AN ANALYSIS OF THE RELATIONSHIP BETWEEN HIGHWAY DISTRIBUTION AND SPATIAL DEVELOPMENT IN THE STATE OF KANSAS

by

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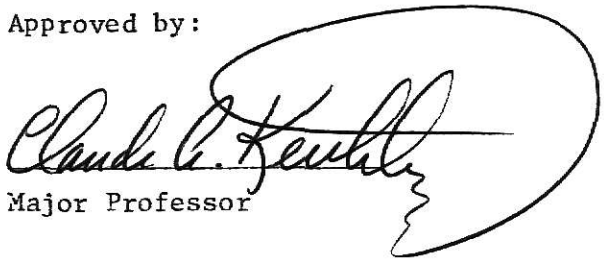

Major Professor

for my parents

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PREFACE

The purpose of this study is to explore the relationships between various socio-economic phenomena and highway distribution in the State of Kansas. The hypothesis constructed is based mainly on economic theory. Correlation and regression have been applied to the analysis of the relationships. It is hoped that the application helps to explain certain facets of spatial development and produces results which may be useful for predicting socio-economic development and for policy formulation.

I am grateful to Professor C.A. Keithley and Professor J. Selfridge, Department of Regional and Community Planning, and Professor E. Russell, Department of Civil Engineering for their helpful criticisms and comments before preparation of the final copy.

February, 1976 Paul Wai-Hung Ho

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Chapter 1

INTRODUCTION

One of the approaches in highway planning is based on demand criterion. Resources are allocated according to the distribution of demand recognized through the existing or projected information. Another approach is on supply criterion. Transportation investment is regarded as a policy tool for inducing development. Traditionally, this approach is related to Hirschman's strategy of development via social overhead capital investment,[1] and the policy formulated in this way is often a reaction to the problem of spatial development and disequilibria among regions or areas. Appalachian and Rocky Mountain Projects are examples of this approach. In addition to the above, a relatively new dimension of transportation planning has recently been developed. Instead of reducing disequilibria, emphasis is on managing growth. In many cases, highways have been manipulated by planners to influence the location of development, to control land use and growth especially in counties or areas with a relatively fast growth rate. Therefore, no matter what the purpose is, implicit in these approaches is the recognition of the impact of highway network on the geographical pattern of spatial development.

However, highway development as a policy tool for promoting or controlling growth is not as simple as it appears. Theoretically, there are three different concepts relating to the issue : positive, permissive and negative. In the positive case, an improvement in transport capacity permits a more effective abridgement of distance, It makes possible

faster, safer and cheaper service which in turn allows a greater movement of goods and people per unit of time. The speed factor helps to reduce the time required as well as the investment in transport to provide the same amount of services and results in capital saving. The safety factor stimulates greater utilization of the facility per time period and reduces costs in the form of damage, loss or insurance. The cost factor refers to the reduction of inputs required to move any given quantity of goods or number of people between two points. In other words, transportation improvement leads to a reduction in the total resources required to produce and distribute a given volume and pattern of output per time period assuming that the released resources as a result of reduced costs are to be employed productively. This will induce an expansion of existing productive patterns or create the possibility of entirely new activities and economic growth.

In the permissive case, the addition of highway mileage does not have much effect on development. It only absorbs some portion of scare resources that may be employed elsewhere. In terms of opportunity cost, this investment is less productive than some other alternatives or below what it would have been if resources are used more efficiently in other kinds of projects. Finally, in the negative case, an increase in mileage does not induce development. On the contrary, it is argued that the backwash effects tend to swamp the spread effects. In this case, the detrimental impact on one segment of the economy is not counter-balanced by an equivalent expansion elsewhere and this implies that there will be set in motion a cumulative mechansism of growing regional disparities.

However, each of the above cases, in fact, tells part of the story and is based on particular assumptions which may be irrelevant to particular situation or on certain criteria upon which the conclusion may not be justifiably made. For instance, in the permissive case, it is assumed that the transportation investment can be more effectively employed in other projects which will have a better result in development. However, this assumption is very questionable because what kind of substitution can be more effective in inducing development than highway investment is already a difficult question to answer. In the negative case, isolated areas in underdeveloped counties are often cited as the locations where adverse effect occurs. Indeed, this kind of example can only represent extreme cases and it may be misleading. As some economists argue, even in an adversely affected area, the adverse effect would be, in the long run, offset if there are some mobility of factors of production, some flexibility in factor supply prices and some entrepreneurial abilities, either local or imported. Therefore, the relationship between highway development and socio-economic profiles is not clear and there is much room for further investigation.

The major purpose of the paper is to analyze the relationship between highway distribution and socio-economic development for the State of Kansas. Spatial aspect of the association is emphasized because one important dimension of development is through space. Kansas counties are regarded as spatial units. In this way, various socio-economic characteristics are included. The size of sample is large enough so that the conclusion is not limited to a particular situation and the finding

would be more useful for practical application. Moreover, different indicators of socio-economic development are used so that a comparatively objective conclusion can be made and the result can serve for the following purposes :

1. To identify the relationship between highway distribution and socio-economic structure so that there are some criteria upon which transportation planning in a county level to regional level can be based.
2. The inherent nature of the regression model can help to predict the future socio-economic development which is of importance to planning, policy formulation and decision making.
3. The finding of the research would be useful for managing growth in particular to land use control which has recently been at the top of the planning agenda in county level, especially in the east and west coasts. The result of the study may also help to discover some of the possible contradictory policies in planning. e.g. preserving agricultural land on one side and increasing mobility by constructing highway on the other.

It is hoped that by the study, some questions in planning may be answered. References for transportation planning in related to development and growth control in region or in county level can be provided.

Chapter 2

THEORETICAL CONCEPTS OF HIGHWAY DENSITY AND SPATIAL ECONOMIC DEVELOPMENT

The Dimensions of Highway Density And Spatial Economic Development

There are several ways to express the highway development of a county but by far "highway density" seems to be easier to define and the one most often used. In this paper, highway density is simply the average miles of highway per ten square miles of land area in each county. The turnpike is also counted as a rural highway. However, if the county has no access to the turnpike, the mileage in the county is excluded because it is assumed that the impact of the section of turnpike on accessibility and connectivity of the county and thus growth is insignificant.

On the other hand, the choice of economic development is a wide one. Therefore, the variables chosen for the study are based on their possible relationship with highway density. Broadly defined, socioeconomic development may include population characteristics and employment variables. The former may be represented by population density, percentage of urban population and population of the largest urban center of each county. These three measures will indicate, in very broad terms, the general changes of population characteristics from county to county. On the other hand, the employment variables represented separately by the number of employed persons engaged in different sectors such as agriculture, manufacturing, retail, financial and

insurance, as well as professional and related services also constitute part of the measure of the differential economic dimensions of counties. In addition to this, the percentage of the employed population in different sectors is also included as a variable. The existence of a relatively high proportion of certain employment in relation to highway density will give more information of the impact of it on the employment structure. All the above indicators are by no means the only ones that could be used but it is felt that they are more directly related with highway density and reflect more important dimensions of the socio-economic development as well as planning in each county.

General Theory of Highway Density and Differential of Development

One conceivable approach to the theory of the relationship between highway development and socio-economic development is to examine the impact of the former in mobilizing growth determinants. It is important because highway development as a policy issue is concerned with the spread of economic growth impulses through space. The major concern in this context is to influence growth differentials among regions or areas.

Theoretically, restrictions in the mobility of growth determinants are a primary cause for the spatial variations in development. The greater the mobility of production factors (natural resources, labour, capital and technology) between areas, the smaller the variation between them, [6] and similarly, the greater the mobility of external economies, the smaller the developmental variations. External economies are savings

resulting from interdependencies among different activities. They can operate through the market mechanism between different production activities via backward or forward linkages. In this case, their mobility and spatial extension depend upon interdependencies facilitated by the interregional transport development. However, if transport development is only limited to an area, and thus binding growth determinants to that specific locality, it will reinforce the development of the area where it is applied and do little to improve the differentials between regions. Therefore, implicit in this concept is the impact of spatial distribution of transport development. The higher the highway density in one area, the greater the mobility of growth determinants and theoretically, the more economically developed the area will be.

