. Categorize the central places into <u>large</u> and <u>small</u>. In this case the division was set at 7,000 (population) since a distinct break in the distribution of central places occurs at this level. (1881 census).

2. Categorize small centres into either <u>early</u> or <u>late</u> taking the median date of awareness as the division.

3. Measure the distances of all the small centres from the nearest large centre which was a prior knower. The small centres can then be dichotomized into near and far with the division made at the median distance of all centres from a larger centre.

The hypothesis can then be set up as follows:-

The average distance of small centres which were aware early, from a larger centre which was aware earlier, is not significantly different from the average distance between small centres and large centres.

The alternate hypothesis is that a significant difference does exist. Since the frequencies of distances are normally distributed the ratio of observed mean - total mean: deviation can be used.

$$\frac{x - \bar{x}}{\sigma} = \frac{52 - 64}{32} = .37$$

An examination of the normal distribution function shows that the null hypothesis must be accepted at the .05 level. Thus, the probability of this type of arrangement occurring by chance is 1 in 3.5. Therefore, there does not seem to be any firm evidence of a neighbourhood effect in the flow of information, as opposed to a random development.

Discussion

A preliminary examination of the newspaper references to the development of electric power systems shows that central places accumulate information through time, similar to the learning curves of individuals. The amount of information accumulation appears to

have a close association with the population size of central place concerned. It also appears that the accumulation of information came as a result of surges of information frequency.

An examination of the specific contacts made by propagators in the spread of power systems, municipally controlled systems, and fluoridation show that large centres tended to be aware of innovations before small centres even though a variety of sources of propagation existed. These observations are in accord with the notions of interaction in urban systems as formulated in gravity models.[12] It is also apparent that a certain number of small centres are aware of power systems prior to larger centres. Although it is apparent that due to historical circumstances two centres were earlier than the size factor would have predicted it is also apparent that some other small centres were aware before larger centres. It was decided therefore to test whether a "neighbourhood effect" occurs since this would disturb the centre/size-awareness/date relationship.[13] However, the analysis of the spatial development of information concerning municipally controlled systems (since there were the greatest number of sample points for this innovation as opposed to power systems and fluoridation) shows that small centres which are early knowers are not significantly nearer to the larger earlier knowers than small

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[12]For a detailed review see: Olsson, G. op. cit. (1966).

[13]Hägerstrand, T. (1966) p. 40.

centres as a whole. The analysis is not entirely conclusive. In the first case the number of sample points is rather small which may have distorted the result. Secondly and on the other hand, although the level of significance moved to reject the hypothesis of a neighbourhood effect, the results were in the right direction.[14]

Clearly, a more thorough investigation of this hypothesis is required; however, it has been shown that a potential source of information for testing this hypothesis lies in the records of municipal meetings, where the awareness of innovations requiring community decisions is recorded. The contacts received by the municipal bodies represent the outcome of the activities of propagators. To see whether the behavior of propagators can throw any light on the spatial development of awareness such as the lack of a distinct neighborhood effect we must examine more closely their activities in space.

The Activities of Propagators

It has been shown that dates of innovation awareness have a close association with the population size of central place. While there is no firm evidence of a neighbourhood effect and since awareness is mainly the outcome of contacts by propagators, an examination of propagators' activities would clarify our understanding of how

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[14] In addition, the data may have been exceptional, but, population inhomogeneities were accounted for. See Cliff, A.D. (1968) p. 82 for further discussion of these points.

TABLE 1

INNOVATION	PROPAGATORS	LOCATION	TERRITORY
Electric Power Supply	Agents for Competing Companies	Large Cities e.g. Toronto (1 exception)	Southern Ontario
Municipally Controlled Power Systems	A few individuals	Towns of Central South West Ontario	Towns of South West Ontario
Fluoridation	Local M.O.H. and Dental Assoc. Field Agents	Toronto	Larger Centres
Credit Unions (Phase A)	Field Agent	Quebec City	French N. America
(Phase B)	Field Agents	Initially U.S.A., later Toronto	Industrial Centres

Table to show the type of propagators and their location in the central place system and field of movement.

awareness develops in this class of innovations since propagators appear to have a city size preference.

Recently, Brown (1966, 1968) has incorporated the propagator in the conceptual framework of innovation diffusion, as applied to those innovations which require the individual to journey to a central place in order to contact the propagator (i.e. a retail situation). In the class of innovations considered here, the propagator, although having a fixed location, journeys to the potential adopter and thereby has a field of movement. (cf. travelling salesmen). Consequently, it will be useful to understand the role and spatial behaviour of the propagator in this class of innovations.

Data is available concerning the behaviour of propagators interested in spreading electric power plants, municipally run power plants, fluoridation and credit unions. The main characteristics of propagation in each case are categorized in table form shown opposite. While credit unions did not require municipal decisions, they are nevertheless community innovations and as such are included in this class of innovations for purposes of comparison.

Power Companies

The location of electrical manufacturing companies from which agents contacted municipalities in the late nineteenth century are shown in Figure 12. In addition to those located in Ontario, companies in the United States and Montreal were also active in Ontario.

The market condition in North America for electrical manufacturers was according to H. Passer (1953) one of easy entry for new companies. This also appears to have been the situation in Ontario where the number of new companies increased rapidly during the decade 1880-1890, so that there were soon several competing manufacturers of electric power systems.[15]

It is apparent from Figure 12 that manufacturers chose to locate in the large urban centres of Southern Ontario, Toronto(1), Ottawa (not shown), Hamilton(2), London(3), Peterborough(4), with the exception located at Waterford(5). The usual procedure adopted in company negotiation with municipalities was that the company would contact the municipality and offer a complete street-lighting and power system to be run by a locally organized subsidiary. The initial contact would be in the form of a circular and after the initial response of the municipality, companies would send agents to obtain a more definite response. The municipality would usually examine more than one tender before coming to a decision. (The decision processing by municipalities will be examined in greater detail later).

From records of the Ontario Hydro Archives it can be established at what date specific adopters (municipalities) began operating power plants and also from which company these electric light/power systems

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[15]The incorporation dates of electrical manufacturing companies can be found in Ontario Sessional Papers, Vol. 24 (1892) and in succeeding years. By 1890 six were in operation.

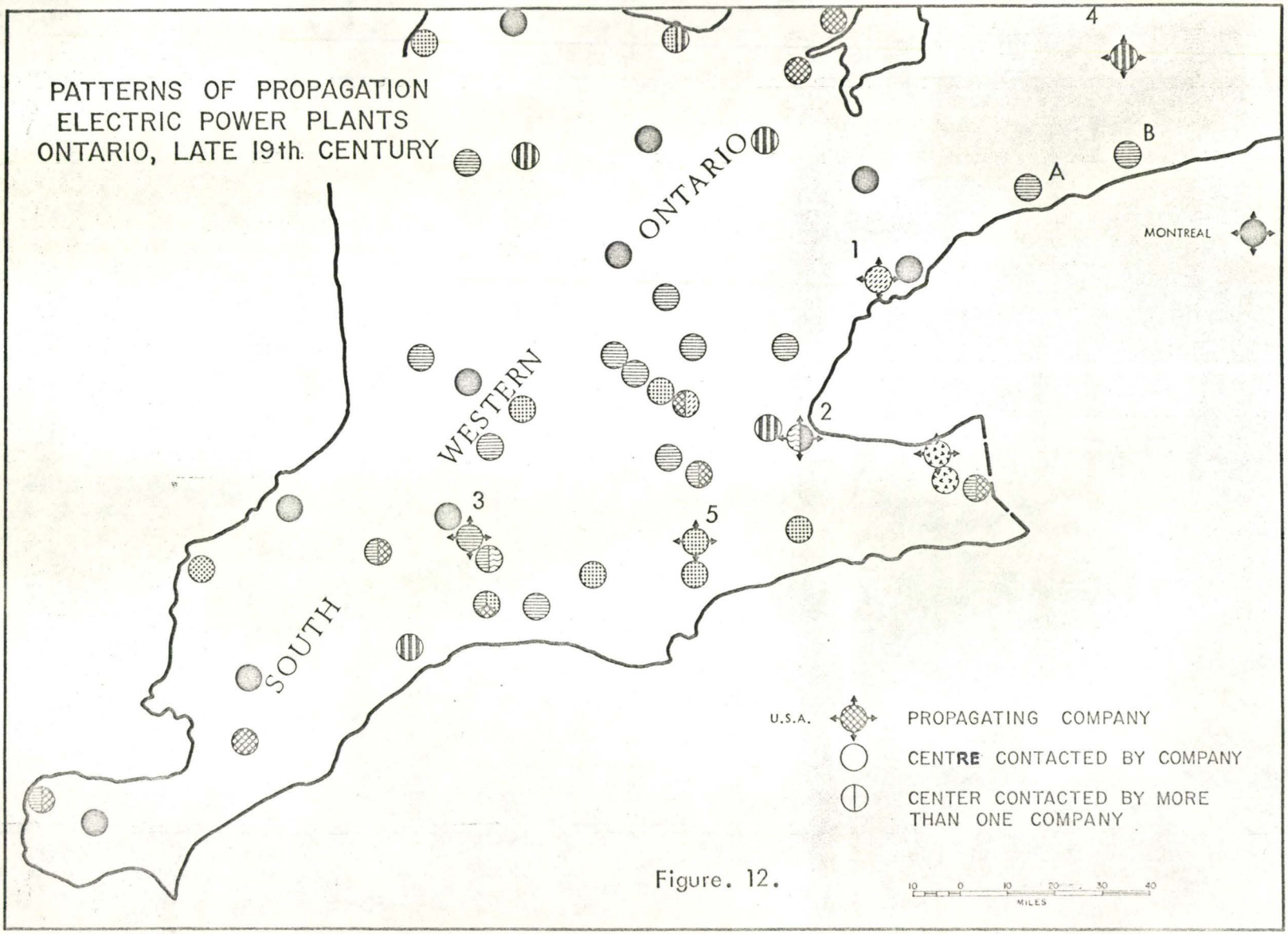
PATTERNS OF PROPAGATION
ELECTRIC POWER PLANTS
ONTARIO, LATE 19th. CENTURY
ONTARIO
WESTERN
SOUTH
MONTREAL
A
B
1
2
3
4
5
U.S.A.
PROPAGATING COMPANY
CENTRE CONTACTED BY COMPANY
CENTER CONTACTED BY MORE THAN ONE COMPANY
10 0 10 20 30 40
MILES

Figure. 12.

were obtained. From this information in addition to the information concerning awareness contacts analyzed above, the patterns of propagation can be mapped for individual manufacturers and hence provide a description of the market areas and propagators behavior in space. A problem does arise in the fact that "free market" conditions only existed during the 1880's-1890's; towards the end of the 19th century mergers and take-overs virtually eliminated the smaller companies and ensured the dominance of American manufacturers. However, the pattern of spatial competition between different companies for the first two decades can be ascertained.

Thus, Figure 12 shows the location of manufacturers and an accumulation of their associated contact and sales areas. It can be seen that each manufacturer propagating the innovation appears to have a core of contacts close to it so that the probability of selling to a potential adopter decreases with increased distance from the base location. Figure 16 illustrates the "distance decay effect"[16] in cross section form for two companies. It is also apparent that propagators do not obey the "rules" of discrete market areas since considerable over-lapping and inter-locking occurs (Figure 12). Although the distance decay effect describes behavior in space it is clearly not a surrogate for spatial behavior since outcome patterns

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[16] By "distance decay effect" meaning that, with increased distance (linear or time) from a given location a corresponding decrease in frequency of related phenomena occurs.

belie processes. Thus, the preference of companies for location in a large centre and the market limitation to six companies ensures that opportunities would be most frequent close to the propagator, hence the distance decay effect.

However, from other evidence available it does appear that propagators considered the greater part of Southern Ontario as one potential sales area; for example, at Chatham (1885)

> "Mr. Lawson, manager of Edison E.L. Co. (U.S.A.) is in town"[17]

> "Mr. Ross, general manager of Royal Electric Light paid a visit on Monday (from Montreal)." 18

While at Sarnia,

> "Mr. Slaught of the Reliance Electric Co. (Waterford) is in town with a view to introducing the electric light." 19

Thus, if an opportunity presents itself propagators are prepared to travel considerable distances to effect an adoption, indicated by the statements above and the occurrence of contacts by American companies. Figure 12 shows that company 3 perceived potential adopters at A and B and made contacts even though a company at 1 was closer to these potential adopters. Furthermore, in 1889 there were several potential adopters closer to the company's location at 3 (Fig. 12).

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[17] Chatham Weekly Planet, March 5th, 1885. (Microfilm, Mills Memorial Library, Hamilton).

[18] Ibid.

[19] Sarnia Observer, February 1st, 1889. (Microfilm, Mills Memorial Library, Hamilton.)

Despite the paucity of information concerning propagators' activities, (the company at A, for example may well have contacted places nearer but no records were kept since the contacts may have been unsuccessful) the inadequacy of the distance decay concept in explaining spatial behaviour is demonstrated since each propagator appears to have treated Southern Ontario as one field of movement. Yet the aggregate market areas describing behavior in space suggest a distance decay effect, as shown in Figure 16a, with distinct areas of dominance by a particular company (Figure 12).

Municipally Controlled Power Systems

It was shown in Figure 8 that the main movement for municipal control of electric power systems spreads through Southern Ontario during the 1890's and early 1900's. This was related to the reform movement in municipal politics,[20] although in certain centres, localized conditions had led to a few early occurrences of awareness in the 1880's. The reform movement had protagonists in most American cities with particularly active proponents in the cities of Detroit, Chicago and Toledo.[21]

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[20] Glabb, C.N. and Brown, T.A. A History of Urban American (New York, 1967), p. 211 ff.

[21] The spread of municipal ownership in the United States can be traced in several reports. Proceedings of the Conference for Good City Government (Philadelphia, 1893). Fourteenth Annual Report of the Commission of Labour 1899 (Washington, 1900). The first legislation in the U.S. in favour of public control of electrical utilities was in Massachusetts, 1891. It seems likely that the innovation had spread from Europe where considerable municipal control of utilities had already been in progress.

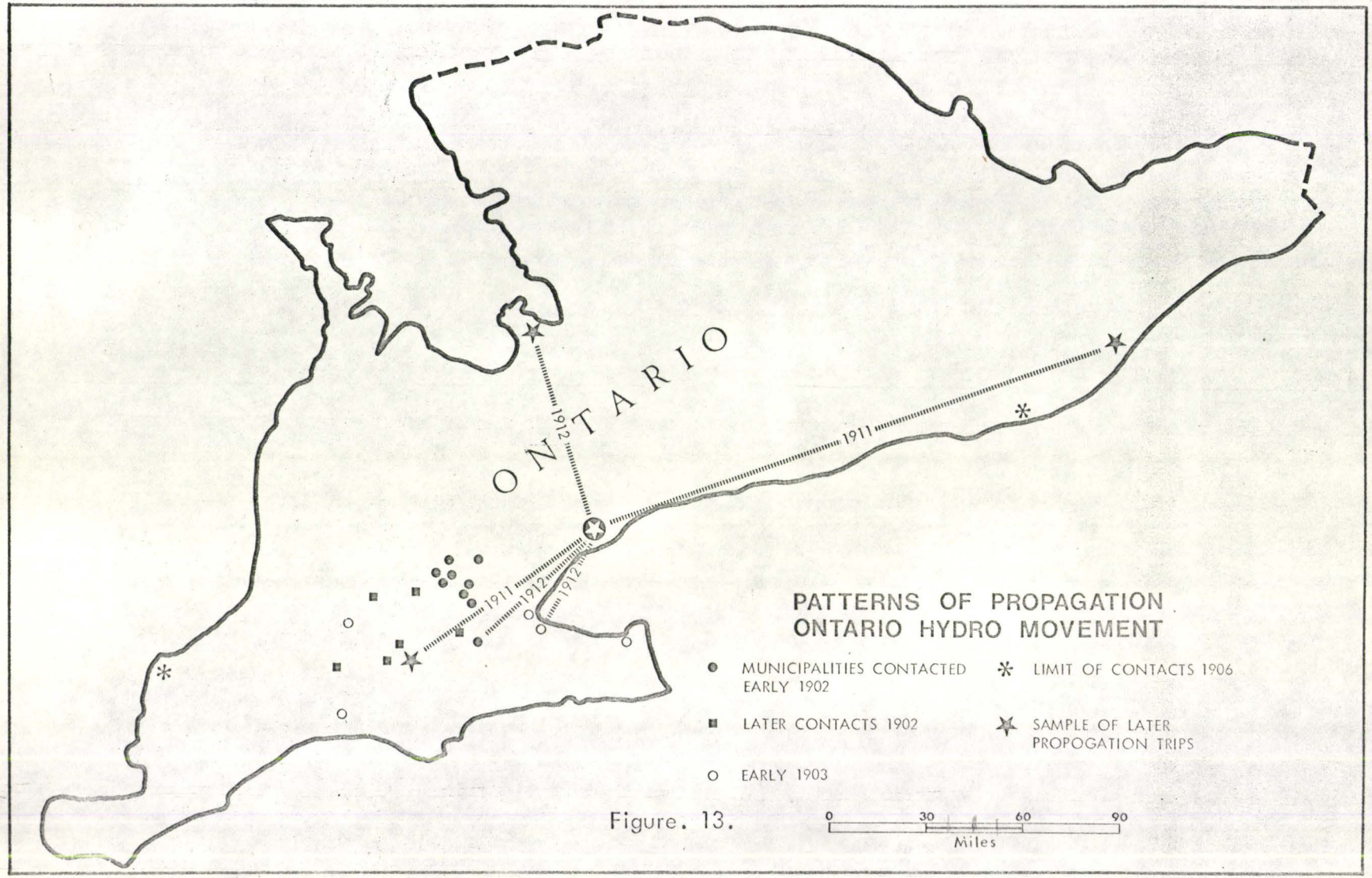
ONTARIO
1912
1911
1911
1912
1912
PATTERNS OF PROPAGATION
ONTARIO HYDRO MOVEMENT
MUNICIPALITIES CONTACTED EARLY 1902
LATER CONTACTS 1902
EARLY 1903
LIMIT OF CONTACTS 1906
SAMPLE OF LATER PROPOGATION TRIPS
0
30
60
90
Miles

Figure. 13.

Initially it may appear that the spread of awareness of this innovation represents direct media influence since there was considerable general discussion of the movement and yet there were no financial incentives to promote it. An examination of historical evidence shows however, that there were several propagators active in spreading and advocating this new form of utilities control and operation in Southern Ontario. What is particularly significant is that these propagators were located in the towns of central South Western Ontario. E. Snyder who lived at St. Jacobs, near Waterloo, designed a scheme for municipal cooperation in the development of publically owned electric power, and actively supported municipal ownership during his years as a member of the Ontario legislature (1881-1894).[22] J. Deitweiler who lived at Kitchener (formerly called Berlin), was another active propagator of the municipally controlled system, he,

> "Cycled over the dusty streets of the Grand (River) Valley preaching to all who would listen, of a day when Galt and other towns would have electricity to light their streets and homes ... " 23

In London, Adam Beck was an active proponent of municipal reform and actively supported the idea of municipal control of utilities,

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[22]Dennison, M. The People's Power (Toronto, 1960) p. 31.

[23]Kitchener-Waterloo Record, June 27, 1967.

initially as an alderman but later as Mayor (1902-1904) and as a member of the Ontario Legislature (1902-1925).[24]

E. Snyder as the chairman of the Waterloo Board of Trade and J. Deitweiler as the chairman of the Kitchener Board of Trade organized jointly, a meeting of the municipalities of south western Ontario at Kitchener in June 1902. The purpose of the meeting was to pressure the Provincial Government into legislating in favour of municipal and public control of power systems.[25] The municipalities which attended the meeting had a close relationship with the towns having an early awareness, but also reflect the propagating activities of Snyder and Deitweiler. They were, Kitchener, Waterloo, Galt, Guelph, Hespeler, Brantford, Preston, Toronto, St. Jacobs, Bridgeport.[26] (Figure 13). The organizing committee formed from this meeting then contacted other centres for support and further information on the question of estimates of requirements (Figure 13).[27] Succeeding meetings held by the organization demonstrate the development of the movement propagated by Snyder and Deitweiler and now joined by Adam Beck, Mayor of London. Thus, by 1903, 19 municipalities attended the next meeting organized

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[24]Grahame, P.W. Sir Adam Beck (London, 1925) unpaginated.

[25]Dennison, M. op. cit. p. 31.

[26]Plewman, W.R. Adam Beck and the Ontario Hydro (Ryerson, 1947), p. 35.

[27]Ibid., p. 36.

at Berlin (Kitchener) with representatives from 90 other communities being present.[28] (Figure 12). By April 1906 when a change of government had resulted in the formation of the publically-owned Ontario Hydro, 1500 delegates attended a meeting in Toronto to discuss Hydro's development,

> "from Kingston in the East to Sarnia in the West"[29]

After the passing of the Ontario Hydro Act Adam Beck and other members of the Hydro Commission were,

> "continuously on the move from one Ontario community to another, preaching the Hydro gospel", 30

in preparation for the January municipal elections. Thus, the municipalities which voted to join the Hydro system reflect the activities of the propagators such as Adam Beck and J. Deitweiler. Subsequently, as the system developed Beck and his associates made trips to specific communities to encourage them to join the Hydro Power system just as had Deitweiler earlier. For example, trips were made to Lindsay 1911, Brockville 1911, Beachville 1911, Peterborough 1912, Elora and Fergus 1913.[31] (Figure 13)

Therefore, although the aggregation of awareness and contacts

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[28] Ibid., p. 37.

[29] Ibid., p. 45.

[30] Ibid., p. 71 ff.

[31] Idem.

describe a distance decay effect (Figure 16), the activities of the propagators must be considered in terms of the opportunities available to them in that they considered the whole of the system as being suitable for the spread of the innovation and thus would travel to those centres where adoption was possible irrespective of the distances involved. The tyranny of the frictional effect of distance must consequently be modified in terms of the propagators' space preferences.[32]

Fluoridation of Water Systems

The idea of adding fluorides to municipal water systems to improve the dental health of the general public developed in the late 1930's and early 1940's. Controlled experiments in Michigan, New York State and Ontario demonstrated the benefits of the practice. The success of these tests led to the practice receiving official approval and endorsement by medical and dental associations.[33]

The city of Brantford began controlled tests in 1944 receiving financial support from the Federal Government in 1948 and later from the Provincial Government. While the Provincial Government gave financial aid the idea was neither endorsed nor actively propagated since it was argued that the tests were still at a trial stage.[34]

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[32]For a discussion of the concepts of behavior in space, spatial behavior and revealed space preference, see, Rushton, G. (1969)

[33]Maier, F.J. Manual of Water Fluoridation Practice (New York, 1963) p. 26.

[34]Ontario Legislature, Proceedings (1954) 5th Assembly of 24th Session, Government reply, March 24th, 1954.

Thus, propagation was the outcome of activity by medical and dental associations until an independent investigating committee appointed by the Provincial Government favoured fluoridation adoption. (1961)[35]

The activities of the professional associations took place at two levels; firstly, municipalities were contacted by the local medical or dental association, usually through the local medical officer of health, or secondly, they were contacted by a representative from the association's headquarters in Toronto. Thus, at Hamilton, the Medical Officer of Health visited Brantford in 1954 and subsequently raised the matter at the next council meeting.[36] At Oakville, the local dental association drew the council's attention to the innovation in 1961.[37] At Kitchener, the council were invited to attend a public meeting on fluoridation given by the regional secretary of the Royal College of Dental Surgeons.[38]

The Ontario Dental Association had field agents whose activities included the propagation of fluoridation by visiting larger municipalities in particular, organizing local dental associations into developing favorable community opinions towards fluoridation.[39]

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[35] Report of the Ontario Fluoridation Investigation Committee, January, 1961.

[36] Minutes of Council Meetings, City of Hamilton (1954, Hamilton Public Library).

[37] Minutes of Council Meetings, Oakville (unpublished).

[38] Minutes of Council Meetings, Kitchener (unpublished).

[39] Personal communication, Glen T. Mitten, field-secretary, Ontario Dental Association.

Unfortunately no records were kept of these trips.[40] However, it is certain that members of such organizations at the local and provincial level moved outside their usual location in order to promote the spread of this innovation, particularly prior to a fluoridation plebiscite.[41]

It can be seen therefore that once again, propagators were very active in spreading awareness of the innovation. What is significant is that Southern Ontario does appear to have been considered as one territory so that where an opportunity arose to promote the innovation, agents would travel to organize favorable opinion, in a manner similar to the propagators of Ontario Hydro.

Credit Unions

Unlike the three innovations described above, which required municipal decisions, credit unions were associated with sub-groups within communities such as workers in a factory of municipal employees. Despite the difference in the decision making group involved (i.e. non-municipal) they still required a form of collective community decision, while the credit union movement had field agents propagating the movement in a manner very similar to the innovations described above. Therefore it will be useful to include them in the present analysis of the propagators' behaviour.

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[40] Ibid.

[41] Ibid.

