THE UNIVERSITY OF ALBERTA

STRUCTURAL ANALYSIS OF CENTRALITY IN THE CHER, FRANCE

by

Gilles ALBAREDES

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

Department of Geography

EDMONTON, ALBERTA

fall 1987

ISBN 0-315-40908-8

University of Toronto
Department of Geography

100 St. George Street,
Toronto, Canada,
M5S 1A1
416 978-3375

August 6th, 1986

Mr. Gilles Albaredes,
The Department of Geography,
The University of Alberta,
Edmonton.

Dear Mr. Albaredes,

Thank you for your letter of August 1st. The copyright on J.U. Marshall, The Location of Service Towns is held by the Department of Geography of the University of Toronto.

You have the Department's permisssion to reproduce the illustrations you list in your letter for your M.A. thesis. Should you publish your thesis, or articles based on the thesis, and wish to include any of the illustrations on which this Department holds the copyright, please write to me again.

Best of luck with your defence,

Yours sincerely,

J.H. Galloway

J.H. Galloway,
Professor.

Gilles ALBAREDES
Graduate Student
Department of Geography
University of Alberta
Edmonton, Alta
Canada

University of Totonto, Reserch publications

August first, 1986.

To whomever it may concern:

My name is Gilles Albaredes and I am presently a Graduate student at the University of Alberta in Geography.

I am now completing my Master's Thesis which rests on Central Place Theory and subsequent experimental studies on the subject.

In order to support its elaboration, I undertook an extensive review on the subject and it was decided to add numerous diagrams to illustrate the statement. A certain number of these diagrams or tables stem from a book published by the Department of Geography at the University of Toronto. The precise references are stated below:

J. U. Marshall, The Location of Service Towns, University of Toronto, Research Publications, 1969:

1. "Christaller's Versorgungsprinzip Model", Figure 5 on page 21.
2. "Christaller's Verkehrsprinzip Model", Figure 7 on page 30.
3. "A Model Statisfying Christaller's Absonderungsprinzip Conditions.", Figure 8 on page 32.
4. "Barrie System: Functional Indices and Related Data", Table 7 on page 133.
5. "Owen Sound System: Functional Indices and Related Data", Table 8 on page 135.
6. "The basic Lattice of Locally Dominany Centres", Figure 20 on page 139.
7. "Barrie System: Hierarchical Classification of Centres", Table 9 on page 142.

I am writing to ask your official authorization in order to reproduce these documents in my thesis by means of photocopying. Since my defense is planed for the begining of September, I would appreciate if you could reply this request as soon as possible.

I thank you for your cooperation.

Respectfully yours,

Gilles Albaredes

Graduate Student

MEMORANDUM

TO: Gilles Albaredes

FROM: Carol M. Hansen

DATE: June 17, 1986

RE: Request to reprint

association for asian studies, inc.
PUBLISHER OF THE JOURNAL OF ASIAN STUDIES
1 LANE HALL. UNIVERSITY OF MICHIGAN
ANN ARBOR. MICHIGAN 48109
PHONE (313) 665-2490

Permission has been granted regarding the reprint cited below:

G.W. Skinner, Marketing and Social Structure in Rural China, Vol. 24, 1964: All the diagrams on pages 19, 22, 23, 25, ff. of the Journal of Asian Studies - for reproduction in Master's thesis.

with appropriate citation and under the following conditions:

Appropriate citation...no fee.

Thank you for contacting us.

Sincerely,

Carol M. Hansen
Administrative Associate

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AU[illegible]les ALBAREDES

TITLE OF THESIS STRUCTURAL AN[illegible]TRALITY IN THE CHER, FRANCE

DEGREE FOR WHICH THESIS WAS PRESENTED Master of Science

YEAR THIS DEGREE GRANTED fall 1987

Permission is hereby granted to THE UNIVERSITY OF ALBERTA LIBRARY to reproduce single copies of this thesis and to lend or sell such copies for private, scholarly or scientific research purposes only.

The author reserves other publication rights, and neither the thesis nor extensive extracts from it may be printed or otherwise reproduced without the author's written permission.

(SIGNED) ....[signature]..........

PERMANENT ADDRESS:

88 rue de Bellevue

91330 YERRES

FRANCE

DATED July 17 1987

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled STRUCTURAL ANALYSIS OF CENTRALITY IN THE CHER, FRANCE submitted by Gilles ALBAREDES in partial fulfilment of the requirements for the degree of Master of Science.

....

Supervisor

....

....

Date.....9 July 1987.............

DEDICATIONS

To my parents, Ursula, and Marie Louise.

ABSTRACT

This study proposes a different approach for analyzing central place systems in a French rural county, the Cher. Initially derived from traditional methodology, an attempt is made to more fully understand the structure of centrality. Various approaches are used in the analysis and this study may be considered largely experimental.

Christaller's idea to combine measures of both the *aggregate* and *relative* importance of towns is adopted and applied to the Cher area. Most central place studies did not define a hierarchy of central places in terms of these two dimensions. A large majority of these works dealt with the *aggregate* importance of places in regarding centers as provisions of goods and services. They quantified the towns' importance by means of demographic, functional and economic indices. In the Cher, the *aggregate* importance of towns is empirically assigned to demographic and functional indices. The *relative* importance of towns involves a more spatial dimension. In the past, a few studies which considered central places in their environmental context usually graded them by measuring the size of their hinterland. In this particular study, a simpler solution is examined. This solution relies on the basic assumption that a town's accessibility is a function of its spatial dominance. Following this assumption, nodal accessibility indices are estimated for the 290 towns present in the Cher.

All together, 15 centrality indices reflecting both dimensions (aggregate and relative) are selected and submitted to principal component analysis. The multivariate model shows three underlying dimensions that characterize the centrality of places in the Cher: "Size-Hierarchy", "Functional Status", and "Accessibility". The importance of the size factor as well as the disassociation of the accessibility indices to the remaining indicators are two major features of this analysis. A grouping procedure is then performed on the factor scores and the obtained results clearly show that in the Cher, accessibility indices represent a poor measure of the *relative* importance of centers due to an unexpected boundary problem. On the other hand, two Christallerian indicators, the inner and outer *range* of towns are shown to be of great interest. The study of centrality profiles for each group of towns outlines a three-step hierarchy. The identification of market systems at each level of the hierarchy reveals competitive systems of supply centers in the Cher.

ACKNOWLEDGMENTS

I wish to express my gratitude to Dr Therese Saint Julien whose brillant teaching first roused my interest in quantitative analysis applied to geography.

I also would like to thank Dr Jean Claude Muller who gave me the opportunity to study at the University of Alberta.

To Dr John Hodgson and Dr Ken Fairbairn, I owe many thanks for reading this study in its preliminary drafts and for many valuable criticisms.

I wish also to thank my parents, Ursula Wendel and Bizzes for their support.

Special thanks to Sasha Dence, Jenny De Lugt and Mike MacGibbon for their precious help in editing this thesis.

Table of Contents

List of Tables

List of Figures

Figure Page

1. INTRODUCTION AND REVIEW OF CENTRAL PLACE STUDIES

1.1 The concept of centrality.

Central place analysis is one of the major themes of Regional Analysis and yet, it leads to confusion. Seventy studies that attempted to classify towns in different regions of the world were surveyed[1], and among them, more than forty different criteria of centrality have been found. The concept of centrality seems, therefore, to be viewed in a multitude of different ways, which casts doubt upon the possibility of a strict definition of centrality.

Centrality is an abstract notion first introduced by Christaller in 1933 [21], and its origin may lie in the economic law of demand and supply. The relationship between demand and supply is viewed by economists as the relationship between the amount of goods or services that consumers are willing to purchase and the various quantity of goods and services which firms are willing to put up for sale over a period of time under a prevailing market price.

Christaller considered the fact that the market for any good or service is an area, not a dimensionless point. By regarding the economic space as a surface, it becomes obvious that the price of a good increases and its consumption drops in proportion to the distance one must travel to get it. Consequently, a group of functions would be located in a position as central as possible in regard to the spatially diffuse purchasing power. At a certain point, the transport costs increase so much that the quantity demanded per person drops to zero and consumers will purchase in another closer center. This maximum distance that consumers are willing to travel to purchase a good was referred to in the translated version of Christaller's book [21] as the *upper limit of the range of goods*. Naturally, in a real situation, this distance may fluctuate according to economic factors. For instance if one institution raises prices, its

[1]A complete list of these works can be found in the bibliography.

cost advantage is eliminated, and neighboring institutions can capture a portion of its market and either destroy the first institution or force it to return to its original price level. One institution may also offer a fairly low uniform price everywhere in order to capture more distant markets and destroy competing centers. Concretely, "abnormal" situations like this occur quite frequently. The economic tactic, "loss leader", is widely used by North American retailers. In France, people will sometimes travel surpisingly long distances to buy gas at the "Leclerc" gas stations which sell gas 10% cheaper than everywhere else. In 1981, a French baker made the news because he sold each "baguette" for 1 Franc whereas everyone else sold it for the unified price of 2.10 Francs. However Christaller ignored such situations and assumed a rational economic system where extra profits are absent and where consumers behave in a rational manner. Therefore, in his model, the maximum distance consumers are willing to travel is assumed to be constant for each type of function found in different centers.

Ideally, firms locate in an optimizing way so that they can supply a maximum number of consumers within a minimum radius of sales. However, a place "A" which offers only usual functions such as bakeries or grocery shops would have a smaller radius of sale since consumers are not ready to travel long distances for this type of function which are qualified of a *lower order*. The importance of this place "A" regarding its surrounding area would thus be limited. Conversely, place "B" which offers rarer functions such as supermarkets or hospitals would attract people from a further distance. The economic scope of place "B", which offer functions of a ***higher order*** would hence be more important than place "A", and place "B" would be qualified as "more central" than place "A". This example shows that the centrality of an urban place may be directly proportional to the order of the functions it supplies. In fact, the centrality of a settlement was defined by Preston as, "(. . .)that part attributable to a settlement's function as a source of goods and services for a surrounding region." [53, p. 38]. Gottman also provided a good definition of centrality: "A successful and durable centrality leads almost inevitably to the grouping in the central place of a mix of diverse activities servicing in various ways areas of varying radius around the centre." [87, p.

4].

Centrality is usually referred to as an abstract notion and difficulties arise when one attempts to measure the centrality of towns in a particular area. Can the importance of a center be regarded as its centrality? Can centers be solely graded according to their centrality?

Christaller [21] provided answers to these last two points. In the theoretical discussion of his book [21], he clearly defines the *absolute* importance of a center as the sum of its *aggregate* and *relative* importance. This distinction between the *aggregate* and *relative* importance of a place is essential in classical Central Place Theory. Christaller assigns the centrality of a place to its *relative* importance: "The centrality of a place is equal to its surplus of importance, that is; equal to the relative importance of this place in regard to a region belonging to it." [21, p. 147]. He then assigns the size of a center to its *aggregate* importance. The combination of these two measures should then provide an adequate image of the absolute importance of central places: "Part of the importance must be ascribed to the town itself as an agglomeration of the population, and another part of a town as a central place." [21, p.18].

This distinction between *relative* and *aggregate* importance of a place was later reaffirmed by several geographers. Among them, Preston [53] assigned the term *nodality* to the *aggregate* importance and kept the term *centrality* solely for the *relative* importance of places. The *relative* importance or centrality represents the level of interactions between a center and its hinterland. Towns are then considered as regional centers. The *aggregate* importance or nodality of a town is rather expressed by some index of its size. Towns are then considered as closed systems and the centers-hinterlands relationships are neglected.

In Central Place Theory, Christaller emphasized the concept of centrality or *relative* importance of centers. He put forth the notion of *economic distance* as one of the major determinants of the centrality of places:

> "One of the most important factors which always determine the range of a central good is the distance between those who live dispersedly and the place where the central good is offered. The distance in Kilometers is economically unimportant. Only the time-cost distance, which we shall call *the economic distance*, can be a determining factor (. . .)" [21, pp. 51-52]

However, he did not refer to the accessibility of centers as their nodal accessibility. Gottman argues that: "Centrality connotes and requires a particularly favourable accessibility to and from the various portions of the space served by the center". [87, p. 4]. Later he adds, "One thus recognizes that the geographical space to which centrality applies depends on the organization of the network of access to the central place." [87, p. 4]. Since the centrality of towns depends upon the distance consumers are willing to travel, it is clear that one fundamental indicator of centrality may be found with the accessibility of centers.

More recently, Bird [76] defined three types of centrality as shown in Figure 1.1. Endogeneous centrality relates to the relative commercial centrality of a center in regard to its hinterland or trade area. On a larger scale, the concept of internal centrality appears within studies of urban agglomeration and scale economies. It is used to depict the internal organization of cities. Conversely, exogeneous centrality describes the importance of a center in terms of its international linkages and extra-regional functions. Christaller and the authors of resulting central place studies restrict their analyses to the endogeneous centrality of centers. Centers were considered as points and not as areas. Functional linkages were studied within the center's trade area, and most of the time, extra-regional linkages were neglected.

Although the concept of centrality prevails in Central Place Theory, most central place analyses dealt with the *aggregate* rather than the *relative* importance of centers in their respective study areas. The general disregard of the *relative* importance of centers may have resulted from the difficulty of finding reliable quantitative indicators to measure it.

1.2 Criteria for grading centers.

One of the first challenges presented by central place studies was to find some way of measuring the importance of urban places in order to stratify them into distinct hierarchical classes. One general issue was raised concerning this problem; what indices should be selected? The problem is indeed fundamental since the credibility of such studies largely rested on these indices. Should one select key criteria or compute a multitude of indicators? The question is not easy to answer and the large variety of indices found in the literature infers that a

This page has been removed because of the unavaibility of copyright permission.

This page contains:

Source: Bird, J. 1977. Centralities and Cities. *Routledge Direct Editions*.

Figure 1.1 Three definitions of centrality.

satisfactory methodology for determining both *aggregate* and *relative* importance of service centers may have not yet be found. As shown in the preceeding section, geographers have different conceptions of urban importance and their measures can range from a simplistic type to a complex mix of numerous criteria. A good illustration of simple measures can be found in Abler's work [3] where in the United States, the importance of urban places is looked at in terms of major league baseball team location. The distribution of teams represents then the central place hierarchy. At the other end of the scale, in Kenya Henkel [30] considered 18 centrality indices to grade 30 centers. Between these two extremes, it is possible to find a wide range of indicators. Basically, they can be divided into three subgroups:

1. Relational criteria.
2. Direct quantitative criteria.
3. Economic criteria.

1.2.1 Relational criteria.

Several geographers who conducted central place analyses attempted to capture the *relative* importance or centrality of places present in their respective study areas. As discussed above, the concept of centrality primarily rests on the distance consumers are willing to travel. Central places which provide functions of a higher order will have larger trade areas than those that offer only functions of a lower order. Therefore the size of the trade area is proportional to the centrality of the corresponding center. A good approach to measure the centrality of a place is to quantify the level of interactions between centers and respective trade areas.

Carruthers [18], Green [27], Ullman [70], and Godlund [26] determined the extent of the area served by the central place by mapping the bus lines radiating from each center. By superimposing these maps, they could recognize the approximate boundaries of urban spheres of influence. The different sizes of these hinterlands permitted them to determine distinct classes of centers in their respective test areas. These techniques were criticized on the grounds that they only considered the rural element of service. However they fulfilled the concept of surplus importance of towns and seem therefore to constitute adequate measures of centrality. A restriction may be that buses are not the only form of transport and have different meanings as centrality indicators in backward or advanced economies.

Another method of measuring the attractive power of centers was based on questionnaires. Their goal was to determine levels of patronage and trading areas. In three different studies, Murdie [45], Saey, Lieter [56], and Bracey [13] asked people to identify the urban places where they usually go to shop for selected goods and services. In Southern England, Bracey scored one point to a center when this center was given as the place visited for one service. At the end of the operation, a certain number of points were allocated to each center which could thus be stratified into distinct hierarchical classes. This system is probably one of the most powerful since it deals with consumers' behaviours. However, the fact that each service is awarded the same value, irrespective of its functional importance, contradicts the concept of the hierarchy of services.

Finally the last set of procedures used to identify the urban fields measured the volume of interactions between different urban places. The first and most famous of these methods was the one found in Christaller's empirical study held in Southern Germany [21]. Christaller recognized the importance of business links as telephone connections and proposed the centrality formula:

$$Z = T - P \, (TR / PR)$$

Where

Z is the centrality of a central place.

T is the number of business telephone connections in that place.

P is the population size of the central place.

TR is the number of telephone connections in the region.

PR is the population of the region.

In this formula, the term T gives the actual observed number of telephone connections in the place while P (TR / PR) gives the expected number for the same place based on the assumption that the density of telephone connections per person was the same in the region. Other geographers utilized the telephone index in their central place analyses. Caroll [17] in Michigan, Borchert, Adams [12] in the Upper Midwest, Kant [37] in Estonia, and Jain [34] in India used the same indicator. However, with the growth of private subscribers, the telephone has ceased to be a purely business tool and does not represent a satisfactory means to assess the surplus of the functional importance of a center. For Taaffe [68] and Reed [55], the pattern of air passenger linkages reflects the centrality of towns. In the United States, Taaffe compared air passengers linkages with gravity-model expectations. Reed examined India's system of airline flows and identified an urban hierarchy with four levels of connectivity. The air traffic procedure is appealing but it seems that this index does not simply summarize the endogeneous centrality of centers, but also partly embraces their exogeneous centrality.

Both Stabler [65] and Stanley [67] included in their centrality models the accessibility of each center as indicated by type of road connections. Although rarely found in central place studies, the nodal accessibility of towns may be a major criterion of centrality. Since the centrality of a town depends on the distance consumers travel, it is obvious that the more central, the more accessible centers should be. In Liberia, Stanley treated the road network as a graph. He then described the relative centrality of a town as the expression of its *centralness* to the entire network.

1.2.2 Direct quantitative criteria.

Apart from the centrality procedures that measure the relations between towns and country, most central place analyses focused upon the *aggregate* importance of centers. They usually based their measures on the assessment of central services and institutions existing at the centre.

A certain number of these models were still conceived in terms of surplus centrality since they compared the center's functional importance with that of its hinterland. A perfect application of this procedure can be found in Johnston's study [36]. In Yorkshire, Johnston compared both population and functional status of 233 centres with the population and functional status of their surrounding regions. He came up with the formula:

$$C = ((PH/SH) - (PV/SV)).(100/(PH/SH)).(SV)$$

where:

C is the required importance of a center.

PH is the population of the urban hinterland.

PV is the population of the center.

SH is the number of shops in the urban hinterland.

SV is the number of shops in the center.

This formula was tested only with one central institution, the grocery general shop, and therefore did not account for the hierarchy of functions. In South Wales, Davies [23] measured the status of a larger group of functions with the formula:

$$C = (t. 100) / T$$

where:

C is the location coefficient of each outlet of individual functions.

t is one establishment of the function.

T is the total number of outlets in the region.

C was then multiplied by the average number of workers in an establishment of each type of function. The result thus obtained was multiplied by the number of establishments under each function to rank each center. This method of assessing services and activities between the center and its region was reapplied by J. Singh [59] and Marshall [43], and seems to have provided satisfactory results. Other approaches, such as the one proposed by O.P. Singh [61] in India compared centers to their hinterland in terms of population indices. In New England, Johnson [35] calculated the ratio *Number of dentists / Population of hinterlands* for each center, and substracted the resident population of the town from the number of people estimated to be served there. She thus obtained positive and negative values for each center.

The simplest measure of the *aggregate* importance of a center consists of adding together all the functions that are found in the central place. This simple method was used in numerous studies. For instance, in India Bansal [5], Mandal [42], and Pandey [49] assigned weights to different service functions considered to be significant, and summed them up to yield a total score. Bracey [13] adopted this method in a classification of villages in Somerset, and Palomaki [48] ranked each central place in South Bothnia upon the basis of the total number of different central functions it possessed. In Australia, Scott [57] examined the relationship between the numbers of functions and establishments to classify towns. Although it is a popular methodology of identifying the hierarchy of towns, it seems that the summation of the crude numbers of outlets alone provides an incomplete measure of the absolute importance of places. This procedure does not permit the measure of the dominance of the center in regard to its surrounding area, but rather assumes centers to be independent systems.

An alternative method was to consider the occurrence of functions instead of their total number. Whether every particular function or a limited number of general classes of activities were considered, this method provided a more complete assessment of the status of a center. In Southern Iowa, Berry and Garrison [8] based their studies on an incidence matrix in which the rows were central places and the columns were central functions. In this matrix, cells were coded 1 if the function was present, and 0 otherwise. By applying Principal Component Analysis to this matrix, they could obtain a hierarchy of towns based on their functional diversity. Similarly, Crissman [22] in Taiwan, and Muwonge [46] in Uganda stratified centers according to the frequency of their central services and institutions. By looking at the level of occurrence of activities for each central place, workers considered the variety of activities offered rather than their crude number.

A more original method proposed by Berry and Garrison [9] in Washington State consisted in evaluating the population thresholds of each function. The population threshold of a function is the lowest population of the central place of its appearance. In India, Prakasaro [51] determined these thresholds by directly comparing the population of each center in which activities appeared. With a large number of centers and activities, this procedure may be tedious. Berry and Garrison [9] estimated statistically the threshold populations of 52 central functions present in 33 urban places in the State of Washington. They based their study on the expected relationship between the population size of a central place and the number of establishments within it by assuming that the following equation held:

$$P = A\,(B^{N})$$

where

P is the population size of a place.

N is the number of establishments for a chosen function.

A and B are coefficients that are calculated from the information provided.

This equation was applied using estimates for A and B together with a value 1 for N. P was termed the threshold population for the function in question and represented an estimate of the average level population required to support one establishment of that function in the system of towns under study. The central functions were ranked on the basis of their population thresholds. They were then divided into groups and groups of centers were statistically defined. This concept of population threshold is very close to the Christallerian *lower limit of the range of goods* defined as, "the minimum amount of consumption of this central good needed to pay for the production or offering of the central good." [21,p. 54]. However, Christaller based his theoretical model of central places on the relationship between the lower limit (population threshold) and the upper limit (maximum distance travelled by consumers) of the range of goods.[2] By using only the threshold measure to grade centers, the *aggregate* importance of centers was then evaluated.

1.2.3 Economic criteria.

A more economic approach can be found in a large number of central place studies where the frequency of central services and institutions is no longer considered as a criterion for measuring the *aggregate* importance of places. Instead of relational or functional indices, several scholars used the retail turnover of a center or the number (or percentage) of active persons in retail trade and services.

In the East Midlands, Brown [15] based his hierarchy model on the total retail turnover of centers. In Sweden, Olsson and Person [47] measured the status of centers by reference to an economic ratio of centralization:

$$C = Sd / (1{,}000 \cdot (P/100) \cdot Ic)$$

where

C is the centrality of a center.

Sd represents the sales of durables in the place.

P/100 is the percentage of per capita income available for durable goods.

Ic is the percentage income in the province in which a central place is located.

Finally, in Wales Carter [20] combined the retail turnover and employment of firms with population indices. The correlation levels between these variables provided adequate indicators of urban hierarchy. Total turnover of firms is a criterion of hierarchy that may be questionnable. Total turnover may vary with the income levels of regions or countries. It seems then necessary to weight it with the hinterlands' income levels as did Olsson and Person [47] in Sweden. Moreover the total turnover of firms present in a center may hide the real functional importance of this centre. The composition of the total is more important, for the

[2]For more precision on the Christallerian concept of the range of goods and its upper and lower limits see Chapter 3.

same total figure may be derived from a number of low order functions, or from one high order function.

The indicator of hierarchy the most frequently used is the number (or percentage) of active persons in retail trades and services. This factor is essentially predominant in studies held in backward countries where collecting precise data of the functional organization of towns is difficult. In Kenya, Henkel [30] evaluated the percentage of workers found in eight categories of activities. Together with population and ethnological criteria, these data were compiled through a factor analysis. Three relevant factors were extracted and a grouping procedure was then carried out on the factor scores. Five distinct levels of towns were established. In Western Guatemala, Smith [63] applied the same statistical method of factor analysis on economic variables measuring the percentage of traders with functional and population attributes. Similarly, K.N. Singh [60] and Sidall [58] calculated the percentage of the total population of centers engaged in specific activities. Finally, in the Pacific Northwest Preston [53] combined four economic indices with a population index in the formula:

$$C = R + S - \&MF$$

where:

C is the importance of a center.

R equals the total sales of retail establishments.

S equals the total sales in selected service establishments.

& is the average percentage of median family income spent on retail items and selected services.

M is the median family income for a central place.

F is the total number of families in a central place.

Although some scholars took the precaution to include economic criteria describing both status of the centers and their surrounding areas, most of the economic centrality ratios solely described the economic importance of centers. The hinterland support for central places is often neglected. However, the price of items or the income of the center's population certainly affects the distance travelled by consumers and therefore the centrality of central places. These two particular criteria seem to be good indicators of centrality.

More recently, the diffusion of goods or phenomena has been viewed as a good indicator of the hierarchy of centers. For instance, Weisbrod [71] described the spread of wage inflation down through an urban hierarchical diffusion process. Berry [7], Huang, Gould [31], and Hudson [32] all recognized the diffusion process in terms of the number and proportions of centers of particular orders that had been reached by the process after stated number of time intervals. However, Pred [52] stressed that in fact very few, if any, phenomena are spread by way of a strict central place hierarchical process.

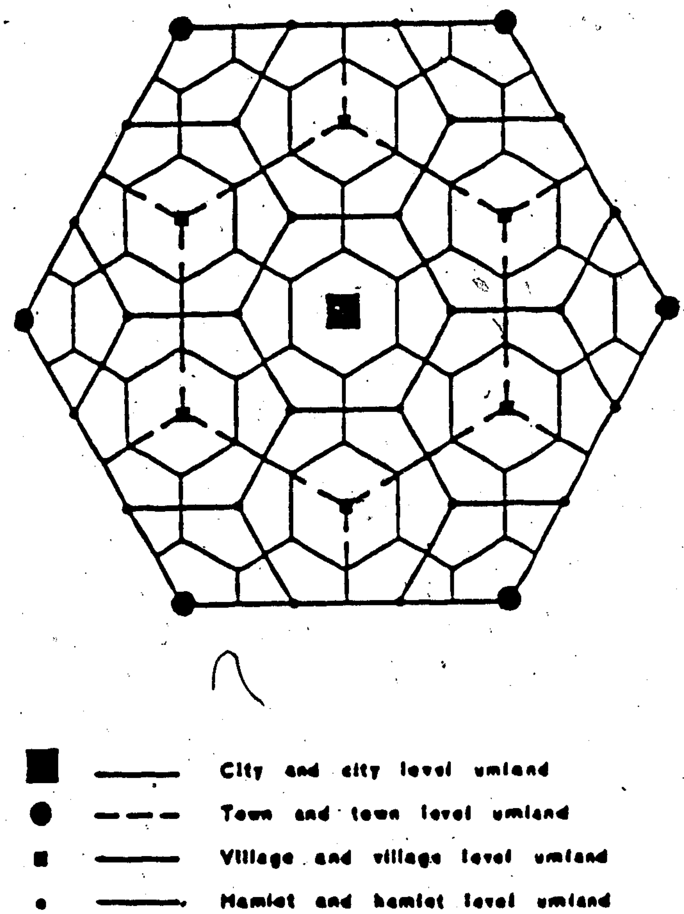
Philbrick stated that "All centers of a given region are not equally significant in the total areal functional organization." [99]. One way of grading centers proposed by Christaller is to measure and combine their *relative* and *aggregate* importance. The above discussion clearly showed that geographers r[illegible] combined these two types of measures in one composite centrality index. One group of geographers measured exclusively the *relative* importance of centers by using relational indicators. Basically, they attempted to measure the expansion of hinterlands and ordered the places according to their respective hinterland size. Another group of geographers dealt more specifically with the *aggregate* importance of towns. By means of direct quantitative or economic criteria, they measured the functional status of centers by considering them as closed systems. They generally ignored any interactions between centers and their surrounding regions.

1.3 Location patterns.

Once the hierarchy of central places was established, most central place studies analyzed the locational patterns of central places at each level of the hierarchy. In summary, two groups of studies can be differentiated. The goal of the studies belonging to the first group was to empirically verify Christaller's locational arrangements of central places. In contrast, several studies attempted to dismiss the classical central place pattern by stressing the differences between the settlement pattern of their test areas and the Christallerian hexagonal distribution of centers.

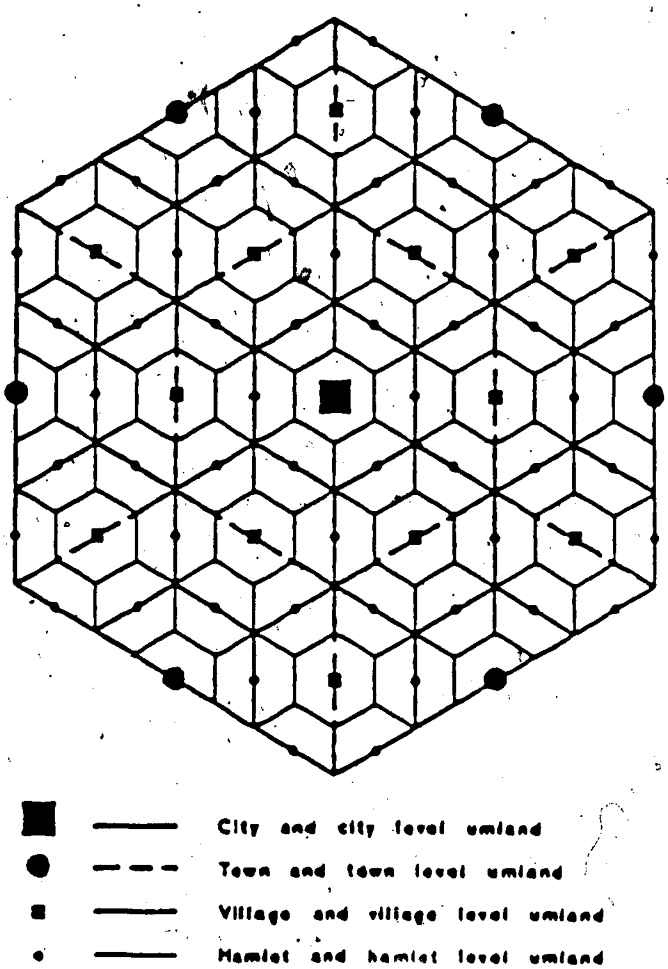
Under the assumption that central places lie on a uniformly populated isotropic plain with a static economic system where consumers behave in a rational manner, Christaller [21] considered that at each level of the hierarchy, a strict, uniform spacing of central place existed. With a hexagonal distribution of central places, he determined for each center at any level of the hierarchy, a set of tributary areas of different size nested within one another. Moreover, he stated that each hierarchical level of central places is separated by a distance that increases by $\sqrt{3}$ (1.73205) from the lowest to the highest.

In the "Versorgunsprinzip" or *Marketing system* shown in Figure 1.2, there is always one center of a higher order surrounded by six centers of the next lower order, and these six surrounding centers are located on the vertices of the higher-order center's largest tributary area. The progression describing the number of different size places is: 1, 2, 6, 18, 54, 162 ... and so on. Figure 1.3 outlines the geometric pattern of central places in the context of the "Verkehrsprinzip" model or *Traffic principle*. The requirement of a long distance transportation system causes centers to be aligned along main routes, and the system is therefore essentially linear. In this system, the number of places in successive order run as follows: 1, 3, 12, 48, 192 ... and so on. By contrast, the "Absonderungsprinzip" or *Separation principle* displayed in Figure 1.4 takes into account the administration boundaries of a region. It results in the creation of virtually complete districts of almost equal area and population, at the center of which lies the most important place. In this arrangement, the number of centers in successive order runs as follows: 1, 6, 42, 294, 2,058 ... and so on. Christaller [21] recognized similar patterns of central places in Southern Germany. However, his work has been widely criticized on the ground that the inherent assumptions were unrealistic. Parr [50] goes one step further and demonstrates that in Southern Germany, the Christallerian frequency of centers of different size-classes is not valid.



Source: The Location of Service Towns, J. U. Marshall, University of Toronto Press, 1969.

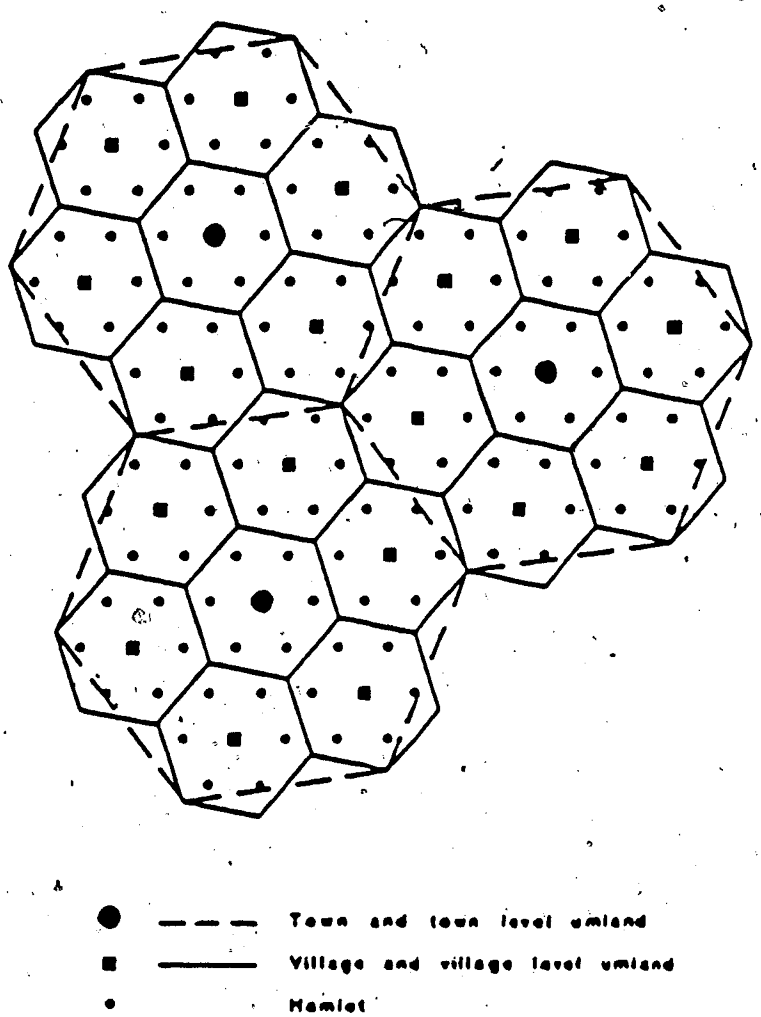
Figure 1.2 Pattern of central places according to the market principle.



Source: The location of Service Towns, J. U. Marshall, University of Toronto Press, 1969.

P. 30.

Figure 1.3 Pattern of central places according to the traffic principle.



Source: The Location of Service Towns, J. U. Marshall, University of Toronto Press, 1969, p. 32.

Figure 1.4 Pattern of central places according to the separation principle.

Despite these difficulties for accepting Christaller's rigid model of central places as an exact description of reality, several studies attempted to verify Christaller's model of central places in their respective test-areas. Johnson [35] tested the most basic outcome issued from Christaller's theory. In New England she tested the uniformity of central place distribution by calculating the percentage of the total area covered by hexagons of equal size centered on central places. Her results showed that 71.5% of the area was covered by the hexagons. She thus concluded that local service centre distribution demonstrated to an acceptable degree the uniformity predicted by Christaller's market principle model. Scott [57] in Australia, and Brush [16] in Wisconsin both verified the uniform increment of distance between each level of central places. As far as sequences of central places are considered, Scott [57] identified a relationship between the progression of numbers found and the ones stated by Christaller. In Southern Ontario, Marshall [43] recognized a progression of central places described as: 1, 2, 8, 52, which is close to the sequence of places found in the Market principle. Finally, several studies outlined the Christallerian lattice of central places. Figure 1.5 shows that the organization of the marketing patterns distinguished by Skinner [64] in China is close to that of the Market principle. Similarly, in Western Guatemala, Smith [63] identified a composite model lying between the Market, Traffic, and Separation principles as illustrated in Figure 1.6. Finally, in Southern Ontario, Marshall [43] demonstrated the triangular lattice of centers shown in Figure 1.7. He wrote that:

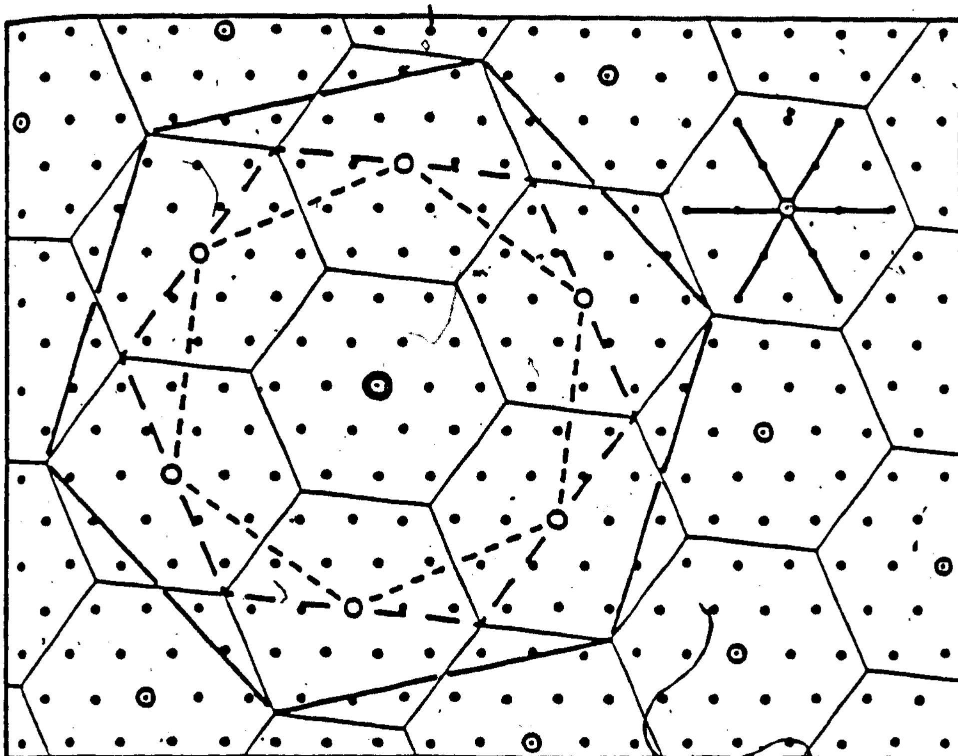
> "The triangular lattice pattern . . . will be recognized as a basic feature of all Christallerian central place models, and it is encouraging to discover this pattern in an empirical study . . . There is a definite tendency for centers to be located to the Versorgungsprinzip model." [43, p. 51]

In contrast with these studies, some geographers have attempted to demonstrate that the Christallerian pattern of central place does not hold in reality. Losch [40] brought Christaller's theoretical landscape closer to reality by incorporating variations in population densities in his central place theory. Following this idea, Isard [92] proposed a central place system where the size of the trade areas differs with unequal population distribution. In a more rigourous manner, both Rushton [103] and Gusein-Zade [88] mathematically demonstrated the relationship between population density and the size of market areas. Hence they proposed different arrangements of central places where the size of the market area becomes a function of the population density. Within an economic context, Dacey [82] denied the rational economic system assumed by Christaller, and identified a probabilistic model that combines a random element with the hexagonal point lattice. Gambini, Huff, and Jenks [85] identified market areas where firms possess unequal levels of attraction. Finally, a series of studies criticized the fact that Christaller built up a system where the time dimension is absent. In order to compensate for this deficiency, geographers like Allen and Sanglier [72] provided a central place organization resulting from a simulated evolution of a centfal place system.

Does the locational pattern of central places recognized by Christaller hold in practice? Despite several attempts to verify this, most geographers criticized the inherent assumptions of Central Place Theory and demonstrated that realistically, the rigid Christallerian pattern of central places could not exist. However, evaluating the functional spatial magnitude of centers and trying to define patterns of central places is still of interest. The concepts of urban hierarchy and nested trading areas are still valid, and studying their characteristics is of deep interest. In such attempts, Christaller's model of central places should be considered as a theoretical reference pattern. The main interest lies then, in the recognition of to what degree the actual pattern departs from the theoretical one.

1.4 Objective of the study.

The above discussion throws light on major issues regarding past central place studies. It appears that a majority of these studies did not fully respect the concept of central place hierarchy which considers a central place as a place of manifold activities responsible for exchanges of socio-economic commodities and necessities for the immediate contiguous surrounding region. One of the disappointing features of these central place studies has been their inability to describe the absolute importance of places by combining indicators describing both their *aggregate* and *relative* importance. Most of them considered the hierarchy of centers in terms of their static importance characterized by their functional degree or discrete



SOURCE: G. V. Skinner, "Marketing and Social Structure in Rural China", Journal of Asian Studies, vol. 24, 1964, p. 21.

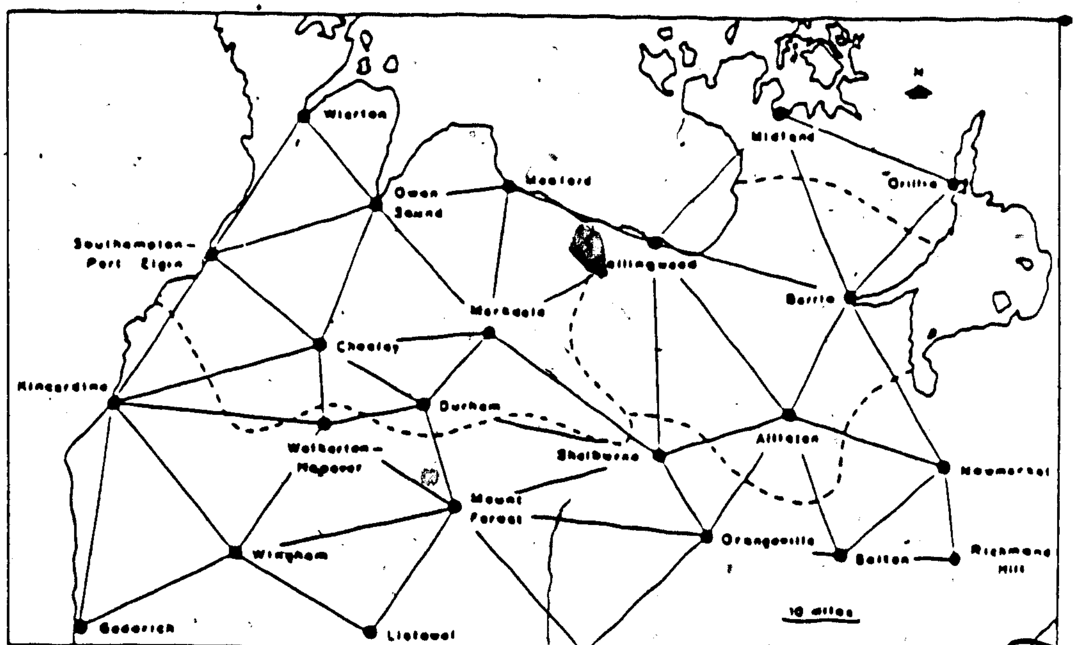
Figure 1.5 Hexagonal marketing area system in China.

This page has been removed because of the unavaibility of copyright permission.

This page contains:

Source: Smith, C. A. 1976, Causes and Consequences of Central Place Type in Western Guatemala. In Regional Analysis 1, Economic Systems, *Ed. C. A. Smith, New York, Academic Press:* 225-300.

Figure 1.6 Central place pattern in western Guatemala.



SOURCE: J. U. Marshall, "The Location of Service Towns", University of Toronto Press, 1969, p. 139.

Figure 1.7 Triangular lattice of central places in Ontario.

population level. They did not account for the fact that the order of a service center depends, to a certain extent, on its interactions with the surrounding region.

In contrast to most of the above mentioned works, this study attempts to give a complex regional analysis of the hierarchy of central places making use of *aggregate* as well as *relative* importance indices. In other words, the purpose of the study is to examine the functional structure of towns in relation to their centrality and their size. The aim is to propose an objective approach to the problem of determining the hierarchy of central places. It is not without problems to apply the central place principle to a region with regards to both the *aggregate* and *relative* importance of places. The main difficulty of such a project is to determine what indices of urban hierarchy should be collected. In fact, it has been seen that the *aggregate* importance of a town can easily be evaluated by several indices such as: the total number and the diversity of functions; the population; or the population thresholds of each activity. More difficult is the collection of appropriate *centrality* data. Centrality indicators should measure the level of interactions between a center and its surrounding region. Most central place studies that dealt with this problem conducted questionnaire surveys to analyze consumer behaviour. Other works studied the flows of commodities between a center and its hinterland. If we assume that the importance of linkage networks between places is proportional to the amount of commodities shipped between them, one simpler solution may be to conduct a network analysis in the region under investigation. The study of road networks and the evaluation of centers' accessibility may then represent adequate tools for measuring the *relative* importance of central places. Christaller also provided an interesting centrality measure, the *upper range of goods* or the maximum distance travelled by consumers to purchase a good when this good is not supplied in their own towns. As a result, in the present study the first index of centrality (the accessibility of towns) was estimated by means of nodal accessibility measures directly calculated from the road network of the region. The *upper range of goods* was evaluated using a reliable source of data, the Inventaire Communal, a French census book which provides all the necessary elements for this project. The area under investigation is a rural area lying in the center of France called the

Cher.

The present study is an attempt toward rectifying the most common deficiency found in central place studies through a combination of indices accounting for both the *aggregate* and the *relative* importance of 290 places located in the Cher (France). Forty-eight central activities were examined and the data thus obtained were computed through Principal Component Analysis. A grouping procedure was then applied to the factor scores to identify hierarchical levels of central places in the Cher. The last task was to analyze the networks of central places and determine whether the area of influence of centers was arranged in geometric patterns with the trade areas of low order centers nested within those of higher order.

To conclude, this study proposes an alternative method of grading centers, with the method being applied to a French area, the Cher. This method attempts to address the defects found in several other central place studies. It offers a composite centrality measure accounting for both the *aggregate* and *relative* importance of centers. One difficulty in this study has been an inability to collect economic variables such as the families' incomes, price of goods or retail sales in the Cher. The centrality model, therefore, essentially rests on relational and direct quantitative indices.

2. THE MATERIAL

The first task, in undertaking the assignment of analyzing both the *relative* and *aggregate* importance of settlements in the Cher consists of finding a reliable source of data. The choice of an appropriate data-source is dependent upon two factors. First, the source must offer the majority of criteria included in diverse past centrality models. Secondly, if it is not possible to extract these criteria without data-operations, these operations must be minimized. These two requirements are essential to assign an accurate centrality index to every central place in an efficient manner. The Inventaire Communal, the French census book containing this information, will be referred to later in this chapter.

After locating an adequate source of information, the next task is to seek a favourable area for study. In keeping with the central place theory, a rural-type area with roughly a plane topography was selected. This area tends to be homogeneously populated, and its settlements tend to be evenly spaced. The study-area, selected on the basis of these criteria, lies in the centre of France and corresponds to the administrative boundaries of a French county ("département"), the Cher.

2.1 The data-source.

This section presents the source of information utilized for the central place analysis in the Cher. Since centrality models largely depend upon the choice and the exactness of the data, special attention is directed toward the method of collecting the data. Then, it is shown how the French census book, the Inventaire Communal, represents a satisfactory source of centrality indicators. Finally, the limitations of the data will be stressed and their reliability will be discussed.

2.1.1 The origin.

The data used in this study are taken from a French source entitled: <u>Inventaire Communal</u> (Municipal Survey), published in 1980. The survey was undertaken when both the French Department of the Interior and Ministry of Finance recognized the lack of complete information concerning both private and public functions at a municipal level. In actual fact, this information was available, but scattered in numerous census books, each of them specific to a particular type of function. Under this old system, it often took up to one day of research to gather a complete description of the functional organization of one single commune! In 1979, it was decided to renovate the system, and the French Bureau of Statistics (Institut National de la Statistique et des Etudes Economiques) undertook a large survey covering the whole country.

A thirteen-page questionnaire was sent to all the councils of the French communes. Every single town, village and hamlet received the questionnaire, and the council members were required to complete the survey as precisely and thoroughly as possible. The questions covered a wide range of subjects and were often not easy to answer. For instance, each municipality had to scientifically measure the level of pollution in their water, soil and air. They were also asked to register such peculiar statistics as the number of hunting licenses issued in a given year, or the exact length of sand and pebble beaches within their territory.

Generally speaking, the questions were designed to evaluate the number and diversity of public and private institutions in each municipality. The majority of the questions dealt with quantitative and qualitative information relative to functions such as educational and health establishments, recreational and cultural facilities, transportation, and private firms. Retail trades, self-employed professions and services such as banking institutions and religious establishments were arbitrarily grouped under the heading "private sector".

Topics such as population, industrial, and agricultural activities, were considered only briefly since this information was readily available in other census books. The scope of the survey was limited to several more specific points. In short, the purpose of the survey was threefold:

1. To make an inventory of all local institutions.
2. To gather previously scattered information into one central source.
3. To extract reliable data on the largest scale.

With the Inventaire Communal, the French Bureau of Statistics (I.N.S.E.E.) attempted to gather complete and reliable data concerning each of the main sectors of local social life. The value of this source lies in its fine geographical frame and its recent establishment. It is also the only inventory of its kind to present an exhaustive portrait of the functional organization of France's municipalities.

2.1.2 A satisfactory source of centrality data.

2.1.2.1 A good description of the rural environment.

The general survey covered a large variety of topics ranging from social information to geographic and demographic data. The Fiches Communales (Municipal Cards), a census book also issued from the general survey had a more economic and quantitative approach.

The Fiches Communales was used to gather information about public and private institutions throughout the 95 French counties ("départements"). All of the 95 Fiches Communales were identically organized. In each of these census books, each category of functions is classified into different tabulations. These tabulations, under headings such as "Recreational and Cultural Facilities" or "Educational and Health Establishments" list all the communes of the county by alphabetical order, and, for each commune, record the number of establishments of up to 75 functions.

Our interest was directed toward one particular tabulation called "Services and Retail Trades". In this section, the services and retail trades are classified into 48 functions as they are listed in Table 2.1. This tabulation provides a list of the municipalities, and for each of them, the number of establishments of the 48 functions is tallied.

Table 2.1 The 48 functions chosen for the study.