Highway Development and Population Distribution

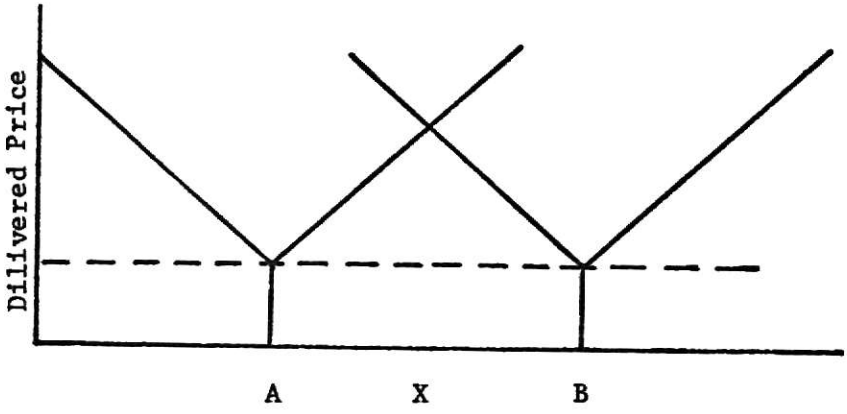
The relationship between transportation development and population distribution has been evident in many cases. Historically, the growth of many urban centers depended much on the transportation routes such as railroad towns. Today, the transportation structure has gradually changed from railroad to highway and the impact of the latter becomes more prominent. Therefore, it is expected that better highway development will attract more population, assuming that people prefer the location which provides better connectivity within the area and with the neighboring regions. However, it is not the intention of the author to say that the transport network is the whole cause for the pattern of population distribution; rather in some cases, it is both the cause and the consequence of

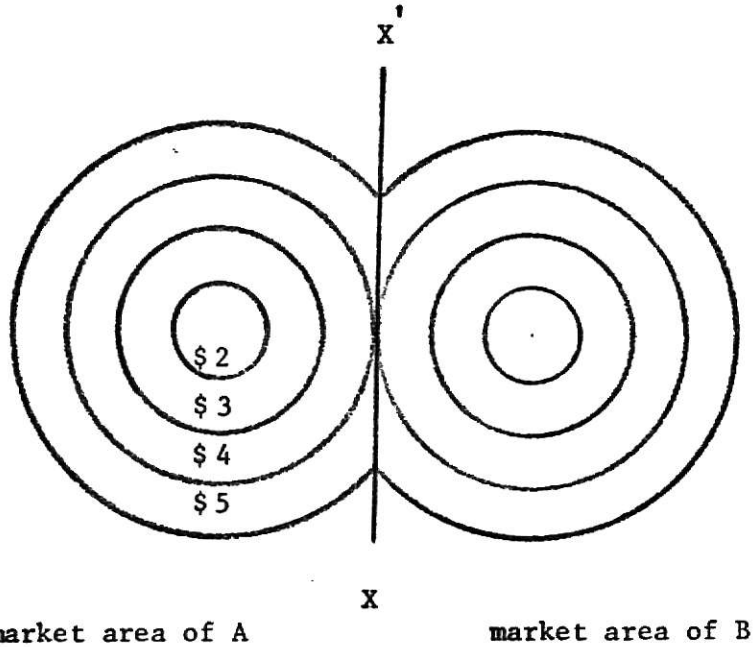
population settlement. When transportation creates new economic opportunities, it attracts more people to the area and they will demand more transportation facilities. However, in policy terms, accessibility is essential as a necessary condition for industrial development. Better accessibility and connectivity makes transportation of goods and services chaper and makes the locality more attractive for the location of economic activities and for population settlement in the center of the network or the most accessible point. Locally, it will encourage the agglomeration of population and development of population centers. Therefore, it is hypothesized that the higher the highway density, the higher the percentage of urban population in each county. In addition to this, with more highway development, people are more concentrated in the larger urban center which is usually in the center of the local transportation network. Therefore, the higher the highway density, the larger the size of the largest urban center in each county.

Impact of Highway Density on Industrial Development

The location of economic activites are determined by many factors some of which are ascertainable in measurable terms while others are merely the result of historical accident. However, there seems to be a general agreement that the principal factors include market, raw material, labour and transportation. Whatever the correct weighting may be, it is reasonable to say that transportation is

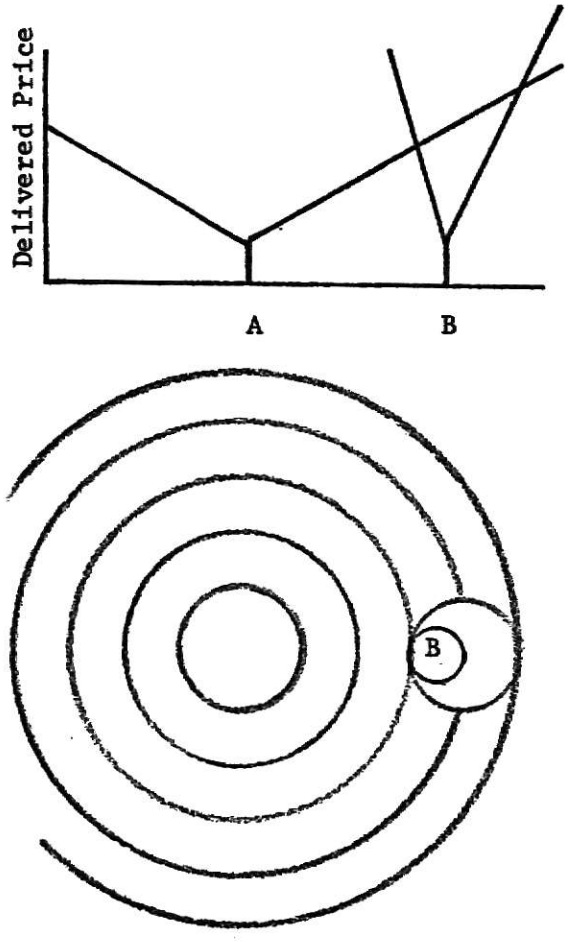
Figure 1 : Market Areas Where Firms Have Identical Production and Transport Costs





Source : M.J. Emerson, Urban and Regional Economics : Structure and Change. (Allyn and Bacon, Inc., 1975), p.67

Figure 2 : Market Areas When Producers Have Different Transportation Costs



Source : M.J. Emerson, Urban and Regional Economics:Structure and Change. (Allyn and Bacon, Inc., 1975), p.70

one of the major factors influencing the location of industrial activities because of its direct impact on transport cost and time as well as its effect on mobilizing other factors or growth determinants. On the one hand, higher highway density will improve linkages and accessibility among localities. These will reduce the total distribution cost and lead to the reduction of production cost. This in turn will make a higher output possible or lower delivered price to consumers, allowing increased savings and an internal capital accumulation, and inducing additional production or new plants which will increase the employment. Similarly, a reduction in procurement cost also yields transfer economies which ultimately leads to the increase of demand for labour.[8]

Another impact of higher highway density is on the inducement of specialization of firms. Better interconnection and accessibility to other industries or firms make it economical to specialize the production process. Therefore, it will reduce the average per-unit cost of production. Again, the effect of this internal scale economies will also lead to the demand for more labour. Moreover, the lower production cost of a firm will reduce the input cost of another, resulting in higher production of the other firms. Furthermore, the direct reduction of transport cost as well as the input cost will attract more new firms, increasing the demand for labour again.

On the other hand, highway density will also affect industrial development by enlarging the market area for a firm or an urban center. Suppose, there are two companies or factories A and B which have the same production cost represented by the height of the vertical stems

of the figure and transportation cost depicted by the gradient. (Figure 1) [9] In this case, the market for these two firms is actually evenly divided and X or the line X X' marks the market boundary because of the equal delivered prices represented by the curve. However, if there is a change in transportation cost because of better accessibility or linkages, the boundary of the market will change. The resulting market areas for the two firms and their corresponding delivered prices will be different (Figure 2). [10] Firm A captures a larger market area because of lower transportation cost. Therefore, larger demand will finally lead to increase in production and in demand for labour. In the above case, transportation cost is referred to as a criteria for transportation advantage. As a matter of fact, other advantages such as safety and time saving are also obtained as a result of better highway network. Central places or urban centers can also be substituted for firms in this illustration. In this case, better accessibility and linkages will attract more customers and strengthen the function of the central place so that there is a general growth of industries.

The theoretical concepts discussed in this section depict clearly the relationship between highway density and employment distribution. Therefore, in addition to the three hypotheses concerning the meaning of highway density in terms of population distribution, it is also hypothesized that the higher the highway density, the more employment in manufacturing and in other tertiary industries in the county.

Highway Density and Agriculture Activity

The traditional concept of the spatial distribution of agricultural

activities and transportation was formulated initially by Von Thunen in 1826 and was made more explicitly by Dun (1954), Losch (1954) and Isard (1956). [12] The main thrust of the model was the recognition of the controlling influence of economic rent on agricultural land use and of the spatial order in rent patterns imposed by transport cost together with the cost of transport. [13] Though the regularities in the agricultural land use pattern described by Von Thunen are less evident in today's complex society, his concept that the land adjacent to urban centers is farmed at the highest intensity remains true in many cases. Gottmann's classic study of Megalopolis is one of the examples.

