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THE IMPACT OF RURAL INDUSTRIALIZATION ON
COMMUNITY POPULATION GROWTH AND
CENTRAL PLACE FUNCTION

DISSERTATION
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By
Michael Alexis Anikeeff, A.B., M.C.P.

* * * * *

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# TABLE OF CONTENTS

**Page**  

ACKNOWLEDGEMENTS ................................................................. ii  

VITA. ....................................................................................... iii  

LIST OF TABLES ....................................................................... vi  

LIST OF FIGURES ..................................................................... viii  

Chapter  

I. PROBLEM STATEMENT .......................................................... 1  

   Introduction  
   The Problem  

II. REVIEW OF THEORY AND EMPIRICAL LITERATURE. .......... 9  

   Static Central Place Theory  
   Empirical Evidence Supporting the Static Theory  
   Dynamic Central Place Theory  
   Ecological Evidence of the Effect of Industrialization on Rural Spatial Structure  
   Empirical Evidence  
   Model of Industrialization of a Rural Region  
   Hypotheses  

III. METHODOLOGY ............................................................... 73  

   Population  
   Concepts and Data Sources  

IV. ANALYSIS ........................................................................ 94  

   Analysis of Variance  
   Test of Linearity  
   Analysis of Covariance  

iv
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Four Ideal Types of Rural Regions</td>
<td>40</td>
</tr>
<tr>
<td>2. Regional Development Continuum</td>
<td>83</td>
</tr>
<tr>
<td>4. Total Miles of Highways in Ohio 1950 and 1970</td>
<td>90</td>
</tr>
<tr>
<td>5. Number of Miles of High Traffic Volume Highways in Ohio 1950 and 1970</td>
<td>91</td>
</tr>
<tr>
<td>7. Comparison of Range and Threshold of Modified Regions</td>
<td>93</td>
</tr>
<tr>
<td>8. Analysis of Variance with Estimates</td>
<td>99</td>
</tr>
<tr>
<td>9. 1954 Population Analysis of Variance</td>
<td>104</td>
</tr>
<tr>
<td>10. 1967 Population Analysis of Variance</td>
<td>106</td>
</tr>
<tr>
<td>12. Comparison of Population Growth by Ecological Position Iowa Study and Ohio Study</td>
<td>110</td>
</tr>
<tr>
<td>13. 1954 Sales (1000's) in 1967 Dollars Analysis of Variance</td>
<td>112</td>
</tr>
<tr>
<td>14. 1967 Sales (1000's) Analysis of Variance</td>
<td>113</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>15. Sales Growth Rate 1954-1967 Analysis of Variance.</td>
<td>115</td>
</tr>
<tr>
<td>16. 1954 Central Place Function Index (Per Capita Sales 1967 Dollars) Analysis of Variance.</td>
<td>118</td>
</tr>
<tr>
<td>17. 1967 Central Place Function Index (Per Capita Sales)</td>
<td>119</td>
</tr>
<tr>
<td>18. Central Place Function Growth 1954-1967</td>
<td>121</td>
</tr>
<tr>
<td>19. Per Cent Change in Central Place Index Comparison of Iowa Study and Ohio Study</td>
<td>123</td>
</tr>
<tr>
<td>20. Comparison of Regression Lines Per Cent Change Retail Sales on Per Cent Change Population.</td>
<td>134</td>
</tr>
<tr>
<td>21. Comparison of Regression Lines Per Cent Increase in Central Place Index on Per Cent Increase in Population</td>
<td>135</td>
</tr>
<tr>
<td>22. Comparison of Regression Lines Per Cent Increase in Central Place Index on Per Cent Increase in Retail Sales</td>
<td>136</td>
</tr>
<tr>
<td>23. Regression Equations for Central Place Index Growth (y) on Retail Sales Growth (x)</td>
<td>139</td>
</tr>
<tr>
<td>24. Regression Equations for Retail Sales Growth (y) on Population Growth (x)</td>
<td>142</td>
</tr>
<tr>
<td>25. Regression Equations for Central Place Index Growth (y) on Population Growth (x)</td>
<td>144</td>
</tr>
<tr>
<td>26. Summary of the Analysis of Variance Findings Showing Significant Per Cent Variance Explained</td>
<td>149</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Factors Affecting the Central Place System</td>
<td>24</td>
</tr>
<tr>
<td>2.</td>
<td>Map with Ecological Positions Delineated</td>
<td>78</td>
</tr>
<tr>
<td>3.</td>
<td>U.S. Census Economic Sub Regions</td>
<td>86</td>
</tr>
<tr>
<td>4.</td>
<td>Map with Regions Delineated</td>
<td>87</td>
</tr>
<tr>
<td>5.</td>
<td>Regression of Central Place Index Growth on Retail Sales Growth</td>
<td>127</td>
</tr>
<tr>
<td>6.</td>
<td>Regression of Retail Sales Growth on Population Growth</td>
<td>129</td>
</tr>
<tr>
<td>7.</td>
<td>Regression of Central Place Index Growth on Population Growth</td>
<td>130</td>
</tr>
<tr>
<td>8.</td>
<td>Regression of Central Place Index Growth on Sales Growth by Ecological Position</td>
<td>140</td>
</tr>
<tr>
<td>9.</td>
<td>Regression of Sales Growth on Population Growth by Ecological Position</td>
<td>143</td>
</tr>
<tr>
<td>10.</td>
<td>Regression of Central Place Index on Population Growth by Ecological Position</td>
<td>145</td>
</tr>
</tbody>
</table>
CHAPTER I

PROBLEM STATEMENT

Central place theory 'explains' the relationship between population growth and community trade function in a period of agricultural settlement. Central place studies\(^1\) demonstrate that there is a continuum of central places. They explain that in rural areas as the population of the towns (central places) increases so do the numbers and types of business establishments, the size of their trade centers and their dependent population. They show that spacing varies inversely with population densities. They show that there is a hierarchy of urban centers. They have identified rural neighborhoods and communities, and the centers and groups of functions that characterize these levels of the hierarchy. But, what will happen to population growth and central place function of the communities as the region industrializes?

This is the problem this research will investigate.

---

\(^{1}\)Chapter II will describe central place studies in detail.
There are two strategies of rural industrialization. One is an even distribution technique; the other believes in concentrated points of industrial development. The even distribution method would not alter the central place system. The concentrated approach can cause changes.

Smith (1971: 453) suggests that a policy of even distribution is easy to devise and relatively simple to apply. 1) The underdeveloped areas are defined according to a prescribed criterion (per cent unemployment or per capita income). 2) All places within the area qualify for the same level of financial assistance payable to incoming or expanding enterprises. 3) Accordingly entrepreneurs will choose to migrate to the region because of public policy inducements, but public policy will have no effect on his exact location in the region. A policy of even distribution is politically popular because the central government can claim that all of the different communities have an equal chance for funding.

The even distribution strategy can be detrimental to development. In depressed regions (those with an outmoded industrial base) it tends to continue the existing form of the spatial economy which may be far from the best with respect to the stated planning goals and may be very inefficient. In underdeveloped regions (those without industrialization) an even distribution strategy
ignores such obvious conditions as the uneven distribution of resources and the economic advantages some places have over others.

An alternative is a selective policy directed toward maximizing regional industrial growth by concentrating investment on those places in which industry can operate most efficiently. This is the essence of the growth center theory.

The concept goes by several names, growth pole, growth center, growth point, and others, while the general idea is the same—concentrated development. They differ in certain aspects.

The concept originated with the work of Francois Perroux (1950), who observed that "poles de croissance" (growth poles) exist as sectors in an economy. Associated with the growth pole is the propulsive industry or firm. Propulsive industries are those having the greatest direct or indirect influence on the welfare and activity of the region. They are highly concentrated, but have a national market. They tend to dominate other firms, they have a high degree of interconnection with other firms. Their activity influences regional income which in turn influences the trade and services of the region (Boudeville 1966: 667).
Initially the concept of growth poles was nonspatial, the pole simply referred to an industry or interrelated group of industries. The concept was expanded to include spatial characteristics and this has led to some confusion. The term growth pole refers to the original concept of Perroux without the spatial aspect while the term growth point or growth center refers to location.

An additional point of confusion is that the term growth center is used to describe an actual existing metropolitan center (spontaneous growth center) as well as a development strategy (induced growth center). Thus one might say Columbus, Ohio, is a growth center (existing condition) and at the same time say Athens, Ohio, is a growth center (potential, if this development strategy were applied to the region around Athens). They are associated in that a place which is exhibiting vigorous growth may be a good location for further planned growth, and an understanding of how growth centers arise naturally in market-regulated economic systems should be of assistance in their artificial creation in planned or partially planned situations.

In this study we will investigate central cities of metropolitan areas assuming they are growth centers which have developed naturally in a market regulated economy. The hope is that this information will also be useful
in planning situations.

If some places are selected as growth centers, then other places in the development region will receive less government assistance. This may have a reasonable economic basis, since some places far from the growth center may not have the industrial potential to make their revival worth the cost. However, in using the growth center strategy it is usually assumed by regional development planners that the prosperity generated by the growth point will spread outward to the hinterland.

The relationship between the growth center and the surrounding area is of underlying importance to this paper.

Myrdal (1957) and Hirschman (1958) have developed economic models of regional development.

Myrdal says that once industrial growth has been initiated flows of capital labor and commodities develop to support it, and that these operate as a backwash effect to the disadvantage of the stagnating areas from which these factors are drawn. But the demand for goods from the periphery may lead to a spread effect where growth at the center is expanded outward.

Hirschman's model suggests interaction between a growing area and lagging area in terms of polarization and trickling down. Polarization includes the depressing
effect of the developed area's economic strength on lagging areas' industry and the migration to the developed area of labor and capital, while some of the developed area's growth will trickle down to the lagging area through the developed area's purchases and investments and the absorption of the lagging areas' unemployment.

The center periphery model is a reformulation and refinement of those of Myrdal and Hirschman by Friedman (1972). Friedman suggests that economic activity be transmitted to the periphery through a hierarchical system of settlements, the creation of which helps to achieve the spatial integration of the economy. The relationship between the growth center and its surrounding area and the central place and its hinterland can be seen. In fact, Richardson (1969) says that the growth centers are likely to be high ranking central places.

The connection between the urban hierarchy of central place theory and the growth center strategy in regional economic development is a matter of great current interest and forms the basis for the spatial planning framework in France.

Besides France, the concentration of investment at selected points as an alternative to even distribution has become a popular strategy for other countries in recent years. It is being used as an instrument in the
stimulation of depressed regions in advanced countries such as Britain and the United States [Appalachian Development Act, Public Works and Economic Development Act, Report of the Commission on Population and the American Future]. And it is being used in underdeveloped countries and regions as a component of the development plans in Southern Italy, Spain, Brazil and Venezuela. In short the growth center concept has become a central aspect of development planning.

The growth center strategy does not necessarily produce the results which are anticipated, particularly with respect to the outward spread of growth. Lasuen (1969: 137) has pointed out that where the concept is used in planning the failure of policies based on the concept is attributed to the means of implementation rather than the concept itself.

The existence and operation of centers of relatively rapid growth is not well understood, but the growth center concept is important in understanding regional development.

Horst (1969: 34) attempts to synthesize regional development theory and concludes by saying

The attempt to synthesize did not succeed quite satisfactorily. This is not much because some major theoretical proposition was left unconsidered, but rather because the synthesis leads to very little in the way of policy advice.
In fact, it seems that regional development theory has so far made available nothing but one sound advise: 'implant growth poles.' But there is more in the problem of regional development than can be solved by following such advice. What, for example, happens to a rural structure when such a pole is established? . . .

This research will attempt to answer the question posed by Horst. "What happens to a rural structure when a growth center is established?" More specifically how will industrialization of the rural central place structure affect community population growth, and central place function?
CHAPTER II

REVIEW OF THEORY AND EMPIRICAL LITERATURE

Our problem is to determine how the implanting of a growth center (propulsive industry) in a rural central place structure will affect the socioeconomic viability of rural communities in that structure.

Central place theory attempts to explain the number, size and distribution of trade centers in a region. A knowledge of this theory in its static and dynamic states should give us an understanding of what will happen when a growth center is introduced into a central place structure.

The following review of the literature is divided into several parts. 1) General assumptions of all models of settlement location and ecological structure. 2) A summation of static central place theory as stated by Christaller (1933), Lösch (1954) and Berry and Garrison (1958). 3) A short review of empirical studies verifying the static theory. 4) A summation of the dynamic theory stated by Christaller. 5) Ecological evidence on the spatial aspects of regional industrialization. 6) A review of empirical evidence verifying the dynamic
aspects. 7) A model of the effect of rural industrialization on community population growth and trade function.

**General Assumptions**

It appears that most models of settlement location and urban structure assume a measurable degree of order in spatial behavior. This common assumption is based on six premises (Garner 1967: 304).

1. The spatial distribution of human activity reflects an ordered adjustment to the factor of distance. Simply stated all things are not concentrated in the same place at the same time. It is the pattern of spatial differentiation and its change which interests us. But in the analysis of order in spatial behavior different distance measures are used in different studies, e.g. travel time, transport costs, road distance weighted by different road surfaces. There are even non-linear measures of distance: density distance, income distance, and land value distance. Travel time or time distance is of most interest here.

2. Location decisions are made to minimize time distance cost. Events reach their goal by the shortest route.

3. All locations are endowed with a degree of accessibility, but some locations are more accessible
than others. Accessibility is the general ease of getting to a place. In a technical sense, accessibility is a relative quality possessed by land as a result of its relationship to a system of transport (Wingo 1961: 26). In an operational sense it is the variable quality of centrality or nearness to other functions or locations.

4. There is a tendency for human activity to agglomerate to take advantage of scale economies. Scale economies mean the savings in costs made possible by concentrating activities in common location. Agglomerations can be viewed as nodes in the landscape arising from centripetal forces in spatial organization. The concentration of activities to form settlements can be seen as a reflection of scale economies.

5. The organization of human activity is essentially hierarchical in character. More accessible locations appear to be the sites of larger agglomerations. Thus there appears to be a hierarchy of locations in terms of accessibility.

6. Human occupance is focal.

The nodes [towns] about which human activity is organized are agglomerations of varying size. These nodes are arranged in a hierarchy, thus the areas which focus on the various nodes are hierarchical also. Movement minimization, accessibility, agglomeration and
hierarchies are linked together to form a system of human organization in space.

**Static Central Place Theory**

Berry and Pred (1967) provided an abridged version of the static elements of Christaller's theory. This version is given here with a few slight modifications. The problem with most secondary interpretations is that they overemphasize the hexagonal structure of the ideal system Christaller proposed. Berry and Pred avoid this. Following the summation of Christaller's theory, Lösch's (1954) contribution to the generalization of the theory is discussed. Finally Berry and Garrison's (1958) contribution is examined.

An abstract of Christaller's central place theory (Berry and Pred 1967):

1. Centralistic principles are basic to human community life. The town is a center of a regional community and the mediator of that community's commerce; it functions as the central place of the community.

2. Central places vary in importance. Those of higher order dominate larger regions than those of lesser order, exercise more central functions, and therefore have greater centrality. For all "the sum of the distances which rural residents travel to the central place is the smallest conceivable sum."
3. The goods and services provided by the central place because it is "central" are known as central place goods and services. Higher order goods are offered in central places of higher order; lower order goods are offered in places of both a higher and lower order.

4. The central place is at the center of a complementary region. Within the region there are relationships of town to country and country to town. Complementary regions are of higher and lower orders. These regions: differ for different types of goods, undergo periodic and seasonal variation, and consistently overlap neighboring complementary regions at the periphery. Thus they are hard to define. Distance is important in determining the region, particularly the time-distance measure. The range of a good is the farthest distance a dispersed population is willing to go in order to buy the good offered at a place. The range is lower if there is a competing center.

5. There is a functional relationship between the size of a central place and the sizes of the complementary region, its population and income. Net income which inhabitants earn is a decisive fact in the development of central places.

6. Central goods at a larger place have a larger range than those offered at a smaller place. The
possibility that on a single trip several goods are offered simultaneously has the same effect as a general price decline in goods offered by larger towns.

7. Every type of good has its special range, which differs at different central places and is not the same in all directions from the same center, but varies according to objective and subjective distance. Range is determined by 1) the size and importance of the center and the spatial distribution of the population, 2) the disposable income of purchasers, 3) time-distance, 4) quantity and price of the good at the central place. The range is a ring with an upper limit beyond which a good is no longer purchased from a center, and a lower limit which is determined by the minimum amount of consumption which is necessary before production or offering the central good will pay.

8. There is a system of central places with places of different sizes; the system is determined by the spatial effects of the upper and lower limits to the range of central goods. Assuming a homogeneous plain with equal access in all directions, then the complementary regions become hexagonal and the lower order centers and their complementary regions nest (fit) within those of larger centers. In this system the relationship between size, spacing functions and hierarchical interdependence is
determined precisely. The simplifying assumptions make this scheme imperfect. In reality price differences, differences in population distribution affect this scheme. There is a strong parallel between size and frequency of central places and intensity of traffic, but it is the former which determines the latter and not vice versa.

9. The system of central places developed on the basis of the range of central goods used the assumption that all areas can be served from a minimum of central places; therefore the principle on which this system is developed is called the marketing or supply principle. There are other factors. The principle of traffic says that the distribution of central places is at an optimum where as many important places as possible lie on one traffic route between larger towns, the route being established as cheaply as possible. Principles of traffic are linear, those of marketing spatial. Principles of administration based on the ideas of separation of complementary regions for purposes of administration or a distinction which implies distinct administrative control.

The three principles determine, each according to its own laws, the system of central places. Two of them are economic; one is political. Under certain circumstances one or the other principle may predominate, but in most instances they compete for dominance.
Lösch (1954) has generalized the central place model. First he provides explicit proof of the optimal shape of the hexagonal trading areas in the case of uniform distribution of purchasing power. He suggests that the three systems of central places—the market, transportation and separation—were three special cases of a whole series of possible hexagonal systems. These are found by varying the orientation and size of the hexagon. Various arrangements of hexagonal nets of different sizes are superimposed on one another so that they all have the same central point. This point is the site of the metropolis, the largest order of central place in the system. By rotating the nets around this point a pattern develops in which six sectors with many and six sectors with few settlements arise. This sectoral pattern is called the economic landscape. In this pattern Lösch says that the greatest number of locations coincide, the aggregate distance between all settlements is minimized, and the maximum number of goods can be supplied locally. The basic features of Lösch's model are: the concentration of settlement into sectors separated by interstitial areas in which settlement is less dense. Within the 'city rich' sectors the larger settlement increases with size with distance from the center. Lösch suggests that there is a hierarchy: "there is a continuous array of centers;
higher order centers do not necessarily provide all of
the functions of lower centers, and centers providing the
same number of functions do not necessarily provide the
same types of functions."

Berry and Garrison (1958) reformulate central place
theory as presented above. They say that as initially
formulated central place theory related only to alternate
urban centers and the transport network system linking
the centers. The statement was in terms of homogeneously
distributed purchasing power (hence hexagonal trade areas).
This restricted its applicability to more realistic
situations. They suggest:

1. That the central place theory is definitely more
applicable when reformulated in terms of simple concept.

2. That reformulation in terms of these concepts
enables a hierarchical structure to be developed without
the assumptions of uniformity concerning purchasing power
which are basic to the arrangement of hexagonal trade
areas. One consequence of this is that the theory
becomes applicable within cities as well as without.

Berry and Garrison analyzed two factors controlling
the distribution of central places which were clearly
implied in Christaller's original work, but which they
more explicitly examine. One of these factors is called
"the range of a good" which is the distance over which
people are willing to travel to obtain a particular good or service. The other concept is "threshold" which is the minimum amount of purchasing power necessary to support the supply of a particular good or service from a central place. The range of a particular good from an urban center has an upper limit which is determined by competition from other places which supply the same service. The range also has a lower limit, controlled by the threshold necessary to allow profitable operation.

As a result of the operation of these two factors a hierarchy of central places develops. More specialized services require a larger threshold, but also have a more extensive range. Therefore they are found in those larger settlements which provide enough purchasers to support them drawn from both their own population and from their larger zones of influence. Larger settlements also provide less specialized services (bread and milk for people in the city), but these services have a smaller range; it is possible for smaller settlements lying between the larger centers to compete effectively. Although each individual service may have a unique range and threshold it must be provided at an urban center where groups of services are concentrated. As a result distinctive groups of services will develop in those settlements which provide approximately the correct
threshold for their survival within the range appropriate for these goods.