1	POST OFFICE
2	FIRE HALL
3	SOCIAL SECURITY OFFICE
4	TAX BUREAU
5	POLICE STATION
6	BANK
7	SAVING BRANCH
8	NOTARY
9	VETERINARIAN
10	CHURCH
11	MINISTER
12	BUILDER
13	PAINTER
14	CARPENTER
15	PLUMBER
16	FURNACE MAN
17	ELECTRICIAN
18	MECHANIC
19	MECHANIC FOR AGRICULTURAL MACHINES
20	SUPERMARKET
21	GROCERY
22	BAKERY
23	CAKE SHOP
24	BUTCHER'S SHOP
25	DAIRY
26	FISH SHOP
27	RESTAURANT
28	BAR
29	BARBER
30	HAIRDRESSER
31	CLOTHING STORE
32	HABERDASHERY
33	SHOE STORE
34	APPLIANCES-STEREO STORE
35	FURNITURE STORE
36	HARDWARE SHOP
37	IRONMONGER'S SHOP
38	SPORTS SHOP
39	SEED SHOP
40	STATIONERY STORE
41	TOBACCO SHOP
42	NEWSPAPER STAND
43	GAS STATION
44	DIESEL STATION
45	GARAGE FOR OIL PURCHASE
46	GRANARY
47	MARKET (MONTHLY)
48	WHOLESALE MARKET (ANNUALLY)

The classification of services and retail trades into 48 functions may appear detailed to the North American. However, retail trade is very important in France, and French consumers generally prefer to conduct their business in small privately owned shops as opposed to shopping-malls which are found only in France's major cities and remain unfamiliar to most rural inhabitants. As a rule, every town or village is characterized by an important retail trade activity and a major part of French social life is centered around the relationships between consumers and retailers. Often, retailers are "family friends" and shopping in stores becomes a usual and daily habit. Therefore, even with a low population, French villages often have an important retail activity. The diversity of functions offered is generally greater than the diversity of functions one can find in North American towns. Functions that may be unknown in North America are often ubiquitous in France, ie. the habberdashery or ironmonger's shop.

Religion is another important aspect of French social life, particularly in the rural areas where the presence of a church or a permanent minister in a village is an indicator of urban hierarchy since ministers generally live in the most important villages. Though churches can usually be found in even the smallest of France's villages, often a minister must travel from another town to celebrate mass where there is no permanent minister in residence. For this reason, "church" and "minister in residence" appear as two separate functions in the section "Services and Retail Trades", and the presence or absence of the latter is an indication of the centrality of a town. Other functions such as dairies, granaries and seed shops are also common to the rural world, and since they are vital to farmers, they tend to be located in towns where they are easily accessible.

All of the above tends to demonstrate that the <u>Fiches Communales</u> and the inventory of services and retail trades in 48 functions is well suited to rural areas. Careful attention was paid to include in the survey functions vital to a rural environment, whether or not they existed in cities. Most central place studies take place in rural areas and the <u>Fiches Communales</u> will be extremely useful for accomplishing our project over the selected rural area.

2.1.2.2 The Fiches Communales and the components of centrality.

Chapter 1 highlighted the centrality indices generally used in past empirical studies. These indices can be gouped into three categories as follows:

1. Relational indices.

2. Direct quantitative indices.

3. Economic indices.

The Fiches Communales of the Inventaire Communal offers the most reliable, complete, and categorical information for evaluating direct quantitative centrality indicators at a municipal level in France. The tabulation that deals with services and retail trades codes most of the elements included in past centrality models. The population density, the nucleated and total population of places are presented in the tabulation. The total number of establishments of each place may easily be determined by adding the number of establishments of the 48 functions. The construction of a binary matrix with "1" when the function is performed in a town and "0" when it is not present allows us to estimate the functional diversity of each town.

However, relational indices and economic criteria cannot be extracted from the Fiches Communales. Relational indices of centrality must be searched into different sources. One simple approach to evaluate the level of interactions between a center and its surrouding region is to consider its accessibility to the road network. Accessibility measures may then be derived through graph theory from large scale road maps. Economic criteria such as family incomes or prices of goods are either scattered among several other sources or simply cannot be found in any statistical reports (e.g. price of goods). For this type of information, the best source would stem from a direct survey by means of questionnaires sent to retailers and families over the whole study area. Such process was virtually impossible to achieve and it was decided not to include economic data in the centrality analysis in the Cher. The centrality model proposed in this region will therefore essentially rest upon direct quantitative and relational indices.

The Fiches Communales of the Inventaire Communal are reliable published sources for the purpose of the present study as far as direct quantitative indices are considered. For every French county, this census gathers almost all the geographical indices found in past centrality models into one tabulation and allows a straight calculation of these indices by simple computations of data. This recent data-source will therefore permit the development of a centrality model that largely relies on direct quantitative centrality indicators. Before choosing an appropriate study area however, it is necessary to stress the limitations of this source of information.

2.1.3 The limits.

The Fiches Communales of the Inventaire Communal is a new source of information that provides new perspectives for geographers who deal with environmental studies. No source is infallible however, and it is therefore necessary to undertake an objective evaluation of this source. To disregard the limits of the sources would certainly result in blinding deficiencies in the final outcome and, therefore, they must be taken into consideration at the beginning of the study.

Two major restrictions are apparent in the Fiches Communales. The first concerns the original questionnaire upon which the whole survey is based. The second involves the actual data.

2.1.3.1 The questionnaire

The examination of the questionnaire leads to two major judgements:

1. The questionnaire is long and complex.
2. The different systems of notation for answering are ambiguous.

The questionnaire may appear excessively long since it is composed of thirteen, densely written pages. Twelve sections and numerous sub-sections are poorly organized and not clearly defined. Moreover, some of the questions require a level of knowledge and degree of precision that may hinder accurate and objective answers. Are all municipality councils aware of the exact level of pollution in the air or the length of pebble beaches within their territories? The questionnaire was obviously addressed to competent staff. However, as complex as it is, one may wonder whether the representatives of every municipality completed it with all the attention and accuracy required.

Adding to these first difficulties, the different systems of notation that are proposed to give quantitative information are ambiguous. The following example may help to illustrate this point. In the section "Services and Retail Trades", one is asked to record the number of services and retail trades that exist within the town based on 48 separate functions. For most services, one is the maximum number allowed. Interestingly, when two services within the same functional category exist, there is no room for proper documentation. As far as retail trades are concerned, one is allowed to record up to five establishments per function. Obviously, this system of notation can easily lead to inaccurate results, since there is a limit of one for services and five for retail trades. Furthermore, why is the upper limit of numbers allowed in both cases so low? As far as rural areas are concerned, these numbers would rarely exceed the upper limits of one and five. On the other hand, for urban areas, the data tend to be inexact, since large settlements may offer more than one service and five outlets for each function. This section of the questionnaire is therefore clearly more suited to rural areas than urban areas with larger settlements. Hopefully, in the Cher seldom are the settlements that offer more than five establishments per function, and except for the three main towns (Bourges, Vierzon, St Amand-Mondrond), the maximum number of five establishments allowed per function will not distort results.

2.1.3.2 The Fiches Communales.

The census book entitled the Fiches Communales deals specifically with the functional organization of municipalities. The same deficiencies noted in the questionnaire occur in this material. Some public services are recorded by means of a "0 to 1" code whereas all retail trades and self-employed professions are tallied with a "0 to 5" code.

Apart from this deficiency, another disadvantage results from the breakdown of functions into fifteen sections. Such a breakdown may prevent a comprehensive study of the functional organization of settlements. For the purpose of this study, it was decided to consider only the section entitled "Services and Retail Trades" and the forty-eight functions listed in Table 2.1. However, one may wonder whether the definition of central functions should not embrace other sections such as "Tourism" or "Educational and Health Facilities". Should services and institutions such as hospitals, drugstores, schools or hotels have been included in the study? In order to reduce the amount of data manipulation in this study, it was decided to restrict the data-source to one single section, thus allowing the French Bureau of Statistics to provide the necessary data-base on magnetic tape with no additional computer operations. Adding to these technical considerations, it seemed that the lack of four to five central functions in the source of data was small enough to have a negligible effect on the remainder of the analysis.

From the standpoint of the present study, the reliability of the material is regarded as satisfactory. First, the areal unit recognized by the Inventaire Communal is the smallest administrative division, the administrative commune. Second, the Fiches Communales describes essentially the functional organization of communes. Past studies had to seek criteria of centrality in numerous statistical reports and an abundance of varied data. The Fiches Communales, however, offers the necessary elements required to evaluate a direct quantitative centrality measure as complete as possible. Since this source of information contains obvious apparent inconsistencies when dealing with urban areas, a rural area of study was chosen for the purpose of obtaining the highest possible reliability in the results.

2.2 An adequate central place laboratory, the Cher.

In this section, it is demonstrated that the selected study area contains the necessary attributes for testing the centrality of places in the Cher. The advantages of the area under investigation is analyzed in two respects. First, it is shown that the general features of the region favour a regular settlement pattern. Secondly, the lattice of central places is examined, focusing on the degree of uniformity in the distribution of towns.

2.2.1 General features of the study area.

The selected area lies in the centre of France as shown in Figure 2.1. The Cher is the eighteenth French county and the fact that the selected area is an administrative entity is advantageous for the collection of data, which is grouped by counties in the Inventaire Communal. The administrative division was therefore chosen over physical or economic regions, principally for better utilization of the data-source. However, it will be shown further that the area under investigation is homogeneous in terms of physical features, economic activities, and population distribution.

The eastern border of the county is defined by a major physical feature, the Loire river, which is the longest in France. This river provides the only major relief feature of the region. A set of hills lies in the eastern part of the county and runs along the valley of the Loire river. This relief is however limited to a small part of the region and rises as much as 400 metres (1200 feet) above sea level. Another set of hills, the Boischaud hills, can be observed in the southeastern part of the county, though they, at 300 metres (1000 feet), are lower than those along the Loire valley. Apart from these minor physical contrasts, the remainder of the selected area has a plane topography. This absence of relief is essentially due to the extension of the low plateau of Berry and Champagne. The altitude of the plateau varies slightly around 200 metres (650 feet), and the surface is uninterrupted by major valleys and escarpments. One single important river, the Cher, crosses the southwestern part of the region, though no escarpments isolate this part of the county from the remaining area. In sum, the Cher is not an area of strong and varied physical features, and the 7325 square kilometers (4522 square miles) under investigation exhibit principally a low plane surface. The terrain is physically homogeneous and almost identical to the isotropic plain of classical central place theory.

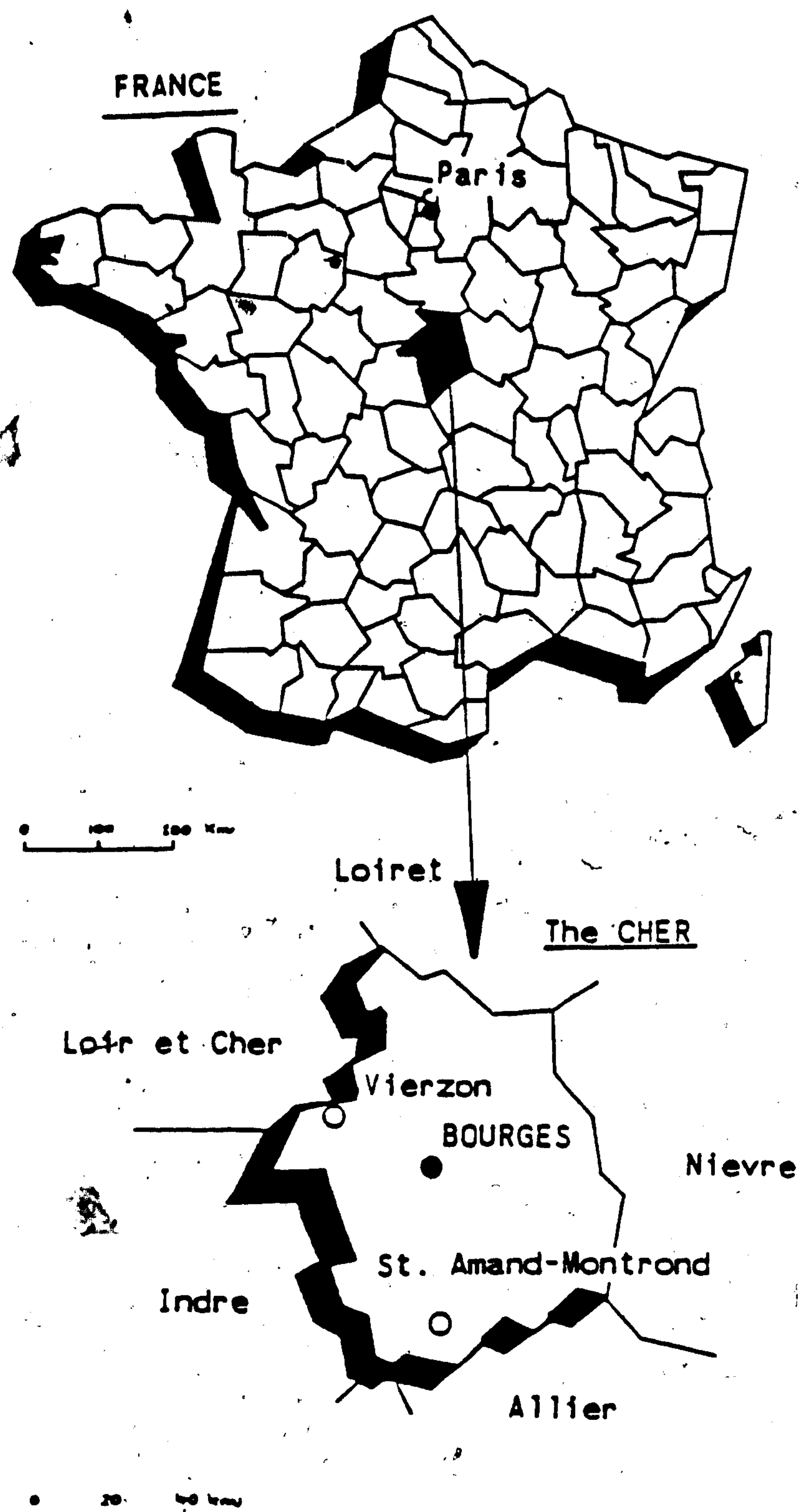


Figure 2.1 Location of the study area

The area's remoteness favours economic independence. The county of the Cher is indeed far away from major cities. The closest, Paris, is 300 kilometers (190 miles) from Bourges, the main town of the area. The Cher was largely uninhabited until the end of the eighteenth century due to land unsuited to farming, and an excessively humid climate. The area was covered by marshlands caused by a clay soil. At the beginning of the nineteenth century, attempts to farm new lands enhanced drainage, and the quality of the soil was improved. Today, the economy of the plain is characterized by extensive farming activity based upon the cultivation of cereals, fodder plants, and vines. Cattle breeding is also important. The low and uniform topography favours the cultivation of wheat while the low hills lying along the Loire valley are suited to the production of reputable wines such as Sancerre wine. The late development of farming activity in the Cher area resulted in a larger partitioning of lands, a larger spacing of farms, and the extensive cultivation of cereals with high rates of production and gross sale value. The area under investigation is one of the richest agricultural regions of France while manufacturing remains largely underdeveloped. Industrial activity is restricted to two sectors-the construction of agricultural machinery, and hardware. Business activity, relatively important in the main town, Bourges, is essentially related to farming trade. The relative lack of non-central activities and the important purchasing power of the wealthy farming population makes the study area a suitable one in which to test the concept of centrality.

According to the 1982 French population census, the area under investigation has a population of about 326,000. The density of the total population outside incorporated centres, including farming as well as non-farming households, varies between 10 and 30 inhabitants per square kilometer, this low population density is essentially due to the abundance of scattered farm households. In rural communes the dispersed population is generally close to fifty percent of the total population. Figure 2.2 indicates, however, that the southwestern part of the county is essentially composed of a rural population scattered throughout isolated farmsteads. It is apparent from Figure 2.3, which indicates population density by commune, that the places where population density is heavy are rare. Out of the 290 communes found in

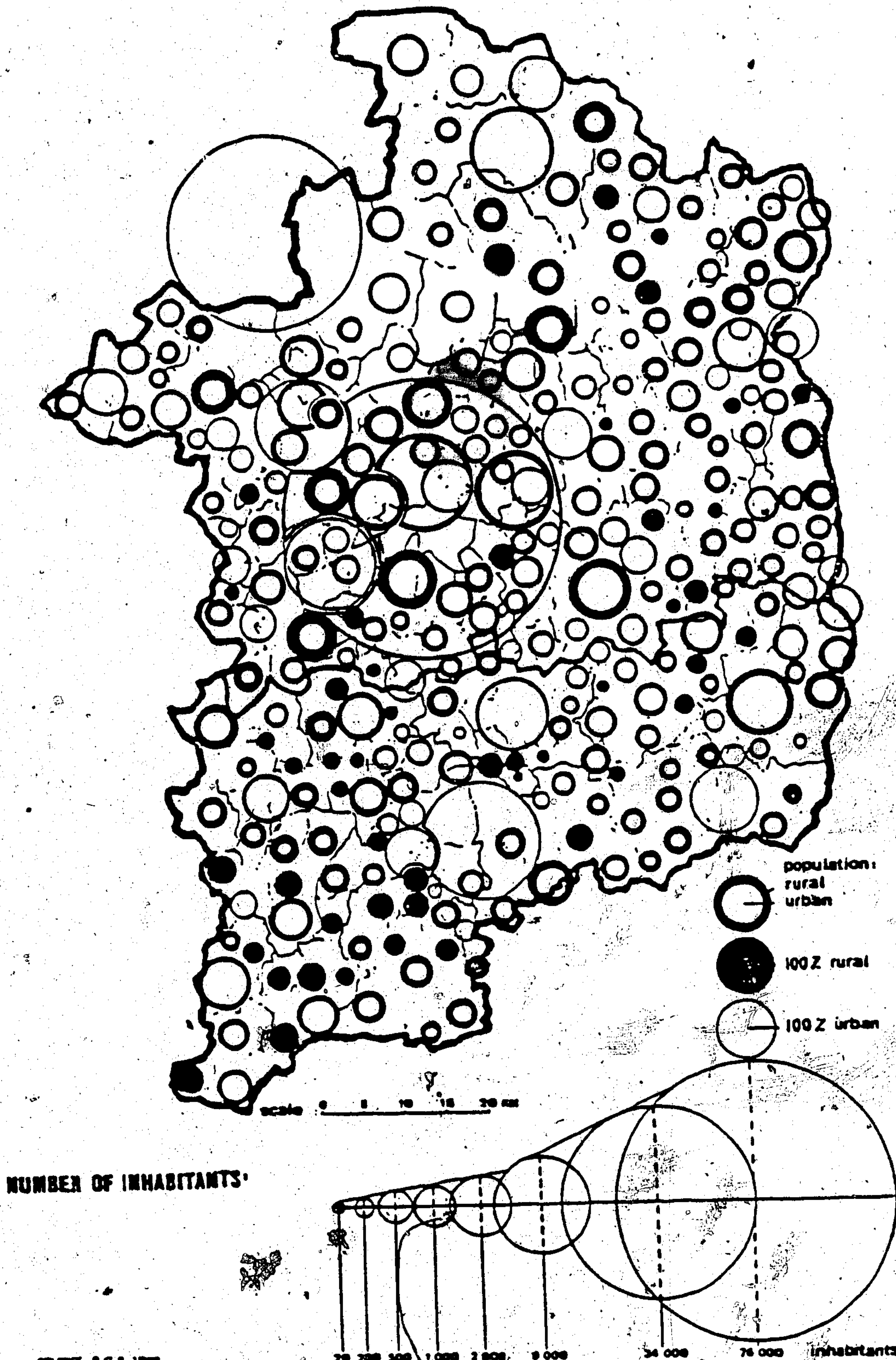


Figure 2.2 Urban and rural population of the Cher area

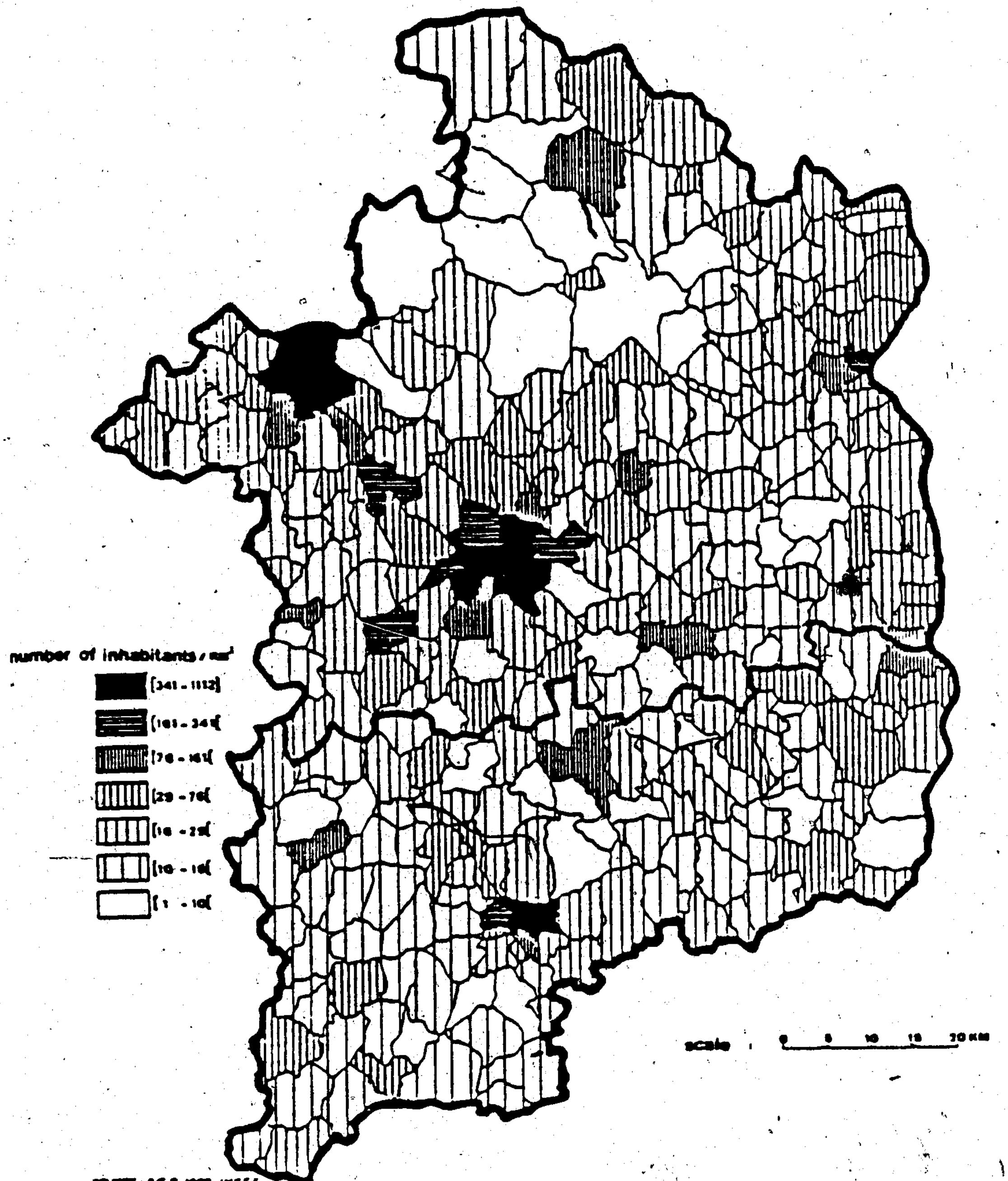


Figure 2.3 Population density by commune

the study area, only 23 have a population density greater than 76 inhabitants per square kilometre. The average population density in the rural communes of the area proper covered by the present study is 15 inhabitants per square kilometre. Dominated by rural communes, the variation observed in the distribution of population is slight. Figure 2.4 and 2.5 confirm the general uniformity of the population distribution in the Cher. Only two major peaks of population can be noticed. They correspond to the two main towns, Bourges with a population of 76,432, and Vierzon, 34,209.

In summary, the Cher area is endowed with features which make it a favorable laboratory for central place investigation. The area investigated is essentially uniform with no major physical contrasts. Futhermore, the economy of the region is dominated by extensive farming activity. Manufacturing is relatively underdeveloped. Rural areas are dominant and their population is generally uniformly distributed over the plain. Since the number of densely populated communes is small and the area is far from the sphere of influence of major cities, the purchasing power of the rural population is directed toward local centres. The [illegible] homogeneity of the selected area is the essential factor in selecting a adequate stud[illegible] the purpose of this study. The settlement pattern, however, should also be su[illegible]tral places analysis.

2.2.2 The settlement pattern

Since one of the major assumptions of central place theory is the uniform spacing of towns, a close investigation of the settlement pattern of the study area is an important criteria to determine whether or not the area is an adequate central place laboratory. In this section, priority will be given to the study of the distribution of towns.

The region under investigation includes 290 agglomerations with population ranging from 22 to 76,432. According to the French criterion for differentiating urban and rural units: "Groups of buildings that have at least 2,000 inhabitants and, in general, have the buildings spaced no further than 200 metres apart, are classified as urban agglomerations", the county of the Cher has only twenty urban agglomerations. Figure 2.6 reveals the areal

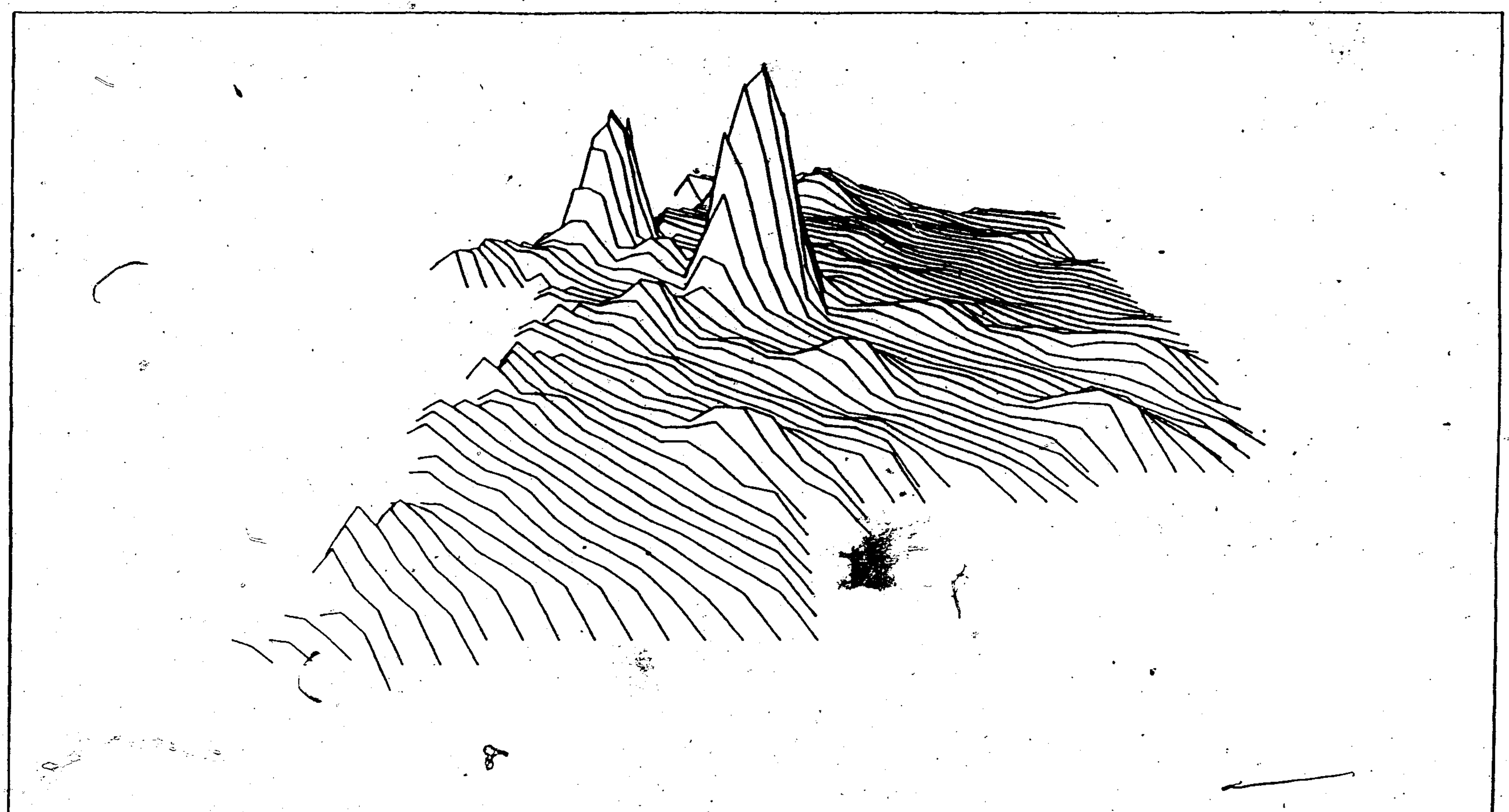


Figure 2.4 Population of the Cher in 1982 (perspective view)

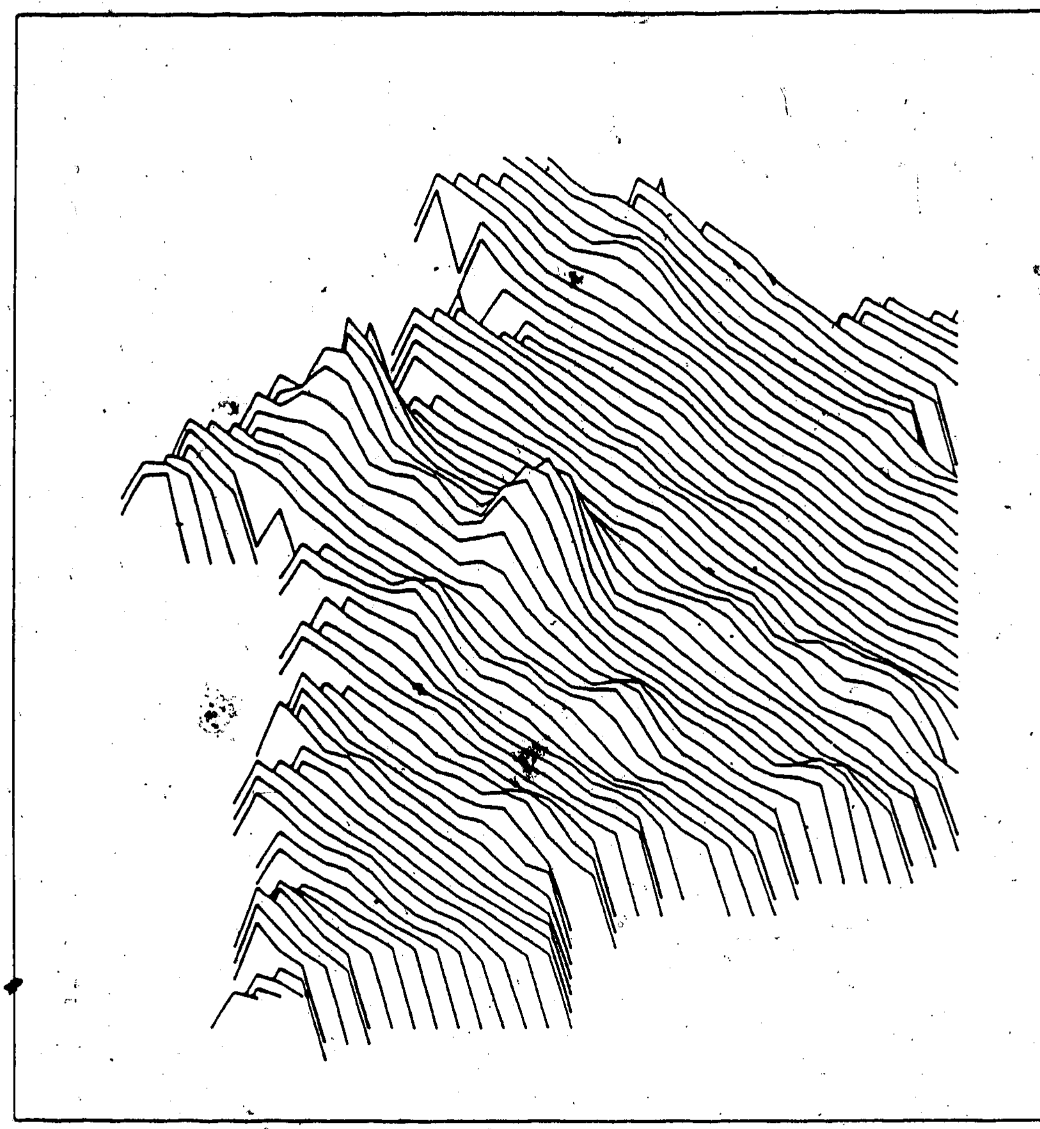


Figure 2.5 Population of the Cher in 1982 (isometric view)

distribution and the population on settlements in this area. A glance at this map shows that small hamlets are typical features. Figure 2.2 suggests that the smallest agglomerations consist, in fact, of a few scattered farmhouses, and essentially of a farming population. The only group of buildings then, consists of a church and several farms, since most of the households are scattered in the farming lands. On the other hand, twenty urban agglomerations lie in the Cher area, though only three of them have a population greater than 10,000. These centres, Bourges with a population of 76,432, Vierzon, 34,209, and St. Amand-Montrond, 12,450, stand out as the largest and most functionally complex of central places in the study area. These three towns are fairly equidistantly situated and as Figure 2.6 indicates, both Bourges and St. Amand-Montrond occupy central positions within their systems. Bourges lies at the centre of the county and St. Amand-Montrond has a central position in the southern part of the county. This town represents the major market centre for the numerous villages that lie in this southern region. Since Vierzon is located on the northwestern end of the county, its sphere of influence probably extends to the adjacent county, the "Loir et Cher". As a result, the northern part of the Cher tends to be divided into two distinct trade areas: those of Vierzon and Aubigny sur Cher. Situated between hamlets and urban agglomerations, a variety of villages provide the principal purchasing power of the Cher. The presence of a few major competitive centres contrasting with a variety of smaller units militate in favour of a central place analysis. However, Figure 2.6 reveals cluster settlements around the main centres that could hamper the success of such analysis.

A nearest-neighbour analysis determined the uniformity of the settlement pattern in the Cher area. Nearest-neighbour analysis is a statistical method developed in 1954 by Clark and Evans [80] to measure the cluster or uniformity of patterns of points. By calculating the mean of the distances between all points and their nearest neighbours, this technique is well suited to the measurement of the arrangement of central places. The mean or "observed" nearest-neighbour distance between the 290 settlements of the area investigated is 3.27 kilometers. The theoretical mean nearest-neighbour distance for a hypothetical random arrangement of agglomerations over the same area can be calculated by the following

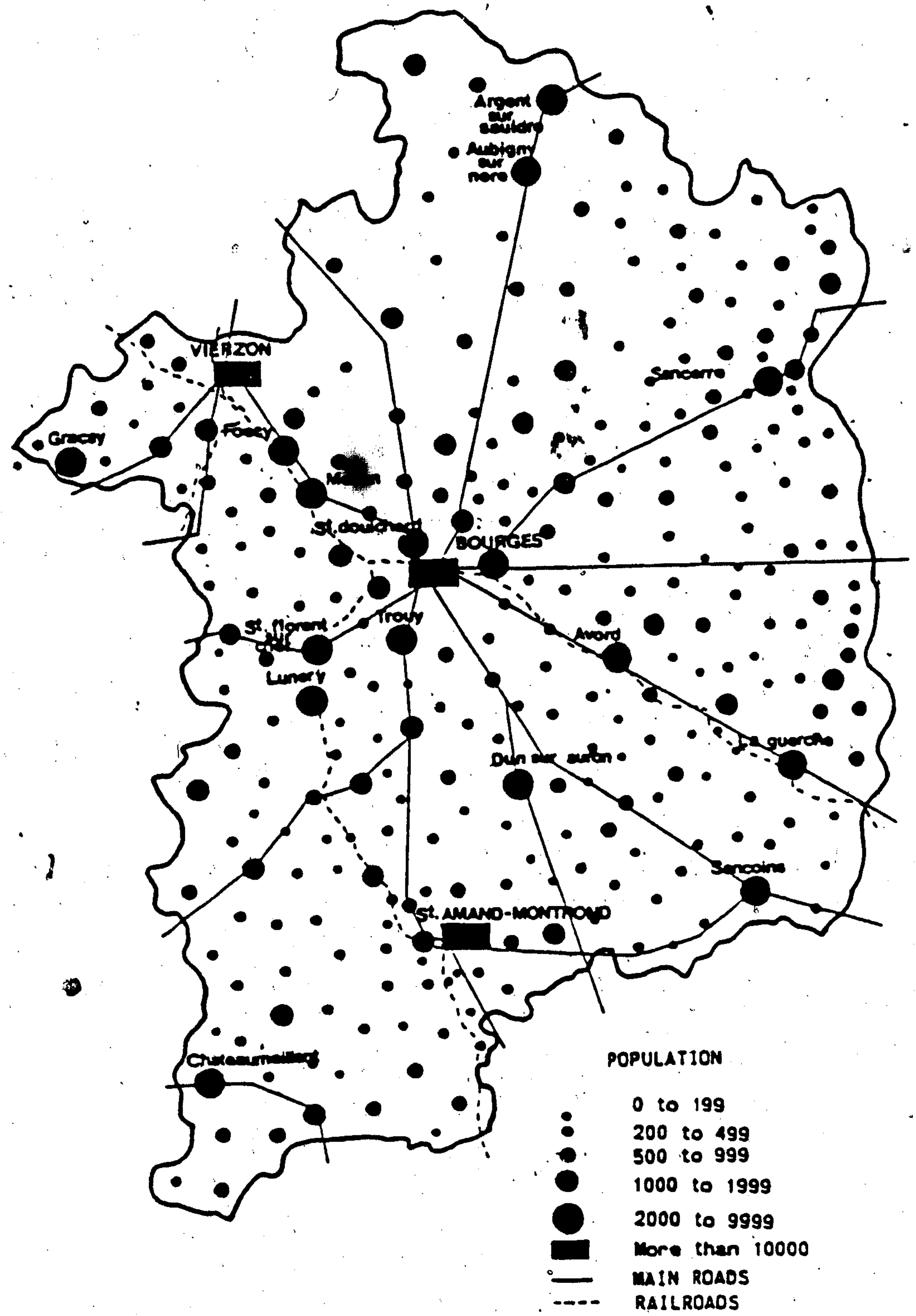


Figure 2.6 Settlement pattern in the Cher

equation:

$$Dran = \frac{1}{2\sqrt{P}} \qquad (1)$$

Where:

Dran is the theoretical mean nearest-neighbour distance.

P is the density of settlements for the Cher area.

Using equation 1, the "expected" mean nearest-neighbour for a random arrangement of settlements in the Cher area is 2.51 kilometers. Barnes and Robinson [74] provided a method to calculate the expected mean nearest-neighbour distance for a more Christallerian pattern of towns. In the case of a regular arrangement of places where the distances separating them are maximized, the mean nearest-distance is given by:

$$Dreg = \frac{1.07453}{\sqrt{P}} \qquad (2)$$

where:

Dreg is the expected mean nearest-neighbour distance.

P is the density of settlements of the study area.

Using equation 2, the expected mean nearest-neighbour distance of a uniform arrangement of the 290 agglomerations is 5.4 kilometers. On the other hand, a cluster pattern of settlements will tend to have a mean nearest-neighbour distance closer to zero.

In the area under investigation, the expected mean nearest-neighbour distance equals zero for a hypothetical cluster pattern of places and 5.4 kilometers for a uniform or "dispersed" pattern. The expected mean nearest-neighbour distance for a hypothetical random arrangement of places is 2.51 kilometers. Since the observed mean nearest-neighbour distance is 3.27 kilometers, it is possible to infer that the arrangement of settlements in the Cher area is somewhat uniform. The degree of uniformity will be identified using the concise measure of the nearest-neighbour index.

The nearest-neighbour index is the observed mean nearest-neighbour distance divided by the expected mean nearest-neighbour distance for a random arrangement of places. It can have a value ranging from 0, indicating a completely clustered pattern, to 2.15, indicating a strictly uniform pattern. A random arrangement is indicated by a nearest-neighbour index of 1. In the present study, the nearest-neighbour index has a value of 1.31 that suggests a tendency to regularity. Due to many factors, among them the clusters of agglomerations in the northern part of the area (see Figure 2.6), the pattern of towns is nevertheless far from the perfect regular arrangement of central places assumed in Central Place Theory.

In conclusion, the data-base and the study area are endowed with favourable features for a central place analysis in the Cher. The data-source has the advantage to offer most of the direct quantitative centrality indicators in one tabulation. This tabulation provides population data as well as functional data for 48 services commonly met in a French rural environment. Unfortunately, the Inventaire Communal does not offer relational and economic criteria. For relational indicators, different type of data must be sought. On the other hand, the economic criteria usually used in central place analyses are difficult to get without conducting a personnal questionnaire survey in the study area. As a result, in the Cher the central place analysis merely rests upon direct quantitative and relational centrality indicators. The homogeneity of the Cher and the regular pattern of settlements make the study area a satisfactory central place laboratory and, apart from the lack of economic data, the material is regarded as good for conducting a central place analysis in the Cher.

3. THE CHRISTALLERIAN INDICATORS OF CENTRALITY IN THE CHER

Although he was not the conceptual originator of Central Place Theory[3], Christaller is regarded as the first geographer who provided a structural analysis of the concept of *centrality*. In this chapter special attention is focused on what is believed to be the main criterion of centrality in Central Place Theory, the *range of goods*. A close investigation of Christaller's theoretical discussion [21] shows that the *range of goods* is in fact viewed as the combination of two factors, namely, the population threshold and the maximim distance travelled by consumers. Since these two factors represent the bases on which Central Place Theory was built, it was decided to include them as centrality indicators in the analysis of central places in the Cher. In the past, few geographers have attempted to include these parameters in their centrality measure. When it was done, divergence regarding the method of measurement occurred. No solution was offered and identifying these two factors poses problems. It seemed therefore necessary to dedicate the second part of this chapter of seeking reliable methods to measure the population thresholds and the maximum distances travelled by consumers for 48 functions in the Cher.

3.1 The concept of the range of goods.

In his theory, Christaller regards the centrality of places in terms of the *range* of their central activities. In the original text, Christaller uses the German term, ."die reichweite der zentralen gueter" translated into English by Baskin [21] as, "range of goods". Christaller by "reichweite" or *range*, refers to the trade area of each activity offered in a central place. This area corresponds to the spatial distribution of customers served by the firm while this firm maximizes profitability. According to Christaller, the two major factors that determines the profitability of a firm are:

1. The number of customers served.

[3]See Cantillon [78] and Reynaud [101]. For reports on their studies, see Fairbairn, Barr [84] and Robic [102].

2. The separating distance between the customers and the firm.

The outer limit of the *range* of central activities is hence defined as the maximum distance that the dispersed population is willing to travel to purchase a good offered at a central place. The inner limit of the *range* of central activities is defined as the minimum amount of population necessary for the subsistence of each activity. Christaller clearly defined these two limits of the *range* of activities in a section translated into English by Baskin [21],

> "When we examine this range in detail, we find, in looking at it spatially, that there is not a line, but rather a ring around the central place. It has an outer (upper) and an inner (or lower) limit. The upper limit of a particular good is determined by the farthest distance from the central place from which it can be obtained from this central place; and indeed, beyond this limit, it will either not be obtained, or it will be obtained from another central place (. . .). The lower limit of the range of the central good is therefore determined by the minimum amount of consumption of this central good needed to pay for the production or offering of the central good." [21, p. 54]

Under the assumption that consumers patronize the nearest center and that firms do not make any excess profits, Christaller builds his theoretical central place system upon the concept of the *range* of goods as shown in Figure 3.1 as well as in the following abstract:

> "We have already stated that each type of central good has its own typical range. If its upper, as well as its lower, limit is high, the good will be offered at central places of a higher order and thus be sold within a larger region. Such a good will be called a *central good of a higher order*. If, however, the upper and the lower limits of the range are low, then the central good must be offered at numerous and also smaller places in order to supply the whole country. Therefore, this sort of good will be called a *central good of a lower order*. And if the upper limit is high and the lower limit is low, the central good may be offered at many central places which, in regard to this good, will compete vigorously for the complementary region. These goods are goods of a lower order because they may be offered at central places of a lower order. If the lower limit is high and the upper limit is low, then the central good can only be offered at central places of a higher order, and only when there is a highly developed complementary region, because the critical ring which determines the gain from the sale of the central goods will be very small." [21, pp. 56,57]

This abstract brings to light three fundamental notions:

1. The order of a good (or activity) can be evaluated from the measure of its *range*.
2. The *range* of a central good (or activity) may be estimated by measuring its inner and outer limits and comparing the two values thus obtained.
3. The importance of a place depends upon the *range* of its goods (or activities).

The order of a place can therefore be measured in terms of the inner and outer limits of the *range* of its activities. The town that provides the most central activities, those with a larger *range*, thus becomes the central place of a higher order. Conversely, the town that provides the least central activities, those with a smaller *range*, becomes the central place of a lower order.

In short, Christaller clearly assigns the theoretical importance of places to the *range* of their activities. Although he specifies several factors that influence this range, e. g. the type, quantity and price of the goods [21, p. 54], as well as the accessibility of the center [21, p. 52] the *range* of activities can simply be evaluated by comparing two measures:

1. The inner limit or minimum population required to support the activities.
2. The outer limit or maximum distance travelled by consumers.

It could be seen in Chapter 1 that the concept of the *range* of activities as described above was rarely utilized in past case studies. In one of them, Berry and Garrison [9] give an accurate definition of the *range* of goods by stating: "The upper limit of the range is the maximum radius of sale. (. . .)The range also has a lower limit, that radius which encloses the minimum number of consumers necessary to provide a sales volume adequate for the good to be supplied profitably from the central place." [9, p. 304]. They however based their study in Snohomish County upon the lower limit and disregarded the upper limit of the *range* of activities. In their study, the lower limit of the *range* of 52 types of retail and service activities present in 33 small urban centers was assigned to the population thresholds of the communities in which they occur. Only three studies out of the 70 surveyed[4] considered the upper limit of the *range* of functions as an index of centrality. The work conducted by Saey and Lieter in Flanders [56] is one of them although their results cannot be verified since they do not specify the procedure utilized to calculate this upper range. In India, Mayfield [44] determined the maximum distance travelled by consumers by means of questionnaires. Unfortunately, this distance was taken into account for only one good, milled white cotton cloth. By basing his study upon one particular good, Mayfield did not respect Christaller's

[4] The complete list of these studies can be found in the bibliography.

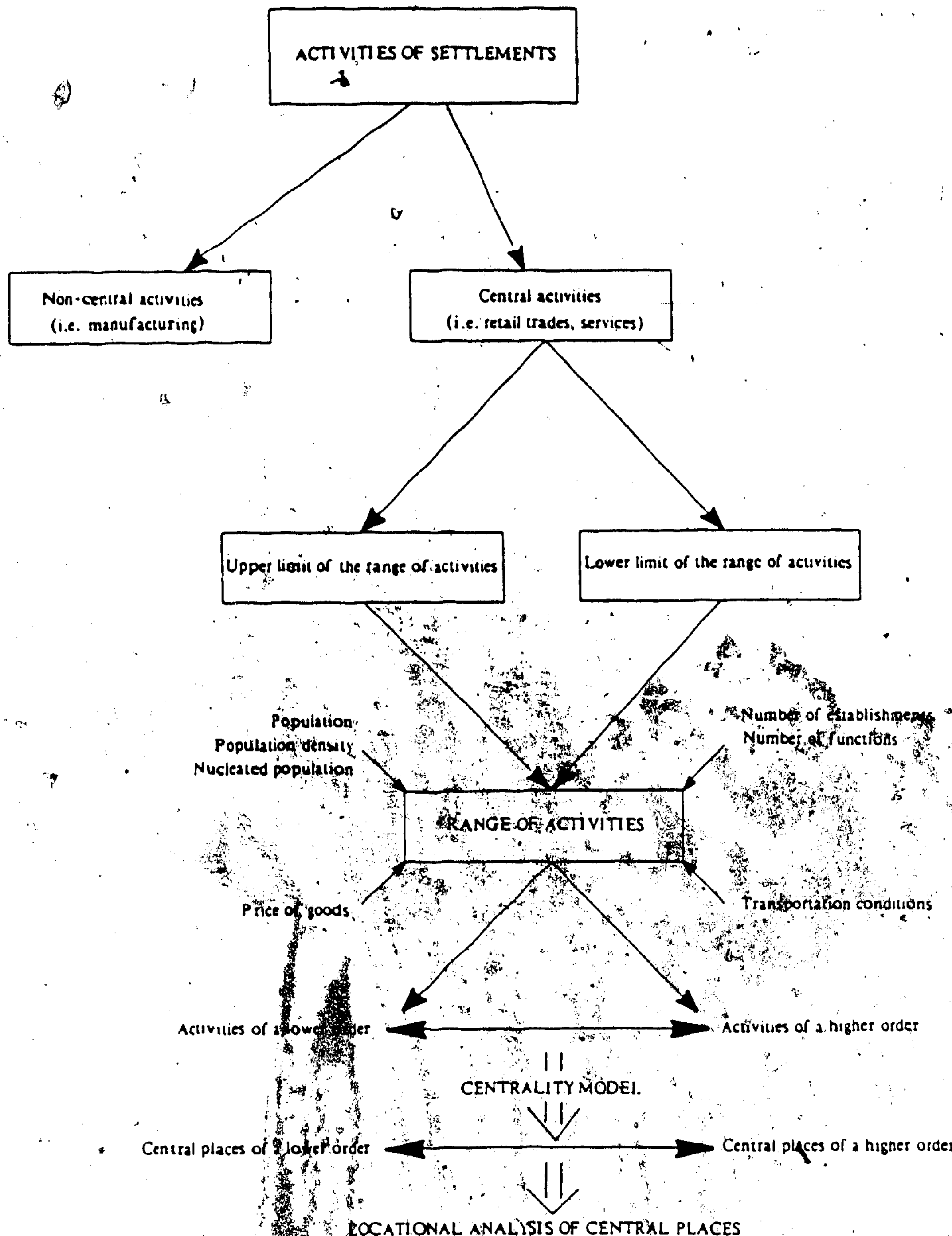


Figure 3.1 Christaller's theoretical components of centrality

concept of the *range* of goods where "every single type of good, even though they are only small differences in quality, has its own typical range." [21, p. 53]. Finally, Berry and Barnum [10] evaluated the maximum distance travelled by consumers in Southwest Iowa as "(...) the upper asymptote of the logistic curve that describe the cumulative distribution of consumers with increasing distance from a central place." [10, p. 37]. Their results are not included in the article and this measure is not utilized in the Principal Component Analysis to define the hierarchy of central places.