With reference to the above concept, it is expected that highway density and farm size are negatively correlated. This hypothesis is made on the basis of the disruptive effect of highway on agricultural land. On one hand, a highway uses a lot of farmland and actually bisects many farms so that it will disrupt the regular agricultural activities and may make extensive farming difficult. On the other hand, highway development generally encourages urbanization and leads to urban sprawl. The land that is expected to become urbanized will have a higher value because of the anticipated change to urban land use and many lots will be held for speculation. The high value of farmland will make it uneconomical to practise extensive farming. Instead, farms will use smaller areas and be more specialized, with emphasis on market gardening, dairying and poultry husbandry which generally have better profit returns. Therefore, it is hypothesized here that the higher the highway density, the smaller the average farm size in each county.

As to the employment in agricultural industry in relation with highway density, there are two hypotheses to be made :

first, highway density and percent of labour force in agricultural industry in each county are negatively correlated,

secondly, highway density and employment in agricultural industry are positively correlated.

It is recalled that the relationship between highway density and urbanization as well as the employment in different sectors is, at least theoretically, positive. In this sense, the percentage of labour force in counties with higher highway density is also larger in manufacturing and tertiary industries but the percentage of employment in agricultural industry is smaller.

Summary of Hypothesis

This section summarizes the hypotheses that have been made. The first three are concerned with the characteristics of population distribution. The next five are related with the absolute number of employment in different sectors. Hypotheses 9 considers farm size while the rest (10 - 14) hypothesize the relationship between highway density and the percent of employment of different sectors in the total labour force.

It is hypothesized that highway density is positively correlated

1. with the population density in each county,
2. with the percent of urban population in each county,

3. with the size of the largest urban center in each county.

4. with the total employment in manufacturing in each county.

5. with the total employment in retail industry.

6. with the total employment in financial and insurance industry.

7. with the total employment in professional and related service.

8. with the total employment in agricultural industry.

negatively correlated

9. with the average farm size of each county.

10. with the percent of labour force in agricultrual industry.

positively correlated

11. with the percent of labour force in manufacturing .

12. with the percent of labour force in retail industry.

13. with the percent of labour force in financial and insurace industry.

14. with the percent of labour force in professional and related service.

Definition of Dependent Variables

Population density:

number of people per square mile.

Urban population:

It comprises all persons living in urbanized areas and in places of 2500 inhabitants or more outside urbanized areas.

Farm size:

average area of farm in acres.

Manufacturing industry:

furniture and lumber and wood products,

machinery, except electrical,

electrical machinery, equipment and supplies,

transportation equipment,

other durable goods,

food and kindred products,

textiles and fabricated textile products,

printing, publishing and allied industries,

chemicals and allied products,

other nondurable goods,

Retail industry:

food, bakery and dairy stores,

eating and drinking places,

general merchandise retailing,

motor vehicle retailing and service stations,

other retail trade,

Financial and Insurance:

banking and credit agencies,

insurance, real estate and other finance,

Professional and related services:

hospitals,

health services, except hospital,

elementary, secondary schools and colleges, both government and private,

other education and kindred services,

welfare, religious and nonprofit membership organizations,

legal, engineering and miscellaneous professional services,

Agricultural industry:

fisheries, forestry,

agricultural production,

agricultural services except horticultural,

horticultural services,

forestry,

fisheries,

agriculture, forestry and fisheries.

Chapter 3

METHODOLOGY

The purpose of the paper is to examine the relationship between highway distribution expressed by highway density of different counties and the spatial economies and to see if it is true that highway distribution is correlated with the spatial pattern of socioeconomic structure between counties. The method used for the study is regression analysis.

Regression Analysis

Essentially, it is a method for finding the linear relation between two variables, Y and X which are sometimes called dependent and independent variables respectively. In this case, Y is represented by the different socioeconomic indicators while X is referred to highway density and their relationship can be written in equation form:

$$Y = a + b\ X$$

where a is the intercept and b is the regression coefficient. By the regression method, the relationship between the dependent variables and highway density can be shown. The hypotheses can be justified and the regression models can be used for prediction.

Study Area and Data Input

The State of Kansas is chosen for the study of the relationship between the dependent variable and highway density. In the study, one

hundred and two counties were selected. Three counties including Johnson, Leavenworth and Wyandotte are excluded in the study mainly because whole or part of these counties are in the metropolitan area of Kansas City. The calculation of highway density in these counties will be misleading.

The data for the population and employment variables are based on the 1970 census published by the Bureau of the Census and other available resources while the highway density is acquired by dividing the 1970 total mileage of highway in each county by the total area of the county and the area unit is expressed in ten square miles.[15] Then every dependent variable will be regressed on the independent variable separately by using the SPSS computer program.

Theoretically, data used in the regression analysis are assumed to be normal but in real world, this is not always the case. Therefore, before the actual computation, all data are tested for their normality by plotting on papers. Generally speaking, the data of highway density were more toward normality than the rest though positive skewness was still obvious. Therefore, it is expected that transformation of the data of dependent variables would probably improve the regression equation. In the first run, regression equations were obtained by using raw data. Then the result would be analyzed. If there is any indication that transformation of data will improve the model, a logarithmic transformation will be performed on the raw data. To certain extent, transformation in this way is based on reasoning. However, in reality, it may be regarded as trial and error.

Accompanied with the equation, several statistical information

essential to the interpretation of the result were obtained. These include the simple correlation coefficient which measures the mutual relationship between two variables, the coefficient of determination which indicates the proportion of variance that can be explained by the regression model, the F-value which tests the significant level of the correlation and the residuals which help to indicate the deviation of spatial distribution from the expected value.

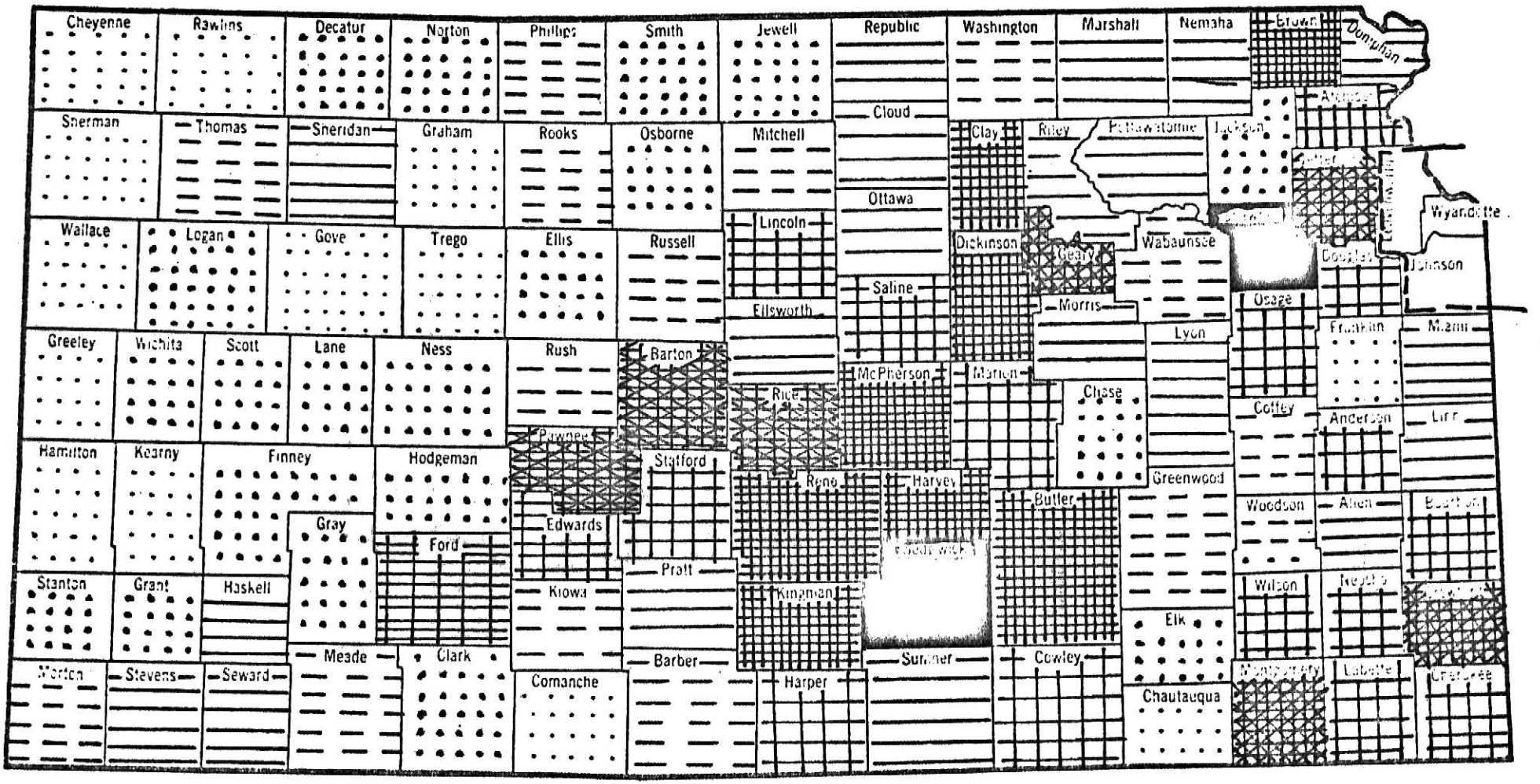
Chapter 4

EMPIRICAL EVIDENCE

The Spatial Distribution of Highway Density

Before the statistical analysis, a brief study of the present spatial distribution of highway density may help us to understand the relationship between the density and the dependent variables. Map 1 shows the pattern of distribution of highway density in the State of Kansas. It indicates a basic west to east increase of mileage with a general high density in subregion 012 of East Central, South East Central and in subregion 051 of South West Central. (refer to Map 2 for the region) The highest density occurs in Shawnee and Sedgwick Counties followed by Jefferson, Rice, Crawford,Barton, Paqnee, Montgomery, Geary and so on. On the contrary, a trough of low density is found in the south section of Flint Hill Region. Then beyond South Central Region, there is a marked decrease in density in the west half of the State. In particular, the north-west and the far west are the regions with the lowest density. However, in subregion 072 of Far South West Region, there are a few counties with comparatively high density and appear as the sub-foci of the hierarchical system of the whole highway network.