**Empirical Verification**

A great deal has been written about the applicability of the central place theory.\(^1\) Most of the research has been of three types: 1) studies demonstrating the generality of the model in different regions of the world, 2) studies which examine the hierarchical aspects of the trade centers, and 3) the development of mathematical models describing the cross sectional relationships among central place variables.

The work of a number of American rural sociologists lends support to Christaller although it was done independently of Christaller's work. Galpin's study of trade areas in Walworth County, Wisconsin, published in 1915 was the first contribution. Since then many studies examining this problem have been completed by others: Kolb and Polson (1933), Melvin (1925), Sanderson (1932), Zimmerman (1930), Smith (1933), Landis (1932). These studies are concerned with the smaller trade areas, but give a great deal of information on distribution of settlements which

\(^1\)For an extensive bibliography see Brian Berry and Allen Pred, CENTRAL PLACE STUDIES, bound together with a supplement through 1964 by H. G. Barnum, R. Kasperson and S. Kiuchi (Philadelphia: Regional Science Research Institute, 1965).
independently substantiates much of what Christaller had to say. They demonstrate that there is a continuum of central places. They demonstrate that in these rural areas as the population of the towns (central places) increases so do the numbers and types of business establishments, the size of their trade function, their dependent population. They show that spacing varies inversely with population densities. They show that there is a hierarchy of urban centers. They have identified rural neighborhoods and communities and the centers and groups of functions that characterize these levels of the hierarchy.

Human ecological studies have examined some of the spatial aspects of areas relevant to central place theory. Gras and McKenzie provide theoretical explanations and Bogue and Tarver give empirical evidence to provide support.

Gras (1922) describes an evolutionary process wherein different types of economic organization bring about the need for different settlement patterns. Economies evolve through the collectional economies, cultural nomadic economy, settled village, town economy and culminated in the metropolitan economy. In each case earlier forms of settlement remained after the emergence of the latest form, but in each case the more recent form coordinates
the functioning of its predecessors in the hinterland. In the metropolitan economy the city and the hinterland are functionally interdependent.

McKenzie (1933) emphasized different points than Gras. Gras saw the interrelationship of the parts more in terms of trade and commerce. McKenzie placed more emphasis on the transportation and communication interrelationships. Although he did recognize a trade area the region of influence which is economically tied to the city. This trade area is similar to Gras's idea of metropolitan economy.

Bogue's (1949) study of the metropolitan community provides supporting evidence for sectoral variation in the distribution of population and economic activity similar to that hypothesized by Lösch. Bogue was interested in the metropolis and its hinterlands; this is not unlike Lösch's system of networks centered around the metropolis. In his analysis Bogue demonstrated that the characteristics of the metropolitan regions had spatial regularities. In all cases population density declines systematically with increasing distance from the metropolis, and this decline continues to the extreme limits of the region. The rate of decline varies according to the size of the metropolis, e.g. the higher the population of the central
city, the higher the population density and the more rapid the decline with distance.

Bogue also noted that there was a regional difference in the rate of decline in the density-distance relationship. The third characteristic of the density patterns is that there is a sectoral variation from the metropolis. Bogue's sectors do not exactly correspond to Lösch's, but there are some similarities. Bogue designated three types of sectors radiating from the metropolis:

1) Intermetropolitan (route) sectors containing a major roadway connecting metropolitan centers.

2) Subdominant sectors, lacking the major roadway but having a major center of more than 25,000 population.

3) Local sectors, without major road or major center.

Bogue found that the highest population densities are found not in the route sector, as Lösch's work might suggest, but in the subdominant sector (perhaps as a result of suburbanization around these centers).

Treadway (1972) in attempting to analyze the gradients of metropolitan dominance in Turkey, a developing country, had difficulty discerning any effect. Suggesting that the metropolitan dominance concept is more valid in developed countries.
Dynamic Aspects of Central Place Theory

Berry and Garrison have described the static system of central places in terms of two variables: the range and the threshold. The "range" of a good is the distance which people are willing to travel to obtain a particular good or service. "Threshold" is the minimum amount of purchasing power necessary to support the supply of a particular good or service from a central place.

Christaller used similar concepts in his theory and suggested how in a dynamic setting changes in these two variables could change the central place system. As an aid to understanding the various interrelationships in the dynamic theory Figure 1 is presented on the following page. It should be of assistance in discerning the relationships between the concepts which will be presented in a very summarized, abstracted form. First we will examine Christaller's analysis of factors affecting the range of a good. Later we will discuss the factors affecting the threshold.

Range

Christaller (1933: 111) says "The system of central places is developed only on the assumption that there are many types of central goods from the lowest to the highest order each having a special range. Every change in the
Fig. 1--Factors Affecting the Central Place System

Technological Innovation

Transportation

Physical Aspects of the Region

Price and Quantity of Goods

Number of Functions in a Community

Subjective/Objective Economic Distance

Price Willingness

Social Structure of the Population

Distribution of Population

Population Density

Size and Distribution of Income

Range

Central Place System

Purchasing Power (Threshold)
range of any good at any place causes simultaneous deviations within the system of central places. The rational scheme of the system is not changed; only the decisive factors are changed. Changes can occur in the distances between central places, in the sizes of central places or in the location and number of central places."

According to Christaller (107) (this was mentioned earlier under the static theory), there are four main factors which determine the range and can bring about a change in the range: the size and importance (number of functions) of the central place; the price willingness (disposable income) of the purchaser; the subjective economic distance (time-cost-distance); and the type, quantity, and price of the good. In the following section each of these factors will be discussed.

**Size and Importance.**—Goods offered at higher order places have a larger range than do the same goods offered at a smaller place since more types of goods are offered at the higher order place than at the lower order place. This means that on the basis of a single trip, one may simultaneously obtain several types of central goods. This has an effect similar to a general price decline in the larger towns.
**Price Willingness.**—Price willingness is defined by Christaller as the part of its income a population is willing to spend on central goods. It is determined first by the quantity of money which is spent altogether for the acquisition of the central good itself, and second by that part of the income which must be spent for travel. The social structure of the population including income, social, occupational, customs, and special demands of the population determines what part of the income the population is willing to spend for the purchase of a certain central good.

**Subjective/Objective Economic Distance.**—The range of a central good is influenced by the distance between those who live in the hinterlands and the place where the central good is offered. Mileage is unimportant. Only the time cost distance is a determining factor. According to Christaller the economic distance means the transportation advantages expressed in money terms or in values which are conscious decisions with regard to transportation costs, loss of time, security, and convenience. There is of course a subjective element in all this. A particular situation looks more advantageous to one person than it does to another. (Economic distance is essentially the same concept that was mentioned by McKenzie (1927)).
Christaller feels that the most important aspects of the economic distance are the objective ones: the freight and passenger fare, costs of insurance, storage, weight loss and possible spoilage caused by delay in transit.

In general high fares reduce the range of a central good; low fares increase it. However, this factor is less important with goods which are valuable in proportion to their weight than with those with less value in proportion to their weight.

One subjective factor has a particularly important effect on time-distance. That is, the valuation of distance differs locally. Costs and burdens of distance are valued less in vicinities of large towns. The central goods attain a larger range which causes favorable development of central places of a higher order. Thus smaller central places lying in the vicinity of central places of a higher order lose their central functions more and more until finally they are absorbed by the larger place.

**Price and Quantity of a Good.**—The consumption of central goods is the determinant of the development of central places. The consumption however is not the same as the demand for the good. The demand is much greater than the consumption. Demand is restricted first by the fact that
the customer has limited funds. The amount of goods imposes a second limitation. The quantity of a good may be limited and not increasable at a given place, or the quantity may be unlimited and increasable as desired. The prices of these two categories of goods are determined differently. For the goods of a given quantity prices are determined by the fact that these goods are scarce; whereas for goods which can be increased through production the price is determined through the costs of production.

The third limitation on consumption of a good is the price of the good. This is related to the existing amount of the good, the supply and the demand, and other factors.

Combining the relationships of the amounts and prices of goods there are four main types of goods.

1. Goods of a given quantity with a fixed price.
2. Goods of a given quantity with a market price.
3. Goods the production of which can be increased as desired with a fixed price.
4. Goods the production of which can be increased as desired with a market price.

With fixed supply and fixed prices, the range is determined almost exclusively by the available quantity of the good. With goods of a fixed supply and a variable
price it is largely determined by the price of the good. With augmentable goods which have fixed prices, the range is determined only by the cost of the distance. With augmentable goods which have variable prices the price at the central place is the prime influence upon the range.

As a rule the same central good can be produced and offered more cheaply in a larger town than in a smaller town, because production in greater quantities is cheaper and the larger amount of sales permits a lower cost per unit. Thus a good offered at a larger central place has a greater range than the same good offered at a smaller central place. A higher population density has the same effect. It makes production cheaper and the range of the central good greater than would be the case in a less dense central place.

The Threshold

Christaller discusses the "lower limit of the range." This is what Berry and Garrison call threshold. Threshold is the amount of purchasing power in an area necessary to make it profitable to provide a good or service.

If the purchasing power is high, then there is the probability that the central good will also be offered at other central places in the region. That is the case if
there is either strong consumption of the central goods at the central place itself or if it is a central good the production of which demands little effort, especially capital or training from the producer, so that it can be produced at little expenditure. If the purchasing power is too low, lower than is necessary for a certain profit, then certain central goods will not be offered in the region at all.

If in a region the purchasing power is lower than usual then the central places are generally more poorly developed because the selling of such goods falls off.

Because the purchasing power is usually determined by the number and distribution, and the social, cultural and professional structure (economic base) as well as by the income conditions of the population, a concentrated, highly cultural and wealthy population increases the purchasing power.

Christaller (1933: 68) says, "we can conclude that in a densely populated, wealthy, and highly cultural industrial region there are more central places of a higher order than in a region with the opposite characteristics . . . But this will occur only if the mutual location-relationships corresponding to the system of central places remain the same."
Factors Affecting the Purchasing Power:

 Distribution of Population.--Consumption of Goods
despite equal demands and equal incomes varies in different places of the region. It is higher near where the
central good is offered and it decreases with increasing distance.

The total consumption of central goods is less in
regions with weakly developed centers than in regions with
strongly developed centers, but higher than in regions
without any centers but an equal population.

In addition to considering whether the population is
central or dispersed we have to realize that the dispersed
population might live in larger settlements--villages,
smaller settlements--hamlets, or on single dispersed
farms.

Small central places are generally less developed
in a region of single farms than in a region of villages.
However, large central places are better developed in the
single farm region.

 Density of Population.--Densely populated regions
generally have a higher consumption of central goods.
This greater consumption enables the denser population
to establish a greater degree of labor specialization
by which many goods previously produced in the hinterlands are now centrally produced. The greater concentration of population enables a greater use of capital necessary for the production of central goods. Thus the product itself becomes cheaper, and an increased consumption of the cheaper good results.

The Structure of the Population.--Individuals of high socio economic standing have a higher consumption of central goods. (Christaller is tapping the status symbol concept.)

The Size and Spatial Distribution of Income.--In regions with generally higher incomes the consumption of central goods is considerably higher than and the development of central places is therefore more likely than in places of lower incomes (assuming the prices the same in both places).

Concerning income distribution, a great number of medium sized incomes is apparently most important in the consumption of central goods.

Concerning spatial distribution, higher incomes in the central place itself lead to more consumption of its central goods than do higher incomes in outlying places, since the transportation costs must be deducted and only the balance can be spent on central goods.
How Changes in the Population Will Affect the Threshold:

Population Changes. — If the population of a region grows evenly in town and country or if there are originally small towns which receive the whole increase in population, then new auxiliary central places will develop at a point which lies as far away as possible from the old central places. The central importance of the old central places does not increase— or it increases very little— despite the growth in population. If, however, there is from the beginning a large town which receives the entire increase in population then no new central place will be formed and the importance of the single place will grow correspondingly greater.

When there is a change in the structure of the population, e.g. a change from agricultural to industrial economic base, there is a change in the increased consumption of central goods and a decrease in the consumption of dispersed goods.

Retardation in the Growth of the Population. — With a general decline in the population of a region the weaker smaller central places die away. But the function of the other central places does not increase proportionately to the added population served, but rather less than proportionately. Under certain circumstances this importance
might be intensified because of the increase in demand of central goods which have been released following the death of the auxiliary central place. Particularly if the dispersed border population decreased markedly and the population of the central places decreases slightly, then the importance of the central places will be intensified.

Related Factors:

Christaller discusses three factors which affect range and purchasing power indirectly. These factors are the transportation system, the region and the impact of technological innovations.

Transportation.--Transportation facilities are the most significant factor determining the size and distribution of towns according to Christaller.

1. "In the framework of our considerations of the essentials, traffic has the immediate importance of determining, in an excellent way, the range of transportation costs and the central goods obstacles."

2. In addition, traffic plays the role of mediator; it usually brings about exchange--it influences the degree of the division of labor, increasing production, decreasing the cost, increasing the quantity of goods. With limited traffic, the division of labor is possible to only a limited degree; with a higher development it is possible to a greater degree. As the division of labor
increases and as many more central goods are produced, moderately mixed according to the number and types, the central places of exchange will be fewer and their development will be stronger.

3. Better traffic conditions mean a reduction in the economic distance—reduction not only of the effective costs, but also of the loss of time and of the psychological restraints by which the inconvenient, dangerous, and at times, almost impassable routes with wretched traffic conditions repeatedly offset the gains of the central good. In a region with better traffic conditions the central place will be larger than in a region with poor traffic conditions.

4. Better traffic conditions lead to an increase in the number of functions in a central place. With cheaper and quicker transportation more types of goods, which formerly were offered only dispersedly or locally, will be centrally offered in all regions. In the larger towns, that means increasing the number of functions in the central place.

5. Improved traffic conditions affect price willingness. In general, lower transportation costs mean that out of that part of income allotted to the acquisition of certain types of goods a greater part can be spent on the goods themselves and a proportionately smaller part
for transportation. The increasing security and comfort of the means of transportation have the result that the obstacles (such as the distance to be covered and the discomforts resulting) preventing more frequent acquisition of these goods are diminished.

6. Also there is a shift of the distribution of the population, with a greater density of the population at the central places and stagnation or decline of the dispersed places, as a consequence of the transfer of the production from dispersed to central places, which causes an additional increase in the development of the central places.

Technical Progress.—Technical progress is represented mainly as an increasing division and specialization of labor, and as the substitution of the more efficient mechanical "labor" of machines for human and animal labor.

Technical progress tends to increase the range of central goods by decreasing transportation costs and production costs through increased specialization of types of goods and through mass production.

Region.—There is a relationship between the size of a central place and the characteristics of its complementary region.
The characteristics of the region: size of area, typography, means of transportation, natural endowment and whether the whole region or only a part belongs to the central place.

1. Size of region: The larger the region the more central goods are sold in it assuming the same population density, income, etc. And the higher the consumption the more important the central place. Thus the larger region will have a larger central place than the smaller region. But this is not a one to one relationship, because in the larger region a proportionately higher share of the income available for the purchase of goods will have to be spent for travel. Plus the inconveniences in purchasing central goods are greater, thus more dispersed goods will be consumed at the periphery.

2. Concerning transportation systems, central places of equal population densities show relatively less development in regions of poor transportation than in regions of good transportation, because relatively more of the income devoted to the purchase of central goods must be spent on travel costs.

3. The natural endowments of a region—fertile soil and minerals—has no immediate effect on the development of central places. Only when it decisively
determines the density, the distribution, and the income conditions of the population.

4. If the central function is shared by two central places which lie close together, there is a greater consumption of central goods, but only in regard to goods of a lower order. The division of sales of specialized goods and services between two neighboring places means a lessening of their aggregate sales of these goods.

Four Ideal Types of Regional Trade Center Structures

It appears that four ideal types of regions can be discerned. Depending upon the relationship between the distance people are willing to travel to buy a good or service (range) and the purchasing power of the population (threshold).

Following Christaller (1933: 120):

1. Low purchasing power and consumers willing and able to travel long distances. The central places of higher order will be developed strongly and those of a lower order will be developed weakly.

2. Low purchasing power and consumers willing and able to travel only short distances. The population consumes only a few central goods because of impoverishment, lack of effective demand, etc. The range is low (little development and expensive traffic net). Thus
all central places both of a lower and a higher order will be less developed—as in poor agricultural countries.

3. High purchasing power and consumers willing and able to travel long distances. This would be a wealthy and densely settled region. Here the larger and smaller central places are well developed. In this case the whole system of central places is raised to a higher level, that is, the small centers in this region will offer goods found only in larger centers in less well developed regions.

4. High purchasing power and consumers willing and able to travel only short distances. The central places of a lower order may be well and regularly developed, but at the same time the places of a higher order may be relatively less developed. This is the case in wealthy agricultural countries which are connected only very slightly to modern civilization.

Table 1 illustrates the relationships.

When there are changes in the factors affecting the purchasing power or the distance people are willing to travel of the region, the individual types of central places are accordingly affected. Thus, the region may change from one category to another.

When industrialization occurs in a rural area the region moves from a region of well developed small
TABLE 1

FOUR IDEAL TYPES OF RURAL REGIONS

<table>
<thead>
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<th>Distance</th>
<th>Population is Willing or Able to Travel to Buy a Good or Service</th>
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<td>Short</td>
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<td>All places</td>
<td>Low poorly developed</td>
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<tr>
<td>Small places well developed</td>
<td>High poorly developed</td>
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centers\(^1\) to a region with a well developed large center, and then to a region with well developed large and small centers. Why do we not have this situation when we implant the large center in the region of well developed small centers? According to Christaller this final stage entails the raising of the whole central place system to a higher level. The process by which this development occurs is described in the next section.

Martin (1957) examines the changes taking place in the rural areas adjacent to cities. His emphasis is on

\(^1\)Industrialization takes place in a region which is relatively well developed agriculturally. This occurs because the food needs of the city must be provided from the agricultural surplus.
the ecological and demographic changes taking place in
the rural sector of satellite areas, a term he uses to
refer to all smaller central places within the region of
the central city.

First Martin determines the conditions under which
a heavily settled satellite area develops. He bases his
discussion on concepts that both the urban and rural
economies are functional parts of the larger economy, and
follows Clark (1940) and Fisher (1945) that industrializa-
tion involves a steady shift of employment and investment
from primary activities to secondary and tertiary activi-
ties.

He develops a model of industrializing society:

1. Industry develops in and is concentrated in urban
centers (growth centers), while agriculture is dispersed
over the rural area.

2. As industrialization progresses the urban indus-
trial sector increases its share of the national labor
force from perhaps 25 per cent to perhaps 90 per cent at
a later time. The shift occurs because of continuing
agricultural productivity which allows more people to work
in non-agricultural activities.

3. The city is an organization with an ability to
maintain large populations in small areas at a relatively
high level of living. The city is not self-contained.
The city has specialization of functions, interdependency of differentiated parts, emphasis on production, dependency on other areas for materials, personnel and markets for its products. The city grows through the development and extension of transportation and communication facilities which tap a larger area of raw materials and customers.

4. The very factors that make possible the modern city and insure its continual growth also make possible the dispersion of population to the surrounding area.

5. However making an event possible does not insure that it will occur—Schnore (1957) points out that theories of differential economic opportunities which serve to explain the growth of independent cities do not explain the growth of individual suburbs.

The suburbs with the fewest job opportunities were growing most rapidly.

6. Schnore suggests that in the period of rapid population growth the bulk of housing construction takes place where level and relatively unencumbered land suitable for mass production of homes is available. Suburban location of mass produced homes derives from the profit-making aspects of the construction industry.

7. Advanced technology provides transportation and communication facilities and the level of living to make
decentralization of populations possible. But a third factor, plentiful suitable land in satellite areas, is also a necessary condition.

Martin then asks, "given a nation that roughly approximates the model discussed above, what changes could be expected to take place in the ecological characteristics of the satellite rural area?"

"Previous analyses of the extension of urban influence changes in rural areas have emphasized variations of two broad principles of change--the gradient principle and the principle of differentiation."