In several other case studies, when the authors considered the lower *range* of activities as a measure of town's importance they neglected the upper *range*. Durand-Dastes [24], Berry, Garrison [8], Prakasarao [51], Haggett, Gunawardena [89], and Bain [73] calculated thresholds of population, but ignored the outer limit or maximum distance travelled by customers. Furthermore, Bunge [77, p. 150] criticized most of these works on the gounds that they referred to thresholds in the population of the settlement rather than in the population of the hinterland. It is certainly true that for most of the central activities of a higher order, the population thresholds may extend beyond the limit of the city. In these cases, the right solution may then be to consider hinterlands rather than settlements' population. The exact definition of population thresholds remains elusive. Confronted with this problem, Haggett and Gunawardena [89] attempted to find a reliable measure of population thresholds. With the Reed-Muench method, they calculated a median population threshold that corresponded to the mid-point between the centers' population and the number of settlements where the activity could be found. Finally, in Southern Ceylon, Gunawardena [28] showed that the population thresholds of centers were significantly correlated with the population thresholds of hinterlands. Both measures may therefore have the same impact on the importance of settlements.

Clearly, the literature dealing with the two theoretical Christallerian centrality indices confronts us with unanswered issues. Why was the outer limit of the *range* of activities neglected while its inner limit was considered? Do the population thresholds of hinterlands and centers have the same meaning as far as the centrality of settlements is concerned?

In the Cher, it was decided to include both inner and outer limits of the *range* of activities as two independent indicators of the centrality of towns. Three measures will be successively calculated for the 48 activities present in the 290 communes. The first operation will evaluate the outer limit or maximum distance travelled by consumers when the activity is not found in the center. This operation will be based upon the assumptions that customers patronize the nearest center and that the distances travelled can be summarized as straight-line distances. The second and third operations will be concerned with the inner limit of the *range* of activities. Both population thresholds of hinterlands and settlements will be calculated and compared for the 48 activities. Finally, the best-fitting measure of population threshold will be selected in the Cher.

3.2 The range of 48 activities in the Cher.

The objective of this section is to recognize Christaller's theoretical centrality indicators in the Cher. To this end, the Cher is assumed to be equivalent to Christaller's ideal space. The Cher is firstly assumed to be an homogeneous plain where distances between settlements are not distorted by topographical irregularities of any kind. Secondly, customers are assumed to behave in an optimizing fashion by patronizing the nearest center when an activity can not be found in a locality. Finally, the economic system is supposed to be static, and activities of same order are supposed to possess equal levels of attraction. Their owners are not supposed to make any "extra-profits".

3.2.1 Upper limit of the range.

This sub-section is concerned with the measurement of the upper range of the 48 selected services and retail trades in the Cher. The upper limit of the range of a good is defined as "the farthest distance from the central place from which it can be obtained from this central place; and indeed, beyond this limit, it will either not be obtained, or it will be obtained from another central place" [21, p. 54].

3.2 Method.

Considering the large number of towns (290) and activities (48), the method of interviewing customers on their travelling habits was neglected. The principal of "least effort" was rather assumed valid in the Cher, and the outer limit of the *range* of the 48 activities was found by means of a simple algorithm.

The method used to calculate the upper range of functions in the Cher relies largely on computer facilities that allow the computation of larger fields of data. The algorithm developed for this purpose is indeed quite simple, but calculating the farthest distance travelled for 48 functions over the 290 settlements of the study area requires a large computer's memory capacity that was non-existent thirty years ago when most empirical studies took place. The flowchart dispalyed in Figure 3.2 describes the algorithm, and for the sake of clarity Figure 3.3 illustrates the six major steps of the algorithm.

First, three elements are extracted from the data-base:

1. Names of settlements.
2. Geographic coordinates of settlements.
3. Number of establishments for the functions present in each settlement.

These three elements are all that is required in order to calculate the upper limit of the range of functions, and are transferred in a separate data-base and put into a readable form.

The next step consists of differentiating the central places that perform the first of the 48 listed functions from the "dispersed places" that do not. In short, the program reads the number of establishments of this function for the 290 settlements. The settlements with a value equal to zero are then dissociated from those having a number equal to or greater than one. For the first function considered, the program thus divides centres and tributary towns into two different groups.

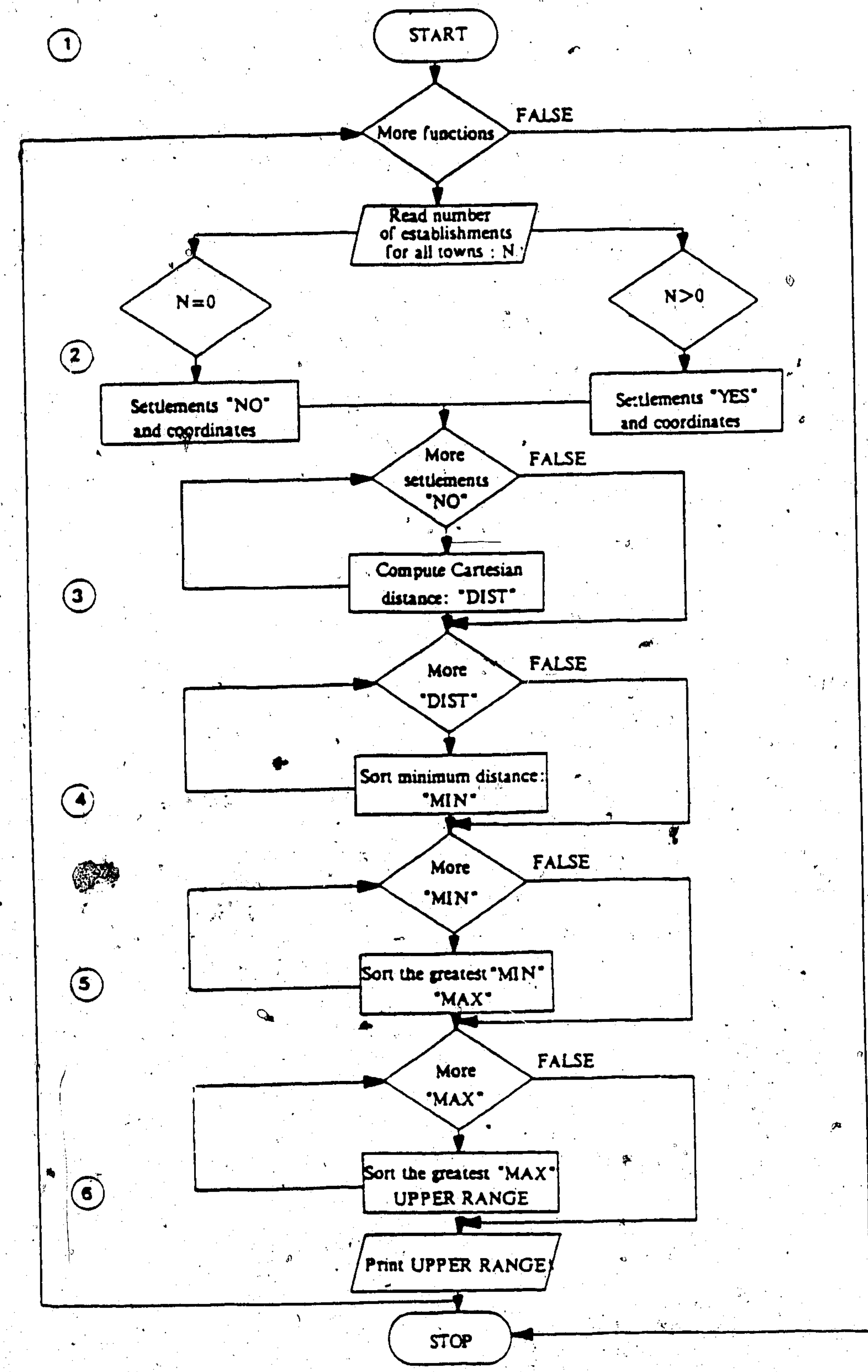


Figure 3.2 Algorithm for the evaluation of the upper range of functions.

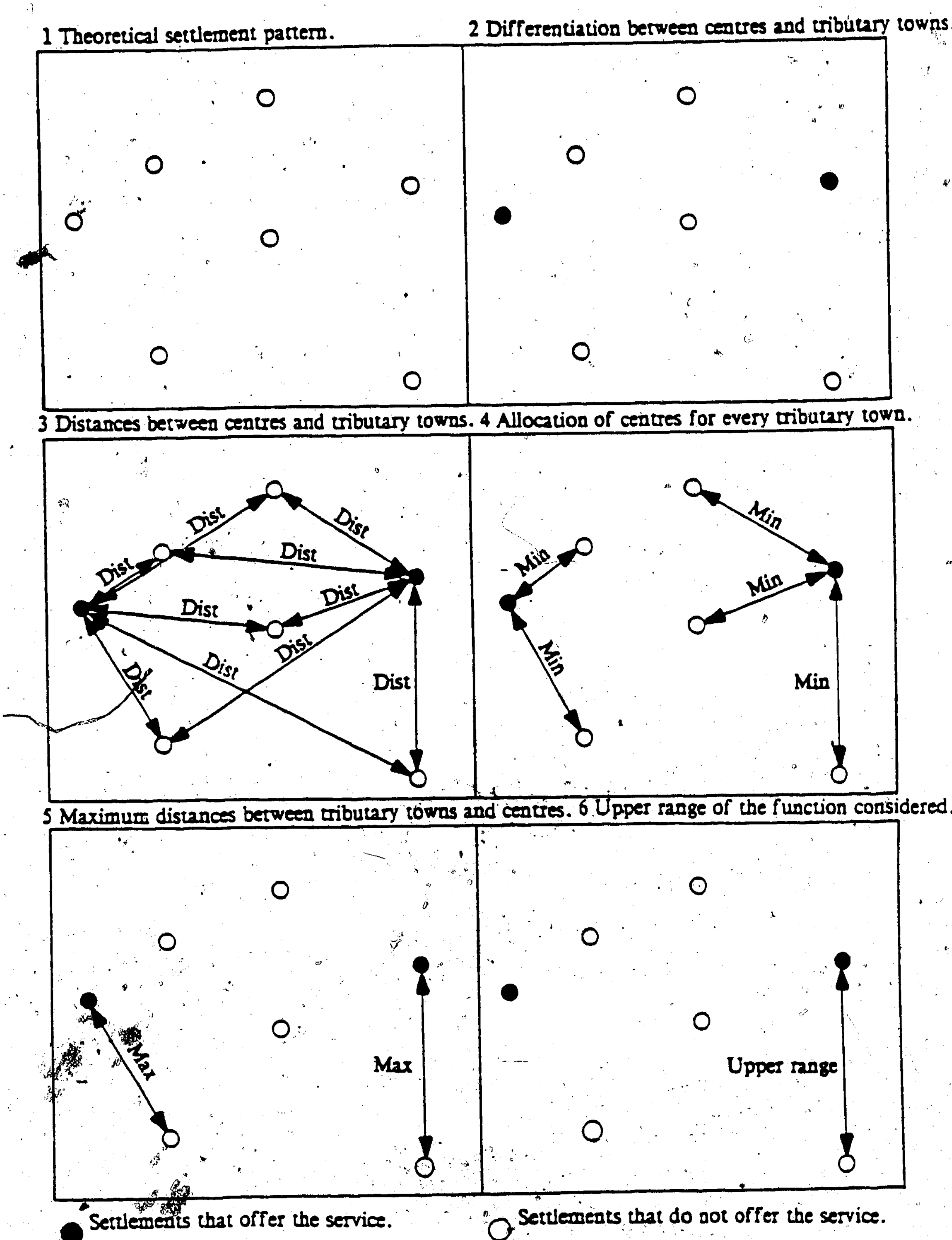


Figure 3.3 Illustration of the major phases for the evaluation of the upper range of functions.

Calculating the Cartesian distances between these two groups of settlements is the next task. Geographical coordinates are assigned to each settlement, and a Cartesian coördinate system is then introduced. These coodinates are determined from two perpendicular axes superimposed on a large scale map-sheet of the region. These coordinate lines intersect in the origin 0 and have the same unit of length. The study area is thus compared to a coordinate plane where each settlement is assigned an ordered pair of coordinates (x-coordinate and y-coordinate), and the distance between two settlements, S1 and S2, is given by:

$$d(S1,S2) = \sqrt{(x2-x1)^2 + (y2-y1)^2}$$

or Cartesian distance formula. Christaller, however, considered the range of the goods from an economic standpoint and defined the "farthest distance" of the upper range not as the geographic distance, "The distance in Kilometers is economically unimportant" [21, p.52], but rather as the economic distance "By which we mean to say in money value instead of numbers" [21, p.22]. He then identified the determinants of the economic distance: "This economic distance is determined by the cost of freight, insurance, and storage; time and loss of weight or space in transit; and, as regards passenger travel, the cost of transportation, the time required, and the discomfort of travel." [21, p.22]. Unfortunately, such information was virtually impossible to collect in the study area. Instead, we arbitrarily decided to base the calculation of the upper range of functions on a strict geographic distance, and the simplest distance measurement was chosen (Cartesian distance). The straight-line or Cartesian distance between settlements, although inexact, remains a satisfactory approach to evaluate the upper range of functions in the Cher, since it is assumed that people patronized the nearest center and the region tends to have a plane topography as well as straight main roads.

Once the distances between centres and tributary towns are calculated, the next step of the procedure consists of allocating centres to each of the tributary towns. To this end, Christaller's underlying assumptions that consumers always travel to the nearest centres to make their purchases, and that all consumers of a given tributary town frequent the same allocated centre are satisfied. A centre is thus allocated to a tributary town when the distance separating the centre from the town is smaller than the distances separating the tributary town from the other centres. This shortest-distance calculation is then repeated for all tributary towns of the area, and as indicated in case number 4 of Figure 3.3, sets of tributary towns are assigned to each centre forming different complementary areas.

Once the space is partitioned off into complementary areas, it is possible to determine the largest distance separating centres and tributary towns within each area. Figure 3.3 illustrates this procedure and case number 5 indicates the greatest distance, "Max", between the centres and the tributary towns within each complementary area.

The final step of the procedure is to select the largest of these distances by considering all complementary areas as a whole. This distance, as illustrated in case 6 of Figure 3.3, is the upper limit of the range of the first function considered. This value is then printed and the program is ready to apply the same algorithm to the second function listed and so on, until it reaches the 48th and last function.

3.2.1.2 Results.

Table 3.1 where the maximum radius of sale of the 48 services and retail trades considered in the Cher is listed indicates a hierarchy of activities that ranges from smoke shops, with an upper range of 5.57 kilometers, to social security offices, with an upper range of 53.80 kilometers. This hierarchical spatial organization of activities tends to confirm that the upper limit of the range of functions is an adequate tool for measuring the centrality of settlements.

The classification of the activities according to their upper range suggests that those of a lower order consist mainly of basic food-retailers and self-employed professions, [illegible] three basic food institutions-bakeries, butcher shops and corner stores-ha[illegible] [illegible]ge varying between 7.47 and 8.34 kilometers. All self-employed

Table 3.1 Upper range of functions in the Cher.

LIST OF FUNCTIONS	UPPER RANGE IN KM
Smoke shop	5.57
Newspaperstand	5.57
Restaurant	6.32
Gas station	6.69
Bar	7.09
Carpenter	7.14
Builder	7.42
Bakery	7.47
Electrician	7.65
Plumber	7.83
Butcher shop	7.83
Corner store	8.34
Mechanic agriculture	9.71
Painter	9.71
Post office	9.71
Diesel station	9.71
Fire hall	9.71
Hairdresser	9.71
Furnace man	10.03
Mechanic	10.10
Oil station	10.92
Church	11.65
Market (monthly)	12.45
Minister	13.74
Hardware shop	13.74
Tax office	13.74
Police station	14.71
Granary	14.96
Notary	16.12
Seed shop	16.12
Stereo store	16.62
Haberdashery	16.62
Shoe store	16.62
Clothing store	16.62
Ironmonger's store	16.62
Bank	16.62
Sports store	16.62
Barber	17.51
Stationery store	17.51
Veterinarian	17.76
Savings branch	19.16
Cake shop	19.38
Furniture store	24.64
Fish shop	24.97
Wholesale market	29.44
Dairy	35.92
Supermarket	[illegible].92
Social security office	53.80

professions (i.e. mechanics, plumbers, painters, carpenters, builders, etc.) have a range smaller than 10.10 kilometers, and the remaining activities of a lower order-smoke shops, newspaperstands, restaurants, and gas stations-have a range smaller than to seven kilometers. As a result, twenty of the 48 selected activities in the Cher have an upper range less than 10.10 kilometers, and the region tends to be well supplied by numerous dispersed basic intitutions. The map presented in Figure 3.4 depicts the range of the most ubiquitous activities-smoke shops, newspaperstands, restaurants and gas stations. On this map, the settlements that perform at least one of these activities are indicated by a black shaded circle whereas the settlements that perform none of them are represented with a blank circle. Respecting central place theory, the range of these functions is then identified on theoretical grounds as the distance between the tributary communes that do not perform the functions, and the nearest centre that performs them. This range is thus determined on the basis of the least average distance consumers are required to travel to reach the centres. A glance at the map shows that only 21 communes do not perform at least one of these functions. Among them, fifteen do not perform any of the 48 services and retail trades. Most of the 21 communes are located in the southern part of the region and a cluster of 13 of these communes is observable in the southwestern part which is economically oriented essentially toward an extensive farming activity. In this area, the population of these "dispersed" communes is very low with an average of 76 inhabitants mostly scattered, with a low population density of nine inhabitants per square kilometer. Urban population is often non-existent and these communes are essentially composed of dispersed farms.

At the other end of the scale, the three most central functions-social security offices, supermarkets and dairies-are found in only a few centres. Only sixteen central places offer at least one of them and, as depicted in Figure 3.5, they are located at the centre of trade areas of varying sizes. By contrast with Figure 3.4, the "dispersed" communes that do not perform these functions of a higher order are frequent, and their separating distances to centres are sometimes important. Again, the southwestern part of

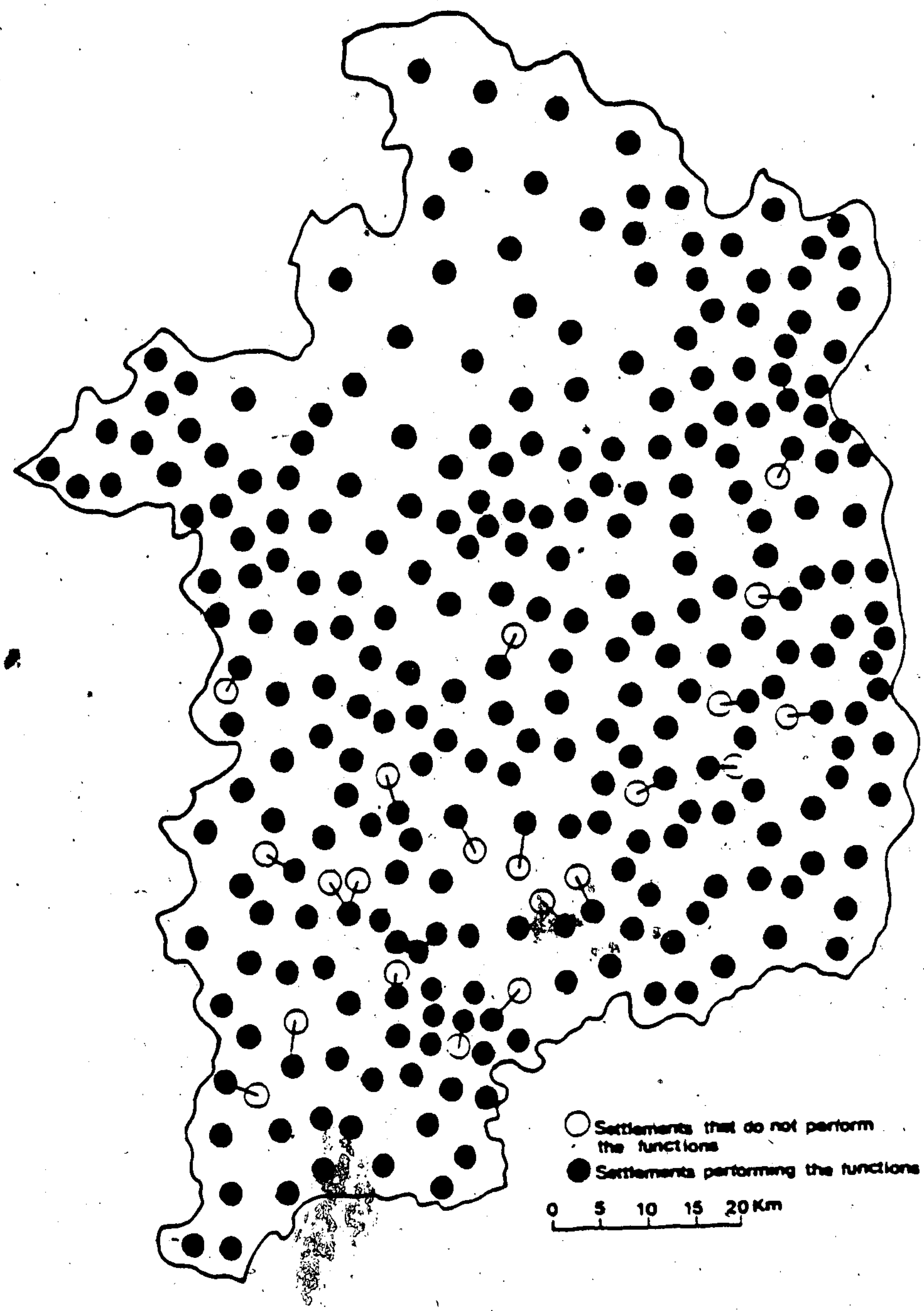


Figure 3.4 Upper range of functions of a lower order.

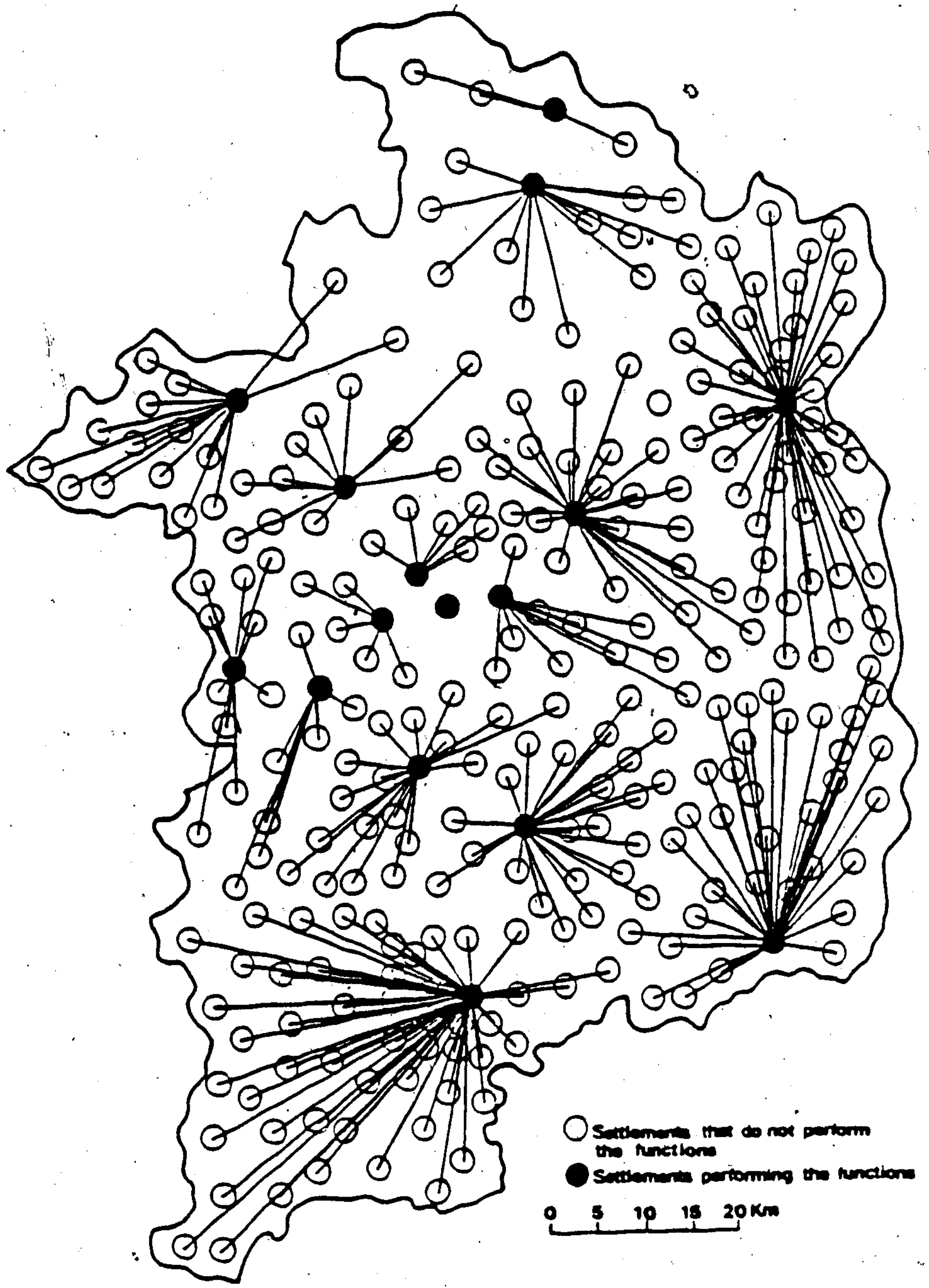


Figure 3.5 Upper range of functions of a higher order.

the county is typical of a rural area where one centre (St. Amand-Montrond) serves 53 tributary communes up to 40 kilometers away. The range of these functions is also high in the eastern part of the county where two centres, Sancerre and Sancoins, serve 81 communes. Probably due to their location next to the administrative limit of the county, they supply communes that are up to 30 kilometers away. But, in the extreme east and southwest of the region, it is highly probable that the most distant tributary commune would, in fact, be considered as belonging to the trade areas of other centres, located in adjacent counties. As suspected, the range of the most central functions is lower in the central part of the county where a larger number of centres is located. A peculiar situation occurs however, when the main agglomeration of the county, Bourges, does not supply any surrounding villages. When Christaller's assumption ("least-effort principle") is applied, satellite-suburb towns such as St. Doulchard, La Chapelle St. Ursin and St. Germain du Puy supply the villages surrounding Bourges with central goods. Hence, we are confronted with an unlikely situation where Bourges, the head-town of the county, does not have a complementary area for the three functions of a higher order. Bourges, however, is considered a market centre, and thus the case depicted in Figure 3.5, draws attention to some difficulties that can arise when one undertakes to apply Christaller's concepts to spaces that are not "ideal", where the underlying assumptions of central place theory are distorted. This fact would tend to support Kolb and Bruner's [96] point of view, namely, that hamlets tend to avoid larger centres rather than cluster near them.

Despite spatial distortions due to satelite towns, the two maps (Figure 3.4 and 3.5) provide a good illustration of the range of two spatially opposite sets of functions.

3.2.2 Lower limit of the range.

In substance, this section introduces the concept of the lower range of goods defined by Christaller as "the minimum amount of consumption of this central good needed to pay for the production or offering of the central good" [21, p. 54]. But the study of past case studies reveals some unanswered issues. Should the lower range of functions be calculated on the basis of local or hinterland population? Do these two measurements have the same significance? The investigation of the two types of thresholds in the Cher and their comparison will provide us with a satisfactory answer.

3.2.2.1 Local and hinterland population thresholds: methods.

Determining the thresholds of local population is straightfoward. The algorithm can be summarized in two phases. The first step consists of dissociating centres from tributary towns. For the first function considered, the communes that perform the function become centres, whereas those which do not perform the function, and where inhabitants need to travel to purchase the good, become tributary towns. To this end, the computer's program so created reads the number of establishments for the first function listed, and rejects the communes recorded with a zero. When the program reads a number equal to or greater than one, it keeps in memory the population of the centre.

The second step of the algorithm is to select the lowest population of the centres. The lowest number of inhabitants then becomes the threshold of the first function considered. The process is repeated until the last function is reached and, as a result, the lower limit of local consumers required before a given type of function could come into existence is assigned to each of the 48 functions.

Determining the thresholds of hinterland population is more complex, since the process of identifying hinterlands requires a more elaborate computation procedure. The algorithm for the calculation of this second type of threshold consists of a procedure of four phases.

The first step consists of dissociating centres from tributary towns for the first function considered. The process is identical to that pointed out in the preceeding sub-section.

Once centres and tributary settlements are differentiated, the next concern is to allocate centres to each tributary town in order to obtain a set of complementary areas or "hinterlands". As described in the preceding section for the estimation of the upper range of functions, the process is twofold:

1. Calculating the Cartesian distances between centres and tributary communes.
2. Allocating centres to the tributary communes that are the closest (the principle of "least-effort" is arbitrarily assumed to be valid in the Cher).

Adding the population of centres to that of tributary communes within each hinterland is the next task. Thus, the hinterland population corresponds to the centres' population added to the population of their complementary areas.

Finally, the last task is to select the least populated trade area. The population of this hinterland is then assigned to the lower range of the first function listed in the data-base. The same process is repeated until the last function is reached, and 48 hinterland population thresholds are thus obtained.

3.2.2.2 Results.

For both thresholds, the results listed in Table 3.2 show a structural organization of the activities ranging from restaurants, with hinterland and local thresholds respectively equal to 87 and 22, to social security offices, 67,710 and 12,451. As seen in the calculation of the upper range of functions in the Cher, basic food-retailers and self-employed professions are the most ubiquitous activities in the Cher, since their local and hinterland population thresholds are low. The three basic food-stores, i.e. corner stores, bakeries, butcher shops, are supported by a hinterland threshold lower than 297 inhabitants and a local threshold lower than 178 inhabitants. All self-employed professions (plumbers, builders, carpenters, mechanics etc.) are supported by a hinterland and local population lower than 381 and 180 inhabitants. The most central activities vary according to the type of threshold considered. As far as hinterland population is concerned, the four most central functions and associated thresholds are:

1. Social security offices (67,710)
2. Supermarkets (5,606)
3. Fish shops (3,341)
4. Dairies (3,026)

Table 3.2 Hinterland and local thresholds of functions in the Cher.

HINTERLAND POPULATION THRESHOLDS		CENTRE POPULATION THRESHOLDS	
Restaurant	87	Restaurant	22
Bar	88	Smoke shop	22
Builder	124	Gas station	22
Church	149	Bar	52
Smoke shop	175	Mechanic agriculture	92
Newspaperstand	175	Mechanic	92
Corner store	175	Newspaperstand	106
Bakery	175	Corner store	106
Mechanic agriculture	209	Church	106
Market (monthly)	216	Minister	106
Granary	257	Carpenter	109
Plumber	270	Builder	123
Gas station	271	Furnace man	124
Carpenter	279	Plumber	124
Furnace man	279	Bakery	127
Oil station	289	Painter	142
Electrician	290	Market (monthly)	153
Butcher's shop	297	Granary	176
Painter	331	Post office	178
Post office	363	Butcher's shop	178
Diesel station	375	Electrician	180
Mechanic	381	Fire hall	180
Stereo store	437	Stereo store	180
Hairdresser	437	Diesel station	182
Barber	455	Hairdresser	182
Fire hall	559	Barber	182
Furniture store	571	Cake shop	216
Veterinarian	579	Oil station	232
Minister	803	Haberdashery	247
Clothing store	868	Dairy	253
Seed shop	888	Fish shop	285
Haberdashery	891	Wholesale market	295
Ironmonger's shop	924	Shoe store	317
Bank	924	Clothing store	331
Hardware shop	1138	Ironmonger's shop	348
Wholesale market	1143	Hardware shop	381
Shoe store	1143	Furniture store	394
Sports store	1203	Stationery store	405
Notary	1782	Tax office	476
Tax office	1849	Police station	476
Stationery store	2316	Veterinarian	476
Saving branch	2361	Saving branch	504
Police station	2401	Notary	551
Cake shop	2600	Bank	566
Dairy	3026	Seed shop	584
Fish shop	3341	Sports store	584
Supermarket	5606	Supermarket	2139
Social security off.	67710	Social security off.	12451

Sports stores and seed shops both have lower thresholds of 1,203 and 888 inhabitants. These two last activities however are classified among the four most central activities in the Cher when local population in considered. In this case, the four most central activities are:

1. Social security offices (12,451)
2. Supermarkets (2,139)
3. Sports stores (584)
4. Seed shops (584)

Surprisingly, dairies and fish shops have relatively low thresholds of 253 and 216 inhabitants.

3.2.2.3 Comparison.

The observation of these two types of thresholds leads to some interesting results. It is now possible to affirm that both thresholds do not have the same meaning in the study area. However, a precise analysis of their relationship is necessary, since it represents the essence of the problems found in experimental works. Scholars, in their attempt to evaluate the centrality of places, largely disregarded the notion of hinterland population thresholds as a measurement of the lower range of functions. Therefore, their work has been based on the underlying assumption of a perfect linear relationship between the two types of thresholds, where, if reported on a graph, all observations should lie on the same straight line as illustated in Figure 3.6. Gunawardena [28] justified this decision by showing a satisfactory correlation between local and hinterland thresholds in southern Ceylon (Sri Lanka). However, similar research could not be found, and the fact that scholars arbitrarily selected one type of threshold without justifying their choice may have led to inconclusive results.

Attention is now directed to find a descriptive device to illustrate the form of the relationship between the two types of thresholds in the Cher. Our first attempt is to measure the degree of association between hinterland and local population thresholds for the 48 activities by using the statistical correlation.

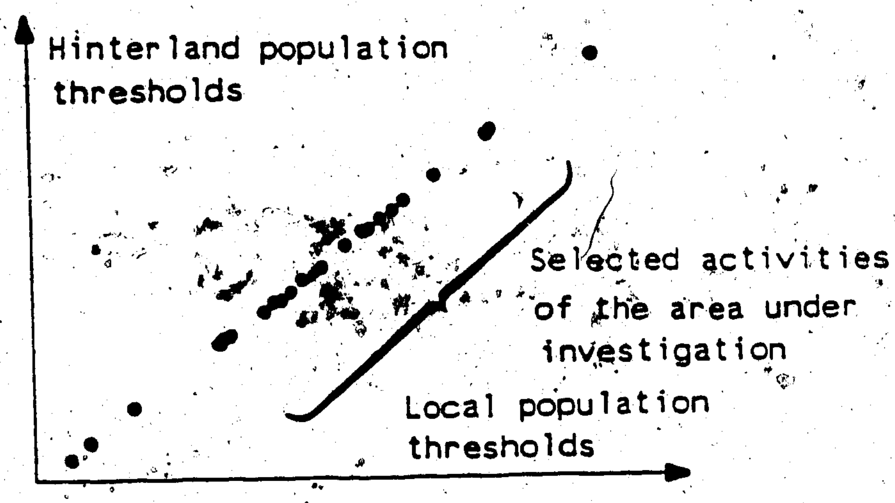


Figure 3.6 Hypothetical relationship between hinterland and local thresholds assumed in experimental works.

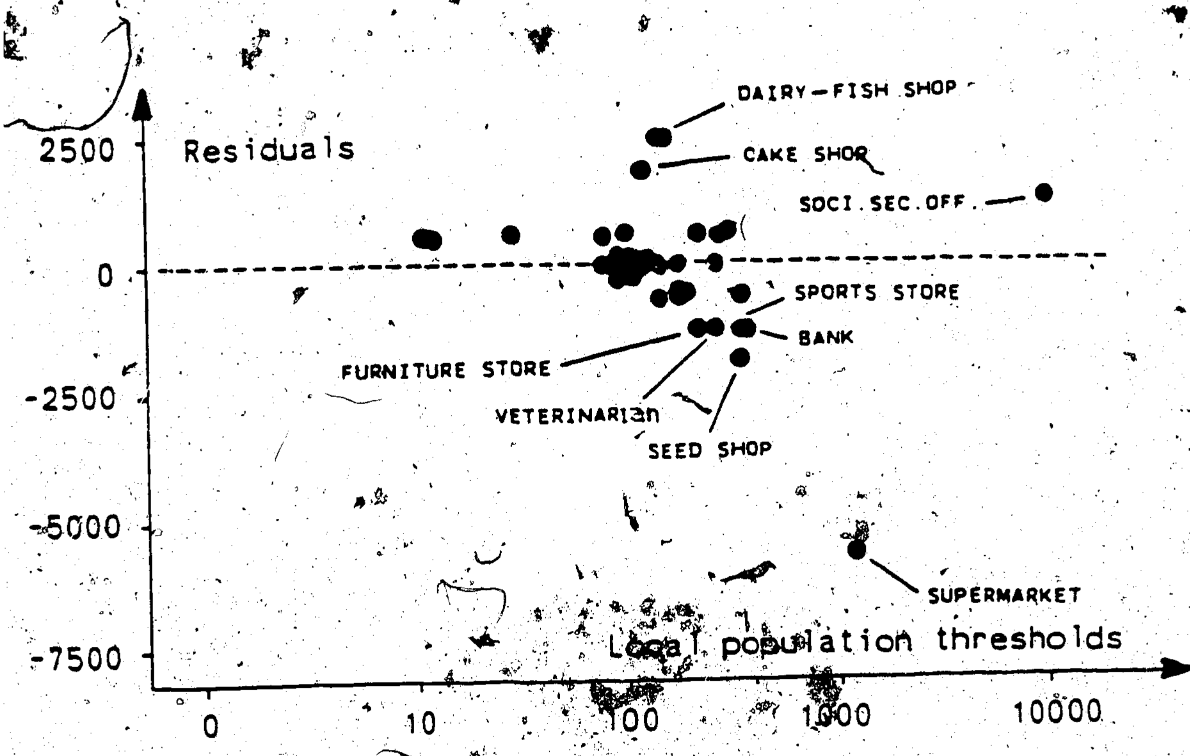


Figure 3.7 Residual plot-hinterland threshold residuals against local thresholds in the Cher.

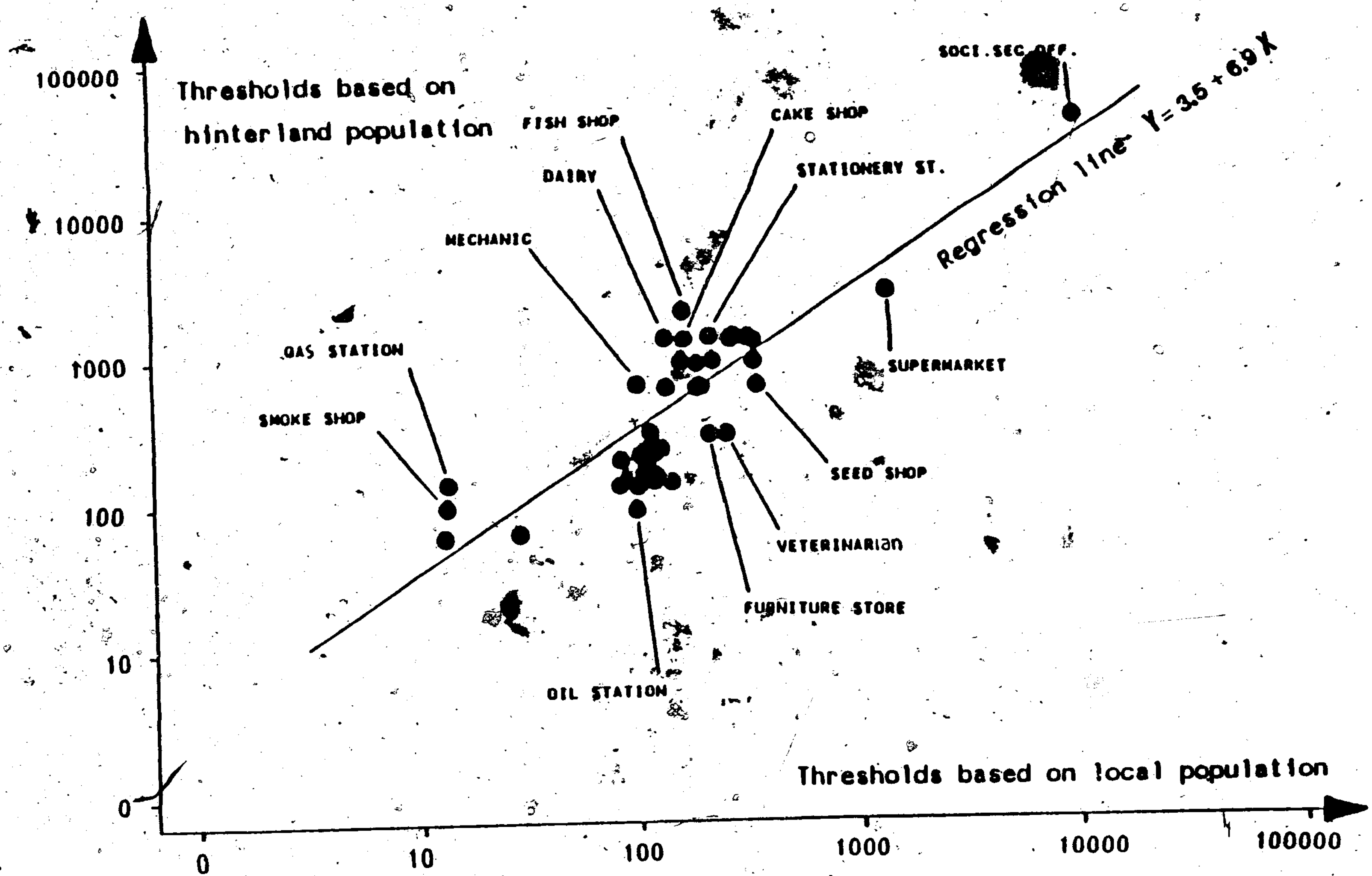
To this end, the starting point is the data listed in Table 3.2. These data classify the 48 activities according to their local and hinterland population thresholds. Since the data are interval, it is convenient to use a correlation coefficient which is based on actual values. The Pearson correlation coefficient was selected. This coefficient would range in value from +1, if there was a perfect positive correlation, to -1, if there was a perfect negative correlation. If there was no relation between the two types of threshold in the Cher, the coefficient would drop off close to the value 0. The result obtained is only partially satisfactory, since the coefficient is equal to +0.89. It indicates a high positive correlation between the two types of threshold in the Cher, but it nonetheless wipes out the perfect coincidence assumed between hinterland and local population thresholds. This coefficient indicates certain discrepancies between the classifications of activities obtained from the two thresholds. It is now possible to to clarify these discrepancies by using the method of simple regression analysis.

Instead of simply measuring the degree of relationship, simple regression analysis consists of producing linear mathematical models that specify the relationship. In short, the procedure rests upon finding the best-fitting line to describe a scatter of data. The insertion of a line which summarizes the relationship between two variables is obtained by means of least squares criteria. The idea is to ensure that the sum of the squares of the differences of the individually observed values from the line is at an absolute minimum. In the present study, the values are the hinterland thresholds (dependent variable), and the local thresholds (independent variable). The individuals are the 48 activities (observations). The extent to which the observations deviate from the regression line are known as "residuals" or vertical distance between each observation and the regression line on the graph. Their analysis will answer the questions of whether or not the discrepancies between the results obtained with local and hinterland population thresholds are significant enough to warrant the inadequacy of local population thresholds utilized in empirical studies.

Figure 3.8 shows the lower range of activities in the Cher when local and hinterland thresholds are associated. As previously suggested with the correlation coefficient, this graph indicates a Log-linear relationship between the two types of thresholds, since the differences between the data points and the regression line are minimized. However, the situation is somewhat different from that of perfect linear relationship showed in Figure 3.6. At first glance, activities such as gas stations, smoke shops, mechanics, dairies, fish shops, cake shops, stationery stores and social security offices lie well above the regression line. On the other hand, oil stations, furniture stores, veterinarian clinics, seed shops and supermarkets are positioned well below the regression line. In summary, two groups of activities indicate discrepancies between the two types of thresholds. The range of the first group of activity is underestimated when local population is considered, whereas the range of the second group is underestimated when hinterland population is considered.

The examination of residuals, or differences between data points and the regression line displayed in Figure 3.7, highlights the disharmony between the two types of lower range in the Cher. The four functions, social security offices, cake shops, dairies, and fish shops, are classified with excessively low thresholds when local population is considered. For example, in the list of the 48 functions ordered by local population thresholds, cake shops are classified in 26th position, and 44th when the activities are ordered by hinterland population. In the first case, a low threshold of 216 inhabitants is assigned to this activity whereas in the second case, cake shops become a more central function with a high minimum hinterland population of 2600 inhabitants. Several illustrations of these irregularities can be observed in the Cher. A typical example is the gas station which is the unique activity of St. Ceol, a small hamlet of 22 inhabitants. When local population thresholds are considered, gas stations are tallied as the most ubiquitous functions in the Cher with a threshold equal to 22 inhabitants (the population of St. Ceol). St. Ceol, however, is an "exception", and if the commune was not "exceptionally" located along a major transport axis, it is highly probable that it

Figure 3.8 Relationship between hinterland and local thresholds in the Cher.



would not perform this service, since its own population is so low. The estimation of hinterland population gives more consistent results. Since it takes into account both the centre's and the trade area's population, it regulates these "exceptional" situations and, for example, gas stations become more central with a hinterland threshold of 271 inhabitants. This problem of "exceptional occurrence" of functions associated with "exceptionally" low population levels certainly distorted the results obtained in most experimental works which based their measurements of range on the minimum centre population.

In [illegible] 3.7, the six activities, furniture stores, veterinarian clinics, seed shops, supermarkets, [illegible] and sports stores, are classified with exceptionally high thresholds when hinterland population is considered. Veterinarians, for instance, are supported by a minimum local population of 476 inhabitants and a minimum hinterland population hardly higher (579 inhabitants). Once more, this example illustrates the inadequacy of local population thresholds for measuring the lower range of functions. Veterinarians, banks, sport stores, and seed shops are functions that are typical of medium-sized villages. They therefore have relatively high local thresholds varying from 476 to 584 inhabitants. With these levels of minimum local population, these functions are of a higher order in the Cher. Their spatial distribution shows that these functions are spatially very flexible, and most of the medium-sized villages of the region support them. Their complementary areas are therefore rather small. These functions, although classified as central with local thresholds are, in fact, quite ubiquitous. More significantly, they are classified of a lower order when hinterland population is considered.

In conclusion, the relationship between thresholds based on local and hinterland population revealed a good correlation between both measurements, but outlined deviations. It appeared that thresholds established with centre population led to erroneous results due to a certain number of anomalies. These anomalies referred principally to the occurrence of central services in settlements with exceptionally low thresholds of population. As a result, hinterland population was recognized as a more satisfactory tool since it regulates such irregularities. Furthermore, since the hinterland population threshold is defined on the basis of the whole complementary area population (center and trade area), it fully respects the Christallerian principle of a "service centre serving a tributary area". It can therefore be concluded that the lower limit of the *range* of functions in the Cher is to be defined as the minimum hinterland population that supports the occurrence of a function.

4. TOWARD A CONDENSED CENTRALITY MEASURE IN THE CHER.

4.1 The problem.

The term "centrality" does not have a universally agreed upon definition. In chapter 1 several case studies attempting to measure the centrality of towns were presented. However, it could be concluded that not one unique definition of centrality was given. Certain geographers, among them Berry [11], Johnson [35], Davies [23], Scott [57], and Bracey [13], considered centrality in terms of population and the number of services offered. Others, like Preston [53], Olsson and Persson [47] or Illeris [33] included economic factors in their centrality models such as the sales of durables or, the average family income of each town. These studies attempted to measure the *aggregate importance* of places. Several other studies estimated the *relative importance* of centers. They used other centrality criteria such as the accessibility of towns [55] or the magnitude of flows between centers [26,68]. There is clearly a wide range of centrality measures found in the literature. This can result in confusion when the problem of finding an adequate measure to classify the towns of an area is encountered. What type of centrality indicator should one select? The solution might be to return to the etymological source of the term "centrality" and apply the original concepts found in Christaller's Central Place Theory. Once more, no satisfactory solution can be found since Christaller's definition of centrality differs depending on whether one examines his theoretical principles or his empirical study in Southern Germany. In the former case, Christaller presented a centrality index based on the relationship between two indicators, namely, the inner limit (threshold of hinterland population) and the outer limit (maximum distance consumers are willing to travel) of the *range* of towns. In the latter, he simply measured the centrality of settlements in Southern Germany by combining their population and number of telephone connections.

As a result, most geographers regard the centrality of towns as an aggregate of different elemental components. The concept of centrality is largely understood, but actually it is reflective of the opinions and expectations of individual researchers. For instance, in their attempt to find an adequate centrality index, some geographers decided to choose a single indicator,[5] whereas others preferred to combine up to five indices in one measure.[6] When this study was initiated there was no preconceived notion that one indicator of centrality was better than another. Rather, the question raised pertained to whether various indicators produce similar or different results. Subsequently, it should be determined whether or not there is any rational basis for combining the indicators into a single measurement of the centrality of settlements. In other words, can a number of centrality measures be condensed into one or more independent factors?

Berry [10] suggested that the number of functions within a town is a good summary of its centrality. This is according to the premise that this indicator is well-correlated with several other indicators, namely, the number of establishments and the population of towns,

> "We have shown number of central functions to be an accurate index of the 'centrality' of a place" [10, p.38]

> "The population of a central place is dependent upon the total number of kinds of retail and service business offered. This number, in turn, in part depends upon and in part determines the centrality and economic reach of the center." [75, p. 37]

Should the "centrality" of a center be measured from one single indicator or from the combination of several indices? In the Cher, would other centrality measures be more adequate than the total number of functions of each center? Can the two Christallerian indices, the outer and inner limit of the *range* of towns, be regarded as a good summary of the hierarchy of towns in the Cher? Is it possible to combine criteria regarding both the

---

[5] In his study in the Philippines, Ullman's [70] indicator of centrality is the traffic flows between towns.

[6] Preston's [53] centrality model combines 5 indicators which are the total sales of retail establishments, the total sales in selected service establishments, the average percentage of median family income spent on retail items and selected services, the median family income of a central place, and the total number of families in a central place.

relative and *aggregate* importance of towns?