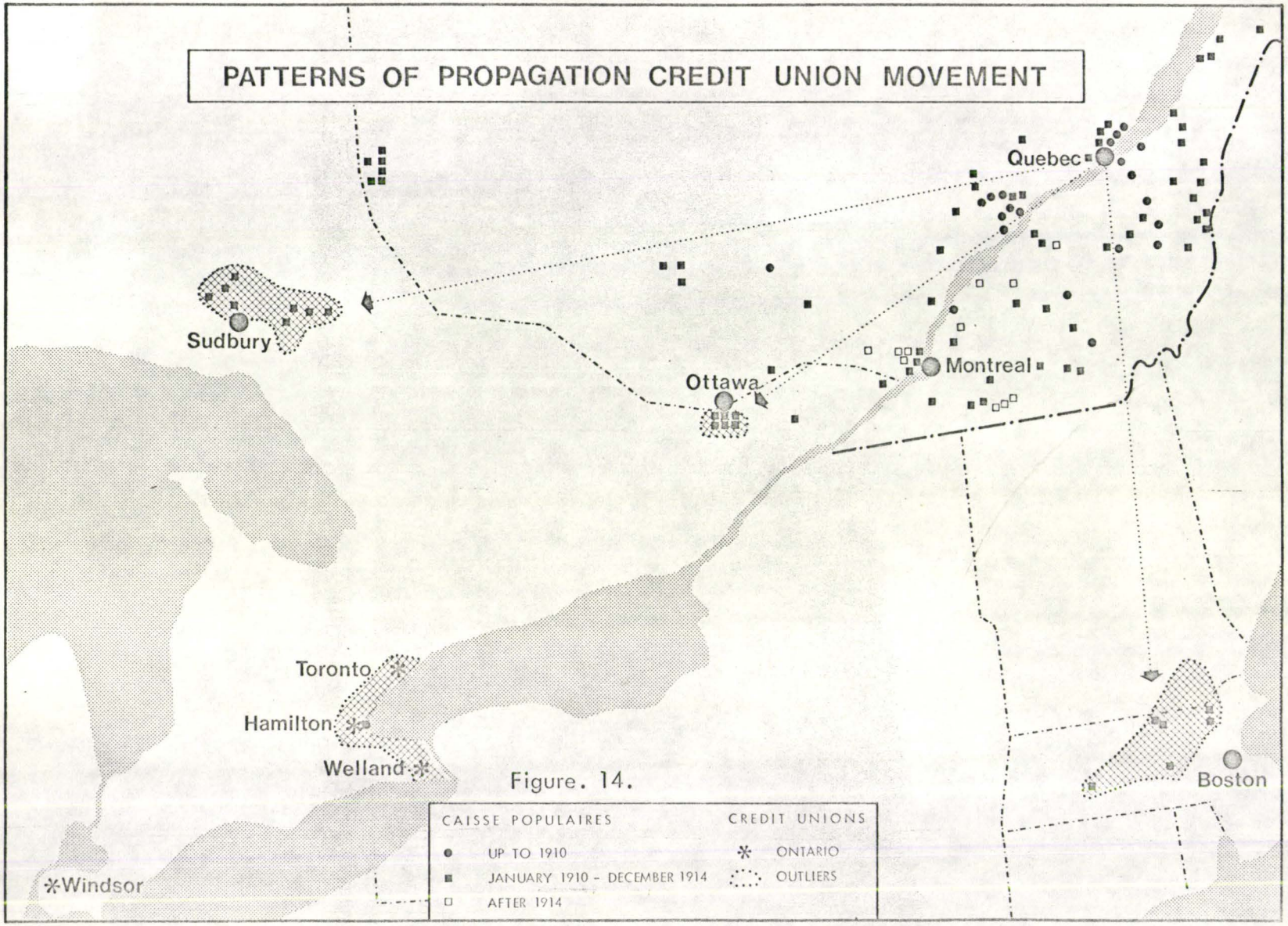
PATTERNS OF PROPAGATION CREDIT UNION MOVEMENT
Quebec
Sudbury
Ottawa
Montreal
Toronto
Hamilton
Welland
Boston
Windsor
CAISSE POPULAIRES
UP TO 1910
JANUARY 1910 - DECEMBER 1914
AFTER 1914
CREDIT UNIONS
ONTARIO
OUTLIERS

Figure. 14.

In North America credit unions first developed in Quebec where Alphonse Desjardins had modified the European idea to fit the American environment.[42] Desjardins was very active in propagating the idea by writing in the press and also through travelling extensively in Quebec to form new caisse populaires (credit unions). Although most of his activities were concentrated in Quebec, he travelled to French Canadian communities outside Quebec, in the United States and Ontario to form these credit societies.[43] The majority of caisse populaires were based upon the parish as the territorial unit relying on the local church organization for support. Their spatial development is shown in Figure 14. With increased distance from Levis there is a decrease in the frequency of caisse populaires (Figure 16). What is perhaps more significant is that there are outliers in the United States and also Ontario (Figure 14). While they were physically separate from the French Canadian cultural area, Desjardins considered them as part of the French Canadian cultural area.[44] This illustrates well the effect of culture ties overcoming the purely physical effect of distance decay. Furthermore, there is evidence of a "travelling salesman" effect in that on the more distant trips, several caisse populaires were founded on the same trip. Although a caisse populaire was founded in Ottawa, the innovation did not spread through the central

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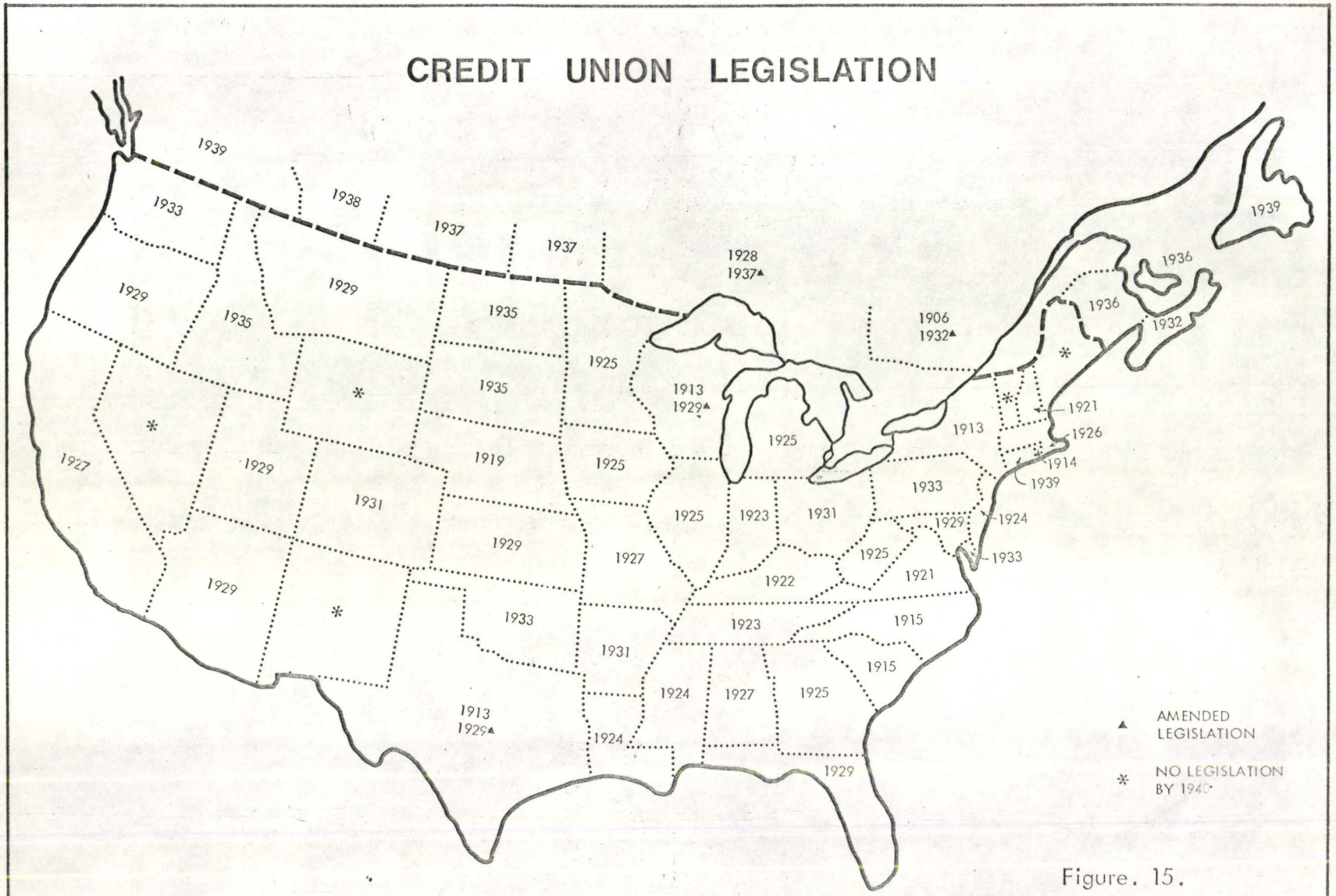
[42] Bergeron, R.F. CUNA Emerges (Boston, 1935), p. 16.

[43] Ibid.

[44] Lamarche, J.A. Le Mouvement Desjardins (Quebec, 1962).


CREDIT UNION LEGISLATION
1939
1938
1937
1937
1928
1937▲
1933
1929
1935
1929
1935
1925
1913
1929▲
1906
1932▲
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1924
1927
1925
1913
1929▲
1924
1929
▲ AMENDED LEGISLATION
* NO LEGISLATION BY 1940

Figure. 15.

place hierarchy of Ontario, reflecting once again the cultural barriers between the French and English communities.

Alphonse Desjardins' trip to New England helped to crystallize the efforts of those interested in forming credit unions in Boston.[45] Under the direction of A. Filene and R. Bergeron, the Boston movement was propagated through the United States during the 1920's and 1930's. Unlike the caisse populaires, the credit unions were credit societies rather than savings banks.[46]

The spread of the movement at the continental scale can be seen in Figure 15, where the east to west development is particularly apparent. While there was some legislation as early as 1921 to permit the formation of cooperative credit societies,[47] the main movement in Ontario came after 1928 when the act was extended to cover activities of credit unions.

The significance of the east-west development of credit union legislation in the U.S.A. is that most states had necessary legislation by 1930. Thus, after the propagation in the United States was more or less complete, the American movement then turned its attention to Canada. In 1931, American propagators formed the first

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[45] Bergeron, R.F. op. cit. p. 16.

[46] Mercure, G. Credit Unions and Caisse Populaires, Working paper prepared for the Royal Commission on Banking and Finance (Nov. 1962, Ottawa). p. 1 ff.

[47] Revised Statutes of Ontario, Chapter 258, para. 51, 1930.

credit union at Welland.[48] Subsequent activity led to formations at Hamilton in 1936 and Toronto 1937. However, the development of further credit unions was restricted by the inadequacies of the existing legislation.[49] Amendments to the Credit Union Act in Ontario in 1938 coupled with the formation of an international organization of Credit Unions (C.U.N.A.) in 1939 led to American field agents moving into Ontario in 1940 and organizing and propagating the innovation.[50]

Consequently, just as a cultural barrier prevented the spread of the movement from Quebec to Ontario so too, the international boundary restricted the movement spreading from the United States into Ontario until the late 1930's. In addition, resistance to the spread of innovation was related to legislative obstacles, shown in the case of municipal power, fluoridation and credit unions. In the latter case, although Ontario was nearer to the propagating centre than western states, the opportunity for propagation was not as attractive to the American movement as the legal and financial system was unfamiliar.

Summary and Discussion

In the class of innovations considered here contact by

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[48] Bergeron, R.F. op. cit. p. 251.

[49] Ibid., p. 252.

[50] Mercure, G. op. cit. p. 29.

PROPAGATORS ACTIVITIES SHOWING DECREASE IN FREQUENCY OF CONTACTS WITH INCREASED DISTANCE

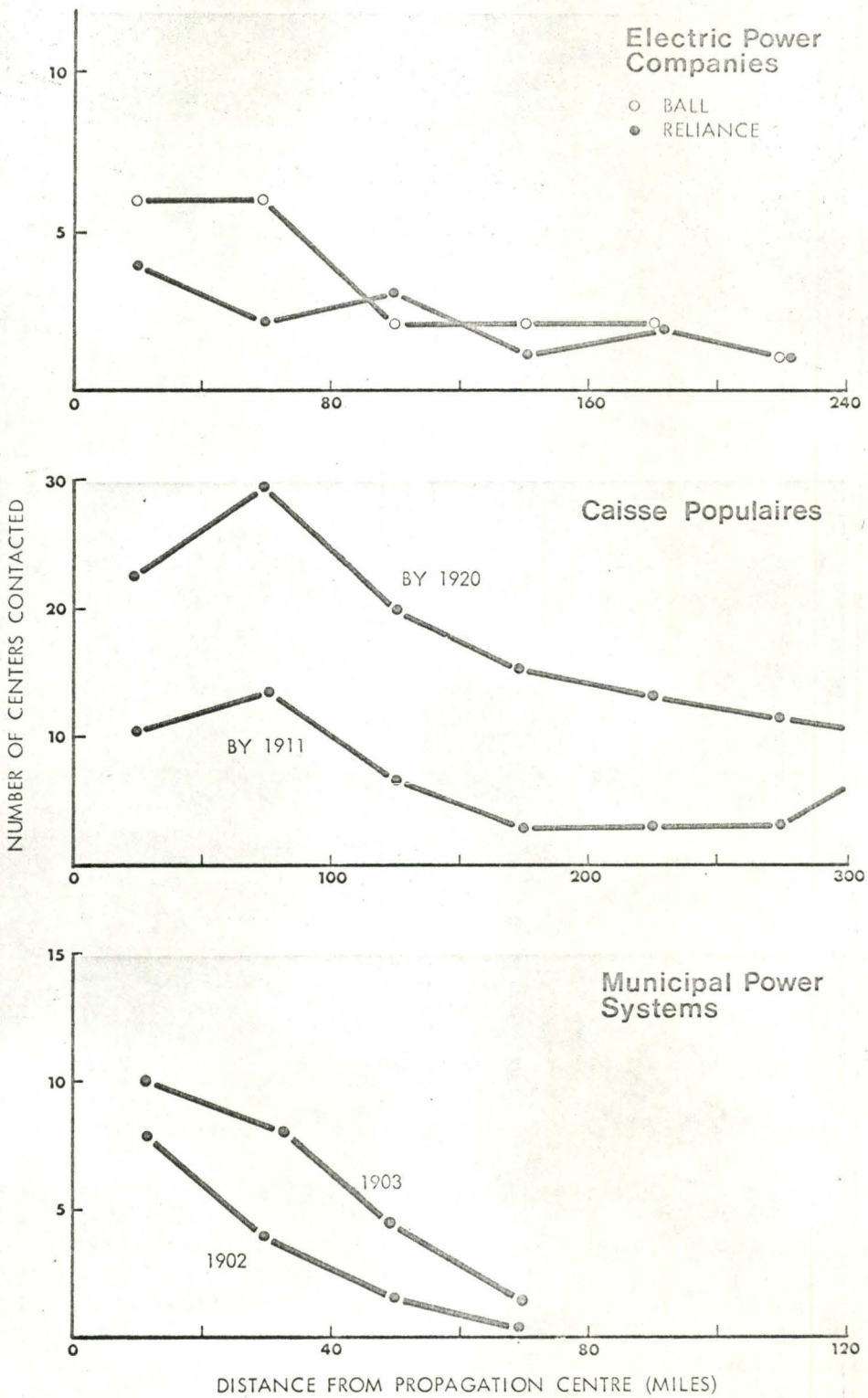

Figure. 16.

propagators is the main source of awareness which results in a response on the part of the decision makers. It is shown that date of awareness has a close association with the population size of central place concerned. An examination of the spatial development of awareness does not show any significant indication of a "neighborhood effect". From this we can conclude that in the flow of information size of centre is probably the most important variable in the spatial development process.

In view of the propagator's importance in spreading awareness of innovations, yet at the same time their relative neglect in previous research, an attempt is made to describe their behaviour in space and also some aspects of their spatial behaviour. It was shown that propagators' behaviour in space could be described by the distance decay effect (Figure 16). This is not unexpected as opportunities for contact were more frequent closer to the propagator, particularly if there were several competing propagators. However, examination of spatial behaviour and the order or preference of contacts suggests that it would be described more accurately in terms of opportunities for potential adoption. Evidence suggests that the propagators have certain territories or fields of movement. In the case of the electrical power companies this means the whole of the southern section of the Province (Figure 12). In the case of the propagators of municipally controlled power systems this means initially the manufacturing towns of central south western Ontario but later the whole of the Province of Ontario. (Fig. 13). Where fluoridation is

concerned, the professional organizations located in Toronto send field agents to those centres where an opportunity arose, which means in effect the whole of the southern section of the Province is the field of movement. Credit unions follow a similar development but bring to notice the modifying effect of cultural and international boundaries (Figure 14). Thus, during the first phase of the movement the propagator makes trips to the outliers of the French cultural territory, which transcend provincial and international boundaries; yet, the movement does not spread through the Ontario system. During the second phase of development American propagators are more concerned with spreading the movement through the United States. Only when this is accomplished do they turn their attention to the towns and cities of Ontario.

It appears therefore that the distance decay effect describes in aggregate form the frequency of opportunities and thus the behaviour in space of propagators. However, from the additional information concerning spatial behaviour it appears that the propagators consider potential adopters in terms of opportunities within a certain area of movement (an area not necessarily continuous) and a preferred ordering of contact. Consequently, the nearest potential adopters may not always be contacted first, while potential adopters at a considerable distance may often be contacted relatively early. From this one can deduce that the frictional effect of distance is less significant than suggested by Figure 16. Furthermore this would

partially explain the earlier finding that the hierarchical flow in initial information in this class of innovations is dominant with no real suggestion of a neighbourhood effect. Although the inadequacy of the distance decay is shown, the alternate information is only sufficient to suggest that opportunities are perceived within a certain area or field of movement. Clearly more research into perception, attitudes and information flow is required before more precise statements can be formed.

Contact by the propagators sets off the decision making processes of the potential adopters leading ultimately to a strategic decision to adopt. The next step therefore is to examine innovation adoption dates with respect to the hypotheses tested above concerning dates of awareness. If there is a close relationship between awareness dates and adoption dates there is every justification for using the latter as a surrogate for the flow of information; if this is not the case, a more critical evaluation of the decision making process is required.

CHAPTER 6

The Adoption of Innovations: The Terminal

From a consideration of the flow of information and awareness of innovations (the arrivals) our attention can focus now upon the dates at which the various innovations are adopted by communities from the terminals. If there is a close similarity between the characteristics of awareness and those of adoption, then clearly there is little need to examine the decision-making processes involved in terms of developing existing models: if on the other hand, there is a discrepancy between the two phases, a need to examine the decision-making process obviously arises since it would invalidate a common assumption of diffusion models. It should be recalled that most previous research uses adoption dates as a surrogate for the flow of information in systems.

Adoption can be defined as the date at which an innovation is actually used at a place.[1] Consequently, a differentiation between a decision which may have considered adoption but which did not result in adoption, and the actual date at which the innovation is first used must be made.

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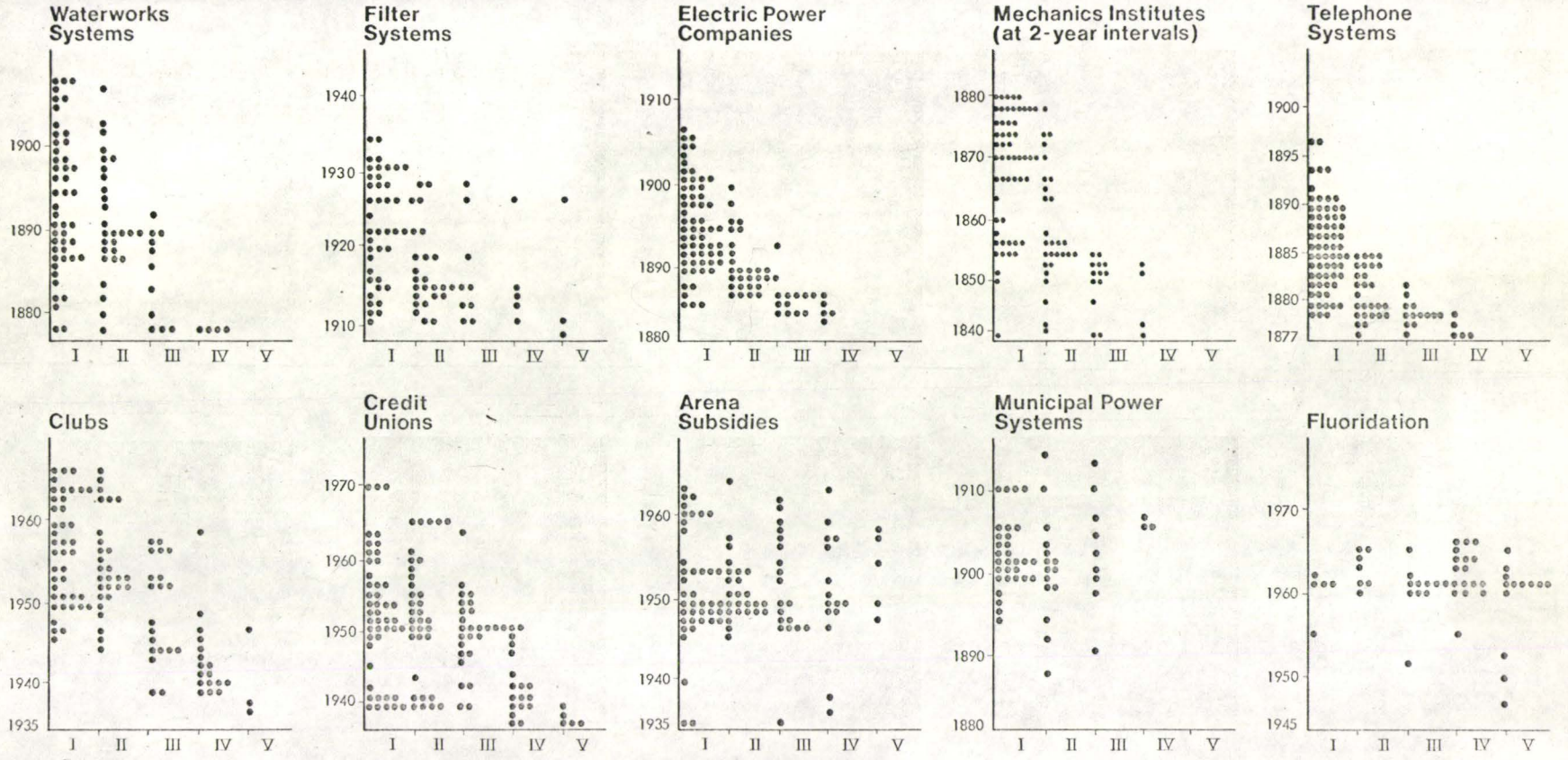
[1] See Katz, E. et.al., op.cit. p. 241 for a discussion of this point.

RELATIONSHIP BETWEEN ADOPTION DATE AND SIZE OF CENTRAL PLACE



Innovations:

NON CONTROVERSIAL

NON-MUNICIPAL

CONTROVERSIAL

Size of Centre (in thousands)

I	1 - 2.5
II	2.6 - 5.0
III	5.1 - 10.0
IV	10.1 - 40.0
V	more than 40

Figure. 17.

Distribution of Adoption Dates

The dates at which the innovations being considered, both municipal and non-municipal, were first used in central places with a population greater than 1,000 can be determined from several sources.[2] The first hypothesis that can be tested as in the case of awareness is that the date of adoption of an innovation requiring a community decision is related to the population size of the centre. Previous tests of this hypothesis have relied mainly on visual examination of the data, concluding that a marked relationship did exist, (Bower, 1937 ; McVoy, 1940 ; Rose, 1948 ; Hägerstrand, 1966 ; Ogburn and Duncan, 1958). However, Gamson and Irons (1961), found that this hypothesis could not be accepted where the adoption of fluoridation of water systems is concerned. The relationships between adoption date and size of centre are shown in Figure 17, where it appears that a relationship does exist for innovations 1-7 but not 8-10. For a more rigorous examination of the relationship a statistical test must be used.

The choice of statistical test presents a problem in that variance of dates of adoption is not normally distributed, since the greatest variance is associated with the class of smallest central places. However, since the adoption dates can be ranked from first to last and the population size of centres can be ranked as well from

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[2] See Bibliography (Appendix 1).

high to low, a non parametric test, Spearman's Rank correlation can be used to test the correlation between the two variables of date and size of centre.[3]

TABLE 2

Correlation Between the date of Innovation Adoption and Population Size of Centre

Innovation	Spearman's R.	T test	D of F
Waterworks	-.54*	7.29	132
Power Companies	-.70*	10.25	110
Credit Unions	-.47*	5.81	119
Filter Systems	-.46*	4.87	86
Mechanics' Institutes	-.70*	9.64	96
Clubs	-.67*	-10.27	123
Telephone systems	-.70*	10.10	111
Municipal Power Systems	.05	.43	57
Fluoridation	.10	1.21	53
Arenas	.03	.38	125

*Significant at the 1% level.

Correlation between the date of innovation adoption and the population size of centre, using Spearman's Rank Correlation coefficient. Calculated using I.B.M. Scientific Subroutine SRANK.

Thus, the hypothesis can be set up as follows:- A significant correlation exists between the ranking of centres by date of adoption,

[3]Gregory, S. op. cit. p. 181 ff.

and the ranking of centres by size of population. The level of significance can be set at $\alpha = .05$.