Map 1 : Spatial Distribution of
Highway Density

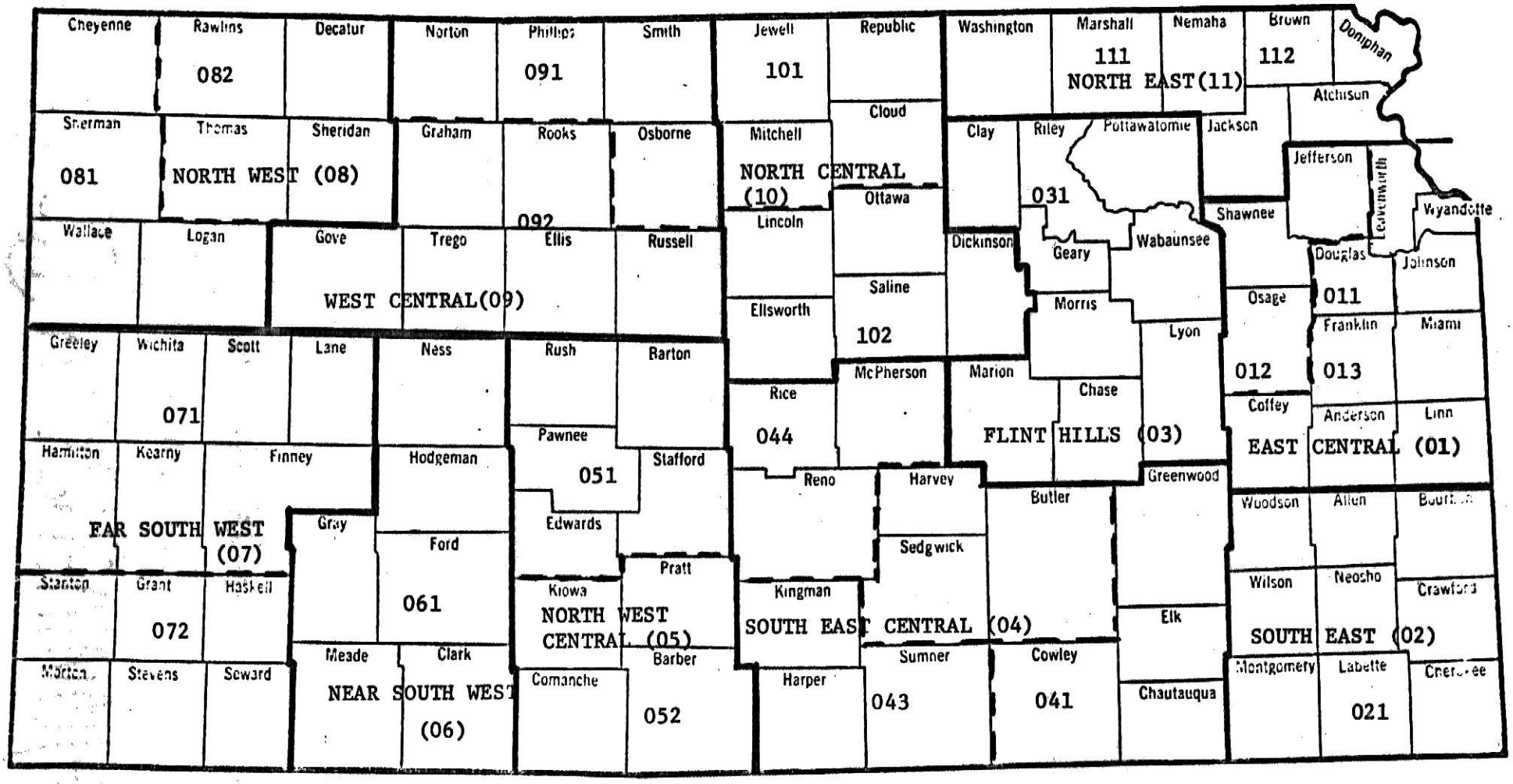


miles of highway / ten sqaure miles of land

below 1 | 1.0-1.4 | 1.5-1.9 | 2.0-2.4 | 2.5-2.9 | 3.0-3.4 | 3.5-3.9 | 4 and over

counties not included

Map 2 : Regions and Subregions of Kansas



Source : Planning Divsion, KDED,
Regional Delineation for Kansas
Report No. 5B (1966)

Code : 01 Region
011 Sub-region

Correlation Analysis

Simple correlation coefficients (r) showing the association between highway density and all dependent variables were tabulated in Table 1. The measure of association is applied to the entire area under study and is used for describing the degree of spatial correspondence among the areal variation of the variables as measured of the validity of hypotheses constructed.

It is recalled that all input data of the first run is without logarithmic transformation. The correlation coefficient between highway density and dependent variables is on the whole not very high. However, statistically, the level of association is still acceptable. This judgement is mainly based on the fact that the study is a cross-section study in spatial correspondence to areal variation whose coefficient is usually not so high as that of longitudinal study. Secondly, the degree of correlation is also affected by the large range of mazimum and minimum data under study. Population density, for instance, ranges from 348 people per square mile in Sedgwick County to two persons per square mile in Greeley County. Similar case is also found in the percent of urban residence, from 90.5 to 0 and in other such as manufacturing data as well as financial and insurance data. In addition to these, the contrast in local characteristics in each county also makes the data comparatively more scattered and thus results in a lower coefficient . Therefore, in interpretating the result, these points may help to make a more objective evaluation.

The correlation coefficient in Table 1 shows that highway density

Table 1 : Summary of Arithmetic Regression Models

(data without transformation)

Regression equation	r	r^2	F
Y1 = -31.90 + 26.543 X	0.53	0.28	38.24
Y2 = -7.408 + 18.200 X	0.55	0.30	43.64
Y3 = -12865.696 + 10640.523 X	0.40	0.16	18.58
Y4 = -2328.852 + 1623.658 X	0.39	0.15	18.47
Y5 = -1469.749 + 1255.677 X	0.46	0.21	27.48
Y6 = -524.369 + 379.868 X	0.44	0.19	23.38
Y7 = -1819.678 + 1510.733 X	0.46	0.21	27.07
Y8 = 363 + 164.656 X	0.50	0.25	33.60
Y9 = 1357.001 - 300.13 X	- 0.65	0.42	74.45
Y10 = 39.241 - 8.279 X	- 0.68	0.46	85.88
Y11 = -1.008 + 5.123 X	0.61	0.37	59.61
Y12 = 17.839 - 0.015 X	0.00	0.00	0.002
Y13 = 2.324 + 0.432 X	0.26	0.07	07.46
Y14 = 10.117 + 4.936 X	0.23	0.05	05.50

Y1 : population density of each county

Y2 : percent of urban population of each county

Y3 : size of the largest population center of each county

Y4 : employment in manufacturing industry of each county

Y5 : employment in retail industry

Y6 : employment in financial and insurance industry

Y7 : employment in professional and related services

Y8 : employment in agricultural industry

Y9 : average farm size of each county

Y10 : percent of labour force in agricultural industry

Y11 : percent of labour force in manufacturing industry

Y12 : percent of labour force in retail

Y13 : percent of labour force in financial and insurance

Y14 : percent of labour force in professional and related services

has a higher correlation with Y9 (farm size), Y11 (percent of labour force in manufacturing), Y10 (percent of labour force in agricultural industry). Then next to this group are Y1 (population density), Y2 (percent of urban population) and Y4 (employment in manufacturing) while the simple correlation coefficient of the rest are below 0.5 with Y12 (percent of labour force in retail industry) the lowest. All dependent variables except farm size and percent of labour force in agricultural industry are positively related with highway density. In the two cases, the negative nature of the function were also hypothesized. The Table also summarizes the regression equations for each dependent variable and other statistical tests. The result of each test supported every hypotheses, except Y12, that were constructed. Though in some cases, the level of explanation is not high, the F-value are also significant at the 0.05 and 0.01 level which indicates that the hypotheses, except Y12, are statistically accepted.