To solve these issues, 15 centrality indices have been identified in the Cher. The method suggested is Principal Component Analysis which starts with a matrix of correlation coefficients measuring the degree of correlation between the 15 indicators. By means of extracting underlying factors which are responsible for the covariation among the variables, it is conceivable that only one significant factor accounts for the intercorrelations of the variables. In this case the concept of centrality may be logically shown in one dimension. If, however, more than one factor is significant in the Cher, then there is a strong argument to support the concept that centrality is multidimensional. Each of the dimensions are then independent of one another. In order to find an adequate solution in the Cher, we will examine three steps successively,

1. Selection of a set of centrality indicators.
2. Method chosen to condense these centrality indicators.
3. Analysis and discussion of the results obtained with the Principal Component Analysis,

4.2 Selection of the centrality indicators in the Cher.

Central places are defined as service centers which act as centers for the exchange of goods. The problem of the development of a central place is thus one of minimizing the distance travelled by consumers while maximizing the profitability of the activities. Since central place activities are essentially distributional and customers are spatially diffuse, the centrality of places is therefore directly proportional to:

1. The distance between the activities and the villagers.
2. The spatial efficiency or level of grouping of the activities.
3. The population served (sales require more customers).

In summary, it seems that the centrality of a settlement can be measured in terms of,

1. Accessibility indices.
2. Functional indices.
3. Population indices.

In addition to these three types of indicators of centrality, the importance of a central place also depends upon the volume of sales and the revenues from customers. Profits of suppliers increase as long as the revenues from customers exceed the costs of serving them. However, the source of information chosen for this study does not provide economic data such as the total sales of retail establishments, the total personal annual income of the population, or the median family income spent on retail items. Rather, the Inventaire Communal offers detailed information concerning population and functional indicators of centrality. The accessibility of settlements can then be easily established from a detailed road map of the region.

4.2.1 Population indices.

The total population, the nucleated population, and the population density of communes were directly extracted from the data source. The total population embraces both urban and rural population of each of the 290 communes of the Cher. By definition, a commune includes an urban settlement (e.g. town, village, or hamlet) and a variable number of farms scattered in the surrounding lands. The population living in these farms is recognized as the "rural" population of the commune. In contrast, the "nucleated" or "urban" population of a commune is that living in the urban settlement. In France, this population is statistically determined according to precise criteria. All people surveyed as living in buildings or houselolds located around the settlement's church are considered as nucleated population. Each building should not be separated by a distance exceeding 200 meters. These two concepts of rural and nucleated population are very important in central place studies. Johnston [36] and Durand-Dastes [24] suggested that the degree of nucleation of the population within a commune is a good index of centrality. The population density is also a good indicator of centrality because it takes into account the size of the commune.

Finally, since the inner limit of the range of towns or threshold of hinterland population is a major component of Christaller's centrality model, this last criterion was required as a centrality indicator of the towns in the Cher. In chapter 3, we described the method of measuring the thresholds of the 48 central activities selected in the Cher. These activities were then ranked according to the minimum hinterland population served by each of them. As a result, Table 3.2 lists the 48 classified activities where restaurants are the lowest level activity with a threshold of hinterland population equal to 87. At the other end of the scale, social security offices require a minimum hinterland population of 67,710 inhabitants to occur in the Cher.

In order to evaluate the inner limit of the range of the 290 towns of the Cher, it was arbitrarily decided to assign it to the threshold of hinterland population of the highest level activity found in each town. For instance, the highest level activity found in Bourges is the social security office. Table 3.2 shows that in the Cher the threshold of hinterland population of this activity is 67,710 inhabitants. Hence, the inner limit of the range of Bourges was set to 67,710 inhabitants. Brecy is a smaller town located 15 Km on the east-side of Bourges. Brecy's highest level activity is the dairy which requires an hinterland population threshold of 3,026 inhabitants (see Table 3.2). The inner limit of the range of Brecy was therefore set to 3,026 inhabitants.

The least satisfactory aspect of this method is that it rests on a single observation for each commune, the most central or "marginal" activity. Considering only the most central activity of each town may be disapproved of when the conditions are too remote from Christaller's ideal economic space. In actual situations, settlements do not always possess the "ideal" arrangement of services where larger centers offer the services not provided in smaller places as well as all services found in smaller places. Brecy, for instance, is a village of 503 inhabitants that offers a dairy, the third most central activity in the Cher (see Table 3.2). Brecy's minimum range of 3,026 inhabitants makes it one of the most central places of the Cher. This village, however, does not provide any intermediate activities, and apart from the dairy, its activities have low thresholds of [illegible]ation. [illegible] of as[illegible]g thresholds of hinterland population to towns may give [illegible] importance to their specialities. The centrality of certain towns may therefore be over-estimated. However, Brecy is an exceptional case and the majority of settlements in the Cher have uniform distributions of activities. One of the advantages of this method is that it is straightforward.

4.2.2 Functional indices.

For the purpose of defining functional centrality indicators in the Cher, the mass of data available has been summarized in terms of functions and establishments for each center. An establishment is the unit in which an activity is performed whereas functions group all establishments by types. Brecy, for instance, supports three bars. Brecy is then recorded with three establishments and one function within the rubrique "bars". Let us assume that there is a town that provides only three functions, bars, restaurants, and post office. One establishment is associated with the post office, and two establishments are associated with the bar and the restaurant respectively. In this case, the town would be recorded with three functions and five establishments. As shown in Chapter 2, 48 functions were extracted from the data source. The maximum number of functions that a town may provide is therefore 48, although it is possible for more than one establishment to be associated with a particular function.

Three summary values were derived from the data source and considered as good indicators of centrality,

1. Total number of establishments.
2. Total number of functions.
3. Average number of establishments per function (number of establishments / number of functions).

4.2.3 Accessibility indices.

Most of the methods to measure the accessibility of towns start with the simplification of the road network as a graph and the elaboration of a connectivity matrix. The road network of any area may be represented as a matrix where the horizontal rows are identified as a set of origin towns or "nodes" and the vertical columns as a set of destination nodes. The number of rows and columns in the matrix corresponds to the total number of nodes in the network. Each cell entry in the matrix is then used to record the direct connection or "linkage" between a pair of nodes. If the two nodes are connected, a "1" is entered in the appropriate cell. If the two nodes are not connected, then the cell is filled with a "0".

From a detailed road map of the Cher, the road network was first abstracted as a graph where any connection between nodes was represented as a straight line defined as a "link". A total of 613 links were found in the Cher and were appropriately coded in a connectivity matrix of 290 rows and columns. In this binary connectivity matrix, the cell entries simply recorded the presence or absence of a linkage between a pair of nodes in the network. The hierarchy of roads, distances, travel time, and the amount of a commodity being shipped from a node to another were voluntarily ignored.

Several measures of accessibility were derived from this connectivity matrix. The first one was obtained by the summation of the individual rows of the matrix. The results measure the total number of direct linkages from a given center to the set of all other centers in the network. With this method, the higher the value of a center, the greater its accessibility. This measure of accessibility was however neglected since it involves only the direct connections between nodal pairs and ignores indirect connections.

A more elaborate accessibility measure developed by Shimbel [104] and Katz [94] and successfully tested by Garrison [86] was applied in the Cher. This measure takes account of both direct and indirect connections between nodal pairs and is determined by matrix multiplication. The original connectivity matrix was powered once to give the number of two linkages connections between pairs of nodes, twice for the number of three linkages connections and so on. Since 15 is the minimal number of links between the two most distant nodes in the network, the connectivity matrix was powered 15 times. The next step consisted in summing the original connectivity matrix C with all the powered matrices in order to get a matrix specifying all direct and indirect connections between the nodes of the network. Garrison [86] applied this method in Southeastern U. S. and decided to decrease the relative importance of indirect connections between nodes by using a scalar of .3 in the multiplication process. Similarily it was decided to multiply the connectivity matrices by the scalar .3 in the

Cher. As a result, the matrix T which represents the accessibility surface of the network was obtained by summing the connectivity matrices as follows:

$$T = .3C + .3^2C^2 + .3^3C^3 + \ldots\ldots + .3^{15}C^{15}$$

Where:

C is the connectivity matrix.

The last step was to rank the nodes in terms of their accessibility by using the row sum of the matrix T. Unfortunately, powering 15 times the 290*290 matrix required too much computer memory and we were not able to achieve the complete multiplication process.

An alternative solution to derive the multiconnections connectivity matrix T was adapted from Shimbel's work [104] by Garrison [86] with the application of the following formula,

$$T = (I - sC)^{-1} - I$$

Where:

I is the Identity matrix.

s is the scalar (.3).

C is the connectivity matrix.

Although tested by Garrison [86] over 45 settlements, this method did not provide adequate results in the Cher. It seemed that this formula was not applicable to large matrices.

Confronted with these successive failures, it was decided to use the shortest path method to calculate the accessibility of the 290 towns of the Cher. Based on the idea that "The importance of a connection between two nodes is inversely related to the number of linkages involved in the connecting path", the shortest path method consists of finding the length of the shortest path between a pair of nodes. Accessibility is then computed in terms of the minimum number of linkages between two places. Two measures of shortest path

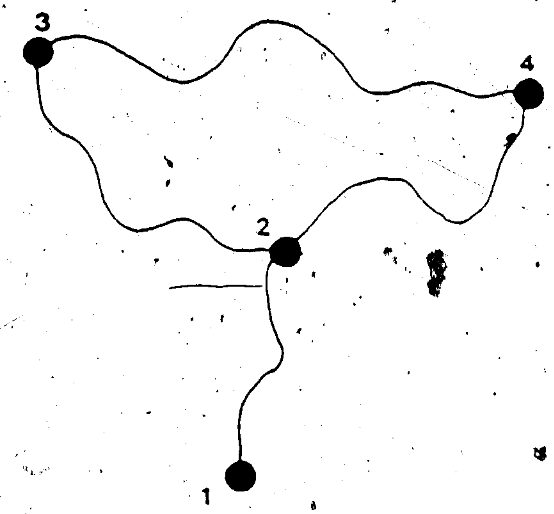


Figure 4.1 Sample road network

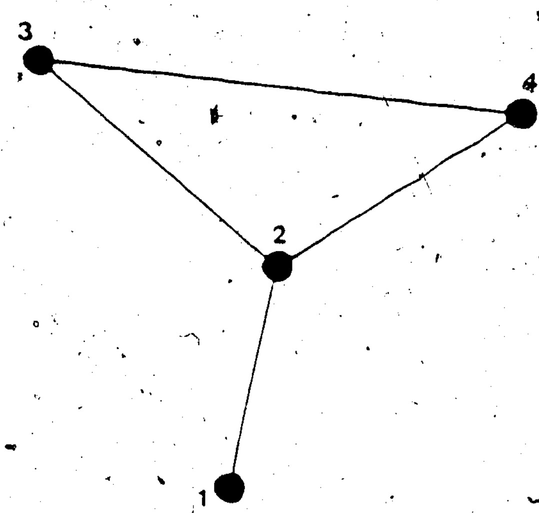


Figure 4.2 Sample road network simplified as a graph

accessibility were undertaken in the Cher.

From the connectivity matrix, the first method evaluates the length of the longest shortest path between pairs of nodes. As illustrated in Figure 4.2 and Tables 4.1 to 4.3, this method can be summarized in four main steps. For better understanding, let us assume that we are dealing with a simple road network linking four nodes as shown in Figure 4.1. The road network is then represented as a graph (Figure 4.2), and the connectivities between pairs of nodes are coded in the connectivity matrix (Table 4.1). The shortest path matrix (Table 4.2) is then derived from the connectivity matrix, and the largest number of each row is reported as the longest of the shortest path between a particular node and the remaining three (Table 4.3). The smaller the numerical value of a node, the greater the accessibility of this node to the network. In the Cher, the length of the longest shortest paths varies from 8 (Bourges) to 15 (Saint Priest la Marche). These results show that a maximum of 15 connections is necessary to reach the least accessible town in the Cher (Saint Priest la Marche), and a maximum of 8 connections is necessary to reach the most accessible town (Bourges).

Another way of finding the shortest path accessibility of the 290 towns of the Cher is to add the lengths of the shortest paths connecting each town to the remaining 289. For the simple network illustrated in Figure 4.1, the accessibility of the four nodes is listed in Table 4.4. In this case, the lowest value still corresponds to the most accessible node of the network. In the Cher, the 290 measures of accessibility range from 1105 for the most accessible town (Bourges) to 2935 for the least accessible (Saint Priest la Marche).

These two measures of accessibility provided satisfactory results in the Cher. The most central towns were found to be more accessible than the marginal ones which were generally poorly connected to the remaining towns. For better clarity the first accessible index or longest shortest path will be further referred as the ACCESSIBILITY INDEX 1. The sum of all shortest paths will be referred as the ACCESSIBILITY INDEX 2.

One weakness of these two measures of accessibility is that they ignore the connections between the marginal towns and those located in adjacent counties. For instance,

Table 4.1 Connectivity matrix of the sample road network

	1	2	3	4
1	1	1	0	0
2	1	1	1	1
3	0	1	1	1
4	0	1	1	1

Table 4.2 Shortest path matrix of the sample road network

	1	2	3	4
1	0	1	2	2
2	1	0	1	1
3	2	1	0	1
4	2	1	1	0

Table 4.3 Longest shortest paths of the sample road network.

1	2
2	1
3	2
4	2

Table 4.4 Sum of the shortest paths of the sample road network

1	5
2	3
3	4
4	4

Sancerre is an important town located in the far east part of the Cher, almost on the border between the Cher and the Nievre. Sancerre, mostly connected with towns located in the next county, the Nievre, is ranked with a high accessibility index of 11. Since all connections between Sancerre and these towns are ignored, Sancerre is thus considered not very accessible. One way of resolving this inadequacy was to weight the accessibility indices with the population of towns. The accessibility of the nodes becomes thus directly proportional to the number of people and inversely to the first power of distance. More precisely, the accessibility of Sancerre becomes a function of the sum of the population of the remaining 289 towns divided by their respective longest shortest path. The accessibility so obtained is referred to as "Population Potential" and the population or total number of people within a given area is opposed to a space dimension that expresses distance or nearness. This method has been widely used in previous studies. In particular, Harris [90] evaluated market potential maps of the United States which provided one type of accessibility measure. The population potential V at the ith location is defined as,

$$V_i = \sum_{j=1}^{n} (P_j / D_{ij})$$

Where:

P_j is the population of place j.

D_{ij} is the distance between the pair of nodes i and j.

This measure of accessibility was computed for each of the 290 towns of the Cher using the total population of communes and the longest shortest path between pairs of nodes. The result plotted in three dimensions in Figure 4.3 shows local peaks of potential around the two major towns, Bourges and Saint Amand-Montrond. Sancerre is ranked as the 98th most accessible town when this method is applied whereas it was ranked only in 148th position when the Accessibility Index 1 was calculated. Therefore this method gives more accurate accessibility indices for the important towns located in marginal zones.

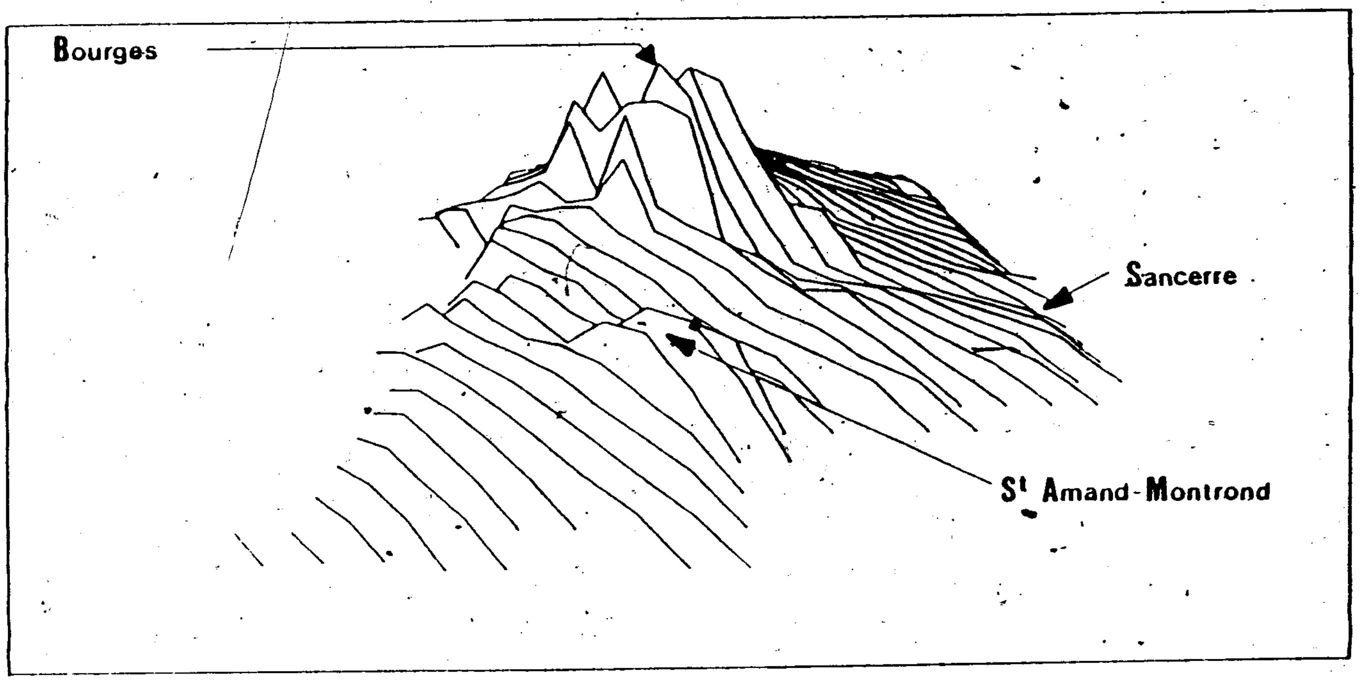


Figure 4.3 Population potential in the Cher

The second centrality factor included in Christaller's theoretical centrality model was the upper limit of the range of centers. This centrality index corresponds to the maximum distance travelled by customers to purchase in a center and is based on the assumption that customers purchase in the nearest center when services are missing in their own town. In the Cher, these distances were evaluated for the selected 48 activities and listed in Table 3.1. This distance ranges from 5.52 Km for smoke shops to 53.80 Km for social security offices. The maximum range [illegible] towns was then estimated as the maximum range of their highest level activity. Bourges provides one social [illegible] and was therefore classified as the most central place of the area with a maximum range of 53.80 Km. In contrast, Chaumont does not offer any activity and was accordingly ranked as the place of the lowest order.

4.2.4 Centrality ratios.

Four centrality ratios combine population and functional indices in the Cher. The ratio *Total population / Number of establishments* refers to the average local population served per establishment. The ratio *Total population / Number of functions* refers to the average local population served per function. The next two ratios combines thresholds of hinterland population and functional indices and therefore take into account both local and trade area population. The ratio *Threshold of hinterland population / Number of establishments* indicates the minimum hinterland population served per establishment. Finally, the ratio *Threshold of hinterland population / Number of functions* refers to the minimum hinterland population served per function in the Cher.

In conclusion, 15 centrality indicators have been selected in the Cher as listed below:

1. Total population of communes.
2. Nucleated population of communes.
3. Population density of communes.
4. Threshold of hinterland population.
5. Total number of establishments per commune.
6. Total number of functions per commune.

7. Average number of establishments per function in each commune (***Number of establishments / Number of functions***).
8. Accessibility index 1 (longest shortest path).
9. Accessibility index 2 (Sum of all shortest paths).
10. Population potential of each commune.
11. Maximum distance travelled by consumers.
12. Population / Number of establishments.
13. Population / Number of functions.
14. Threshold of hinterland population / Number of establishments.
15. Threshold of hinterland population / Number of functions.

4.3 Structural description of centrality in the Cher.

Central Place Theory is a structural theory in the way that it regards the centrality of places as an aggregate of elemental components interrelated in a lawful way. One of the most difficult problems of formulating a structural theory involves discovering the rules which govern the composition of the aggregates of components. For instance, in linguistics, the structural description of language analyzes speech into phonems or morphemes. In a similar manner, geographers described the centrality of towns in terms of population, number of functions, accessibility, distance travelled, etc... We propose to find a reliable statistical method which will allow us to analyze the concept of centrality in the Cher. To this end, we propose to determine the relationships among the 15 selected centrality indicators. The work will be carried forth under the premise that these centrality indices provide a satisfactory image of the centrality of towns in the Cher. However, no argument is presented that these centrality indicators are the best that could be devised, but they were selected as most appropriate from a large number representing the spread of available data.

4.3.1 The method.

Principal Component Analysis stems from the work of Pearson (1901) [98] and Hotelling (1933) [91]. It is a relatively straightforward method of determining a minimum number of common factors that would satisfactorily produce the correlations among the observed variables. Most of the pioneer work in multivariate analysis has been carried out by psychologists to deal with problems similar to the one considered here; to condense a number of measures [illegible] one or more independent factors.

Principal Component Analysis assumes that the observed variables are linear combinations of some underlying source variables or factors, and indicates which, and to what degree, variables relate to an underlying and undefined factor. This statistical technique starts with a matrix of correlation coefficients measuring the degree of correlation between the indicators. Operations upon the basic data matrix then extract the first factor which accounts for the greatest proportion of the intercorrelations, leaving those not accounted in a residual matrix. These operations are repeated upon successive residual matrices and further independent factors are extracted. The magnitude of descending values of *eigenvalues* indicates the relative importance of each factor and the *communality* often designated as H^2 determines the percentage of the variance of the variable explained by the components. Finally the factor *loadings* are equivalent to correlations between factors and variables and will provide measures of association between the centrality indices and the principal components in the Cher. In short, Principal Component Analysis is a reliable method for our purpose since, "It represents a simple, straightforward problem of description in several dimensions of a definite group functioning in definite manners". [Kelley, 95, p. 120]

In the Cher, Principal Component Analysis was applied to a matrix quantifying the 15 centrality indices for each of the 290 communes. In this matrix, the communes are identified in the rows and the centrality indices in the columns. Each cell represents the corresponding centrality measure. Principal Component Analysis of this "centrality matrix" yields the 15 succeding components. If there is an organization of the centrality indices in the Cher, a limited number of these components will identify the appropriate patterns of centrality. This number of components may be derived from the *Scree Test*. Advocated by Catell [79] in 1965, the Scree Test directs one to examine the graph of eigenvalues, and to stop factoring at the point where the eigenvalues begin to level off forming a straight line with an almost horizontal slope. Figure 4.4 depicts the graph of eigenvalues obtained from the "centrality matrix", and indicates clearly a sharp bend at the fourth eigenvalue. Three large positive eigenvalues account together for 85.5% of the common variance. Thus the first three components provide an adequate summary of the centrality indicators. The three first components should therefore be sufficient to satisfactorily explain the correlations between the 15 centrality indices in the Cher.

4.3.2 The results.

The first component observed accounts for a proportion of 52% of the total variance of the variates, which is considerable. Table 4.5 shows the loadings of the 15 centrality indicators on the first component and suggests that all variables in the set share something in common. This component correlates most highly with the first ten variables with loading-values greater than 0.62. The three variables with the highest loadings are the population indices; the threshold of hinterland population, the total population, and the nucleated population with high loading-values greater than 0.87. However, the population density is underestimated by the first component with a low loading value of 0.68. Among the ten first variables are also found the two Christallerian indices of centrality, the outer limit of the range of settlements (maximum distance travelled to purchase in a centre), and the inner limit of the range of settlements (thresholds of hinterland population) with respective loading-values of 0.72 and 0.90. Finally, the variates related to the functional organization of towns are also highly accounted for by the first component with loading-values as high as 0.81 for the number of establishments and 0.76 for the ratio *number of establishments/number of functions*.

On the other hand the five last variates namely, *population/number of establishments, threshold of population/number of establishments*, and the three accessibility indices are

Table 4.5 Loadings of the centrality indices on the first three unrotated factors

VARIABLES	LOADINGS Factor 1	LOADINGS Factor 2	LOADINGS Factor 3	H^2
Thresholds of population	0.90	0.21	-0.05	0.99
Total population	0.88	0.20	-0.22	1.00
Nucleated population	0.87	0.20	-0.23	1.00
Threshold / Number of functions	0.85	0.31	-0.12	1.00
Population / Number of functions	0.84	0.23	-0.38	1.00
Number of establishments	0.81	-0.19	0.49	0.96
N. of establishments / N. of functions	0.77	-0.14	0.41	0.84
Outer limit of the range of towns	0.72	-0.09	0.39	0.80
Population density	0.68	-0.18	0.24	0.7[illegible]
Number of functions	0.62	-0.30	0.66	0.94
Population / N. of establishments	0.50	0.23	-0.58	0.96
Threshold / N. of establishments	0.49	0.36	-0.18	0.98
Population potential	0.29	-0.78	-0.29	0.79
Accessibility index 1	-0.27	0.[illegible]5	0.45	0.86
Accessibility index 2	-0.30	0.78	0.38	0.86
Variance explained	52%	18%	15.6%	

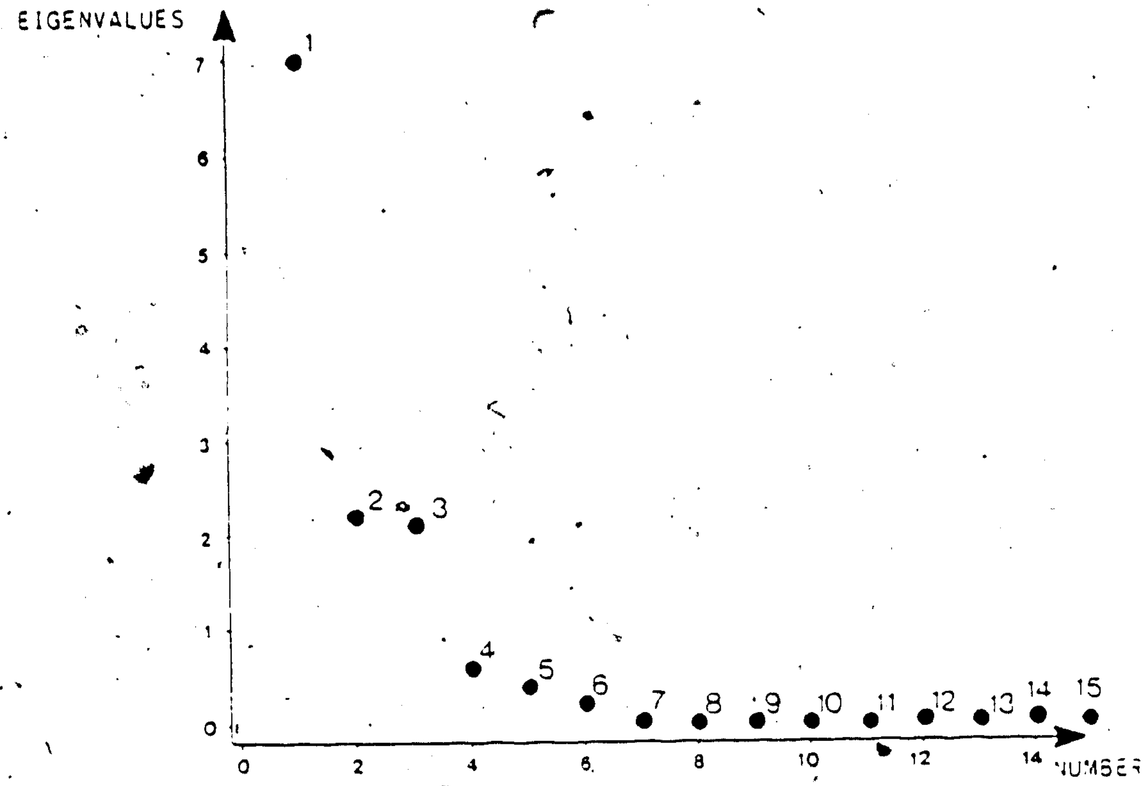


Figure 4.4 Scree plot of the eigenvalues

underestimated by the first component. This is essentially true for the indices of accessibility of each town, poorly correlated with loading-values lower than 0.29. An interesting point to note is the opposition of the accessibility index 1 and 2 negatively loaded (-0.27, -0.30) with the population potential positively loaded (0.29).

Since the first component loads high with most of the population variables, it might be described as the "size" of the settlements in the Cher.

The second component accounts for an additional 18% of the variance of the variables, and for it the scale weights are reported in Table 4.5. This component loads high essentially on the accessibility measures of the towns. Again it contrasts the population potential (-0.78) with the remaining two accessibility indices (0.75 and 0.78). This conflict can, however, be easily explained by the fact that the most accessible towns of the Cher have high population potential whereas the same towns are reported with low accessibility indices. Apart from these accessibility indices, the remaining 12 centrality indicators are underestimated with a low maximum loading-value of 0.36. On these variables, the second component is bi-polar as it indicates a classification of the variates into two subgroups; it loads positively on some variables and negatively on others. Seven variables namely, *threshold of population/number of establishments, threshold of population/number of functions, population/number of establishments, population/number of functions, threshold of hinterland population, total population, nucleated population* (0.36, 0.31, 0.23, 0.23, 0.21, 0.20, 0.20) lie in one subgroup and the remainder in the other. In the latter, the *number of functions* gets the highest loading-value with a correlation of -0.30. The other variates have a correlation varying from -0.18 for the population density to -0.09 for the outer limit of the range of towns. The different factor loading signs mean that the variables are related to the second factor in opposite directions. Hence the second component distinguishes between the demographic measurements (population, thresholds of population) on one hand and functional measurements (number of functions, number of establishments) on the other. The population density is once more associated with the functional indices. Among the two subgroups we can find the two Christallerian indices of centrality, the outer and inner limits of the range of towns, which are thus opposed.

The second factor loads high exclusively with the three accessibility indices and can thus be referred as the "accessibility" of towns.

The third component accounts for 15.6% of the variance and does not really add substantial information. This component is bi-polar and clearly contrasts the population indices loaded negatively, with the functional indices loaded positively. The population density with a positive loading sign contrasts with the remaining population variables which load negatively. The highest loading-values are related to the functional centrality indicators which range from 0.41 for the *number of establishments/number of functions* to 0.66 for the number of functions. This component also opposes the outer limit (0.39) and the inner limit (-0.05) of the range of towns.

Since the third component loads high on the functional variables, it may be described as the "functional centrality" of the places in the Cher.

The analysis of the first three components and variables' loadings clearly outlines three centrality dimensions in the Cher; the size, the accessibility and the functional organization of towns.

An alternative way of interpreting the information given by the first two components is seen if the variates are plotted using orthogonal axes. The plot of the 15 centrality indices, using for their coordinates the loadings of the variables on the two first unrotated factors reveals remarkably clearly these three clusters of variates in the data. The resulting plot given in Figure 4.5 brings to light a cluster of points in the upper left-hand quadrant (outer limit of the range, number of establishments, number of functions, number of establishments/number of functions, population density) and a cluster of points in the upper right-hand quadrant (total and nucleated population, threshold of population, population/number of functions). The two ratios, *population/number of establishments* and *threshold of population/number of establishments* appear to be poor measures of these two dimensions. A glance at the plot of the variables on factor 1 and 3 on one hand (Figure 4.6), and factor 2 and 3 on the other hand (Figure 4.7) indicates similar clusters of variables where the three centrality dimensions

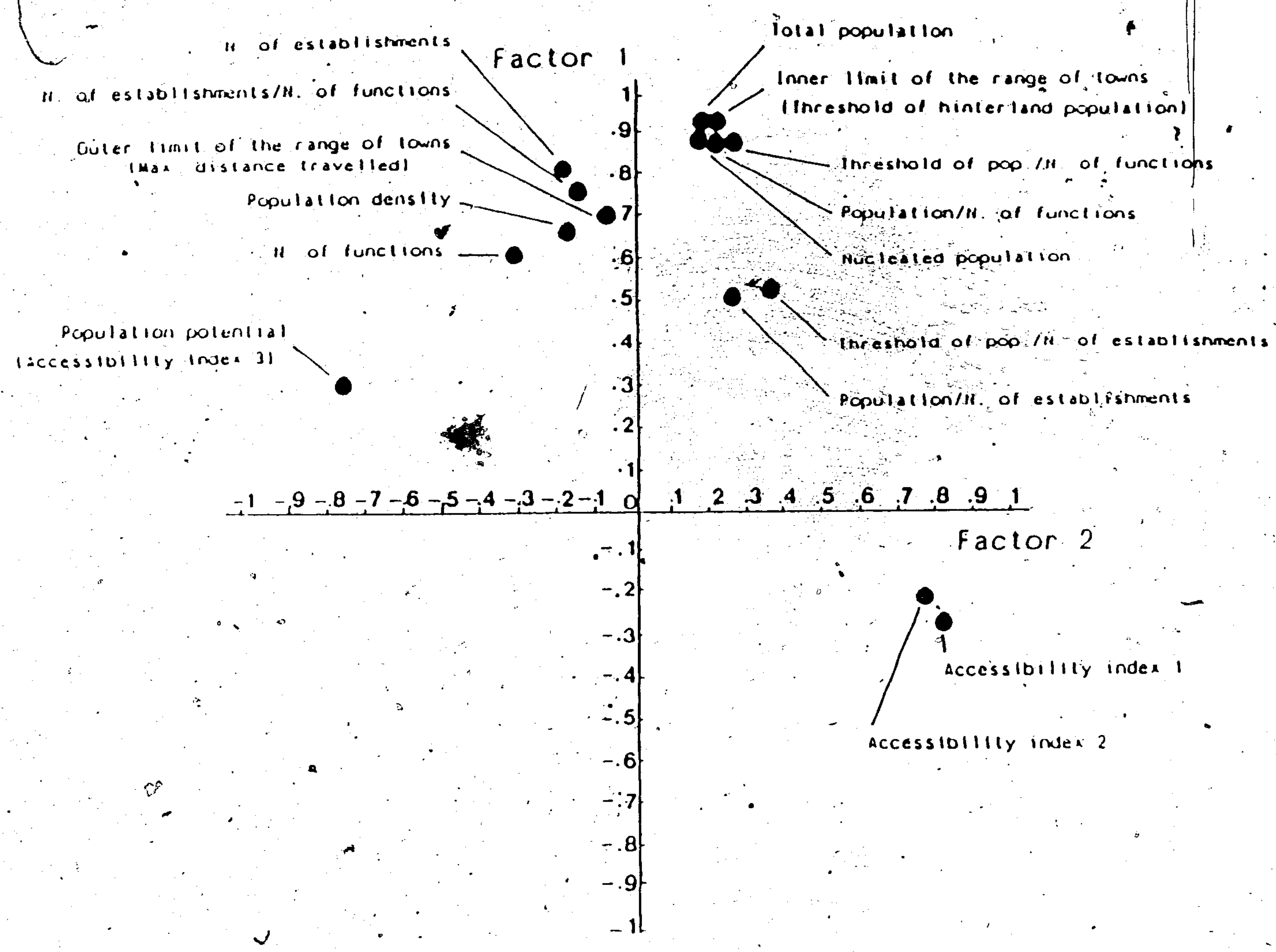


Figure 4.5 Plot of the centrality indicators on unrotated factors 1 and 2

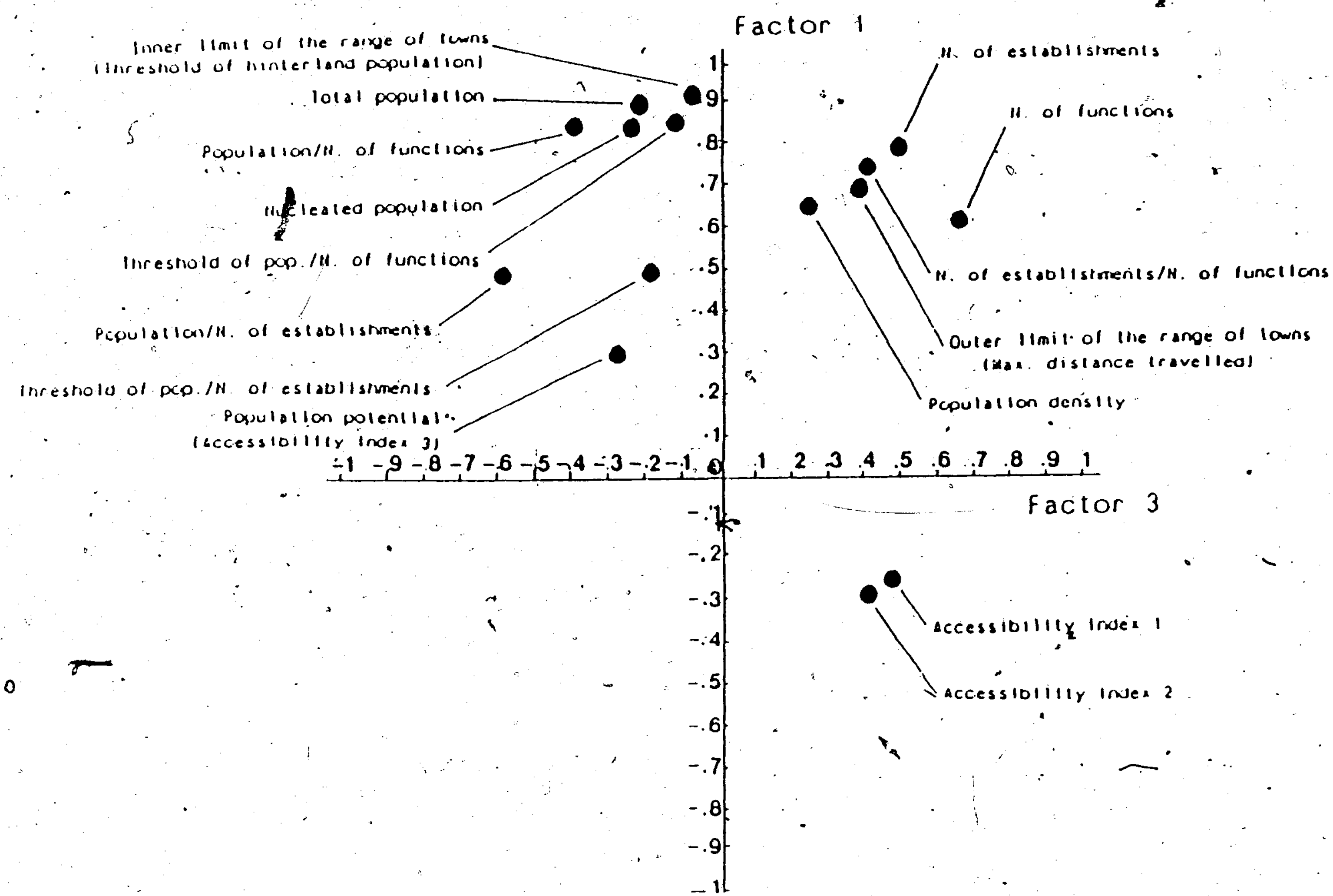


Figure 4.6 Plot of the centrality indicators on unrotated factors 1 and 3

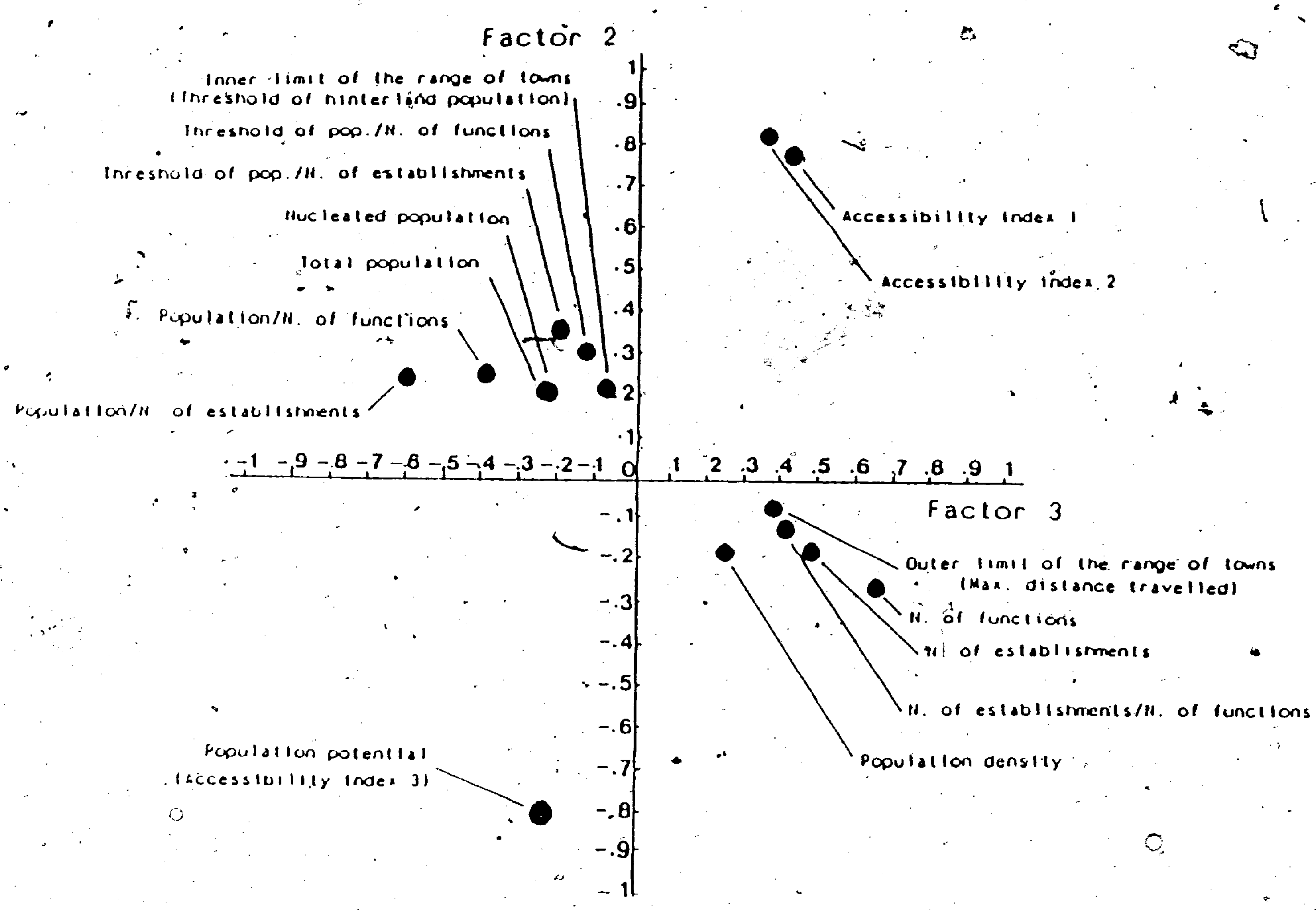


Figure 4.7 Plot of the centrality indicators on unrotated factors 2 and 3

are brought to light.

Although these three factors do not seem difficult to interpret, it was nevertheless decided to rotate them to explore the possibility of an even simpler pattern. With the method of *Varimax* rotation followed by the *Promax* method [81] the two first factors were rotated in a clockwise direction through about 110°. Passing near three clusters of variables, the two rotated factors showed in Figure 4.8 confirm the three dimensions of the centrality indices in the Cher. Rotated factor 1 appears most exclusively associated with the population variables and the inner limit of the range of towns (threshold of hinterland population). On the other hand, rotated factor 2 appears most closely associated with the variables dealing with the functional organization of towns and the outer limit of the range of towns (maximum distance travelled). The three accessibility indices are poorly correlated with either of these two rotated factors.

The two plots of the rotated factors 1 and 3 (Figure 4.9) and the rotated factors 2 and 3 (Figure 4.10) reveal the same three dimensional structure of the centrality indicators in the Cher. Factor 3 appears in both cases closely associated with the three accessibility indices. On the other hand, factor 1 is clearly associated with the population variables whereas factor 2 is associated with the functional indices as well as the outer limit of the range of towns (maximum distance travelled). Finally, the population density has an ambiguous position since it contrasts with the remaining population variables and departs slightly from the cluster of functional indices. With the lowest communality of variance accounted by the common factors (0.70), the population density does not seem to fit the three dimensions suggested by the Principal Component Analysis.

In conclusion, Principal Component Analysis has isolated three dimensions among the 15 centrality indices in the Cher. The first dimension revolves around a series of population indices where both the total population of communes and the first Christallerian index, the threshold of hinterland population, arise. The second dimension is centered around the functional indices of centrality and highlights both the number of establishments and functions of each commune as best centrality measures. This dimension also includes the

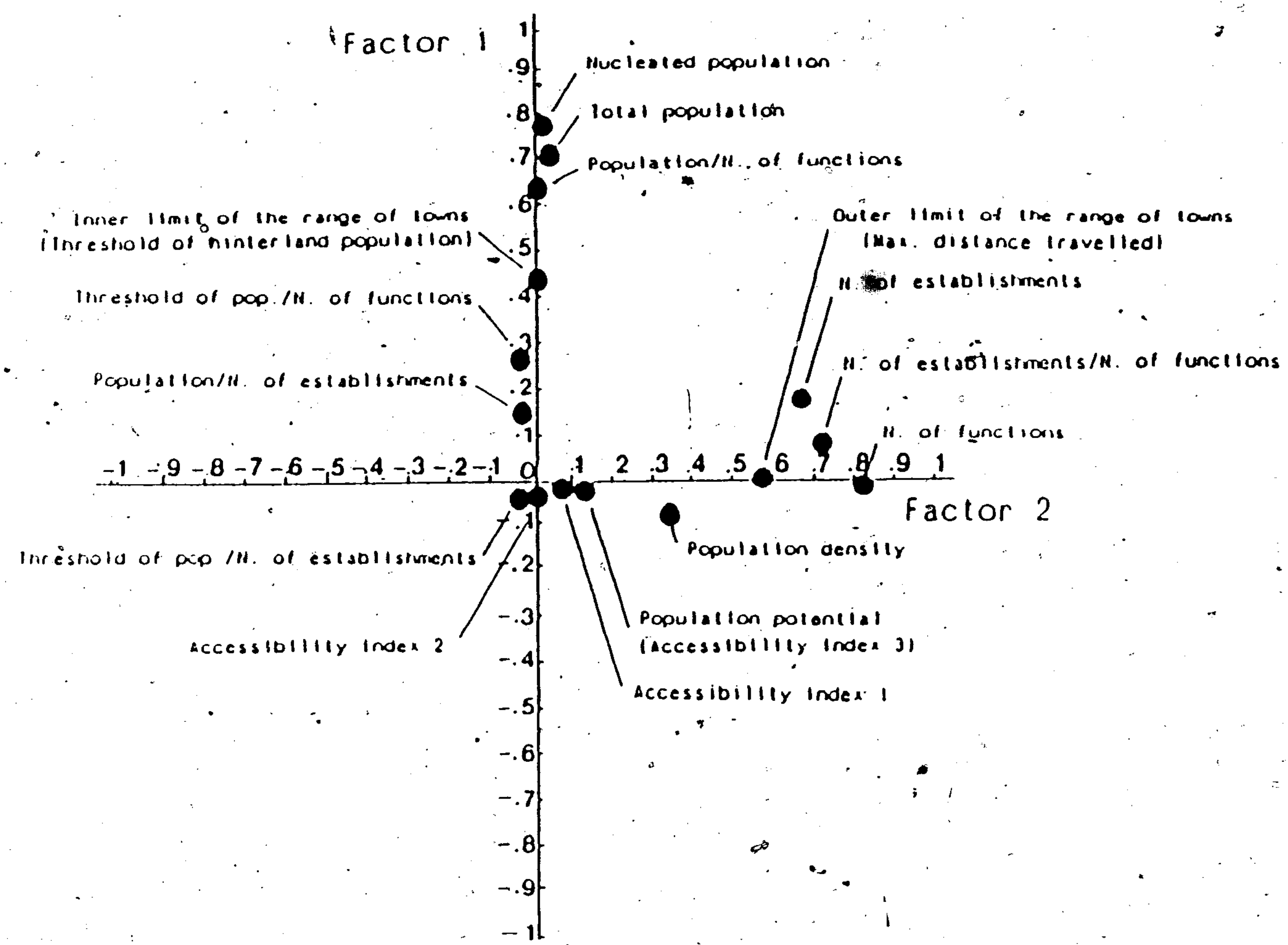


Figure 4.8 Plot of the centrality indicators on rotated factors 1 and 2 (angle=110°)

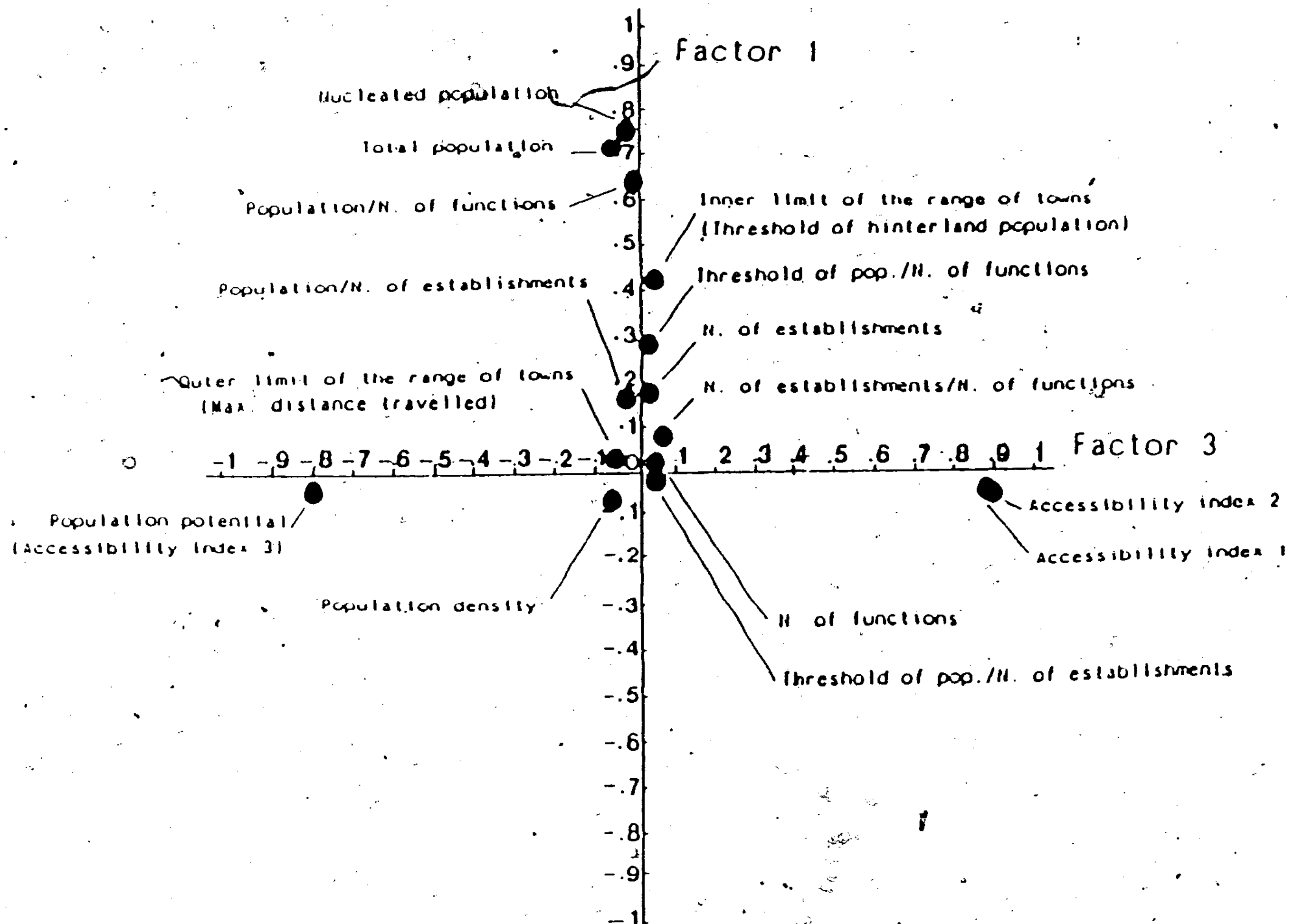


Figure 4.9 Plot of the centrality indicators on rotated factors 1 and 3 (angle = 90.69°)

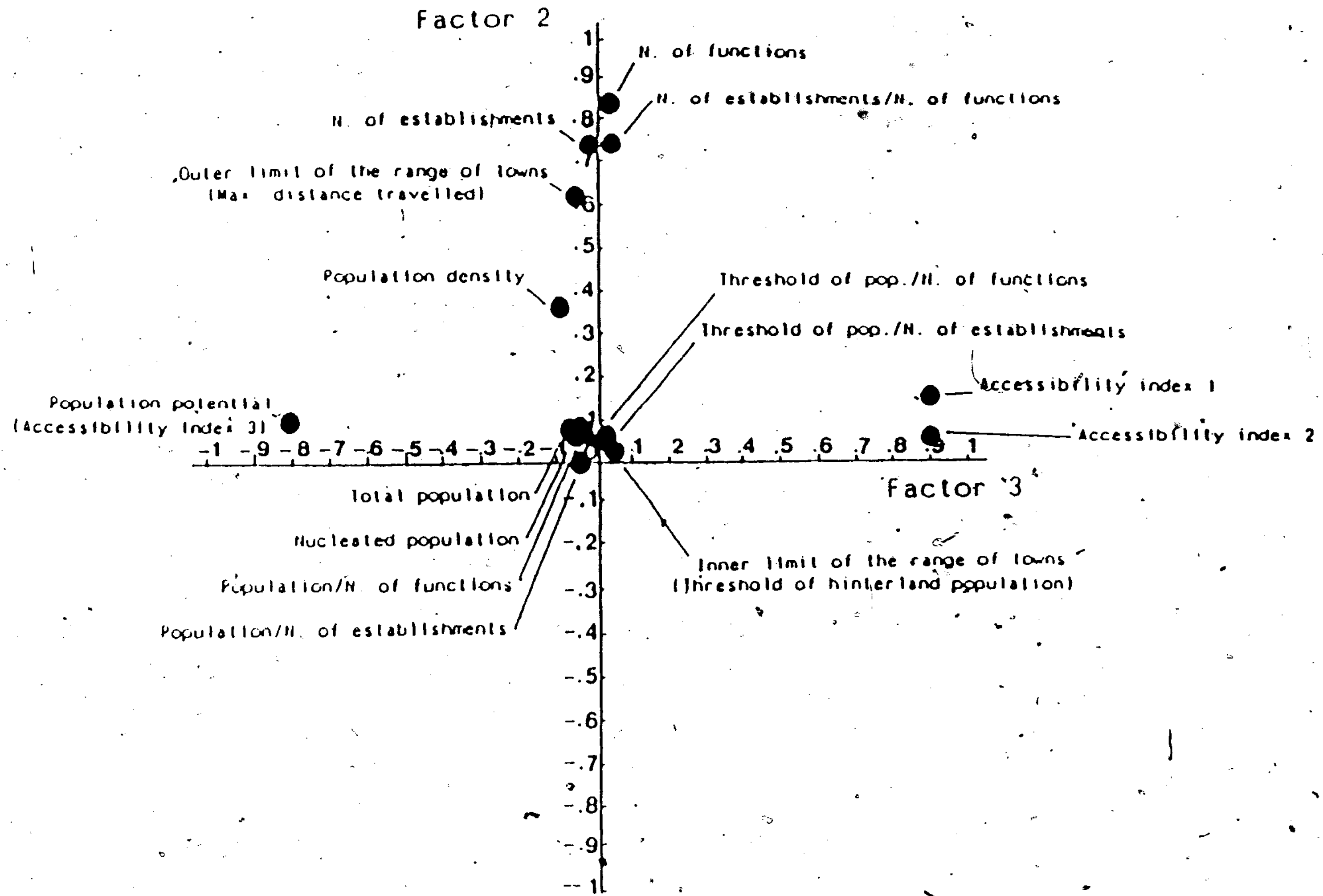


Figure 4.10 Plot of the centrality indicators on rotated factors 2 and 3 (angle=80.86°)

second Christallerian index, the outer limit of the range of towns (maximum distance travelled). Finally, the third dimension clearly refers to the accessibility indices of towns in the Cher. The population density does not seem to represent a good index of centrality in the Cher.