The results of correlating the two variables for the ten innovations are shown in Table 2. It is apparent that a significant correlation exists between population size of centre and the adoption dates of waterworks systems, electric power companies, credit unions, filter systems, civic clubs, and telephone systems, since coefficients are significant even at the .01 level. In contrast to this, three innovations, municipally controlled power systems, arenas/community centres and fluoridation do not have a significant correlation between adoption date and population size of centre. Thus, the correlation coefficients would appear to confirm the hypothesis in many cases, but not always particularly where municipal decisions are required. In the latter case, some innovations do not follow the usual relationship. Consequently, this would appear to confirm Gamson & Irons (1961) hypothesis concerning fluoridation.

The emergence of a sub-class of innovations which do not follow the adoption date - city size relationship is significant in three ways. Firstly, it indicates the danger of using adoption dates as a surrogate for information flow since adoption does not take place as soon as awareness. Secondly, it suggests that there is a generality of process which results in the emergence of a sub-class of community innovations of this kind. Finally, it also indicates the presence of a common resistance factor which is aspatial in nature.

Cumulative growth of Innovation Adoption Dates

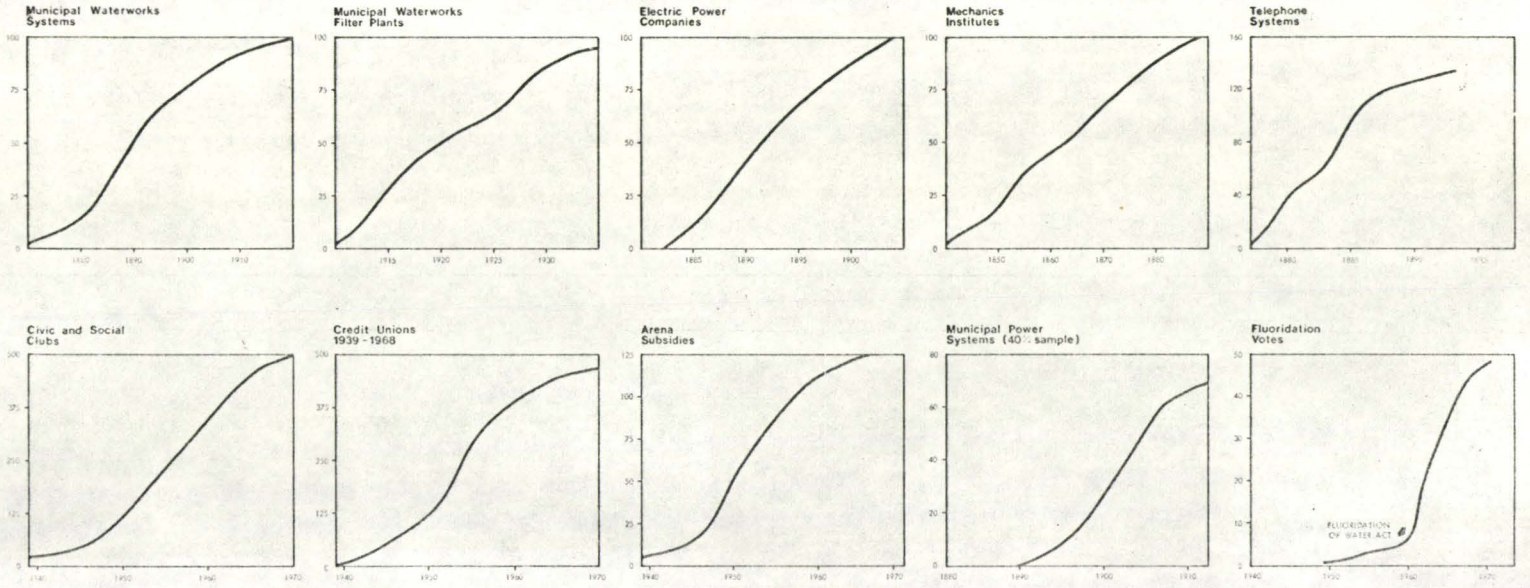

Figure. 18.

Rates of Adoption

The increase of adoptions over time, as a changing proportion of the total population, can be described in the form of cumulative frequency curves. Several studies have shown that the accumulation of adoptions can be described by a logistic function with a characteristic "S" shaped curve. (Dodd, 1955 ; Griliches, 1957 ; Mansfield, 1961 ; Brown, 1966 ; Casetti, 1969). This function describes a situation where adoptions increase slowly at first, then rapidly and finally taper off.[4]

Figure 18, shows the accumulation of innovation adoptions by the central place system of Southern Ontario. It is apparent that a similar "S" shape is characteristic of the form of the curves and that a logistic function would describe the relationship. The exception to the general pattern is the adoption of fluoridation, which has already been shown to be exceptional to the general relationship between adoption date and size of centre.

If there appears to be a similarity between innovations in the growth of adoptions through time as represented by the shape of the curves, given an adopting system which has reached dynamic equilibrium, and a class of innovations which appear to be similar in type of propagation and decision making group involved, one might expect that

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[4]Casetti, E. (1969) has recently shown that with the assumptions that adoption is an outcome of intra-group contacts, varying resistance thresholds exist, and resistance is overcome by learning, a logistic function results.

TABLE 3

DIFFERENCES BETWEEN MEDIAN DATES OF ADOPTION FOR DIFFERENT CLASSES OF CENTRAL PLACES BY POPULATION SIZE.

INNOVATION	DIFFERENCES BETWEEN MEDIAN ADOPTION DATES BY CLASS OF CENTRE			
	1 and 2	2 and 3	3 and 4	1 and 4
Mechanics Inst.				29
Waterworks Systems	14	10	11	35
Filter Plants	6	2	3	11
Power Plants	1	4	7	12
Telephone Systems	2	2	3	7
Credit Unions	9.4	1.2	.6	10.6
Clubs	7	4.5	2	13.5
Municipal Power	*	*	*	12
Arena Subsidies	*	*	*	12
Fluoridation	*	*	*	12

* Less than 1.

Differences between median dates of innovation by different classes of central place and different innovation class.

1. > 40,000
2. 10 - 40,000
3. 5 - 10,000
4. 1 - 5,000

the time taken for these innovations to diffuse through the adopting system would be approximately the same apart from some random variation.

If the categorization of adopters by size of centre and date of adoption is used, the average time for each innovation to diffuse through the four classes of central place size can be calculated. The differences between the averages of each class can be estimated and then compared for different innovations (Table 3).

Table 3 shows that the average time taken for an innovation to diffuse through the system is approximately twelve years (i.e. the difference between the average adoption dates of the class of large centres and the class of small centres (i.e. between class 1 and 4). The two exceptions to this general relationship are the diffusion of Mechanics' Institutes and Waterworks systems. These exceptions may be explained by the fact that the latter innovations diffused while the system itself was still developing. The remaining eight innovations with similar diffusion times, develop and spread after the system was established. Aside from these two exceptions, the remaining innovation adoption dates suggest a close similarity in the time taken to diffuse irrespective of the relationship between adoption and size of central place.

An examination of the differences between the time taken for innovations to be adopted by different size-classes (Table 3) brings out certain dissimilarities between innovations. Thus, there are no significant differences of median date of adoption between the class

groupings of those innovations having no relationship between adoption date and size of central place. Further examination of Table 3 shows that Filter Plants, Credit Union and Clubs diffused more slowly from the group of largest centres to the next largest group than through the other two groups. Power Plants, however, spread more quickly through the larger centres, slowing down as they spread down through the central-place system. Telephone systems show a consistently even rate of diffusion, reflecting perhaps the monopoly position of the propagating company.

It can be seen therefore that given a stable system of potential adopters, the average time for innovations requiring community decisions to diffuse from the largest to the smallest member of the system are not significantly different, irrespective of the relationship between adoption date and size of central place. However, differences in the rate of adoption appear to have existed between innovation adoption dates and different size classes of centres. Although some tentative explanations are advanced the reasons for this are not clear, and must therefore await further research.

Modification of the Adoption Date - Centre Size Relationship: Spatial Patterns of Adoption.

The variation in association between adoption date and population size of central place, the emergence of a distinct class of community innovations with no relationship between adoption date and size of centre, and the variations in diffusion rates between different

classes, suggest that other factors are modifying the hierarchical diffusion of these innovations.

The most frequently advanced hypothesis (in geographical analyses) is that, since diffusion is presumed to be a contagious process, a "neighbourhood effect" ensues in the development of innovation adoptions over space. In a system of central places, this would mean that some small centres near large centres which had already adopted would be more likely to adopt earlier than centres further away.

After stating that adoption initially follows the urban hierarchy, Hägerstrand (1966) states,

> "soon this rank order is broken up and replaced by one where the neighbourhood effect dominates over pure size succession."[5]

Consequently, not only does Hägerstrand suggest a "neighbourhood effect" occurs, but that it dominates over the rank succession. It has already been shown that the rank size/adoption date rule does not always hold, but this is not the modification of the rank-size succession as conceived by Hägerstrand. An examination of Figure 17 does indicate however that a "neighborhood effect" might be present since in each innovation several small centres adopt before larger centres, even though there was a significant relationship between adoption date and size of centre (Table 2). Furthermore, the evidence of this effect is

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[5] Hägerstrand, T. (1966) p. 40.

more apparent than in the flow of information-awareness described in the previous chapter. If there were a close relationship between adoption dates and size of centre, there would be no overlapping of classes in this way. Therefore if a neighborhood effect is present, it has to be shown to be more than a random dislocation.

This still leaves unresolved the sub-class of innovations which have no significant relationship between adoption date and size of centre as shown in Table 2. This is particularly significant in terms of the neighborhood effect where the designation of "leaders" and "followers" is on a size basis in a central-place system, that is, large centres adopt first and then smaller centres nearby follow, and clearly, this would not be possible for these three innovations. It is possible that these three innovations diffuse as a non-hierarchical wave or that the dichotomy into "leaders" and "followers" need not necessarily be on a size basis at all but still nevertheless present.

Consequently, in order to determine whether the neighborhood effect is present we now turn our attention to analyzing the spatial development of adoption. Furthermore, such an analysis might throw light on the sub class of innovations described above. Finally, it must be recalled that previous analyses of adoption patterns have been made on the basis that it is a surrogate of the process of inter-adopter influence.

Patterns of Adoption

Patterns of adoption are outcomes of the decision making process;

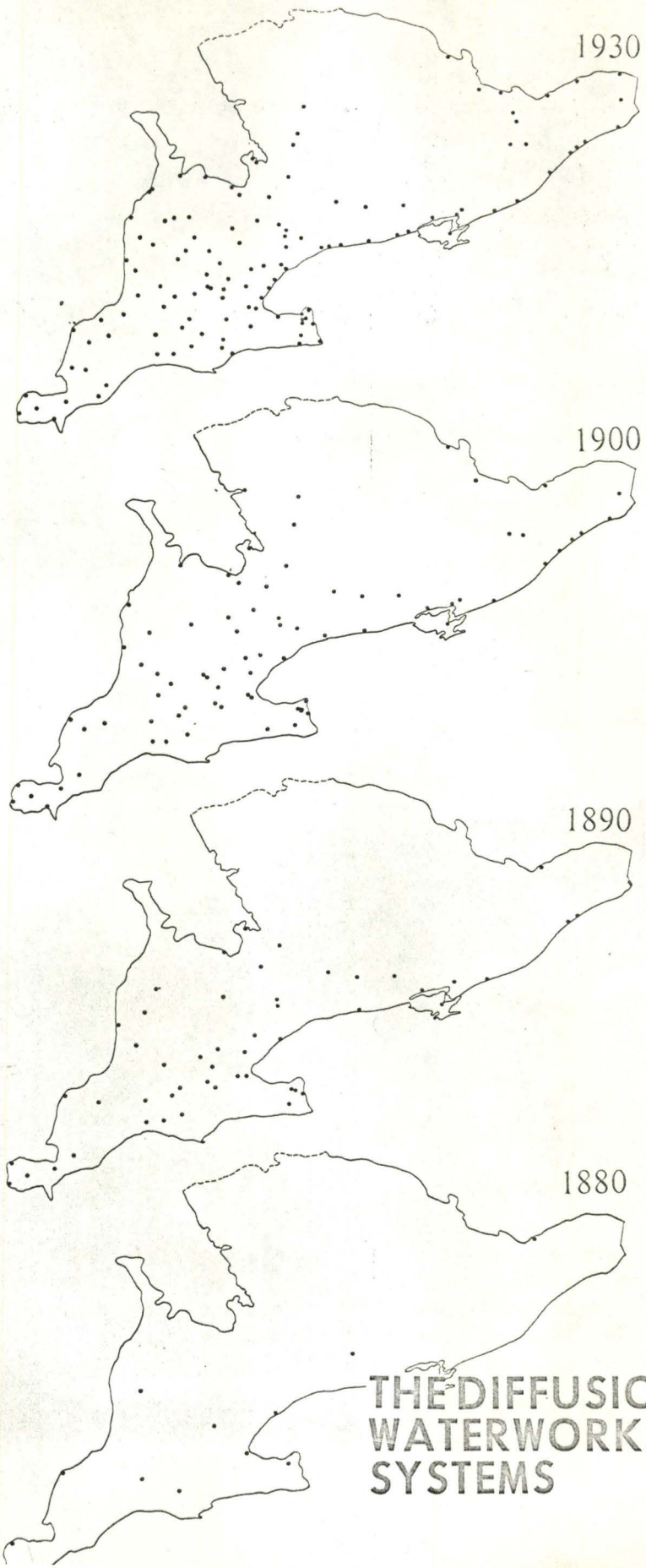

Figure. 19. THE DIFFUSION OF WATERWORKS SYSTEMS

if the spatial development of adoption does in fact show a "neighborhood effect" a clustering of adopters through time, would occur. (Hägerstrand, 1952, 1966). Therefore, in a situation where central places are the adopters, innovation leaders (the larger central places) should influence the spread of adoptions so that small centres close to prior adopters would have a higher probability of adopting than those small centres further away.

To see whether this clustering effect does occur and additionally to see whether any spatial ordering exists in that sub-group of innovations whose adoption dates are unrelated to size of central place, the spread of each innovation must be described, methods of analysis discussed and then applied. In this chapter we shall examine the pattern of adoptions for evidence of this effect. In the next chapter we shall examine direct evidence of inter-adopter contacts and influence.

Waterworks Systems (Figure 19)

Systems of water supply were already part of the urban fabric in the early 19th century in both Britain and the United States, Philadelphia having a municipally owned system as early as 1801.[6]

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[6]Private companies also supplied water prior to the municipal systems during the first half of the nineteenth century. By 1861 however, eighty private companies and sixty-eight private ones were in operation in the United States (Glaab, C. & Brown, A.T. op. cit. p. 97). In 1857 Upper Canada had less than six private companies and two municipal systems (Lovell's Directory, Montreal (1857)).

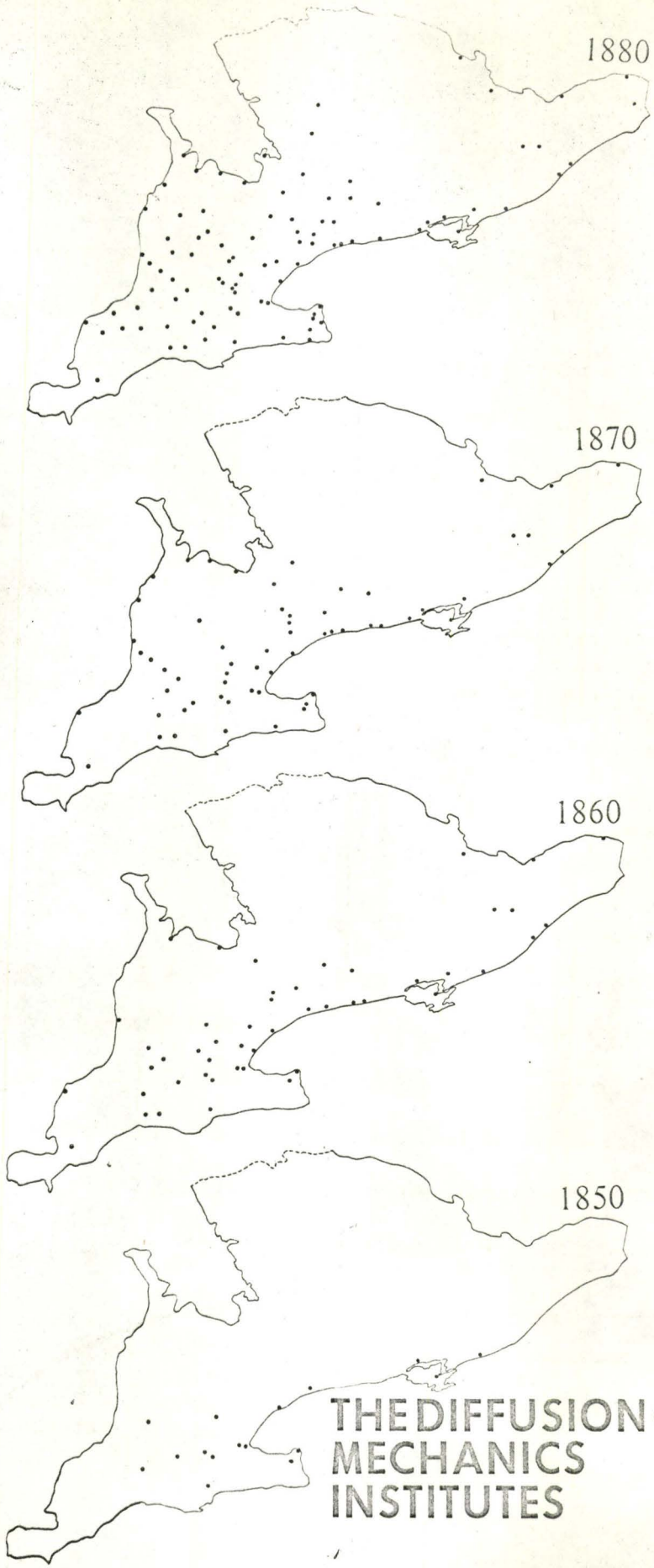

Figure. 20.

Waterworks systems were part of the "sanitary reforms" of the 19th century and also were necessary for fire control. They represented the first real development of municipal authority since they required capital expenditure and resort to the loan and bond market. The spread of waterworks systems in Southern Ontario is seen in Figure 19. By 1880 most cities and large towns have a municipally owned system. Subsequent adoptions by 1890 show a concentration in Western-Southern Ontario and a movement northwards as well; Eastern Ontario has a few adoptions. At the turn of the century the progress northwards continues although there are empty areas towards the Bruce Peninsula and central Eastern Ontario. Eastern Ontario has now acquired some adoptions. The process continues up until the late 1930's with infilling of existing areas rather than further expansion at the edge. There is some indication of clustering in 1890 and in succeeding years.

Mechanics' Institutes (Figure 20)

Mechanics' Institutes were a product of the Industrial Revolution in early 19th century Britain and provided a means for the diffusion of knowledge among the skilled artisan class.[7] They varied in form from a collection of technical books and newspapers in the small towns to larger collections with formal lectures and courses in the large towns and cities. The spread of Mechanics' Institutes in Southern

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[7]Mechanics' Institutes were founded in Glasgow in 1780 and in Manchester in 1825. The earliest record in Upper Canada is 16th April 1835 when they were founded at Toronto and Kingston (Special Report of Minister of Education on Mechanics' Institutes, Ontario Sessional Papers. Vol. 46. 1881, Toronto.)

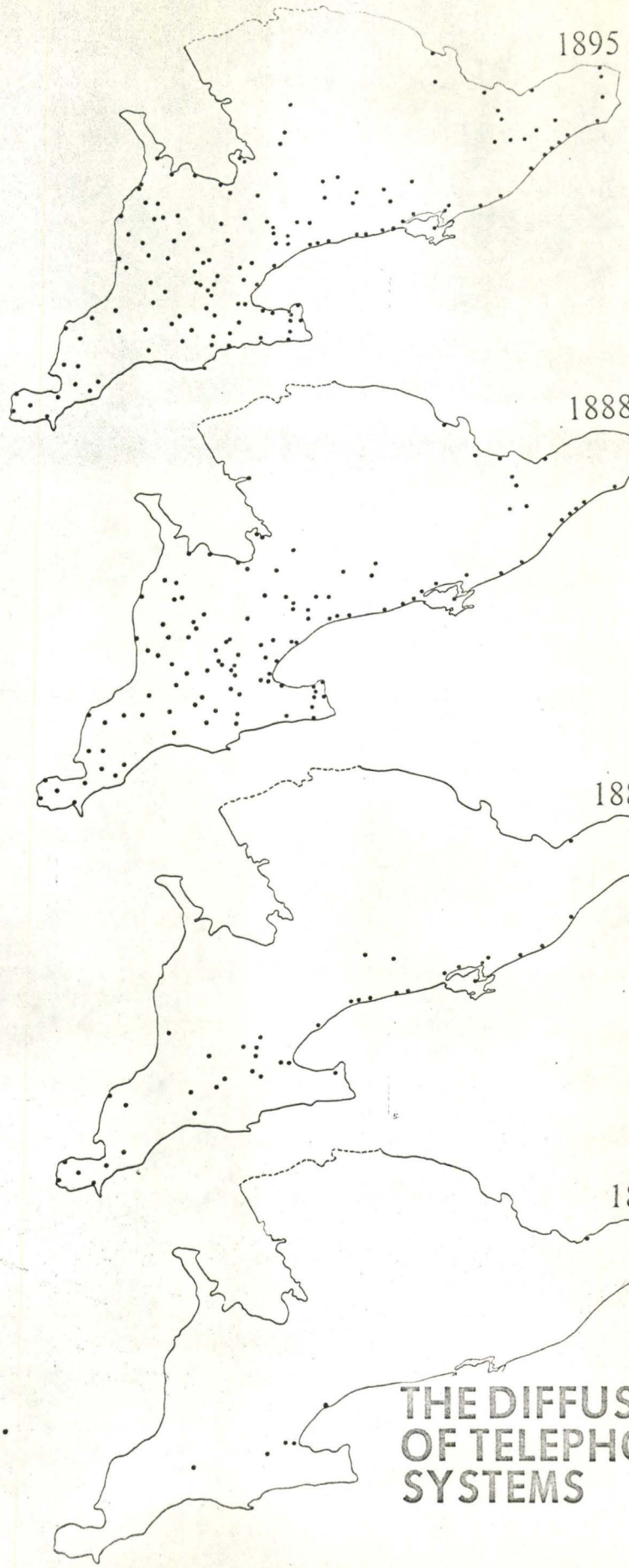

Figure. 21.

Ontario is shown in Figure 20. The core area of central Western Ontario is evident from the onset and from this concentration subsequent adoptions are added northwards. Once again Eastern Ontario is relatively devoid of adoptions. By the end of the period an infilling occurs although the extreme west and east peninsulas of the area are still empty.

Waterworks systems and Mechanics' Institutes are two innovations which are already part of the urban milieu which colonized Southern Ontario and therefore in a sense they do not really represent innovations. In addition it is only towards the last few decades of the century that dynamic stability in the central place system was reached, so that there would be a pre-determined diffusion from south to north with the diffusion of the urban frontier.

Telephone Systems (Figure 21)

The early development of telephone systems in Ontario was an outcome of its invention and testing at Brantford. The first telephone exchange in the Commonwealth was built at Hamilton in 1878. Subsequent development was mainly the outcome of activity by the Bell Telephone Company;[8] although the Bell Company was not entirely in a monopoly position they are representative of an innovation spread by one major propagator.[9]

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[8]For a history of the growth of the telephone system in Ontario see Patten, W. Pioneering the Telephone in Canada. Montreal, 1926.

[9]Bell owned the long distance lines and leased out local areas thus requiring exchanges only in larger centres, Patten, W. op. cit., p. 106.