On the Choice of Regression Model

One of the assumptions of the preceding regression models are linear and the data are normally distributed but in many cases, the relationship between two variables may not be linear and the data are not in normal curve. As it has been pointed out before, plotting shows that most of the data of the regression model tend to form a skew frequency distribution and quite a large proportion of data is clustered in the lower values and as a result of this, the placing regression line is unduly influenced by a relative few high values. This suggests that

a simple linear relationship between highway density and other dependent variables may not be able to indicate vividly the real relationship between variables. Rather, the relationship that exists has a closer approximation to some other non-linear function, so that the " best-fit " regression line is in fact a curve which can be defined by a mathematical expression. Therefore, all data of each dependent variable were transformed into logarithms. In this case, the semi-logarithmic model indicates that the dependent variable will increase at an increasing rate. However, for some variables such as employment in agricultural industry, reasoning seems to favour different rate of change. e.g. increase at a decreasing rate. Therefore, in order to get an in-depth analysis, relationships were also investigated in terms of logarithmic transformation in addition to semi-logarithmic.

The transformation of the data of the dependent variable does help to improve the regression model. Almost all of the correlation coefficient of each model have increased. Consequently, the coefficient of determination is raised and therefore the variation that can be explained by highway density has significantly been improved. In the case of employment in manufacturing, the coefficient of determination has increased over 40 percent more than that of the arithmetic model. Similarly, other models concerning population density, employment in retail industry, employment in financial and insurance and employment in professional and related services have increased more than 30 percent while the increase of r^2 in other models ranges from one to thirty.

Beside coefficient of determination, other statistical information

Table 2 : Summary of Chosen Regression Models

Dependent variable	Equation
population density of each county	log Y1 = 0.312 + 0.371 X
percent of urban population of each county	log Y2 = 0.309 + 2.391 log X
size of the largest urban center in each county	log Y3 = 2.988 + 0.293 X
employment in manufacturing of each county	log Y4 = 1.158 + 0.591 X
employment in retail industry of each county	log Y5 = 2.108 + 0.329 X
employment in financial and insurance industry	log Y6 = 1.210 + 0.385 X
employment in professional and related services	log Y7 = 2.047 + 0.362 X
employment in agricultural industry	log Y8 = 2.693 + 0.440 log X
average farm size of each county	log Y9 = 3.020 - 0.820 log X
percent of labour force in agricultural industry	log Y10= 1.741 - 0.229 X
percent of labour force in manufacturing	log Y11= 0.482 + 1.293 log X
percent of labour force in financial and insurance	log Y13= 0.353 + 0.057 X
percent of labour force in professional and related services	log Y14= 1.152 + 0.053 X

Equation	correlation coefficient	coefficient of determination (r^2)	F
Y1	0.77	0.59	146.59
Y2	0.58	0.34	51.65
Y3	0.57	0.33	49.17
Y4	0.76	0.58	132.68
Y5	0.72	0.52	106.21
Y6	0.68	0.46	87.48
Y7	0.73	0.53	112.97
Y8	0.51	0.26	35.89
Y9	0.71	0.50	100.58
Y10	0.69	0.48	92.11
Y11	0.70	0.49	94.70
Y13	0.29	0.08	9.14
Y14	0.32	0.10	11.27

and observation are also of importance to the evaluation of the validity of regression models such as the F-value, the intercept of the equation, sign of the equation and the reasoning of the change between independent and dependent variables. The final regression models to interpretate the relationship between highway density and the dependent variables were summarized in Table 2. The selection is based on different aspects mentioned above. For instance, in the regression model for population density (Y1), the semi-logarithmic regression equation is much higher than that of the arithmetic one and the power of explanation of the variance of population density has increased significantly. The F-value which tests the significant level of the correlation between X and Y variables is also higher. This semi-logarithmic regression equation has the same advantage over the logarithmic equation with both variables transformed. In addition to this, the rate of change in Y in response to per unit change in X is more toward reality because the semi-logarithmic equation indicates an increase at an increasing rate. Similarly, the choice of the agricultural employment models is based mainly on reasoning as well as the trend of development of agricultural industry in the State because the simple correlation coefficient, r^2 , and F-value are very close. Of the three forms of equation, they indicate the same positive relationship between X and Y variable but in terms of rate of change, the arithmetic model shows a constant increase of employment, the semi-logarithmic model shows an increase at an increasing rate while the logarithmic equation, on the contrary, indicates an increase at a decreasing rate. Therefore,

with reference to the trend of development of agricultural employment as well as the higher coefficient of determination, the logarithmic model was chosen.

Among the selected regression models, there is no arithmetic one included because it has been shown that transformation makes the curve fit the data better particularly the semi-logarithmic models which are characterized by their change at an increasing rate if the relationship between X and Y is positive and at a decreasing rate if the relationship is negative. Indeed, this form of relationship tells much about the space economy and highway density which will be discussed next chapter.

Analysis of Residuals

Most of the spatial patterns of economic landscape are highly complex and apparently result from the interplay of different variables. Owing to the purpose of the study, only one independent variable is used to explain the variation of space economy in the State. Therefore, there is need to assess the efficacy of the regression model developed and to examine the empirical and conceptual relevance by mapping and analyzing of the residuals so that more confidence can be realized in using the regression model to explain and estimate the distribution of economy.

The simplest way to obtain the residual is to substract the predicted or computed from the observed value.[16] In some cases, however, researchers would favour the standardized residual to render

the residual from magnitude free by putting in the standard error of estimate as shown in the following formulae. [17]

$$\frac{Y - Y_c}{S_y}$$

where Y = observed value of Y for the n^{th} county

Y_c = computed or predicted value of Y for the n^{th} county.

S_y = standard error of estimate for Y.

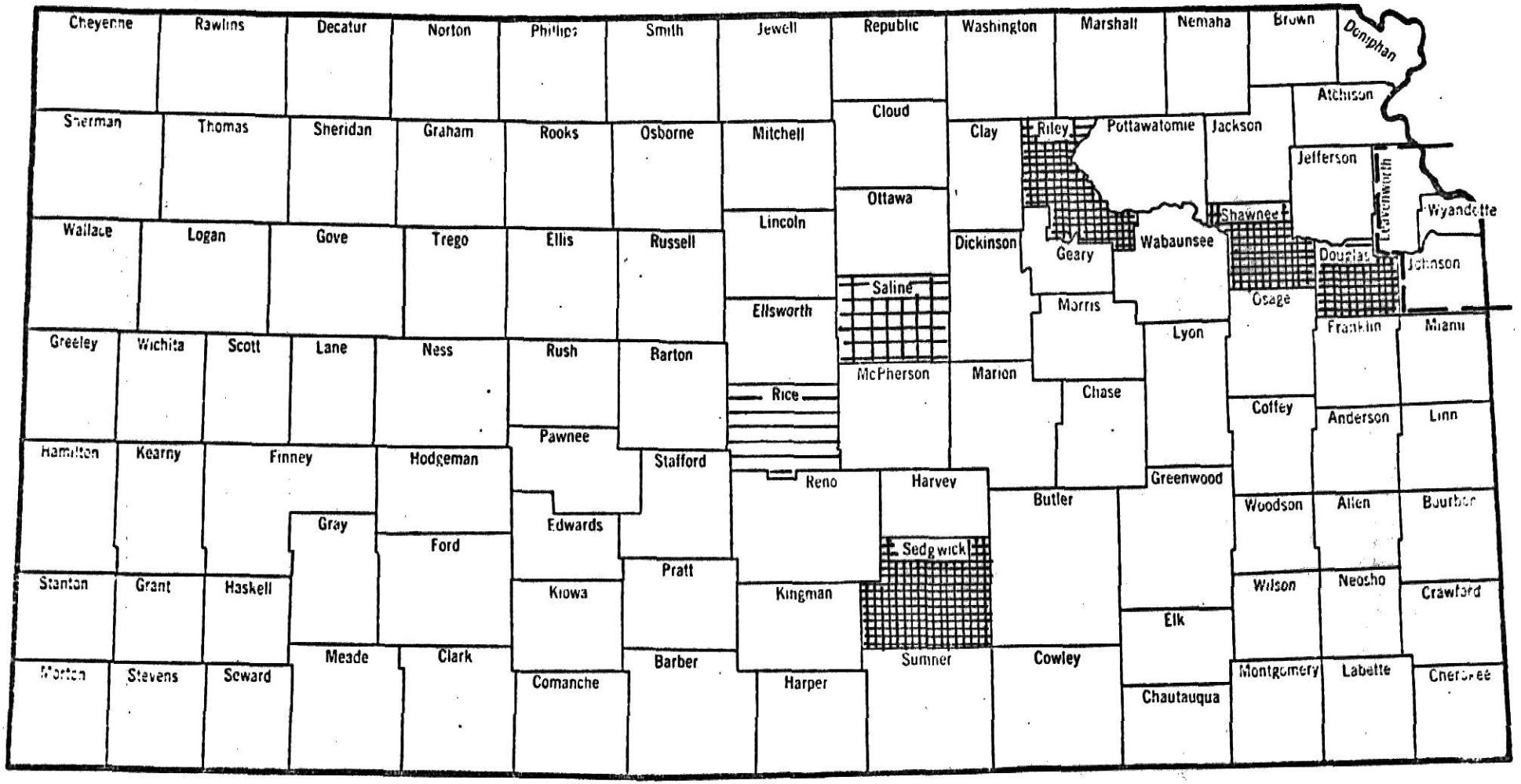
Therefore, the positive value of the residual indicates that the computed is less than the observed. It represents an under-prediction wile a negative value denotes an over-prediction.