The gradient principle has been a very fertile area for research. Perhaps von Thünen (1910) is one of the first to develop this concept. He developed a theoretical model of the patterning of agricultural activity on a plain of uniform soil fertility surrounding a single city. He developed a scheme of concentric zones of farming activities resulting from the differential requirements of various farm products for accessibility to the central market. Burgess (1922) classic ecological concentric zone theory describes the patterning of different ecological land uses of a city around a central core using this concept. Colin Clark (1951) demonstrated the empirical generality of the concept for measuring population density in westernized cities throughout the world. Berry et al.
(1963), Newling (1966), and Winsborough (1961) expanded the concept.

The principle is in line with the ecological dominance concept Gras, McKenzie, Bogue, etc., mentioned earlier.

Although there is no complete explanation for the empirical regularity, Alonso (1964) and Muth (1962) suggest that it results from substitution on the part of households and firms of rents for transport costs.

The principle as verified by Clark, Berry et al., and Newling related to the falling population density found with distance from the center of the city. Martin generalizes the concept stating that "urban characteristics are distributed in the satellite rural area so as to form gradients of decreasing incidence with distance from the city." Martin goes on to say that in a dynamic sense the influence of the expanding urban center can be thought of as extending into the rural area in a gradient which declines in accordance with diminishing transportation.

The gradient principle states that the extent of urban influenced changes in rural areas varies inversely with distance to the nearest city and directly with the size of that city. In addition, Martin hypothesized that with increasing technological development the slope of the gradient becomes less steep. Berry et al. (1963: 403)
verified the fact that in Western cities the gradient does decrease with time. Although this is not the case in non-Western cities. They attribute this to two features in Western cities. The more flexible system of transport and the fact that there is a different organization of society, in which richer people live on the periphery.

The second general principle put forth by Martin is that there is a tendency for urbanization to transform previously undifferentiated territories by introducing complex specialization of function, differentiation of sub-areas and functional interdependency of the differentiated parts. This statement is based on basic ecological theory. McKenzie (1933), Hawley (1950), Shevky and Bell (1953), Greer (1962), Murdie (1968), Anderson and Egeland (1961). This point was also made by Christaller and mentioned earlier in the summary of his theory (p. 34).

According to ecological theory areal differentiation within the city decreases with distance from the city center. Martin extends this principle and suggests that rural areas most under the influence of the city would show the greatest differentiation and rural areas most isolated from cities would show the least differentiation. Differentiation concept: "The extent of specialization and differentiation of sub-areas in rural territory
varies inversely with distance to the nearest city and directly with the size of that city."

Martin considers the two principles as complementary. The two are partially independent in the sense that demonstrating the gradient principle provides no basis for evaluating the differentiation principle, while acceptance of the differentiation indicates that the gradient holds for at least that particular characteristic. Martin analyzed several variables in his study, but the ones which concern us are those of population and establishments.

Population decentralization—Martin found that recent (1950-55) population growth occurred mainly in the standard metropolitan areas, and that within these areas the greatest growth was in the satellite areas especially the satellite areas where land suitable for mass produced housing was most readily available.

Martin reports on the differential rates of growth within the metropolitan rings. He shows that the rate of increase of the metropolitan ring in relation to the total SMSA rate increased consistently each decade from 1900-1950. The larger cities in the metropolitan ring had their most rapid relative growth in 1900-10 but since then the shift has been toward rapid growth of the smaller areas.
Business deconcentration--The satellite rural areas are also changing through a deconcentration of business activities within SMSA's. There was considerable variation among the individual SMSA's. There was a general rapid development in the metropolitan ring.

Cuzzort (1955) found that for 147 SMSA's in 1948 the metropolitan ring and particularly the rural segment of the ring did not have its proportionate share of service receipts, service establishments or service employees, but during the preceding decade the rate of redistribution of service activities had been so rapid as to indicate that eventually the distribution of these activities may approximate the distribution of population in the SMSA's. He feels that this deconcentration of service establishments is mainly explained by the deconcentration of population.

Newman and Chase (1956) reported that a survey of building permits for 1955 demonstrated that 61 per cent of all stores and other mercantile buildings were built in the metropolitan ring. This was 65 per cent of the value of such new buildings.

Martin (1973) demonstrated the correctness of the gradient principle, but found that the slope of the gradient decreased with distance from the center.
Concerning the differentiation principle Martin says: "While the idea has been stressed by McKenzie and others, there is a surprising lack of empirical research."

In the next section we will review some empirical studies which shed some light on changes in the central place hierarchy of rural regions and also on the gradient principle and the concept of differentiation.

**Empirical Evidence of Change in the Central Place Structure**

Empirical investigations are generally concerned with four areas of study: 1) the relationship between population and retail services, 2) the debilitating effect of large trade centers on small centers, 3) the trend toward greater specialization in trade centers, 4) various social and technological factors which affect the growth and decline of communities.

**The Relationship between Population and Services**

Empirical evidence demonstrates: Trade centers offering a small variety of goods and services are more likely to decline than those offering large varieties.

Hassinger (1957b: 238) found that centers which offered more specialized retail services with greater selection and variety showed a population increase. He discovered that there is a trend toward more centers at
both ends of the spectrum, an increase in simple service centers and more complex retail service centers.

There was a general trend at all levels—the proportion of places that gained 5 per cent or more in population was largest for places that gained retail services.

Wakeley (1962) suggests a principle of competitive exclusion which indicates that any center which can maintain a competitive advantage, however small, will eventually replace the disadvantaged center. In most competitive situations primary service centers do not die; they just perform more limited functions.

Fuguit and Deeley (1966) attempted to extend Hassinger's work by taking size of place and central place position (rank in hierarchy) into account in population growth.

They attempt this control, since there is an association between population size and service hierarchy position. They found a low positive association between retail service score (central place rank) and population change.

Controlling for central place rank they found a low positive association with size of place and population change. Controlling for size of place they found a low positive association between population change and central place rank in places less than 300, but no
association for larger places.

Lively (1931) concluded that the appearance and disappearance of certain trade centers was but one aspect of differential growth and decline of all trade centers. Among several causal factors he mentioned population density in the region. He found a high correlation between the unincorporated populations and land area per tributary area. The greater the density the more trade centers per unit area. He found a higher correlation between incorporated centers and population density than between unincorporated centers and density. The unincorporated center represents a more fluctuating group. It is the elasticity of this group which maintains the balance between the number of trade centers and density of the population. He also found a high correlation between farm value, population and trade center decline.

Higgs (1969: 369) examined the growth of cities in the Western Prairie region in the period 1870-1900. He found that the main source of city growth could be attributed to the growth of population density from a high rate of agricultural settlement.

Scott (1968: 436) found as the density of rural farm population decreases with growth in farm size and farm mechanization the market area necessary to support a particular trade function increases. But if the extent of
the market area comes to exceed the distance that a customer is willing to travel in the absence of additional trading attractions then the function must move up to a higher order center. He also determined that the distance between centers, the functional structure of centers, and the rate of substitution of capital for labor in farming, all vary with the type of farming. Thus he found that the centralization tendencies within trade center systems varied with farming type.

Johansen and Fuguit (1973) found a positive relationship between community population size and number of service functions in their sample of Wisconsin villages (places less than 2500 inhabitants) in the years 1939-1954-1970. However, they say that there has been a decline in the number of functions corresponding to a given population level. The ratio of individuals to functions went from 42:1 in 1939 to 49:1 in 1954 and was 67:1 in 1970. Then too, the mean number of functions per village declined, from 17.4 in 1939, to 15.1 in 1954 to 12.1 in 1970. The investigators found that average population change during this period differed. When the largest city within 30 miles of the villages was less than 25,000 they declined. But when the largest city was over 25,000 they increased in population. Although,
mean number of functions remained the same for both categories.

Borchert and Adams (1963: 5), investigating the Upper Midwest region, found that there is a tendency for the level of trade center to be directly related to its population size, but there is also a wide range of populations within any given class of trade center. The strength and growth of the trade center depends in part upon the character and size of its surrounding trade area. They also determined (p. 8) the sizes of trade areas and spacing of trade centers depends mainly upon population density.

In addition (p. 16) the concentration of trade area population at major trade centers is generally higher in the less densely populated areas. Retail strength is high at those centers with a high concentration of their trade area population.

Hodge (1966) in a study of Saskatchewan found that trade centers that have small populations are more susceptible to decline.

Chittick (1955) found that in South Dakota the growth and decline of trade centers have been closely related to changes in their surrounding areas. As the rural farm population declined there was a corresponding decrease in the number of trade centers.
Berry and Barnum (1963) and Berry, Barnum, and Tennant (1962) demonstrate the relationship between trade areas, population served and population densities. They found that as population densities diminish, centers of any rank serve larger areas, but fewer people. Thus they become simpler in function.

Lively (1931) found that during the 1905-1930 period in Minnesota total number of trade centers increased 2 per cent. But of the 799 trade centers with less than five establishments in 1905, 39.5 per cent disappeared and 46 per cent declined by 1930.

Nelson and Jacobson (1941) analyzed farm trade centers in Minnesota to find what changes had taken place during the depression years (1929-33) and post depression years (1933-37). They found that during the depression years small and medium sized centers lost business establishments, while larger centers (over 75 establishments) actually gained slightly (1.1 per cent). It appears that the depression accelerated a trend already observed as under way during the previous decade (1915-29). The trend continued in the 1933-37 post depression period where the number of business establishments in major centers grew 15.8 per cent, medium 11.7 per cent and small 7.2 per cent.
Hodge (1966: 195) suggests that small centers were found to decline faster than large ones, but there was not a successively increasing rate of decline for each lower ranking center, and mid range centers made a strong showing.

**Empirical evidence shows a debilitating effect of large trade centers on small centers.**

Borchert (1963) found that in the Upper Midwest larger cities were "penetrating" their trade areas more fully and attracting buying power away from small centers. He said that large centers were in a favorable position because of the economies of scale in their establishments, increased speed of travel and range of transportation in bringing both goods and customers to them and the increasing competition among the large centers that encourages further internal economies.

Scotton (1953) examined the trends in rural retailing in Illinois and found that there were changes in sales volumes and kinds of goods sold and retail operating methods; there were shifts in places where rural families bought these goods. He found that there was no evidence to support the hypothesis that the village centers should be able to hold their trade better than the stores located closer to the [larger] trading centers.
Anderson and Collier (1956) found that rural areas are spatially organized in terms of the urban (over 2500 population) areas. This was tested and confirmed for a sample of counties in Missouri. They found that in the rural hinterland the organization was oriented more toward the larger towns than toward the distant metropolitan centers.

Kolb and Polson (1933) examined the changes which had occurred in Wadworth County, Wisconsin, since Galpin made his study in 1913. They found that the general trend of change from 1913 to 1929 was marked by expansion of twelve large centers into the territory formerly served by small country neighborhood and crossroad centers.

Smith (1933) found that trade centers less favorably situated in regard to population and transportation had been smothered out of existence, while a greater share of activity had been organized about large centers.

Hart and Salisbury (1965) state: "Distance from a larger city is more significant as a determinant of population change than the size of the village. Village population change and city distance are negatively correlated."

Neidercorn (1973) applies a static optimization technique to a two stage model to demonstrate that urban
land rents, population density and employment densities all conform to a negative exponential distribution (decline with distance from metropolitan center).

Butler and Fuguit (1970) attempted to analyze the apparent contradiction in the set of studies showing that towns near large cities were growing more rapidly in population and another set showing towns near large cities to be losing services and trade more rapidly than others. They found that in Wisconsin 1940-50, a) competition between a small town and a neighboring town if the neighboring town was only slightly smaller, and b) symbiotic relationship between a small town and the neighboring town if the neighboring town was considerably larger. In the symbiotic case the shorter the distance to the nearest larger town the greater the growth.

Empirical Evidence Demonstrating a Trend Toward Greater Specialization in Trade Centers

According to the theory various types of centers should provide various types of specialized services. The smaller the center the more localized the activities. Studies suggest that there is a trend toward greater specialization in trade centers. This trend has been noted in various investigations.

Wonderer and Smart (1969: 374) found that centers of the same size in Colorado and in Sweden offered
similar services supporting the concept of a hierarchy of services in a rural-urban continuum.

Hoffer (1931) studied trade centers in Minnesota from 1905-29 and delineated three types of service centers which appeared to have emerged during this period. The primary (1000 inhabitants), shopping (1000-5000 inhabitants) and terminal trade center (5000 plus inhabitants). He emphasized that marketing and financial services; professional and municipal services were all centralizing in various types of specialized centers. He also mentions that the three types are becoming increasingly interdependent with each other and larger urban agglomerations (p. 68).

Kolb and Polson (1933) re-examined the Walworth, Wisconsin, area first studied by Galpin in 1913. They state that (p. 29) running through the whole analysis is specialization and interdependence. "Service centers in the county are reorganizing and readjusting in order to perform the services for which they are best fitted . . . In so doing they are becoming increasingly interdependent with urban centers [Milwaukee and Chicago]. This is not urbanization, it is no more urbanization of the country and small town territory than it is ruralization of urban territories."
Kolb and Day (1950) in a follow up study found the trend continuing through the 1940's.

Smith (1933) in analyzing trade centers in Louisiana from 1905-1931 found communities of different size and position to have an increasing tendency to become functionally specialized in terms of services offered.

Brunner and Smith (1944) studied the place of the village in rural America. They found data to support the hypothesis that there may be emerging two distinct types of service centers in the United States for rural populations. One of these is the traditional type of village, the other is the market town of 2500-10,000 inhabitants.

Kolb (1959) in summing up the Wisconsin findings from 1913-1950 discussed the trend toward differentiation, with degrees of specialization for centers and their communities. This inevitably brought about a greater interdependence among the various types of communities. He suggests that there were three phases in the process: community formation, differentiation and interdependence.

Borchert and Adams (1963) in their study of Upper Midwest trade centers found that many convenience centers in farm areas though static for several decades were not declining. They suggest that these are viable business locations for the purposes they serve and merit continued maintenance, replacement and modernization. Others they
Empirical Evidence of Other Factors Which Affect the Growth and Decline of Communities

Lively (1931) concludes that the appearance and disappearance of certain trade centers was but one aspect of differential growth and decline of all trade centers. In addition to factors mentioned previously he includes stage of region's development; decline of the post office due to RFD and the relationship between the number of automobiles and improved roads. He also mentions various socioeconomic events which may have a particular impact on a local community (e.g. discontinuance of a dairy).

Landis (1938) studied the decline of Washington farm trade areas from 1900-1935. He found that trade center population increased 200 per cent during the period while the number of trade centers had increased only 15 per cent. Smaller trade centers were found to be declining in importance due to increased mobility provided by the automobile.

Landis (1932) when mentioning factors affecting trade center decline discusses the changes in life styles in rural-urban trade relations. He also mentions the changes in income and tastes, and the growth of chain stores.
Converse (1928) found that increased mobility of the consumer led to a relative decrease in importance of those places at the lower end of the hierarchy of trading centers.

Chittick (1955: 49) in examining the decline of centers in South Dakota 1901-1951 states that the first great decrease in the total number of trade centers was between 1911 and 1921, which may be associated with among other things the first general use of the automobile. The second period of loss was between 1941 and 1951 which he attributed to the trend toward specialization in the complex of interrelated factors such as agricultural mechanization, transportation, and merchandizing.

In summarizing the factors affecting the size and distribution of trade centers Chittick has this to say. "The construction of railroads and the location of county seats early in the state's history established the general framework for the distribution of trade centers during the fifty year period. This resulted in quite definite 'constellations' of trade centers (distribution according to relative size). These constellations are made up of a larger central, growing trade center, usually a county seat surrounded by any number of smaller trade centers many of which are declining in population with some of the smallest hamlets disappearing."
Hodges (1966: 195) based on his studies in the plain areas in Canada outlines trends in the changing pattern of the rural structure.

1. The number of farm trade centers will continue to decline as an increase occurs in farm size and farm mechanization. This lowers the man-land ratios and the market potential for trade center establishments.

2. Hamlets will satisfy most daily shopping needs, and convenience centers will be bypassed by rural people seeking centers with a wider range of specialized goods. Convenience centers will decline to hamlet status in most instances and many present hamlets will disappear.

3. Except for a limited amount of "suburbanization" around large cities, small trade centers will likely disappear within a radius of ten miles of larger trade centers and will show substantial decline in areas up to 15 miles away. Only beyond this distance is the trade area integrity of small centers likely to remain secure.

4. As the thinning out of small centers continues, rural people will have to travel as much as one-third farther to reach a center offering even day to day necessities. Higher order centers will tend to emerge in a more regularly spaced pattern to serve the demands created by expanded farm incomes and the ability to exercise greater choice of increased mobility.
Lewis and Prescott (1972: 68) examined the development of growth centers 1958-1963. They found policies promoting centralized urban growth alone will have severe impact on commercial sales in peripheral communities, although central city retail and service sales are substantially influenced by incomes earned in peripheral towns. The effects of increasing demand in the growth center tend to be spatially self-contained.

In addition agricultural incomes have their strongest impact on commercial roles in the smallest communities. Conversely, retail purchases by manufacturing employees residing in peripheral communities will be typically spread throughout the larger cities including the growth center itself.

The effect of highway development has been studied by Garrison et al. (1959). They looked at the effect on a particular town, Marysville, Washington, of the construction of a new, divided, four lane, limited access highway that bypassed the downtown area. They found the following: First, that there was a substantial reduction (about two-thirds) in the number of travelers passing through Marysville. Second, that traffic congestion north and south of the town declined as its residents shopped more frequently at a larger center. Marysville appeared to take on some of the functions of a
residential area for the large town as a result of improved access. Third, the reduction of traffic volume eased movement and parking in the downtown area and the attractiveness of Marysville as a shopping center increased. Fourth, changes in the competitive position of Marysville and its larger center relative to centers in the north have resulted from the improvement in the north-south highway system. Finally, Marysville became more desirable as a residential area.

Model

Mark-Schwirian (1967) developed a model based on central place theory which specifies the nature of the relationship between central place function and local population growth at different stages of regional development, specifically levels of transportation technology and regional industrialization.

This model is generally in accord with the summary of the dynamic model and with the empirical evidence presented.

The model describes spontaneous growth centers, centers which arise naturally in a market-regulated economy, but, as stated in the first chapter, this information can be used as a policy guide to the industrializing of an agricultural region.
Alonso and Medrich (1972: 230) point out that there are two types of growth centers. Induced growth centers are those in which public policy is trying to promote growth. Here the designation of a locality as a growth center is a normative one. Spontaneous growth centers are those that are growing without benefit of special assistance, or at least without benefit of conscious or explicit policy. In a viable socioeconomic system there will always be a number of these centers.

The model to follow is essentially the Mark-Schwirian model, with a few slight modifications.

Central Place Theory and Population Growth

On the basis of the central place model Mark and Schwirian assert that in any given time period the general relationship between urban central place function and community-population growth is a function of both the level of regional industrialization and the particular ecological niche or position of the community in the total pattern of inter community relations.

They also suggest that as a region moves through the various stages of industrialization there is a decline in the importance of central place function as a population agglomerating activity.

Mark and Schwirian say they feel that the key factor in determining the ability of a community to attract the
necessary activities to maintain and expand its population or trade functions is its ecological niche, which is assigned initially for most communities in the original period of regional settlement. Some ecological positions are favorable for future economic and population expansion while others are not.¹

In the Mark-Schwirian model there are three levels of regional development relevant for analyzing the relationship between population growth and central place function in the various communities.

These are called 1) agricultural settlement, 2) industrialization and 3) metropolitanization.

Agricultural Settlement.--The period in which the trade center hierarchy emerges to provide goods and services to the dispersed agricultural population.

During this period population growth and trade function expansion occur for all of the urban centers.

¹This is in line with Christaller (1933: 122) where he says that the establishment of any point on the earth's surface as a central capital or other important place determines simultaneously an entire system of central places, which is developed from below, from the smallest units up to the top of the pyramid of sizes; moreover, the fixed points of such a system are determined by such capitals.

Thus the rule is that the older system previously determined always determines the more recent system developed under other economic laws and conditions with other types of central goods and other ranges of these central goods.
Central place function is the major city building activity.

An important point is that in this period each trade center as it emerges is assigned a definite ecological position which places the limits upon its future growth potential.