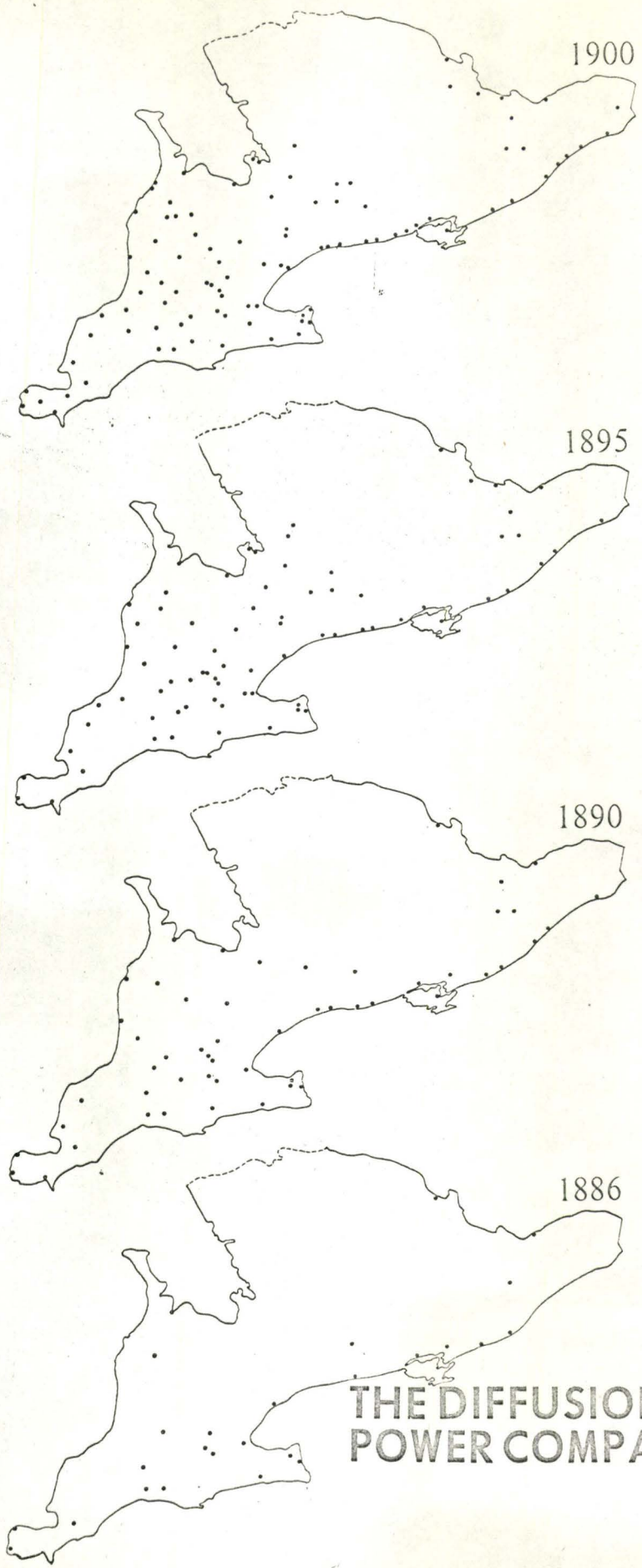

Figure. 22. THE DIFFUSION OF POWER COMPANIES

The spread of the innovation can be seen in Figure 21, showing the initial adoptions in western central Ontario. After five years, expansion through the towns of the Toronto to Windsor "corridor" is evident while growth eastwards along the shore of Lake Ontario and the St. Lawrence is a result of a link between Toronto and Montreal. (Adoptions near Windsor are partly due to the activities of another company propagating in that area). By 1888 much of Western Southern Ontario have telephone exchanges especially those centres towards Lake Huron. Expansion into the interior of the Eastern counties is also apparent. By the mid 1890's all towns with a population over 1,000 have exchanges so that the final map reflects the uneven regional distribution of central places in the Southern section of the province.

Power Companies (Figure 22)

Power companies were formed by local businessmen (often with help by electrical companies who made the systems) interested in bringing electric light to their community. In the first decade of development, 1885-1895, this usually meant arc light systems run by thermal generating plants. After 1894 hydro-electric power became a feasible proposition and incandescent lighting for street lighting really began to be developed.[10] Initial adoptions were in Toronto, London, Hamilton, Ottawa and Windsor. By 1886 most other large towns

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[10]The early phase of electric power development in Ontario (and Canada as a whole) has not been analysed in any great detail. For a penetrating analysis of entrepreneurial activity and the development of the United States power system see, Passer, H. The Electrical Manufacturers, 1875-1890, (Harvard U.P., 1953, 412 pp.)

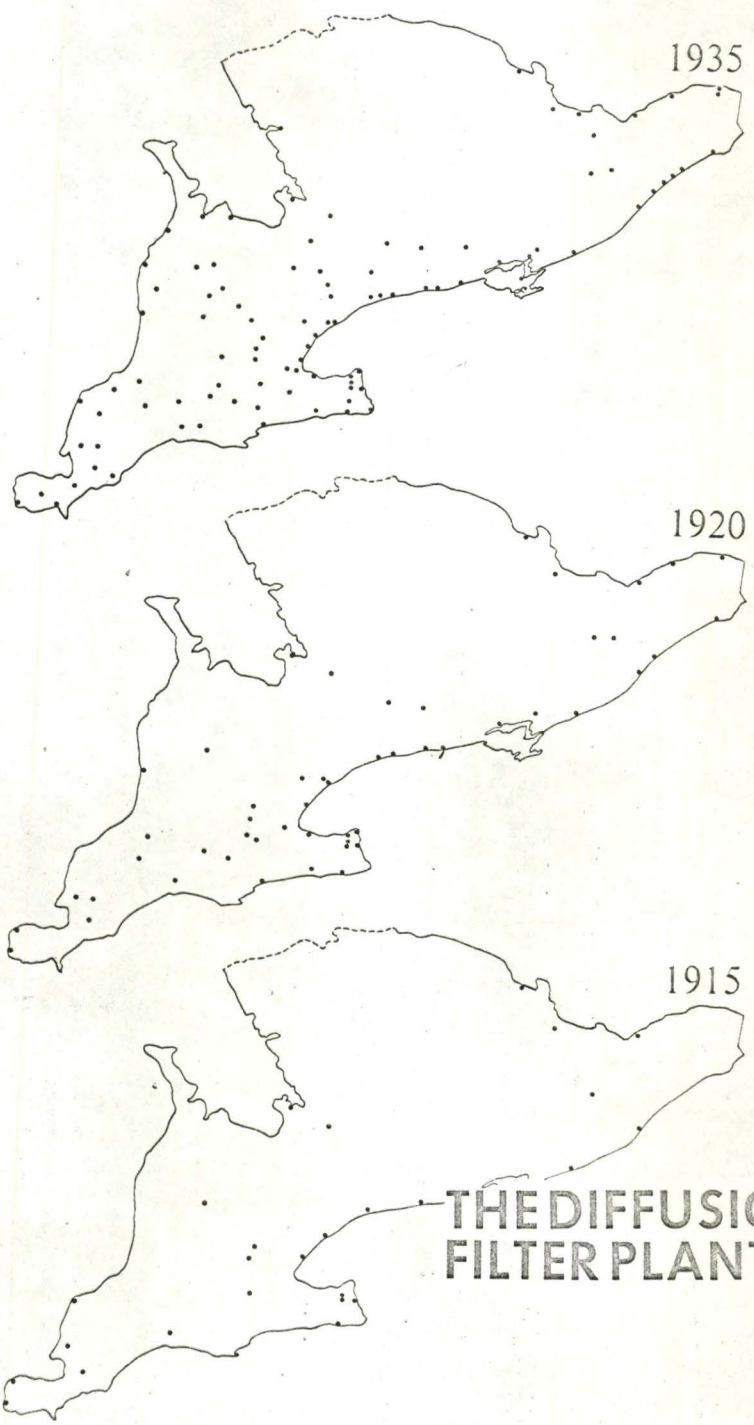

Figure. 23. THE DIFFUSION OF FILTER PLANTS

have also adopted (Figure 22). By 1890 there is a significant increase in adoptions spreading northwards into the smaller towns, and into the smaller industrial towns of south west and central Ontario. There is some indication that diffusion into the North Western section of the peninsula is less retarded than with the innovations described previously. At the turn of the century most centres had electric power of some form although small centres in the Southern section are still in the pre-electric age.

Filter Plants (Figure 23)

Filtration and purification plants became increasingly necessary at the turn of the century due to increasing pollution of natural supplies of water. Furthermore, the setting up of a Branch of Sanitary Engineering within the Department of Health of the Province of Ontario aided the propagation of more hygienic public services.[11] The spread of filtration/purification plants is shown in Figure 23. The progression of adoptions from south to north through the larger towns is apparent, particularly lakefront centres of the Niagra peninsula and those drawing water from the Detroit River (Figure 23). By 1920

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[11]Chlorination of public water systems was first tried in Maidstone (Eng.) 1897, and in North America at Jersey City, 1909. Its success in purifying water and preventing typhus led to its quick adoption. It was tested in Toronto in 1910, and included in the system at the same time that filter plants were also introduced to remove colouring from water. The amended Public Health Act of 1913 gave the Ontario Board of Health power to force municipalities to improve their waterworks systems. See, The Annual Reports of the Provincial Board of Health, Ontario Sessional Papers. 1911 onwards.

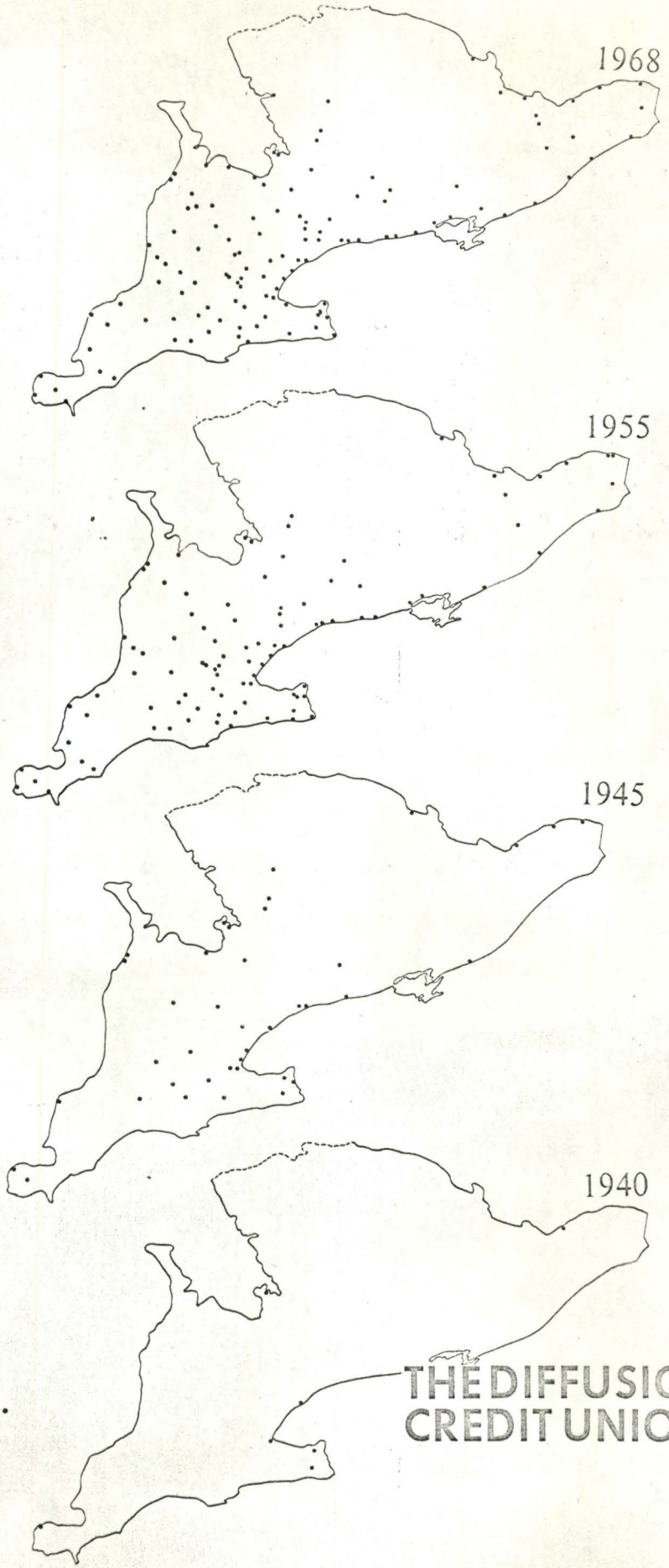

Figure. 24. THE DIFFUSION OF CREDIT UNIONS

adoptions increase in the south emphasizing the lack of adoptions in the north. Further increases are evident by 1935, although some large towns and cities do not adopt until the late 1920's, (London, Hamilton). In many centres there was some opposition to the idea of chlorinating and filtering the water, characteristic of the opposition to fluoridation which was to come three decades later.

Credit Unions (Figure 24)

Credit Unions and Clubs (see below) were not innovations requiring municipally organised community decisions since they were associated with social and economic sub-groups within towns and cities. However, it is useful to include them to see if they differ in spatial evolution from the other class of community innovations. Credit Unions are credit societies for working and lower level professional groups. Although they were founded (in North America) in Quebec, the main impetus for growth in Ontario came from the United States Credit Union movement which itself had evolved in part from the Quebec movement.[12]

The spread of credit unions is shown in Figure 24, each point representing the first occurrence of a credit union in a town. The initial concentration in the Niagara area is particularly apparent. By 1945 expansion into the small industrial towns of central South West Ontario is noticeable with few adoptions in Eastern Ontario. Adoptions in the Georgian Bay area and Ottawa River Valley were rurally orientated and associated with Caisse Populaires and Farmers' Co-Ops.

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[12] Bergeron, R.F. op. cit. 1935.

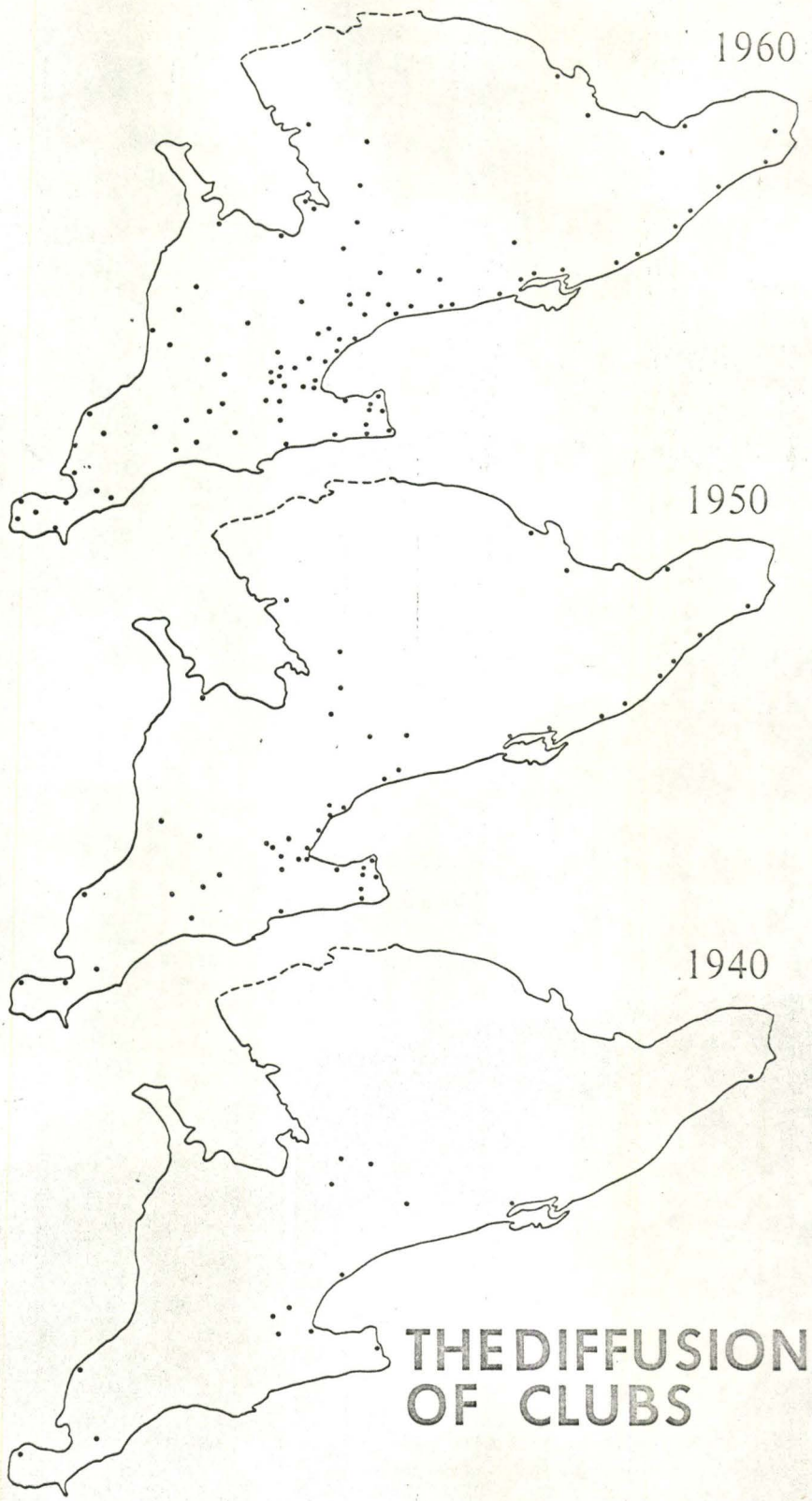

Figure. 25.

Succeeding adoptions increase the density of existing areas with only a few adoptions in Eastern Ontario even by the mid 1960's.

Civic Clubs (Figure 25)

Clubs organised for the benefit of the community as a whole rather than for specific socio-economic sub-groups became popular after World War I.[13] They gradually spread through the larger centres and then diffused particularly early in the Toronto, Hamilton, St. Catharines area perhaps reflecting their routes of introduction from the United States.

Having described the spatial development of those innovations having an association between date of adoption and size of centre we can now turn to those where a relationship between adoption date and centre size do not exist.

Municipal Power Plants (Figure 26)

The idea of municipally owned utilities was a major issue to evolve in municipal government in the late part of the 19th century.[14] An examination of the growth of adoptions suggests three main core

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[13] The Clubs involved are the Kiwanis and Lions Clubs. The Kiwanis Clubs were founded in Jan. 1915 at Detroit. The Lions Clubs, Chicago, 1917. The former were to promote vocational guidance and social welfare, the latter (ex-service) were for business and professional people.

[14] An examination of the Bibliography compiled by the 1903 Ontario Govt. Report on Municipal Trading (Ownership of Utilities) show that most references date from 1890 onwards and cover a whole range of municipally-owned "services" from Housing to Orchestras. (Appendix to Legislative Assembly Journals 1904).

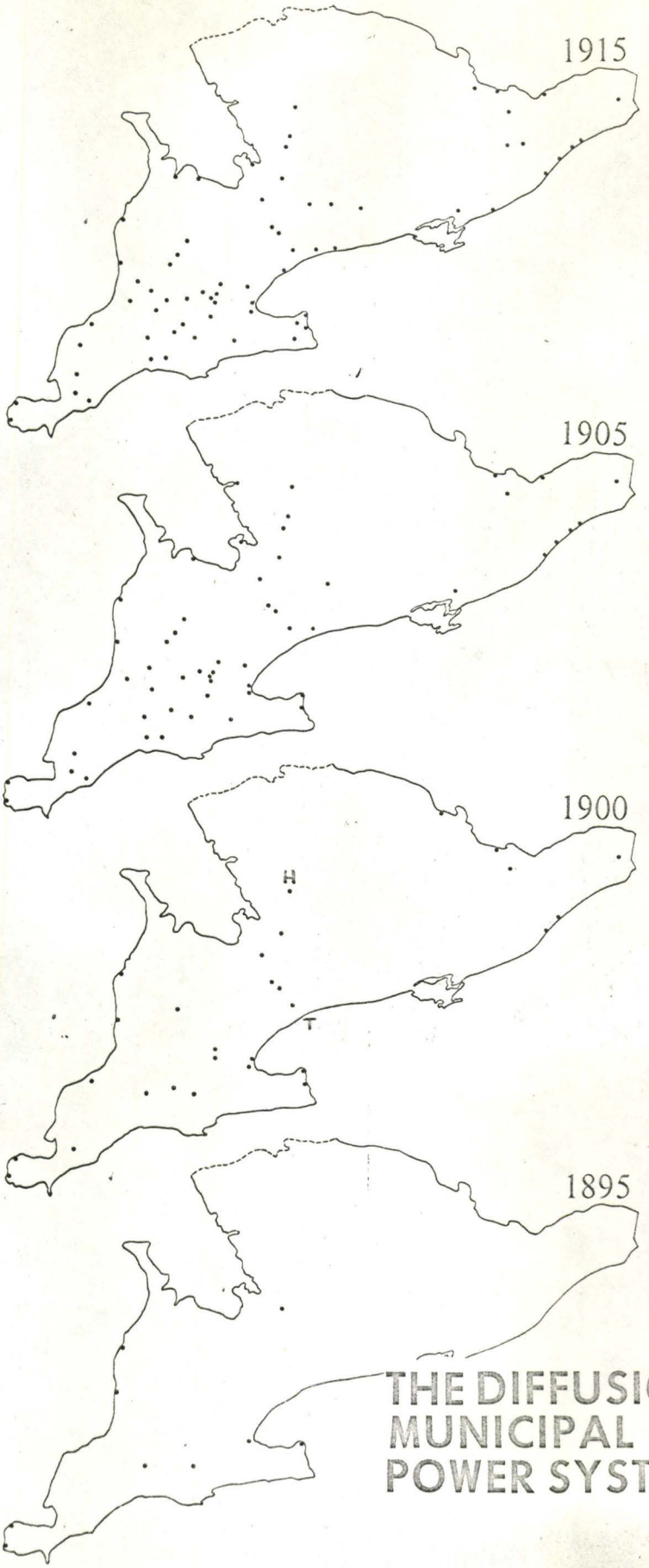

Figure. 26. THE DIFFUSION OF MUNICIPAL POWER SYSTEMS

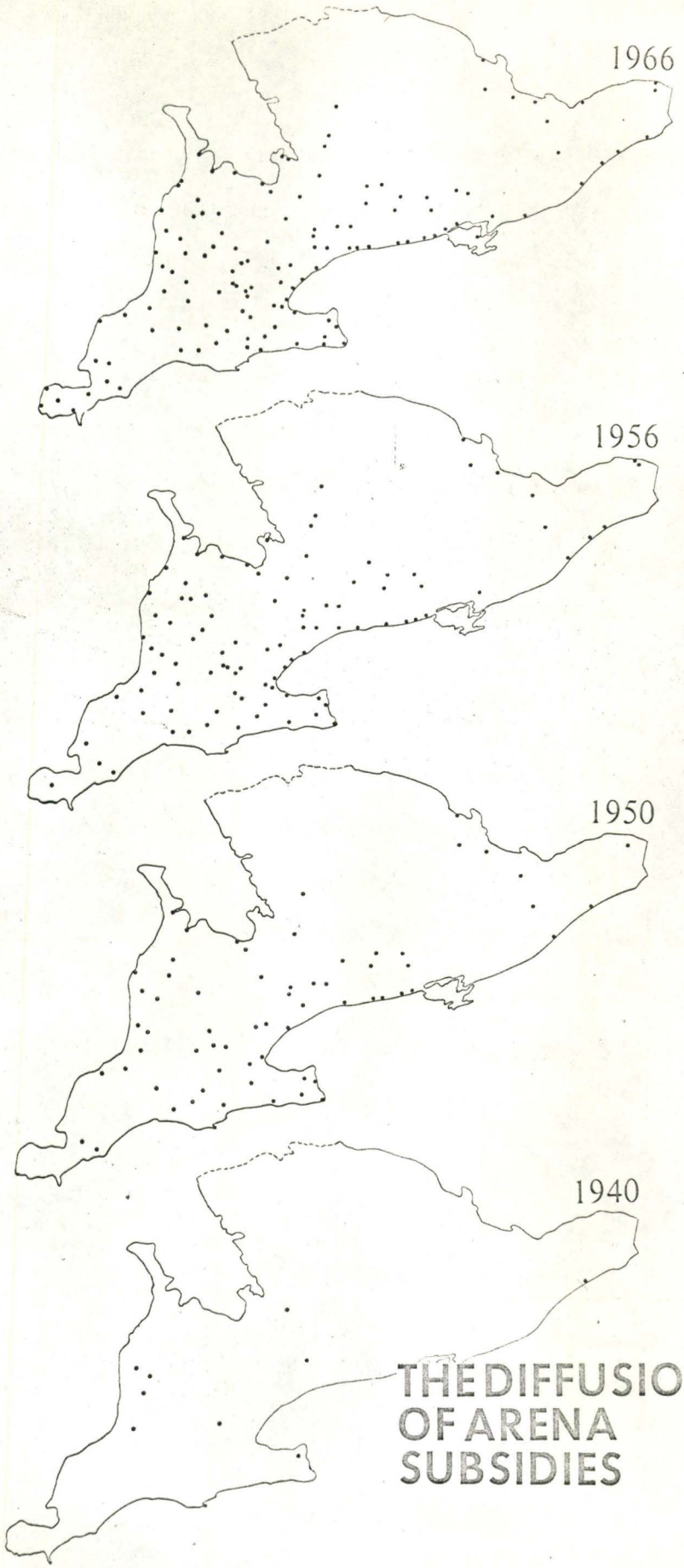

Figure. 27. THE DIFFUSION OF ARENA SUBSIDIES

areas firstly in the Windsor/Chatham area, secondly in the central South Western area and finally towns strung out along the route from Toronto (T) to Huntsville (H). By the end of the period under consideration centres around Ottawa appear to be another core. Areas without adoptions which stand out particularly are central Eastern Ontario and the area North West from Toronto to Georgian Bay. There is some evidence therefore of clusters of adopters.

Arena Subsidies (Figure 27)

Subsidies were given by the Provincial Government to develop community centres and arenas initially in rural areas (Act passed in 1919). Immediately prior to World War II some larger centres applied for grants. With the return to normal conditions after World War II other towns and cities began to apply for subsidies.[15] The location of the initial adopters are shown in Figure 27. Subsequent adoptions (1950) suggest a clustering towards the Lake Huron shore and the southern section near the initial adopters. Adoptions in the south west and also east of Kingston are few. Further adoptions fill in the early clusters so that by 1966 they coalesce.