Residuals from selected regression models were mapped in Map 3 through Map 5. Since the predicted value were in logarithmic form, they were retransformed back into absolute value. In other words, the value is the antilog of the computed logarithm of dependent variable.

The residual from the regression model of population density was mapped in Map 3. Of the one hundred and two counties, there were ninety-five within one standard error and only seven counties were beyond this limit. Sedgwick County was under-predicted by seven standard errors, followed by Douglas (2.73), Shawnee (2.28), Riley (2.05), Saline (1.05). Riley County was the only one that was over-predicted. The reason for the under-prediction may be due to the fact that every one of these six counties has a city with large

Map 3 : Highway Density -- Population Density

Residuals from Regression Model



standard error

over -1.5 | -1.0 to -1.5 | -1.0 to 1.0 | 1.0 to 1.5 | over 1.5

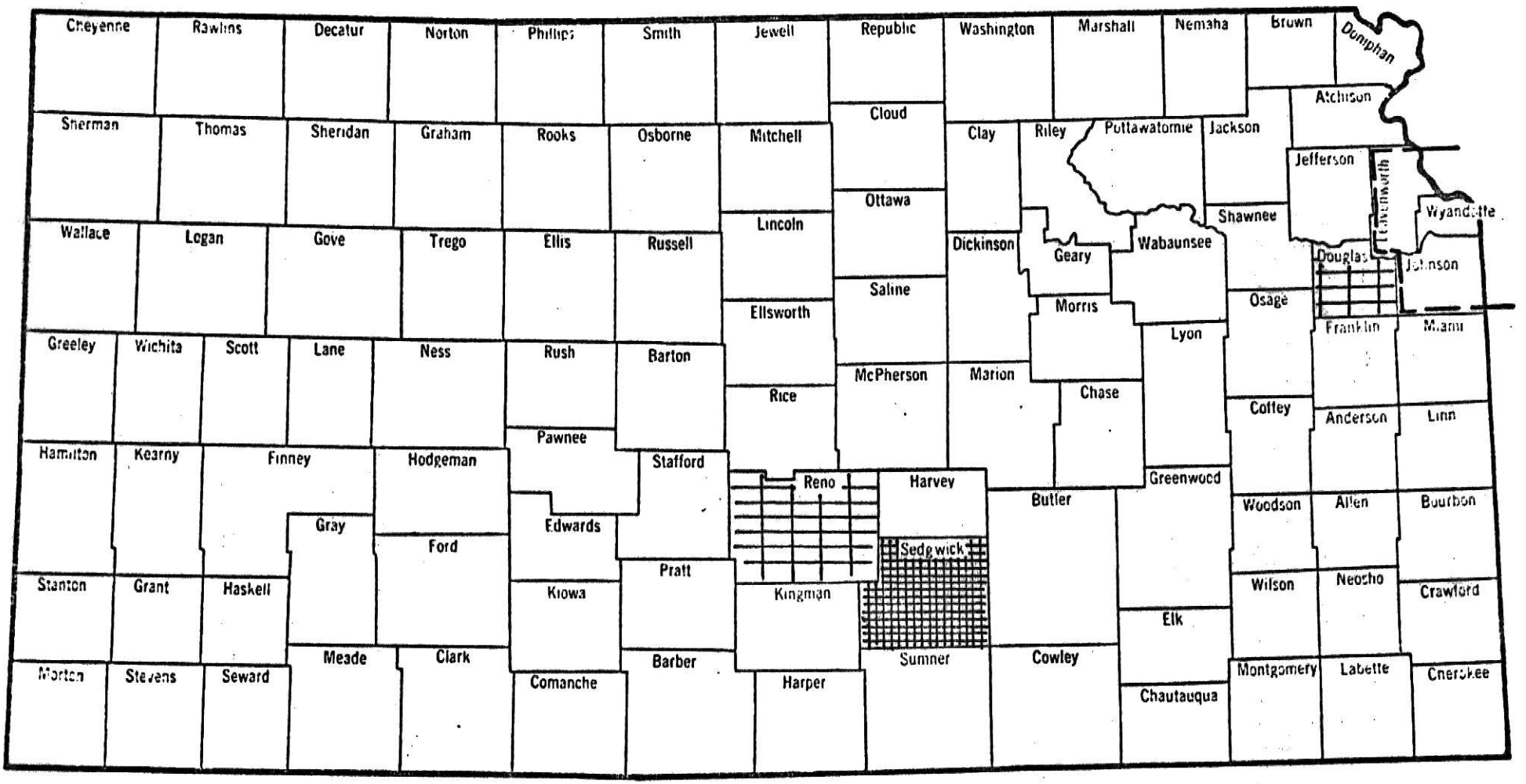
counties not included

population. For instance, the average population density of each county in the State is only 24 but the population density of Sedgwick County is 348, Shawnee is 283 and Douglas is 123. As to the other ninety-five counties, most of them were within 0.5 to -0.5 standard error and only eight counties were within 0.5 to 1.0. Therefore, the accuracy of the regression model can be reliable in these counties.

Residual mapping for the regression model of employment in manufacturing (Map 4) revealed similar distribution pattern of under-prediction. There were only three counties under-predicted : Sedgwick (9.8), Douglas (1.0) and Reno (1.1). The large standard error of Sedgwick County yields no surprise. In comparison with the State average of manufacturing employment (1078), the extreme large number of employment in manufacturing (36602) makes it an exceptional case and same are the cases in Douglas (3906) and Reno (4950). As to the rest of the counties, seven of them had a standard error within 0.5 to 0.9 or -0.5 to -0.9. They were Butler (0.83), Cowley (0.60), Jefferson (0.62), Labette (0.55), Montgomery (0.66), Pawnee (-0.53) and Shawnee (0.58). Then the other 92 were within 0.5 to -0.5. On the other hand, an overview of all residuals shows that there appears to be a tendency to over-predict those counties away from large urban centers e.g. those in the far west and far north and under-predict (with positive residuals) those close to large centers. This reflects the impact of urban centers in the employment distribution. Therefore, if in-depth analysis is required, the study area can be subdivided into regions with different levels of manufacturing growth potential. This