**Industrialization.**—At this point, in an induced growth center, the propulsive industry would be introduced. In the case of spontaneous centers this is the point when industries are attracted to the region.

During this stage the total region experiences a diversification of its economic base, a rapidly improving transportation system and an increasing population.

Economic and population growth are not uniform throughout the region. Certain ecological classes of cities experience the expansion, while others do not. The large cities attract industry and labor; these were the centers which emerged at the top of the original central place hierarchy. These become the focal points of regional change. It is in these centers that expansion of existing industry takes place as well as investment in new manufacturing. These large cities are attractive since the ecological position of each is at a main node in existing and improving transportation systems. In
addition the large population offers a larger market for
the manufactured products [see Harris 1959].

The economic expansion and diversification of the
large centers through attracting new workers and their
dependents to the community stimulates expansion of local
retailing.

Therefore the centers have growing population and
trade.

The expansion of retailing in the central city, the
improved transportation arteries radiating through the
surrounding hinterland to other towns affects the four
factors (size, price willingness, time-distance, and
price) which affect the range of the large town. People
are now willing to travel farther to this town. This
increase in range exerts a more far-reaching pull on
hinterland shoppers than in the initial period of agri-
cultural settlement. Thus the central place activities
of the large cities are both more attractive and more
accessible to hinterland residents. This results in an
expansion of the central place functions of the large
city at the expense of its nearby smaller neighbors.

The demographic and economic growth of the large
cities in this period is not contained within the original
spatial boundaries of the cities.
Both population and economic activities diffuse from the large cities to the adjacent rural areas channeled by new and improved highways. The result of this development is the conversion of formerly agricultural land to urban land use. Agricultural villages are converted to dormitory satellites, and new residential or industrial suburbs develop on previously vacant land.

The centers involved in this decentralization process grow in population and trade functions. Some of the centers become residential suburbs growing by attracting central city workers and their families. A few of these rural marketing centers attract some of the decentralizing employing activities and their transition is from service center to employment center, attracting workers who commute from other parts of the metropolitan area.

Many of the suburban communities take on an increased central-place function as new suburban shopping centers emerge.

These retail service areas place the suburb in a favorable position to compete for retail trade with the larger metropolitan center and with the agricultural service centers at the periphery of the metropolitan area. Suburbs with large shopping centers are able to absorb much of the rural trade attracted to the metropolitan centers. The favorable ecological position of the
suburbs is reflected in population growth, employment increase, and expansion of central place function.

The ecological niche of communities at the periphery of the metropolitan area is favorable for population growth, but unfavorable for central place activities. Since they are within a reasonable driving distance of the largest centers, these centers attract a commuter population.

The central place functions (except low level ones) are at a disadvantage as a result of metropolitan proximity.

They are too far from the metropolitan centers to attract the decentralizing retail activities located in the suburban shopping centers. Thus the metropolitan neighbors must compete for trade with both the central city and the suburbs. They must lose trade in the short run and experience a decline in their former trade area. In future metropolitan expansion they may be drawn into the metropolitan complex (increasing population density and thus lowering of the threshold) and experience a rejuvenation of higher order central place activities.

The communities with poor ecological positions for both population growth and economic expansion are the hinterland centers. These trade centers face three major problems:
1. Their isolation from the metropolitan centers makes it unlikely that they will attract much of the decentralizing population or trade.

2. Their trade areas are decreasing in population (thus their thresholds are rising) as mechanization of farming and the attraction of new industrial centers brings about rural out-migration.

3. The change in time-distance brought about by transportation modernization forces the hinterland centers into competition for the decreasing rural trade with neighboring towns.

As an ecological class the hinterland towns are characterized by little population growth, a declining central place function, little economic expansion. If any hinterland towns have a relative advantage in this period it is those whose competition is limited to smaller neighbors.

Metropolitanization.--In this period the region continues its population growth, retail trade expansion, and expansion of the economic base and development of the transportation system. Agriculture is no longer the region's dominant economic activity; the economy becomes more balanced with almost equal roles for agriculture and urban-industrial enterprises. Agricultural activities
change. Productive land near the metropolitan centers is changed from more basic crops to a concentration in truck garden activities. Formerly marginal land is brought into cultivation for high demand products in the nearby metropolis. The section of the region more isolated from urban centers continues production of the more basic crops, but there is a changing organization of farming activities. There is a decrease in the family farm pattern and an increase in the more bureaucratic, corporate form of structure.

This changing organization pattern in farming further accelerates the decline of the rural population. The net result for the hinterland towns is a further loss of their market and a further decline of their central place functions.

Through continued decentralization of economic activities and population from metropolitan centers, an increasingly larger segment of the region adjacent to the metropolitan centers becomes drawn into the metropolitan area.

The trade centers in these areas become the new suburbs and experience an increase in population and trade.

Not all of the metropolitan decentralization is contained within areas contiguous to the larger centers. With increasing frequency the larger more accessible
hinterland centers become the sites for industrial development.

As some of these hinterland centers grow, their smaller neighbors who lost trade during the period of industrialization begin to take on dormitory function and gain some trading activity.

The only class of town not to grow in this period is the isolated hinterland center unable to attract new industry and too far from expanding hinterland centers to become residential satellites.
CHAPTER III

METHODOLOGY

Hypothesis

The general hypothesis is that: The relationship between urban central place function and community population growth is a function of both level of regional development and of the ecological position of the community. The growth center can be seen as a type of ecological position. In the model, previously described, development was brought about by implanting industry in the primary central place of the region. This in turn changed the range and threshold or purchasing power of the region and in turn the nature of the rural central place system.

In this section we will develop the scheme to demonstrate the generalization empirically. The design follows that of Mark-Schwirian (1967: 37). But while they demonstrated the relationship between population growth, central place function and ecological niche at one level of development, this study attempts to analyze the
relationship at various levels of regional development. In addition changes have been made in the operationalization of certain variables.

The analysis consists of three parts. One involves two way analysis of variance; the second correlation; the third part covariance analysis.

**Universe**

The communities selected for the study are the incorporated places and counties of Ohio, the cities of Wheeling and Huntington, West Virginia; and Ashland, Kentucky. ¹ There were 906 Ohio communities that were incorporated places in 1950 and 1970. The total population of places not a sample will be used.

Ohio serves as a good area of investigation for several reasons:

1. Ohio was an essentially rural state which developed into one of the most highly industrialized areas in the country.

2. While parts of Ohio are highly developed metropolitan areas, there are regions in the Appalachian areas which are quite underdeveloped. In fact, six economic subregions (see map, page 78) have been differentiated

¹ The West Virginia and Kentucky cities are included because they are the central cities for Ohio communities in their regions.
in Ohio which are relatively homogeneous in terms of economic and social characteristics. This should yield areas with different purchasing power.

3. "The original road pattern in Ohio indicates a three way division of the state into an irregular road system in the southeast, a well established mathematical pattern in the northwest, based on the township and range survey system. Between the two zones is an intermediate transitional area in which traces of the rectangular pattern appear, but with large elements of unpatterned confusion as well." (Raup and Smith, 1973: 49). Thus the ease of travel in the regions should differ.

The Basic Concepts of the Study

Community Ecological Position.—Community ecological position is a town's general niche in the total pattern of inter community relations. Eight ecological positions are designated in terms of community size and distance from other communities:

1. Central city, composed of the metropolitan centers defined by the United States Census as central cities of Standard Metropolitan Statistical Areas (SMSA's) in 1954.

2. Suburban urban places, the incorporated places outside the central cities but within SMSA's, over 2500 population.
3. Suburban rural areas, the remainder when the suburban urban places of 1954 in a county are subtracted from the county total.

4. Metropolitan urban places: The fourth ecological class of cities consists of those independent communities at the periphery of the metropolitan area. The exurban areas or metropolitan neighbors are the incorporated places not within the SMSA's, but within those counties the major portion of which is within thirty miles of a central city. Thirty miles is used to delineate the zone of easy commuting.

5. Metropolitan rural areas: The remainder when the metropolitan urban places (in 1954) in a county are subtracted from the county total.

6. The sixth ecological position consists of cities which are small hinterland towns. They are hinterland towns at least thirty miles from central cities so that they are not strongly under the cities' influence. But they are within a short distance of a center of similar or larger size. Thus they are in actual competition for retail trade. These centers are neither within nor near metropolitan centers, but are within a county of a similarly sized or larger center.

7. Hinterland rural areas: This is the remainder of the county after the data for those towns which
qualified as hinterland urban centers in 1954 are substracted from the county total.

8. The eighth type of community is the hinterland center. These cities are near neither expanding metropolitan centers, nor similarly sized trade centers with which they must compete. Hinterland centers may expand their hinterlands unimpeded by those of other large centers to the extent that the mode of transportation permits.

These centers are not within SMSA's, or counties containing metropolitan neighbors, but are the largest towns of the remaining counties.

**Population Growth.**—The variable community population change is the percent change in local population between 1954 and 1967 in the 1954 community area.

\[
\text{Population Growth} = \frac{\text{population 1967} - \text{population 1954}}{\text{population 1954}}
\]

The use of the years 1954 and 1967 requires an explanation since accurate census data is collected decenially: 1950, 1960, 1970, etc.

The problem is that census economic data, necessary for operationalizing the central place variable, is not collected at the same time that population data is collected. Yet our study requires the comparison of these two variables. Thus either the economic data must be adjusted to coincide with population data or vice versa.
Fig. 2—Map with Ecological Positions Delineated

- Hinterland
- Suburban
- Metropolitan
In this study population estimates are compared with economic data.

The census data for community population for 1950, 1960, and 1970 is available. Thus the growth rate\(^1\) between these periods is easily ascertained using:

\[
\text{Growth rate} = \frac{\text{population year}_{time_2} - \text{population year}_{time_1}}{\text{population}_{time_1}}
\]

To find the growth rate from 1954-1967:

1954 population = (1950 population) + (.4)(population change 1950-60)

1967 population = (1960 population) + (.7)(population change 1960-70)

**Growth rate 1954-1967**

\[
\frac{\text{population 1967} - \text{population 1954}}{\text{population 1954}}
\]

**Central Place Function.**—In many studies central place is measured by the number of retail stores and service establishments. The problem with this is the assumption that each unit adds to the attraction of the center to the hinterland, but there is often failure to see if the units duplicate each other in what they offer the consumer.

\(^1\)Note that this formula assumes equal growth in all years.
A Guttman scale for establishments has been used in rural sociological research (Hassinger-Fuguit). This avoids the problem of giving higher status to communities with duplicate services, by giving a score to the community on the basis of the community function with the highest threshold. The complication here is in obtaining the data on establishments in towns less than 2500. The census does not list such information. Often studies use Dunn and Bradstreet listings which include communities with less than 2500. However, Dunn and Bradstreet list only those establishments which they have investigated for a subscriber. If a subscriber has not requested a rating on an establishment it will not be mentioned. This would cause problems if the unlisted establishment were the highest order function in the community.

Employment in wholesaling and retailing establishments has been used to measure central place function (Siddal 1961). But this data is not readily available for the small towns (less than 2500).

Per capita retail sales, used by Isard and Whitney (1949) and others, is another measure. This is the measure used here. It also serves as the indicator used by marketing and retail decision-makers as indicated in their publication "Sales Management". Thus it has a certain face validity. The concept is that hinterland
residents contribute to the dollar volume of trade of a center without contributing to the base on which the index is computed.

The measure has certain defects. It exaggerates the hinterland function in the case of transients and others who neither live in the community nor in the hinterland, but who spend money there.

There is a certain advantage. It measures not only the attraction of the trade center but also the ability of the center to keep the trade of the local residents.


This includes all establishments included in retail trade in accordance with the principle of the standard distribution by kinds of business. Food stores constituted the largest single group of retailers, 23.4 per cent in 1954. Automotive dealers were the second largest group in volume of sales, 17 per cent in 1954. Gasoline service stations, 5 per cent in 1954. General merchandise stores were the third largest group with 10.5 per cent in 1954.

Another problem is that data is not available for communities less than 2500. However, data for these communities can be determined on a residual basis by
subtracting the data on communities over 2500 in a county from the data on the county as a whole.

The effect of inflation will be controlled by using the Department of Labor Consumer Price Index.

Regions.—Regions will be delineated into levels of development based upon the theoretical concepts range and threshold. According to the theory, range is the distance people are willing to travel to purchase a good or service. Threshold taps the amount of purchasing power in the region.

By combining range and threshold concepts four different ideal types of regions can be differentiated (see Table 1, page 40).

In the study area the range and threshold should not be as independent as theory suggests, because both range and threshold are changed when a region industrializes. Thus there is actually a continuum in our study area (Table 2).

Operationalizing the concepts:

Threshold.—According to the theory the threshold or purchasing power of a region is a function of four interrelated factors: distribution of population, size and distribution of income, socioeconomic status of the
population and population density. The six economic sub-regions of Ohio were used to delineate regions of various purchasing power or threshold (see map). These regions consist of groups of counties which have similar economic and social characteristics. The boundaries are drawn so that the state is subdivided into parts such that each part has significant characteristics which distinguish it from adjoining areas. In establishing the economic subregions, industrial-commercial activities, demographic, climatic, physiographic, cultural factors, and factors relating to the production and exchange of agricultural goods were considered. See Bogue and Beal (1961: 1142-1155) for details on the procedure.

To rank order the regions from high purchasing power to low purchasing power a formula has been developed:
Household median income x Households
Square miles in region

This is a rough attempt to estimate the disposable income available for the purchase of goods and services. Median income is used rather than mean because mean would distort the formula. The existence of a few very wealthy individuals in the region would skew the actual disposable income of the general population.

Problems arise when the economic subregions, as defined by the census, are used to delineate our regions without modification. As one can see from the map Lucas County and Toledo would be excluded from the analysis if the strict definition were used. In addition Hamilton County and Cincinnati would be included in region 46 which is made up primarily of southern Ohio counties. The southern Ohio counties are quite unlike Hamilton County as far as household income and population density are concerned. The small area of Region 46 (in comparison to the other regions) and the linking of high density Hamilton with the other very low density, low income counties yields a distorted region.

Table 3 compares the thresholds of modified and unmodified counties. By adding Lucas County to Region 48 the purchasing power of the region increases by almost 70 per cent. This changes the rank order of Region 48, placing it before Region 29.
TABLE 3

THRESHOLD (PURCHASING POWER) INDEX FOR ECONOMIC SUBREGIONS AND MODIFIED ECONOMIC SUBREGIONS.
AGGREGATE HOUSEHOLD INCOME PER SQUARE MILE (IN THOUSANDS) 1950

<table>
<thead>
<tr>
<th>Economic Subregion</th>
<th>Modified ESR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region 28</td>
<td>418</td>
</tr>
<tr>
<td>Region 29</td>
<td>85</td>
</tr>
<tr>
<td>Region 30</td>
<td>51</td>
</tr>
<tr>
<td>Region 46</td>
<td>262</td>
</tr>
<tr>
<td>Region 47</td>
<td>221</td>
</tr>
<tr>
<td>Region 48</td>
<td>67</td>
</tr>
</tbody>
</table>

Source: Calculated from U.S. Census.

The other modifications do not cause a change. Region 46 which contains Hamilton County and the southern Ohio counties is separated. Hamilton County is allocated to Region 47 which contains, Dayton, Columbus and other metropolitan centers. The southern Ohio counties are allocated to Region 30. As one can see from the table this modification changes the rank order on neither Region 30 nor Region 48.

Range.--The range, the distance people are willing to travel to purchase a good, is a direct function of four factors. The price and quantity of goods, the
Fig. 3--U.S. Census Economic Sub Regions
Fig. 4—Map with Regions Delineated
number of goods and services available, the price willingness of the population and the subjective economic distance. All of these factors are in turn affected by transportation. Thus Christaller said that the transportation facilities are the most significant factor determining the size and distribution of towns.

In the period of consideration 1950-1970 it would appear reasonable to assume that the quality of the highway network in the region could be used as a surrogate for the quality of the transportation system in the region. In addition, there is theoretical and empirical rationale for adopting this measure.

R. D. McKenzie (1927: 623) hypothesized "Community organization inevitably becomes accommodated to space and time factors. The local community is spatially organized with reference to daily movements of population which in turn are limited by the prevailing forms of communication and transportation. In other words the local distribution of homes and interest centers falls within a plane the maximum area of which cannot be greater than the physical distance which can be daily traversed using the current mode of transportation."

\[1\] For a full discussion of these relationships see page 34.
He says later "The great revolution in local fluidity came not with the railway and telegraph, but with local forms of transportation and communication, the electric tram, the telephone, and, more especially, the automobile."

"In other words, the automobile, by providing every village and almost every farmstead with rapid transportation has converted the entire country into an urban pattern of home and service center distribution."

If one considers the automobile and road network as a system the rationale for using improved highways as an indicator of range seems reasonable.

In addition, empirical work demonstrates the validity of using the quality of roads as an indicator. Berry, Barnum and Tennant (1962) reported tests of factors affecting distance travelled by rural residents to central places. They found the maximum distance an individual is willing to travel for any particular central good increases 1) with the number of central functions offered at the center, 2) with the lower the frequency of trips. They found distance will decrease with 1) the friction created by poor quality roads, 2) proximity to and increasing size of an alternative center (a second choice center), but this was also affected by quality of roads to the center of second choice.
The Ohio Department of Highways, Division of Planning and Programming, Bureau of Planning Survey, produces an annual booklet, "Classification by Surface Type of Existing Mileage in Each County on State Highway, County and Township Systems". Comparing this data in 1950 (the first year of data collection) with 1970 points out an interesting fact. The actual mileage of roads in Ohio actually decreased from 1950 to 1970 (Table 4).

### TABLE 4

<table>
<thead>
<tr>
<th></th>
<th>1950</th>
<th>1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>2,340</td>
<td>3,011</td>
</tr>
<tr>
<td>Rural</td>
<td>86,286</td>
<td>84,479</td>
</tr>
<tr>
<td>Total</td>
<td>88,626</td>
<td>87,490</td>
</tr>
</tbody>
</table>

Source: Ohio Department of Highways.

Cities have been growing in terms of central place function and population while highway mileage has been decreasing. Therefore, 'indices' which would use miles of highways in an area as a measure of range would appear to be inappropriate.

Further investigation of highway classification data provides a clue to what would appear to be a valid measure. The number of miles of high traffic volume
highways in the state increased by about four times between 1950 and 1970. See Table 5.

TABLE 5

<table>
<thead>
<tr>
<th></th>
<th>1950</th>
<th>1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>Municipal</td>
<td>1,731</td>
<td>2,948</td>
</tr>
<tr>
<td>Rural</td>
<td>10,099</td>
<td>44,653</td>
</tr>
<tr>
<td>Total</td>
<td>11,830</td>
<td>47,601</td>
</tr>
</tbody>
</table>

Source: Ohio Department of Highways.

High traffic highways include high type bituminous, bituminous concrete and cement concrete roads.

These are roads which can be expected to carry a volume of traffic in excess of 300 vehicles per day. We are excluding those roads which are surfaced with unimproved earth, graded and drained earth, gravel or stone, surface treated low type bituminous, and brick.

To subdivide the state of Ohio into regions of different range, we will use the economic subregions and apply the following formula:

\[
\text{Region's range} = \frac{\text{Number of miles of high traffic volume highways in 1954}}{\text{Number of square miles in the region}}
\]
In determining the range of the regions the economic sub-regions as defined by the census must again be modified to include Toledo and Lucas County in the study and to reallocate the heterogeneous elements of Region 46. The modification is done in the same way. Lucas County is included in Region 48. Hamilton County of Region 46 is allocated to Region 47 and the southern Ohio counties of Region 46 are allocated to Region 30. Table 6 demonstrates the effects of this change. This modification causes no change in the rank order of the various regions.

### Table 6

<table>
<thead>
<tr>
<th>Economic Subregion</th>
<th>Modified ESR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region 28</td>
<td>.422</td>
</tr>
<tr>
<td></td>
<td>.422 unchanged</td>
</tr>
<tr>
<td>Region 29</td>
<td>.201</td>
</tr>
<tr>
<td></td>
<td>.201 unchanged</td>
</tr>
<tr>
<td>Region 30</td>
<td>.1352</td>
</tr>
<tr>
<td></td>
<td>.1354</td>
</tr>
<tr>
<td>Region 46</td>
<td>.206</td>
</tr>
<tr>
<td></td>
<td>Allocated to other ESR</td>
</tr>
<tr>
<td>Region 47</td>
<td>.503</td>
</tr>
<tr>
<td></td>
<td>.503 unchanged</td>
</tr>
<tr>
<td>Region 48</td>
<td>.231</td>
</tr>
<tr>
<td></td>
<td>.242</td>
</tr>
</tbody>
</table>

Source: Ohio Department of Highways.