It thus appears that the wide spectrum of information sampled by the 15 centrality indices can well be summarized under three labels. The structural relationships of centrality found in the Cher partly reinforce Christaller's concepts of centrality. Both inner and outer ranges of towns represent two distinct dimensions. It also partly supports the idea of assigning the centrality of towns to their "size" or level of population. However, by revealing three aggregate components of centrality in conflict in the Cher, the best measure of centres' hierarchy will result from their respective positions upon these three centrality scales.

5. CENTRAL-PLACE SYSTEM IN THE CHER

This chapter is first concerned with the identification of a hierarchy of towns in the Cher. Its second objective is to analyze the arrangement of central places at each level of the hierarchy. In an attempt to combine criteria measuring both *relative* and *aggregate* importance of centers, 15 centrality indicators were selected and subjected to principal component analysis. The analysis provided satisfactory results from the standpoint that it condensed the 15 indicators into three factors or "dimensions" independent of each other:

1. The size of towns essentially characterized by population indices.
2. The functional status of towns.
3. The accessibility of places.

The first dimension clearly reveals the aggregate importance of towns whereas the third dimension indicates their relative importance. The second dimension associates both types of dominance. It includes direct quantitative variables such as the number of functions as well as relational indices such as the outer range or maximum distance travelled to reach centers, one of Christaller's major components of centrality.

These underlying dimensions of variance in the structure of the absolute importance of towns can then be used to discriminate between places and determine hierarchical levels of central places. To this end, centers were classified into homogeneous groups by means of a cluster analysis. Special attention was focused on ranking these groups. In particular, the role of the accessibility indices in the hierarchy of central places was closely examined. Finally, each level of central places was plotted by means of different symbols and trade areas were identified for each center of higher order.

5.1 Hierarchy of central places

Classical Central Place Theory [21] advocated the existence of a finite discrete hierarchy of central places considered by Berry as ". . . the generic base and single most important statement of Central Place Theory" [10, p. 146]. Since Christaller's discovery of seven levels of central places in Southern Germany, a number of geographers disproved the concept of a step hierarchy. Among them, Vining [107] and Davies [83] suggested that the distribution of towns is more accurately a continuum. Others, however, provided evidence that a hierarchy of central places does exist [10]. Generally speaking, most scholars neglected this problem when they conducted central place studies. Vining is certainly the one who expressed most clearly the idea that hierarchies identified by Central Place Theory may not exist ". . . the terms hamlet, village and town are convenient modes of expression; but they do not refer to structurally distinct natural entities" [107, p. 169]. Today, it seems that the question still prevails: are central places differentiated along a continuum or in a class-system? No satisfactory answers have yet been found.

This section will not definitively resolve the issue. On the other hand, it is a stated intention of this study to classify places into distinct classes. To this end, one of the assumptions of this study is that there exists a hierarchical class-system of towns. This study voluntarily rejects the idea of a continuum of central places, and rather than an exact method, the following scheme will be referred to as an approximate method for the derivation of hierarchies. It is recognized that the discriminating method proposed in this study is to a certain extent hypothetical and may represent a too rigid approach towards breaking down the continuum of central places into broad classes.

5.1.1 Grouping of towns

The grouping of settlements in the Cher may be discussed on the basis of the three principal components previously identified. To differentiate classes of central places, the towns' scores on these three components (Appendix) were examined and associated by means of a cluster analysis. The purpose of this technique is to compare a series of score profiles for every town. These score profiles are supposed to represent a thorough centrality image of each town belonging to the study area. Using the factor scores as coordinates, a distance grouping was carried out with a cluster analysis in order to classify centers. This clustering method permitted us to measure similarities between the 290 centrality profiles and to partition the corresponding places into homogeneous and compact classes (statistical groups).

The hierarchical classification was chosen over partitioning or clumping methods because it provides a concise summary of the inter-relations between the variables and shows the organizational structure of the data. Cluster analysis is a technique often used in biology, medicine and psychology to measure similarities and proximities among objects, and to classify them into optimally homogeneous groups. It represents a hierarchical classification of the data under the form of trees or "dendrograms" which enable us to visualize the inherent structure of the entities. This method rests on distance measurements between objects. In the present case, since the scale between variables is identical (scores on the factors), it was decided to use the euclidian distance between pairs of observations. The first cluster contains variables separated by the smallest distance. The objects contained in this cluster are then replaced by a summary measure such as their average, weighted average, centroid, or median. The procedure is then repeated and this sequence of events can be represented graphically by linking together the elements in a dendrogram. However, the choice of an appropriate summary measure may be a problem. It is not the objective of this sub-section to describe and evaluate each one of them, but rather, to focus on explaining the measure that was chosen.

A systematic study was executed on a large-scale basis by Milligan [97] using a Monte Carlo approach. Milligan tested all measurements of similarity by simulation and determined that the group average method is 0.998 error free and is the most reliable. Sneath [105] compared the three most popular methods of similarity. Among the single, complete and group average linkages, he gives preference to the group average method. For his testing, 20 points A to T were marked in a square grid with sides of 100 units. This matrix was then clustered by the three methods, and the results showed that the cluster with group average gives the best representation of the original distance between a pair of objects to be clustered. Following this discussion, the method selected was directed toward the group average method. This technique was conceived by Sokal and Michener [106] in 1958 so that the merging of two clusters depends upon a single similarity value, the average distance between pairs of observation. The basic feature of the group average method is that it gives equal weight to the elements when calculating the distance between two clusters.

The principal weakness of hierarchical methods is that it is difficult to decide which clusters are significant. The identification of homogeneous groups of objects remains subject to the user's own appreciation. One of the possible way to isolate clusters is to state that all links higher than a certain distance should be cut. Figure 5.1 indicates the links between the 290 towns of the Cher based on the analysis of 15 centrality indicators. The limit is set at eight, and five clusters can be observed. These five groups of towns were numbered from one to five according to the number of towns embraced by each of them. Group one includes a small number of centers whereas 174 settlements are included in the fifth group. It is important to note that these five groups of towns cannot be ordered from the simple analysis of the dendrogram shown in Figure 5.1. In fact, the cluster analysis reveals five homogeneous groups of towns in the Cher, but does not indicate the hierarchy of centers. However, as a general rule, the link levels of higher order centers will tend to occur at lower levels of homogeneity and the distance separating their linkages should be higher. The first group includes only two towns, Bourges and Vierzon. These towns are the most populated settlements of the Cher with populations of 76,432 and 34,209 respectively. In the hierarchical tree shown in Figure 5.1, the distance level separating this group from the remaining four is exceptionally high. The high rescaled distance (24) outlines an important gap between the two centers and the remaining towns. As far as centrality is concerned, it is obvious that the first group of towns represents the highest order class of centers in the Cher. Classifying the remaining groups remains a difficult task since the dendrogram does not indicate important heterogeneity between their linkages. Attention is now focused on the classification of these four groups of centers.

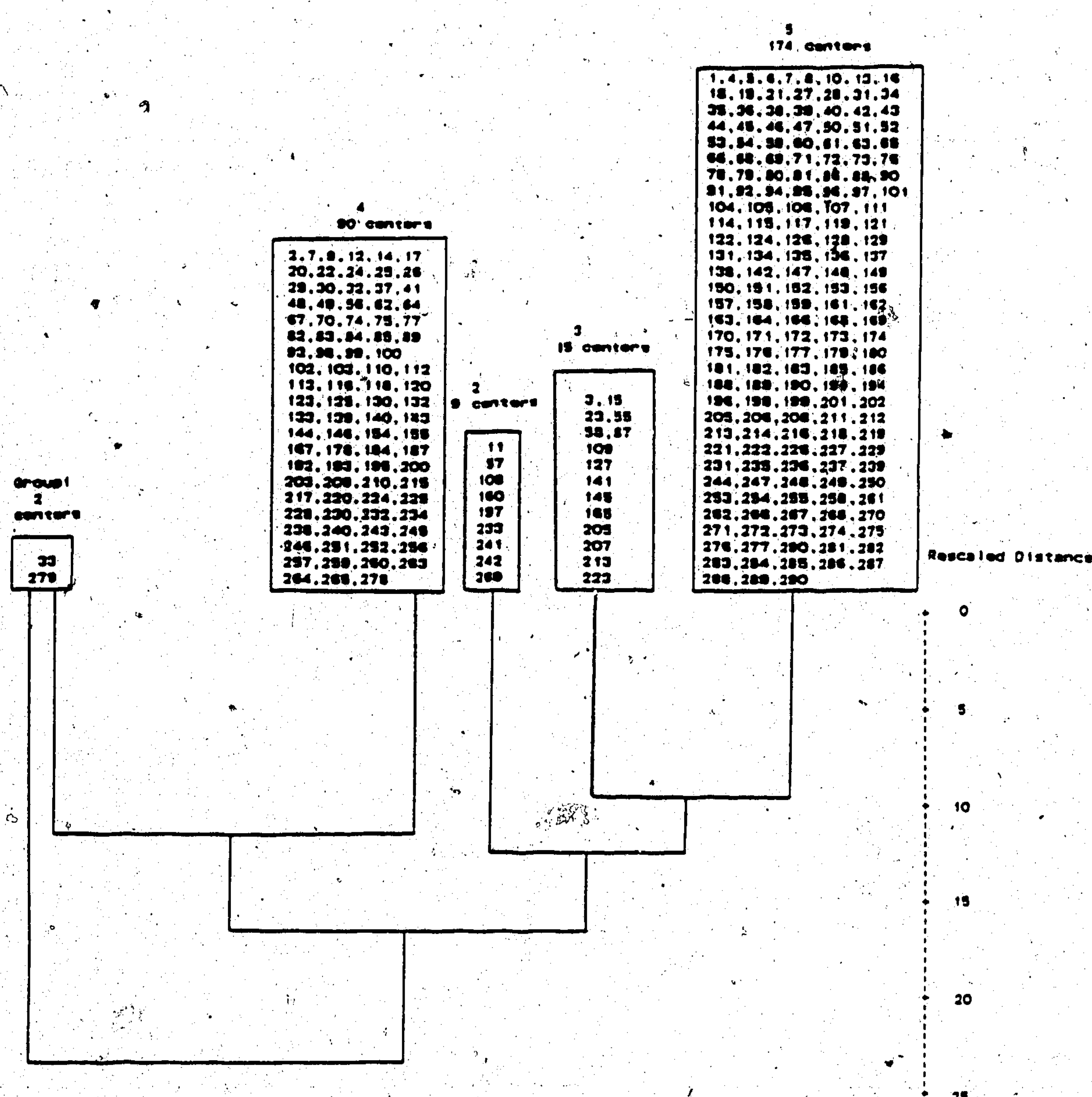


Figure 5.1 Simplified relationship between places in the Cher. (adapted from a group average clustering analysis)

5.12 Group-ranking procedure

In his study in southern Germany, Christaller used an explicit ranking procedure. He simply ranked the centrality indices extracted for each town from their number of telephone connections and their population. In contrast, his grouping method is unexplicit and rests on pure mental estimation. The relevance of the class-order of centers thus obtained is nonetheless confirmed with criteria such as population, number of telephone connections, number of places as well as average range and area of trade areas. For the seven levels of centers found, Christaller noticed a regular decrease of these values from the higher order to the lower order levels of centers.

In the Cher, Table 5.1 shows a remarkable distribution of centers close to the K=3 Christallerian sequence. However, the mean population for each level of centers listed in Table 5.2 contradicts the idea of a five step hierarchy. Both group 2 and 3 have similar mean populations of 3,402 and 3,447 respectively. The same situation occurs with group 4 and 5. Both groups have a mean population of 484 and 480. A clear population drop-off may be observed between group three (3,447) and group four (484). Obviously population alone does not suggest the expected pyramidal hierarchy of centers. Instead, three main population levels can be observed and the examination of mean population does not confirm the partition of towns into five groups but rather into three.

An alternative method to rank the groups of towns is to analyze their centrality profiles. Centrality profiles account for the mean values of selected centrality indices by plotting them in a graph. In this case, eight centrality indices were retained:

1. Number of establishments.
2. Number of functions.
3. Average number of establishments per function.
4. Population.
5. Nucleated population.
6. Population density.
7. Hinterland population theshold.

Table 5.1 Regional system of centers in the Cher.

Groupings of places	Theoretical number of places when K=3	Theoretical number of places when K=4	Actual number
5	162	768	174
4	54	192	90
3	18	48	15
2	6	12	9
1	2	3	2

Table 5.2 Theoretical and actual population of centers in the Cher.

Groupings of places	Frequency in %	Theoretical mean population	Freqency in %	Actual mean population
5	2.	2,000	.87	480
4	4.	4,000	.88	484
3	10.	10,000	6.20	3,447
2	30.	30,000	6.10	3,402
1	100.	100,000	100.00	55,320

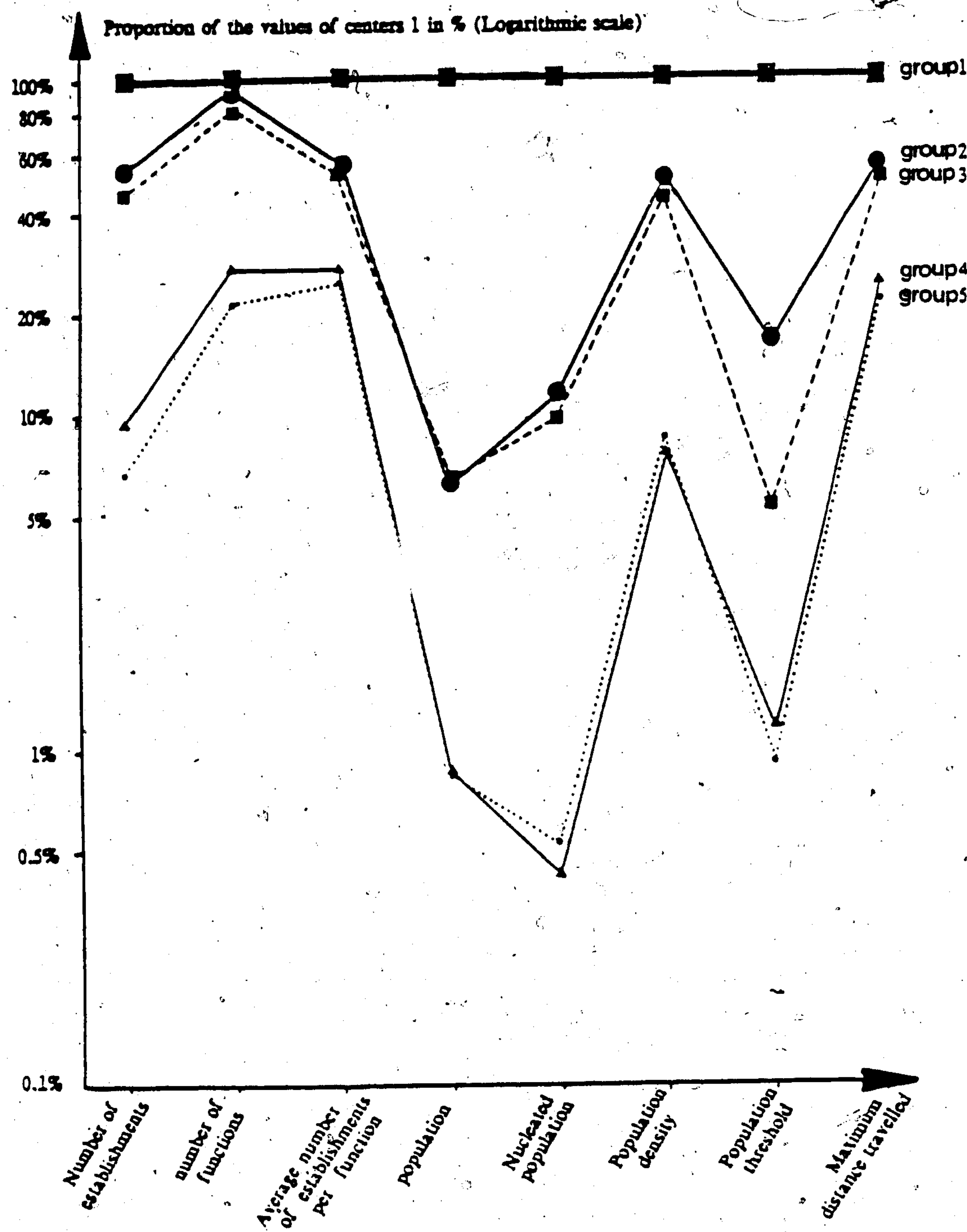


Figure 5.2 Centrality profiles in the Cher (based on mean values).

8. Maximum distance travelled to purchase in a center.

Both centrality ratios and accessibility indices were excluded from the analysis of centrality profiles. Accessibility indices are scaled differently and their inclusion would have adversely affected the clarity of the outcome. The eight average values of the first group of centers (Bourges and Vierzon) were calculated and kept as a base reference. These eight values were arbitrarily set at 100%. The differences between these reference values and the eight values found for each successive group were then evaluated and recorded as percentages. These deviations are reported in Figure 5.2 by using different symbols for each group of towns. Straight lines joining these symbols display five curves showing the centrality profiles of centers in the Cher. The profile of the first group of centers is represented by a straight line since all values found were set at 100%. The four next curves reveal the centrality disparities between the two head-towns, Bourges and Vierzon, and the remaining four groups of centers.

In the Cher, the centrality profiles clearly disapprove the partition of towns into five distinct groups. However, they do confirm the three-step hierarchy suggested by the population group averages. The profiles of groups two and three are similar. The only deviation between the two curves occurs when hinterland population thresholds are considered. The second group of towns has an average threshold of 10,969 whereas this threshold drops to 3,665 for the third group. Although their mean population and average functional importance are identical, the second group of centers offers functions of a higher order that serve a larger population. Functions such as notaries, veterinarians, clothing stores and shoe stores are mainly found in group two and rarely supported by the third group of towns. However the presence of such functions is not the main reason for the high average threshold found in group two. In fact, by looking at the original data matrix, it was easy to verify that this average was distorted by an outer value associated with social security offices. In Chapter three, social security offices were classified as the highest order function in the Cher with an exceptionally high hinterland population threshold of 67,710. The impact of this service is very important in France which still relies on a social system created in 1936 by a socialist government (Front Populaire). Important services such as health care, governement welfare and unemployement security are all centralized in social security offices and the French social system heavily relies on these institutions. In the Cher, three social security offices span the whole county's population. One of them is located in Saint Amand-Montrond, one of the nine towns belonging to the second group. Since the threshold of centers was determined by the threshold of their highest-order function, Saint Amand-Montrond was tallied with a threshold of 67,710. This high value distorted the average found for the second group of towns. When Saint Amand-Montrond is retrieved from group two, the average threshold drops to 3,876 which is very close to the average obtained for group three (3,665). Basically, as far as hinterland population thresholds are considered, Saint Amand-Montrond is an exceptional case and, when removed, both group two and three have similar centrality profiles.

Figure 5.2 also reveals identical centrality profiles for groups four and five. Moreover, it indicates important gaps separating the first and the second as well as the third and fourth groups. These centrality profiles do not expose five distinct classes of centers as suggested by the cluster analysis. Instead, they yield a definite three-step hierarchy of centers in the Cher. However, one should not doubt the five-step structure outlined by the cluster analysis since all centrality indices were not included in the centrality profile analysis. In particular, for the sake of clarity, the accessibility indices were neglected although they represent a separate centrality dimension in the Cher. On the other hand, the cluster analysis dealt with the 15 centrality indices. Therefore, it can be predicted with confidence that the discriminant factors between groups two and three as well as between groups four and five are the accessibility indices.

5.2 Accessibility and hierarchy of central places.

When selected for this study, accessibility indices were assumed to represent an adequate measure of the *relative importance* of towns as defined in Chapter 1. In the literature dealing with central place analyses, several other criteria have been used to measure the degree of interactions between centers and respective tributary areas. Commonly found in past

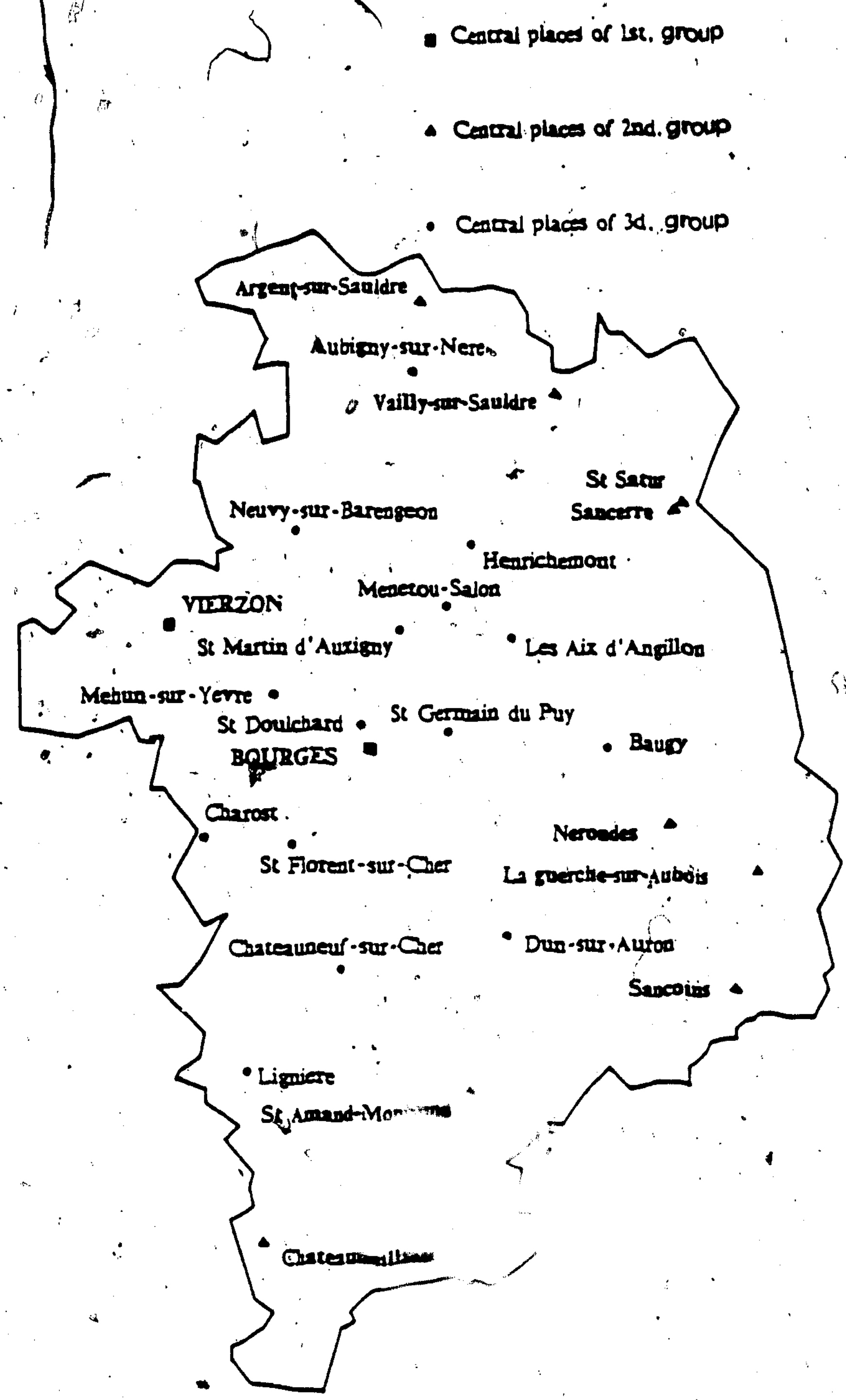


Figure 5.3 Location of the first three groups of centers in the Cher.

empirical studies are the number of telephone connections, bus lines or air passenger linkages. Most studies used flows of commodities between centers and rural settlements surrounding them when attempting to define the relative importance of towns. The present study aims to find a simpler way of identifying the relative importance of towns by using data readily available. Under the assumption that the connecting transport routes are related to the flows of commodities shipped from one place to another, one way to approach the problem was to analyze the road network of the Cher. With several shortest-path measures, the nodal accessibility was calculated for the 290 places present in the Cher. Accessibility indices were assumed to be satisfactory indicators of the relative importance of towns and thus to reflect the structure of towns in the Cher. This assumption was supported by different studies. One of them conducted by Kansky [93] showed satisfactory correlations between the structure of transportation networks and the economic characteristics at a state and county level in the United States. However, accessibility indices were not popular in central place studies and few geographers attempted to include them in their centrality models. The objective of this section is to test the validity of accessibility indices for measuring the relative importance of towns in the Cher.

5.2.1 Role of the accessibility indices in the grouping procedure.

In order to verify the effects of the accessibility indices in the grouping process, it was decided to examine these measures for the groups of towns that were not discriminated by the centrality profiles. The two main accessibility measures[7] were correlated for groups two and three as well as for groups four and five. The results plotted in Figure 5.4 and 5.5 show a strong organization of the data points into two distinct groups. Figure 5.4 indicates disparities between group two and three in terms of accessibility. The towns belonging to the third group are clustered with low accessibility values as opposed to those belonging to group two, clustered with higher accessibility values. As a result, the towns belonging to group three are

[7] Accessibility index 1 is the length of the longest shortest path between a town "A" and the remaining towns of the network. Accessibility index 2 is the sum of all the shortest paths linking a town "A" to the remaining towns of the network.

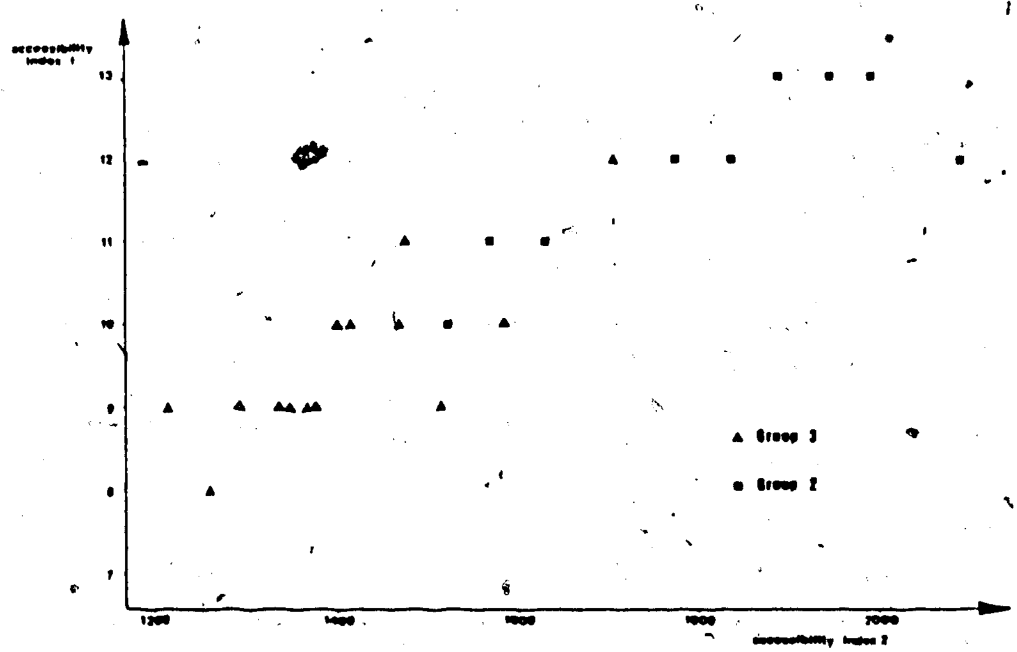


Figure 5.4 Accessibility indices for groups 2 and 3.

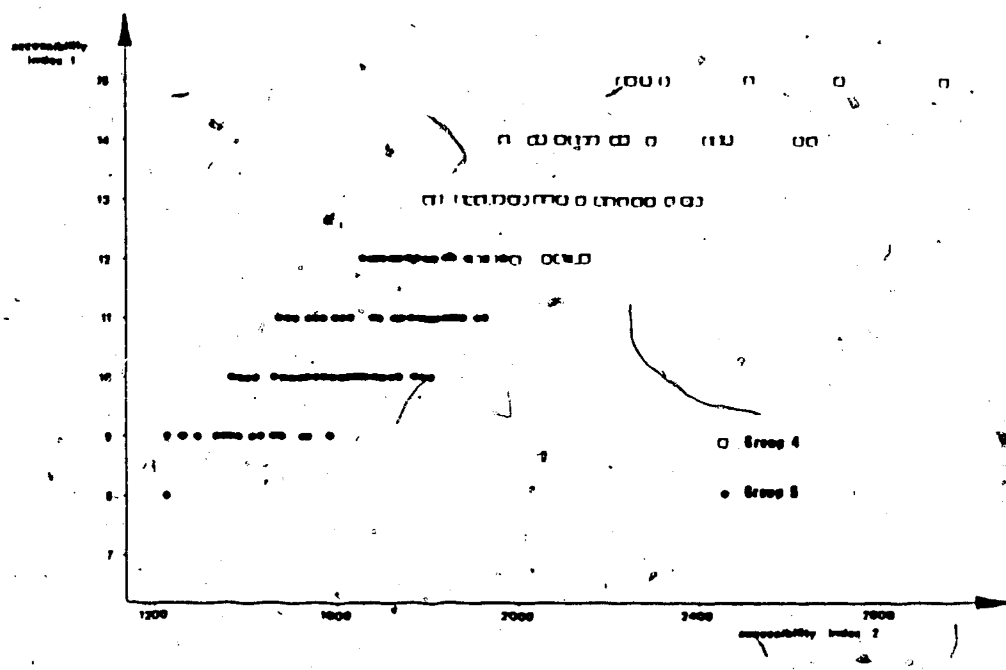


Figure 5.5 Accessibility indices for groups 4 and 5.

clearly more accessible than those belonging to group two. A similar accessibility divergence may be observed between groups four and five. Figure 5.5 outlines towns belonging to group five clustered with low accessibility values whereas those belonging to group four have higher values. Towns belonging to group five are therefore more accessible to the network than those belonging to group four.

Accessibility indices oppose groups two and four (poorly connected to the network), to groups three and five (more accessible). From the standpoint of these two graphs (Figures 5.4 and 5.5), it is clear that groups two and three as well as groups four and five were discriminated by cluster analysis merely in terms of their nodal accessibility. From now on, the partition of the 290 towns present in the Cher into five classes makes sense. How relevant are these groupings of centers in the context of a central-place analysis? To answer this question, it is necessary to test the assumption that accessibility indices are a function of the relative importance of centers in the Cher. In short, the problem is to know whether the nodal accessibility of towns may be considered as a hierarchy factor.

5.2.2 Problems related to the use of accessibility indices

In the Cher, the analysis of centrality profiles (Figure 5.2) and accessibility indices (Figures 5.4 and 5.5) showed no relationships between the economic status of towns and their accessibility. In contrast, the groups of towns with opposed accessibility indices belong to the same hierarchical group and vice versa. This result totally contradicts the idea of nodal accessibility standing as a factor of hierarchy, where towns of a higher order should also be more accessible. In theory, the concept of a positive relationship between the accessibility and the importance of towns should prevail. In the Cher, empirical research showed that, in fact, the two phenomena are independent. It is now our intention to seek the reasons for such deficiencies.

The mapping of the five groups of towns provides a precise idea of the actual role of the accessibility indices as centrality components in the Cher. Figures 5.6 to 5.9 show a strong organization of the particular groups of towns in different concentric zones surrounding

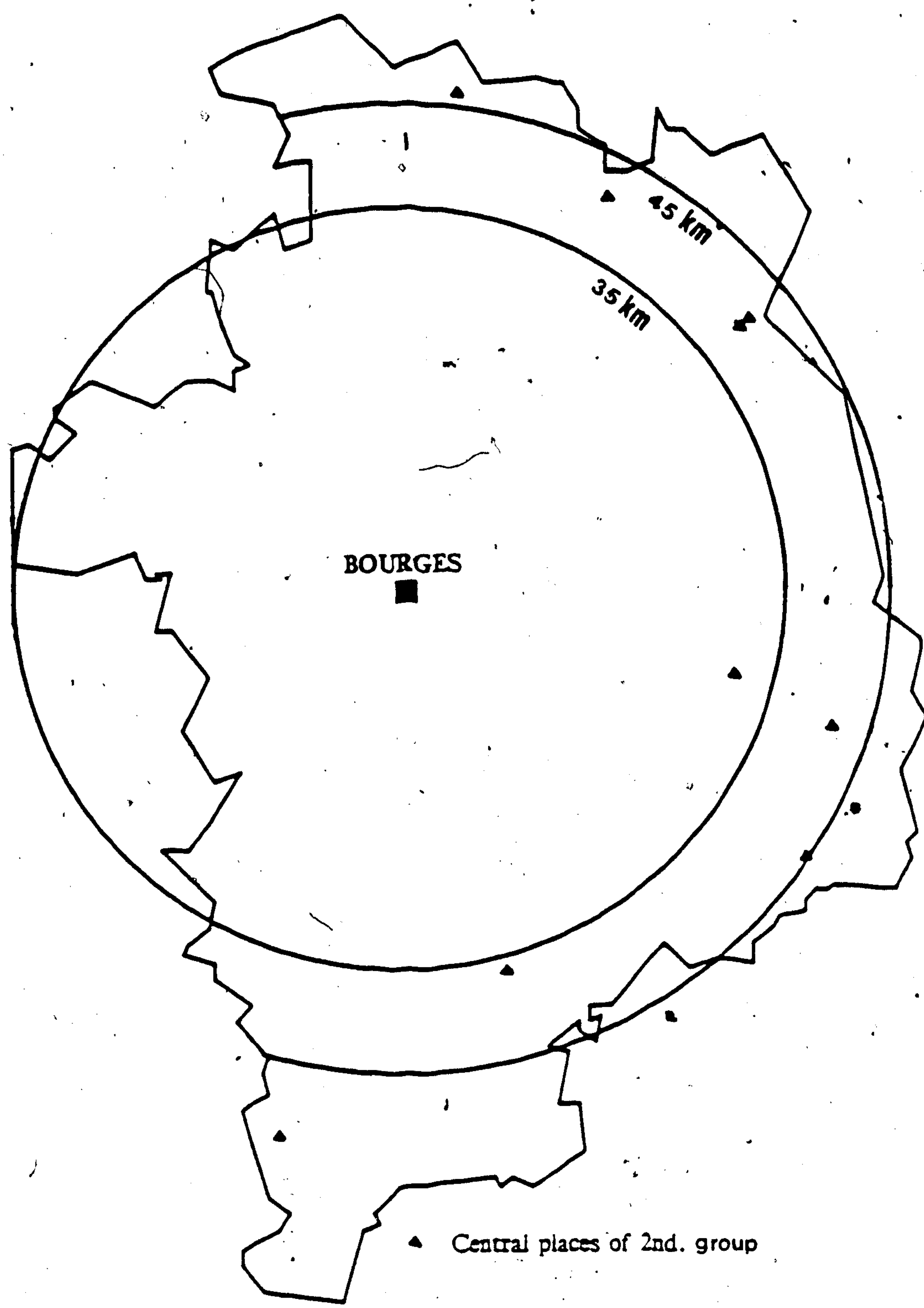


Figure 5.6 Circular pattern of the second group of centers in the Cher.

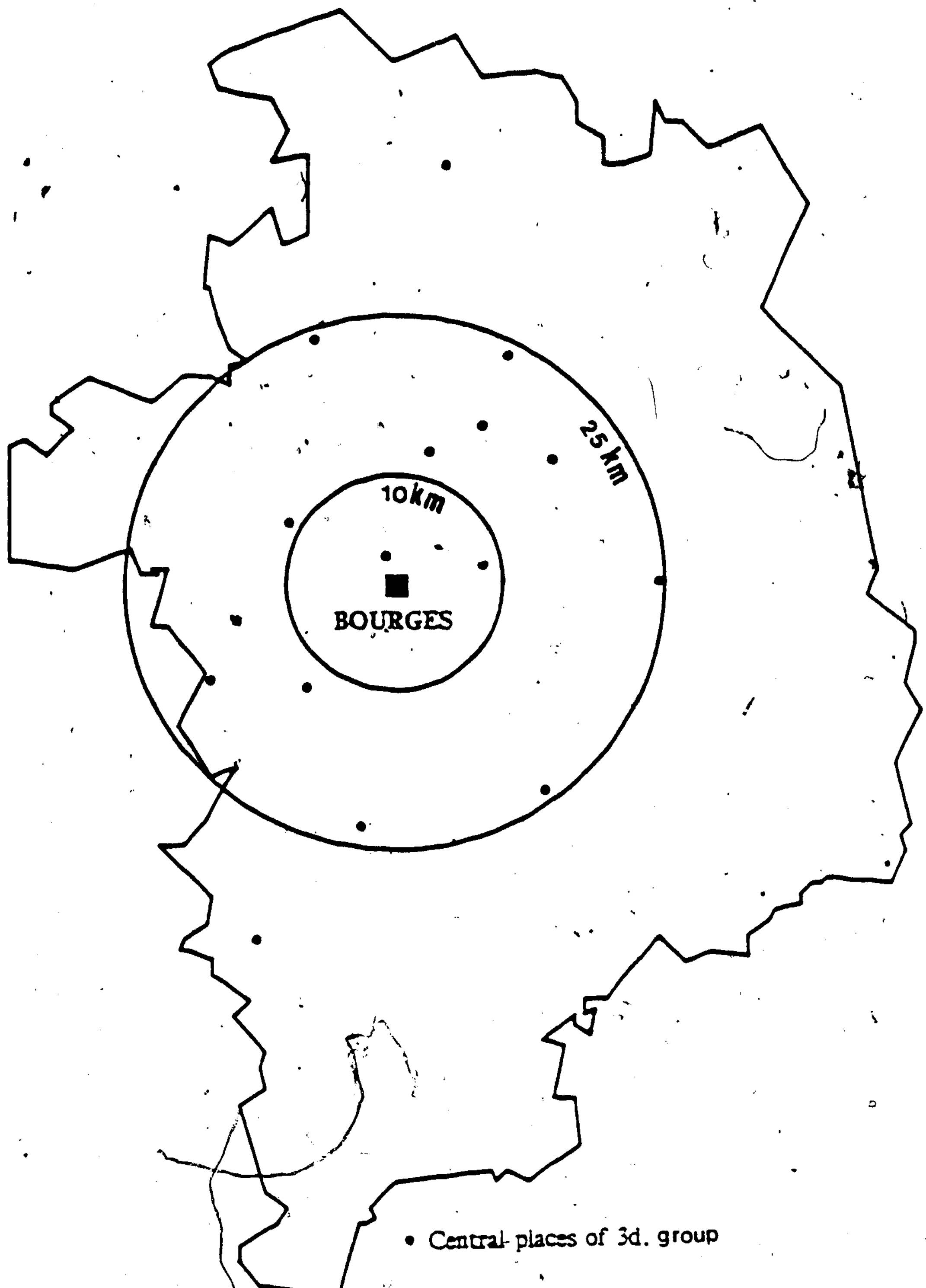


Figure 5.7 Circular pattern of the third group of centers in the Cher.

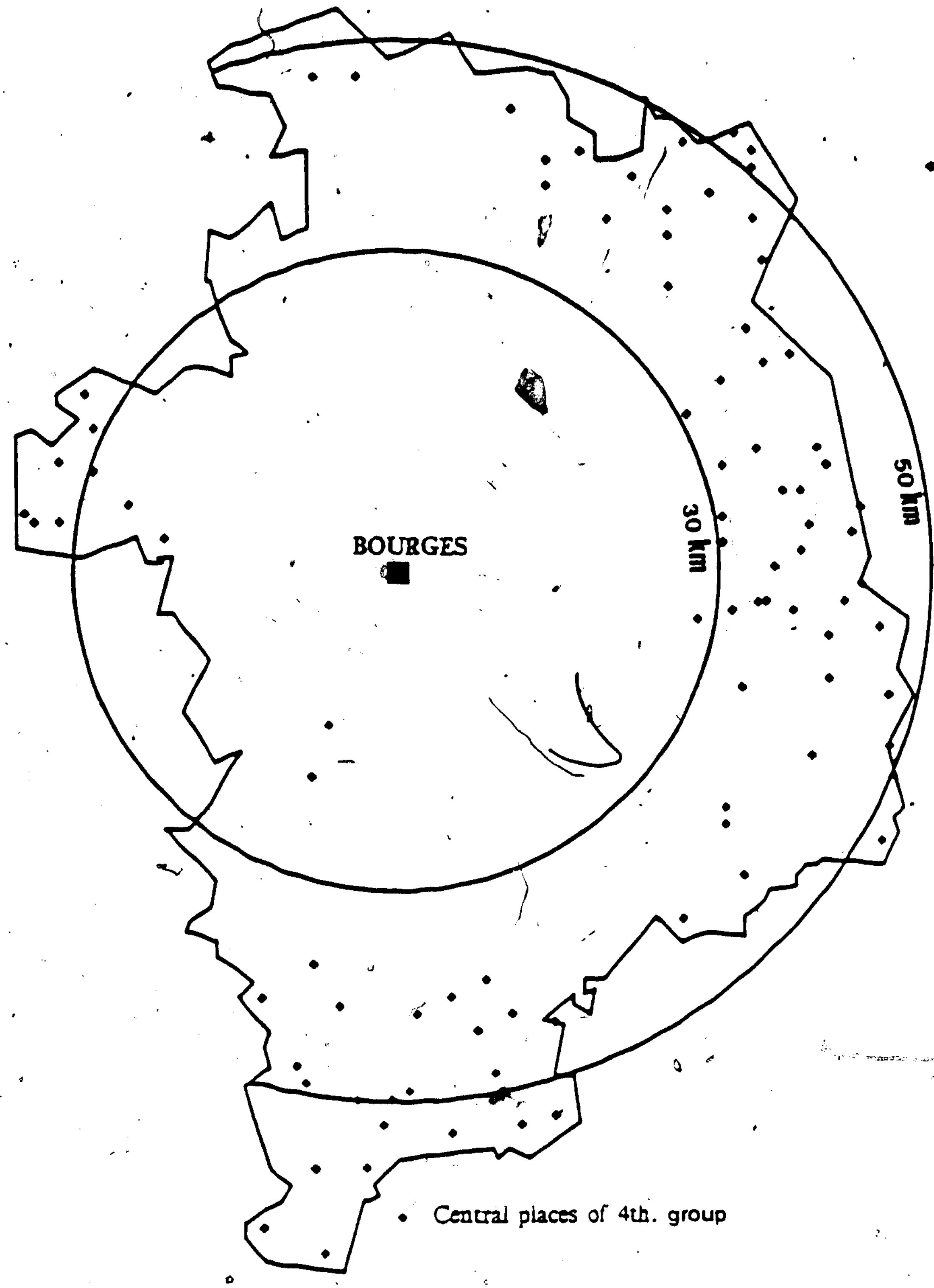


Figure 5.8 Circular pattern of the fourth group of centers in the Cher.

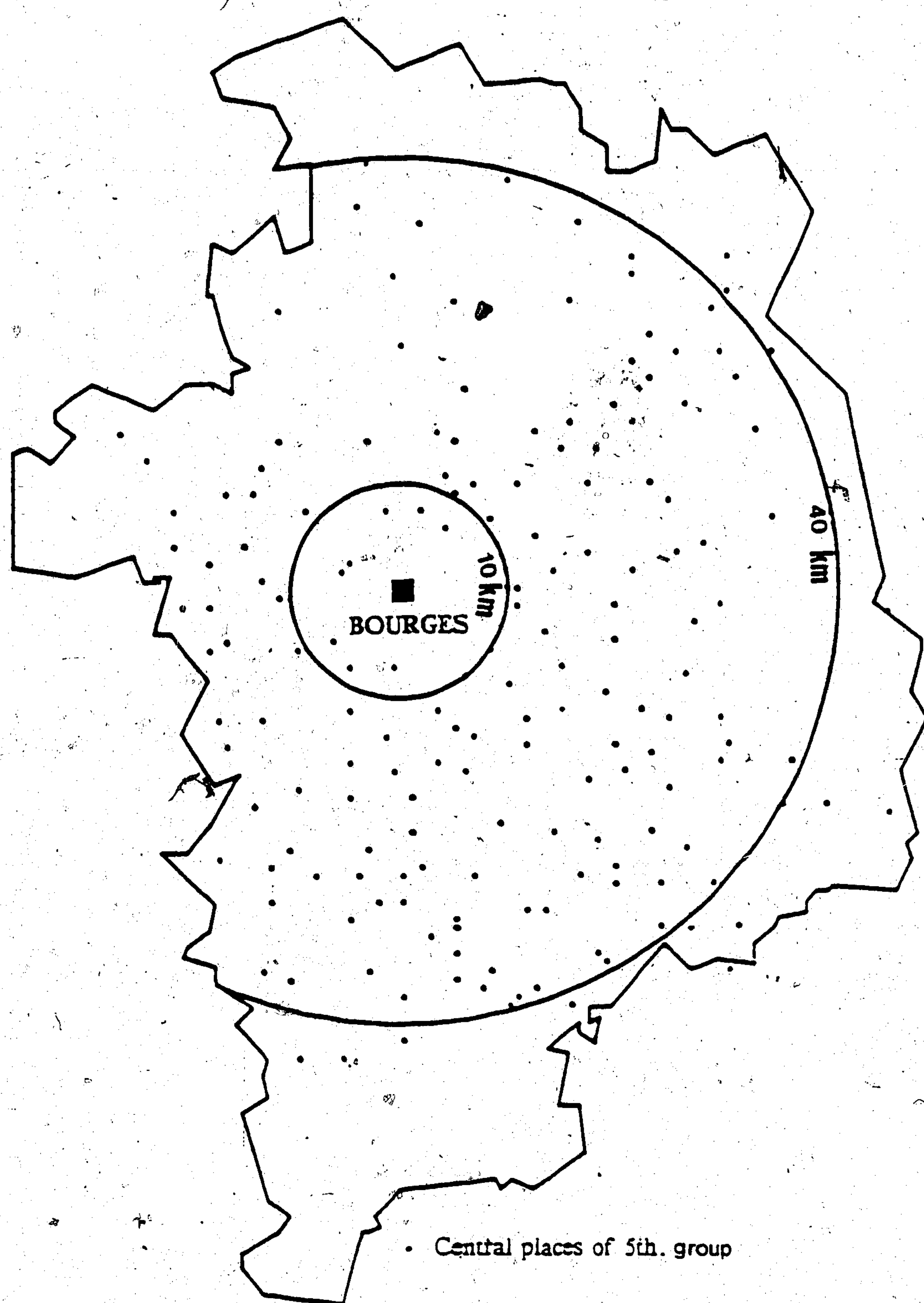


Figure 5.9 Circular pattern of the fifth group of centers in the Cher.