Map 4 : Highway Density -- Employment in Manufacturing

Residuals from Regression Model

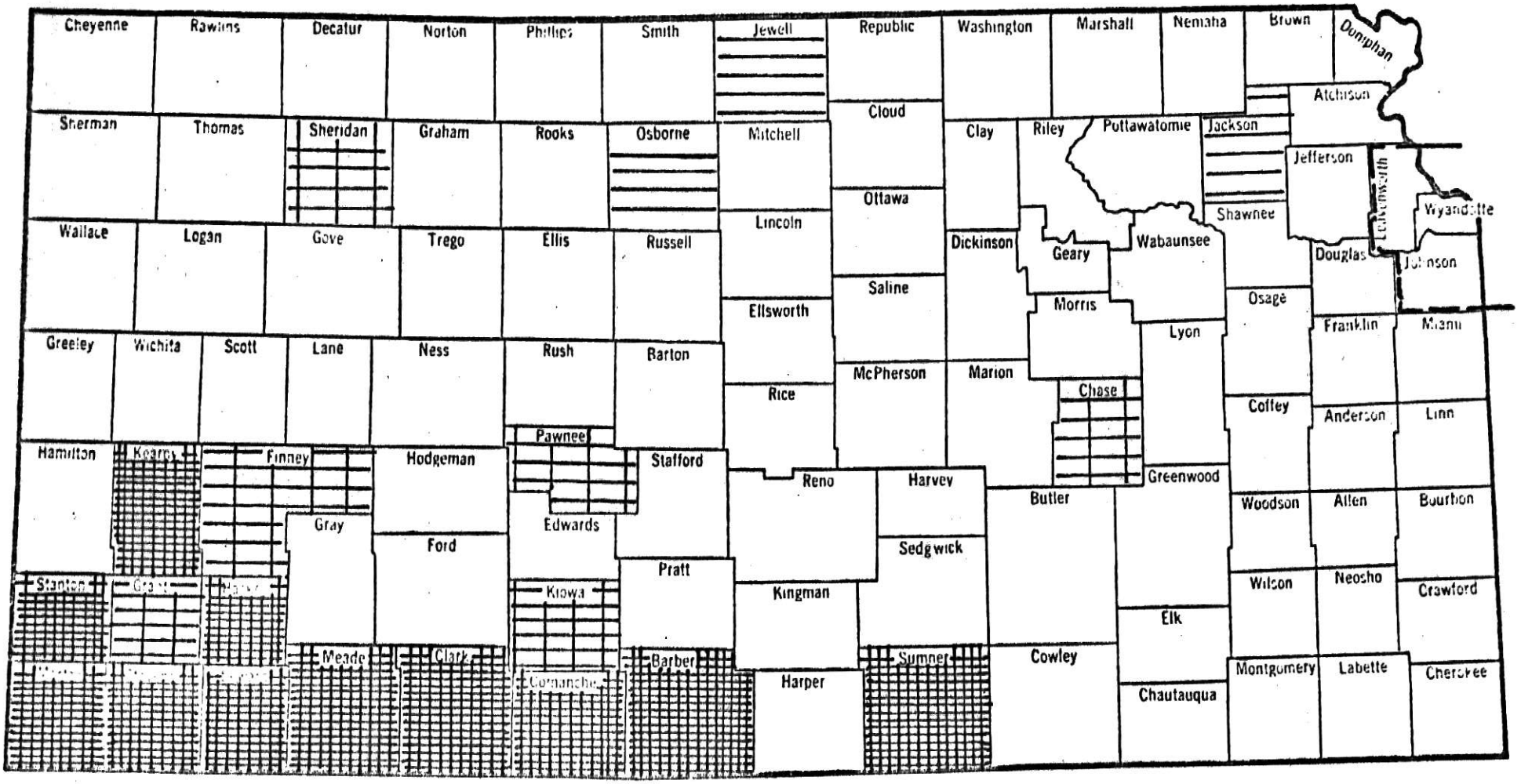


standard error

over -1.0 -1.0 to 1.0 1.0 to 1.5 over 1.5

counties not included

Map 5 : Highway Density -- Average Farm Size
Residuals from Regression Model



standard error

Over -1.0 | -1.0 to 1.0 | 1.0 to 1.5 | over 1.5

counties not included

stratification may give more insight to the distribution of employment in manufacturing.

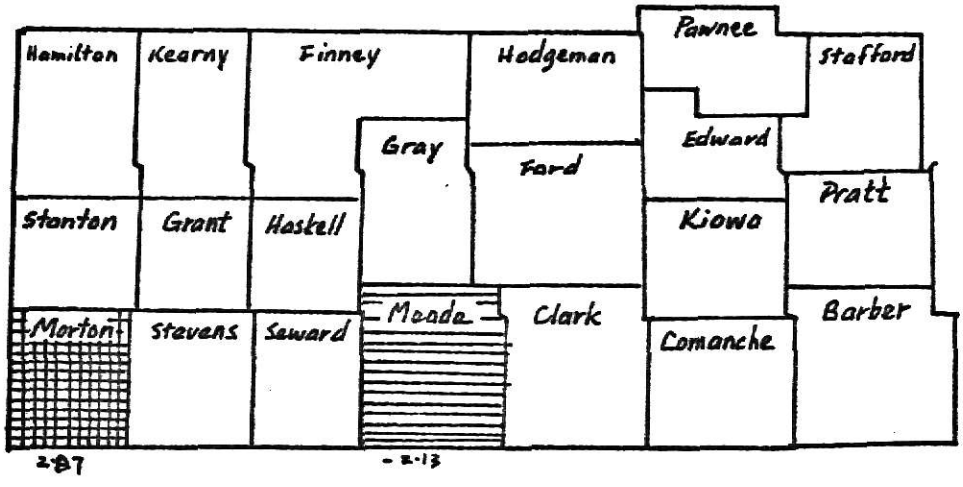
As to the residual map of the average farm size of each county, there were 22 counties predicted with more than one standard error. Of these counties, 15 of them were located in the south-west region of the State and all of them were under-predicted. This implies that the average farm size in the region is different. This variation may be due to the impact of other variables such as soil, climate and water availability in the area. Therefore, these twenty-one counties in the region were separated from the rest and recompute the data. Two new regression equations were obtained, one for the south-west region and one for the other eighty-one counties.

Regression Equation	r	r^2
South-west Region		
$\log Y = 3.183 - 0.557 \log X$	0.74	0.55
Other eighty-one counties		
$\log Y = 2.953 - 0.785 \log X$	0.78	0.61

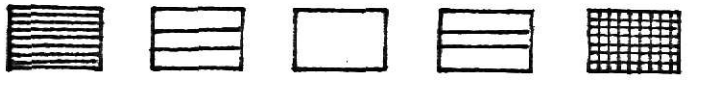
The residual from the new regression model for the south-west region was shown in Map 6. It shows that there were only two counties with more than one standard error. One is under-predicted and another is over-predicted. These two may be regarded as exceptional cases because as it will shown later (Map 10), Morton County is one of the three counties with the largest farm size in the State of Kansas.

Map 6 : Highway Density -- Farm Size (south-west region)

Residuals from the Regression Model



standard error



over -1.5 | -1.0 to 1.5 | -1.0 to 1.0 | 1.0 to 1.5 | over 1.5

Chapter 5

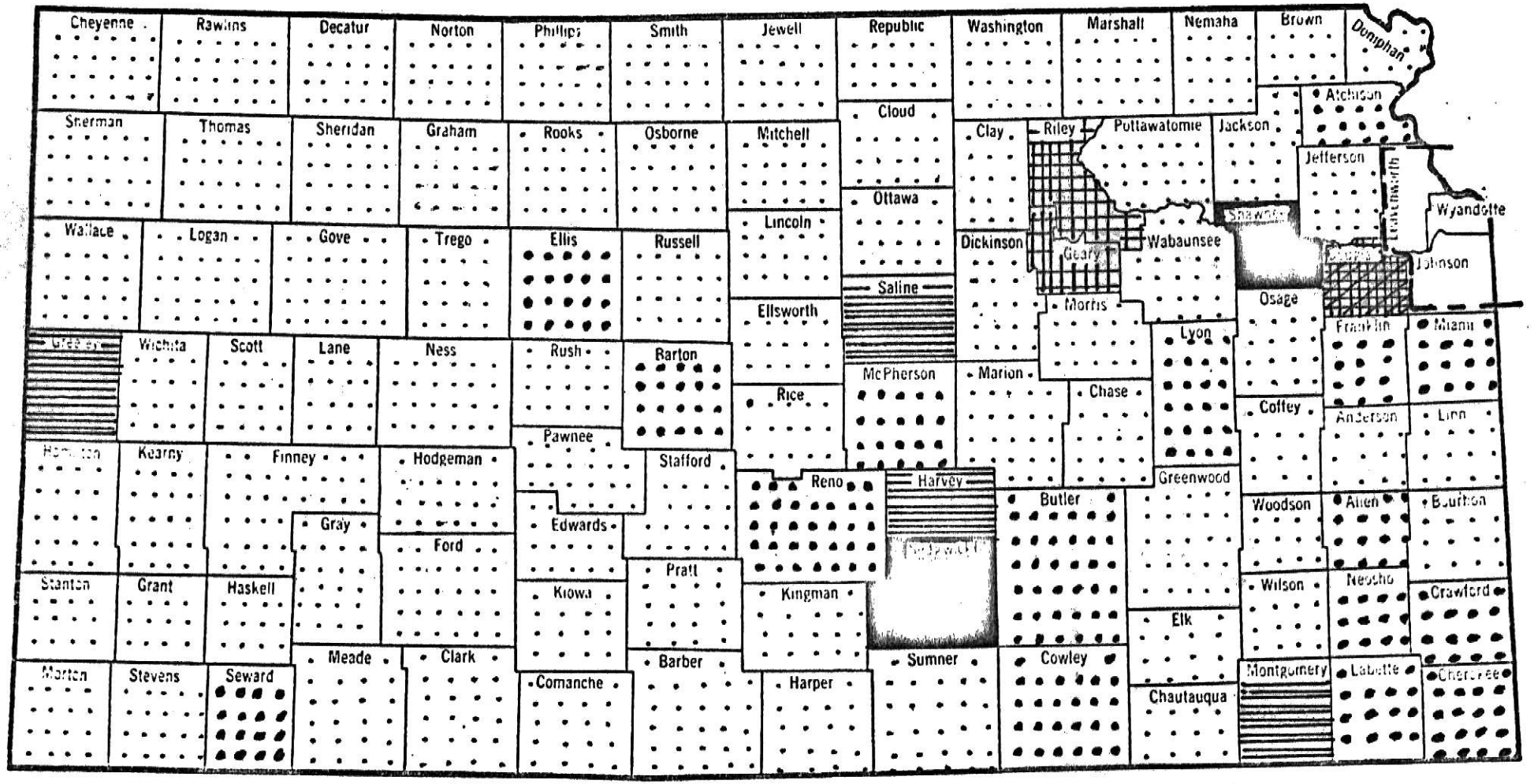
EMPIRICAL ANALYSIS

Population Dimension

It has been shown that highway density distribution is positively correlated with population density, percent of urban population and size of the largest population center. Sedgwick and Shawnee County have the highest highway density and act as the center of their own region. Other sub-foci can be found in the south-east region such as Montgomery and in the south-west region such as Seward County and Ford County. This pattern of distribution is consistent with that of the population variables. Map 7 shows that Sedgwick and Shawnee are at the top of the population hierarchy with the same population sub-foci as the pattern of highway density in the south-west and the south-east. The low population profile in the far west and the north-west can also be reflected by the low density of highway in these regions.