Thus far the two concepts have been operationalized. We still have to find out if the two are associated.
That is, if they have a similar rank order as mentioned earlier.

Table 7 compares the rank order of the regions in terms of range and threshold. The rank order is identical, except that Regions 47 and 28 rank one, two on range and two, one on purchasing power.

Therefore it appears that we were correct in assuming that in Ohio regional development of range and threshold go hand in hand.

**TABLE 7**

**COMPARISON OF RANGE AND THRESHOLD OF MODIFIED REGIONS**

<table>
<thead>
<tr>
<th>Region</th>
<th>Range</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region 47</td>
<td>.503</td>
<td>291.</td>
</tr>
<tr>
<td>Region 28</td>
<td>.422</td>
<td>418.</td>
</tr>
<tr>
<td>Region 48</td>
<td>.242</td>
<td>113.</td>
</tr>
<tr>
<td>Region 29</td>
<td>.201</td>
<td>85.</td>
</tr>
<tr>
<td>Region 30</td>
<td>.135</td>
<td>45.5</td>
</tr>
</tbody>
</table>

Source: Adapted from preceding tables.
CHAPTER IV

ANALYSIS

The general hypothesis of this study is that the relationship between central place function and community population growth is a function of both the level of regional development and the ecological niche of the community. In this analysis we will attempt to discover three things: 1) if there is a relationship between ecological position, region and the variables central place function and population growth, 2) the size of this relationship, 3) the nature of this relationship.

In order to better understand the relationships between central place function and population growth we will first examine the effect of the relationship between ecological position and region on three variables: population, retail sales and central place function.

Analysis requires decomposing the general hypothesis into test hypotheses:

FOR POPULATION:

1. *Community population 1954*¹ is a function of both

¹Dependent variable is underlined.
the level of regional development and ecological position.

2. **Community population 1967** is a function of both the level of regional development and ecological position.

3. **Community population growth** is a function of both the level of regional development and ecological position.

FOR RETAIL SALES:

4. **Retail sales 1954 (in 1967 dollars)** is a function of both the level of regional development and ecological position.

5. **Retail sales 1967** is a function of both the level of regional development and ecological position.

6. **Retail sales growth** is a function of both the level of regional development and ecological position.

FOR CENTRAL PLACE FUNCTION (PER CAPITA SALES):

7. **Central place function 1954** is a function of both the level of regional development and the ecological position.

8. **Central place function 1967** is a function of both the level of regional development and ecological position.

9. **Central place function expansion** is a function of both the level of regional development and ecological position.

10. **The relationship between population growth and retail sales increase** is a function of level of regional
development and the ecological position of the community.

11. **The relationship between population growth and central place function expansion** is a function of level of regional development and the ecological position of the community.

12. **The relationship between retail sales increase and central place function expansion** is a function of regional development and ecological position of the community.

The first nine hypotheses can be tested using analysis of variance. Analysis of variance is a procedure for testing for differences among means of two or more populations. It is based upon the fact that if means of subgroups are greatly different, the variance of the combined groups is much larger than the variances of the separate groups.

There are a variety of analysis of variance models. The one used here to evaluate the first two hypotheses is the 2-way classification, factorial design or Model I (Dixon and Massy 1969: 152). In this analysis individual communities are categorized on the basis of two characteristics (niche and region). Each community will belong to exactly one category for each variable. Region is arbitrarily called the first variable and has five
categories, while ecological niche, the second variable, has eight categories.

Thus in a table there will be five categories for the first variable and five columns in the table. There will be eight rows corresponding to the niche categories. Each of the C x R categories = 8 x 5 = 40 cells is considered a separate population. Each community belonging to only one of the 40. We are interested in how the means of these 40 populations differ from each other.

Using this model one must assume that the niche by region categories exhaust all categories of interest for niche and region categories respectively; neither is considered a sample of categories for the particular variable.

The model makes two basic assumptions (Dixon and Massey 1969: 178):

1. The observations in the ith column and jth rows are random samples from a normal population with mean M + c_i + r_j + I_{ij} where M is the same for all cells, c_i is the same for all cells in the ith column, r_j is the same for all cells in the jth row and where the I_{ij}'s may be different for each i and j.

2. Assume that the variance is the same for each of the normal populations.
The method of computing the various statistics in the analysis are given in Table 8 on the next page.

I. Experimental Hypothesis:

The dependent variable is a function of both the level of regional development and the ecological niche of the community.

II. Test Hypotheses:

a. The column (regional) effects are zero. The test of this hypothesis is made independent of the row (niche) effects and interaction effects.

b. The row effects (niche) are zero. The test of this hypothesis is made independent of the column effects and interaction effects.

c. The interaction effects are zero; the test of this hypothesis is made independent of the column effects and row effects.

III. The level of significance .05

IV. The statistic used is F. For Hypothesis 'a' the ratio of the mean square for columns to the within groups mean square; for Hypothesis 'b' the ratio of the mean square for row means to the within groups mean square; for Hypothesis 'c' the ratio is the mean square for interaction to the within groups mean square.
<table>
<thead>
<tr>
<th>Sum of squares</th>
<th>Degrees of freedom</th>
<th>Mean square</th>
<th>Estimate of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Column means</td>
<td>$r n \sum (\bar{X}<em>{i..} - \bar{X}</em>{..})^2 = S_C$</td>
<td>$c - 1$</td>
<td>$\frac{S_C}{(c - 1)}$</td>
</tr>
<tr>
<td>Row means</td>
<td>$c n \sum (\bar{X}<em>{..j} - \bar{X}</em>{..})^2 = S_R$</td>
<td>$r - 1$</td>
<td>$\frac{S_R}{(r - 1)}$</td>
</tr>
<tr>
<td>Interaction</td>
<td>$S_S - S_C - S_R = S_I$</td>
<td>$(c - 1)(r - 1)$</td>
<td>$\frac{S_I}{(c - 1)(r - 1)}$</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$n \sum (\bar{X}<em>{ij..} - \bar{X}</em>{..})^2 = S_S$</td>
<td>$r c - 1$</td>
<td></td>
</tr>
<tr>
<td>Within</td>
<td>$S_R - S_S = S_W$</td>
<td>$r c (n - 1)$</td>
<td>$\frac{S_W}{r c (n - 1)}$</td>
</tr>
<tr>
<td>Total</td>
<td>$\sum \sum (X_{ijc} - \bar{X}_{..})^2 = S_R$</td>
<td>$r c n - 1$</td>
<td></td>
</tr>
</tbody>
</table>
V. If we accept the assumptions of the model tables showing percentiles of the F distribution are readily available.

VI. The critical region for Hypothesis 'a' is

\[ F > F_{1-a}[c-1, rc(N-1)] \]

The critical region for Hypothesis 'b' is

\[ F > F_{1-a}[r-1,(r-1)rc(N-1)] \]

The critical region for Hypothesis 'c' is

\[ F > F_{1-a}[(c-1)(r-1)rc(N-1)] \]

VII. Compute F ratios

VIII. Accept or reject the hypothesis

IX. Conclusions

A cursory view of Tables 9 through 18 shows a significant effect of ecological position on all of the variables under consideration. Retail Sales 1954, Retail Sales 1967, the Growth Rate in Sales; Population 1954, Population 1967, the Growth in Population, the Central Place Index in 1954, the Central Place Index in 1967 and the Rate of Change in the Central Place Index.

The analysis of variance of these nine tables all had an F ratio significant at the .001 level.

The effect of range was not so pronounced. The analysis of variance demonstrated an F ratio significant beyond the .05 level in only three analyses. Population
1967, Sales Growth Rate and Population Growth Rate. Sales in 1967 was significant at the .058 level though not at the .05 level.

The effect of the interaction of ecological position and region was significant in only two instances, 1967 Sales and 1967 Population.

Snedecor and Cochran (1967: 348) offer advice in interpreting interaction. "... the F-test of the AB interaction sum of squares as a whole is not a good guide as to whether interaction can be ignored. It is well to look over the two way table of treatment totals or means before concluding that there are no interactions, particularly if F is larger than 1."

Thus in addition to the two tables mentioned, tables concerning Population 1954, Sales 1954, and Central Place Function 1967 should be examined.

However, they go on to say: "Another working rule tested by experience in a number of areas is that large main effects are more likely to have interactions than small ones."

This appears to be the case in each of these tables. The main effect, ecological position, accounts for from 35 to 40 percent of the total sum of squares (variance) in each of these tables.
Individual Comparisons

When there is a significant F ratio this means that a difference exists between means in the particular table, but it fails to tell which means differ significantly. In order to make individual comparisons an additional test is required. The test used here is the test for Least Significant Difference or LSD.

The formula:

$$t_a \sqrt{s^2 \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}$$

where:

- $n_1 = \text{number of observations in first cell under consideration}$
- $n_2 = \text{number of observations in second cell under consideration}$
- $s^2 = \text{within (error) mean square}$
- $t_a = 1.96 \quad p < .05 \quad \text{D.F. 266}$

Note that if the number of observations were the same for all cells the formula would be

$$\sqrt{s^2 \left( \frac{2}{n} \right)}$$

This is the popular formula for LSD.

In this study the number of observations in each cell varies. In order to make an accurate comparison among all pairs of means the test would have to be calculated using the applicable number of observations for $n_1$ and $n_2$ in each case.
But each time the LSD is used there is an error possibility of .05, thus multiple comparisons within a single table would entail an unacceptable level of risk.

In order to give some guidance in discerning individual differences an LSD was computed using $n_1 = 10$ and $n_2 = 5$.

**Population Analysis**

Analysis of population and population growth rates demonstrate certain marked effects.

Table 9 shows us that ecological position explains about 36% of the variance in the size of communities (more if you follow Snedecor and Cochran's rules of thumb). This should not be too surprising since size and location are two of the attributes of ecological position.

A note of caution when examining the means in this table. The 'rural area' categories are composed of all the population in a county in places less than 2500. Thus the large means are an aggregate of all places less than 2500 and open country rural areas in the county. As a result rural areas appear rather large when compared to urban places in a similar category. For example, in Region 28, 1954, the average size of an urban place (over 2500) in the suburban category was 15,054.
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>( F ) Ratio</th>
<th>( P ) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Position</td>
<td>35,05</td>
<td>7</td>
<td>5448.4922</td>
<td>769,6416</td>
<td>24.552</td>
</tr>
<tr>
<td>Region</td>
<td>7</td>
<td>3</td>
<td>142.010</td>
<td>47.3502</td>
<td>1.449</td>
</tr>
<tr>
<td>Interaction</td>
<td>7</td>
<td>3</td>
<td>0.6497</td>
<td>0.1965</td>
<td>0.294</td>
</tr>
<tr>
<td>Error</td>
<td>7</td>
<td>3</td>
<td>157,73,722</td>
<td>11,759</td>
<td>1.226</td>
</tr>
<tr>
<td>Total</td>
<td>325</td>
<td>25</td>
<td>50,323,2654</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Score: Computed from U.S. Census Data.
However, the suburban rural areas had an average size of 75,792. This means that in Region 28 in the suburban areas an average of 75,792 individuals per county lived in places less than 2500.

This lack of comparability exists here and in the next table, Population 1967, and in the tables on Sales 1954 and 1967. In all of the other tables all categories are comparable.

Table 10, Population 1967, shows that some changes occurred during the analysis period. The main effects and the interaction are all significant at the .05 level and they explain almost 50 per cent of the variance. Note that ecological position now explains 39 per cent of the variance versus 36 per cent in 1954. Region is not particularly important, explaining only about 1.9 per cent of the variance. The interaction is important, explaining 8.3 per cent of the variance. The interaction appears to be taking place in the suburban areas (urban places and rural areas) of the more developed regions.

The suburbs are in an advantageous position as far as size is concerned, and communities in developed regions are in an advantageous position as far as size is concerned. However, the size of the suburbs in these developed regions appears to be slightly greater than one would expect if the two factors were simply additive.
TABLE 10

POPULATION 1967

<table>
<thead>
<tr>
<th>Region 20</th>
<th>Region 21</th>
<th>Region 23</th>
<th>Region 24</th>
<th>Region 25</th>
<th>Region 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 214.516</td>
<td>229,012</td>
<td>208,499</td>
<td>36,164</td>
<td>53,482</td>
<td>179,137</td>
</tr>
<tr>
<td>SD = 253,999</td>
<td>220.333</td>
<td>210,014</td>
<td>11,922</td>
<td>33,412</td>
<td>220.01</td>
</tr>
<tr>
<td>N = 7</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Suburban Urban Places</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 11,441</td>
<td>12,110</td>
<td>11,094</td>
<td>6,919</td>
<td>15,245</td>
<td>17,522</td>
</tr>
<tr>
<td>SD = 18,152</td>
<td>8,666</td>
<td>3,205</td>
<td>2,916</td>
<td>2,916</td>
<td>2,916</td>
</tr>
<tr>
<td>N = 56</td>
<td>28</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Suburban Rural Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 21,613</td>
<td>164,492</td>
<td>72,931</td>
<td>48,125</td>
<td>41,194</td>
<td>127,522</td>
</tr>
<tr>
<td>SD = 25,132</td>
<td>111,538</td>
<td>34,648</td>
<td>6,736</td>
<td>6,736</td>
<td>6,736</td>
</tr>
<tr>
<td>N = 7</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Metropolitan Urban Places</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 11,178</td>
<td>10,478</td>
<td>9,896</td>
<td>12,351</td>
<td>7,876</td>
<td>10,812</td>
</tr>
<tr>
<td>SD = 8,501</td>
<td>9,360</td>
<td>8,017</td>
<td>13,735</td>
<td>13,735</td>
<td>13,735</td>
</tr>
<tr>
<td>N = 17</td>
<td>12</td>
<td>16</td>
<td>10</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Metropolitan Rural Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 54,427</td>
<td>37,081</td>
<td>26,378</td>
<td>33,050</td>
<td>14,613</td>
<td>35,079</td>
</tr>
<tr>
<td>SD = 23,197</td>
<td>23,476</td>
<td>15,644</td>
<td>17,226</td>
<td>17,226</td>
<td>17,226</td>
</tr>
<tr>
<td>N = 6</td>
<td>9</td>
<td>10</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Hinterland Urban Places</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 7,944</td>
<td>9,710</td>
<td>7,642</td>
<td>2,867</td>
<td>4,356</td>
<td>6,642</td>
</tr>
<tr>
<td>SD = 3,574</td>
<td>5,436</td>
<td>1,634</td>
<td>1,634</td>
<td>1,634</td>
<td>1,634</td>
</tr>
<tr>
<td>N = 6</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Hinterland Rural Areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 36,509</td>
<td>23,449</td>
<td>19,819</td>
<td>25,858</td>
<td>22,235</td>
<td>24,145</td>
</tr>
<tr>
<td>SD = 20,134</td>
<td>11,869</td>
<td>4,222</td>
<td>9,101</td>
<td>11,143</td>
<td>11,143</td>
</tr>
<tr>
<td>N = 17</td>
<td>3</td>
<td>10</td>
<td>6</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Hinterland Centers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N = 27,273</td>
<td>12,152</td>
<td>13,514</td>
<td>16,096</td>
<td>14,256</td>
<td>16,071</td>
</tr>
<tr>
<td>SD = 17,506</td>
<td>439</td>
<td>10,715</td>
<td>11,160</td>
<td>10,154</td>
<td>10,154</td>
</tr>
<tr>
<td>N = 6</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Region Rural Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40,866</td>
<td>49,610</td>
<td>24,085</td>
<td>19,584</td>
<td>19,165</td>
<td>24,461</td>
</tr>
</tbody>
</table>

Source: Computed from U.S. Census data.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>P &lt; .05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Position</td>
<td>39.35</td>
<td>7</td>
<td>4100.1197</td>
<td>886.5969</td>
<td>29.461</td>
</tr>
<tr>
<td>Region</td>
<td>01.33</td>
<td>4</td>
<td>127.8801</td>
<td>31.9700</td>
<td>2.724</td>
</tr>
<tr>
<td>Interaction</td>
<td>08.35</td>
<td>28</td>
<td>1160.9542</td>
<td>41.4475</td>
<td>1.791</td>
</tr>
<tr>
<td>Error</td>
<td>246</td>
<td>25</td>
<td>8261.2374</td>
<td>31.4812</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>305</td>
<td>25</td>
<td>9088.0891</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Computed from U.S. Census data.
In Table 11, Population Growth, the effects of ecological niche and region account for about 20 per cent of the variance in population growth. Ecological position explains 11.5 per cent, while region explains 8.2 per cent. The average population growth for all areas was 27 per cent. However, the only communities which had rates of increase greater than average were suburban urban places and rural areas; and the metropolitan rural areas. And these exceeded the average only in the more developed regions.

It is important to note that there was no interaction. This means that the effect of ecological position and region on population growth is additive. Note the marginals for the suburban categories. First they far outstrip all of the other ecological positions. Second, they are almost identical for urban places and rural areas.

The findings for the analysis of population compare favorably with those of other investigators of similar phenomena in some respects and unfavorably in other respects.

Concerning the regional effect, Thomas (1970: 72) found results similar to those reported here. In that study the regional effect on small town (1000 to 10,000) population growth was analyzed using all of the
### TABLE 11

**POPULATION GROWTH RATE 1954-1967**

<table>
<thead>
<tr>
<th>Region</th>
<th>Region 10</th>
<th>Region 11</th>
<th>Region 12</th>
<th>Region 13</th>
<th>Region 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>08.04%</td>
<td>11.12%</td>
<td>12.20%</td>
<td>12.00%</td>
<td>10.20%</td>
</tr>
<tr>
<td>SD</td>
<td>5.50%</td>
<td>6.60%</td>
<td>7.70%</td>
<td>8.80%</td>
<td>9.90%</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Suburban Urban Places</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>60.1%</td>
<td>60.3%</td>
<td>60.5%</td>
<td>60.7%</td>
<td>60.9%</td>
</tr>
<tr>
<td>SD</td>
<td>5.50%</td>
<td>5.60%</td>
<td>5.70%</td>
<td>5.80%</td>
<td>5.90%</td>
</tr>
<tr>
<td>N</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Suburban Rural Areas</td>
<td></td>
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</tr>
<tr>
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<td>50</td>
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</tr>
<tr>
<td>N</td>
<td>25.4%</td>
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</tr>
<tr>
<td>SD</td>
<td>5.50%</td>
<td>5.60%</td>
<td>5.70%</td>
<td>5.80%</td>
<td>5.90%</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
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<td>25</td>
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<tr>
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<tr>
<td>Hinterland Urban Places</td>
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<td></td>
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</tr>
<tr>
<td>N</td>
<td>16.2%</td>
<td>16.3%</td>
<td>16.4%</td>
<td>16.5%</td>
<td>16.6%</td>
</tr>
<tr>
<td>SD</td>
<td>5.50%</td>
<td>5.60%</td>
<td>5.70%</td>
<td>5.80%</td>
<td>5.90%</td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
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<td>9</td>
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<td>Suburban Rural Areas</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>16.2%</td>
<td>16.3%</td>
<td>16.4%</td>
<td>16.5%</td>
<td>16.6%</td>
</tr>
<tr>
<td>SD</td>
<td>5.50%</td>
<td>5.60%</td>
<td>5.70%</td>
<td>5.80%</td>
<td>5.90%</td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>16</td>
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</table>

**Source of Variation**

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<th>Source of Variation</th>
<th>DF</th>
<th>SS Contained</th>
<th>SS Sum of Squares</th>
<th>SS Total</th>
<th>SS Error</th>
<th>F Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
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<td>3.6923</td>
<td>0.5965</td>
<td>5.085</td>
<td>0.025</td>
<td></td>
</tr>
<tr>
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<td>4</td>
<td>1.9672</td>
<td>1.0481</td>
<td>0.7185</td>
<td>0.375</td>
<td>0.670</td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>20</td>
<td>1.2031</td>
<td>0.2143</td>
<td>0.3185</td>
<td>0.542</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>26</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.0014</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
<td>1.5945</td>
<td>0.5965</td>
<td>0.5965</td>
<td>0.5965</td>
<td>0.025</td>
<td></td>
</tr>
</tbody>
</table>

Source: Computed from U.S. Census Data
census economic subregions in the United States. Thomas found region explained 14 per cent of the variance, when size and location of the towns were not controlled. Thomas found that controlling for size of a place reduced the explained variance of the regional effect by 1.9 per cent to 12.2 per cent. Controlling for location lowers the explained variance 0.2 per cent from 14.1 to 13.9.