Fluoridation (Figure 28)

Fluoridation of water systems (i.e. the addition of artificial

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[15] Thus in 1919 a bill was introduced by Mr. Keriny, "An Act Respecting the establishment of community halls in Rural Districts." 9 Geo. v. ch. 55 p. 336, Statutes of Ontario (1920). The Govt. would provide 25% cost. In 1950, the act was amended to "any municipality". (i.e. not necessarily rural).

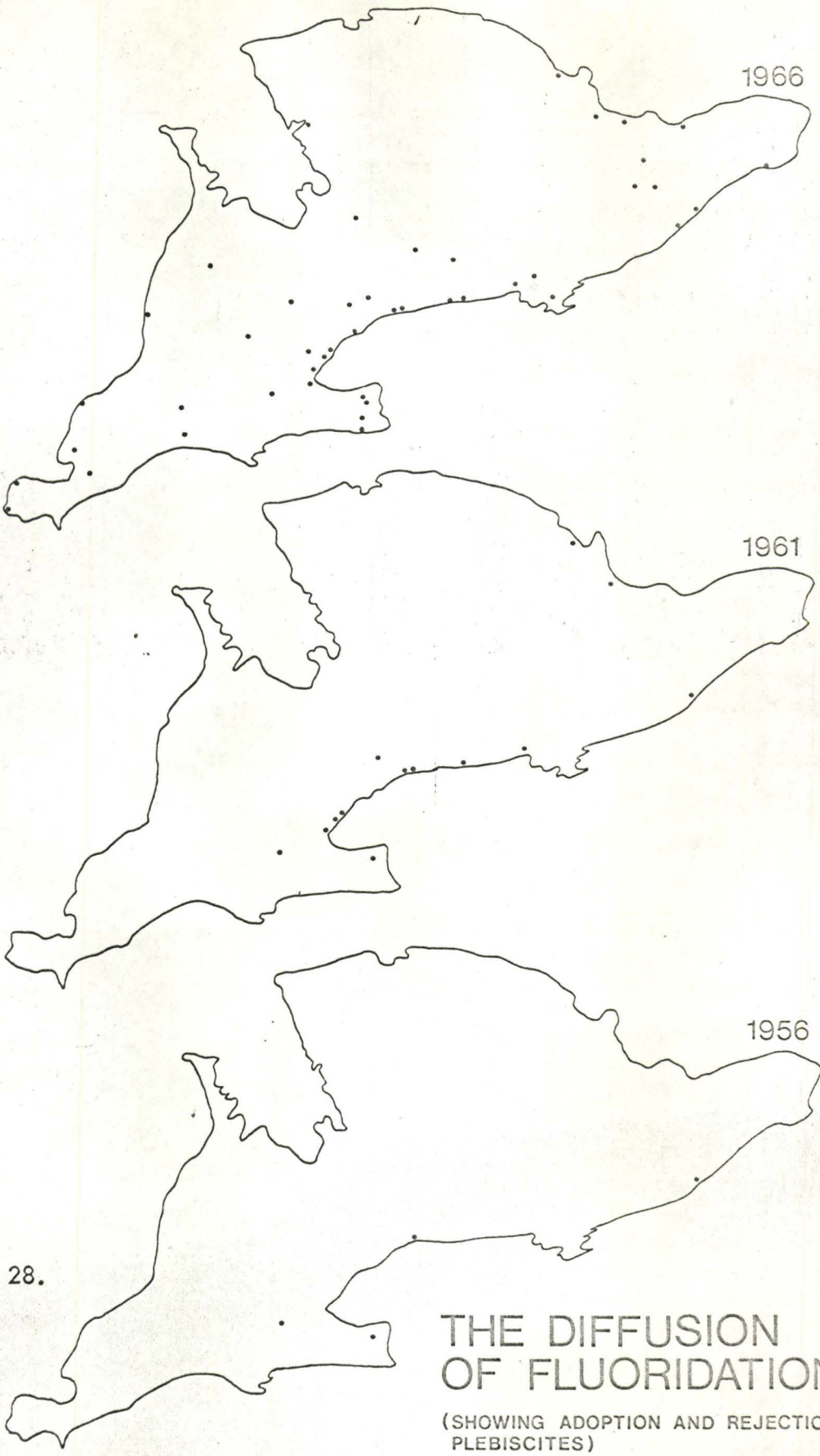

Figure. 28.

THE DIFFUSION OF FLUORIDATION

(SHOWING ADOPTION AND REJECTION PLEBISCITES)

fluorides) as a means to reduce dental cavities began in the 1940's in a series of controlled experiments in Michigan, New York and Brantford (Ontario). The success of these experiments led to approval and endorsement of the practice by National Medical and Dental Associations.[16] Consequently, other municipalities with low natural fluoride content in their water supplies also began fluoridation. However, certain groups opposed to fluoridation on political and medical grounds resulted in the innovation becoming a controversial issue.[17] The spread of fluoridation decisions is shown in Figure 27.

Initially, decisions are close to Brantford during the early 1950's. Subsequent decisions appear to be strung out but generally in southern sections of the province. Up until 1967 most decisions are made in centres with a population greater than 2,500.

Discussion

The complexity of the spatial development of adoptions as shown in Figures 19-28 illustrates the problem of deriving general statements from visual examination of point patterns. However, certain tentative observations can be made.

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[16] For a comprehensive account see: - Maier, F.J. Manual of Water Fluoridation Practice. (McGraw-Hill, 1963).

[17] The controversy over fluoridation can be followed in the Debates of the Ontario Legislation from 1954 onwards. The Ontario Govt. carried out a report into the matter (1960), and the Federal Govt. also carried out an Inquiry (1962), both of which favoured fluoridation.

A comparison between the pattern of centres as illustrated in Figure 4A (page 46) and the diffusion of adoptions as shown in Figures 19-28, demonstrates the influence of the clustering of centres in the south central section, which tends to be an area of early concentration of adoptions and the absence of centres in the eastern part, which has few adoptions.

A south to north progression of adoptions is evident probably related to the concentration of larger towns and cities along the southern edge of the area.

The effect of transportation and communication links is manifest with early adoptions strung out from west to east (e.g. Figures 21-23) in a "corridor" effect along the southern edge. In addition, the effect of other routeways is also evident with adoptions spreading along the roads to Goderich, Owen Sound and Huntsville, in a finger like manner. This is shown not only in the spread of the early innovations, such as Mechanics' Institutes (Figure 20) but also in the recent innovations such as credit unions (Figure 24). Thus, there may well be a parallel with Hägerstrand's observation in Europe, that routeways of ideas have roots in the past which have maintained a certain continuity up to the present. The importance of the southern "corridor" is reinforced by its close proximity to the United States. It is from the latter source that most of the innovations were derived even though the innovation originated in Europe or even Quebec.

Turning from a visual examination of the spread of adoptions we

now attempt to understand how the process of diffusing adoptions occurs. Did the larger centres influence the spread of adoptions, as the clustering effect suggests? The patterns of spatial diffusion of innovations in Southern Ontario suggest from a visual examination, that a clustering of followers near initial leaders may have occurred both in those cases where innovation adoption dates are related to population size of centre and where no relationship between the two exists.

However, it is obviously difficult to estimate whether this apparent clustering is significantly different from a random pattern unless a more precise measurement of the relationship is made. Furthermore, the clustering may be due to a clustered population which would pre-determine a contagious process. Consequently, some more precise methods of description and analysis must be discussed and then applied to the patterns of diffusion.

Methods of Analysis

Various methods have been developed to describe and categorize point patterns and their deviation from randomness. Clark and Evans (1954) define a random point pattern where

> "any point has had the same chance of occurring on any given sub area as any other point, that any sub area of specified size has had the same chance of receiving a point as any sub area of that size; and that the placement of each point has not been influenced by that of any other point."[18]

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[18] Clark, P.J. and Evans, F.C. (1954). Distance to nearest Neighbor as a Measure of Spatial Relations in Populations. Ecology, 35, 445-53.

The methods employed to test the deviation of an observed pattern from a random pattern can be classed into two groups: quadrat analysis and order neighbour distances.

The use of the quadrat counting method has been discussed by P. Greig-Smith (1967) and K.A. Kershaw (1964). The application of this methodology to geographical problems has been mainly by A. Getis (1964), M.F. Dacey (1966, 1968), D.W. Harvey (1966, 1968), and G. Olsson (1966). The method consists of counting the frequency of occurrence of a population in either a sample of randomly located quadrats or in all the quadrats of a grid and then comparing the observed distribution with an expected distribution generated from an hypothesized process.

Harvey (1966) has shown that the negative binomial distribution gives a consistent description of diffusion patterns as originally mapped by Hägerstrand (1952). Despite the generality of the model certain problems exist in using the quadrat counting method. The chief problem concerns the size of quadrat used since by variation in quadrat size one also varies the density of points and consequently the rates of diffusion and the basic assumption of independence (Harvey 1968).

The problem therefore is, given the "successful fits in a wide range of circumstances" there are opposed theoretical interpretations.[19]

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[19] Harvey, D. op. cit. (1968) p. 92.

Consequently Harvey (1968) suggests three lines of approach. (1) further statistical analysis of the point patterns noting the behaviour of the parameters. (2) evaluation of the scale factor and (3) more empirical data to see whether contagion is "true or apparent".

Order Neighbor Distance Measures

The nearest neighbour method has been reviewed by Clark and Evans (1954), P. Haggett (1965) and L. King (1969). In geographical studies the method has been used by Dacey (1963, 1964-A, 1966-A), King (1961) and Getis (1964). There are two tests for randomness of the distribution of distances between neighbours. The first test is based on the assumption that given a random point pattern, the nearest neighbour distances are normally distributed.

A second test makes use of a x^2 statistic (Dacey 1963, 1964a) where the distance from a randomly selected point to its j^{th} nearest neighbour is described by a gamma probability law.

Reflexive Pairs

Clark and Evans (1955) show however, that a random pattern contains a high proportion of reflexive pairs, that is, where two points have each other as a nearest neighbour (in a random distribution the proportion of points having N^{th} order reflexive pairs is $(2/3)^N$). To overcome this problem analysis has been extended to include first, second,..., N^{th} order distances and comparing the averages of each order to the expected value of a random pattern. Dacey and Tung (1962) have also extended the statistic by dividing the area around points

into sectors and then finding the nearest neighbour in each sector. But this latter method has the disadvantage that assumptions underlying the derivation of r_e do not allow for empty sectors, while a nearest neighbour in a sector may actually be further away.

Dacey has recently shown that the method of calculating values for the theoretical proportions of reflexive pairs is wrong.[20]

Other Problems

In an empirical analysis other problems arise with the use of nearest neighbour methods. Firstly, points outside the area may be nearer neighbours to points specified within the area. A similar problem associated with boundary definition is that by varying the area one automatically varies the density of points. The effect of this can be seen in Table 4 in which we have a nearest neighbor analysis on the 112 sample points of central places for different definitions of Southern Ontario. Land area A represents Southern Ontario with a northern boundary drawn at French River/Mattawa River, giving a total land area of 45,656 square miles (excluding Algonquin Park). Land area B represents Southern Ontario south of a line drawn approximately between Bracebridge and Pembroke, giving a total land area of 38,249 square miles.

The result of calculating the nearest neighbor statistic show "R" values for area A that they are significantly different from random at

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[20] Dacey, M.F. Proportion of Reflexive n^{th} order Neighbours in Spatial Distributions (unpubl.) (n.d.).

some points in time but not others (diffusion of power companies).[21] On the other hand, "R" values for area B are never significantly different from a random pattern.

The boundary problem also arises since some central places in the United States are nearest neighbours to certain Canadian places. (Detroit/Windsor, Buffalo/Fort Erie).

Finally, the statistic is not particularly useful if the final pattern is more clustered than random, rather than towards evenly spaced, since this would not necessarily mean a contagious process per se but the predetermined outcome of a clustered group of adopters.

TABLE 4

Table of values of Nearest Neighbour Statistic "R" for two definitions of Southern Ontario

Area A	N	Area B
.69	13	.74
.83	33	.89
.93	51	1.00
.92	73	.98
.88	93	.95
.88	107	.94
.88	112	.94

Significant at .95 level.

Area A = Boundary drawn at French/Mattawa Rivers, with Algonquin Park omitted.

Area B = Boundary drawn as a line between (approx.) Gravenhurst and Pembroke.

[21] $R_n = \overline{D}obs/\{0.50(A/N)^{\frac{1}{2}}\}$, see Haggett, P. op.cit. p. 232 for a discussion of this statistic.

Cliff (1968) uses the contiguity ratio to examine Hagerstrand's data for statistical evidence of a "neighbourhood effect", and concludes that the pattern of adoptions is not significantly different from random.[22] Apart from the possibility that the data is exceptional and the usual scale problem associated with quadrat methods, Cliff also suggests that the effect (neighbourhood) may be distorted by population inhomogeneities.

Eidem (1968) employs the nearest neighbour statistic (R) to examine patterns of adopting of innovations requiring community decisions (e.g. fluoridation, swimming pools) in North Dakota. He shows that 'R' values vary over time and between different innovations and then gradually approach the present urban pattern which is more regular than random.

Developing a Measure

In view of the problems which have arisen in the implementation of the methods described above and in view of the type of data being processed it was decided to employ the simple measure developed in Chapter five (p.69ff.) The procedure is outlined as follows:-

(1) Dichotomize central places as potential adopters, into LEADERS and FOLLOWERS: such a division will necessarily vary from

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[22] For a review of contiguity methods see:- Dacey, M.F. A Review Measures of Contiguity for Two and K Color Maps. Tech. Rep. 2. Spatial Diffusion Study, Department of Geography North Western University (1965).

system to system and according to the innovation concerned; however, considerable empirical research justifies this dichotomy but so far has only designated "peers" at the micro scale. It is feasible that a trial and error method could be employed to achieve the dichotomy if necessary. For example, in the analysis of Power Companies the division was set at places with a population > 5,000 designated as Leaders, < 5,000 designated as followers. (Population size of central places).

(2) The FOLLOWERS can then be dichotomized into EARLY and LATE with the division being set at the median year of adoption. Clearly the division need not necessarily be a dichotomy but could be extended according to a further subdivision of the adoption curve for that class. (c.f. early, early majority, late majority, laggards).

(3) Measure distances of FOLLOWERS from LEADERS, where distance is defined as a straight line between two points. Check whether the distances approximate a normally distributed random variable.

(4) Calculate the average distances of FOLLOWERS from nearest LEADER.

(5) Test whether the average distance of EARLY followers is significantly different from average distance of followers from a leader using "t" test for differences between means.

Results

The measure was applied first to three innovations where an association between adoption date and size of centre exists. The hypothesis can be framed as follows:

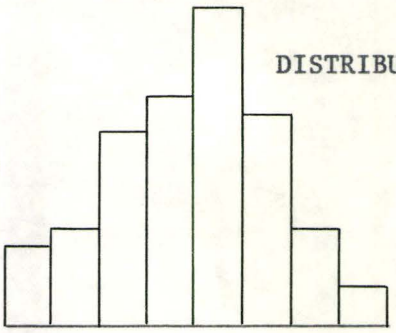
TABLE 5

INTER-ADOPTER INFLUENCE AS SHOWN BY THE ORDERING OF POINTS IN SPACE

Innovation	Mean Distance of Early Followers From a Larger Earlier Adopter	Total Average Distance of All Followers From Earlier Adopters	"t" Test
(1) Credit Unions	33.6	37.7	signif. at .001 level
(2) Power Companies	37.0	45.0	signif. at .05 level
(3) Waterworks	50.8	70.8	signif. at .001 level
(4) Arena Subsidies (no significant relationship between adoption date and size of centre)	36.5	46.4	signif. at .001 level

DISTRIBUTION OF DISTANCES

1.



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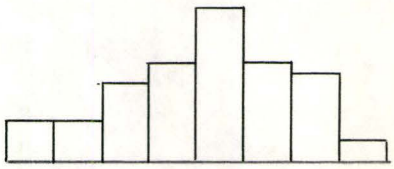

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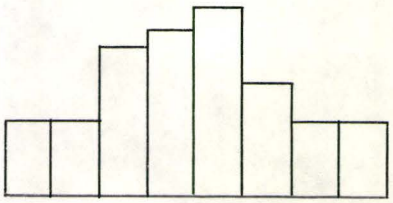

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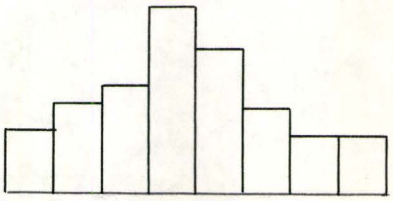

> "small central places which are early adopters tend to be nearer to larger centres which are previous adopters than those small centres which are late adopters."

The level of significance can be set at $\alpha = .05$. A check of the distribution of distances between centres shows that they are normally distributed (Table 5). Applying the "t" test to the distances of early adopters it is observed that they do have a significantly shorter average distance from a leader than the later adopters (Table 5). It can also be seen that results significant are at the .05 level. Therefore the hypothesis is accepted.

If the same hypothesis is applied to that sub-class of innovations requiring community decisions which do not have a significant association between adoption date and size of centre, the designation of "leaders" and "followers" has to be defined in a slightly different manner. Since the adoption date/centre size relationship does not hold, leaders can be designated as the first 10% of adopters.[23] Again, a trial and error scheme could be devised to accommodate varying definitions of the total percentage of adopters who are leaders. (The lower inflection point of the adoption curve might be a suitable division).

Having defined "leaders" as the first 10% to adopt, the same procedure of measuring distances of followers from leaders can then

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[23] See Rogers, E. (1962) for further discussion of this point; see especially Chapter 7.

be employed to analyse the patterns of communities adopting community centres/arenas, an innovation where a significant relationship between adoption date and size of central place does not exist. The results are shown in Table 5 where it can be seen that the distances of early adopters are again significantly shorter.

Discussion

Chapter 5 shows that awareness of innovations (the arrival) is closely associated with the population size of central place. However, it has also been demonstrated in this chapter, that adoption dates (terminals) do not necessarily have this relationship with the independent variable, but that two distinct sub-classes of innovations requiring community decisions exist; those having a significant correlation and those without.

It has also been found that the rate of adoption varies according to the innovation concerned. Some innovations diffuse quickly from large to small centres while others are adopted in larger centres for several years and then spread very quickly through the remainder of the system. The reasons for these variations are as yet unclear and await further investigation. Despite this variation, the number of years taken for adoptions to diffuse through the system from large to small centres are not significantly different for each innovation except for waterworks and mechanics' institutes which develop with the urban frontier in the mid 19th century and would hence have taken longer to diffuse.

The spread of adoptions reflects also the uneven pattern of centres with the concentration of large cities and towns along the southern edge. Since most innovations discussed here have a close association between adoption date and size of centre, a south to north development is observed. The influence of routeways is also apparent, not only in channelling growth but also in creating a "corridor effect" along the southern edge of the province. This reflects not only the pattern of larger urban channels but also the proximity to the United States, the immediate source of most of the innovations.

An analysis of the adoption patterns attempts to describe how the diffusion process takes place. It does appear that evidence of a neighborhood effect is present, where small centres near larger earlier adopters adopt earlier than those further away.

In view of the existence of two sub groups of adoption dates and in view of the uneven distribution of central places in Southern Ontario (centres are clustered in central and South West Ontario) the fact that a "neighbourhood effect" is observed in both sub groups by a method which is not a pattern measurement demonstrates the generality of the neighbourhood hypothesis. However, the foregoing analysis of adoption dates still represents a surrogate method for establishing inter-adopter influence where early adopters tend to be closer to previous adopters than those which adopt later.

Consequently, in order to understand how some adoption dates of

innovations requiring community decisions are related to centre size and others are not, and also to establish that decision makers in this class of innovations do make contacts for further information about innovations, an examination of the decision making process which occurred between awareness and adoption must be made. In doing so, it is hoped that some indication of the nature of variation in the length of the adoption process will emerge.

CHAPTER 7

An Analysis of Decision Making: the Processing of Innovation Decisions

Introduction

From a consideration of "arrivals" and terminals we can now examine direct evidence of the intervening decision making activity, the "process time". It was shown in Chapters 5 and 6 that innovation awareness dates have a significant association with the population size of central place; however, the analysis of adoption dates shows that while a similar association exists with size of centre for some innovations, a distinct sub-group exists in which there is no apparent association between adoption date and population size of central place.

Analyses of the spatial development of adoption show that a neighborhood effect appears to have been present although this had not been the case in the spread of initial awareness. However, this type of analysis of inter-adopter influence still represents a surrogate method based upon the relative position of points in space and is not a direct measure of behavior.

Consequently, there is every need to examine the decision making processes which result in an adoption both in terms of understanding why a deviant sub-class should occur and secondly to clarify our

understanding of the spread of adoptions by direct analysis of inter-adopter influence through the actual contacts made between adopters.

The importance of understanding and describing decision making systems and measuring their learning capacity in terms of innovation adoption is stressed by Deutsch.[1] However, an operational problem lies in the lack of an analytical framework within which to analyse the processes of decision making.[2] Several qualitative models have been advanced, ranging from Weber's "ideal types"[3] to the structure-function concepts of Talcott Parsons[4], and more recently, Simon's models of rationality and adaptive behaviour.[5] The problem lies in applying the general conceptual models to a specific set of systems. Several analyses of the processes of decision making in urban systems have been made but these are not described in general terms.[6]

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[1] Deutsch, K.W. The Nerves of Government: Models of Political Communication and Control, (Free Press of Glencoe, 1966) p. 161 ff.

[2] Numerous studies have been made of municipal government and also of urban politics and the processes of decision making involved. However, the greater part are case studies and provide no general approach to describing and measuring decision processing.

[3] Weber, M. The Theory of Social and Economic Organization, (Free Press Glencoe, 1947).

[4] Parsons, T. & Shils, E. Towards a General Theory of Action, (C.U.P. 1951)

[5] Simon, H. Administrative Behaviour: A Study of Decision Making Processes in Administrative Organization, (New York, 1957).

[6] See for example, Dye, T. & Hawkins, B. Politics in the Metropolis (Merrill, Columbus 1967).

Furthermore surrogate methods are used to differentiate between optimum and actual outcomes. (i.e. to identify the behavioural factors involved).[7] Yet despite these conceptual advances little empirical work has been produced,[8] other than case studies of individual cities.

The conceptual outline describes an approach to the description of the processing of decisions using a queuing analogue. This type of analogue has been applied so far to physical systems rather than to socio-economic systems.[9] However, in using an analogue of this kind it should be possible to organize and measure the processes and structures whereby an innovation is processed by a decision making system. There are certain limitations to the following analysis in that certain variables such as the attitudes, education levels, social, political and ethnic backgrounds of the members of the decision making group are not considered![10] However, despite these limitations if some simple statements concerning the processing of innovation decisions are possible, the outstanding problems in diffusion research could possibly be tackled more effectively.

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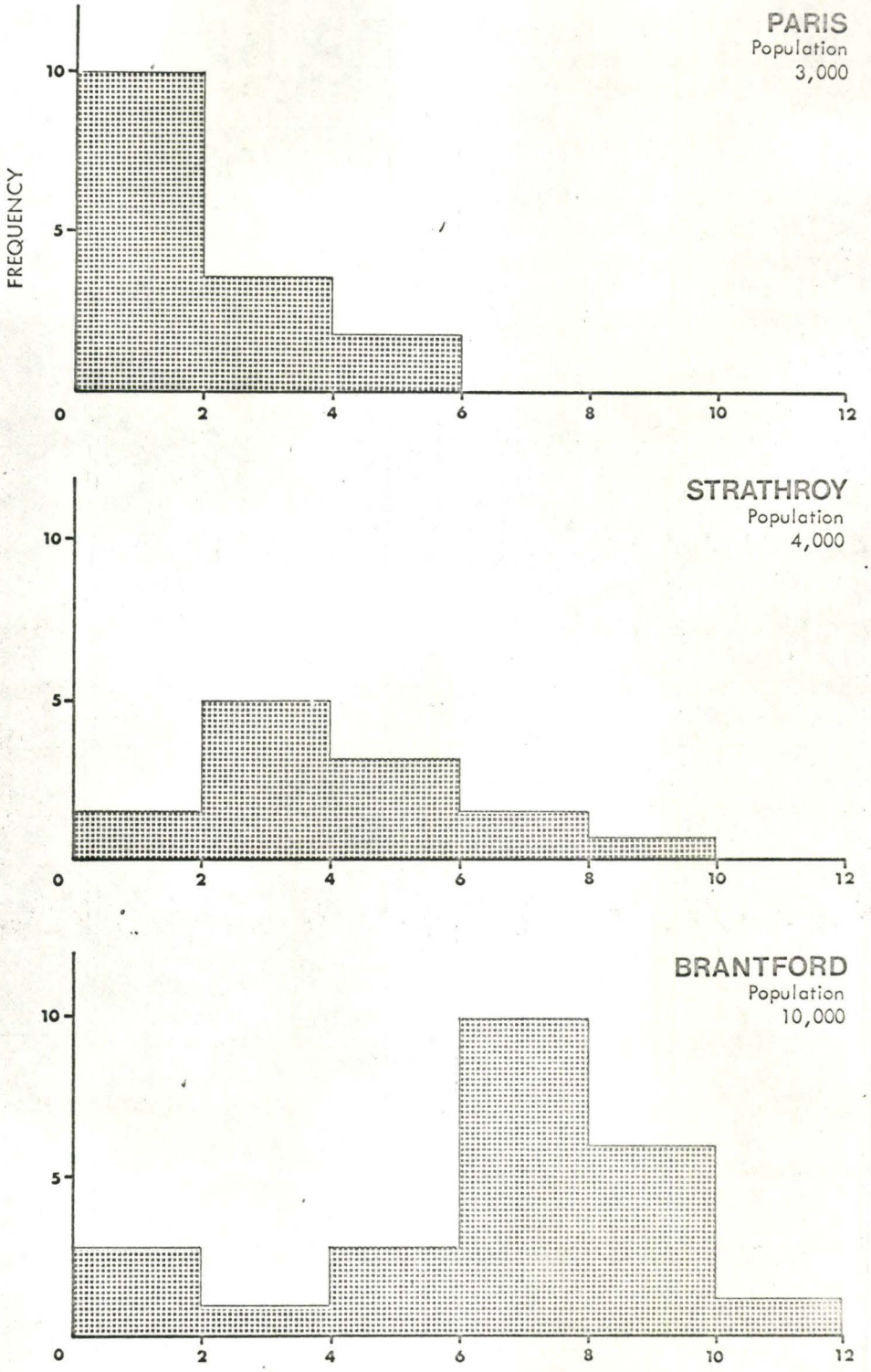
[7] Wolpert, J., op. cit. (1964).