Bourges. The centers belonging to the second and fourth groups are mainly located in remote zones. For instance, more than 75% of the centers belonging to the second group are located in a circular zone comprised of a radius varying between 35 and 45 kilometers from Bourges. Similarly, most of the centers that belong to group four are located in a circular zone 30 kilometers away from Bourges. On the other hand, groups three and five are less remote. Figure 5.7 shows that most of the towns included in the third group are located in a circular zone with a radius varying between 10 and 25 kilometers from Bourges. Figure 5.8 also reveals that most of the towns belonging to group five are included in a circle whose circumference is 40 kilometers distant from Bourges. In short, the least accessible towns (group three and five) are located in remote areas. The most accessible towns (group two and four) surround Bourges in a more central zone.

Accessibility indices seem to reflect remoteness rather than the relative importance of centers. This idea is confirmed when correlation coefficients are calculated between the towns' accessibility and the distance separating them from Bourges. The correlation coefficients obtained vary between 0.66 and 0.76, showing a significant positive relationship between the nodal accessibility of towns and their remoteness. Important towns located in the margins of the county may be considered as not very accessible. Small hamlets located in the center of the county may then be considered as very accessible. In the Cher, accessibility indices primarily stress the "centralness" of the towns to the entire network. Accessibility indices do not seem to relate to the structure of central places but rather to their position to the network.

In fact, if the study was limited to the central part of the county, it seems that these accessibility indices would indeed relate to the structure of towns. However, problems tend to arise with towns located on the margins of the study area. Since they are mainly connected with towns belonging to adjacent counties, these towns are recorded as not very accessible although they may be important. Nodal accessibility measures are therefore subject to a boundary problem and do not represent a perfect measure of the relative importance of marginal towns. In theoretical cases such as those of Christaller [21] or Lösch [40], infinite planes were assumed and the boundary problem was thus avoided. However, in empirical research, boundaries and their effects cannot be avoided. In the Cher, Figure 5.3 shows several important towns located on its margin (i.e. Sancerre, St Satur, La Guerche sur Aubois, Sancoins, Chateaumeillant). Their major connections are with towns located across the boundary outside the area of interest. By considering only towns within the boundary, results are biased. If, on the other hand, towns across the boundary are considered, the definition of central-place system becomes suspect because towns that do not belong to the Cher system of central places are incorporated. One solution may be to include towns located in a limited zone around the boundary. But problems arise when the size of this zone must be determined. The lack of alternative solutions may simply imply that network theory is not suited to small bounded areas like the Cher. The problem becomes one of knowing whether or not one should reject accessibility indices as adequate measurements of centrality.

Nonetheless the idea of accessibility measures seems to be valid if the region under investigation is an isolated system. Obviously, the fact that administrative boundaries exist does not mean that the Cher is an isolated system. The dense road connections separating marginal towns such as Sancoins or Sancerre with towns across the boundary indicate that in fact, these towns may be very accessible within an area that largely overlaps the next county. Since they neglected connections with external towns, the accessibility indices did only measure partial accessibilities. The Cher was arbitrarily assumed to be a closed system whereas in fact, the Cher is an open system which has definite administrative boundaries accross which sets of towns are related through network connections.

The validity of measuring the towns' relative importance by means of their nodal accessibility lies in the assumption that the Cher system of roads is an isolated network. The above discussion revealed that boundaries interfere with dominance arrangements. Rather than confirming the underlying hierarchical structure of places, the accessibility indices disclose rearranged dominance patterns. Based on graph theory, these topological measures evaluate the centrality or remoteness of any places and ranks them according to their access to other places. With an imposed administrative boundary that truncates the road network, these measures redefined the centermost places in the regional system. The difficulty of measuring the relative accessibility of marginal towns raises acute problems of zonality in the outcome. In the Cher, the second and third as well as the fourth and fifth group of towns were disassociated merely on the basis of their centrality or remoteness to the Cher network. Their patterns in definite circular zones is then simply an artifact opposing central to marginal places. In this case, the imposed administrative boundary distorts the outcome so that accessibility indices do not reflect the underlying hierarchy of centers but rather their remoteness.

Although major deficiencies were found with nodal accessibility indices applied to a small administrative unit, the accessibility of towns may remain a good index of their relative importance. New measurements more suited to bounded areas that estimate the nodal accessibility of places within market areas rather than to the entire network should be explored. That is not the goal of this study and, in the Cher, topological measures based on graph theory appeared to be poor measures of the structure of central places. This deficiency enabled us to reunify group two and three as well as group four and five in two distinct class-order of [illegible]al places.

In the Cher, the central places were classified into three levels of hierarchy. With an average population of 55,320, the first level includes two units, Bourges and Vierzon, and was renamed "Regional Towns". The second level of central places embraces a variety of smaller towns with a population vaying between 856 and 12,451. This order of centers contains 24 places and was renamed "Country Towns". The remaining 264 places form the third level of central places in the Cher. Despite its large number of towns, this class-order is homogeneous. The population of towns slightly varies around the mean population of 482. Level three was renamed "Rural Settlements".

5.3 Market areas in the Cher.

Up to this point, the main emphasis of the investigation has centered on the establishment of a hierarchy of central places in the Cher. According to central place analysis, service areas should be hierarchically arranged in a parallel fashion so that hinterlands of lower order centers are included as components of higher order hinterlands. It is the objective of this section to test the market system in the Cher. Finding local market areas within the regional system of the Cher introduces the problem of identifying hinterlands. In research literature, several deductive methods were commonly used, among them, one simple method was selected and applied to the Cher:

1. Proximal method: Thiessen Polygons.

Apart from several hypothetical methods, past empirical studies were not very successful in finding appropriate quantitative techniques to identify market areas. As a result, the best method available today is to conduct a questionnaire survey asking questions on the spatial behaviour of consumers. In the second part of this section, an attempt is made to find a meaningful statistical device in order to determine market areas for the three class-order of centers in the Cher.

5.3.1 Proximal model.

A simple method of identifying complementary areas makes use of a wholly geometrical procedure in delimiting their boundaries. This method, referred to as Thiessen Polygons, is simple and fully respects the principle of least effort assumed in classical Central Place Theory. Considering the pattern of towns of second order, the question is: "how can we apportion the area of this map into regions about each center so that every location in a region is nearer to that region's center than to any other center?"

The construction of Thiessen polygons is simple although time consuming. Each center is joined to its neighboring centers; these lines are then bisected vertically; the bisectors meet in threes or terminate at the border of the area and, hence, define a set of hinterlands. Under the assumption that a town dominates all of the area that lies geometrically nearest to it, the application of this method to the Cher area yields the pattern of complementary regions shown in Figure 5.10.

It is interesting to notice that the Thiessen Polygons found in the Cher vary from Christaller's hexagons. Their shapes are not geometrically significant and do not reveal a

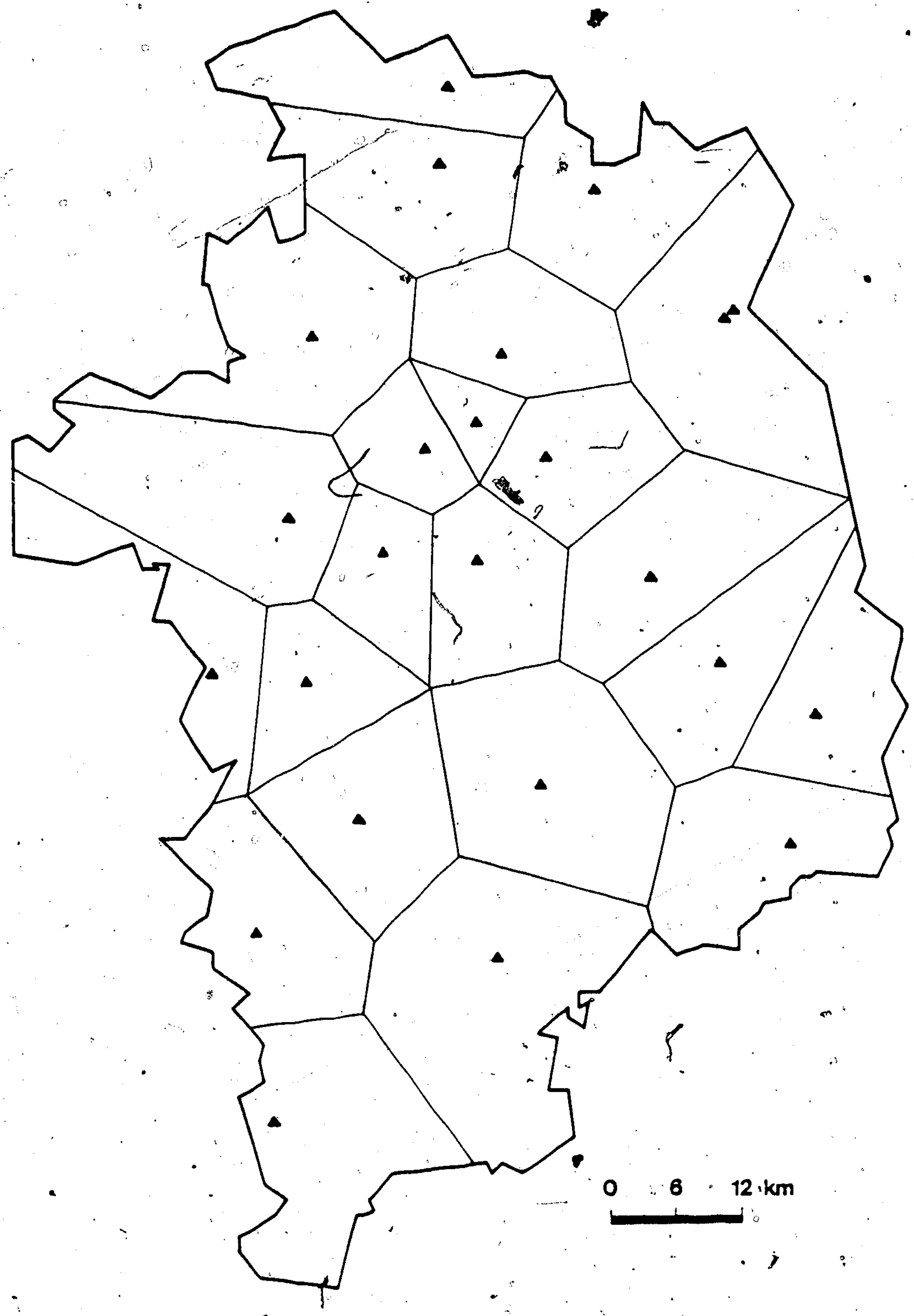


Figure 5.10 Thiessen Polygons for second-order centers in the Cher.

regular lattice of central places of second order. The size of the market areas differ. Market areas tend to be smaller in the center of the county and become larger in remote areas. Figure 5.10 clearly demonstrates the increase in size of complementary regions with distance from the larger city (Bourges). This finding supports Isard's [92] contention that market areas increase in size with distance from a city in any direction. For instance, the complementary areas of St. Martin d'Auxigny, St. Doulchard or les Aix d'Angillon are small compared to those of Mehun sur Yevre or St. Amand Montrond that extend to the administrative boundary of the county.

However, the market areas of marginal towns may be excessively large due to a boundary problem which may therefore represent a practical limitation on Thiessen Polygons. Moreover, defining nearness solely in terms of straight distance may lead to real distortions. Thiessen Polygons only consider the effect of distance on the location of a trade boundary between competitors but do not account for the importance of centers. The results obtained in the Cher show a system of perfect competition between centers which implies a perfectly inelastic demand and the transportation costs are assumed to be equivalent for any directions. It is therefore difficult to use this method to estimate the spatial efficiency of each settlement as a source of service.

5.3.2 Empirical model

In the past, apart from questionnaire surveys or studies of commodity flows between places, few attempts were made to find an appropriate quantitative method for identifying urban hinterlands. Rather than deductive methods that hypothesize the level of interactions between centers, this sub-section offers an alternative way to determine hinterlands. The method proposed mainly relies upon the *outer range* of functions as defined in Chapter 3. The outer range of a function "F1" corresponds to the maximum distance travelled to patronize it. This distance was estimated under the rigid assumption that consumers always patronize the closest center when the service desired is not performed in their own town. This outer range was first calculated for each of the 48 functions chosen for this study (see Table 3.1). In the

Cher, the range of a town was then assigned to the outer range of its highest-order function. This range was an ideal summary measure of the relative importance of towns that could easily be compiled with other centrality indices, through principal component analysis, to yield a hierarchy of central places. However, it is not meaningful to use the longest distance travelled by any one customers as the radius of complementary areas, in a small rural area like the Cher. The result would then consist of an unclear pattern of overlapping arcs so that it would be impossible to recognize distinct market areas. Instead, it seems necessary to seek a more intermediate measure.

Whereas a questionnaire automatically reveals which places the local population regards as centers, this is not the case with outer range measures. In fact, a center can not theoretically be characterized by one single complementary area, but rather by a number of complementary areas corresponding to the different types of services offered. Every single function has a territory of its own, and these territories do not coincide. Market areas can be vizualized as a series of concentric demand zones surrounding the central town, each corresponding to a particular commodity or service. Lower order services possess a limited demand zone since they are ubiquitous, and the distance travelled for them is generally short. Their complementary areas may be referred to as "low order complementary areas", and their boundaries should not extend far beyond the limits of the city. These limits may even be comprised within the city's own limits for services of very low order. However, intra-urban marketing structures were neglected by most central place studies. At the other end of the scale, higher order services have larger complementary areas that expand outward from the center. Higher order complementary areas overlap similar areas of other centers. For any market analysis, the problem becomes one of knowing what type of complementary area to consider, and whether or not it is possible to describe generalized, composite trade areas for different grades of centers. As mentioned above, the selection of high order complementary areas would hamper the clarity of the outcome. On the other hand, low order complementary areas may be of little interest, especially for high order centers. Is it possible to find an "average" hinterland well suited to the three class-order of centers present in the Cher?

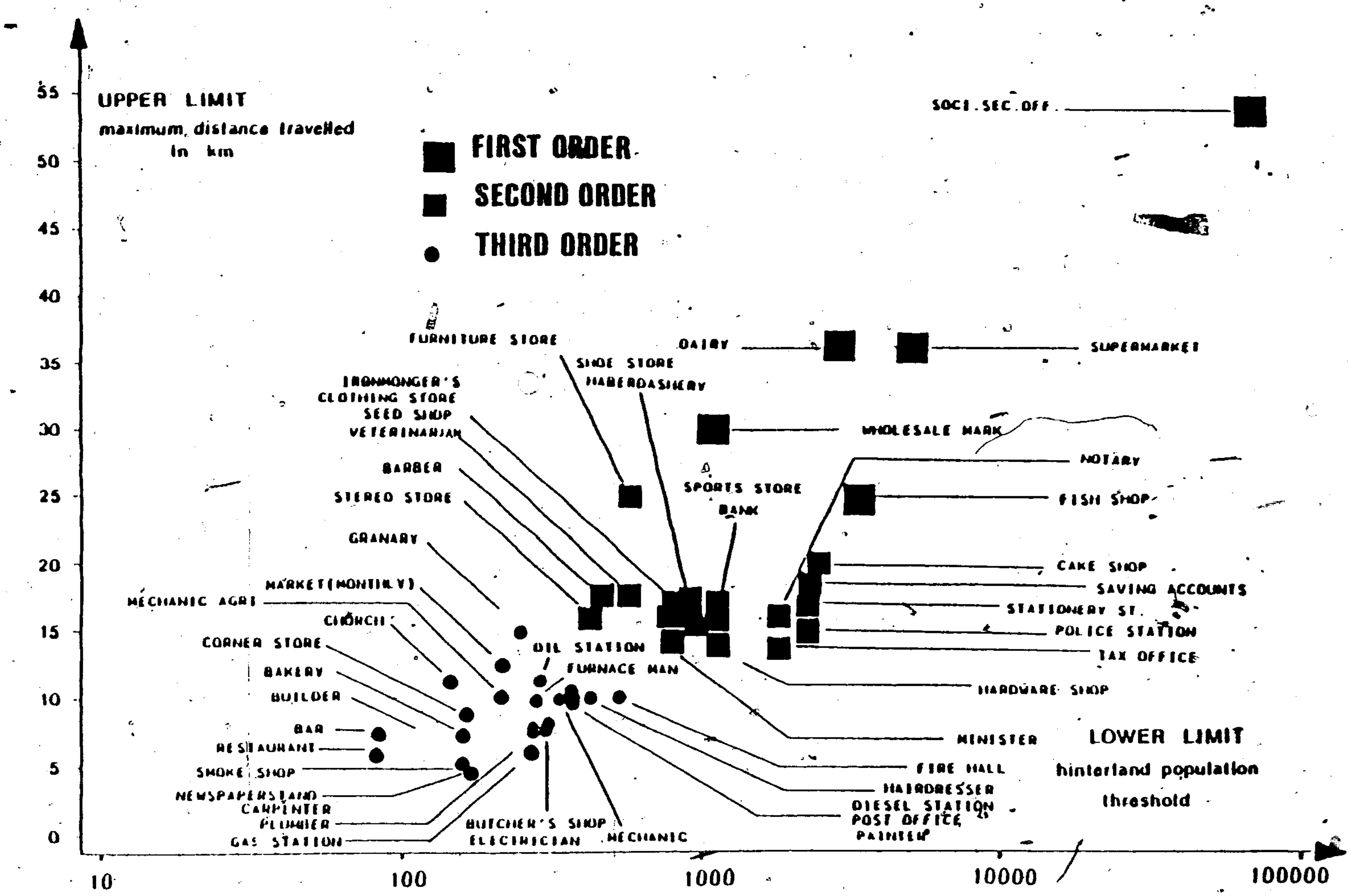


Figure 5.11 Class-order of functions in the Cher.

One solution to this problem starts with the definition of functions that best represent the three class-order of centers in the Cher. The hinterland measure is then based on the outer range of these particular functions. One of the tenets of Central Place Theory is that centers of each higher order perform all the functions of lower orders as well as carrying on a set of central functions that differentiates them from the lowest order centers. Following this idea, in the Cher it should be possible to outline specific functional orders that reflect the centers hierarchical order. To this end, it was decided to rank the 48 functions by plotting their outer range against their inner range.[1] The resulting plot shown in Figure 5.14 clearly reveals three orders of functions in the Cher. The first-order functions, namely, social security offices, supermarkets, dairies, fish shops and wholesale markets are merely performed by first-order centers and are not offered in most of the remaining places. The average radius of their hinterland is 36 kilometers and they serve an average threshold of 16,500 inhabitants. The second-order functions include a much greater variety of services such as veterinarians, barbers, banks and police stations. This group also embraces urban retail trades such as clothing stores, furniture stores, sports stores, stationery stores and cake shops. The average range of these activities is 17 kilometers and they serve an average threshold of 1,193 potential customers. These facilities are mainly characteristic of the intermediate group of towns, the country-towns. Finally, the third-order functions are mainly rudimentary retail trades (bars, gas stations, bakeries, grocery stores) and tradesmen professions (builders, plumbers, carpenters, electricians). In the Cher, these functions are ubiquitous since they serve an average threshold of 260 inhabitants and their average range is only nine kilometers. These functions are best represented in rural settlements.

Once specific orders of functions have been found, it is possible to describe generalized trade areas for each grade of centers in the Cher. The average market areas of the two regional towns may then be identified by the average catchment area of the first-order functions. Whenever one of the first-order functions is performed by the center, the

[1]The outer range is the maximum distance travelled by consumers when the service is not offered in their own town. The inner range is the minimum hinterland population required to support a particular service (threshold of hinterland population).

function's outer range is added up. This operation is carried on for the five functions belonging to this group. The sum thus obtained is divided by the total number of first-order functions (5) and the average distance thus obtained represents the radius of the catchment area of the center under investigation. Similar operations are carried forth for the two next grades of centers and their corresponding functional groups. By assuming the market areas to be of circular shape, their radii R, are the mean values in the frequency distribution of the maximum distance travelled by customers for particular functions orders which correspond best to the supply structure of centers.

This method of determining the approximate boundaries of urban spheres of influence rests on the idea to assign a center's trade area to the average catchment area of its dominating functional group. This procedure has the advantage of taking into account the different orders of activities and their respective range. It thus provides individual functional hinterland measurements for each class-order of centers in the Cher. An attempt was made to compile composite maps showing the complementary areas thus found in the Cher. These maps shown in Figure 5.15 to 5.17 reveal much different patterns than those obtained from proximal and deductive methods.

Although Bourges is not located at the geographic center of the county, Figure 5.15 shows that it serves the major part of the county for many specialized central services and stands as the regional center for a large immediate hinterland. Particularly, it serves as the center for most of the eastern and southern regions. As far as the north-western part of the county is concerned, Bourges competes with Vierzon and the two trade areas meet. In fact, most of the area covered by Vierzon's sphere of influence in the Cher is also covered by that of Bourges. Vierzon seems therefore dependent on Bourges which stands as a large county seat and retail center, providing a wide range of economic, political and social services. Vierzon is equally important as a general supply source but its catchment area extends more to the adjacent county. Since most of Vierzon's trading area covering the Cher is included in Bourges's sphere of influence, one question arises immediately: what center do the people living in the intersection zone travel to? The problem is not easy to solve without carrying a

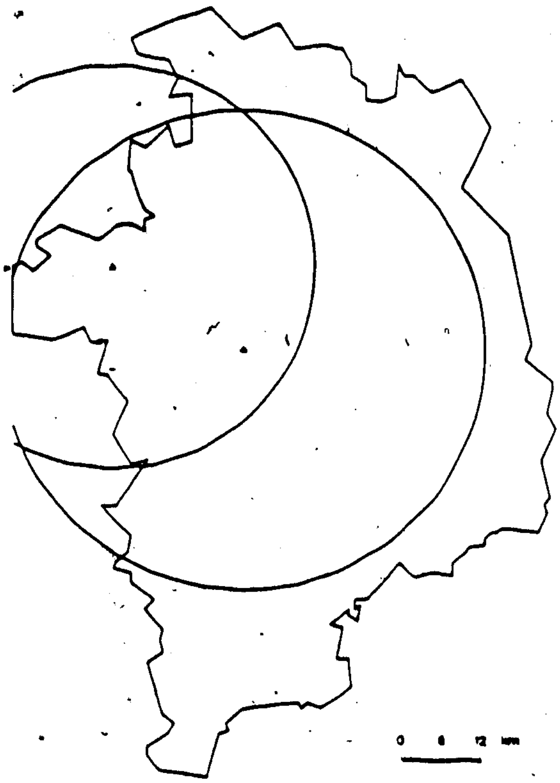


Figure 5.12 Empirical market areas of regional towns in the Cher.

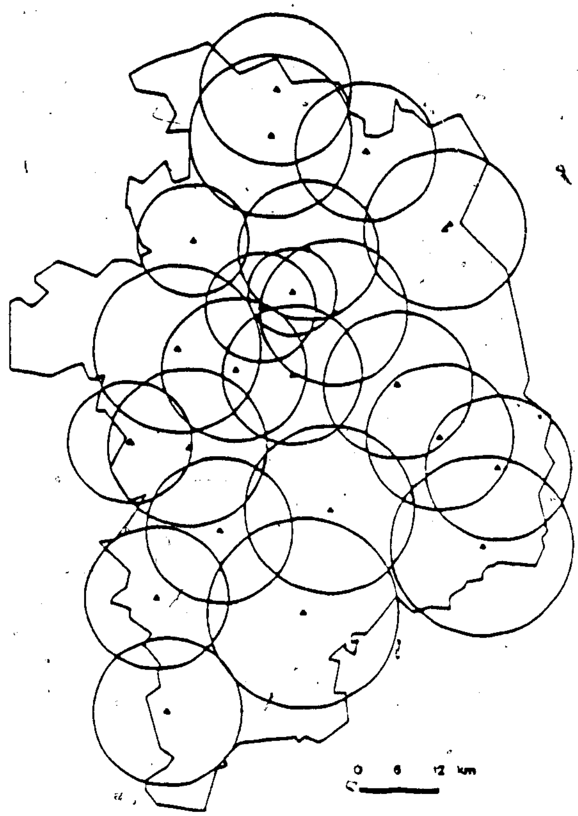


Figure 5.13 Empirical market areas of country towns in the Cher.

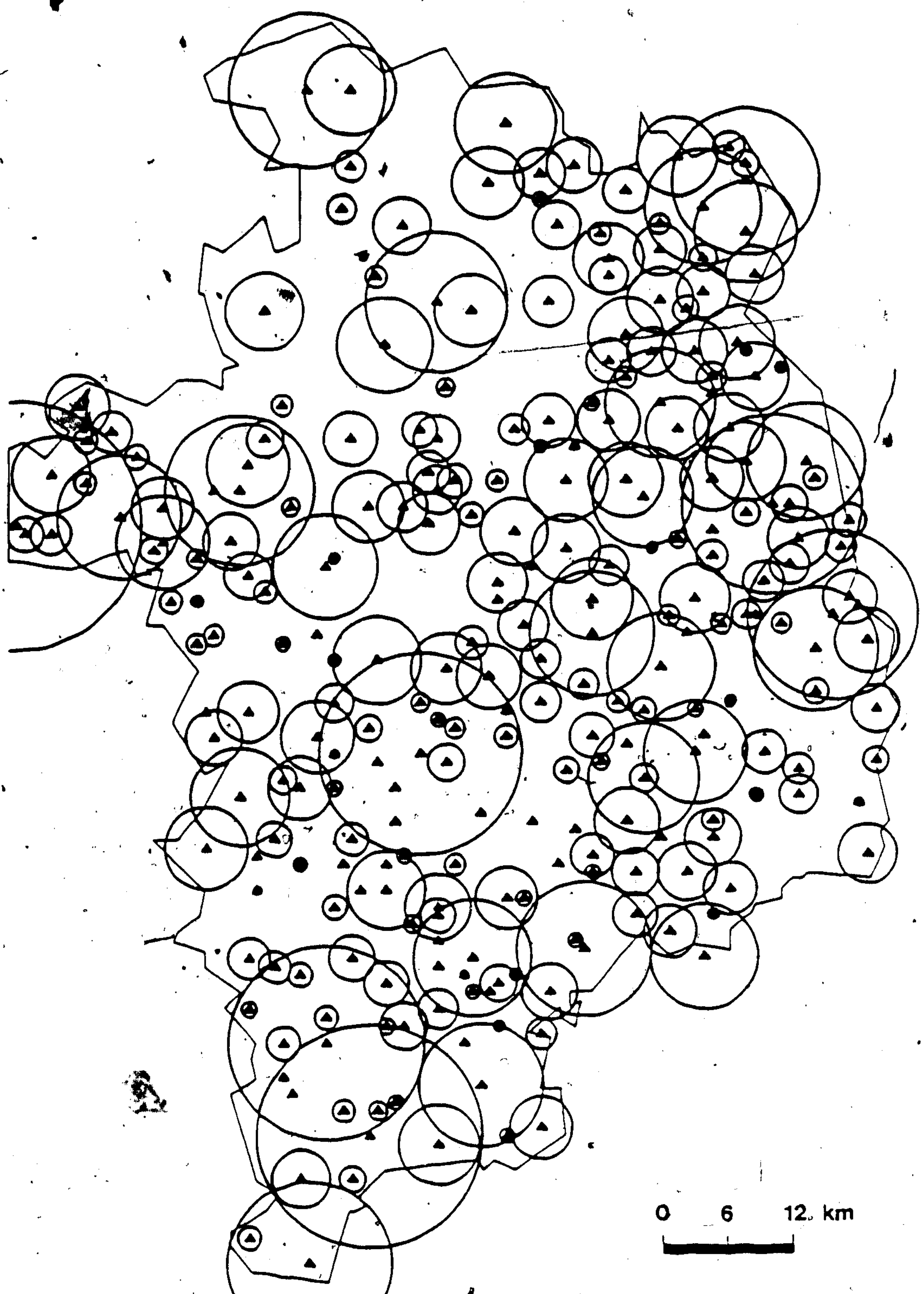


Figure 5.14 Empirical market areas of rural settlements in the Cher.

personal survey in the field. It can nonetheless be predicted that this intersection zone is approximatively divided in two by an imaginary line. People living in the northern half certainly travel to Vierzon whereas those living in the southern half are more inclined to travel to Bourges. Both Bourges and Vierzon have large trade areas with radii of 31 and 37 kilometers respectively. Bourges draws people from most of the towns and villages of the study area. Only the marginal towns are not under its influence. This is especially true for the southern and eastern remote regions of the Cher. For the provision of central goods, these regions probably depend on other major centers located in adjacent counties. Otherwise, the role of the country towns located in these "independent regions" may be considerable.

Contrasting with the results obtained from the application of deductive models, Figure 5.16 illustrates strong competition among country towns in the Cher. These interferences are important for seven towns, namely, Mehun sur Yevre, St. Doulchard, St. Germain du Puy, St. Martin d'Auxigny, Menetou Salon, Henrichemont and Les Aix d'Angillon. Located in the central portion of the Cher, these towns have interlocked market areas which indicate vigorous competition. The zone covered by these interlocked market areas represents approximatively one fifth of the total Cher area. It is a complex area in which a considerable lack of coherence emerges. The market areas of St. Martin d'Auxigny and Menetou Salon are the smallest with radii close to five kilometers. They are almost entirely covered by trading areas of neighboring centers. This strong competition results from the small distances separating four country towns, namely, St. Martin d'Auxigny, Menetou salon, Henrichemont and Les Aix d'Angillon. However, although competitive, the country towns belonging to this system are highly specialized and each of them respond to particular needs. Poorly populated, these four country towns provide a functional complexity comparable to larger towns. Menetou Salon is a typical example of French country towns. With a low population of 1,447, it is a religious center and a market place where farmers gather every sunday for mass as well as during market days. The dominant feature of Henrichemont is its complete range of alimentary retailers. Les Aix d'Angillon does not offer such a complete range of retailers but in counterpart, this town is well supplied with tradesmen (i.e. builders, carpenters, plumbers, furnace men, electricians). Finally, St. Martin d'Auxigny stands as the "administrative and financial center" within this group of country towns. It provides services that are rarely met in the three other settlements such as banks, saving branches, notaries, tax offices and one police station. These country towns have different functional structures although they belong to the same order of central places. Their interlocked market areas are in fact different types of functional hinterlands.

In the remaining part of the county, country towns compete less vigorously. In the eastern part, Sancerre and St. Satur are two "twinned towns" and one hinterland can summarize their economic influence. Another example of competitive centers is found in the northern part of the county: Argent sur Sauldre and Aubigny sur Nere have trading areas that largely overlap. Aubigny sur Nere has more than twice as many inhabitants (5,600) than Argent sur Sauldre (2,687). However the functional status of both places is similar. The only functions lacking in Argent sur Sauldre are specialized rural facilities such as granaries, veterinarians and mechanics for agriculture machines. Both towns supply all the rudimentary retail trades and services. Since they are so close and have comparable economic status, they represent a good example of competitive centers. Such an "abnormal" situation may have a logical explanation. It would be interesting to study their growth by means of time tables. It would certainly indicate one of these towns to be growing as opposed to the other which would be declining. It is highly probable that these two towns will not belong to the same hierarchical group in the future.

Apart from the central part of the county, trade areas for the country towns are of the same order of size. Their average radius is 14.5 kilometers and they cover the most part of the county. The Cher is therefore well supplied by country towns which play an important economic role in its rural environment.

Figure 5.17 indicates a much more complex arrangement of trading areas for the rural settlements. What is immediately clear is the size difference of the trade areas. Some rural settlements have no trading areas since they do not perform any functions. Mainly located in the southern part of the county, these settlements are composed of several farm houses and farmers shop in neighboring rural settlements or country towns. At the other end of the scale, a glance at the map reveals several larger trade areas with radii close to nine kilometers. Such is the case for Gracay at the extreme west of the county, which serves an area that is not supplied by any country towns. Despite this size difference, rural settlements do not serve the entire Cher region, and several "empty zones" occur. These zones are mainly located in the northwestern part of the Cher where rural settlements are seldom and sparsely located. On the other hand, there is a strong competition between numerous closely spaced rural settlements in the eastern part of the county.

In summary, these three maps are interesting to look at from the standpoint that they denote the lack of a rigid marketing structure in the Cher. The marketing systems outlined by these maps confirm the three-step hierarchy of central places found in the Cher. The size of the market areas decrease with the order of the centers. However, at each level of the hierarchy, these maps reveal strong competitions between centers. Bourges and Vierzon stand on their own as centers of first order, containing functions which are performed nowhere else in the county. The two centers compete vigorously and the influence of Vierzon is limited to the northwestern part of the county. At the other end of the scale are what are described as "rural settlements", which provide rudimentary facilities as well as some more specific rural facilities such as diesel and oil stations, granaries and mechanics for agricultural machines. The size of their trade areas is irregular though limited in space. Their excessive overlapping indicates strong competition in the eastern part of the Cher. Between the two extremes, country towns can be recognized. They are small towns with minimum urban functions. The fact that their hinterlands overlap in the central part of the county reveals strong competition between the country towns surrounding Bourges. These centers are a dominant feature of the rural economic system of the Cher and supply the region remarkably well. Empirical evidence largely departs from the perfect competition system outlined in Central Place Theory. In the Cher, trade areas overlap frequently and lower order centers are not located at the edge of higher order trade areas. The Cher district is clearly "oversupplied" and its rural marketing system does not satisfactorily relate to central place models.

6. CONCLUSION

This study has been concerned with the empirical identification of central place systems in the Cher, France. An attempt has been made to understand more fully the concept of urban hierarchy developed in Christaller's classical statement [21]. The comparison of Christaller's original statement and resulting central place analyses yielded four interlocking contentions:

1. The first is that Christaller expressed the concept of urban hierarchy in two dimensions, the *aggregate* and *relative* importance of places.
2. Secondly, most research carried out by geographers concerned with central place systems has concentrated upon either the *relative* or the *aggregate* importance of towns. Rare are the works that have combined both dimensions in their centrality models.
3. Thirdly, most methods used for measuring the *relative* importance of centers rely on data difficult to collect (i.e. bus lines, passenger linkages, telephne calls).
4. Finally, most traditional methods of grading centers do not consider the two major Christallerian indicators, the outer and inner *range* of towns, as two distinct hierarchy factors.

In an attempt to solve these issues, this study revolved around a set of investigational stages:

1. Definition of theoretical variables.
2. Definition of empirical indicators.
3. Episrnetic correlation.
4. Testing the reliability and validity of the indicators.

6.1 Definition of theoretical variables.

The leading theoretical variable of this study may be referred to as "urban hierarchy in the Cher". However, following Christaller's concepts, it was possible to derive two secondary theoretical variables from it, the *aggregate* and *relative* importance of places. The *aggregate* importance or *nodality* of places has been defined as an index of their "size" where centers are considered as closed systems. On the other hand, the *relative* importance of places or *centrality* regards towns as service centers which provide commodities to a surrounding region. Many writers have failed to appreciate this spatial aspect in their centrality models and most of them confined their studies to the *aggregate* importance of towns. This study has tried to present a complete structural analysis of the concept of urban hierarchy, by identifying empirical indicators measuring both the *aggregate* and *relative* importance of places in a French rural area.

6.2 Definition of empirical variables.

At the stage of defining empirical variables, two problems remained unresolved in most central place analyses:

1. To find a reliable methodology to measure both inner and outer range of places.
2. To find a simple method to measure the *relative* importance of towns.

In the present study, the unit of analysis is the commune. Two hundred and ninety communes belonging to a small French rural county[9] were examined. The Cher, located in the center of France, was regarded as a satisfactory central place laboratory. It is characterized by a homogeneous topography, a settlement pattern that tends to be regular, and by a significant farming activity. Functional and population data were readily available for the 290 communes of the Cher. A recent French census book (1980), the Inventaire Communal, lists the number of establishments for 48 functions present in the communes. Moreover, this census book provides population data such as total and nucleated populations of the commune.

The first problem dealt with was the estimation of the outer and inner range of towns. These two variables were recognized as the two major centrality variables in Christaller's Central Place Theory. The outer range was empirically defined as the maximum distance travelled by consumers when a particular service is not performed in their own towns. In a few central place studies, this distance was estimated mainly from questionnaire surveys

[9] The term "county" was used as a translation of the French term "département".

asking where people travel to when they need a service lacking in their own town. In the Cher, it was assumed that the principle of "least effort" held, so that the outer range of the 48 functions could easily be established. The outer range of towns was then recorded on the basis of the outer range of their highest-order function. Measuring the inner range, defined as the minimum number of consumer units necessary to support a firm, brought to light some methodological problems. Following Bunge's [77] concepts[10], the problem consisted of knowing whether local or hinterland population thresholds should be considered. To solve this issue, both types of thresholds were estimated for the 48 functions and compared through a bivariate regression analysis and an analysis of residuals. Although well correlated ($r = .89$), hinterland population thresholds provided better results since these measures appeared to be less distorted by outliers. The inner range of towns was then assigned to the hinterland population thresholds of their highest-order function.

In addition to the two Christallerian indicators, this study sought simple means for measuring the *relative* importance of towns. The underlying principle of *relative* importance is that the hierarchy of towns is bound up with the level of interactions between themselves and their hinterlands. Following this concept, the measurement method was established under the assumption that the importance of linkages between places was proportional to their degree of interaction. Road linkages were examined from a large scale road map of the region and subsequently simplified as a graph. Shortest-path measurements provided an estimation of the nodal accessibility of the 290 towns present in the Cher.

An easier task was to find empirical indicators reflecting the *aggregate* importance of towns, since most central place studies already dealt with this problem. These indicators were all extracted from the census book, the Inventaire Communal, and consisted of population and functional data.

In order to investigate real central place networks in the Cher, a total of fifteen empirical indicators have been selected to translate theoretical variables into operational terms. Three accessibility indices and the outer range of towns were more specifically designed to

[10]Bunge criticized central place studies on the ground that they calculated the inner range of centers in terms of local rather than hinterland population.

reflect the *relative* importance of centers. On the other hand, population data and functional indices were related to their *aggregate* importance.

6.3 Epismetic Correlation

Once the empirical indicators were established, an attempt was made to define how closely related theoretical and empirical variables were. In other words, the second part of the study estimated the connection between concepts and empirical evidence. To this end, a factor analysis of the empirical variables and a distance grouping of the factor scores were subsequently performed.

The structural analysis of the empirical variables was carried out using principal component analysis. This analysis produced three statistically independent dimensions of urban hierarchy in the Cher:

1. A size-hierarchy factor made up of population data.
2. A functional-index factor.
3. An accessibility factor.

The results of the principal component analysis clearly demonstrated that in the Cher, the major indicators of hierarchy are demographic. Among them, the inner range of towns is the dominant factor. However, considering the hierarchy of centers under an "operationist" perpective, that would claim a direct correpondence between the hierarchy concept and the inner range of towns, is not valid for obvious reasons. Principal component analysis revealed that urban hierarchy may be viewed in three dimensions. Although population variables best summarize the importance of towns, other dimensions partly explain the original theoretical variables. Accessibility indices, for instance, were shown to represent a unique dimension in the Cher. The indicators related to this dimension are clearly opposed to the remaining set of empirical indicators. An interesting point stressed in this study was the lack of association between the outer range and the accessibility of towns. In the Cher, the outer range of towns was found to be associated with functional indices, and to a lesser extent, with population data.

In summary, the structural analysis of the empirical variables did not show a direct relationship between the *relative* importance and both the outer range and the accessibility of towns. On the other hand, these two indicators have different meanings in the Cher. The *aggregate* importance of towns was clearly associated with the population and inner range of towns.

6.4 Testing the reliability and validity of the indicators

The fact that in the Cher, the accessibility indices are strongly disassociated from any other empirical variables is an important finding which contradicts the idea to relate the accessibility of places to their "size" as well as to their functional status. Further investigation supported this point and in the last part of the study, it was shown how nodal accessibility indices represent a poor measure of the *relative* importance of centers.

First, it was established that in the Cher, the accessibility measures played an important role in the grouping procedure. A clustering analysis performed on the factor scores yielded five groups of towns. The study of centrality profiles for these five groups revealed three hierarchy levels, and it appeared that two pairs of groups were discriminated on the single basis of their accessibility.

Secondly, it was decided to test the reliability of nodal accessibility measures as an index of the *relative* importance of towns. Each successive group of central places were plotted on different maps and the major feature of the output was a circular zonal arrangement of the towns. This zonality suggested that nodal accessibility indices simply indicated the "centralness" of the towns to the entire road network rather than their importance.

Thirdly, this series of observations led to the point where nodal accessibility indices seemed to be irrelevant indicators of urban hierarchy when applied to a small adiministrative area. In the Cher, accessibility measures were subject to a boundary problem which distorted the results.

As a result, accessibility indices were considered to be invalid indicators of the *relative* importance of towns in the area under investigation. Their effect on the grouping procedure was therefore ignored and a three step hierarchy was confirmed. Two towns of higher-order were classified as regional towns. At the other end of the scale, 216 rural settlements were identified and, between the two extremes, 24 country towns represented another class-order of central places.

A different approach was taken in order to analyze the trade areas of the centers at each level of the hierarchy. Traditional methods of hinterland delimitation failed to identify meaningful systems by being too deductive. Instead of consumer's behaviour or commodity flows, the average outer range of incremental class-order of functions was examined for each town at each hierarchical level. Approximate composite trade areas could thus be identified for every settlements. The size of these trade areas confirmed the three step hierarchy found in the Cher. Each lower-order of centers are characterized by smaller hinterlands. The analysis of market areas emphasized the role of competition between central places. Each hierarchical order of places does not occupy the interstices in the pattern formed by centers of higher rank. Similarly, trade areas of lower-order are not systematically embraced by higher-order trade areas. Instead, the marketing system of the Cher is marked by a vigorous competition among centers at each level of the hierarchy. Sometimes, the overlap is considerable and it is difficult to distinguish a rigid spatial organization of market areas. The empirical arrangement of market areas contrasts with the ones observed when deductive methods were applied to the Cher. Outer range measurements represent a more reliable indicator than straight distances separating centers or population data.

6.5 Prospect of the study and suggestions for further research

The original goal of this study has been achieved in part. This study has succeded in undertaking a structural analysis of centrality in the Cher and has provided an original method of delineating market areas for each center. However, it failed to find a valid measure of the *relative* importance of central places. This is an significant imperfection, but in the context of the present research, it may be seen as informative and several conclusions may therefore be drawn.

1. The role of a town is to administer internal flows in the area of which it is the main center. It is determined by the interconnections between a center and its hinterland. The fact that a large number of central place studies neglected to consider the spatial influence of centers in their centrality model is misleading. In one way or another, the spatial interactions between a center and its surrounding region should be fully explored and evaluated by means of pertinent empirical indicators. These indicators should be included in any structural analyses of urban hierarchy.
2. Urban hierarchy is not a simple equation. The complexity of this concept has been confirmed by the structural analysis of centrality in the Cher. This analysis disclosed three hierarchy dimensions and emphasized the fact that urban hierarchy should not be examined from one single perspective (i.e. total number of functions or functional occurrence). Instead, geographers should recognize its pluralism and study the concept of urban hierarchy under different facets.
3. Finding meaningful empirical indicators to quantify the concept of centrality poses problems. The unpredicted invalidity of accessibility indices as indicators of centrality shows how complex the process of finding reliable indicators may be. In particular, the task of measuring the *relative* importance of towns without resorting to direct questionnaire surveys is difficult. Measuring theoretical variables has always been a task that requires numerous precautions. One way to resolve the problem may consist of sample testing the predicted indicators before including them in the general model.
4. In the Cher, both Christallerian indicators represent reliable measures of urban hierarchy. The inner range was estimated to be a very good indicator of the *aggregate* importance of central places. Although the role of the outer range measure is less relevant in terms of grading centers, it is a meaningful tool for empirically determining market systems.

There appear to be three main dimensions for further expansion and refinement of this study. First, since the methodology developed in this study relies upon the questionable principle of "least effort", there is a need to build a more realistic framework. Throughout this study, repeated comparisons between "classical" Central Place Theory have been made. Further investigations should depart from the unrealistic assumptions tied with Central Place Theory by incorporating a more behavioral philosophy. Secondly, the inability encountered to characterize the *relative* importance of towns with accessibility indices must be overcome. More refined nodal accessibility indices should be explored. They should measure the "local" accessibility of centers rather that their accessibility to the entire network. Finally, other contextual factors should be considered to reinforce the pluralism that features urban hierarchy. More particularly, to ignore the influence of economic criteria such as median family income or the price of goods is to block out possible effects that may have an important impact. In future research, there is a great need to introduce economic factors into centrality models.

The principle of combining both the *aggregate* and *relative* importance of towns through a complete structural analysis of centrality may therefore be expanded. The scope of such attempts will be related highly to the choice of empirical indicators. This study proposed a pertinent methodology for such projects, and by raising the issue of the validity of centrality indicators, may be of great help for future works.

BIBLIOGRAPHY

Central Place Studies:

1. Abiodun, O. J. 1968 Central Place Study in Abeokuta Province, Southwestern Nigeria. *Journal of Regional Science* 8: 56-76.

2. -------------- 1967 Urban Hierarchy in a Developing Country. *Economic Geography* 43: 347-367.

3. Abler, R. Adams J. S. and Gould P. 1971 Spatial Organization. *Prentice Hall Inc., Englewood Cliffs, New Jersey.*

4. Amrit Lal, L. 1959 Some Aspects of Functional Classification of Cities and a Proposed Scheme for Classifying Indian Cities. *National Geographical Journal of India* 5: 12-24.

5. Bansal, S. C. 1975 Town Country Relatio[illegible] in Saharanpur City-Region. A Study in Rural-Urban Interdependence Problems. *S[illegible] Prakashan, Saharanpur.*

6. Beavon, K. S. O. 1977 Central Place Theory: a Reinterpretation. *New York: Longman.*

7. Berry, B. J. L. 1972 Hierarchical Diffusion: the Basis of Developmental Filtering and Spread in a System of Growth Centers. In "Growth Centers in Regional Economic Development", *Ed. N. M. Hansen, New York: the Free Press*: 108-138.

8. Berry, B. J. L. and Garrison, W. L. 1958. The Functional Bases of the Central Place Hierarchy.

9. ----------------------------------. 1958. A Note on Central Place Theory and the Range of a Good. *Economic Geography* 34: 304-311.

10. Berry, B. J. L. and Barnum, H. G. 1962. Aggregate Relations and Elemental Components of Central Place Systems. *Journal of Regional Science* 4: 35-68.

11. Berry, B. J. L., Barnum, H. G. and Tennant, R. J. 1962. Retail Location and Consumer Behavior. *The Regional Science Association: Papers* 9: 64-106. *Economic Geography* 34: 304-311.

12. Borchert, J. R. and Adams, R. B. 1963. Trade Centers and Trade Areas of thr Upper Midwest. *Urban Report 3. Upper Midwest Economic Study. Minneapolis: University of Minnesota.*

13. Bracey, H. E. 1955. A Rural Component of Centrality Applied to Six Southern Counties in the United Kingdom. *Economic Geography* 32: 38-50.

14. -----------. 1962. English Central Villages: Identification, Distribution and Function. *Proceedings of the I. G. U. Symposium in Urban Geography* 169-190.

15. Brown, P. A. 1956. Centers of Retail Distribution in the East Midlands. *East Midlands Geographer* 6: 3-9.

16. Brush, J. E. 1953. The Hierarchy of Central Places in Southwestern Wisconsin. *Geographical Review* 43: 380-402.

17. Caroll, J. D. 1955. Spatial Interaction and the Urban Metropolitan Regional Description. *Papers: Regional Science Association* 1: 1-14.

18. Carruthers, W. I. 1957. A Classification of Service Centers in England and Wales. *Geographical Journal* 22: 371-385.

19. ----------------- 1962. Service Centres in Greater London. *Town Planning Review* 33: 5-21.

20. Carter, H. Stafford, H. A. and Gilbert M. M. 1970. Functions of Welsh Towns: Implications for Central Place Notions. *Economic Geography* 46: 25-38.

21. Christaller, W. (translated by Baskin, C. W.) 1933 (1966). Die Zentralen Orte in Suddeutschland (Central Places in Southern Germany). *Prentice hall, Inc., Englewood Cliffs, New Jersey.*

22. Crissman, L. W. 1976. Specific Central Place Models for an Evolving System of Market Towns on the Changua Plain, Taiwan. In "Regional Analysis 2" *C. A. Smith, Academic Press*: 183-218.

23. Davies, W. K. D. 1967. Centrality and the Central Place Hierarchy. *Urban Studies* 4: 61-79.

24. Durand-Dastes, Calmes R., Delamarre A., Gras J., and Peyon J. P. 1979. Les Reseaux du Commerce de Detail dans le Gers. *Revue Geographique des Pyrenees et du Sud-Ouest* 50.

25. Godlund, S. 1956. The Function and Growth of Bus Traffic within the Sphere of Urban Influence. *Lund Studies in Geography, Series B* 18.

26. ---------- 1956. Bus Service in Sweden. *Lund Studies in Geography, Series B* 17.

27. Green, F. H. W. 1950. Urban Hinterlands in England and Wales: an Analysis of bus Services. *The Geographical Journal* 66: 64-81.

28. Gunawardena, K. A. 19[illegible]. Service Centers in Southern Ceylon. *University of Cambridge, PHD Thesis.*

29. Hagerstand, T. 1966. Aspects of the Spatial Structure of Social Communication and the Diffusion of Information. *Papers of the Regional Science Association* 15: 27-42.

30. Henkel, R. 1979. Central Places in Western Kenya. *Selbstverlag des Geographischen Instituts der Universitat Heidelberg.*

31. Huang, J. C. and Gould, P. 1974. Diffusion in an Urban Hierarchy: the Case of Rotary Clubs. *Economic Geography* 50: 333-340.

32. Hudson, J. 1972. Geographical Diffusion Theory. *Studies in Geography 19. Evanston, IL: Northwertern University, Department of Geography.*

33. Illeris, S. 1964. The Functions of Danish Towns. *Geografisk Tidsskrift* 63: 203-236.

34. Jain, N. G. 1971. Urban Hierarchy and Telephone Service in Vidarbha. *National Geographical Journal of India* 17: 134-137.