In this study regional effect explained only 8 per cent of the variance, not 14.1. However, consider certain major differences:

1) five modified regions versus the 121 total economic subregions

2) the analysis of the total size range of towns versus only small towns

3) the fact that in our analysis the effect of size and location of community were included in the concept of ecological position

4) the different time period 1954-67 versus 1950-60, the results seem compatible.

Now for the disconcerting part. Mark and Schwirian (1967: 37) using the same ecological positions used in this study (with the exception of the rural categories) found that they could explain 44 per cent of the variance in population growth in Iowa (1950-60). This study could explain only 11 per cent. An analysis of the same data
eliminating the rural categories produced a decline from
11 per cent to about 7 per cent.

The problem comes from the variance in population —
growth in Ohio versus that in Iowa. Table 12 gives a
comparison. The means are not overly disproportionate
but the standard deviations are.

**TABLE 12**

**COMPARISON OF POPULATION GROWTH BY ECOLOGICAL
POSITION, IOWA STUDY AND OHIO STUDY**

<table>
<thead>
<tr>
<th></th>
<th>Iowa Study</th>
<th>Ohio Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cities</td>
<td>M = 10.0</td>
<td>M = 05.4</td>
</tr>
<tr>
<td></td>
<td>SD = 6.0 N = 6</td>
<td>SD = 15.9 N = 20</td>
</tr>
<tr>
<td>Suburbs</td>
<td>M = 40.4</td>
<td>M = 48.1</td>
</tr>
<tr>
<td></td>
<td>SD = 21.9 N = 5</td>
<td>SD = 52.6 N = 96</td>
</tr>
<tr>
<td>Metropolitan Towns</td>
<td>M = 12.4</td>
<td>M = 18.1</td>
</tr>
<tr>
<td></td>
<td>SD = 10.0 N = 19</td>
<td>SD = 20.3 N = 56</td>
</tr>
<tr>
<td>Hinterland</td>
<td>M = 0.5</td>
<td>M = 7.6</td>
</tr>
<tr>
<td></td>
<td>SD = 7.4 N = 14</td>
<td>SD = 12.7 N = 19</td>
</tr>
<tr>
<td>Hinterland Centers</td>
<td>M = 3.8</td>
<td>M = 10.7</td>
</tr>
<tr>
<td></td>
<td>SD = 7.9 N = 48</td>
<td>SD = 15.0 N = 28</td>
</tr>
<tr>
<td>Total Urban Places</td>
<td>6.0%</td>
<td>28%</td>
</tr>
</tbody>
</table>

The explanation of the discrepancy in that there is
simply more variance within Ohio categories than within
Iowa categories. Thus variance explained by categories
is going to be less.
Retail Sales

In analyzing retail sales, one must again use caution when comparing categories. Rural areas contain an aggregation of all places in a county less than 2500; on the other hand, urban place categories are of individual communities.

Table 13, Retail Sales 1954 (these were adjusted to 1967 dollars) is interesting in that it shows that the ecological position explains about 36 per cent of the variance. This is the same amount of variance explained as in 1954 population. In addition, the effects of region and the interaction effect are almost identical. This does not mean that there is a relationship between community sales and population, but it does cause one to wonder about such a relationship.

Average sales were greatest in central cities with hinterland centers a poor second averaging only one-tenth as many sales.

Table 14, 1967 Sales, shows that the classification explains 48 per cent of the variance in 1967 community sales. If the effect of region were significant at the .05 level rather than the .058 this table would correspond almost exactly to the table on 1967 population as far as variance explained is concerned. Note, too, that the amount of variance explained by ecological position
### TABLE 13

1954 CORRECTED SALES (1000's)

<table>
<thead>
<tr>
<th>Region</th>
<th>Central Cities</th>
<th>Suburban Urban Places</th>
<th>Suburban Rural Areas</th>
<th>Metropolitan Urban Places</th>
<th>Metropolitan Rural Areas</th>
<th>Hinterland Urban Places</th>
<th>Hinterland Rural Areas</th>
<th>Hinterland Centers</th>
<th>Region National Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M = 424,945</td>
<td>442,157</td>
<td>320,695</td>
<td></td>
<td></td>
<td>78,262</td>
<td>104,599</td>
<td>40,318</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD = 579,104</td>
<td>380,971</td>
<td>311,735</td>
<td>46,631</td>
<td>61,921</td>
<td>75,449</td>
<td>63,021</td>
<td>336,318</td>
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</tr>
<tr>
<td></td>
<td>H = 7</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>M = 20,231</td>
<td>11,566</td>
<td>12,938</td>
<td>9,952</td>
<td>13,324.0</td>
<td>16,827</td>
<td>16,827</td>
<td>16,027</td>
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<td>12,348</td>
<td>1,262</td>
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<td></td>
<td>H = 56</td>
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<td>2</td>
<td>8</td>
<td>1</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>M = 49,520.4</td>
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<td>44,000</td>
<td>30,521</td>
<td>38,950</td>
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</tr>
<tr>
<td></td>
<td>SD = 13,798.3</td>
<td>30,533.9</td>
<td>34,267</td>
<td>7,560</td>
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</tr>
<tr>
<td></td>
<td>H = 7</td>
<td>6</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>M = 19,819</td>
<td>18,769</td>
<td>17,723</td>
<td>21,080</td>
<td>19,201</td>
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<td>12,566</td>
<td>22,937</td>
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<td>H = 17</td>
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<td>16</td>
<td>10</td>
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</tr>
<tr>
<td></td>
<td>M = 20,891</td>
<td>19,620</td>
<td>13,829</td>
<td>14,600</td>
<td>18,022</td>
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<td>SD = 5,001</td>
<td>12,028</td>
<td>7,849</td>
<td>6,163</td>
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</tr>
<tr>
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<td>H = 6</td>
<td>9</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>M = 12,310</td>
<td>20,600</td>
<td>12,197</td>
<td>3,114</td>
<td>11,025</td>
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<tr>
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<td>8,295</td>
<td>7,147</td>
<td>2,814</td>
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</tr>
<tr>
<td></td>
<td>H = 6</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>M = 16,657</td>
<td>17,355</td>
<td>12,956</td>
<td>11,231</td>
<td>13,400</td>
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</tr>
<tr>
<td></td>
<td>SD = 7,946</td>
<td>11,627</td>
<td>4,899</td>
<td>3,749</td>
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<td>H = 5</td>
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<td>10</td>
<td>6</td>
<td>14</td>
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</tr>
<tr>
<td></td>
<td>M = 57,289</td>
<td>30,438</td>
<td>28,012</td>
<td>35,991</td>
<td>35,100</td>
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<td>16,820</td>
<td>26,265</td>
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<td>H = 4</td>
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<td>5</td>
<td>8</td>
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</tr>
<tr>
<td></td>
<td>M = 48,543</td>
<td>56,505</td>
<td>29,464</td>
<td>22,219</td>
<td>49,469</td>
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</tr>
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<td>Source of Variation</td>
<td>DF</td>
<td>Sum of Squares</td>
<td>Mean Square</td>
<td>F Ratio</td>
<td>P Value</td>
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<td>2694.3341</td>
<td>24.595</td>
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<td>510.2595</td>
<td>127.5649</td>
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<td>26</td>
<td>1889.5256</td>
<td>73.5902</td>
<td>1.265</td>
<td>.175</td>
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<td>109.5674</td>
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</tr>
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<td>535</td>
<td>233,2142</td>
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</table>

Source: Computed from U.S. Census Data.
TABLE 14
1967 SALES (1000's)

<table>
<thead>
<tr>
<th>Region</th>
<th>Region 1A</th>
<th>Region 1B</th>
<th>Region 1C</th>
<th>Region 1D</th>
<th>Region 1E</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>391,416</td>
<td>499,081</td>
<td>393,044</td>
<td>89,469</td>
<td>126,313</td>
</tr>
<tr>
<td>Suburban Urban Places</td>
<td>437,618</td>
<td>409,800</td>
<td>409,781</td>
<td>44,276</td>
<td>81,184</td>
</tr>
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<td>37,854</td>
<td>18,811</td>
<td>37,128</td>
<td>10,458</td>
<td>41,887</td>
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<td>51,192</td>
<td>202,009</td>
<td>9,903</td>
<td>863</td>
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</tr>
<tr>
<td>Metropolitan Rural Areas</td>
<td>25,488</td>
<td>209,410</td>
<td>11,072</td>
<td>44,276</td>
<td>29,767</td>
</tr>
<tr>
<td>Interland Urban Places</td>
<td>37,416</td>
<td>28,439</td>
<td>11,420</td>
<td>29,767</td>
<td></td>
</tr>
<tr>
<td>Interland Rural Areas</td>
<td>13,859</td>
<td>26,251</td>
<td>14,436</td>
<td>27,765</td>
<td></td>
</tr>
<tr>
<td>Interland Centers</td>
<td>46,014</td>
<td>61,015</td>
<td>39,680</td>
<td>27,114</td>
<td>27,180</td>
</tr>
<tr>
<td>Region Interland Totals</td>
<td>104,570</td>
<td>104,370</td>
<td>104,570</td>
<td>104,570</td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{LSD} 100,970 \] \( F \) 265 0.05

Source of Variation: Computed from U.S. Census Data.
increases from 1954 to 1967. Finally, compare the number of sales in the suburban rural areas for 1954 with those of 1967. The change is spectacular. The sales in these areas are about 40 per cent of the sales of central cities and are over three times as great as individual hinterland centers. Although the marginal totals for suburban rural areas give us this cue, closer examination tells us that it is the suburban rural area in the more developed regions which is responsible for this phenomenon.

Table 15, Percent Change in Retail Sales 1954-1967, explains about 13 per cent of the variance in the rate of change in retail sales. Ecological position is responsible for 10 per cent, region 3 per cent. Ecological position explains about as much of the variance in population change, Table 11, as it does rate of retail sales change. Region explains 8 per cent of population change, but only 3 per cent of sales change. In both instances there is no interaction, thus the effects are additive.

Looking at the marginals of Table 15 one cannot help but notice the spectacular growth of the suburbs particularly the rural areas of the suburbs.

Retail sales in the urban places in the suburbs increased by 150 per cent, twice the mean for communities in the state. However, the suburban rural areas grew by 226 per cent, over three times the mean rate. Considering
<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Per Cent Variation</th>
<th>df</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F Ratio</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Position</td>
<td>10.00</td>
<td>7</td>
<td>95.7923</td>
<td>13.6846</td>
<td>4.799</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>3.00</td>
<td>4</td>
<td>20.1263</td>
<td>5.0316</td>
<td>2.641</td>
<td>.014</td>
</tr>
<tr>
<td>Interaction</td>
<td>2.90</td>
<td>20</td>
<td>7.5316</td>
<td>0.3766</td>
<td>0.473</td>
<td>.993</td>
</tr>
<tr>
<td>Error</td>
<td>3.00</td>
<td>246</td>
<td>754.1297</td>
<td>3.1018</td>
<td>1.000</td>
<td>.492</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>305</td>
<td>922.424</td>
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</tbody>
</table>

Source: Computed from U.S. Census Data.
the other ecological positions grew at rates far below
the mean of 78 per cent, the growth of the suburban cate-
gories is rather spectacular.

Examining the regional marginals one can find other
contrasts. Region 28, the region with the highest thresh-
old, increased its sales 140 per cent. Region 47, number
two in purchasing power, increased sales at 70 per cent,
slightly less than average. The other regions did not
fare too well. Region 48, 44 per cent; Region 29, 21 per
cent; and Region 30, 18 per cent.

Comparing the regional marginals in Table 11, Popu-
lation Growth, and Table 15, Sales Growth, one sees what
appears to be a multiplicative relationship between the
growth in sales and the growth in population. Population
increases 44, 33, 19, 05, and 02 per cent in the regions,
while sales in corresponding regions increased 140, 70,
44, 21 and 18 per cent. This result can be explained by
a closer look at the data. In Region 28, 56 of the 108
observations are suburban urban places with the phenome-
nal 209 per cent growth rate. In Region 47, 28 of the
40 observations are suburban urban places with growth
rates of only 77 per cent. The other regions have very
few suburbs and the resulting regional totals do not
show their effects. Thus the regional totals simply
reflect the growth of the suburban areas.
Central Place Function Index

Table 16, Central Place Function Index for 1954, gives the per capita sales per category. There is a relationship between ecological position and community per capita sales for 1954. There is no relationship between region and per capita sales, nor is there an effect of interaction.

Ecological position explains 28 per cent of the variance in 1954 per capita sales. Thus it has less explanatory power for per capita sales than it does for 1954 retail sales or 1954 population (about 36 per cent in both cases).

Hinterland centers had the greatest central place index, $2,550, followed by metropolitan urban places and central cities.

The communities with the lowest central place indices were the suburban rural areas, $490 per capita, hinterland rural areas, $650, and metropolitan rural areas, $800. All urban places were above the mean of $1500 per capita; all rural areas were below the mean.

Table 17, Central Place Index 1967, points out a significant relationship between niche and per capita sales for 1967. There are no significant effects of region and there is no significant interaction.
### TABLE 16

#### 1954 CENTRAL PLACE INDEX

(FOR CAPITTA SALES IN 1967 DOLLARS)

<table>
<thead>
<tr>
<th>Region</th>
<th>Central Cities</th>
<th>Suburban Urban Places</th>
<th>Suburban Rural Areas</th>
<th>Metropolitan Urban Places</th>
<th>Metropolitan Rural Areas</th>
<th>Hinterland Urban Places</th>
<th>Hinterland Rural Areas</th>
<th>Hinterland Centers</th>
<th>Region Total</th>
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**LSD 1,402 F 2.6 p .05**

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<th>F Ratio</th>
<th>P Value</th>
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Source: Computed from U.S. Census Data.
### TABLE 17
1967 CENTRAL PLACE FUNCTION INDEX (PER CAPITA SALES)

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<th>Region</th>
<th>Central Cities</th>
<th>Suburban Urban Places</th>
<th>Metropolitan Urban Places</th>
<th>Metropolitan Rural Areas</th>
<th>Hinterland Urban Places</th>
<th>Hinterland Rural Areas</th>
<th>Hinterland Centers</th>
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**LSD .874 DF .203 p .05**

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Source: Computed from U.S. Census Data.
### TABLE 13

#### CENTRAL PLACE FUNCTION GROWTH 1954-1967

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</tr>
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<tr>
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<td>M = 2%</td>
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<td><strong>Hinterland Urban Places</strong></td>
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<td>N = 6</td>
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<td>SD = 0%</td>
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<td>M = 0%</td>
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<tr>
<td><strong>Hinterland Rural Areas</strong></td>
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<td>N = 5</td>
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<tr>
<td>SD = 3%</td>
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<td>3%</td>
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<tr>
<td>M = 3%</td>
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<tr>
<td><strong>Hinterland Centers</strong></td>
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<tr>
<td>N = 4</td>
<td>4</td>
<td>4</td>
<td>4</td>
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<tr>
<td>SD = 2%</td>
<td>2%</td>
<td>2%</td>
<td>2%</td>
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<tr>
<td>M = 2%</td>
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<td></td>
<td></td>
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<tr>
<td><strong>Region Marginal Totals</strong></td>
<td></td>
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</tr>
<tr>
<td><em>LSD</em> 80.31 or 26 p .05</td>
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<td></td>
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</tr>
</tbody>
</table>

**Source of Variation**

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>d.f.</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F Ratio</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological Position</td>
<td>17</td>
<td>7</td>
<td>17.5726</td>
<td>2.760</td>
<td>4.909</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>4</td>
<td>3.4996</td>
<td>.865</td>
<td>1.574</td>
<td>.182</td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>28</td>
<td>7.0577</td>
<td>.229</td>
<td>.467</td>
<td>.997</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>236</td>
<td>104.025</td>
<td>.9425</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>261</td>
<td>171.042</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Source:** Computed from U.S. Census Data.
Ecological position explains more of the variance in 1967 than it did in 1954, 36 per cent versus 28 per cent. Although it explains a good portion of the variance in per capita sales it does not explain as much variance as it did for 1967 population or 1967 retail sales (about 40 per cent in both cases).

As in 1954, hinterland centers, neighboring metropolitan urban places and central cities have the highest per capita sales. Rural areas have the lowest. Two points about the rural areas. First the rural areas in the hinterland have the lowest per capita sales of any category. Compare this with the fact that hinterland centers have the highest per capita sales. Second, the suburban rural areas increased per capita sales from $490 in 1954 to $1030 in 1967.

In Table 18, Per Cent Change in Central Place Function Index, one can find a significant relationship between niche and per cent change in central place index. There is no significant interaction; the regional effect is not significant.

Ecological position explains 9.8 per cent of the variance. It has almost as much explanatory power here as it did with population change (11.5 per cent) and change in retail sales (10 per cent).
Hinterland centers, and central cities while having high indices, demonstrate only moderate growth in their central place functions. Metropolitan urban places show little growth (6 per cent). The same can be said for hinterland urban places (5 per cent).

The suburban category demonstrated the most pronounced growth in central place function.

The urban places in the suburbs increased their per capita sales by 56 per cent. The suburban rural areas (at least they were rural in 1954) increased their per capita sales by 99 per cent.

The findings in this study concerning central place index differ from the Mark-Schwirian (1967) study in a manner similar to the way they differed on population. (Table 19).

Mark-Schwirian found their five categories of ecological position accounted for 17 per cent of the total sum of squares of their 1950 central place index (this study explained 28 per cent of the 1954 CPI). They explained 13 per cent of the 1960 central place index (this study explained 40 per cent of the 1967 CPI). They explained 26 per cent of the sum of squares of rate of change in the central place index (this study explained 9.8 per cent).


<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Freedom of Df</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F Ratio</th>
<th>Sig. p</th>
<th>Source: ECONOMIC POSITION GROUPS 1951-1967</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecological Position</td>
<td>09.81</td>
<td>7</td>
<td>17.5726</td>
<td>2.760</td>
<td>4.909</td>
<td>.001</td>
</tr>
<tr>
<td>Region</td>
<td>4</td>
<td>3.4696</td>
<td>.885</td>
<td>1.574</td>
<td>.182</td>
<td></td>
</tr>
<tr>
<td>Interaction</td>
<td>28</td>
<td>8.0599</td>
<td>.229</td>
<td>.407</td>
<td>.797</td>
<td></td>
</tr>
<tr>
<td>Error</td>
<td>266</td>
<td>149.6163</td>
<td>.567</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>323</td>
<td>173.7132</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 19

**PER CENT CHANGE IN CENTRAL PLACE INDEX: COMPARISON OF IOWA STUDY AND OHIO STUDY**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Cent Change</td>
<td>Per Cent Change</td>
</tr>
<tr>
<td><strong>Central Cities</strong></td>
<td>M = 41.2</td>
<td>M = 12.4</td>
</tr>
<tr>
<td></td>
<td>SD = 9.0</td>
<td>SD = 16.2</td>
</tr>
<tr>
<td><strong>Suburbs</strong></td>
<td>M = 73.5</td>
<td>M = 55.2</td>
</tr>
<tr>
<td></td>
<td>SD = 41.6</td>
<td>SD = 120.5</td>
</tr>
<tr>
<td><strong>Metropolitan Urban Places</strong></td>
<td>M = 34.4</td>
<td>M = 06.2</td>
</tr>
<tr>
<td></td>
<td>SD = 8.7</td>
<td>SD = 18.8</td>
</tr>
<tr>
<td><strong>Hinterland Urban Places</strong></td>
<td>M = 32.7</td>
<td>M = 04.7</td>
</tr>
<tr>
<td></td>
<td>SD = 13.4</td>
<td>SD = 17.8</td>
</tr>
<tr>
<td><strong>Hinterland Centers</strong></td>
<td>M = 32.7</td>
<td>M = 14.0</td>
</tr>
<tr>
<td></td>
<td>SD = 13.3</td>
<td>SD = 18.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>35.8</td>
<td>12.7</td>
</tr>
</tbody>
</table>

*Not corrected for inflation.