[8] White, G. Social and Economic Aspects of Natural Resources, in Burton, I. & Kates, R. op. cit. p. 504 ff.

[9] See for example, Thomas, A.H. Queuing Theory and Reservoir Design, Proc. of a Symposium on Computer Applications, Harvard, 1962.

[10] For a recent appraisal of such factors see: Schiff, A.L. Innovation and Administrative Decision Making: the Conservation of Land Resources. Administrative Science Quarterly 1967, p. 1-30.

FREQUENCY DISTRIBUTION FOR ARRIVALS AT DIFFERENT SIZED CENTRAL PLACES PER MEETING



ARRIVALS OR PROBLEMS REQUIRING EVALUATION PER COUNCIL SESSION BASED ON RECORDS FOR FIVE YEARS

Figure. 29.

The Structure of Decision Making

The processing of problems by municipal councils[11] can be described as a waiting line or queuing analogue. Just as cars arrive at tolls, passengers at counters and components at an assembly point, so too, problems requiring evaluation, discussion and decisions, arrive and confront decision makers and thus can be described in the same manner. In this case, this means that problems recorded in the minutes and records of council meetings (in queuing terminology designated as "arrivals") can be described as they pass through or are processed by the system. Naturally, the same approach could be applied to other decision making systems as well as municipalities.

The actual "arrivals" take on several forms, being either a letter, petition, personal representation or actually an issue raised by a member of the council. The processing of the problems depends upon the frequency of their arrival and the structure of the processing system. The frequency of arrivals can be measured for certain centres at different times. Typical frequency distributions for arrivals for different sized centres are shown opposite. (Figure 29)[12] Not unexpectedly a relationship appears to exist between the frequency of arrivals and the size of centre concerned. If one wanted to evaluate

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[11] For a history of the development of the system see Plunkett, J.T. Urban Canada and Its Government (Toronto 1968).

[12] From a preliminary survey of municipal records for recent years, it seems as if no great increase of arrivals has occurred, except in the largest cities.

TABLE 6

ARRIVALS REQUIRING STRATEGIC DECISIONS

INNOVATIONS REQUIRING MUNICIPAL DECISIONS SOUTHERN ONTARIO 1850-1968

Waterworks	Electrical Power	
Library(free)	Fire Brigades	
Town Hall	Transit Systems	Mid and
Street Cars	Telephone Systems	Late C19th
Civic Hospital	Theatre Opening(Sundays)	
Bridges		
Branch Railway Lines	Fair Grounds	
Chlorination of Water	Sewage Systems	Early C20th
Filter Systems		
Prohibition		
Local Option(Liquor By-Law)		
Parking - By-Laws		
Pasteurization	City Manager Plan	
Community Halls/Swim Pools	Civic Arenas	
Parking Meters	Skating Rinks	
Fluoridation	Civic Airports	
Civic Malls	Freeways	
Public Housing	Urban Planning	Mid C20th
Redevelopment	Senior Citizens Houses	
Social/Welfare Centres		

the capacity of the system for effectively processing all types of arrivals, the frequency of the arrivals would be an important consideration. However, we are concerned with the processing of innovation decisions, a particular category of arrival requiring a strategic decision.

Many of the arrivals are problems which are routine in nature such as street repairs, traffic controls, annual tax collection and aldermanic elections. Usually, such routine matters are summarily dealt with.[13] However, certain other arrivals represent a departure from existing norms, requiring evaluation and strategic decisions on the part of the municipality. Innovations are typical of these non-routine or unprogrammed arrivals. Table 6 lists some of the more important innovations which have been and in some cases are still being considered in the central places of Southern Ontario and many other urban systems of the world.

The general structure of the processing of these problems or "arrivals" can be shown in flow diagram form describing the interaction of various sub-routines. (Figs. 30-32). These sub-routines (e.g. contact, consideration, searching) are the sub-decisions which comprise the total processing time (that is the elapsed time between the initial awareness of the innovation and the

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[13] For a simulation of routine decision processing see:- Crecine, G.P. A Computer Simulation Model of Municipal Budgeting, Management Science Vol. 13 (2) 786-815 (1967).

Flow Diagram of
Decisions Made By Municipalities Concerning Power Systems

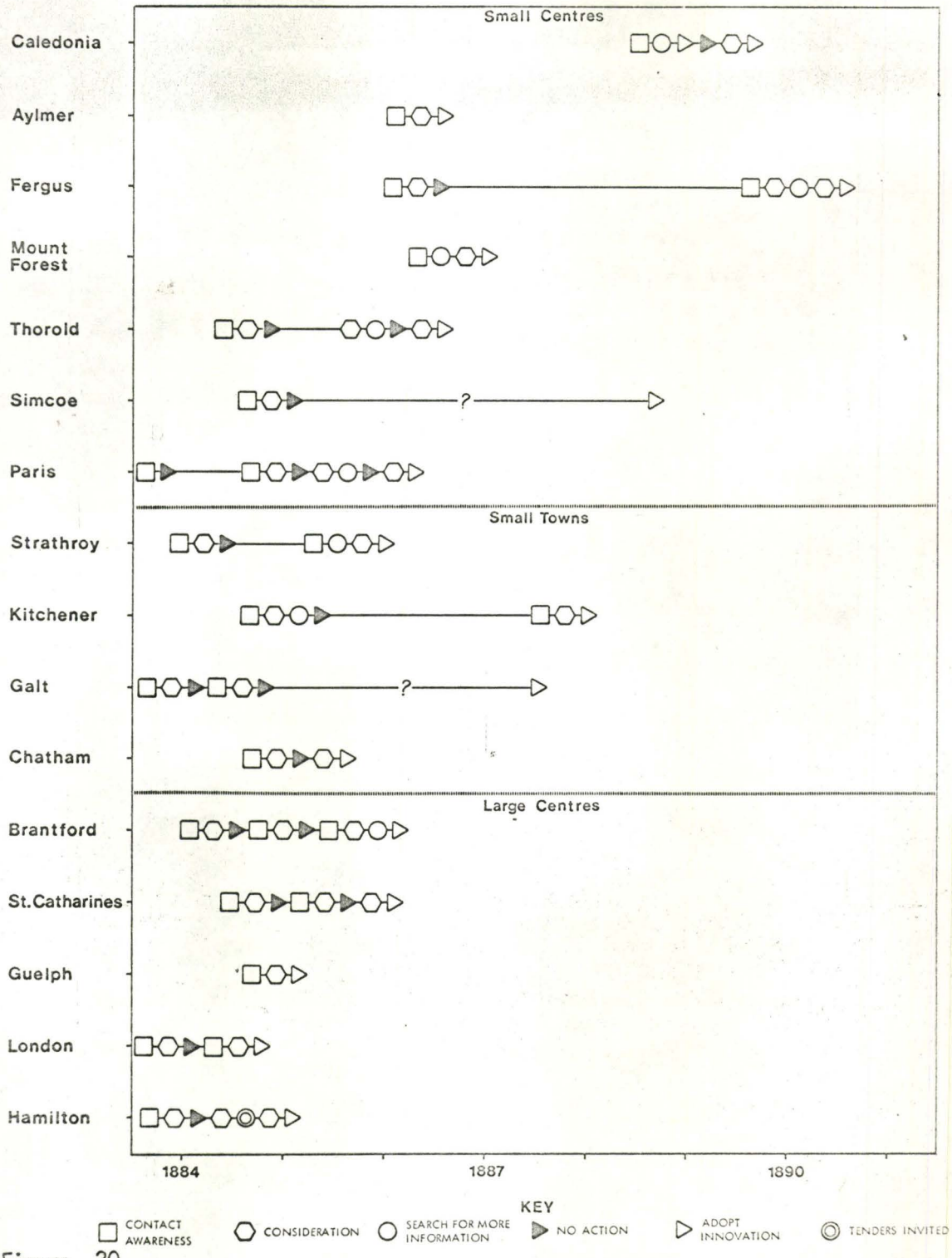

Figure. 30.

final decision). Sufficient data are available for a description and analysis and decision processing concerning power systems, municipally controlled power systems and fluoridation.

Description and Analysis of Decisions

ELECTRIC POWER SYSTEMS

The structure of decisions made by municipalities concerning electric power systems during the late 19th century is shown in Figure 30. The innovation was brought to the attention of the councils most frequently by propagators' agents and to a lesser extent by public petition and initiative on the part of a particular council member. It can be seen that the time taken to process the innovation is relatively short in most cases since most decisions to adopt the innovation were made within one year of the initial awareness. (Figure 30). Irrespective of the population size of the centres concerned, a negative decision[14] appears to have been made first (i.e. not necessarily one of rejection, but one of no further action). This response may represent a form of insurance reflecting uncertainty until more information is forthcoming.

The centres then appear to have been contacted a second time by the propagators; this appears to result in a more concerted attempt to evaluate the innovation either by searching for more

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[14] Here a positive decision is defined as one which leads to a change in the system by some action on the part of the decision makers. A negative decision - as one which leaves the system unchanged.

information by contacting other municipalities or inviting tenders from electrical companies. The outcome of this search for information in most cases leads to a decision to adopt the innovation; however, this is not always the immediate result since some centres go through the contact-evaluation-search process several times before a decision to adopt is actually reached. This "looping" effect is evident in the decisions made by Galt, Fergus and Thorold; in the latter case the looping goes on several times before a decision is eventually reached, even though the councils are aware of the innovation as early as 1886.

The process times for the larger centres are short in that a decision is arrived at quickly. (e.g. Hamilton, Chatham). The city council of Hamilton first became aware of the innovation late in 1884. After consideration, the propagator's offer is turned down, but the matter is then put to open tenders with the lowest tender being accepted within a few months.[15]

Further examination of the flow diagrams reveal that although it is quite common for municipalities to search for more information (more than 50% of the councils did undertake a search), From an examination of the municipal records there is evidence that a search is undertaken by some of the other centres but no information concerning the other centres actually contacted was recorded (thus 50% can be regarded as a very conservative figure).

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[15]Minutes of council meetings, City of Hamilton, Hamilton Public Library (unpublished).

Flow Diagram of
Decisions Made By Municipalities Concerning Power Systems

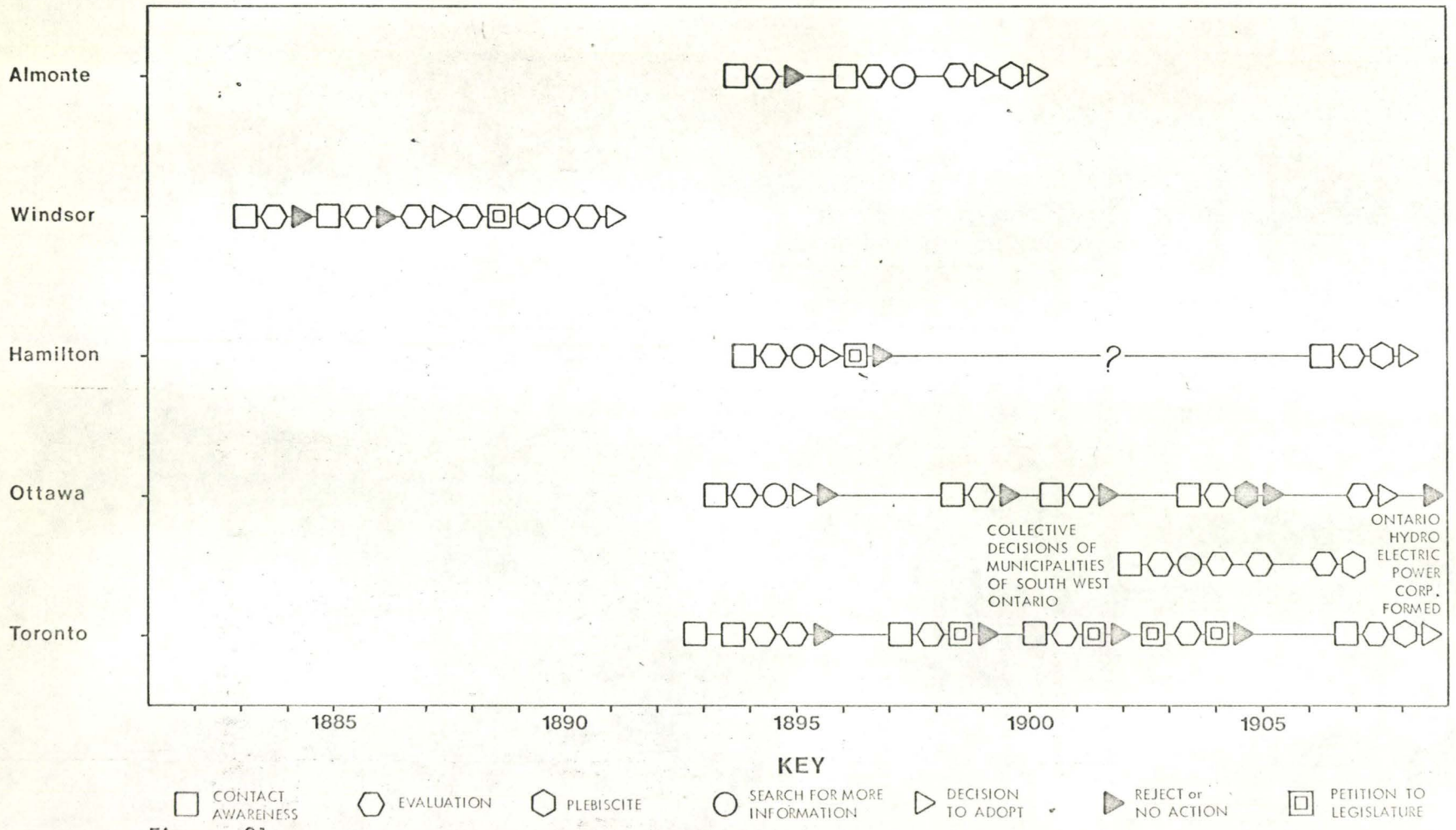

Figure. 31.

The decisions made concerning power systems can be taken as representative of the majority of innovations which are non-controversial in that no resistance is present and a close association between size of centre and date of adoption exists. From a consideration and description of this type we now turn to a description of two "controversial" innovations, namely municipally controlled power systems and fluoridation.

MUNICIPALLY CONTROLLED POWER SYSTEMS

The flow diagrams of the decisions made concerning municipally controlled power systems are shown in Figure 31. Awareness is invariably the result of interested council members raising the question. Unlike the previous innovation which, although a technological innovation is propagated in a traditional and acceptable form (companies), municipally controlled systems represent a radical and innovative departure in municipal government itself.

An examination of Figure 31 shows that overall process times are much longer for this innovation than in the case of power companies. This longer process time probably reflects the greater frequency of sub-decisions and repetition or looping of decision sequences (Figure 31). It is also apparent that the longer process times can be associated with larger centres which are aware of the innovation early but take a long time to arrive at an adopting decision. Figure 31 shows that process times are typified by negative decisions which produce the looping effect. Examination of municipal records

show that sub-groups within and beyond the council opposed to the innovation are active in preventing adoption particularly in the larger centres, resulting in the negative decisions.[16]

In the case of Windsor one of the larger centres which adopts relatively early (1890), the idea of municipal control is raised late in 1886 by the sub-committee on lighting. The council was already dissatisfied at the service given by the power company who was experiencing difficulties operating the system. However, the idea is rejected by the Financial Committee of the Council. Disagreement between the two committees continues and the power company continues intermittently until 1890 when a by-law to develop a municipal system is put to a plebiscite vote and then passed.[17] Similar decision structures with repetition and looping effects are a feature of other large centres but in these cases power companies were extremely profitable and were naturally unwilling to relinquish control to the municipalities. (e.g. Toronto, Ottawa, Hamilton).

Therefore, the complex decision flow diagrams reflect the effect of opposition groups to the innovation both at the municipal level and at the legislative level. From their structure one can discern not only the search component but also the process which results in this particular innovation requiring community decisions differing

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[16] e.g. Toronto, Ottawa.

[17] Minutes of Council Meetings: Chatham, Windsor op. cit.

Flow Diagram of Municipal Decisions Concerning Fluoridation

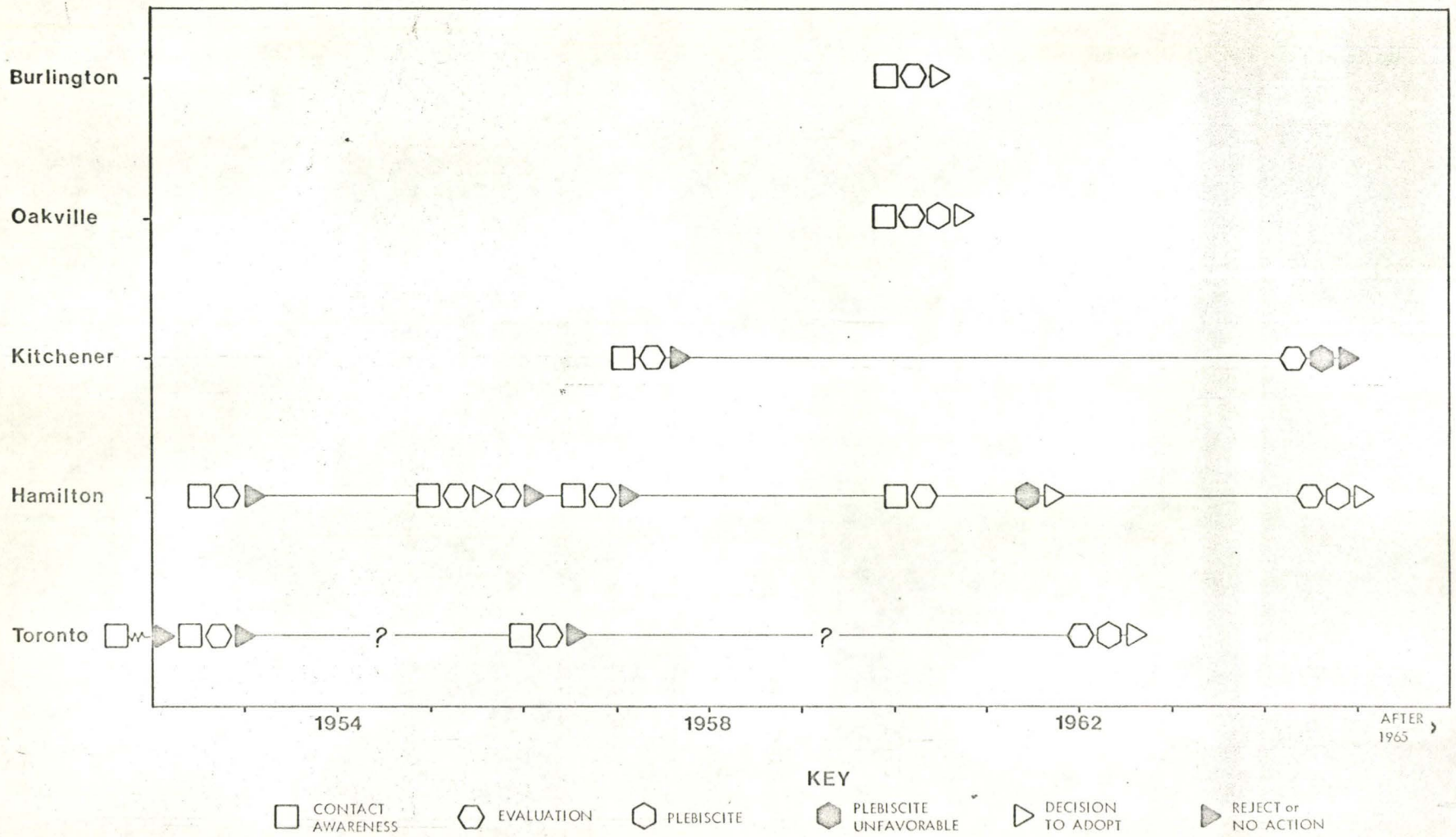

Figure. 32.

from the usual relationship between adoption date and size of centre.

Another significant feature of the decision process is the invariable occurrence of plebiscite votes on the issue, again reflecting the controversial nature of the innovation.

FLUORIDATION OF WATER SYSTEMS

The flow diagrams of decisions made concerning fluoridation of municipal water supplies are shown in Figure 32. It can be seen that in a manner similar to the preceding innovation the sub-decisions are complex and show repetition of certain sub-routines. Thus, large centres proceed through the contact, consideration, search and "no action" routine several times (e.g. Toronto, Hamilton). Small centres on the other hand, although they become aware of the innovation at a later date, process the innovation and came to a strategic decision to adopt quickly.

In Hamilton (Fig. 32) the innovation is first mentioned in 1953 by the Medical Officer of Health; no action resulted. The issue is raised again in 1956 and a motion to have a plebiscite is tabled. This is initially carried but later rescinded and the matter dropped. In 1957 the matter is revived and an attempt is made to have a private Bill introduced into the Provincial Legislature, but this is defeated in the council discussion. In 1961 the Municipal Board of Health backs the idea and a plebiscite in 1967 leads to its adoption.[18] Similar complex repetitive processes occur in other large centres

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[18] Minutes of Council Meetings: City of Hamilton. Hamilton Public Library.

(Toronto, London, Windsor).

In small centres, however, the innovation is adopted soon after initial awareness. In Burlington, for example (Fig. 32) the idea of fluoridating water supplies is discussed in April 1961 prompted by a letter from the local association of dentists. A decision to adopt is made and the plant is installed later in the year.[19] A similar short process time occurs at Oakville although a plebiscite vote is taken.[20]

The similarity between the processing of fluoridation decisions and municipal power system decisions is very striking especially taking into consideration the small capital outlay required for fluoridation plants (generally less than $1,000. installation) and yet contrasting with the large capital outlay required for municipal power plants ($15,000. for a town). The various negative decisions (e.g. in the case of Hamilton) reflect the controversial nature of the innovation rather than the capital costs involved.

Unlike the two previous innovations there is little evidence to suggest that municipalities conducted extensive contact and searching for more information.

Relationship Between Awareness Date and Adoption Date

The relationship between awareness date and adoption date (the

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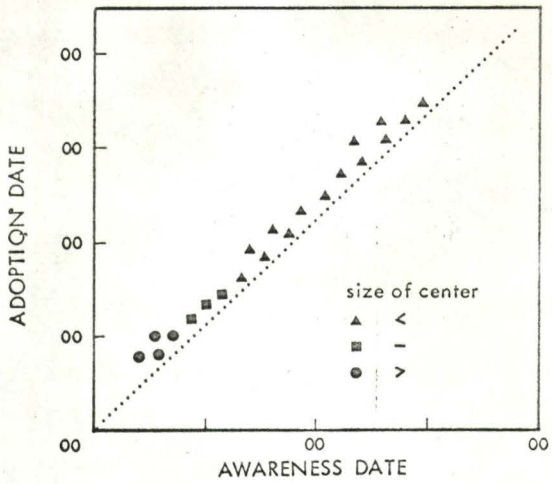
[19] Minutes of Council Meetings: Burlington; Burlington Public Library (unpublished).

[20] Minutes of Council Meetings: Oakville: Town Hall, Oakville (unpublished).

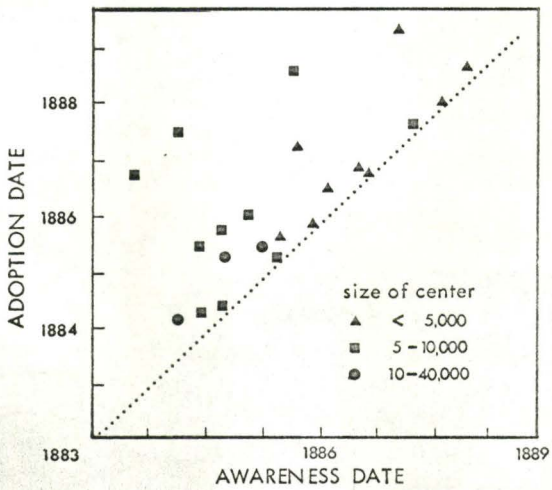
RELATIONSHIP BETWEEN AWARENESS AND ADOPTION

A.