35. Johnson, L. J. 1971. The Spatial Uniformity of a Central Place Distribution in New England. *Economic Geography* 7:156-170.

36. Johnston, R. J. 1966. Central Places and the Settlement Pattern. *Annals of the Association of American Geographers* 56: 541-549.

37. Kant, E. 1951. Umland Studies and Sector Analysis. *Lund Studies in Geography, Series B* 3: 3-13.

38. Kelley, K. B. 1976. Dentritic Central-Place Systems and the Regional Organization of Navajo Trading Posts. In *Regional Analysis 2, C. A. Smith, Academic Press*: 219-254.

39. King, L. J. 1961. The Functional Role of Small Towns in Canterbury. *Proceedings of the Third New Zealand Geographical Conference, Palmerston North*: 139-149.

40. Losch, A. 1940 (Translated in 1954 by Stolper, W. F.). Die Raumliche Ordnung der Wirtschaft (Economics of Location). *New Haven: Yale University Press.*

41. Lomas, G. M. 1964. Retail Trade in the Midlands. *Town Planning Institute* 50: 104-119.

42. Mandal, R. B. 1975. Central Place Hierarchy in Bihar Plain. *National Geographical Journal of India* 21.

43. Marshall, J. U. 1969. The Location of Service Towns. *University Toronto Press.*

44. Mayfield, R. C. 1963 The Range of a Central Good in the Indian Penjab. *Annals of the Association of American Geographers* 53: 38-49.

45. Murdie, R. A. 1965. Cultural Differences in Consumer Travel. *Economic Geography* 41: 211-233.

46. Muwonge, J. W. 1973. Functions and Characteristics of Trading Centers in Uganda. *East African Geographical Review* 11: 52-64.

47. Ollson, G. and Person, A. 1963. The Spacing of Central Places in Sweden. *Regional Science Association, Papers* 12: 87-93.

48. Palomaki, M. 1964. The Functional Centres and Areas of South Bothnia, Finland. *Fennia* 88.

49. Pandey, P. 1970. Impact of Industrialization on Urban Growth: a Case Study of Chotanagpur. *Central Book Depot, Allahabad.*

50. Parr, J. B. 1980. Frequency Distributions of Central Place in Southern Germany. A Further Analysis. *Economic Geography* 56: 141-154.

51. Prakasarao, V. L. S. 1974. Planning for an Agricultural Region in Mistra. *R. P. et al. Regional Development Planning in India, Vikas Publishing House, Dehli.*

52. Pred, A. R. 1977. City-Systems in Advanced Economics. *London Hutchison and Co.*

53. Preston, R. E. 1971. The Structure of Central Place Systems. *Economic Geography* 47: 136-155.

54. Rallis, T. 1962. Urban Development in Denmark: a Communication. *Regional Science Association, Papers* 10: 153-156.

55. Reed, W. E. 1970. Indirect Connectivity and Hierarchy of Urban Dominance. *Annals of the Association of American Geographers* 60: 770-786.

56. Saey, P. and Lietaer, M. 1980. Consumer Profiles and Central Place Theory. *Tijdschrift voor Economische en Sociale Geografie* 71: 180-186.

57. Scott, P. 1964. The Hierarchy of Central Places in Tasmania. *The Australian Geographer* 9: 134-147.

58. Sidall, W. R. 1961. Wholesale-Retail Trade Ratios as Indices of Urban Centrality. *Economic Geography* 37: 124-132.

59. Singh, J. 1979. Central Places and Spatial Organization in a Backward Economy: Gorakhpur Region. *The Tara Printing Works, Varanasi.*

60. Singh, K. N. 1959. Functions and Functional Classification of Towns in Uttar Pradesh. *National Geographical Journal of India* 5: 121-148.

61. Singh, O. P. 1971. Towards Determining a Hierarchy of Service Centers: a Methodology for Central Place Studies. *National Geographical Journal of India* 17: 165-177.

62. Smailes, A. E. 1944. The Urban Hierarchy in England and Wales. *Geography* 29: 41-56.

63. Smith, C. A. 1976. Causes and Consequences of Central Place Type in Western Guatemala. In "Regional Analysis 1, Economic Systems", *Ed. C. A. Smith, New York, Academic Press*: 225-300.

64. Skinner, G. W. 1964. Marketing and Social Structure in Rural China, Part II. *Journal of Asian Studies* 24: 195-228.

65. Stabler, J. and Williams, P. 1973. The Dynamics of a System of Central Places. *Geographical Papers, Department of Geography, University of Reading.*

66. Stafford, H. A. 1963. The Functional Bases of Small Towns. *Economic Geography* 39: 165-175.

67. Stanley, W. R. 1970. Transport Expansion in Liberia. *Geographical Review* 60: 529-545.

68. Taaffe, E. J. 1962. The Urban Hierarchy: an Air Passenger Definition. *Economic Geography* 38: 1-14.

69. Tinbergen, J. 1968. The Hierarchy Model of the Size Distribution of Centers. *Papers of the Regional Science Association* 20: 65-68.

70. Ullman, E. L. 1960. Trade Centers and Tributary Areas of the Philippines. *Geographical Review* 50: 203-218.

71. Weisbrod, R. 1974. Diffusion of Relative Wage Inflation in Southeast Pennsylvania. *Studies in Geography 23, Evanston, IL: Northwestern University, Department of*

Geography.

Other references:

72. Allen, P. M. and Sanglier, M. 1981. A Dynamic Model of a Central Place System II. *Geographical Analysis* 13: 149-164.

73. Bain, J. S. 1954. Economies of Scale, Concentration, and the Condition of Entry in Twenty Manufacturing Industries. *The American Review* 44: 15-39.

74. Barnes, J. A. and Robinson, A. H. 1940. New Methods for the Representation of Dispersed Rural Population. *Geographical Review* 30: 134-137.

75. Berry, B. J. L. 1967. Geography of Market Centers and Retail Distribution. *Prentice Hall, New York.*

76. Bird, J. 1977. Centralities and Cities. *Routledge Direct Editions.*

77. Bunge, W. 1966. Theoretical Geography. *Lund Studies in Geography, Ser. C, General and Mathematical Geography* 1.

78. Cantillon, R. 1755. Essai sur la Nature du Commerce en General. *Edited with an English Translation by Higgs H., C. B. Reissued for the Royal Economic Society by Cass F., London, 1959.*

79. Catell, R. B. 1966. The Scree Test for the Number of Factors. *Multivariate Behavioral Research* 1: 245-276.

80. Clark, P. J. and Evans, F. C. 1954. Distance to Nearest Neighbour as a Masure of Spatial Relationships in Populations. *Ecology* 35: 445-453.

81. Cureton, E. E. and Mulaik, S. A. 1975. The Weighted Varimax Rotation and the Promax Rotation. *Psychometrika* 40: 183-195.

82. Dacey, M. F. 1966. A Probability Model for Central Place Locations. *Annals of The Association of the American Geographers* 56: 550-568.

83. Davies, R. J. 1967. The South African Urban Hierarchy. *South African Geographical Journal* 49: 9-19.

84. Fairbairn, K. J. and Barr, B. M. 1974. Acknowledging the past: Richard Cantillon's Pattern of Urban Settlement Location. *Area Institute of British Geographers* 6: 208-210.

85. Gambini, R. and Huff, D. L. and Jenks, G. F. 1967. Geometric Properties of Market Areas. *Regional Science Association: Papers* 20: 85-92.

86. Garrison, W. L. 1960. Connectivity of the Interstate Highway System. *Papers and Proceedings of the Regional Science Association* 6: 121-137.

87. Gottman, J. 1974. The Evolution of Urban Centrality: Orientations for Research.

Research Papers, School of Geography, Unversity of Oxford.

88. Gusein-Zade, S. M. 1982. Bunge's Problem in Central Place Theory and its Generalizations. *Geographical Analysis* 14: 246-252.

89. Haggett, P. and Gunawardena, K. A. 1964. Determination of Population Thresholds for Settlements Functions by the Reed-Muench Method. *The Professional Geographer* 16: 6-9.

90. Harris, C. D. 1954. The Market as a Factor in the Localization of Industry in the United States. *Annals of the Association of American Geographers* 44: 315-348.

91. Hotelling, H. 1933. Analysis of a Complex of Statistical Variables into Principal Components. *Journal of Educational Psychology* 24: 417-441.

92. Isard, W. 1956. Location and Space-Economy. *The Massachussetts Institute of Technology.*

93. Kansky, K. J. 1963. Structure of Transportation Networks. *University of Chicago Press.*

94. Katz, L. 1953. A New Status Index Derived from Sociometric Analysis. *Psychometrika* 18: 39-43.

95. Kelley, T. L. 1940. Comments on Wilson and Worcester's Note on Factor Analysis. *Psychometrika* 5: 117-120.

96. Kolb, J. H. and Brunner, E. de S. 1946. A Study of Rural Society. *W. F. Ogburn, ed. (Boston: Houghton, Miffin co.).*

97. Milligan, G. W. 1908. An Examination of the Effect of Six Types of Error Perturbation on Fifteen Clustering Algorithms. *Psychometrika* 45: 325-41.

98. Pearson, K. 1901. On Lines and Planes of Closest Fit to Systems of Points in Space. *Philosophical Magazine* 6: 559-572.

99. Philbrick, A. K. 1957. Principles of Areal Functional Organization in Regional Human Geography. *Economic Geography* 33: 299-336.

100. Reilly, W. J. 1929. Methods for the Study of Retail Relationships. *University of Texas Bulletin* 2944.

101. Reynaud, J. 1841. Villes, Voies de Communication, Terre, Vauban. *Encyclopedie Nouvelle* 8: 670-687, 700-712, 417-448, 609-614.

102. Robic, M. C. 1982. Cent Ans Avant Christaller... Une Theorie des Lieux Centraux. *L' Espace Geographique* 1: 5-12.

103. Rushton, G. 1971. Map Transformations of Point Patterns: Central Place Patterns in Areas of Variable Population Density. The Regional Science Association: Papers 28: 111-129.

104. Shimbel, A. 1953. Structural Parameters of Communication Networks. *Bulletin of Mathematical Biophysics* 15: 501-507.

105. Sneath, P. H. A. 1966. A Comparison of Different Clustering Methods as Applied to Randomly-Spaced Points. *Classification Society Bulletin* 1: 2-18.

106. Sokal, R. R. and Michener, C. D, 1958. A Statistical Method for Evaluating Systematic Relationships. *University of Kansas Science Bulletin* 38: 1409-1438.

107. Vining, R. 1955. A Description of Certain Spatial Aspects of an Economic System. *Economic Development and Cultural Change* 3: 147-195.

APPENDIX

LIST OF THE 48 FUNCTIONS

1 POST OFFICE
2 FIRE HALL
3 SOCIAL SECURITY OFFICE
4 TAX BUREAU
5 POLICE STATION
6 BANK
7 SAVING BRANCH
8 NOTARY
9 VETERINARIAN
10 CHURCH
11 MINISTER
12 BUILDER
13 PAINTER
14 CARPENTER
15 PLUMBER
16 FURNACE MAN
17 ELECTRICIAN
18 MECHANIC
19 MECHANIC FOR AGRICULTURAL MACHINES
20 SUPERMARKET
21 GROCERY
22 BAKERY
23 CAKE SHOP
24 BUTCHER'S SHOP
25 DAIRY
26 FISH SHOP
27 RESTAURANT
28 BAR
29 BARBER
30 HAIRDRESSER
31 CLOTHING STORE
32 HABERDASHERY
33 SHOE STORE
34 APPLIANCES-STEREO STORE
35 FURNITURE STORE
36 HARDWARE SHOP
37 IRONMONGER'S SHOP
38 SPORTS SHOP
39 SEED SHOP
40 STATIONERY STORE
41 TOBACCO SHOP
42 NEWSPAPER STAND
43 GAS STATION
44 DIESEL STATION
45 GARAGE FOR OIL PURCHASE
46 GRANARY
47 MARKET (MONTHLY)
48 WHOLESALE MARKET (ANNUALLY)

LIST AND CODES OF THE 15 CENTRALITY INDICATORS

1	NUMBE:	TOTAL NUMBER OF ESTABLISHMENTS.
2	NUMBF:	TOTAL NUMBER OF FUNCTIONS.
3	POP. :	TOTAL POPULATION.
4	NUCPOP:	NUCLEATED POPULATION.
5	DENS:	POPULATION DENSITY.
6	THRESH:	HINTERLAND POPULATION THRESHOLD.
7	DIST:	OUTER RANGE.
8	ACCESS:	ACCESSIBILITY INDEX 1.
9	SHORT:	ACCESSIBILITY INDEX 2.
10	POT:	POPULATION POTENTIAL.
11	NEONF:	NUMBE / NUMBF.
12	POPONE:	POP / NUMBE.
13	POPONF:	POP / NUMBF.
14	THRONF:	THRESH / NUMBF.
15	THRONF:	THRESH /NUMBE.

* TABULATION OF THE NUMBER OF ESTABLISHMENTS FOR 48 FUNCTIONS *
* IN THE CHER *

ACHERE	000000000000011000001000001000000000000011000000
AINAY VIEL	100000000001001000101101001110000000000011101100
AIX ANGILLON	110112011214435323212215005542211201102111312241
ALLOGNY	000000000210000012101001005010000000000011110000
ALLOUIS	000000000000200000010000000010000000000000110000
ANNOIX	000000000100000000000000000010000000000000000000
APREMONT ALLIER	000000000110000000001000001100000000000011000000
ARCAY	000000000103100000000000001100000000000010000010
ARCOMPS	100000000101001002201000000400000000000011100000
ARDENAIS	000000000001010000100000001000000000000010000000
ARGENT S SAULDR	110112110515545432015415015332311312211121212040
ARGENVIERES	000000000000000000102101001400000000000011202000
ARPHEUILLES	000000000001000000002000000200000000000012000000
ASSIGNY	000000000000001110000000001100000000000010000000
AUBIGNY S NERE	110115111515555545115535015555533422323234552140
AUBINGES	000000000100000000000000000000000000000001001000
AUGY S AUBOIS	100000000000200110000100100110000000000001111100
AVORD	110011000211211014102102001421030100000112300040
AZY	100000000020101222130210100130000010000002210010 0
BANNAY	100000000101111000001100001201000000000011111000
BANNEGON	110000000001010000001101002100010000000011100000
BARLIEU	110000000001010011002101002100000000001011100000
BAUGY	110111112414225122104302003321221222211121311242
BEDDES	000000000000000000000000000010000000000000000000
BEFFES	100000000100001101101101003200000000110001121104 0
BELLEVILLE S L	000000000000012330002100003000000000000011100000
BENGY S CRAON	100000000111110001101101001111111001100011100000
BERRY-BOUY	000000000001000000000000002000000000000001100000 0
BESSAIS L FROM.	100000000000200100110110000220000000000001111100 00
BLANCAFORT	110000000512241012004101001212000100101021200000
BLET	110000000111011111003102002511021100000011330040
BOULLERET	100000000215223130201103003311000200000011212100
BOURGES	111115555555555555255555555555555555555555555251
BOUZAIS	000000000000000000000000000010000000000011000000
BRECY	110000000100011010001101100300000000000011100100
BRINON S SAULDR	110002000515543332002202002422101101210111321010
BRUERE-ALLICHAM	100000000001001001002202004111010000000011200100
BUE	100000000110010001000101101100000000000011110000
BUSSY	000000000110000000000100001000000000000011100000
LA CELETTE	000000000100000000000000001000000000000010000000
LA CELLE	000000000102110010001100000100000000000011000000
LA CELLE-CONDE	000000000000000000000000000010000000000011000000
CERBOIS	000000000002001110100000000000000000000000000000
CHALIVOY-MILON	100000100001111110102100001200000000000011100040
CHAMBON	000000000000000000000000000010000000000001000000
LA CHAPELLE ANG	110111010110112113103101002423000200000112332040
LA CHAPELLE HUG	100000000102000000002100001200000000000011000000
LA CHAPELLE MON	000000000000010000000100000550000000000000010000100
LA CHAP.ST URS	110001000005523011001101102520110000000013201000

LA CHAPELOTTE	110000000000000111101100002000000100000011100000
CHARENTON SCHER	110110000111113213005402004311000100100121320140
CHARENTONNAY	00000000000010010100000000100000000000001100100
CHARLY	0000000000000110002010000011000000000000011100000
CHAROST	110101110103212113104114102511210101100112321340
CHASSY	100000000000100000000000000011000000000000011000000
CHATEAUMEILLANT	110113113235554444404425015532411421302221431140
CHATEAUNEUFCHER	110112011133102233105315013421211111211131211140
LE CHATELET	110111011111332113105303003211010101102121420241
CHAUMONT	00000000000000000000000000000000000000000000000000
CHAUMOUX-MARCIL	000000000000000000110000000110000000000000010000000
LE CHAUTAY	0000000001001000000010010011000000000000001000000
CHAVANNES	000000000000000000000000000100000000000010000000
CHERY	00000000000001100000010000001000000000000011000100
CHEZAL-BENOIT	1100010001011010011022010011110000000000011100040
CIVRAY	11000000101100001102100001400000000000001222 1000
CLEMONT	1100000010201111002102001300000110001011210000
COGNY	00000000000000000000000000000000000000000000000000
COLOMBIERS	000000000001000000000000001000000000000011000000
CONCRESSAULT	110000000200000010101011001200000000000011100000
CONTRES	00000000000000000000000000000000000000000000000000
CORNUSSE	00000000001001000001001002200000000000012000000
CORQUOY	000000000001000000000100000220000000000000010000000
COUARGUES	0000000000000000000010000003000000000000011000000
COURS LESBARRES	0000000000010011120021010033010200000000011111000
COUST	00000000000202211110110100110000000000011101000
COUY	100000000103000000001100001200000000000012000000
CREZANCAY SCHER	00000000000000000000000000000000000000000000000000
CREZANCY EN SAN	1000000000011032020011010012000000000000011100000
CROISY	000000000000000000000000011000000000000000000000
CROSSES	0000000001011011100001010001000000000000011000000
CUFFY	100000000102000101000200005101000000000012110000
CULAN	110103111114231124304414004320111111220012131214
DAMPIERREENCROT	000000000000100000000000000020000000000000011100000
DAMPIERREENGRAC	0000000000000000001010000011000000000000011100000
DREVANT	00000000010000000100100000110000000000001111000
DUN-SUR-AURON	110112111115453244315424024044221322311231333241
ENNORDRES	1000000002000110012011010024001000000000012100000
EPINEUIL FLEURI	110000010101011020101101001300000000000011100000
ETRECHY	100000000512012111102101000120001100101011100000
FARGES ALLICHAM	000000000000000000000110000120000000000000012000000
FARGES EN SEPT.	110000100200001100001101003311100000001011100000
FAVERDINES	00000000000000000000000000001000000000000000000000
FEUX	1000000001021110011012010012011000000000011100000
FLAVIGNY	00000000000100000000010000001000000000000010100000
FOECY	110002100514341111004202003521010110100111110040
FUSSY	100000000511200001101001003001100000000011100000
GARDEFORT	00000000000000000000000000000000000000000000000000
GARIGNY	0000000000000112011021000023000000000000001100000
GENOUILLY	110000000004011011102102003011010001000011100000
GERMIGNY EXEMPT	10000000000410000000210100011000000000000011001000
GIVARDON	000000000111002111101101000300000000000000011200000
GRACAY	110112112113442222104315004532221212121132422142
GROISES	00000000000000000000000000000000000000000001000000
GRON	000000000100000010000000001000000000000000000000000
GROSSOUVRE	1000000000001000000002101000100100000000011001000
LA GROUTTE	00000000000000000000000000000000000000000000000000
LA GUERCHE AUBO	110112112113522235105415005542312211231121551140
HENRICHEMONT	110112012513214422105415004521441211322122512140
HERRY	110000110513024311202102001211001000000011101100

HUMBLIGNY	000000000001000000000100000000000000000011000000
IDS ST ROCH	100000000101000000000100000100000000000011000000
IGNOL	00000000000000000000011000010000000000000001000000
INEUIL	0000000000000000000100000000100000000000012111000
IVOY LE PRE	1100000002011111010031010004000000000001012100100
JALOGNES	1000000000010010002010000013110000000000011101001
JARS	1000000005130101111021010012000000000000011200100
JOUET S AUBOIS	1100100101143122430042030053223202022111212211040
JUSSY CHAMPAGNE	0000000000011000000010000012000100000000011000000
JUSSY CHAUDRIER	1000000000052000010021011023000000000000011110000
LANTAN	000000000101000000000000000100000000000011000000
LAPAN	00000000000000000000000000022000000000000001000000
LAVERDINES	00000000000000000000000000001000000000000000000000
LAZENAY	0000000000000000000100100000010000000000011000200
LERE	1101120105120211213041020022011103010000112101 40
LEVET	11001101012052322120410211122111100220111130114 0
LIGNIERES	11011212221543553420531500353224221221022 1200 45
LIMEUX	0000000000010000000000000001000000000000011000000
LISSAY-LOCHY	00000000010011000000000000220000000000000000000000
LOVE S ARNON	1000000001110211100000000011000000000000011100000
LUGNY-BOURBONNA	00000000000000000000000000000000000000000000000000
LUGNY-CHAMPAGNE	00000000051102100120110100020000000000000011101100
LUNERY	1100000000102110002103201000400000000000001231100 50
LURY S ARNON	1001110101031211100021020022010000010000111 00000
MAISONNAIS	000000000000200212010100000010000000000000111 00000-
MARCAIS	1000000001011110000001010012000000000000011200000
MAREUIL S ARNON	1000000001011111221031010015110000000000011211140
MARMAGNE	1000000001122011010011020051120100000000011100141
MARSEILLE AUBIG	1000000001001011010021010003000000000000011100040
MASSAY	1000000001032233210032020033111110010020222330240
MEHUN S YEVRE	1101151111155555250155350255635543121422355531 41
MEILLANT	1000000001110110000011010012110000000000012100000
MENETOU-COUTURE	1000000000010000000010000001000000000000001100000
MENETOU-RATEL	1000000003110210010021010020001100000000011100000
MENETOU-SALON	1100000005121541332042030041120004001010112 21241
MENETREOL SS SA	1000000000010111021022010104210000000000011100000
MENETREOL S SAU	0000000000010000010010010021000000000000011100000
MEREAU	0000000001013211112012010022000000000000001200 1000
MERY-ES-BOIS	1100000000021322111021010012110000001000111 01100
MERY-SUR-CHER	0000000000010000011011000021010000000000011220000
MONTIGNY	110000000100120001102101001200000000000001 2200100
MONTLOUIS	00000000000000011000000000011000000000000000000000
MORLAC	100000000110020001101001001100000000000011000000
MORNAY-BERRY	10000000010100000010000100020000000000000 11000000
MORNAY S ALLIER	1000000000020120011001010031000000100000112 20000
MOROGUES	1100000003011110000011000011000010000000 11000000
MORTHOMIERS	00000000000000000000000000001000000000000001000000
MOULINS S YEVRE	1000000000000111110102100003501000000000002 2200100
NANCAY	10000000020022110210210100411101000000000 11200000
NERONDES	110112122124312212105213003421122102331131211142
NEULLY EN DUN	000000000001111111101100001000000000000012111000
NEULLY EN SANC	1000000004120100101010000020000000000000011100000
NEUVY DEUX CLO.	100000000001000000101000001000000000000001000000
NEUVY LE BARROI	00000000000000100000000000001000000000000010000000
NEUVY S BARANG.	110111000114132113102112003322111101100111411100
NOHANT EN GOUT	00000000000000000000000000021000000000000010000000
NOHANT EN GRACA	00000000000010010011011000021000000000000011110000
LE NOYER	00000000000110411010000000120100000000000011000000
NOZIERES	00000000010000000000000000000000000000000000000000
OIZON	1100000005133111011021010032000000000000011100000

ORCENAIS	000000000000000000000000000020000000000000000000000
ORVAL	100001000111423312001101005221000000002124110140
OSMERY	000000000100010001101100000200000000000001111000
OSMOY	000000000000000000000000000000000000000000000000000
OUROUER L.BOUR.	100000000101322001002203002133000011000011221140
PARASSY	000000000110000000102000001200000000000001100000
PARNAY	000000000000000000000000000000000000000000000000000
LA PERCHE	000000000101000000000000000100000000000100101000
PIGNY	010000000100111101101000001100000000000001100000
PLAINPIED-GIV.	110000000111200001001101000210000000000001111000
PLOU	010000000010000000000000000220000000000000110000 0
POISIEUX	000000000100000000000010000110000000000000110000 0
LE PONDY	000000000000000000000110000200000000000000110000 0
PRECY	000000000001001100101001001300000000000001100010 0
PRESLY	100000000000000000000200000220000000000000111000 00
PREUILLY	100000000101111110001100001000000000000001200000 0
PREVERANGES	110001002104242232102102002111001310010011211141
PRIMELLES	000000000000010000102000001300000000000001200001 0
QUANTILLY	000000000100011000101000001100001000000001110100 0
QUINCY	110000000102015001001101002101000000000001210000 0
RAYMOND	000000000000000000100000001100000000000000110010 0
REIGNY	000000000001001000002000000100000000000001100000 0
REZAY	000000000000000000100000000140000000000001010000 0
RIANS	110000000101201001102101101100000000000001111000
SAGONNE	000000000100000000100001000100000000000001100000 0
ST AIGNAN D NOY	000000000000000000000000000110000000000000110000 0
ST AMANO MONTR.	111115143335554355345535125555355323224555405 2
ST AMBROIX	100000000111110100020010002000000000000001100010 0
ST BAUDEL	100000000100010000101100000100000000000001110000 0
ST BOUIZE	100000000112012210001101003000000101000011100000
ST CAPRAIS	000000000001101110000000002200001000000000110000 0
ST CEOLS	000000000000000000000000000100000000000000101000 00
ST CHRISTO. L.C	000000000001010000000000000100000000000000110000 0
ST DENIS DE PA.	000000000001001100000000000100000000000000100001 00
ST DOULCHARD	100002100515424555325405511543122221112133552040
ST ELOY DE GY	100000000211122113103202005300000000000000221000 00
ST FLORENT S CH	110115110135445435235424015553533412343335525240
STE GEMME SANC.	000000000000000010101100000000000000100011000000
ST GEORGES POI.	000000000001101000000000000100000000000000000000 00
ST GEORGES/PREE	000000000001010000001100000100000000000001110000 0
ST GEORGES/MOUL	000000000003201101000000003100000000000001110200
ST GERMAIN BOIS	100000000102010000002100002200000000000001110000 0
ST GERMAIN PUY	100001100510525122112333151421104421111225300 40
ST HILAIRE COU.	000000000000000100010000001200000000000000111000 00
ST HILAIRE GON.	000000000001001000000000000000000000000000000000 00
ST HILAIRE LIG.	100000000102011000000000001200000010000011000000
ST JEANVRIN	000000000000000000000000000000000000000000000000000
ST JUST	100000000114201221202100002300000000000001110000 0
ST LAURENT	000000000100010000100000100000000000000000001000020
ST LEGER PETIT	110000000000100010000000001101000000000000110000 00
ST LOUP CHAUMES	000000000001010000000000000200000000000000110000 0
STE LUNAISE	000000000000000000000000000000000000000000000000000
ST MARTIN AUXI.	110112011212232143305314002532111201100012200040
ST MARTIN CHAMP	000000000001001210000000000100000000000001110110 0
ST MAUR	000000000002020100000000000200000000000001110000 0
ST MICHEL VOLA.	000000000100100000001000000100000000000001110000 0
STE MONTAINE	000000000000100011000000001200000000000001110100 0
ST OUTRILLE	000000000000000100020000101000000000000001100010 0
ST PALAIS	000000000100100000001100001100000000000001211000 0
ST PIERRE BOIS	000000000101000001101000001000000000000000000000 00

```
ST PIERRE ETIEU000000000000212200000000000000000000000000000000000
ST PRIEST MARCH0000000000000000000020000000200000000000011000140
ST SATUR         1001020005144322331044050153211121011011335 12240
ST SATURNIN      1100000001030000110021010020110000000000011100000
STE SOLANGE      1100000001100111110021010002000000000000011100100
ST SYMPHORIEN    000000000100000000000000000000000000000000000000
STE THORETTE     000000000001000001001000003000000000000011100000
ST VITTE         000000000000000000000000000010000000000001 1000100
SALIGNY LE VIF   0000000000001000001010000011000000000000010000000
SANCERGUES       110112111111210023003303003222100200111111110240
SANCERRE         110112121531525453115334015533352102122252322021
SANCOINS         110113123115531215215525115532431332223235551245
SANTRANGES       1100000002121322200021000022110000000000112 10000
SAUGY            000000000000000000000000000000000000000000000000
SAULZAIS POTIER  110110001111111110002102002110000000101012212040
SAVIGNY SANCERR  1100000011031122211022010013010001001000111 00105
SAVIGNY SEPTAI.  1000000001020100010010010033010000000000011110000
SENNECAY         000000000000010000000000000110000000000000 1000000
SENS-BEAUJEU     110000000403411120201100002000000000010001 1000140
SERRUELLES       000000000000000000000000000001000000000000000000
SEVRY            000000000000000000000000000000000000000000000000
SIDIAILLES       0000000000101111000000000002000000000000011000000
SOULANGIS        0100000001000000000001000000100000000000011000000
SOYE SEPTAINE    000000000101001000002100002200000000000011200000
LE SUBDRAY       000000000000000100000000000110000000000000 1000000
SUBLIGNY         000000000112001111001101000100000000000011100000
SURY-PRES-LERE   000000000003101001000100001000000000000011000000
SURY EN VAUX     100000000202011010101101000100000100000011000000
SURY-ES-BOIS     100000000000020011300201001100000000000011101000
TENDRON          000000000000000000000000000000000000000000000000
THAUMIERS        100000000101010100102100001100000000000011000000
THAUVENAY        000000000001000000000000000100000000000011000000
THENIOUX         1000000000011110010011000031000000010110 1100000
THOU             000000000000110000001000000100000000000011100000
TORTERON         100000000102212001103201003511111000111021101040
TOUCHAY          000000000100001000101000001000000000000011110000
TROUY            100000000101543132103101002511000000000014310100
UZAY LE VENON    100000000100000000000100000020000000000011000000
VAILLY S SAULOR  110111013101325523303202004522411311111112221141
VALLENAY         100001000110011100004201003400000000100012100140
VASSELAY         000000000511011111020000001000000000000011000000
VEAUGUES         110000000202321101003101001111000100100011211240
VENESME          000000000100020010001100001100000000000011100000
VERDIGNY         000000000510011000000100000000000000000010100000
VEREAUX          000000000000000001001000000000000000000011000000
VERNAIS          000000000000202100010100000010000000000010100000
VERNEUIL         000000000000000000000000000000000000000000000000
VESDUN           100000000101012111203101002110000000000011100140
VIERZON          111155555555555515555555555555555555555555555150
VIGNOUX SS AIX   000000000101000100001100001200000000000011100000
VIGNOUX S BARAN  100000000101011111102101003310010000030013100000
VILLABON         110000000102000000101001001200000000000011000000
VILLECELIN       000000000000000000000000000010000000000000000000
VILLEGENON       000000000110000010000100101100000000000011100000
VILLENEUVE S CH  000000000000000000000200000240000000000001 2000000
VILLEQUIERS      100000000000022221101102002500000000000011210001
VINON            000000000000001110000110000010000000000001 1100000
VORLY            000000000100000000100000000300000000000011100000
VORNAY           100000000001001100001101001100000000000011100000
VOUZERON         100000000000001000000100001100000000000011100001
```

*** TABULATION OF THE 15 CENTRALITY INDICATORS IN THE CHER ***

ACHERE	6.	6.	273.	203.	21.	270.	7.83	10.	1411.	106166.50	1.0	45.0	45.0	45.0	45.0
AINAY VIEL	16.	16.	182.	177.	13.	455.	17.51	12.	1981.	59026.80	1.0	11.0	11.0	28.0	28.0
AIX ANGILLON	90.	42.	2146.	2066.	146.	5606.	35.92	9.	1219.	151744.63	2.1	23.0	51.0	133.0	62.0
ALLOGNY	19.	13.	765.	539.	15.	455.	17.51	9.	1261.	162401.69	1.5	40.0	58.0	35.0	23.0
ALLOUIS	6.	5.	639.	121.	18.	375.	9.71	10.	1530.	105529.81	1.2	106.0	127.0	75.0	62.0
ANNOIX	2.	2.	286.	264.	24.	88.	7.09	11.	1916.	60455.40	1.0	143.0	143.0	44.0	44.0
APREMONT ALLIER	7.	7.	106.	55.	3.	803.	13.74	13.	2093.	54292.20	1.0	15.0	15.0	114.0	114.0
ARCAY	9.	7.	337.	290.	18.	216.	12.45	9.	1524.	99675.60	1.3	37.0	48.0	30.0	24.0
ARCOMPS	16.	11.	310.	0.	15.	363.	9.71	12.	2138.	52860.20	1.5	19.0	28.0	33.0	22.0
ARDENAIS	5.	5.	198.	0.	11.	279.	7.14	11.	1848.	65993.38	1.0	39.0	39.0	55.0	55.0
ARGENT S SAULDR	100.	42.	2687.	2196.	40.	5606.	35.92	13.	1992.	66975.31	2.4	26.0	64.0	133.0	56.0
ARGENVIERES	16.	10.	402.	112.	27.	297.	7.83	15.	2227.	47261.60	1.6	25.0	40.0	29.0	18.0
ARPHEUILLES	8.	5.	244.	0.	5.	124.	7.42	11.	1764.	68694.50	1.6	30.0	48.0	24.0	15.0
ASSIGNY	6.	6.	207.	51.	12.	279.	10.03	14.	2146.	56811.10	1.0	34.0	34.0	46.0	46.0
AUBIGNY S NERE	146.	45.	5600.	4972.	91.	5606.	35.92	12.	1710.	80329.81	3.2	38.0	124.0	124.0	38.0
AUBINGES	3.	3.	226.	0.	21.	289.	10.92	10.	1464.	97453.00	1.0	75.0	75.0	96.0	96.0
AUGY S AUBOIS	15.	14.	395.	86.	13.	257.	14.96	12.	2094.	53543.50	1.1	26.0	28.0	18.0	17.0
AVORD	46.	27.	2492.	1751.	89.	2316.	17.51	10.	1384.	99637.63	1.7	54.0	92.0	85.0	50.0
AZY	30.	19.	479.	218.	17.	437.	16.62	11.	1499.	83365.88	1.6	16.0	25.0	23.0	14.0
BANNAY	17.	16.	785.	555.	31.	289.	10.92	13.	2069.	58665.00	1.1	46.0	49.0	18.0	17.0
BANNEGON	14.	13.	297.	109.	14.	891.	16.62	10.	1555.	82750.19	1.1	21.0	22.0	68.0	63.0
BARLIEU	17.	15.	413.	171.	15.	888.	16.12	14.	2159.	57271.80	1.1	24.0	27.0	59.0	52.0
BAUGY	83.	43.	1144.	1058.	51.	2361.	19.16	11.	1478.	81220.31	1.9	13.0	26.0	54.0	28.0
BEDDES	1.	1.	125.	54.	10.	88.	7.09	13.	2369.	48733.90	1.0	125.0	125.0	88.0	88.0
BEFFES	26.	19.	662.	655.	56.	1138.	13.74	15.	2322.	45212.90	1.4	25.0	34.0	59.0	43.0
BELLEVILLE S L	18.	10.	448.	362.	41.	279.	7.14	15.	2510.	46166.40	1.8	24.0	44.0	27.0	15.0
BENGY S CRAON	23.	23.	584.	499.	17.	455.	17.51	11.	1594.	79290.81	1.0	25.0	25.0	19.0	19.0
BERRY-BOUY	5.	4.	807.	320.	26.	124.	7.42	9.	1351.	153938.19	1.3	161.0	201.0	31.0	24.0
BESSAIS L FROM.	17.	14.	405.	157.	16.	2316.	17.51	12.	1942.	58457.60	1.2	23.0	28.0	165.0	136.0
BLANCAFORT	40.	23.	1070.	286.	17.	455.	17.51	13.	1991.	68304.38	1.7	26.0	46.0	19.0	11.0
BLET	41.	25.	713.	421.	24.	455.	17.51	10.	1416.	101282.19	1.6	17.0	28.0	18.0	11.0
BOULLERET	45.	24.	1417.	658.	43.	455.	17.51	14.	2288.	51406.10	1.9	31.0	59.0	19.0	10.0
BOURGES	210.	48.	76432.	74622.	113.	67710.	53.80	8.	1105.	105603.31	4.4	364.0	1592.0	1410.0	322.0
BOUZAIS	3.	3.	227.	0.	68.	88.	7.09	12.	1972.	61450.70	1.0	75.0	75.0	29.0	29.0
BRECY	17.	15.	503.	290.	13.	3026.	35.92	11.	1548.	80522.13	1.1	29.0	33.0	201.0	178.0
BRINAY	2.	2.	452.	140.	15.	279.	7.14	11.	1697.	109211.88	1.0	226.0	226.0	139.0	139.0
BRINON S SAULDR	68.	32.	1249.	846.	11.	2316.	17.51	13.	2110.	60498.20	2.1	18.0	39.0	72.0	34.0
BRUERE-ALLICHAM	23.	16.	631.	571.	45.	455.	17.51	9.	1380.	111560.13	1.4	27.0	39.0	28.0	19.0
BUE	14.	14.	362.	362.	56.	3026.	35.92	12.	1762.	68453.50	1.0	25.0	25.0	216.0	216.0
BUSSY	7.	7.	453.	63.	17.	803.	13.74	10.	1569.	80266.31	1.0	64.0	64.0	114.0	114.0
LA CELETTE	3.	3.	200.	0.	8.	803.	13.74	12.	1985.	59849.00	1.0	66.0	66.0	267.0	267.0
LA CELLE	11.	10.	264.	233.	22.	331.	9.71	10.	1572.	81591.13	1.1	24.0	26.0	33.0	30.0
LA CELLE-CONDE	3.	3.	217.	75.	7.	88.	7.09	11.	1862.	67145.69	1.0	72.0	72.0	29.0	29.0
CERBOIS	6.	5.	253.	232.	14.	279.	10.03	11.	1785.	82023.63	1.2	42.0	50.0	55.0	46.0
CHALIVOY-MILON	22.	17.	504.	262.	26.	2361.	19.16	11.	1625.	77442.00	1.3	22.0	29.0	138.0	107.0
CHAMBON	2.	2.	143.	0.	10.	88.	7.09	10.	1653.	79487.31	1.0	71.0	71.0	44.0	44.0
LA CHAPELLE ANG	52.	30.	756.	637.	74.	2316.	17.51	11.	1559.	100745.69	1.7	14.0	25.0	77.0	44.0
LA CHAPELLE HUG	12.	9.	327.	135.	20.	363.	9.71	13.	2019.	57426.40	1.3	27.0	36.0	40.0	30.0
LA CHAPELLE MON	14.	6.	515.	96.	30.	257.	14.96	14.	2059.	52872.30	2.3	36.0	85.0	42.0	18.0
LA CHAP ST URS	42.	22.	2430.	2391.	310.	3026.	35.92	9.	1346.	150867.13	1.9	57.0	110.0	137.0	72.0
LA CHAPELOTTE	14.	13.	180.	86.	6.	437.	16.62	11.	1539.	86648.31	1.1	12.0	13.0	33.0	31.0
CHARENTON SCHER	54.	29.	1292.	748.	27.	2316.	17.51	11.	1727.	69229.50	1.9	23.0	44.0	79.0	42.0

CHARENTONNAY	7.	7.	317.	102.	15.	257.	14.96	12.	1714.	67566.81	1.0	45.0	45.0	36.0	36.0
CHARLY	10.	9.	272.	188.	11.	270.	7.83	11.	1633.	76556.19	1.1	27.0	30.0	30.0	27.0
CHAROST	64.	37.	1152.	1130.	105.	3026.	35.92	9.	1515.	101757.63	1.7	18.0	31.0	81.0	47.0
CHASSY	6.	6.	231.	0.	13.	309.	9.71	14.	2117.	51803.90	1.0	38.0	38.0	60.0	60.0
CHATEAUMEILLANT	119.	43.	2186.	1758.	51.	3341.	24.97	12.	2095.	55882.80	2.8	18.0	50.0	77.0	28.0
CHATEAUNEUFCHER	77.	42.	1657.	1374.	75.	3341.	24.97	9.	1379.	109978.63	1.8	21.0	39.0	79.0	43.0
LE CHATELET	65.	37.	1151.	784.	35.	2316.	17.51	11.	1836.	67416.81	1.8	17.0	31.0	62.0	35.0
CHAUMONT	0.	0.	48.	0.	23.	0.	0.0	11.	1623.	78054.00	0.0	0.0	0.0	0.0	0.0
CHAUMOUX-MARCIL	5.	5.	92.	50.	6.	381.	10.10	12.	1672.	66709.63	1.0	18.0	18.0	76.0	76.0
LE CHAUTAY	7.	7.	[illegible]17.	159.	22.	331.	9.71	14.	2209.	51956.10	1.0	45.0	45.0	47.0	47.0
CHAVANNES	2.	2.	141.	98.	6.	88.	7.09	10.	1558.	82388.69	1.0	70.0	70.0	44.0	44.0
CHERY	7.	7.	266.	213.	20.	257.	14.96	14.	2427.	55722.00	1.0	38.0	38.0	36.0	36.0
CHEZAL-BENOIT	25.	20.	1315.	669.	28.	455.	17.51	11.	1839.	67174.31	1.3	52.0	65.0	22.0	18.0
CIVRAY	23.	16.	813.	451.	20.	559.	9.71	8.	1520.	102377.81	1.4	35.0	50.0	34.0	24.0
CLEMONT	27.	21.	600.	457.	12.	571.	24.64	13.	1994.	68749.50	1.3	22.0	28.0	27.0	21.0
COGNY	0.	0.	40.	0.	2.	0.	0.0	10.	1629.	78783.81	0.0	0.0	0.0	0.0	0.0
COLOMBIERS	4.	4.	260.	192	27.	331.	9.71	11.	1812.	73411.63	1.0	65.0	65.0	82.0	82.0
CONCRESSAULT	15.	13.	216.	161	29.	2600.	19.38	13.	1979.	69012.13	1.2	14.0	16.0	200.0	173.0
CONTRES	0.	0.	21.	0.	1.	0.	0.0	10.	1558.	81144.00	0.0	0.0	0.0	0.0	0.0
CORNUSSE	11.	8.	355.	198.	18.	297.	7.83	12.	1727.	66468.81	1.4	32.0	44.0	37.0	27.0
CORQUOY	7.	5.	216.	0.	10.	124.	7.42	10.	1659.	79731.50	1.4	30.0	43.0	24.0	17.0
COUARGUES	6.	4.	211.	0.	18.	175.	8.34	13.	1978.	56405.70	1.5	35.0	52.0	43.0	29.0
COURS LESBARRES	24.	17.	906.	530.	43.	289.	10.92	14.	2117.	52208.50	1.4	37.0	53.0	17.0	12.0
COUST	19.	16.	460.	220.	21.	289.	10.92	11.	1739.	75550.50	1.2	24.0	28.0	18.0	15.0
COUY	13.	9.	305.	106.	17.	363.	9.71	13.	1824.	59536.30	1.4	23.0	33.0	40.0	27.0
CREZANCAY SCHER	0.	0.	73.	0.	10.	0.	0.0	11.	1863.	64507.40	0.0	0.0	0.0	0.0	0.0
CREZANCY EN SAN	19.	14.	511.	111.	27.	363.	9.71	12.	1728.	70785.31	1.4	26.0	36.0	25.0	19.0
CROISY	2.	2.	149.	0.	11.	88.	7.09	12.	1863.	62802.10	1.0	74.0	74.0	44.0	44.0
CROSSES	11.	11.	247.	217.	9.	279.	10.03	10.	1507.	81048.00	1.0	22.0	22.0	25.0	25.0
CUFFY	20.	13.	871.	395.	25.	279.	10.03	13.	2007.	56608.10	1.5	43.0	67.0	21.0	13.0
CULAN	78.	40.	1055.	895.	52.	2600.	19.38	13.	2336.	49733.60	1.9	13.0	26.0	65.0	33.0
DAMPIERREENCROT	6.	5.	239.	0.	11.	271.	6.69	13.	1923.	66629.88	1.2	39.0	47.0	54.0	45.0
DAMPIERREENGRAC	7.	7	170.	80.	18.	271.	6.69	13.	2183.	70694.63	1.0	24.0	24.0	38.0	38.0
DREVANT	10.	10.	486.	159.	101.	289.	10.92	11.	1798.	73528.63	1.0	48.0	48.0	28.0	28.0
DUN-SUR-AURON	110	45.	4238.	3826.	85.	5606.	35.92	9.	1348.	102228.19	2.4	38.0	94.0	124.0	51.0
ENNORDRES	22.	15.	589.	146.	9.	868.	16.62	12.	1763.	78748.81	1.5	26.0	39.0	57.0	39.0
EPINEUIL FLEURI	20	17.	551.	227.	13.	1782.	16.12	13.	2261.	49135.70	1.2	27.0	32.0	104.0	89.0
ETRECHY	30.	22.	448.	281.	14.	437.	16.62	12.	1703.	66886.13	1.4	14.0	20.0	19.0	14.0
FARGES ALLICHAM	8.	6.	204.	158.	25.	87.	6.32	10.	1641.	79771.00	1.3	25.0	34.0	14.0	10.0
FARGES EN SEPT.	23.	18.	566.	337.	23.	2361.	19.16	10.	1432.	98762.13	1.3	24.0	31.0	131.0	102.0
FAVERDINES	1.	1.	147.	0.	8.	88.	7.09	13.	2229.	50520.30	1.0	147.0	147.0	88.0	88.0
FEUX	21.	18.	375.	191.	14.	868.	16.62	12.	1709.	68308.38	1.2	17.0	20.0	48.0	41.0
FLAVIGNY	5.	5.	204.	105.	16.	271.	6.69	12.	1802.	65655.50	1.0	40.0	40.0	54.0	54.0
FOECY	58.	30.	2185.	1530.	135.	2361.	19.16	11.	1730.	106892.31	1.9	37.0	72.0	78.0	40.0
FUSSY	22.	15.	1762.	1632.	160.	868.	16.62	9.	1353.	146610.69	1.5	80.0	117.0	57.0	39.0
GARDEFORT	0.	0.	112	0.	13.	0.	0.0	13.	1827.	58629.60	0.0	0.0	0.0	0.0	0.0
GARIGNY	17.	12.	222.	127.	11.	381.	10.10	13.	1809.	61795.50	1.4	13.0	18.0	31.0	22.0
GENOUILLY	26.	19.	721.	498.	21.	455.	17.51	14.	2464.	56120.50	1.4	27.0	37.0	23.0	17.0
GERMIGNY EXEMPT	15.	11.	383.	227.	14.	455.	17.51	12.	1822.	66561.81	1.4	25.0	34.0	41.0	30.0
GIVARDON	19.	15.	342.	134.	16.	803.	13.74	12.	1862.	63054.60	1.3	18.0	22.0	53.0	42.0
GRACAY	94	44	1844.	1456.	58.	2600.	19.38	14.	2465.	54757.00	2.1	19.0	41.0	59.0	27.0
GROISES	1.	1.	197	78.	11.	175.	5.57	12.	1680.	69687.13	1.0	197.0	197.0	175.0	175.0
GRON	3.	3.	302	0.	12.	290.	7.65	12.	1762.	64085.60	1.0	100.0	100.0	96.0	96.0
GROSSOUVRE	11.	10.	331.	271.	21.	868.	16.62	12.	1846.	65691.81	1.1	30.0	33.0	86.0	78.0
LA GROUTTE	0.	0	89	89	31	0	0.0	11.	1780.	74467.19	0.0	0.0	0.0	0.0	0.0
LA GUERCHE AUBO	102.	43	3326.	2608.	63	2600.	19.38	13.	1944.	56576.90	2.4	32.0	77.0	60.0	25.0
HENRICHEMONT	99	42	1826	1442	72	2600	19.38	11	1477.	91262.63	2.4	18.0	43.0	61.0	26.0
HERRY	42	26	1024	425	21	2361.	19.16	13.	1916	58062.90	1.6	24.0	39.0	90.0	56.0
HUMBLIGNY	5	5	221	60	11	124	7.42	12.	1684.	72909.31	1.0	44.0	44.0	24.0	24.0
IDS ST ROCH	7	7	342	67	12.	363	9.71	42.	2065.	56179.20	1.0	48.0	48.0	51.0	51.0