Possible explanations: Mark and Schwirian did not control for inflation in retail prices, while the consumer price index was used to control for inflation in this study. The index used by Mark and Schwirian was based on Iowa sales tax and thus included all retail sales. The index used here was based on retail sales in the census which contains only certain categories, mostly lower order goods (food, gasoline).

Aside from the differences mentioned, the basic problem stems from the variance (note SD's) within the
cells of the Ohio categories, as with the analysis of the population data the within cells variance is high in comparison to the variance in the cells in the Iowa study.

**Analysis of Relationships**

In the foregoing analysis we have investigated the effect of the relationship between ecological position and level of regional development on the static and dynamic behavior of population, retail sales and the central place index.

At this time let's look at the relationships between population growth and retail sales growth, population growth and CPI, and retail sales growth and CPI.

Here we are looking at the overall ratios for the whole state. Niche and region are ignored for the time being.

The following analysis tests if there is a relationship between the two variables. This is done using the personian correlation coefficient and the correlation ratio. The correlation ratio indicates an association either linear or curvilinear. The personian r describes a linear relationship.

In addition, the test of linearity will give an indication of the nature of the relationship. Basically, the greater the difference between these two correlations the greater the probability of non linearity.
The Statistics for the Tests

1) To determine the personian correlation coefficient (Ezekiel and Fox 1959: 136):

\[ r_{xy} = \frac{\sum(xy) - nM_x M_y}{\sqrt{\sum(x)^2 - nM_x^2} \sqrt{\sum(y)^2 - nM_y^2}} \]

\[ = \frac{\sum(xy) - nM_x M_y}{NS_x S_y} = \frac{\sum(xy)}{NS_x S_y} \]

2) To determine the correlation ratio (Ezekiel and Fox 1959: 378):

\[ y_x = \frac{\sqrt{\sum[N_o (M_o^2)] - N (M_y)^2}}{NS^2_y} \]

\[ N_o = \text{number of cases in each group} \]
\[ M_o = \text{mean of dependent variable } y \text{ in each group} \]
\[ M_y = \text{mean of } y \]

3) The F ratio for linearity (Guilford 308-317).

The hypothesis is that the regression of \( y \) on \( x \) is linear.

\[ F = \frac{(n - 1) (N - K)}{(1 - n^2) (K - 2)} \]

degrees of freedom \( K - 2; N - K \)
In this analysis _x_ was divided into 10 intervals or groups (see scattergrams) for each of the three investigations.

In the analysis of central place index and population we find:

\[ r = 0.3694 \]

\[ \text{corr. ratio} = 0.4103 \text{ with a std. error } 0.0477 \]

Note that the greater the difference between these two correlations the greater the probability of non-linearity.

The test of the hypothesis of linearity of regression of central place index on population

\[ F = 1.4129 \text{ DF } 8,295 \]

This is not significant.

The problem here is that there is really not much of a relationship either linear or curvilinear. Both of the correlation coefficients are low. The scatter diagram (next page) indicates the nature of the relationship. The pattern is very dispersed although it seems to have a linear tendency.

In the next section an analysis of covariance will be used in an attempt to define relationship more clearly.
FIGURE 5 REGRESSION OF CENTRAL PLACE INDEX GROWTH ON RETAIL SALES GROWTH

<table>
<thead>
<tr>
<th>LT</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.79</td>
<td>-0.79</td>
<td>-0.68</td>
<td>-0.57</td>
<td>-0.46</td>
<td>-0.35</td>
<td>-0.24</td>
<td>-0.13</td>
<td>-0.02</td>
<td>0.09</td>
<td>0.20</td>
<td>0.31</td>
<td>0.42</td>
<td>0.53</td>
</tr>
</tbody>
</table>

The table above represents the regression of central place index growth on retail sales growth. Each row corresponds to a different value of the independent variable (LT), with the dependent variable (GE) shown in the second column. The values range from -0.79 to 1.19, indicating the strength of the regression for each point.

The table includes a column for each increment of the independent variable, with the dependent variable's growth rate shown in the corresponding row. This format allows for the visualization of how changes in retail sales growth affect central place index growth across the specified range.
The relationship between retail sales and central place index was shown to be linear and very strong.

\[ r = 0.9216 \]

corr. coef. = 0.9163

standard error of corr. ratio 0.0092

Test of linearity of regression: hypothesis that regression of central place index on retail sales is linear. \( F = -2.2535, \text{ DF} = 8,296. \) (The negative \( F \) resulted because \( r^2 \) was greater than \( \eta^2 \). See formula.) This is significant at the 0.5 level. The scattergram indicates the nature of this relationship.

The relationship between retail sales expansion and population growth yielded the following:

\[ r = 0.6366 \]

corr. coef. = 0.6850

std. error of correlation ratio 0.0304.

Test of the linearity hypothesis the regression of sales growth on population growth is linear.

\[ F = 4.447 \quad \text{DF 8,296} \]

The scattergram indicates the nature of this relationship.
FIGURE 6 REGRESSION OF RETAIL SALES GROWTH ON POPULATION GROWTH

<table>
<thead>
<tr>
<th>LT</th>
<th>GL</th>
<th>GL</th>
<th>GL</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
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<th>GE</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.86</td>
<td>-0.86</td>
<td>-0.70</td>
<td>-0.55</td>
<td>-0.39</td>
<td>-0.24</td>
<td>-0.08</td>
<td>0.07</td>
<td>0.23</td>
<td>0.38</td>
<td>0.54</td>
<td>0.70</td>
<td>0.85</td>
<td>1.01</td>
<td>1.16</td>
<td>1.32</td>
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</tbody>
</table>
FIGURE 7 REGRESSION OF CENTRAL PLACE INDEX GROWTH ON POPULATION GROWTH

<table>
<thead>
<tr>
<th>LT</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
<th>GE</th>
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</tr>
</thead>
<tbody>
<tr>
<td>-0.86</td>
<td>-0.86</td>
<td>-0.70</td>
<td>-0.55</td>
<td>-0.39</td>
<td>-0.24</td>
<td>-0.08</td>
<td>0.07</td>
<td>0.23</td>
<td>0.35</td>
<td>0.54</td>
<td>0.70</td>
<td>0.85</td>
<td>1.01</td>
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<tr>
<td>1.16</td>
<td>1.32</td>
<td>1.47</td>
<td>1.63</td>
<td>1.78</td>
<td>1.94</td>
<td>2.10</td>
<td>2.26</td>
<td>2.43</td>
<td>2.61</td>
<td>2.78</td>
<td>2.95</td>
<td>3.12</td>
<td>3.29</td>
</tr>
</tbody>
</table>

Note: The table above represents the regression of central place index growth on population growth. The values indicate the relationship between the two variables, with higher values indicating a stronger relationship.
Comparison of Regression Lines

In this analysis a one way analysis of covariance using ecological position is used. Region is excluded from this analysis. The explanatory power of region for the variables retail sales and central place index change was too low to be considered worth further investigation. In addition, the number of observations in some of the cells of a two way classification would not allow for covariant analysis.

In this part of the study we are concerned with three relationships: population and sales, population and central place index and sales and central place index. We will see if the linear regression of the first variable on the second is the same in all eight of the niches. They may differ in slope or in elevation. The general procedure is to compare the slopes first, and then the elevations (Snedecor and Cochran 1967: 432-436).

The model is the familiar

\[ y = a + bx. \]

The procedure for comparing the eight slopes (regression coefficients) is the same in each analysis.

1. Obtain the degrees of freedom and the sum of squares for the deviations from the individual regressions. Total these. The resulting mean square is the
residual mean square obtained when separate regression lines are fitted in each state.

2. Add the sum of squares and products for individual regression lines to determine the pooled slope; these are deviations from a model with a single slope fitted for all variables.

3. The difference line 11 with 7 degrees of freedom (number of coefficients - 1) measures the contribution of the differences between the eight regression coefficients to the sum of squares of deviations.

4. The corresponding mean square is compared with the within niche mean square by the F test.

In the data the comparison of regressions resulted in the following:

Regression of sales on population

\[ F = \frac{7.138}{1.682} = 4.244 \]  p less than .001

Regression of central place index on sales

\[ F = \frac{.161}{.085} = 1.891 \]  
p less than .071

Regression of central place index on population

\[ F = \frac{1.311}{0.469} = 2.797 \]  
p less than .008
Thus the F tests suggest that the slopes of the regression of central place index on sales do not differ. On the other hand, the F tests support the view that the slopes of the regression of retail sales on population and central place index on population do differ significantly.

In the previous analysis the regressions were found to differ significantly in two out of three cases. The question about elevations of the regression lines usually has little meaning unless the lines are parallel (Snedecor and Cochran 1967: 435). However, the data will be presented for all three of the analyses completed above. The test is an F test of the differences between adjusted means. The pooled within niche sum of squares and products on Line 10 (Tables 20, 21, 22). Line 12 gives the between niche sums of squares and products. In Line 13 these are combined. A deviation sum of squares is obtained from Line 13 and the deviation sum of squares Line 10 is subtracted to give the sum of squares between adjusted means.

The F ratios which concern us:

\[
\begin{align*}
\text{Mean squares of adjusted means} & \quad \text{(Line 14)} \\
\text{Pooled mean square} & \quad \text{(Line 10)}
\end{align*}
\]

Results of comparison of elevations:
### TABLE 20

**COMPARISON OF REGRESSION LINES, PER CENT CHANGE RETAIL SALES ON PER CENT CHANGE POPULATION**

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>$E_{x}^{2}$</th>
<th>$E_{x}$</th>
<th>$E_{y}^{2}$</th>
<th>Mean $x$</th>
<th>Mean $y$</th>
<th>Regression Coef.</th>
<th>Deviations from Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Central cities</td>
<td>19</td>
<td>.477380</td>
<td>.464531</td>
<td>.962940</td>
<td>05.4</td>
<td>18.1</td>
<td>0.973</td>
<td>18 .410911</td>
</tr>
<tr>
<td>(2) Suburban urban places</td>
<td>94</td>
<td>.279764</td>
<td>87.848194</td>
<td>740.571815</td>
<td>48.3</td>
<td>150.5</td>
<td>3.340</td>
<td>93 447.114075</td>
</tr>
<tr>
<td>(3) Suburban rural areas</td>
<td>17</td>
<td>1.972407</td>
<td>0.725072</td>
<td>61.508192</td>
<td>49.3</td>
<td>225.6</td>
<td>4.424</td>
<td>16 22.912263</td>
</tr>
<tr>
<td>(4) Metropolitan urban places</td>
<td>55</td>
<td>2.274201</td>
<td>1.475461</td>
<td>1.186138</td>
<td>18.1</td>
<td>24.2</td>
<td>0.649</td>
<td>54 2.228884</td>
</tr>
<tr>
<td>(5) Metropolitan rural areas</td>
<td>31</td>
<td>3.684403</td>
<td>1.438220</td>
<td>6.468740</td>
<td>27.6</td>
<td>46.8</td>
<td>0.390</td>
<td>30 5.907325</td>
</tr>
<tr>
<td>(6) Hinterland urban places</td>
<td>18</td>
<td>.291846</td>
<td>.191278</td>
<td>60.07520</td>
<td>07.6</td>
<td>12.2</td>
<td>0.655</td>
<td>17 682206</td>
</tr>
<tr>
<td>(7) Hinterland rural areas</td>
<td>17</td>
<td>.490711</td>
<td>1.419755</td>
<td>11.474110</td>
<td>09.7</td>
<td>33.1</td>
<td>2.893</td>
<td>36 7.366386</td>
</tr>
<tr>
<td>(8) Hinterland centers</td>
<td>27</td>
<td>.609607</td>
<td>.534706</td>
<td>1.504647</td>
<td>10.7</td>
<td>25.9</td>
<td>0.877</td>
<td>27 1.035639</td>
</tr>
<tr>
<td>(9) Total</td>
<td>290</td>
<td>487.756</td>
<td>1.682</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10) Pooled slope W</td>
<td>12.707319</td>
<td>102.097217</td>
<td>826.484154</td>
<td>2.828</td>
<td>297</td>
<td>537.720</td>
<td>1.811</td>
<td></td>
</tr>
<tr>
<td>(11) Difference between slopes</td>
<td>7</td>
<td>49.984</td>
<td>7.133</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(12) Between B</td>
<td>32.553300</td>
<td>33.527071</td>
<td>130.151305</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(13) W &amp; B</td>
<td>45.260619</td>
<td>135.624288</td>
<td>965.635459</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(14) Between adjusted means</td>
<td>7</td>
<td>21.512</td>
<td>3.073</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comparison of slopes**
- $F = 7.133/1.682 = 4.244$  $p < .001$

**Comparison of elevations**
- $F = 3.073/1.811 = 1.697$  $p < .109$
### Table 21

Comparison of Regression Lines, Per Cent Increase in Central Place Index on Per Cent Increase in Population

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>$Dx^2$</th>
<th>$Dy$</th>
<th>$Sy^2$</th>
<th>Mean $x$</th>
<th>Mean $y$</th>
<th>Regression</th>
<th>Deviation from Regression</th>
<th>DF</th>
<th>Sum of Sq.</th>
<th>Mean Sq.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central cities</strong></td>
<td>19</td>
<td>477,380</td>
<td>-64,943</td>
<td>497,989</td>
<td>05.4</td>
<td>12.4</td>
<td>-0.136</td>
<td>18</td>
<td>.489154</td>
<td>.027175</td>
<td></td>
</tr>
<tr>
<td><strong>Suburban urban places</strong></td>
<td>94</td>
<td>279,764</td>
<td>231,280</td>
<td>134,172,082</td>
<td>48.3</td>
<td>53.5</td>
<td>0.826</td>
<td>93</td>
<td>116.199332</td>
<td>1.249455</td>
<td></td>
</tr>
<tr>
<td><strong>Suburban rural areas</strong></td>
<td>17</td>
<td>1,972,407</td>
<td>2,771,476</td>
<td>12,262,092</td>
<td>49.3</td>
<td>07.8</td>
<td>1.405</td>
<td>16</td>
<td>8.367823</td>
<td>.522988</td>
<td></td>
</tr>
<tr>
<td><strong>Metropolitan urban places</strong></td>
<td>55</td>
<td>2,274,201</td>
<td>-693,403</td>
<td>1,948,622</td>
<td>18.1</td>
<td>06.2</td>
<td>-0.305</td>
<td>54</td>
<td>1.737204</td>
<td>.032170</td>
<td></td>
</tr>
<tr>
<td><strong>Metropolitan rural areas</strong></td>
<td>31</td>
<td>3,684,403</td>
<td>-1,417,684</td>
<td>3,409,956</td>
<td>27.6</td>
<td>18.5</td>
<td>-0.385</td>
<td>30</td>
<td>2.864460</td>
<td>.095482</td>
<td></td>
</tr>
<tr>
<td><strong>Hinterland urban places</strong></td>
<td>18</td>
<td>291,846</td>
<td>-100,852</td>
<td>571,222</td>
<td>07.6</td>
<td>04.7</td>
<td>-0.346</td>
<td>17</td>
<td>.536371</td>
<td>.031551</td>
<td></td>
</tr>
<tr>
<td><strong>Hinterland rural areas</strong></td>
<td>37</td>
<td>490,711</td>
<td>657,118</td>
<td>5,726,521</td>
<td>09.7</td>
<td>19.8</td>
<td>1.339</td>
<td>36</td>
<td>4.864565</td>
<td>.134626</td>
<td></td>
</tr>
<tr>
<td><strong>Hinterland centers</strong></td>
<td>27</td>
<td>609,607</td>
<td>-101,132</td>
<td>883,108</td>
<td>10.7</td>
<td>14.0</td>
<td>-0.166</td>
<td>26</td>
<td>.866331</td>
<td>.033320</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>290</td>
<td>135,907</td>
<td>469</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pooled slope, W</strong></td>
<td>9,590,098</td>
<td>1,281,860</td>
<td>159,453,592</td>
<td>0.631</td>
<td>297</td>
<td>145,082</td>
<td>.489</td>
<td>7</td>
<td>9.175</td>
<td>1.311</td>
<td></td>
</tr>
<tr>
<td><strong>Between adjusted means</strong></td>
<td>7</td>
<td>10.125</td>
<td>1.476</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of slopes: $F = \frac{1.311}{.469} = 2.797 < 0.008$

Comparison of elevations: $F = \frac{1.446}{.488} = 2.961 < 0.005$
### TABLE 22

REGRESSION OF PER CENT INCREASE IN CENTRAL PLACE INDEX ON PER CENT INCREASE IN RETAIL SALES

<table>
<thead>
<tr>
<th></th>
<th>DF</th>
<th>$\Sigma x^2$</th>
<th>$\Sigma xy$</th>
<th>$\Sigma y^2$</th>
<th>$\Sigma x$ Mean</th>
<th>$\Sigma y$ Mean</th>
<th>Regression Coef.</th>
<th>Deviations from Regression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\Sigma y^2$</td>
<td></td>
<td></td>
<td>CPI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central cities</td>
<td>19</td>
<td>962,940</td>
<td>433,775</td>
<td>497,989</td>
<td>0.181</td>
<td>0.124</td>
<td>.450</td>
<td></td>
</tr>
<tr>
<td>Suburban urban places</td>
<td>94</td>
<td>740,571,815</td>
<td>292,280,282</td>
<td>134,172,082</td>
<td>1.505</td>
<td>0.535</td>
<td>.395</td>
<td></td>
</tr>
<tr>
<td>Suburban rural areas</td>
<td>17</td>
<td>61,508,192</td>
<td>25,658,422</td>
<td>12,262,092</td>
<td>2.256</td>
<td>1.078</td>
<td>.417</td>
<td></td>
</tr>
<tr>
<td>Metropolitan urban places</td>
<td>55</td>
<td>3,186,130</td>
<td>1,481,299</td>
<td>1,948,622</td>
<td>0.242</td>
<td>0.062</td>
<td>.465</td>
<td></td>
</tr>
<tr>
<td>Metropolitan rural areas</td>
<td>31</td>
<td>6,468,740</td>
<td>3,184,222</td>
<td>3,409,956</td>
<td>0.468</td>
<td>0.185</td>
<td>.492</td>
<td></td>
</tr>
<tr>
<td>Hinterland urban places</td>
<td>18</td>
<td>807,572</td>
<td>535,770</td>
<td>571,222</td>
<td>0.122</td>
<td>0.047</td>
<td>.663</td>
<td></td>
</tr>
<tr>
<td>Hinterland rural areas</td>
<td>27</td>
<td>1,504,647</td>
<td>854,726</td>
<td>883,108</td>
<td>0.259</td>
<td>0.140</td>
<td>.568</td>
<td></td>
</tr>
<tr>
<td>(9) Total</td>
<td>298</td>
<td>8,484,154</td>
<td>395,459</td>
<td>159,453,592</td>
<td>332,272,951</td>
<td>25,484,154</td>
<td>297</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pooled slope W (regression line for total)</td>
<td>298</td>
<td>8,484,154</td>
<td>395,459</td>
<td>159,453,592</td>
<td>332,272,951</td>
<td>25,484,154</td>
<td>.402</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between B</td>
<td>1</td>
<td>139,151,305</td>
<td>54,536,014</td>
<td>22,683,782</td>
<td>1</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>W &amp; B</td>
<td>299</td>
<td>965,635,459</td>
<td>385,808,965</td>
<td>182,137,374</td>
<td>298</td>
<td>27,192</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comparison of slopes \( F = \frac{161}{.085} = 1.891 \) \( p < 0.071 \)

Comparison of elevations \( F = \frac{186}{.087} = 2.137 \) \( p < 0.040 \)
Retail sales on population

\[ F = \frac{3.073}{1.811} = 1.697 \]

\( p \) is less than 0.109

Central place index on retail sales

\[ F = \frac{0.186}{0.087} = 2.137 \]

\( p \) is less than 0.040

Central place index on population

\[ F = \frac{1.446}{0.488} = 2.961 \]

\( p \) is less than 0.005

The analysis tells us that the adjusted means in the niches are significantly different in two instances, regression of central place index on retail sales and regression of central place index on population.