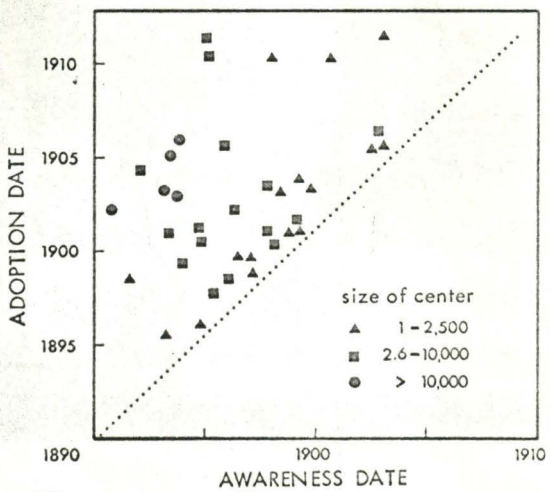
HYPOTHETICAL INNOVATION ADOPTED AS SOON AS AWARE

B.



ELECTRICAL POWER SYSTEMS LOW RESISTANCE

C.



MUNICIPAL POWER SYSTEMS HIGH RESISTANCE

Figure. 33.

elapsed time period being the process time) can be seen in Figure 33 which illustrates the longer process time required for the controversial innovations.

An examination of the process times according to size of centre can be made by correlating the date of innovation awareness and the date of adoption. Under conditions where no opposition to innovation occurs adoption should correlate highly with awareness. Furthermore, on the basis of knowledge of the information flow, the sample of points should show a progression from large cities close to the origin to smaller centres further away. (Figure 33A).

The relationship between date of awareness and date of adoption by municipalities of power systems (private companies) is shown in Figure 33B. It is apparent that the distribution of points is very similar to that hypothesised in Figure 33A where large centres are aware early and adopted early. Figure 33C (relationship between awareness and adoption of municipally controlled power system) shows a contrasting situation where the innovation is controversial. Although the larger centres are aware of the innovation early, process times are longer so that the actual adoption dates are not related to size of centre. Thus the contrast between controversial and non-controversial innovations which require community decisions is reflected in the average process times by different sized centres, so that the process times provide an index of the degree of controversy involved and the degree of resistance to be overcome.

The Nature of Resistance in Decision Making

The descriptions of decision processing show that resistance to innovations is present in each of the three innovations described in detail. Resistance to innovation takes two forms; first there is the resistance resulting from the doubt and uncertainty on the part of the potential adopter. This is present in each innovation considered and is present always in the early stages of a learning situation.[21] Secondly, there is the resistance associated with groups specifically opposed to the innovation.

In the first case, doubt and uncertainty are overcome in most cases by the potential adopters contacting other municipalities for further information, a process which has important geographical ramifications. In respect of opposition groups a repetitive looping effect of certain basic sub-routines occurs until eventually a favorable decision is reached.

Consequently, if any description or formulations of the resistance threshold are to be made for this class of innovations these two components should be examined in more detail. The first component is examined in detail; the second component concerning opposition groups, entails considerations beyond the scope of this thesis. However certain general observations derived from the available data

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[21] Hence the rising "S" shaped learning curve. For a complete discussion see, Atkinson, R.C., Bower, H. & Crothers, E.J. An Introduction to Mathematical Learning Theory. (New York, 1965)

will be presented. It must be recalled also that uncertainty occurs in evaluation by the decision makers in all innovations whereas active opposition groups occurred in three of the ten innovations considered. Therefore of the two components of resistance the former is more general and therefore of more significance.

Uncertainty, Information Deficit and Searching

When people or groups are confronted with strategic decisions they often seek advice from those in the group who have previously reached a decision. Cyert and March (1963) claim that there are three main rules that provide an initial basis for searching.

(1) search in the neighborhood of the problem
(2) search in the neighborhood of the current alternative
(3) if not satisfactory a more distant search.

In the geographical literature it is argued that a neighborhood effect occurs in the spatial development of this inter-adopter influence. (Hägerstrand, 1952, 1966). However, the greater part of previous research relies upon surrogate methods to describe the process, such as analysis of point patterns of adoption dates. (a method we discussed and employed in section 5). Turning to the analysis of decisions made by municipal councils at the macro scale, we must establish first that information contacts do occur and then attempt to describe their characteristics.

From the minutes and records of council meetings it is apparent that contacts between municipalities frequently occur on a variety of matters such as taxation and by-laws. Contacts are also made in

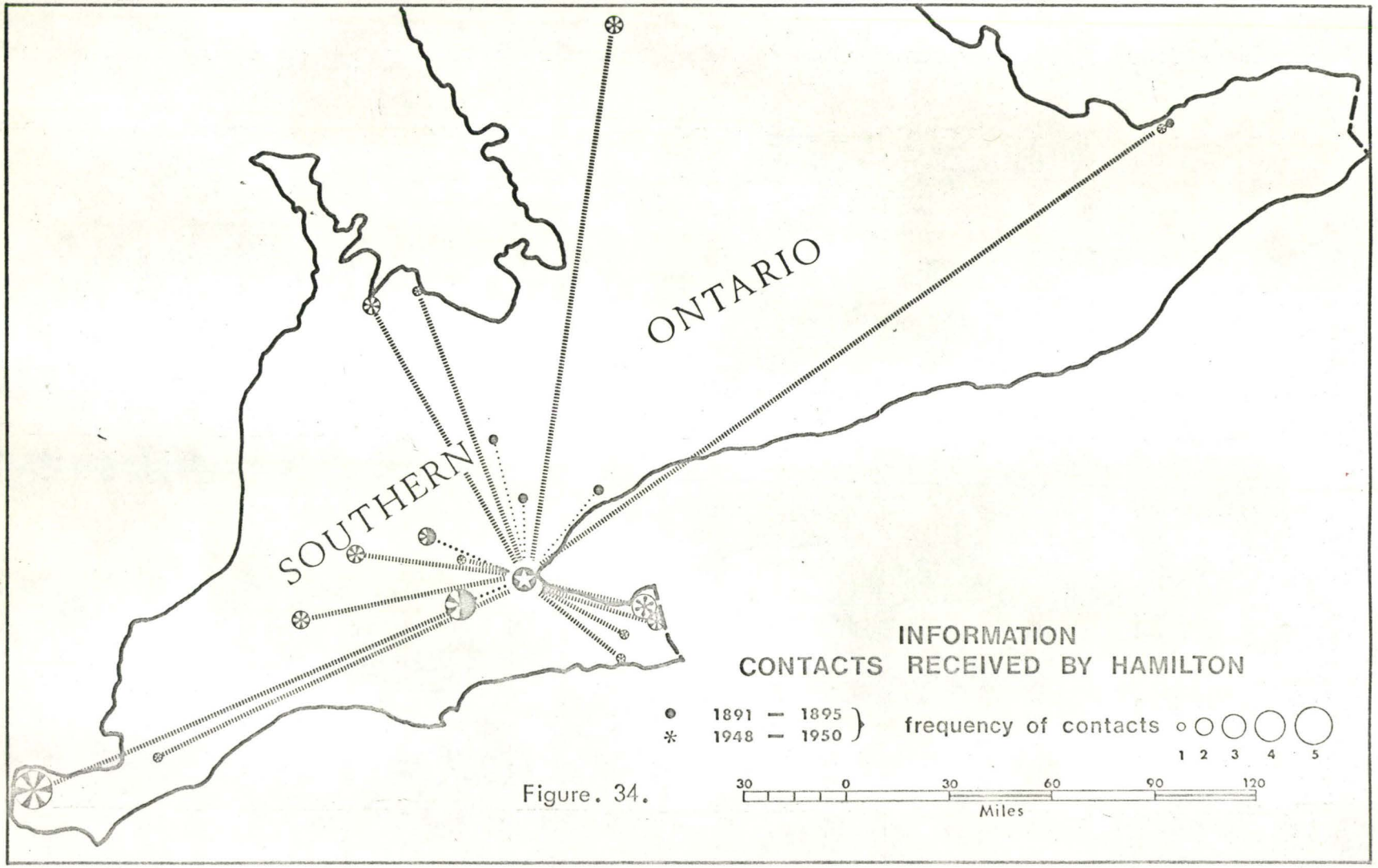
ONTARIO
SOUTHERN
INFORMATION
CONTACTS RECEIVED BY HAMILTON
1891 — 1895
1948 — 1950
frequency of contacts
1 2 3 4 5
30 0 30 60 90 120
Miles

Figure. 34.

order to raise support for briefs and petitions to be presented to the Federal or Provincial Governments. As an example of these contacts Figure 34 shows the contacts received by Hamilton during the periods 1890-1895 and 1945-1955 from other municipalities wanting information about certain matters.[22] Examination of other municipalities show a similar type of activity; furthermore, there is evidence that it occurs during the whole of the time period under consideration.[23] Some of the contacts concern matters which are innovations according to the definition offered earlier. These contacts take the form of either a written communication or an actual visit from the inquiring municipality. Therefore the point has been made that these contacts are not unique forms of behaviour but occur frequently and especially during the evaluation of innovations.

The flow diagrams of municipal decisions show that strategic decisions are never reached immediately. Problems requiring further evaluation result in the matter being either referred to a sub-committee for further investigation, or are filed indefinitely for future consideration. Such responses reflect the uncertainty associated with each innovation. However, where the interest of the municipality is sufficiently aroused contacts for further information are made with other municipalities to reduce this uncertainty and find out more about the innovation, a searching process.

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[22] Minutes and Records of Council Meetings, Hamilton op.cit.

[23] Figure 34 also suggests that the contacts over space have lengthened during the interval of 60 years.

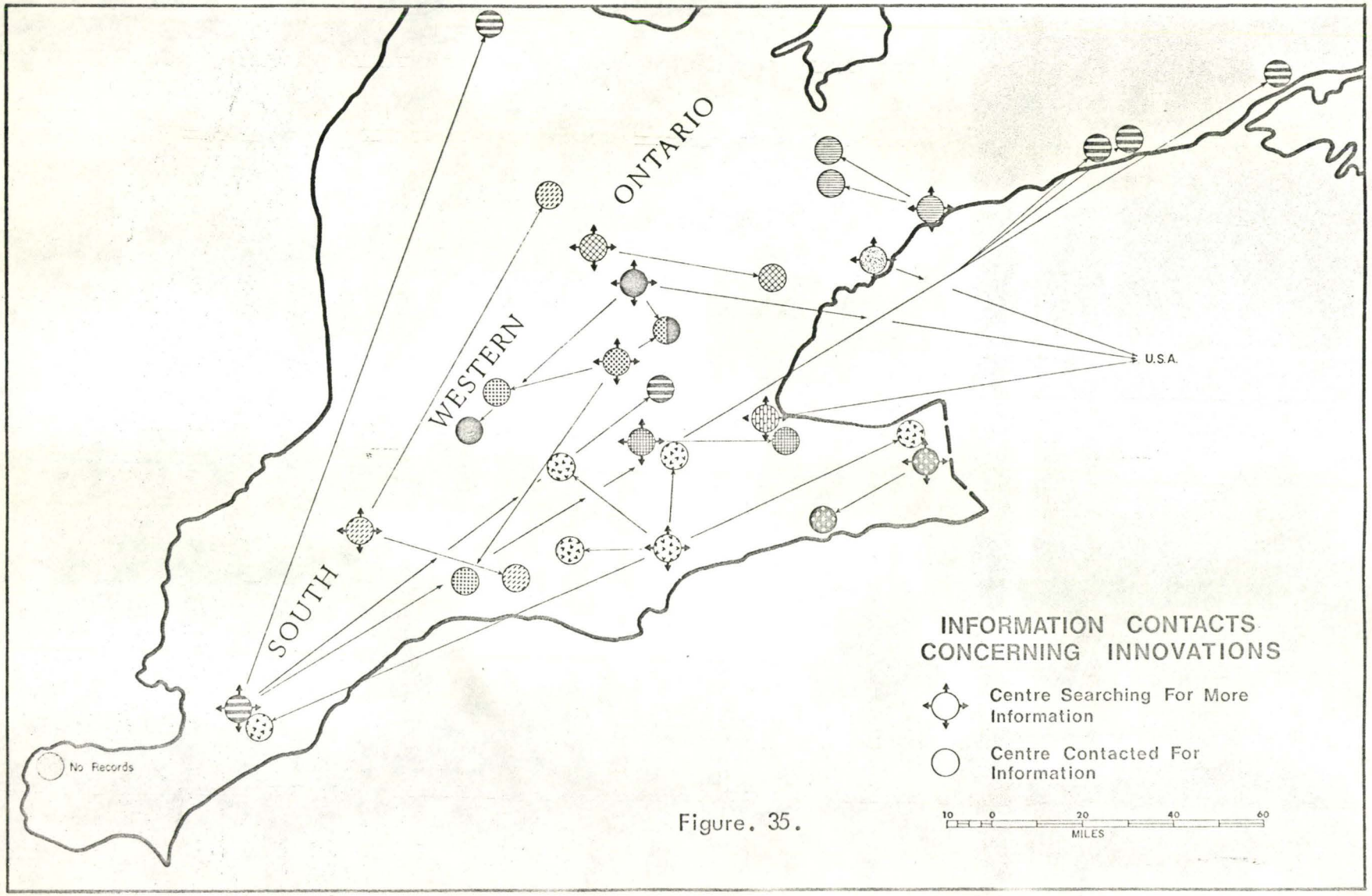
ONTARIO
WESTERN
SOUTH
U.S.A.
No Records
INFORMATION CONTACTS
CONCERNING INNOVATIONS
Centre Searching For More Information
Centre Contacted For Information
10 0 20 40 60
MILES

Figure. 35.

Ideally, it would be best to have information of contacts for several innovations by a large sample of municipalities. This would entail however, an extensive examination of municipal records. However, a sufficient sample of information is available to describe some characteristics of the spatial development of these contacts and their relationship to the size of central place.

The pattern of contacts for further information for power systems and waterworks for a sample of centres in South West Ontario is shown in Figure 35; the centre which sends the contact and the recipients of the contact are distinguished.

The first observation that can be made is that the number of other centres contacted is larger for the larger centres (large centres such as Toronto and Hamilton make more than twenty contacts for further information about this innovation (Figure 36). (Figure 36 also includes contacts made for waterworks systems and parking by-laws). Medium sized centres such as Chatham, Brantford and Kitchener make between five and ten contacts. Finally, small centres such as Thorold, Acton and Fergus make either one or two contacts.

While the frequency of contacts can be interpreted in terms of the size of the centre requiring more information, it is also a function of the earliness of the contact. The larger centres are at an earlier point of the adoption cycle than the smaller centres and thus would require more supporting information. The small centres

THE RELATIONSHIP BETWEEN SIZE OF CENTER AND FREQUENCY OF CONTACTS FOR INFORMATION

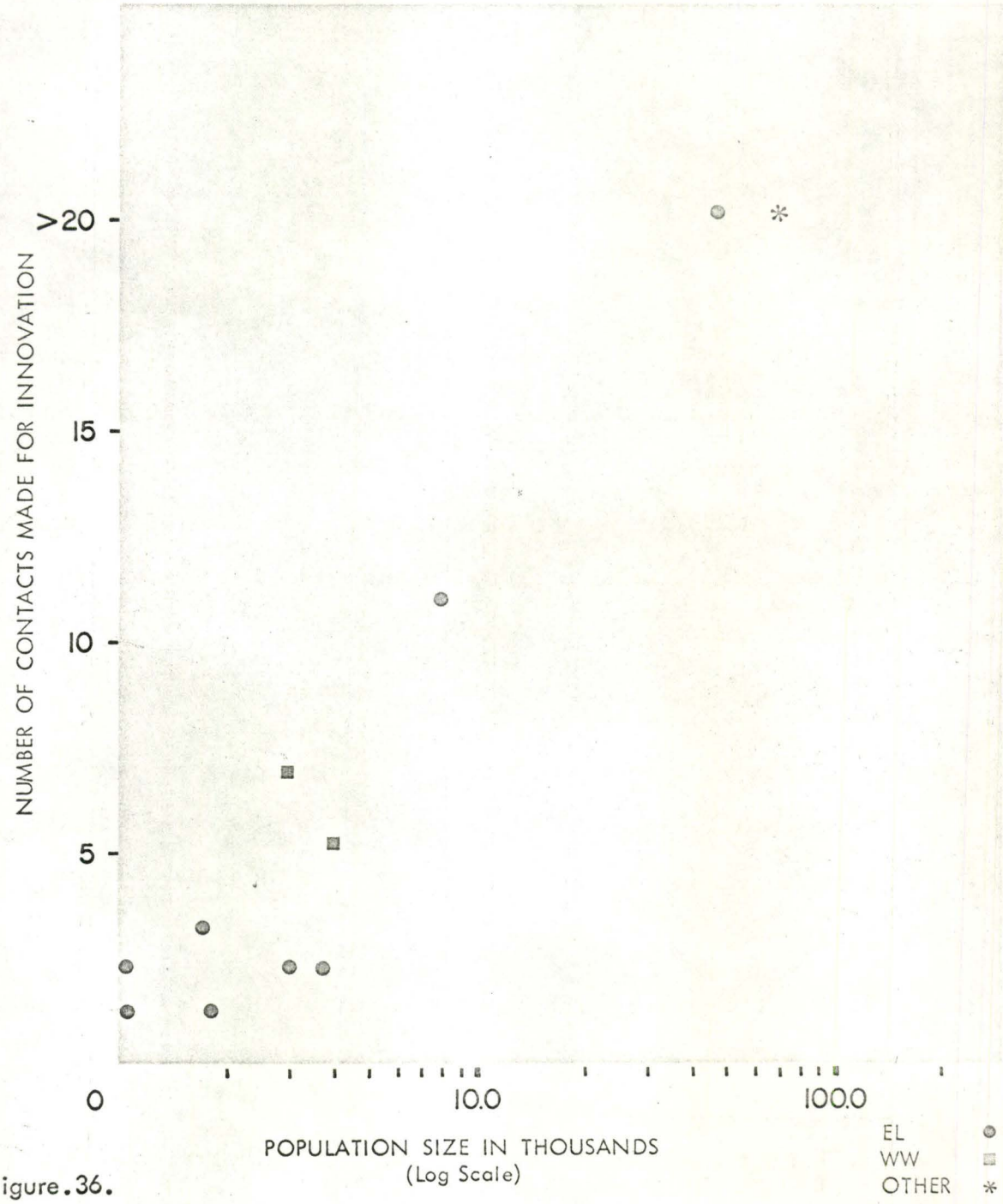

Figure.36.

are aware later and adopted later, but by that time there are more adopters to support a decision in that direction, hence they might require very few contacts.

The second observation that can be made is that centres appear to obtain information from other centres of similar size rather than the nearest previous adopter. Thus, in Figure 35, Thorold contacts Dunville for advice even though St. Catharines, Welland and Niagara Falls had already adopted and are nearer. Similarly, Strathroy, contacts Aylmer and Mount Forest, even though London and St. Thomas are previous adopters and are also nearer. Chatham contacts several other centres of similar size further away than Windsor and Detroit which were nearer but larger (Figure 35). Further evidence is found of this identity preference in the municipal records of Ingersoll where the council directs the sub-committee searching for more information about municipal fire brigades to,

> "visit towns of similar size and importance as Ingersoll" (24)

In the case of Toronto and Hamilton the two largest centres under consideration, potential contacts of similar size within Canada are few, so that most contacts are made with cities located in the United States.

The third observation that can be made is that while there is a definite preference among the centres for information from other

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[24] Minutes of Council Meetings, Ingersoll, Province of Ontario Archives; Toronto (unpublished).

THE RELATIONSHIP BETWEEN SIZE OF CENTER AND DISTANCE SEARCHED FOR MORE INFORMATION

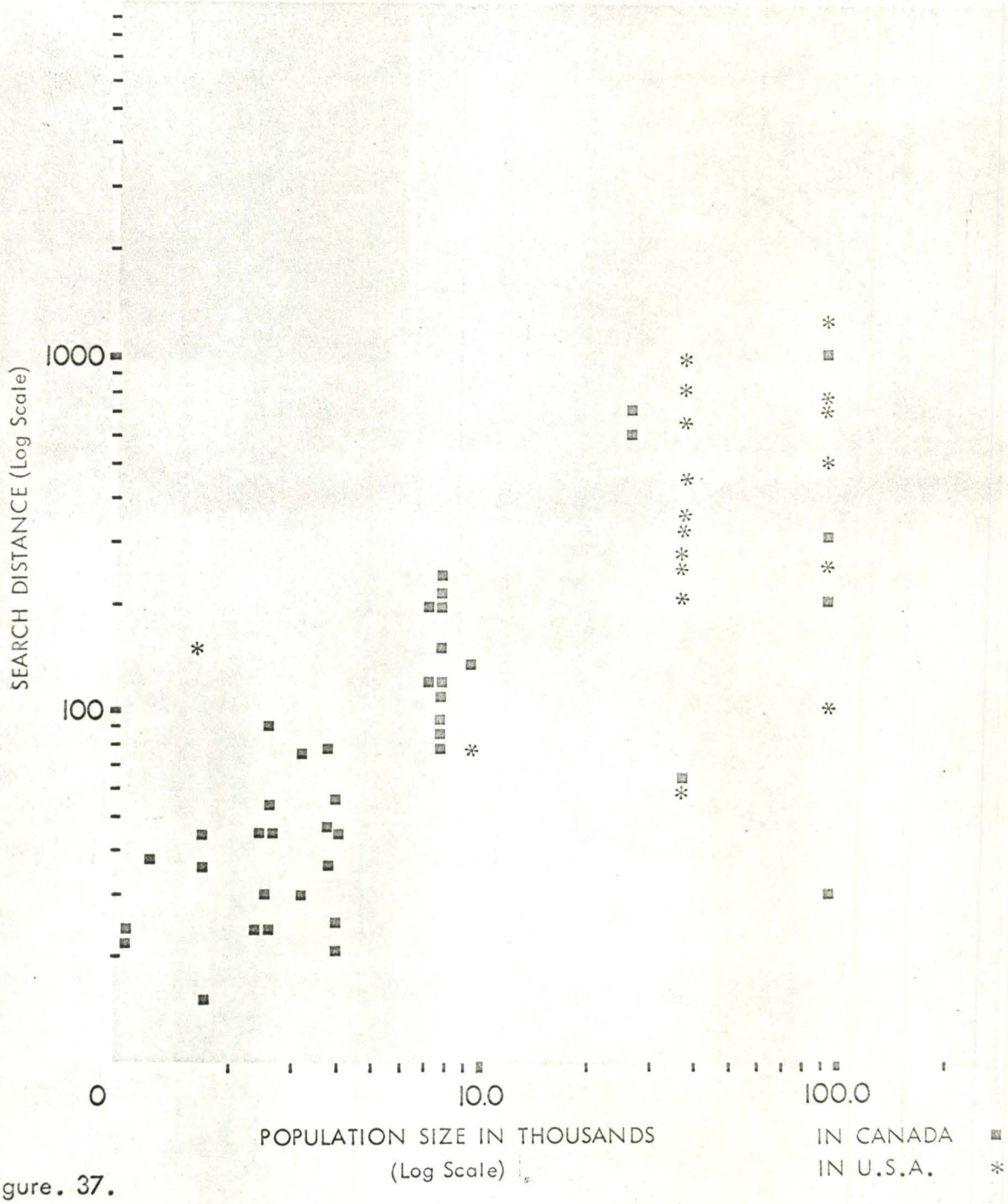

Figure. 37.

centres of a similar size so that the nearest previous adopter is not necessarily contacted, there is an apparent limit to the distance that a particular centre would search for more information. The variation in the distances searched is shown in Figure 37, where the relationship with size of centre is particularly apparent. Thus, the limit to the distance searched for small centres is approximately 100 miles, for medium sized centres the limit to the distance searched is approximately 300 miles, while for the largest centre the distance searched is approximately 1000 miles (i.e. Eastern North America). This distance/size relationship is not unexpected since small centres are more frequent and closer together while the larger centres are spaced further apart so that the respective distance searched would have been further. In addition the larger centre would have been searching for information at an earlier point in time and would therefore have had to search further for information, since the previous adopters would be fewer and higher up the central-place hierarchy.

Consequently, a more accurate indication of influence of United States centres is apparent. The influence is most marked in the early stages of adoption when larger centres sought information and could only derive it from large centres in the United States.

Evaluation of Cost and Opposition Groups: The Nature of Resistance

The purpose of searching is to derive information concerning the cost of innovating relative to maintaining conventional technology or organization. In the case of electric power this means a straightforward

TABLE 7

COSTS OF STREET LIGHTING LATE C19th S. ONTARIO

Year	Town/City	Gas (monthly)$	Electricity (monthly)$
1885	Chatham	154	
1885	Fergus	*	64
1885	Guelph	*	333
1884	Hamilton	102	390
1885	London	171	310
1886	Mt. Forest	*	48
1886	Paris	65	133
1884	St. Catherines	350	730
1887	Strathroy	*	45
1885	Windsor	100	130(?)
1885	Brantford	100	183
1884	Toronto	425	975

Based on Municipal Records (Unpubl.)

* Data unavailable.

comparison between existing methods of illumination, usually gas and the new form of lighting by electricity. Some cost evaluations made by municipalities of different sizes are shown in Table 7. All of this information is obtained either by search or by tender invitation.