IGNOL	4	4	179.	72.	10.	87.	6.32	13.	2087.	54134.00	1.0	44.0	44.0	21.0	21.0
INEUIL	8.	7.	269.	58.	10.	289.	10.92	11.	1882.	63851.80	1.1	33.0	38.0	41.0	36.0
IVOY LE PRE	25	18.	933.	403.	9.	888.	16.12	11.	1514.	94659.31	1.4	37.0	51.0	49.0	35.0
JALOGNES	17.	14.	295.	127.	10.	1143.	29.44	13.	1886.	59710.10	1.2	17.0	21.0	81.0	67.0
JARS	27.	18.	554.	225.	15.	803.	13.74	12.	1734.	78377.81	1.5	20.0	80.0	44.0	29.0
JOUET S AUBOIS	71.	34.	1488.	1199.	86.	2316.	17.51	14.	2043.	53233.20	2.1	21.0	43.0	68.0	32.0
JUSSY CHAMPAGNE	9.	8.	247.	214.	9.	891.	16.62	10.	1503.	83688.81	1.1	27.0	30.0	111.0	99.0
JUSSY CHAUDRIER	23	14.	545.	156.	21.	3026.	35.92	14.	1967.	55647.90	1.6	23.0	38.0	216.0	131.0
LANTAN	5	5.	140.	76.	10.	124.	7.42	11.	1857.	62458.50	1.0	28.0	28.0	24.0	24.0
LAPAN	5.	3.	131.	89.	12.	175.	5.57	10.	1728.	77727.63	1.7	26.0	43.0	58.0	35.0
LAVERDINES	1.	1.	58.	0.	6.	87.	6.32	13.	1954.	56784.60	1.0	58.0	58.0	87.0	87.0
LAZENAY	7.	6.	300.	154.	10.	381.	10.10	11.	1754.	83578.19	1.2	42.0	50.0	63.0	54.0
LERE	53.	31.	925.	573.	58.	2401.	14.71	14.	2288.	51898.10	1.7	17.0	29.0	77.0	45.0
LEVET	60.	36.	1266.	1057.	49.	3026.	35.92	8.	1226.	154433.19	1.7	21.0	35.0	84.0	50.0
LIGNIERES	106.	41.	1829.	1746.	84.	2600.	19.38	10.	1585.	85335.81	2.6	17.0	44.0	63.0	24.0
LIMEUX	4.	4.	133.	0.	10.	124.	7.42	10.	1592.	96650.63	1.0	33.0	33.0	31.0	31.0
LISSAY-LOCHY	7.	5.	142.	71.	6.	331.	9.71	10.	1680.	76187.00	1.4	20.0	28.0	66.0	47.0
LOYE S ARNON	14.	13.	329.	60.	10.	803.	13.74	12.	2058.	56173.70	1.1	23.0	25.0	61.0	57.0
LUGNY-BOURBONNA	0.	0.	35.	0.	7.	0.	0.0	11.	1609.	76916.13	0.0	0.0	0.0	0.0	0.0
LUGNY-CHAMPAGNE	23.	16.	221.	119.	7.	803.	13.74	13.	1916.	58439.90	1.4	9.0	13.0	50.0	34.0
LUNERY	33.	18.	2021.	547.	61.	2316.	17.51	9.	1521.	101390.13	1.8	61.0	112.0	128.0	70.0
LURY S ARNON	29.	22.	566.	557.	41.	2401.	14.71	11.	1745.	91198.00	1.3	19.0	25.0	109.0	82.0
MAISONNAIS	13.	10.	276.	276.	10.	279.	10.03	12.	2110.	55341.40	1.3	21.0	27.0	27.0	21.0
MARCAIS	15.	13.	372.	130.	13.	363.	9.71	10.	1605.	82199.63	1.2	24.0	28.0	27.0	24.0
MAREUIL S ARNON	36.	24.	659.	483.	25.	455.	17.51	10.	1689.	78673.31	1.5	18.0	27.0	19.0	12.0
MARMAGNE	33.	22.	1774.	1610.	47.	1143.	29.44	10.	1577.	103423.00	1.5	53.0	80.0	52.0	34.0
MARSEILLE AUBIG	20.	14.	876.	753.	89.	279.	10.03	14.	2046.	53303.60	1.4	43.0	62.0	19.0	13.0
MASSAY	55.	27.	1339.	984.	28.	455.	17.51	13.	2139.	69925.50	2.0	24.0	49.0	16.0	8.0
MEHUN S YEVRE	141.	45.	7178.	7178.	294.	5606.	35.92	9.	1290.	159163.00	3.1	50.0	159.0	124.0	39.0
MEILLANT	18.	16.	685.	473.	17.	455.	17.51	10.	1505.	90891.81	1.1	38.0	42.0	28.0	25.0
MENETOU-COUTURE	6.	6.	369.	84.	13.	363.	9.71	15.	2294.	47010.70	1.0	61.0	61.0	60.0	60.0
MENETOU-RATEL	21.	16.	506.	129.	18.	891.	16.62	13.	1908.	64601.20	1.3	24.0	31.0	55.0	42.0
MENETOU-SALON	66.	30.	1477.	817.	39.	1143.	29.44	10.	1401.	103619.31	2.2	22.0	49.0	38.0	17.0
MENETREOL SS SA	24.	17.	389.	361.	69.	3341.	24.97	13.	2045.	55805.20	1.4	16.0	22.0	196.0	139.0
MENETREOL S SAU	10.	9.	223.	168.	4.	381.	10.10	11.	1628.	96413.19	1.1	22.0	24.0	42.0	38.0
MEREAU	25.	17.	1756.	417.	94.	289.	10.92	12.	1868.	97022.13	1.5	70.0	103.0	17.0	11.0
MERY-ES-BOIS	30.	23.	637.	447.	7.	455.	17.51	10.	1374.	115232.31	1.3	21.0	27.0	19.0	15.0
MERY-SUR-CHER	15.	12.	555.	77.	27.	437.	9.71	12.	1929.	95137.50	1.3	37.0	46.0	36.0	29.0
MONTIGNY	21.	16.	422.	164.	15.	257.	14.96	11.	1475.	86301.13	1.3	20.0	26.0	16.0	12.0
MONTLOUIS	4.	4.	124.	0.	7.	279.	10.03	11.	1913.	63160.00	1.0	31.0	31.0	69.0	69.0
MORLAC	13.	12.	314.	73.	10.	803.	13.74	11.	1847.	65478.80	1.1	24.0	26.0	66.0	61.0
MORNAY-BERRY	9.	8.	178.	91.	19.	363.	9.71	13.	1883.	59080.20	1.1	19.0	22.0	45.0	40.0
MORNAY S ALLIER	21.	15.	394.	206.	18.	571.	24.64	12.	1914.	62956.30	1.4	18.0	26.0	38.0	27.0
MOROGUES	16.	14.	376.	183.	12.	1143.	16.62	10.	1371.	104125.88	1.1	23.0	26.0	81.0	71.0
MORTHOMIERS	2.	2.	409.	365.	28.	88.	7.09	10.	1625.	94969.13	1.0	204.0	204.0	44.0	44.0
MOULINS S YEVRE	26.	16.	369.	220.	24.	257.	14.96	9.	1366.	148478.81	1.6	14.0	23.0	16.0	9.0
NANCAY	28.	19.	748.	512.	7.	455.	17.51	11.	1638.	112681.13	1.5	26.0	39.0	23.0	16.0
NERONDES	82.	43.	1343.	1115.	40.	2600.	19.38	12.	1775.	67229.63	1.9	16.0	31.0	60.0	31.0
NEULLY EN DUN	17.	16.	338.	171.	11.	289.	10.92	11.	1767.	67990.69	1.1	19.0	21.0	18.0	17.0
NEULLY EN SANC	17.	12.	252.	71.	10.	803.	13.74	12.	1704.	75170.63	1.4	14.0	21.0	66.0	47.0
NEUVY DEUX CLO.	6.	6.	345.	71.	21.	363.	9.71	12.	1699.	73225.50	1.0	57.0	57.0	60.0	60.0
NEUVY LE BARROI	3.	3.	165.	0.	4.	279.	7.14	12.	1892.	63785.00	1.0	55.0	55.0	93.0	93.0
NEUVY S BARANG.	55.	36.	1219.	1075.	18.	2600.	19.38	10.	1416.	132999.88	1.5	22.0	33.0	72.0	47.0
NOHANT EN GOUT	4.	3.	374.	268.	15.	88.	7.09	10.	1483.	97482.13	1.3	93.0	124.0	29.0	22.0
NOHANT EN GRACA	13	12.	318.	134.	13.	381.	10.10	14.	2416.	57936.40	1.1	24.0	26.0	31.0	29.0
LE NOYER	15.	11.	296.	107.	15.	279.	10.03	12.	1713.	79790.19	1.4	19.0	26.0	25.0	18.0
NOZIERES	1	1.	154.	0.	15.	149.	11.65	10.	1662.	78840.00	1.0	154.0	154.0	149.0	149.0
OIZON	31.	19.	725.	458.	12.	803.	13.74	12.	1783.	76885.81	1.6	23.0	38.0	42.0	25.0
ORCENAIS	2.	1.	233.	107.	12.	0	0.0	11.	1928.	62118.00	2.0	116.0	233.0	0.0	0.0
ORVAL	49.	26.	2055.	2035.	269.	2316.	17.51	11.	1725.	76927.50	1.9	41.0	79.0	89.0	47.0

OSMERY	13.	12.	309.	234.	15.	289.	10.92	11.	1689.	65954.50	1.1	23.0	25.0	24.0	22.0
OSMOY	0.	0.	210.	0.	9.	0.	0.0	9.	1351.	146387.13	0.0	0.0	0.0	0.0	0.0
OUROUER L BOUR.	41.	23.	758.	455.	31.	571.	24.64	11.	1613.	77695.00	1.8	18.0	33.0	24.0	13.0
PARASSY	10.	8.	346.	86.	13.	803.	13.74	10.	1395.	104109.00	1.3	34.0	43.0	100.0	80.0
PARNAY	0.	0.	30.	0.	2.	0.	0.0	11.	1917.	61240.90	0.0	0.0	0.0	0.0	0.0
LA PERCHE	7.	7.	232.	72.	22.	888.	16.12	13.	2207.	50971.00	1.0	33.0	33.0	126.0	126.0
PIGNY	13	13	597.	419.	74.	559.	9.71	10.	1541.	99622.13	1.0	45.0	45.0	43.0	43.0
PLAINPIED-GIV.	19.	17.	1100.	469.	27.	455.	17.51	9.	1370.	146535.50	1.1	57.0	64.0	26.0	23.0
PLOU	8.	6.	410.	160.	12.	803.	13.74	10.	1731.	80914.81	1.3	51.0	68.0	133.0	100.0
POISIEUX	6.	6.	167.	142.	16.	88.	7.09	10.	1737.	80254.81	1.0	27.0	27.0	14.0	14.0
LE PONDY	6.	5.	127.	127.	19.	175.	8.34	11.	1756.	74466.31	1.2	21.0	25.0	35.0	29.0
PRECY	13.	11.	262.	114.	18.	257.	14.96	14.	2086.	51296.10	1.2	20.0	23.0	23.0	19.0
PRESLY	10.	7.	247.	119.	3.	363.	9.71	11.	1608.	94328..9	1.4	24.0	35.0	51.0	36.0
PREUILLY	14.	13.	342.	267.	23.	279.	10.03	9.	1484.	108547.88	1.1	24.0	26.0	21.0	19.0
PREVERANGES	54.	32.	861.	333.	23.	1143.	29.44	14.	2647.	41911.10	1.7	15.0	26.0	35.0	21.0
PRIMELLES	12.	8.	264.	194.	10.	216.	12.45	10.	1767.	76370.19	1.5	22.0	33.0	27.0	18.0
QUANTILLY	12.	12.	346.	78.	27.	1143.	16.62	11.	1624.	84859.88	1.0	28.0	28.0	95.0	95.0
QUINCY	23.	16.	759.	547.	42.	559.	9.71	10.	1507.	114227.69	1.4	33.0	47.0	34.0	24.0
RAYMOND	6.	6.	177.	155.	19.	257.	14.96	11.	1569.	70288.60	1.0	29.0	29.0	42.0	42.0
REIGNY	7.	6.	317.	0.	13.	270.	7.83	12.	2113.	54230.60	1.2	45.0	52.0	45.0	38.0
REZAY	8.	5.	262.	0.	12.	381.	10.10	12.	2116.	54966.50	1.6	32.0	52.0	76.0	47.0
RIANS	21.	19.	836.	701.	26.	3026.	35.92	10.	1385.	100242.00	1.1	39.0	44.0	159.0	144.0
SAGONNE	6.	6.	199.	110.	11.	297.	7.83	13.	2046.	55013.40	1.0	33.0	33.0	49.0	49.0
ST AIGNAN D NOY	4.	4.	110.	66.	10.	88.	7.09	11.	1814.	66551.19	1.0	27.0	27.0	22.0	22.0
ST AMAND MONTR.	169.	47.	12451.	11961.	617.	67710.	53.80	10.	1525.	79537.31	3.6	73.0	264.0	1440.0	[illegible]
ST AMBROIX	16.	14.	406.	243.	13.	803.	13.74	10.	1792.	75602.50	1.1	25.0	29.0	57.0	50.0
ST BAUDEL	10.	10.	310.	193.	10.	363.	9.71	10.	1625.	81986.38	1.0	31.0	31.0	36.0	36.0
ST BOUIZE	22	17.	348.	238.	23.	437.	16.62	13.	1921.	58621.00	1.3	15.0	20.0	25.0	19.0
ST CAPRAIS	12.	10.	317.	0.	22.	1143.	16.62	9.	1468.	105275.13	1.2	26.0	31.0	114.0	95.0
ST CEOLS	3.	3.	22.	0.	7.	271.	6.69	10.	1390.	101984.19	1.0	7.0	7.0	90.0	90.0
ST CHRISTO. L.C	5.	5.	123.	0.	7.	279.	7.14	13.	2298.	50185.90	1.0	24.0	24.0	55.0	55.0
ST DENIS DE PA.	6.	6.	327.	86.	11.	257.	14.96	10.	1598.	93113.13	1.0	54.0	54.0	42.0	42.0
ST DOULCHARD	115.	39.	7928.	7338.	330.	3341.	24.97	9.	1339.	152255.13	2.9	68.0	203.0	85.0	29.0
ST ELOY DE GY	36.	19.	1071.	390.	20.	803.	13.74	10.	1627.	100987.69	1.9	29.0	56.0	42.0	22.0
ST FLORENT S CH	141.	44.	7611.	7469.	340.	3341.	24.97	8.	1260.	150979.88	3.2	54.0	173.0	75.0	23.0
STE GEMME SANC.	7.	7.	361.	88.	[illegible]	924.	16.62	12.	1795.	69774.69	1.0	51.0	51.0	132.0	132.0
ST GEORGES POI.	4.	4.	302.	0.	19.	331.	9.71	13.	2230.	50776.80	1.0	75.0	75.0	82.0	82.0
ST GEORGES/PREE	8.	8.	367.	114.	16.	279.	7.14	13.	2200.	68202.50	1.0	45.0	45.0	34.0	34.0
ST GEORGES/MOUL	17	11.	524.	332.	56.	279.	10.03	10.	1537.	101051.81	1.5	30.0	47.0	25.0	16.0
ST GERMAIN BOIS	15	11	557.	193.	19.	363.	9.71	9.	1413.	101113.63	1.4	37.0	50.0	33.0	24.0
ST GERMAIN PUY	85.	37.	4997.	4232.	231.	5606.	35.92	9.	1371.	143410.81	2.3	58.0	135.0	151.0	66.0
ST HILAIRE CO	9.	8.	668.	629.	57.	270.	7.83	12.	1920.	96429.31	1.1	74.0	83.0	33.0	30.0
ST HILAIRE GO	2.	2.	155.	0.	8.	270.	7.83	14.	2030.	54569.20	1.0	77.0	77.0	135.0	135.0
ST HILAIRE LIG	12	10	572.	127.	11.	571.	24.64	11.	1828.	68485.38	1.2	47.0	57.0	57.0	47.0
ST JEANVRIN	0.	0.	178.	0	10.	0.	0.0	14.	2640.	41630.30	0.0	0.0	0.0	0.0	0.0
ST JUST	28.	17	558	431.	37.	803.	13.74	9.	1235.	153971.69	1.6	19.0	32.0	47.0	28.0
ST LAURENT	7.	6.	253.	91.	7.	3026.	35.92	11.	1746.	108540.13	1.2	36.0	42.0	504.0	432.0
ST LEGER PETIT	9	9	324.	71.	32.	559.	9.71	15.	2239.	47478.70	1.0	36.0	36.0	62.0	62.0
ST LOUP CHAUMES	6.	5.	302.	178.	16.	279.	7.14	11.	1674.	71812.00	1.2	50.0	60.0	55.0	46.0
STE LUNAISE	0	0.	36.	0	3.	0.	0.0	10.	1651.	80650.13	0.0	0.0	0.0	0.0	0.0
ST MARTIN AUXI.	72.	35.	1705.	883	71.	2600.	19.38	10.	1467.	110657.50	2.1	23.0	48.0	74.0	36.0
ST MARTIN CHAMP	11	10	356	142	19.	257	14.96	15.	2230.	46968.60	1.1	32.0	35.0	25.0	23.0
ST MAUR	10	7	329	0	13.	279.	10.03	14.	2618.	42442.50	1.4	32.0	47.0	39.0	27.0
ST MICHEL VOLA	7	7	261	169	15.	331.	9.71	9.	1333.	147352.69	1.0	37.0	37.0	47.0	47.0
STE MONTAINE	10.	9	233	126.	4.	289.	10.92	12.	1823.	79412.19	1.1	23.0	25.0	32.0	28.0
ST OUTRILLE	8	7	288.	189	23.	3341.	24.97	15.	2703.	47997.00	1.1	36.0	41.0	477.0	417.0
ST PALAIS	11	10	587	271	22	375.	9.71	11.	1697.	81342.13	1.1	53.0	58.0	37.0	34.0
ST PIERRE BOIS	6	6	302	0	15.	381	10.10	12	2086.	55691.30	1.0	50.0	50.0	63.0	63.0
ST PIERRE ETIEU	7	4	636	92	23	331	9.71	11.	1755	75004.00	1.8	90.0	159.0	82.0	47.0
ST PRIEST MARCH	11	6	282	0	14	257	14.96	15.	2935	36860.60	1.8	25.0	47.0	42.0	23.0

ST SATUR	86.	36.	1961.	1952.	249.	3341.	24.97	12.	1836.	65547.50	2.4	22.0	54.0	92.0	38.0
ST SATURNIN	19	15.	605.	98.	15.	455.	17.51	13.	2377.	48896.70	1.3	31.0	40.0	30.0	23.0
STE SOLANGE	19	17.	1089.	844.	34.	803.	13.74	10.	1466.	100542.63	1.1	57.0	64.0	47.0	42.0
ST SYMPHORIEN	1.	1.	111.	0.	12.	149.	11.65	11.	1909.	62892.80	1.0	111.0	111.0	149.0	149.0
STE THORETTE	9.	7.	366.	197.	14.	381.	10.10	9.	1346.	153486.31	1.3	40.0	52.0	54.0	42.0
ST VITTE	4	4.	176.	59.	11.	257.	14.96	14.	2459.	45270.90	1.0	44.0	44.0	64.0	64.0
SALIGNY LE VIF	6	6.	151.	58.	10.	331.	9.71	12.	1730.	65719.81	1.0	25.0	25.0	55.0	55.0
SANCERGUES	55.	34.	865.	647.	56.	2361.	19.16	13.	1801.	62222.40	1.6	15.0	25.0	69.0	42.0
SANCERRE	114.	44.	2139.	1762.	131.	5606.	35.92	11.	1569.	80857.69	2.6	18.0	48.0	127.0	48.0
SANCOINS	129.	47.	3667.	3045.	69.	5606.	35.92	11.	1628.	75550.13	2.7	28.0	78.0	119.0	43.0
SANTRANGES	31.	20.	420.	135.	17.	455.	17.51	14.	2229.	54239.40	1.5	13.0	21.0	22.0	14.0
SAUGY	0.	0.	57.	0.	6.	0.	0.0	10.	1803.	74243.31	0.0	0.0	0.0	0.0	0.0
SAULZAIS POTIER	36.	27.	476.	231.	15.	2401.	14.71	13.	2186.	52341.30	1.3	13.0	17.0	80.0	66.0
SAVIGNY SANCERR	38.	25.	891.	376.	27.	579.	17.76	13.	2008.	61193.60	1.5	23.0	35.0	23.0	15.0
SAVIGNY SEPTAI	19.	14.	546.	355.	26.	437.	9.71	9.	1259.	151202.50	1.4	28.0	39.0	31.0	23.0
SENNECAY	5.	5.	258.	193.	18.	279.	7.14	9.	1426.	100136.31	1.0	51.0	51.0	55.0	55.0
SENS-BEAUJEU	32.	18.	430.	205.	20.	1924.	16.62	12.	1747.	72599.81	1.8	13.0	23.0	51.0	28.0
SERRUELLES	1.	1.	52.	0.	7.	88.	7.09	10.	1701.	76002.38	1.0	52.0	52.0	88.0	88.0
SEVRY	0.	0.	69.	0.	8.	0.	0.0	13.	1915.	55619.30	0.0	0.0	0.0	0.0	0.0
SIDIAILLES	9.	8.	467.	0.	15.	279.	10.03	14.	2618.	43231.80	1.1	51.0	58.0	34.0	31.0
SOULANGIS	6.	6.	391.	93.	28.	559.	9.71	10.	1407.	103331.31	1.0	65.0	65.0	93.0	93.0
SOYE SEPTAINE	14.	10.	446.	265.	24.	270.	7.83	10.	1557.	94179.00	1.4	31.0	44.0	27.0	19.0
LE SUBDRAY	4.	4.	431.	320.	21.	279.	10.03	9.	1577.	96879.88	1.0	107.0	107.0	69.0	69.0
SUBLIGNY	15.	14.	348.	116.	20.	803.	13.74	13.	1943.	65588.31	1.1	23.0	24.0	57.0	53.0
SURY-PRES-LERE	10.	8.	673.	142.	38.	381.	10.10	14.	2285.	52618.60	1.3	67.0	84.0	47.0	38.0
SURY EN VAUX	16.	14.	371.	114.	23.	437.	16.62	12.	1797.	68854.38	1.1	23.0	26.0	31.0	27.0
SURY-ES-BOIS	17.	13.	378.	228.	12.	289.	10.92	13.	1991.	63835.50	1.3	22.0	29.0	22.0	17.0
TENDRON	0.	0.	99.	0.	9.	0.	0.0	13.	2048.	55274.50	0.0	0.0	0.0	0.0	0.0
THAUMIERS	13.	12.	397.	135.	15.	279.	10.03	11.	1731.	68906.81	1.1	30.0	33.0	23.0	21.0
THAUVENAY	4.	4.	274.	117.	28.	124.	7.42	12.	1778.	66532.81	1.0	68.0	68.0	31.0	31.0
THENIOUX	18.	16.	584.	382.	32.	1203.	16.62	13.	2202.	67959.13	1.1	32.0	36.0	75.0	66.0
THOU	7.	7.	109.	0.	12.	331.	9.71	13.	1901.	67337.50	1.0	15.0	15.0	47.0	47.0
TORTERON	42.	26.	826.	636.	61.	455.	17.51	13.	1948.	58749.60	1.6	19.0	31.0	17.0	10.0
TOUCHAY	9.	9.	298.	81.	13.	375.	9.71	11.	1857.	66703.31	1.0	33.0	33.0	41.0	41.0
TROUY	46.	22.	2845.	1363.	123.	455.	17.51	9.	1365.	146275.50	2.1	61.0	129.0	20.0	9.0
UZAY LE VENON	7.	6.	357.	279.	10.	363.	9.71	11.	1747.	68432.31	1.2	51.0	59.0	60.0	51.0
VAILLY S SAULDR	83.	41.	856.	745.	47.	2316.	17.51	13.	1894.	67483.50	2.0	10.0	20.0	56.0	27.0
VALLENAY	31.	18.	833.	534.	33.	924.	16.62	11.	1779.	65714.31	1.7	26.0	46.0	51.0	29.0
VASSELAY	18.	13.	735.	300.	36.	803.	13.74	9.	1298.	152146.81	1.4	40.0	56.0	61.0	44.0
VEAUGUES	37.	25.	603.	472.	22.	455.	17.51	12.	1668.	72333.81	1.5	16.0	24.0	18.0	12.0
VENESME	11.	10.	669.	163.	21.	290.	7.65	10.	1652.	79344.13	1.1	60.0	66.0	29.0	26.0
VERDIGNY	11.	7.	303.	269.	61.	803.	13.74	12.	1815.	67021.50	1.6	27.0	43.0	114.0	73.0
VEREAUX	4.	4.	182.	54.	8.	384.	10.10	12.	1814.	67660.00	1.0	45.0	45.0	95.0	95.0
VERNAIS	10.	8.	280.	0.	11.	5606.	35.92	11.	1765.	67490.00	1.3	28.0	35.0	700.0	560.0
VERNEUIL	0.	0.	48.	0.	4.	0.	0.0	11.	1771.	67773.81	0.0	0.0	0.0	0.0	0.0
VESDUN	28.	20.	721.	300.	15.	455.	17.51	14.	2439.	46881.80	1.4	25.0	36.0	22.0	16.0
VIERZON	207.	47.	34209.	33093.	459.	67710.	53.80	11.	1649.	81565.13	4.4	165.0	727.0	1440.0	327.0
VIGNOUX SS AIX	11.	10.	418.	285.	28.	279.	10.03	10.	1512.	98064.31	1.1	38.0	41.0	27.0	25.0
VIGNOUX S BARAN	29.	20.	1503.	731.	60.	455.	17.51	10.	1497.	131175.19	1.4	51.0	75.0	22.0	15.0
VILLABON	13.	11.	462.	388.	25.	559.	9.71	11.	1595.	76669.50	1.2	35.0	42.0	50.0	43.0
VILLECELIN	1.	1.	117.	0.	12.	87.	6.32	11.	1909.	64184.80	1.0	117.0	117.0	87.0	87.0
VILLEGENON	10.	10.	271.	90.	8.	3026.	35.92	12.	1662.	81705.80	1.0	27.0	27.0	302.0	302.0
VILLENEUVE S CH	11.	5.	371.	153.	14.	175.	5.57	9.	1538.	100839.50	2.2	33.0	74.0	35.0	15.0
VILLEQUIERS	28.	17.	433.	277.	15.	143.	29.44	12.	1693.	67324.50	1.6	15.0	25.0	67.0	40.0
VINON	9.	9.	271.	143.	15.	279.	10.03	12.	1718.	69085.88	1.0	30.0	30.0	31.0	31.0
VORLY	8.	6.	254.	119.	14.	271.	6.69	9.	1348.	104174.50	1.3	31.0	42.0	45.0	33.0
VORNAY	12.	12.	341.	255.	13.	279.	10.03	10.	1628.	76435.00	1.0	28.0	28.0	23.0	23.0
VOUZERON	10.	10.	394.	175.	17.	381.	10.10	10.	1479.	137662.50	1.0	39.0	39.0	38.0	38.0

CORRELATION MATRIX
OF THE 15 CENTRALITY INDICATORS

	NUMBE	NUMBF	POP	NUCPOP	DENS	THRESH	DIST	ACCESS
NUMBE	1.00000	0.91792	0.60423	0.59585	0.69815	0.64414	0.73726	-0.13890
NUMBF	0.91792	1.00000	0.37388	0.36281	0.55975	0.41023	0.74022	-0.08870
POP	0.60423	0.37388	1.00000	0.99915	0.41250	0.82790	0.46318	-0.17025
NUCPOP	0.59585	0.36281	0.99915	1.00000	0.40969	0.82765	0.45602	-0.17141
DENS	0.69815	0.55975	0.41250	0.40969	1.00000	0.64107	0.55486	-0.20797
THRESH	0.64414	0.41023	0.82790	0.82765	0.64107	1.00000	0.56763	-0.12760
DIST	0.73726	0.74022	0.46318	0.45602	0.55486	0.56763	1.00000	-0.10334
ACCESS	-0.13890	-0.08870	-0.17025	-0.17141	-0.20797	-0.12760	-0.10334	1.00000
SHORT	-0.19493	-0.17103	-0.18157	-0.18282	-0.22224	-0.14559	-0.18166	0.88557
POT	0.22070	0.22039	0.13627	0.13231	0.30470	0.07672	0.21055	-0.80779
NEONF	0.86662	0.79123	0.54594	0.53413	0.63453	0.57007	0.70816	-0.11104
POPONE	0.12266	-0.08634	0.55161	0.54873	0.18600	0.41773	0.09319	-0.17866
POPONF	0.48914	0.23509	0.94777	0.94557	0.37633	0.76837	0.36853	-0.19445
THRONF	0.51446	0.28731	0.73691	0.73762	0.55684	0.92718	0.60406	-0.09224
THRONE	0.14983	0.02351	0.33493	0.33775	0.24392	0.50870	0.49119	-0.00196

	SHORT	POT	NEONF	POPONE	POPONF	THRONF	THRONE
NUMBE	-0.19493	0.22070	0.86662	0.12266	0.48914	0.51446	0.14983
NUMBF	-0.17103	0.22039	0.79123	-0.08634	0.23509	0.28731	0.02351
POP	-0.18157	0.13627	0.54594	0.55161	0.94777	0.73691	0.33493
NUCPOP	-0.18282	0.13231	0.53413	0.54873	0.94557	0.73762	0.33775
DENS	-0.22224	0.30470	0.63453	0.18600	0.37633	0.55684	0.24392
THRESH	-0.14559	0.07672	0.57007	0.41773	0.76837	0.92718	0.50870
DIST	-0.18166	0.21055	0.70816	0.09319	0.36853	0.60406	0.49119
ACCESS	0.88557	-0.80779	-0.11104	-0.17866	-0.19445	-0.09224	-0.00196
SHORT	1.00000	-0.81811	-0.15724	-0.12061	-0.17785	-0.10524	-0.00998
POT	-0.81811	1.00000	0.21270	0.13944	0.15438	0.04493	-0.02387
NEONF	-0.15724	0.21270	1.00000	0.23252	0.51129	0.48654	0.17376
POPONE	-0.12061	0.13944	0.23252	1.00000	0.77755	0.45084	0.34592
POPONF	-0.17785	0.15438	0.51129	0.77755	1.00000	0.71108	0.36495
THRONF	-0.10524	0.04493	0.48654	0.45084	0.71108	1.00000	0.78962
THRONE	-0.00998	-0.02387	0.17376	0.34592	0.36495	0.78962	1.00000

SCORES OF THE 290 TOWNS ON THE THREE FIRST FACTORS OF PRINCIPAL COMPONENT ANALYSIS

		FACTOR 1	FACTOR 2	FACTOR 3
1	ACHERE	-0.1409000	-0.6653400	-1.0451002
2	AINAY VIEL	-0.1858000	-0.1349400	0.5459000
3	AIX ANGILLON	0.0851000	2.2205000	-2.0228996
4	ALLOGNY	-0.1330000	0.0518600	-1.9857998
5	ALLOUIS	-0.0458000	-0.5518000	-0.9111000
6	ANNOIX	-0.0200000	-0.9201100	0.2058000
7	APREMONT ALLIER	-0.1786000	-0.5395300	0.9968000
8	ARCAY	-0.1394000	-0.4600200	-1.0705004
9	ARCOMPS	-0.1422000	-0.2170900	0.8364000
10	ARDENAIS	-0.1363000	-0.7366000	0.1158000
11	ARGENT S SAULDR	0.2082000	2.3471899	0.7367000
12	ARGENVIERES	-0.1399000	-0.1997900	1.6791000
13	ARPHEUILLES	-0.1445000	-0.4896200	0.0059000
14	ASSIGNY	-0.1626000	-0.6421500	-1.2533998
15	AUBIGNY S NERE	0.6290000	3.2565899	0.0116000
16	AUBINGES	-0.1256000	-0.7358500	-0.9122000
17	AUGY S AUBOIS	-0.1379000	-0.2038400	0.7384000
18	AVORD	0.2261000	0.9113000	-1.0987997
19	AZY	-0.1567000	0.3416300	-0.5018000
20	BANNAY	-0.0457000	-0.1569300	0.8716000
21	BANNEGON	-0.1501000	-0.2079300	-0.6568000
22	BARLIEU	-0.1426000	-0.1004800	1.2489996
23	BAUGY	-0.0619000	1.8456898	-0.5185000
24	BEDDES	-0.0715000	-0.9307200	1.3671999
25	BEFFES	-0.0818000	0.1966000	1.7755003
26	BELLEVILLE S L	-0.1285000	-0.1305000	-2.0481005
27	BENGY S CRAON	-0.1075000	0.1840000	-0.3797000
28	BERRY-BOUY	-0.0199000	-0.5417000	-1.8299999
29	BESSAIS L FROM.	-0.0911000	-0.0792000	0.5309000
30	BLANCAFORT	-0.0880000	0.6848000	0.7013000
31	BLET	-0.1401000	0.6895000	-1.0115995
32	BOULLERET	-0.0257000	0.8479000	1.4406996
33	BOURGES	14.7625999	4.0065002	-1.8165998
34	BOUZAIS	-0.1181000	-0.8050000	0.4786000
35	BRECY	-0.1116000	0.1697000	-0.4415000
36	BRINAY	0.0450000	-0.8244000	-0.5326000
37	BRINON S SAULDR	-0.0255000	1.3528996	0.9773000
38	BRUERE-ALLICHAM	-0.1249000	0.1159000	-1.3979998
39	BUE	-0.1424000	0.1086000	0.1324000
40	BUSSY	-0.0805000	-0.5248000	-0.6252000
41	LA CELETTE	-0.1050000	-0.6391000	0.5709000
42	LA CELLE	-0.1435000	-0.4475000	-0.6169000
43	LA CELLE-CONDE	-0.1066000	-0.8564000	0.1140000
44	CERBOIS	-0.1373000	-0.6207000	-0.1125000
45	CHALIVOY-MILON	-0.0900000	0.1311000	-0.2858000
46	CHAMBON	-0.1229000	-0.8854000	-0.4908000
47	LA CHAPELLE ANG	-0.1071000	1.0228004	-0.6095000
48	LA CHAPELLE HUG	-0.1402000	-0.3796000	0.8613000
49	LA CHAPELLE MON	-0.1370000	0.0263000	-1.1836004

50	LA CHAP.ST URS	0.1424000	1.1198997	-2.0440998
51	LA CHAPELOTTE	-0.1985000	-0.2120000	-0.4797000
52	CHARENTON SCHER	0.0119000	1.0506001	-0.0738000
53	CHARENTONNAY	-0.1399900	-0.5478000	0.1275000
54	CHARLY	-0.1404700	-0.5114000	-0.2530000
55	CHAROST	-0.0660700	1.5922003	-1.2049999
56	CHASSY	-0.1493700	-0.6372000	1.2609997
57	CHATEAUMEILLANT	0.0678300	2.5883999	0.7642000
58	CHATEAUNEUFCHER	0.0338400	1.8086996	-1.3992004
59	LE CHATELET	-0.0241700	1.3922997	0.0686000
60	CHAUMONT	-0.2332600	-1.3667002	-0.2808000
61	CHAUMOUX-MARCIL	-0.1794300	-0.6839000	0.1227000
62	LE CHAUTAY	-0.1274100	-0.6058000	1.3641996
63	CHAVANNES	-0.1212500	-0.8928000	-0.6328000
64	CHERY	-0.1606100	-0.5559000	1.5981998
65	CHEZAL-BENOIT	0.0272300	0.2383000	0.0257000
66	CIVRAY	-0.0635200	0.0233000	-1.1014996
67	CLEMONT	-0.1430300	0.3593000	0.6839000
68	COGNY	-0.2244700	-1.3921003	-0.4893000
69	COLOMBIERS	-0.1082500	-0.7392000	-0.0224000
70	CONCRESSAULT	-0.1394400	-0.0813000	0.7070000
71	CONTRES	-0.2287100	-1.3905001	-0.5998000
72	CORNUSSE	-0.1224800	-0.4153000	0.1880000
73	CORQUOY	-0.1517100	-0.5713000	-0.4652000
74	COUARGUES	-0.1502400	-0.5508000	0.8300000
75	COURS LESBARRES	-0.0573400	0.0998000	1.2208004
76	COUST	-0.1263200	-0.0948000	-0.1331000
77	COUY	-0.1466500	-0.3329000	0.6019000
78	CREZANCAY SCHER	-0.2172300	-1.3902998	0.1578000
79	CREZANCY EN SAN	-0.1231500	-0.0769000	0.1295000
80	CROISY	-0.1210100	-0.8806000	0.3809000
81	CROSSES	-0.1481400	-0.4527000	-0.6895000
82	CUFFY	-0.0565300	-0.0509000	0.8354000
83	CULAN	-0.0635700	1.6773996	1.3176003
84	DAMPIERREENCROT	-0.1445900	-0.6348000	0.6676000
85	DAMPIERREENGRAC	-0.1742700	-0.6396000	0.9536000
86	DREVANT	-0.1104800	-0.4125000	-0.1184000
87	DUN-SUR-AURON	0.4764500	2.5664997	-1.3661003
88	ENNORDRES	-0.1212400	0.1075000	0.1095000
89	EPINEUIL FLEURI	-0.0807500	0.0249000	1.2370996
90	ETRECHY	-0.1524500	0.3615000	0.1271000
91	FARGES ALLICHAM	-0.1531300	-0.5863000	-0.4993000
92	FARGES EN SEPT.	-0.0870400	0.1804000	-0.9525000
93	FAVERDINES	-0.0506700	-0.9269000	1.1654997
94	FEUX	-0.1461900	0.0694000	0.1230000
95	FLAVIGNY	-0.1366700	-0.7368000	0.2857000
96	FOECY	0.1143500	1.2627001	-0.5203000
97	FUSSY	0.0[illegible]15900	0.2173000	-1.8659000
98	GARDEFORT	-0.[illegible]10400	-1.3674002	0.6174000
99	GARIGNY	-0.1690400	-0.1999000	0.5690000
100	GENOUILLY	-0.1064300	0.2335000	1.6356001
101	GERMIGNY EXEMPT	-0.1457100	-0.1627000	0.2877000
102	GIVARDON	-0.1407300	-0.0613000	0.3779000
103	GRACAY	0.0349900	2.0829000	1.6583004
104	GROISES	0.0127600	-0.8968000	0.0554000
105	GRON	-0.0684200	-0.7950000	0.2301000
106	GROSSOUVRE	-0.1328300	-0.3406000	0.3203000
107	LA GROUTTE	-0.2227400	-1.3733997	-0.0552000
108	LA GUERCHE AUBO	0.2916700	2.2624998	0.7430000
109	HENRICHEMONT	0.0168200	2.1925001	-0.6068000

110	HERRY	-0.0312800	0.7563000	0.7139000
111	HUMBLIGNY	-0.1441800	-0.7337000	0.0664000
112	IDS ST ROCH	-0.1099800	-0.6181000	0.6936000
113	IGNOL	-0.1417500	-0.8104000	0.9823000
114	INEUIL	-0.1397200	-0.5623000	0.1712000
115	IVOY LE PRE	-0.0591100	0.2098000	-0.5926000
116	JALOGNES	-0.1866500	0.0518000	0.6349000
117	JARS	-0.1269700	0.2165000	0.0789000
118	JOUET S AUBOIS	0.0111200	1.4928999	1.1175003
119	JUSSY CHAMPAGNE	-0.1428700	-0.4303000	-0.7175000
120	JUSSY CHAUDRIER	-0.1018400	0.3448000	1.0185003
121	LANTAN	-0.1545700	-0.7610000	0.1619000
122	LAPAN	-0.1401400	-0.5959000	-0.3377000
123	LAVERDINES	-0.1454700	-0.9116000	0.7970000
124	LAZENAY	-0.1317000	-0.5615000	-0.1644000
125	LERE	-0.0558300	1.0200005	1.4587002
126	LEVET	-0.0[illegible]2300	1.5355997	-2.2348003
127	LIGNIERES	0.[illegible]5200	1.2594995	-0.6353000
128	LIMEUX	-0.1[illegible]1500	-0.7729000	-0.7134000
129	LISSAY-LOCHY	-0.1533800	-0.5642000	-0.3968000
130	LOYE S ARNON	-0.1357900	-0.2482000	0.6868000
131	LUGNY-BOURBONNA	-0.2315800	-1.3788004	-0.2743000
132	LUGNY-CHAMPAGNE	-0.1723100	0.0376000	0.7338000
133	LUNERY	0.1355700	0.5715000	1.1[illegible]5002
134	LURY S ARNON	-0.0828600	0.3094000	-0.2614000
135	MAISONNAIS	-0.1394300	-0.3760000	-0.7778000
136	MARCAIS	-0.1317400	-0.2575000	-0.5766000
137	MAREUIL S ARNON	-0.1173900	0.[illegible]305000	-0.4639000
138	MARMAGNE	0.[illegible]2400	0.6069000	-0.89[illegible]
139	MARSEILLE AUBIG	-0.0524600	-0.0424000	1.0873003
140	MASSAY	-0.0488600	1.0488005	0.8823000
141	MEHUN S YEVRE	0.8774300	3.2893000	-2.1114998
142	MEILLANT	-0.0882700	-0.0636000	-0.8190000
143	MENETOU-COUTURE	-0.1089500	-0.6382000	1.7472000
144	MENETOU-RATEL	-0.1313500	0.0576000	0.6360000
145	MENETOU-SALON	-0.0692100	1.5144997	-1.0713997
146	MENETREOL SS SA	-0.0967600	0.2538000	0.8741000
147	MENETREOL S SAU	-0.1719200	-0.4682000	-0.434[illegible]000
148	MEREAU	0.0479900	0.2915000	-0.[illegible]3000
149	MERY-ES-BOIS	-0.1394800	0.3922000	-1.1889996
150	MERY-SUR-CHER	-0.1267500	-0.1972000	0.1592000
151	MONTIGNY	-0.1594800	0.0246000	-0.5662000
152	MONTLOUIS	-0.1587300	-0.7481000	0.2266000
153	MORLAC	-0.1349500	-0.2940000	0.1081000
154	MORNAY-BERRY	-0.1696600	-0.5152000	0.6739000
155	MORNAY S ALLIER	-0.1710700	0.1238000	0.4153000
156	MOROGUES	-0.1479100	-0.1290000	-1.0805998
157	MORTHOMIERS	0.0357700	-0.9095000	-0.7317000
158	MOULINS S YEVRE	-0.2170100	0.2114000	-1.7142000
159	NANCAY	-0.1268400	0.3152000	-0.5942000
160	NERONDES	-0.0164300	1.8320999	0.2203000
161	NEULLY EN DUN	-0.1402100	-0.1659000	-0.0213000
162	NEULLY EN SANC	-0.1666700	-0.1389000	0.0835000
163	NEUVY DEUX CLO	-0.1142400	-0.6331000	0.0645000
164	NEUVY LE BARROI	-0.1284400	-0.8077000	0.4254000
165	NEUVY S BARANG.	-0.0273600	1.1946001	-1.2882996
166	NOHANT EN GOUT	-0.0946400	-0.6683000	-0.8786000
167	NOHANT EN GRACA	-0.1545000	-0.3351000	1.5843000
168	LE NOYER	-0.1644500	-0.2383000	0.0475000
169	NOZIERES	-0.0488000	-0.8346000	-0.5117000

170 OIZON	-0.0962500	-0.3184000	0.1595000
171 ORCENAIS	-0.1327400	-0.4451000	0.2611000
172 ORVAL	0.1427700	1.0198002	-0.3580000
173 [illegible]ERY	-0.1357500	-0.3519000	-0.1001000
174 [illegible]	-0.2517300	-1.3226004	-1.6920996
[illegible] ROUE[illegible] R	-0.1369400	0.7671000	-0.3339000
[illegible] ASSY	-0.1375500	-0.3523000	-1.0369997
[illegible] NAY	-0.2199800	-1.4019003	0.2639000
[illegible] ENCH	0.1471100	-0.4963000	1.1457005
[illegible]	-0.0862700	-0.3032000	-0.8807000
[illegible] IV.	-0.0556100	0.0566000	-1.7477999
[illegible]	-0.0905700	-0.4553000	-0.4003000
[illegible] EUX	-0.1578100	-0.7186000	-0.3856000
183 LE PONDY	-0.1694100	-0.6533000	-0.0743000
184 PRECY	-0.1741800	-0.2805000	1.2129002
185 PRESLY	-0.1632800	-0.4304000	-0.4279000
186 PREUILLY	-0.1498500	-0.2959000	-1.2087002
187 PREVERANGES	-0.1376800	1.2314997	1.9776001
188 PRIMELLES	-0.1517500	-0.3462000	-0.3040000
189 QUANTILLY	-0.1455800	-0.2541000	-0.3736000
190 QUINCY	-0.0900200	0.0463000	-1.0132999
191 RAYMOND	-0.1672800	-0.6033000	-0.3018000
192 REIGNY	-0.1143200	-0.6026000	0.7804000
193 REZAY	-0.1300800	-0.4517000	0.7990000
194 RIANS	-0.0546400	0.3365000	-1.0799999
195 SAGONNE	-0.1456700	-0.6852000	0.9230000
196 ST AIGNAN D NOY	-0.1637300	-0.8073000	0.0726000
197 ST AMAND MONTR.	3.3221197	3.2623997	-0.4004000
198 ST AMBROIX	-0.1193800	-0.2049000	-0.2862000
199 ST BAUDEL	-0.1304200	-0.4933000	-0.5499000
200 ST BOUIZE	-0.1655500	0.0740000	0.7018000
201 ST CAPRAIS	-0.1491600	-0.2597000	-1.1957998
202 ST CEOLS	-0.2085200	-0.7895000	-0.9957000
203 ST CHRISTO. L.C	-0.1650300	-0.7388000	1.2974997
204 ST DENIS DE PA.	-0.1373400	-0.5905000	-0.7054000
205 ST DOULCHARD	1.0080099	2.7426996	-2.0555000
206 ST ELOY DE GY	-0.0641500	0.5346000	-0.7295000
207 ST FLORENT S CH	0.9288200	3.2207003	-2.3460999
208 STE GEMME SANC.	-0.1176900	-0.4713000	0.2087000
209 ST GEORGES POI.	-0.0975600	-0.7308000	1.1697998
210 ST GEORGES/PREE	-0.1230800	-0.5916000	0.9856000
211 ST GEORGES/MOUL	-0.1313300	-0.1467000	-0.8614000
212 ST GERMAIN BOIS	-0.1026800	-0.2306000	-1.2227001
213 ST GERMAIN PUY	0.5937400	2.1730003	-1.8599997
214 ST HILAIRE COU.	-0.0613900	-0.5144000	0.1018000
215 ST HILAIRE GON.	-0.1168700	-0.8120000	1.1308002
216 ST HILAIRE LIG.	-0.1149300	-0.1917000	0.0170000
217 ST JEANVRIN	-0.2097800	-1.3832998	2.0347004
218 ST JUST	-0.1671500	0.2668000	-1.9335003
219 ST LAURENT	-0.1241200	-0.0842000	-0.4017000
220 ST LEGER PETIT	-0.1380600	-0.4842000	1.6650000
221 ST LOUP CHAUMES	-0.1092300	-0.6506000	-0.1602000
222 STE LUNAISE	-0.2271300	-1.3902998	-0.4790000
223 ST MARTIN AUXI.	0.0154800	1.6145000	-1.0452003
224 ST MARTIN CHAMP	-0.1548300	-0.3587000	1.6539001
225 ST MAUR	-0.1430700	-0.4278000	1.9924002
226 ST MICHEL VOLA.	-0.1836400	-0.5688000	-1.7424002
227 STE MONTAINE	-0.1695300	-0.4660000	0.1905000
228 ST OUTRILLE	-0.0762700	-0.2295000	-2.2874002
229 ST PALAIS	-0.0774000	-0.4204000	-0.2440000

230	ST PIERRE BOIS	-0.1169800	-0.6476000	0.7226000
231	ST PIERRE ETIEU	-0.0671400	-0.29[illegible]00	0.1021000
232	ST PRIEST MARCH	-0.1697200	-0.255[illegible]000	2.6774998
233	ST SATUR	0.0677700	1.9727001	0.1577000
234	ST SATURNIN	-0.1148600	-0.0031000	1.3635998
235	STE SOLANGE	0.0096300	-0.0461000	-0.9675000
236	ST SYMPHORIEN	-0.0887500	-0.8359000	0.1940000
237	STE THORETTE	-0.1701400	-0.4219000	-1.7735004
238	ST VITTE	-0.1623100	-0.6848000	1.7445002
239	SALIGNY LE VIF	-0.1656300	-0.6527000	0.1962000
240	SANCERGUES	-0.0754000	1.1595001	0.5022000
241	SANCERRE	0.0752700	2.6744003	-0.4381000
242	SANCOINS	0.3304100	2.9422998	-0.2721000
243	SANTRANGES	-0.1792700	0.3656000	1.3690996
244	SAUGY	-0.2199300	-1.3956003	-0.2306000
245	SAULZAIS POTIER	-0.1019000	0.5378000	1.1231003
246	SAVIGNY SANCERR	-0.0954600	0.6348000	0.7744000
247	SAVIGNY SEPTAI.	-0.1510400	-0.0496000	-1.8746004
248	SENNECAY	-0.1220200	-0.7344000	-1.1948996
249	SENS-BEAUJEU	-0.1521900	0.3868000	0.1557000
250	SERRUELLES	-0.1468400	-0.9131000	-0.3826000
251	SEVRY	-0.2247900	-1.3774996	0.[illegible]618000
252	SIDIAILLES	-0.1082000	-0.5044000	1.9621000
253	SOULANGIS	-0.1041000	-0.6040000	-1.0403996
254	SOYE SEPTAINE	-0.1226000	-0.3057000	-0.7432000
255	LE S[illegible]Y	-0.0455700	-0.7559000	-1.0037003
256	SUB[illegible]	-0.1464100	-0.1829000	0.6733000
257	SURY-[illegible]LERE	-0.0661500	-0.3816000	1.4331999
258	SURY EN [illegible]AUX	-0.1586600	-0.1460000	0.2147000
259	SURY-ES-BOIS	-0.1463000	-0.1841000	0.7670000
260	TENDRON	-0.2212900	-1.3775997	0.9327000
261	THAUMIERS	-0.1222300	-0.3458000	-0.0769000
262	THAUVENAY	-0.1092600	-0.7796000	0.2216000
263	THENIOUX	-0.1008600	-0.0461000	0.9628000
264	THOU.	-0.1947900	-0.5948000	0.6272000
265	TORTERON	-0.1073700	0.7341000	0.7001000
266	TOUCHAY	-0.1305500	-0.5311000	0.1086000
267	TROUY	0.1507700	1.0583000	-1.8[illegible]7
268	UZAY LE V[illegible]N	-0.0954000	-0.5920000	-0.0[illegible]0
269	VAILLY S SAULDR	-0.1199100	1.7926998	0.6085000
270	VALLENAY	-0.0665400	0.3508000	0.0066000
271	VASSELAY	-0.1199200	-0.0112000	-1.8542004
272	VEAUGUES	-0.1360100	0.5882000	0.0253000
273	VENESME	-0.0509400	-0.4465000	-0.5118000
274	VERDIGNY	-0.1253100	-0.2866000	0.2661000
275	VEREAUX	-0.1421700	-0.7206000	0.2838000
276	VERNAIS	-0.0016900	0.0314000	0.0379000
277	VERNEUIL	-0.2222400	-1.3910999	0.0169000
278	VESDUN	-0.1097400	0.298[illegible]000	1.6993999
279	VIERZON	7.1500196	3.9517002	-0.0684000
280	VIGNOUX SS AIX	-0.1246700	-0.4220000	-0.857[illegible]
281	VIGNOUX S BARAN	-0.0129700	0.4167000	-1.240799[illegible]
282	VILLABON	-0.0978400	-0.3416000	-0.3182000
283	VILLECELIN	-0.0756500	-0.9341000	0.1892000
284	VILLEGENON	-0.1622300	-0.0232000	-0.0651000
285	VILLENEUVE S CH	-0.1278500	-0.2333000	-1.0135002
286	VILLEQUIERS	-0.1679000	-0.3887000	0.1022000
287	VINON	-0.1468000	-0.5210000	0.1362000
288	VORLY	-0.1458100	-0.5572000	-1.3115997
289	VORNAY	-0.1245300	-0.4115000	-0.5023000
290	VOUZERON	-0.1624900	-0.4249000	-1.2510996