How does one interpret the findings? From the analyses of slope one can draw three conclusions.

The average change in per cent central place index growth per unit increase in percent retail sales growth is about the same for all ecological positions.

The average change in per cent retail sales growth per unit increase in per cent population growth is not the same for all ecological positions.

The average change in per cent central place index growth per unit increase in per cent population growth is not the same for all ecological positions.
As mentioned before, the information about the elevation, adjusted means, has little meaning unless the lines are parallel (Snedecor and Cochran 1967: 435). This is the case for only the relationship between retail sales and central place index growth.

The analysis of the adjusted means tests to see if differences in retail sales would disappear after allowing for the relationship between retail sales growth and central place index growth.

The regressions within the ecological positions appear to be linear, and the values of b do not differ significantly from one ecological position to another (according to our test of slope). But there is a significant difference between adjusted means.

Therefore we can assume that the differences between central place expansion in the different ecological positions would not disappear even after the relationship between central place index growth and retail sales growth is controlled.

The relationship between growth in retail sales and central place function expansion is demonstrated in Figure 8.

The graph demonstrates that while the slope (rate of change) is about the same for all ecological positions the levels are different. This is not an unexpected
<table>
<thead>
<tr>
<th>Central Cities</th>
<th>$y = 4.24 + 0.45(x)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban Urban Places</td>
<td>$y = -5.91 + 0.39(x)$</td>
</tr>
<tr>
<td>Suburban Rural Areas</td>
<td>$y = 13.70 + 0.41(x)$</td>
</tr>
<tr>
<td>Metropolitan Urban Places</td>
<td>$y = -5.06 + 0.46(x)$</td>
</tr>
<tr>
<td>Metropolitan Rural Areas</td>
<td>$y = -4.53 + 0.49(x)$</td>
</tr>
<tr>
<td>Hinterland Urban Places</td>
<td>$y = -3.33 + 0.66(x)$</td>
</tr>
<tr>
<td>Hinterland Rural Areas</td>
<td>$y = -2.90 + 0.68(x)$</td>
</tr>
<tr>
<td>Hinterland Centers</td>
<td>$y = -7.17 + 0.56(x)$</td>
</tr>
</tbody>
</table>

TABLE 23

REGRESSION EQUATIONS FOR CENTRAL PLACE INDEX GROWTH ($y$) ON RETAIL SALES GROWTH ($x$)
Fig. 8—Regression Central Place Index Growth on Sales Growth by Ecological Position
phenomenon. Since central place index is by definition the retail sales divided by population we would expect that ecological positions would disappear only if all the ecological positions had similar changes in population.

If the sales and population rates of change in each niche were the same, then of course the CPI would also be the same, and all three growth rate variables would be the same.

Examining the data on the relationship between sales growth and population growth we find that the slopes do differ by ecological position. Figure 9 shows us that in the suburban areas and the hinterland rural areas, sales are increasing faster than population. While in metropolitan categories and hinterland urban places the population increases at a greater rate than sales.

Finally, let us examine the relationship between central place function expansion and population growth.

In the preceding analysis we found that the suburban areas and hinterland rural areas had sales growth exceeding population growth. Thus the central place index increased in these places.

This is demonstrated in a graph (Figure 10) which shows the regression of central place expansion on population growth.
<table>
<thead>
<tr>
<th>Location</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cities</td>
<td>$y = 12.85 + 0.973x$</td>
</tr>
<tr>
<td>Suburban Urban Places</td>
<td>$y = 0.0080 + 3.340x$</td>
</tr>
<tr>
<td>Suburban Rural Areas</td>
<td>$y = 7.62 + 4.424x$</td>
</tr>
<tr>
<td>Metropolitan Urban Places</td>
<td>$y = 12.46 + 0.649x$</td>
</tr>
<tr>
<td>Metropolitan Rural Areas</td>
<td>$y = 35.97 + 0.390x$</td>
</tr>
<tr>
<td>Hinterland Urban Places</td>
<td>$y = 7.17 + 0.655x$</td>
</tr>
<tr>
<td>Hinterland Rural Areas</td>
<td>$y = 4.95 + 2.895x$</td>
</tr>
<tr>
<td>Hinterland Centers</td>
<td>$y = 16.44 + 0.877x$</td>
</tr>
</tbody>
</table>
Fig. 9—Regression Sales Growth on Population Growth by Ecological Position
### TABLE 25

**REGRESSION EQUATIONS FOR CENTRAL PLACE INDEX GROWTH (Y) ON POPULATION GROWTH (X)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Cities</td>
<td>$y = 13.1 + (-0.136)(x)$</td>
</tr>
<tr>
<td>Suburban Urban Places</td>
<td>$y = 13.5 + 0.826(x)$</td>
</tr>
<tr>
<td>Suburban Rural Areas</td>
<td>$y = 38.5 + 1.405(x)$</td>
</tr>
<tr>
<td>Metropolitan Urban Places</td>
<td>$y = 11.7 + (-0.304)(x)$</td>
</tr>
<tr>
<td>Metropolitan Rural Areas</td>
<td>$y = 29.0 + (-0.384)(x)$</td>
</tr>
<tr>
<td>Hinterland Urban Places</td>
<td>$y = 7.36 + (-0.345)(x)$</td>
</tr>
<tr>
<td>Hinterland Rural Areas</td>
<td>$y = 6.71 + 1.339(x)$</td>
</tr>
<tr>
<td>Hinterland Centers</td>
<td>$y = 15.76 + (-1.65)(x)$</td>
</tr>
</tbody>
</table>
Fig. 10—Regression Central Place Index on Population Growth by Ecological Position
The regression lines show that in these areas an increase in population was related to an increase in central place function. However, in the other categories sales increased more slowly than population. Thus these have negative relationships with population growth. Even though they increased their population their central place function decreased.
CHAPTER V
SUMMARY AND CONCLUSIONS

The purpose of this study was to investigate the effect of ecological position and level of regional development on the community population, retail sales, central place function and the relationship between these variables.

The first part of the study examined theoretical and empirical studies concerning the relationships between the variables. A great deal of emphasis was put upon classic central place theory. This was done because the theory has proved valid in exploring the relationship between population growth and trade function in many studies analyzing rural areas throughout the world. Rather than belabor the geometric relationships with which central place theory has become identified, we emphasized the little mentioned theoretical factors which are supposedly responsible for the development of the system and which when changed should change the system. All of the factors could be placed into two basic categories, range and threshold. Those aspects which
would cause people to expend time and effort to cover a distance to purchase a good determined the range.

Christaller suggested that the single most important factor affecting range was the transport system used by the individual. In this study the amount of improved highways in a region was used as an indicator.

The other basic factor affecting the system of cities in a region was called the threshold. This was basically the purchasing power of a region. The purchasing power was dependent on the population density and wealth of the population. Regions with a high amount of purchasing power were supposed to have more central places than those with low purchasing power. In this study median household income multiplied by the number of households divided by the square miles in the region was used to operationalize threshold.

In Ohio the range and threshold rankings of the regions were almost identical.

Five regions were defined. In each region communities were defined as to ecological position.

Ecological position and region were then used as the main effects in a two way analysis of variance, factorial design.

The results are summarized in Table 26. The ecological position had the most significant effect overall.
Region was significant in four categories, the most important being population growth.

**TABLE 26**

**A SUMMARY OF THE ANALYSIS OF VARIANCE FINDINGS SHOWING SIGNIFICANT PER CENT VARIANCE EXPLAINED**

<table>
<thead>
<tr>
<th></th>
<th>Niche</th>
<th>Region</th>
<th>Interaction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population 1954</td>
<td>35.96</td>
<td>--</td>
<td>--</td>
<td>35.9</td>
</tr>
<tr>
<td>Population 1967</td>
<td>39.25</td>
<td>0.019</td>
<td>8.35</td>
<td>47.62</td>
</tr>
<tr>
<td>Population Change</td>
<td>11.52</td>
<td>8.28</td>
<td>--</td>
<td>19.80</td>
</tr>
<tr>
<td>Sales 1954</td>
<td>36.00</td>
<td>0.09</td>
<td>--</td>
<td>36.09</td>
</tr>
<tr>
<td>Sales 1967</td>
<td>40.03</td>
<td>--</td>
<td>8.62</td>
<td>48.65</td>
</tr>
<tr>
<td>Sales Change</td>
<td>10.00</td>
<td>3.00</td>
<td>--</td>
<td>13.00</td>
</tr>
<tr>
<td>Central Place Index 1954</td>
<td>28.36</td>
<td>--</td>
<td>--</td>
<td>28.36</td>
</tr>
<tr>
<td>Central Place Index 1967</td>
<td>36.40</td>
<td>--</td>
<td>--</td>
<td>36.40</td>
</tr>
<tr>
<td>Central Place Index Change</td>
<td>9.83</td>
<td>--</td>
<td>--</td>
<td>9.83</td>
</tr>
</tbody>
</table>

Ecological position was shown to have an important effect on communities in Ohio. It explained 36 per cent of the size of communities in 1954, 40 per cent in 1967. Not only is a large portion of this variable explained in both periods, but it also appears that this is becoming increasingly important.
Ecological position explains about 11 per cent of the population growth in the state of Ohio. With the urban and rural suburban areas showing the greatest increase. The tremendous growth of the rural suburban areas would seem to be a potential problem area for development specialists. The greatest population change is in this area, yet this area lacks the social organization to handle large scale development.

Ecological position also explained 36 per cent of the variance in retail sales in 1954 and 40 per cent in 1967. Again the fact that the amount explained is increasing is notable.

About 10 per cent of the change in retail sales could be accounted for by ecological position.

Twenty-eight per cent of central place function index (per capita sales) in 1954 was accounted for by ecological position. Twenty-six per cent was accounted for in 1967. About 10 per cent of the change in central place function could be accounted for by ecological position. Those areas with the highest per capita sales--hinterland centers, central cities--showed the least amount of increase. Rural areas of suburbia had the greatest increase.

Region demonstrated a capability of explaining about eight per cent of the variance in population
growth and about three per cent of the change in retail sales.

The interaction between niche and region explained as much as eight per cent of the variance in certain instances, but this may be considered an artifact of the strong influence of ecological position.

The low explanatory power of the analysis in terms of accounting for population change, and change in central place index when compared to a similar study was discussed.

The next part of the analysis investigated the relationship between population and retail sales; population and central place function index; retail sales and central place function index.

Two of the three were shown to be linear. Population and central place function index appeared to have a negligible relationship, though a tendency toward linearity could be discerned from the scattergram.

In an attempt to achieve greater specification, an analysis of covariance was completed. One way analysis of covariance using ecological position was used. In the two way analysis of variance the explanatory power of region for the variables retail sales change and central place index change was too low to be considered worth additional analysis.
First, the slopes of the regression of central place index growth on retail sales growth were not found to differ significantly between ecological positions. Therefore, change of central place index per unit change in retail sales growth was the same for all ecological positions.

The relationship between the rate of central place expansion and retail sales growth as demonstrated by the slopes in the regression of central place index growth on sales growth appeared to be the same in all ecological positions.

However, even though the rate of change is the same for each category there is still a significant difference among ecological positions concerning the relationship between central place index growth and retail sales increase.

Second, the slopes of the regression of retail sales on population were found to differ significantly between ecological positions. Thus the unit change in retail sales growth per unit change in population growth differed among ecological positions. The relationship between retail sales and population demonstrated that growth in the suburban areas and the hinterland rural areas differed from growth in the other ecological positions. In these three locations the
retail sales growth rate exceeded the population growth rate.

Third, the slopes were significantly different for the regression of central place expansion on population growth. Thus the average change in central place index per unit increase in population growth is not the same for all ecological positions.

The relationship between central place expansion and population growth appeared as two different types of relationships. Suburban locations and the hinterland rural areas demonstrated increased population growth and central place function expansion.

The other ecological positions demonstrated a negative relationship between central place index expansion and population growth.

In summation, the general hypothesis of this study was that the relationship between urban central place function and community population growth is a function of both level of regional development and of the ecological position of the community.

The analysis demonstrated that population growth was a function of ecological position, which explained 11.5 per cent of the variance, and regional development, which explained 8.3 per cent of the variance. It is evident that there are other variables operating which
explain about 80 per cent of the variance.

This study found that central place function was a function of ecological position, which explained 9.8 per cent of the variance, but not level of regional development, which produced no significant explanation.

Since level of regional development was not a significant factor in central place function expansion, the relationship between central place function expansion, community population growth and retail sales growth was examined using only ecological position.

The relationship between central place function expansion and community population growth was found to differ significantly by ecological position.

The relationship between the rate of sales growth and community population growth differed significantly by ecological position.

The relationship between rate of change in retail sales and central place index did not differ significantly.

In Retrospect

The technique used to differentiate the levels of regional development could be improved upon. The categories would probably have been more effective if fewer classifications were used. The highly developed regions 47 and 28 should have been combined and contrasted with
the less developed regions. This classification scheme would also have increased the number of observations per cell, and this would improve the analysis.

**Implications for the Model**

The model suggests that the variables are affected by ecological position and level of regional development. In this study, the effect of the level of regional development could be discerned for population, and to a limited extent for retail sales. It had negligible effect on central place index.

The effect of ecological position on the relationships between changes in the variables population, retail sales and central place function followed the industrialization stage of the model, with one exception. The hinterland rural areas increased in central place function and population. According to the model this should not have happened. They should have remained constant or declined. This decline occurred with the hinterland urban places. Since the hinterland urban places followed the model and the hinterland rural areas did not, a closer examination of these rural areas is required.

According to the model the central place function of these areas should have been absorbed as their larger neighbors took over their retail activities. An increase
in population was considered possible if the communities assumed a dormitory function for larger hinterland centers nearby.

The central place index for these areas is the lowest of all communities studied in spite of the growth during the period. Per capita sales increased from $657 in 1954 to $747 in 1967. Average population in the area increased 10 per cent; average sales 33 per cent. It is important to note that with such a small base figure even modest growth is reflected in high percentage growth.

All of the measures are below the average but we cannot avoid the fact that these rural areas grew when they were expected to decline. While the hinterland towns over 2500 declined as expected.

The small community, under 2500, and the open country absorbed the growth. Perhaps this is simply hinterland sprawl, urban sprawl on a smaller scale, occurring in the hinterlands.

The growth is probably due to the strip residential development along highways. Much growth in this unincorporated, unzoned area occurs because of the low cost of building on such sites.

Central place growth could occur as small shopping centers are located on the outskirts of hinterland centers.
The increase in sales could also occur as strip commercial facilities develop to serve residential areas. These facilities are oriented toward highway traffic rather than central place location and their location cannot be easily explained using central place theory.

This is of course conjecture and further study is required.

**Implications for Communities**

The analysis demonstrates that community economic and population growth are not uniform throughout the state. In general the changes which occurred during the 1954-1967 period reflect the changes predicted by the model for the industrialization period. This leads to certain implications for Ohio communities.

The large central cities are the focal points of regional change. Industry expands in these areas and new industry is attracted to the area. They achieve this position because they are at the prime location in the transportation network. The industrial expansion and diversification attracts workers and their dependents to the area. This population growth increases the local retail trade. The study demonstrated that as a group the central cities increased in both population (5 per cent) and retail trade (18 per cent).
The increase in sales could also occur as strip commercial facilities develop to serve residential areas. These facilities are oriented toward highway traffic rather than central place location and their location cannot be easily explained using central place theory.

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The expansion of retail services coupled with an improved transportation system radiating into the hinterlands creates a situation in which people are willing to travel farther to the central city. Thus the retail trade functions of the central city are both more attractive and more convenient for those in the hinterland. This brings about an increase in the central place function of the central city at the expense of smaller neighboring towns. The central place function of the central cities increased 12 per cent during the 1954-1967 period. (The neighboring metropolitan urban places grew 6 per cent.)

The population and economic growth of the central city are not limited to the boundaries of that city. The population and economic activities diffuse to adjacent rural areas. This brings about a change in land use from agricultural to urban. Agricultural villages are converted into dormitory suburbs (suburban urban places increased their population by 48 per cent) and new residential areas develop on previously vacant land (suburban rural areas increased their population by 49 per cent).

Some suburban communities increase their central place function as new suburban shopping centers develop. These retail centers place the suburbs in a favorable competitive position. They can compete with the
metropolitan center and with the communities at the periphery of the metropolitan area. Retail sales of suburban urban places increased 151 per cent, while sales in suburban rural areas increased 226 per cent in this period. Suburbs with the large shopping centers are able to absorb much of the rural trade attracted to the central cities. The central place function of the suburban urban places and suburban rural areas increased by 56 per cent and 99 per cent respectively.

The metropolitan communities on the periphery are in a good position for population growth but in a poor position for economic expansion. Since they are within easy driving distance of the largest centers these centers attract a commuting population. During the study period the metropolitan urban places increased their population by 18 per cent; the metropolitan rural areas' population increased by 28 per cent.

The metropolitan central place functions (except low level ones) are at a disadvantage because of the location. They are too far from the metropolitan centers to attract the decentralizing retail activities which locate in the suburban shopping centers. Thus the metropolitan communities must compete for trade with both the central city and the suburbs. They must lose trade in the short run and experience a decline in their former trade area.
The central place function index of metropolitan urban places increased six per cent, while the metropolitan rural areas had an 18 per cent increase (probably reflecting the low initial base figure used in computation as well as the propensity to sell low level goods in these areas).

The communities with poor ecological positions for both population growth and economic expansion are the hinterland communities.

As an ecological class the hinterlands are characterized by little population growth, a declining central place function, little economic expansion. If any hinterland towns have a relative advantage in this period it is those whose competition is limited to smaller neighbors. In this study, hinterland centers demonstrated an 11 per cent increase in population and a 14 per cent increase in central place function. While the smaller hinterland urban places had an eight per cent population increase and only a five per cent increase in central place function.

The hinterland rural areas' population grew 10 per cent and their central place function 20 per cent. In this instance the size of the increases is due in large part to the small initial base on which they were calculated.
Policy Implications

This analysis suggests certain policy implications. First, there is a need for planning on a regional level, because the growth of communities occurs in part as a result of its ecological position. The place of the community in the total regional organization of communities. Second, there is a need for an institutionalized process to help communities to reorganize as regions develop and their functions change.

The need for regional planning results from the fact that growth in population and retail sales occurs as a spillover effect when population and sales decentralize from the central city. The growth occurs in those areas least capable of dealing with change brought about by development. Population growth occurs not only in suburban communities, but also in the rural suburban and metropolitan rural areas. The suburbs may have the governmental organization to plan and prepare services and facilities for incoming people, but the small communities and open country rural areas do not.

If a regional authority were responsible for the provision of facilities and services the regional development process would be greatly facilitated. This need not be an abdication of local government control to a higher authority. Services could be provided on a
contractual basis, local governments would simply contract with the authority to provide needed services. As population increased the amount of contracted services would be increased. A system of this type is in use in Los Angeles County where it is known as the Lakewood plan.

We have seen that as regions develop the functions of communities change. This change often calls for a reorganization of the physical structure of the community. The most common instance is the change from small trade center to residential community which occurs in the areas around the central city. There are also instances of the decline of towns in the hinterlands.

The model suggests that the process of regional change is one of concentration followed by eventual decentralization. The growth and decline of communities is part of this process. There is a need for an institutionalized means of dealing with this growth, decline, new growth process. Ideally there would be a procedure to increase and decrease the scale of operations of a community as conditions change.

However, many community functions are of a fixed nature—the sewer and water facilities are built and must be maintained, a certain minimal police force must always be on hand. It would appear that a method of federal, state or regional funding for operating costs of these
necessary functions should be made available. These would be used to fund minimal services until the community began its renaissance. Without this aid the burden of providing the services would fall on the remaining population and commercial establishments. This increased burden would cause a hardship situation which might bring about greater out migration and further decline.

**Implications for Further Research**

1. What are the effects on other types of community functions, services, schools, governments, when the nature of the community changes from rural trade center to urban suburb?

2. What effect does sector as described by Lösch and Bogue (see pages 16 and 21) have on community population growth and trade function? How does sector relate to ecological niche and region?

3. More observations are needed for a better breakdown. With 306 observations and 40 classifications there were several cells with only one or two observations.
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