From Table 7 it can be seen that although returned information shows that monthly running costs were higher than gas lighting, in the early years almost double, the majority of councils go ahead and adopt the innovation. Two councils consider the cost as being too high, but even so, adopt the innovation within a short time (Galt and Kitchener). It appears that the advantages of electric lighting outweigh the extra cost involved, while electricity also had fashionable appeal as well.

Opposition to the new form of lighting comes from the gas companies who had previously supplied lighting. Thus, in St. Catharines, the gas company attempted to charge the council for displaced lamps.[25] One centre where opposition was particularly strong is Sarnia. Gas lighting diffuses through the larger central places during the 1850's and reached Sarnia in 1884. However, rather than adopt electric light which had only been installed in a few places by 1884, the council adopts gas lighting.[26] In 1889, the median year of adoption of electricity for towns of this size, an attempt is made to introduce

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[25] St. Catharines, Minutes of Council Meetings, op. cit. (Nov. 1886).

[26] Sarnia Observer 1884, August 18.

electric light but this is rejected by a majority of the council who supported those who had bought stock in the gas company.[27] Consequently, electricity is not adopted until 1900.

Some gas companies attempt to circumvent the economic challenge of the new technology by generating electricity themselves and offering to supply electric power as well as the traditional form of gas lighting. This happens both in Guelph and Toronto, as well as other places. Whereas in Guelph this was accepted with little opposition[28], in Toronto some councillors were averse to the gas company's interest in one of the power companies since it was,

> "emerging from one monopoly to fall in hands of another" 29

As a compromise, many councils adopt electric light for the main street and continued with gas light on the side streets.

It can be seen that searching was important for providing information for cost evaluation of the innovation in relation to the existing form of lighting by gas. While the cost was higher, this was disregarded in the view of improved lighting obtained and increased community prestige. That it was an improvement is invariably stated in the information provided by other previous adopters.

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[27] Ibid.

[28] Guelph, Minutes and Records of Council Meetings.

[29] Toronto Mail, April 16, 1884.

Municipally Operated Power Systems

Just as searching provides information on costs of electricity as supplied by companies, so too, searching provides data for the evaluation of municipally operated power plants. Evaluation is based on the cost of electricity supplied by the local company and the cost of power when supplied by a municipally owned power system.

In 1894, Hamilton's contacts with several American cities show conclusively that the costs of operating a municipal system are much less than the rates charged by the local power company.[30] In the same year Ottawa contacts other American cities operating power systems (e.g. Chicago and Fort Wayne) and concludes that the costs of municipally operated power are less.[31] A similar enquiry by a sub-committee of Toronto City Council also show that costs of electric power would be less with a municipally-run system.[32] Consequently, the decisions to proceed with a municipal system by these cities are based on the information provided by the searching process and an evaluation of the costs involved.

Opposition to the adoption decisions comes from the power companies working through the provincial legislature who prevent municipalities from competing with private systems. Thus, although

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[30] Special Report of Electric Light Committee. Hamilton City Council. Hamilton, 1894 (Hamilton Public Library).

[31] Records of Ontario Hydro Corporation filed under Ottawa (Records Division) (unpublished).

[32] Ibid. filed under Toronto.

municipalities had explored and evaluated the costs involved, the provincial government prevents them from going ahead with their plans to adopt the innovation. The struggle between municipalities and the power corporations is described by Bolton, R.P. (1913), Biggar, E. (1920), Ashworth, E.M. (1955), and Dennison, M. (1960).

The resistance of powerful economic groups is also manifest in the political opposition to the innovation, so that it is only after tremendous pressure that the Provincial government inquires into the problem (1903). The innovation is challenging control of the political system in advocating public ownership of utilities,[33] since the existing provincial government favored private corporation development and in attempting to prevent the development of this innovation inserted the Conmee Clause into the existing utility legislation.[34]

Ultimately, the formation of the Ontario Hydro Power Commission in 1906 after a prolonged government inquiry on municipal ownership, enables towns and cities to provide their own power, and compete with private utility companies. The rates charged to consumers as a result are frequently halved.

Part of the difficulty in the way of municipal ownership lay in

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[33] The Return of Municipal Undertakings (1903) Appendix to Legislative Assembly Journals - has a detailed discussion of the economic, political and social ramifications of municipal ownership.

[34] The Conmee Clause was passed in 1899 to prevent competition between existing power companies and any new publicly owned company. Dennison, M. (1960) op. cit. p. 28 ff.

TABLE 8

INDEBTEDNESS OF MUNICIPALITIES 1904

Town	Amount of Capital Borrowed (thousands of dollars)
Toronto	3895
Ottawa	1524
St. Catharines	331
London	799
Hamilton	1134
Windsor	316
Woodstock	146

Capital borrowed to operate waterworks, electric power systems, gas systems.

Based upon the Report of the Select Committee on Public Utilities, Toronto, 1903.

the high initial cost in building a power system, particularly when it is realised that many centres were already borrowing heavily to finance other municipal undertakings such as waterworks, and the subsequent increase in local taxes involved. The larger the centre involved the greater the amount of capital that had to be raised. Table 8 shows some of the indebtedness of municipalities at this time, indicative of the economic deterrent to adoption.

Consequently, it can be seen that searching provides data for evaluation and can lead to favorable decisions to adopt since despite high initial outlay on capital, operating costs would be much less for a municipally operated system. However, despite the favorability of information received, the groups in control of the system at the Provincial government level effectively delayed the actual implementation of the adoption decision particularly in the large centres, such as Toronto, Hamilton, Ottawa and St. Catharines for two or even three decades.

Fluoridation of Water Systems

The diffusion of fluoridation displays similar decision making structures to the previous innovation described above, whereby large towns and cities although aware early adopt later due to the presence of opposition groups, particularly active in larger towns and cities. However, unlike the previous innovations described, cost is not a main feature of the controversy, nor a major concern of the opposition groups.

Evaluation depended upon the evidence furnished in medical and dental reports. Early adopters follow the advice of local medical/dental associations and interpreted existing legislation favorably, adopting the innovation as an internal decision or as a plebiscite decision.

However, opposition to the innovation gradually develops for various reasons such as, fluoridation represents enforced medication, is unsafe, or has not been tested long enough.[35] Opposition groups use as a main weapon the fact that under the existing Municipal Waterworks Act, municipalities could not add fluorides to water systems. In addition a greater part of the opposition to the innovation comes from the Government side of the Provincial Legislature.[36] The ensuing conflict and controversy prevents any adoptions during the period 1957-1961; but, under pressure from those favouring fluoridation a commission of inquiry is held in 1961 which ultimately leads to Government approval of the practice. Thus, the Municipal Waterworks Act is amended to allow fluoridation as an outcome of plebiscite voting.

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[35] In Toronto, there was also the opposition from the suburban municipalities who saw the decision of the metro city council(who sold water to them)as further evidence of centralization to which they were opposed. See, Kaplan, H. (1967) p. 115 ff.

[36] Debates of the Provincial Legislature of Ontario. See from 1954 onwards - intermittent debates but mainly in debates over Department of Health estimates.

Therefore, it can be seen that a considerable similarity exists between the resistance to municipal electric power and the resistance to fluoridation. Even though municipalities acquire sufficient supporting information and reach adoption decisions, actual implementation is blocked by the provincial level of government. Consequently, the existence of a sub-class of innovations (requiring community decisions) which do not follow the usual relationship between size of centre and date of adoption can be explained in terms of social and economic variables such as opposition groups and costs involved.

Although the discussion has been concerned with innovations requiring municipal decisions, it can be seen that similar resistance is encountered in the spread of credit unions in both Canada and the United States, particularly in the case of the latter country. Until legislation is passed either at the provincial or state level the innovation can not diffuse through the system of central places within them. Hence this would explain the hold-out of some states and provinces in Figure 14, (e.g. Pennsylvania).

Overview

This chapter examines the processing of innovations requiring municipal decisions using a queuing analogue. Particular attention focuses on those sub components of the decision making process having geographical significance, such as inter-adopter influence. It is found that the frequency of arrivals requiring processing are related

to size of centre. Furthermore examples of innovations as arrivals during the period 1850-1970 are cited, representing arrivals requiring strategic as opposed to routine decisions. An index of the degree of controversy and hence length of processing time involved is provided by a correlation between date of awareness and date of adoption.

While total process times are composed of several sub-components attention focuses on inter-adopter influence during evaluation, because of its significance as a component of the learning process and its inherent geographical ramifications. Contacts between decision making groups appear as common forms of behavior varying according to size of centre, the linear distance between sender and receiver and according to some form of identity preference. The results of the pattern analyses of the previous section are confirmed, in addition significant characteristics not discernable by pattern analysis have also been observed such as the identity preference.

It can be seen that the influence of the United States on the spread of adoptions is most marked during the early stages of adoption, when large centres can only refer to other large centres in the U.S. While the cost factor appears to be a major motivation behind the searching process, it must also be viewed as a process of seeking group support as well for something more beneficial yet more costly. This is borne out by the fact that electricity is twice as expensive as gas yet centres go ahead and adopt; that the adoption of municipal power systems entails considerable controversy and high

initial capital costs and that fluoridation while costing very little also provokes considerable argument and criticism.

The flow diagrams make possible an identification of the sub-components of the decision making process, showing how resistance in the learning process is composed of elements both internal and external to the decision-making group, that the process time is composed of certain basic sequences repeating themselves and that the decision making involved can be described in general terms.

What emerges from this is that while it may be difficult to predict how long resistance will continue in the evaluation and adoption of any specific innovation it is possible to describe how the resistance process takes place and the geographical pattern of development likely to emerge. From this, strategies to modify this resistance, where socially desirable, might be formulated.

CHAPTER 8

Summary and Conclusions

This study attempts to analyze geographical aspects of the process of change in the central place system of Southern Ontario using the concept of innovation diffusion and concentrating on innovations which require community decisions. An underlying assumption is that general statements concerning location and the decision making processes involved, based on precise description using quantitative methods and analysis, are a necessary part of the study.

Consequently, the approach adopted has been to test certain concepts of innovation diffusion previously developed in micro-scale analyses where the decision makers are individuals, by applying these concepts to a macro scale where the adopting system consists of communities or their representatives who arrive at a single collective decision.

The conceptual framework describes certain geographical and non-geographical statements of the process formulating the nature of decision-making involved. A review of the literature relevant to this class of innovations and cognate fields of decision making and urbanization provides a matrix of working hypotheses specifying where the conceptual framework is weak and empirical data is lacking. In order to organize the testing and further development of these

hypotheses a paradigm of the process based upon a queuing analogue has been developed. The nature of the system involved and characteristics of the data are specified. The analysis is carried out by examining two main hypotheses, the city size factor and the neighborhood effect, in relation to the phases of the process. Ten innovations are examined, eight of which required municipal decisions (electrical power systems, waterworks, filter systems, municipal power systems, telephone systems, mechanics' institutes, arenas and community centres, and fluoridation) and two which were non-municipal (credit unions and clubs).

The analysis is undertaken in the form of firstly cartographic and general description of the three main elements of the paradigm and then secondly measurement and testing of certain characteristics of geographical significance using simple quantitative methods, within the overall framework of the queuing analogue.

Awareness (The Arrival)

The description and analysis of awareness attempts to describe aspects of the flow of information concerning three of the innovations, power companies, municipal power systems, and fluoridation. A preliminary examination of a sample of newspapers of Southern Ontario during the decade 1880-1890 suggests that mass media information concerning an innovation is related to the size of centre. An examination of the specific contacts made by propagators, that is, the sources of direct information about the innovations shows a similar relationship.

Although significant correlations between date of awareness and size of centre emerge, a visual examination of the developing patterns and arrangement of points suggeststhat a"neighborhood effect" might modify the size/date relationship. However, a more precise measurement of the "neighborhood effect" derived by examining the relative location of new knowers does not demonstrate any conclusive evidence of a "neighborhood effect" in the spatial flow of information but rather a random pattern.

The spread of initial awareness is the outcome of propagators' activities. Consequently, an attempt is made to describe characteristics of their spatial behavior. Despite the fact that a cumulative pattern of contacts suggests a distance decay effect, the close relationship between awareness date and size of centre describes a space preference as well since the propagators appear to consider the whole of the province as one territory or area of movement. This results in a by-passing of intervening (yet smaller) centres early in the spread of information, in contacting the larger centres as potential adopters. Furthermore, this preference is modified according to national, provincial, and cultural boundaries.

Adoption: The Terminal

In order to determine whether a further examination of the decision-making processes between awareness and adoption is itself necessary, attention is focused upon the adoption of the innovations (the "terminal" decision).

An examination of the growth of adoptions over time shows that the accumulation of adoptions displays a characteristic cumulative "S" shaped form. However, the relationship between adoption date and size of centre reveals the existence of two sub-groups of innovation adoptions. Some innovations have a significant correlation between adoption date and size of centre (waterworks, power systems, mechanics' institutes, filter plants, telephone systems, credit unions, clubs) while others clearly do not (municipal power systems, community centres/arenas and fluoridation). As in the development of awareness, indications are that other factors modify the adoption date/size of centre relationship apart from the discrepancy noted above; consequently, the spatial development of adoptions is analyzed.

The spread of innovation adoptions is described in map form. In view of the analytical problems involved in the use of established pattern description techniques, the distance/date measure developed in chapter 5 is employed again. In contrast to the patterns of awareness, where spatial development appears to be random, in the spatial development of adoptions a significant "neighborhood effect" is present according to the spreading of new adoptions through time. This "neighborhood effect" is present in both sub-groups of innovations. In the first case the designation of leaders is based on earliness and size, in the latter case on earliness alone (that is innovations without a size-date relationship, municipal power, arenas, fluoridation).

The emergence of a group of innovations whose adoption date is

not related to size of centre and the fact that the analysis of point patterns is still a surrogate method of establishing inter-adopter influence, prompts an examination of the decision making process and direct evidence of inter-adopter influence.

Decision Making: The Process Time

The decision making processes and the associated time taken to process a problem (an arrival) are examined in greater detail for innovations requiring municipal decisions. An examination of a sample of centres show that the frequency of arrivals increases with the size of centre concerned. Furthermore, numerous examples are cited of some of the innovations requiring strategic as opposed to routine decision making which diffuse through the system during the time period under consideration. A measure of the resistance threshold and an index of the degree of controversy involved is provided by correlating the awareness date with the adoption date.

Process times for municipal power systems and fluoridation are much longer than for electrical power companies, suggesting a stronger form of resistance than that normally present during the learning process. While total process times are composed of several sub components, attention concentrates on those having geographical importance. It is shown that inter-adopter influence is present and that such contacts have certain general characteristics in relation to distance, frequency and preference.

From the description of the sub-components of the decision making process it is possible to identify the repetition of certain basic processes and the significance of opposition groups in recycling the whole process so as to give pronounced resistance thresholds for certain innovations. In an information deficit situation where the response is to search for more information, the presence of opposition groups modifies the size/adoption date relationship beyond the usual resistance present.

CONCLUSIONS

What conclusions can be drawn from applying the concept of innovation diffusion to understanding change in the central place system of Southern Ontario?

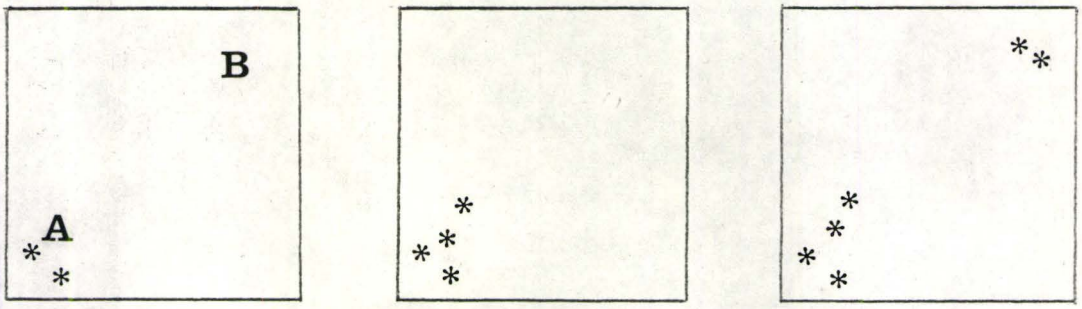
The Diffusion of Innovation

Just as individuals progress through a sequence of learning phases so too, representatives of a community arriving at a collective decision have a similar development. The occurrence of phases of the process can be mapped in point pattern form.

In describing both the spatial structure and the dynamics of the process, studies at the larger scale have distinct advantages. Thus, most if not all decision making groups keep records of their actions, consequently resort does not have to be made to "recall" methods. Since the group has permanence, patterns and processes over a period of time can be compared and described with greater predictability than in the case of the individual (i.e. at the micro scale).

From this it can be concluded that the process of innovation diffusion is scale free since the concept and its refinements developed for individuals at the micro scale and described in the conceptual framework, can also be used to describe the process of change in an urban system, where communities arrive at a single collective decision.

Just as limitations in representation and analysis of the process in point pattern form are acknowledged at the micro scale, so too the limitations of this surrogate are demonstrated at this scale. Not only are there limitations to visual examination and statistical description but the patterns themselves belie the processes involved. Thus, while adoption dates can represent the outcome of the process they may not describe the characteristics of the several phases of the process. Therefore it may well be erroneous to project backwards from the outcome pattern a statement of the genetic process. This is illustrated in the following diagram:



Here it might be supposed from a model of the pattern that innovation x diffused from point A to point B. However, it has been shown that several innovations such as municipal power arenas and fluoridation diffuse from B to A. The presence of opposition groups prevent its adoption at B so that A adopts earlier and thus appears to influence B!

What emerges from this is that a basic prerequisite to understanding the process is a description and analysis of the actual patterns and

processes of behavior involved. The significance of this will be brought out in the following conclusions.

Diffusion and the Class of Innovations Considered

In the flow of information and awareness in this class of innovations, an hierarchical progression is more significant than a spatial ordering in the form of a neighborhood effect. In understanding this process, it is fundamental to understand the behavior of the propagators, the senders of the information. The preference of propagators is to seek out potential adoptions in the larger centres in the system. As a result, the province as a whole is treated as one field of movement, despite the fact that an accumulation of these contacts appears to describe a "distance decay" effect from the propagators' base locations. Furthermore, this preference is modified by national, provincial and cultural boundaries. Thus, the frictional effect of increased distance is less significant than might be supposed. The description of the awareness and flow of information is fundamental to understanding the process as a whole.

The propagators, through their activity, set off the decision making activity of the adopters. What conclusions can be drawn about the receiving system and the groups which are confronted with and have to process the arriving problem?

The analysis shows that while date of adoption may be associated with population size of centre, this is not always the relationship (e.g. municipal power, arenas and fluoridation). Thus, size alone

is not an infallible predictor of earliness of adoption. The existence of a sub group of innovations suggests that an underlying regularity is present in those situations where pronounced resistance occurs. Consequently, it might be conceived that given the appropriate form of resistance, analysis of patterns of innovation adoptions may show diffusion from small centres to large centres up through the hierarchy.

From the analysis of adoption dates one can also conclude that given a specific class of innovations (such as those requiring community decisions) and given a relatively stable central place system, the time taken for diffusion is very similar for innovations of that class. However, within the specified time period variations can occur. For example, one innovation may diffuse quickly through the large centres and then slowly through the small centres while another may diffuse slowly through the large centres and then quickly through the smaller centres but the total time for the two innovations to diffuse is approximately the same. Whether this factor has discernible cause requires further analysis.

Although there is no firm indication of a "neighborhood effect" in the flow of information, it appears that a "neighborhood effect" is present during adoption and hence modifies the adoption date size of centre relationship. Clearly, since there is a difference between the spread of awareness and the adoption and since a sub-class of "deviant" innovation adoptions not related to size of centre occurs, a more thorough examination of the decision-making processes is required.

In terms of the paradigm introduced at the onset of the analysis the decision-making represents the processing of the innovation between awareness and adoption. The frequency of arrivals increases with the size of centre involved; while the time taken by the centre to process the problem could be related to this, further examination of this point is required.

Analysis of the arrivals shows conclusively that contacts between centres occurs; comparable to the informal "face to face" contacts of individuals; moreover, they appear to have increased in frequency through time. During the processing of innovations a frequent sub routine is that of searching for more information by contacting other adopters; thus the indications of the pattern analysis of the earlier chapter are validated. Examination of the searching routine shows that in addition to a "distance decay" effect and a frequency to size relationship, an identity preference is also present. From this it can be seen how the neighborhood effect itself is modified and hence is less discernible than it might otherwise have been without this preference.

If centres do not necessarily contact the nearest other previous adopter (due to the preferences already described) but do contact nearer previous adopters the definition of a "neighborhood effect" is clearly one of degree. However, the evidence clearly supports Hägerstrand's basic contention of a "neighborhood effect" in this class of innovations. Furthermore, it points up some modifications such as

identity preference which should be considered at the micro scale where they would modify the "neighborhood effect" in terms of social and cultural preferences.

The pursuit of more information to aid evaluation appears to be a function not only of cost but also of social support. "If they have it, so can we." However, no matter how favorable the subsequent decision, the ultimate adoption in this class of innovations depends upon the legislative authority above that of the municipality. The legal approbation of an innovation often lags behind the early occurrences of adoption. Consequently, groups opposed to the innovation seek support from strict interpretation of existing legislation and thus prevent additional adoptions. However, ultimately and usually with a change in government, legislation is passed and the innovation then proceeds.

Whether this is a serious obstacle depends upon one's attitude to society as a whole. A conservative person or group may resist innovation because it may appear to disturb the stability of the existing system and may lead to social upheaval and/or economic redundancy for displaced technology. In contrast to this attitude the history of man has been one of evolution and an ever increasing rate of change. Resisting change may therefore lead to even more serious tensions than might have occurred if some degree of change is allowed. Through attempts to understand innovation and plan for it the maximum benefit and minimum social tension might be possible.

Decision Making in Urban Systems

By considering innovation diffusion as a decision making process and examining it in an urban system the analysis has brought to light significant characteristics of decision making in urban systems some of which have already been mentioned above. The flow diagrams of decision making show that certain components such as evaluation, search and plebiscite delegation are general to all urban centres irrespective of size. This finding is of considerable importance in developing general statements and behavioral models of urban systems.

Secondly, the analysis shows quite clearly that the decision makers have distinct perceptions of those other centres of the urban system which relate to them. Therefore in developing further understanding of this problem area research might investigate how these differences in the system are perceived.

In measuring and describing the critical paths in the processing of a decision or an innovation, the simplicity yet utility of the queuing analogue and its description in network form is demonstrated. Thus, the re-cycling of certain basic routines is particularly evident. If a more complete analysis of the process is desired, other paths, such as the role of propagator-adopter negotiations can be incorporated into the scheme, in addition, the analysis may be extended to derive probability values of process times for these innovations.

However, the analysis has its limitations in not taking into account social variables such as the racial, ethnic and social

composition of the decision making group; the importance of these factors relates closely to the degree of sophistication and understanding required.

Change in the Central Place System of Southern Ontario

It can be seen that the uneven distribution of centres in Southern Ontario has a marked effect on the diffusion of innovations. The concentration of centres in the western central section contrasting with the relative absence in the east means that this core area is the nucleus for new ideas arriving and spreading through the system. For example, the proximity of this core to large, adjacent American cities means that it is readily accessible to new ideas infiltrating across the border. This contrasts markedly with the low density of urban centres in eastern Ontario and western Quebec and therefore accentuates the cultural barrier between the two provinces. This is shown particularly with credit unions which diffuse effectively from Quebec to Ontario via the United States.

The concentration of larger centres in the southern section of the province tends to result in a south to north trend in diffusion patterns. At the same time it also reflects a route-way effect along the Kingston, Toronto, Windsor corridor, spreading from the core. However, the trends are not always evident; for example, community centres originate in the western areas and spread east and south, reversing the normal condition of diffusion from large to small centres. Such deviant innovation patterns, where large centres adopt last, illustrate the influence of

social and political variables.

From this we can conclude that the direction of change in Southern Ontario is fairly predictable both in terms of direction and time. This finding supports Hägerstrand's contention that the routeways of new ideas and change have a certain permanence through time. What still needs to be understood is the variation in rate of diffusion between different innovations.

Finally, while the analysis throws some light on the spatial structure and processes of municipal decision-making in Southern Ontario little is as yet known about the power structures of these communities and the effect this can have on change and development. What is emphasized is the important source of information deposited in municipal records for analyzing and describing the behavioral dynamics of the urban system and also how such analyses might be organized to develop general statements of the process.

General Conclusions

The first general conclusion to emerge is that spatial diffusion of innovation is a scale free process. Concepts developed at the micro scale are tenable at the macro scale.

A second conclusion to emerge is that spatial patterns cannot be understood and effectively described without an examination of the generative processes, meaning the decision making, involved. Thus spatial patterns can only be described and understood within a dynamic framework.

Thirdly, through the analysis of decision-making, it appears that certain spatial behaviors such as the movement of propagators and inter-adopter contact do not have aspatial counterparts. Thus, they are fundamentally geographical and in their conceptualization are not derivative from any other conceptual area.

Finally, in understanding the spatial structure of systems whether urban, rural or industrial, geographical thought has concentrated on analysing concrete structures. This geographical perception of human systems must now become familiar with the human decision-making involved particularly those elements of geographical significance in order to fully comprehend man as a part of these dynamic systems.

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3. business - main discussion points
4. special meetings
5. decisions.

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