The relationship between the independent variable and population dimension was examined in terms of three different data transformation: arithmetic, semi-logarithmic and logarithmic. The semi-logarithmic model of population density indicates that relative to highway density, the dependent variable increases at an increasing rate as shown in Figure 3. This reflects the nature of the relationship and suggests a system not in equilibrium (theoretical equilibrium would result in return to mobile factors being everywhere the same.) mainly because of the fact that most of

Map 7 : Spatial Distribution of Population Density



Source : based on

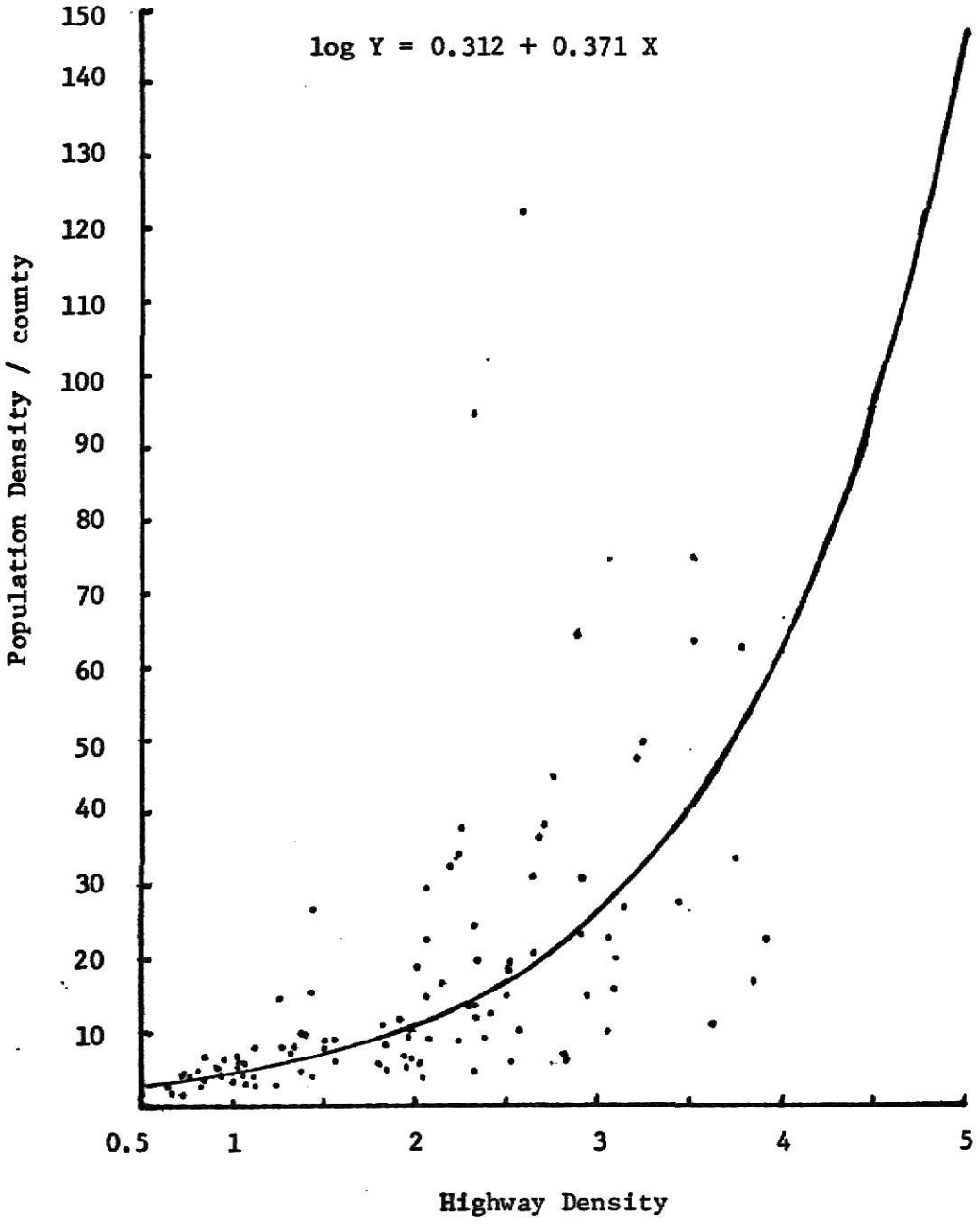
Bureau of the Census

person/ square mile

under 25 | 25-50 | 50 - 75 | 75-100 | 100-125 | over 125

counties not included

Figure 3 : Population Density --- Highway Density Relationship



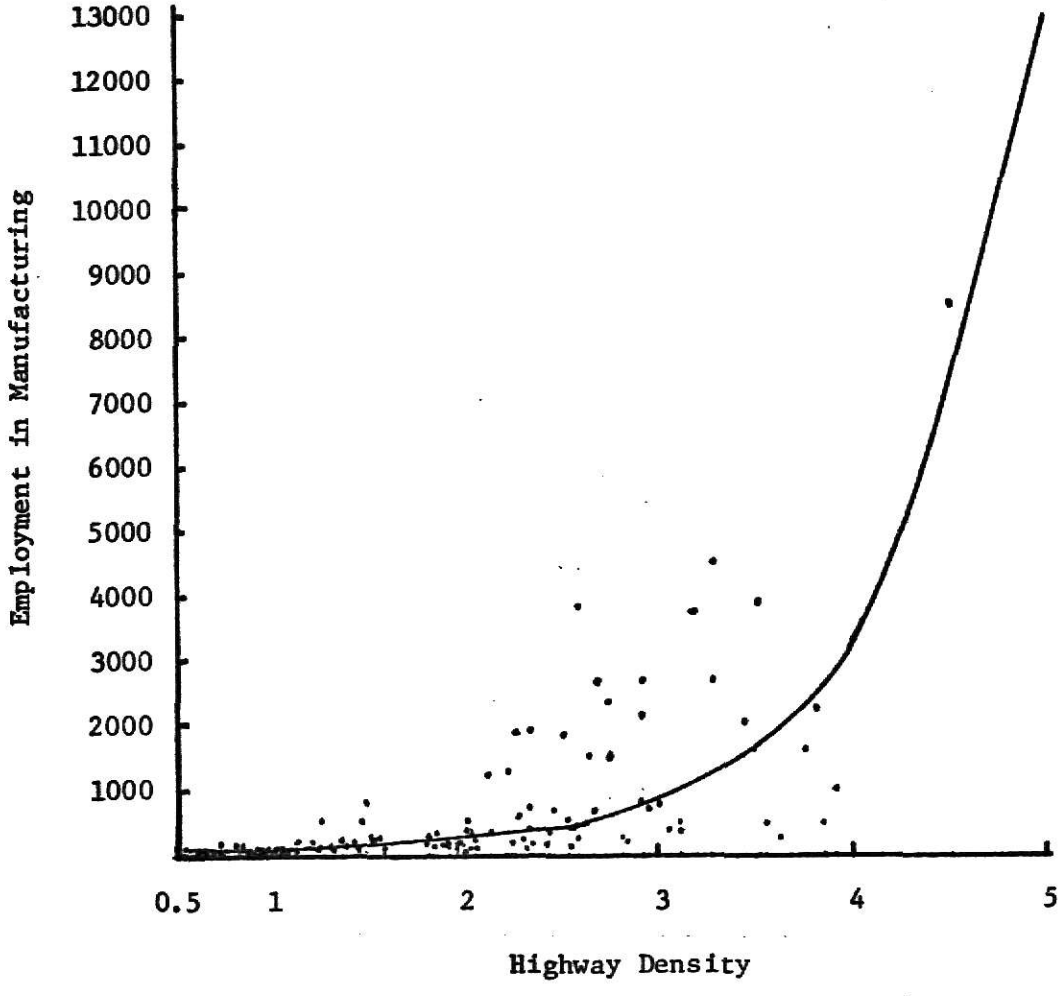
the counties in the study area do not have large enough population and activity concentrations to sustain population growth and thus the response of these counties to the increase of highway density would be inelastic while the more populated counties would function more efficiently and attract more population and are more responsive.

Highway Density and Spatial Variation of Employment

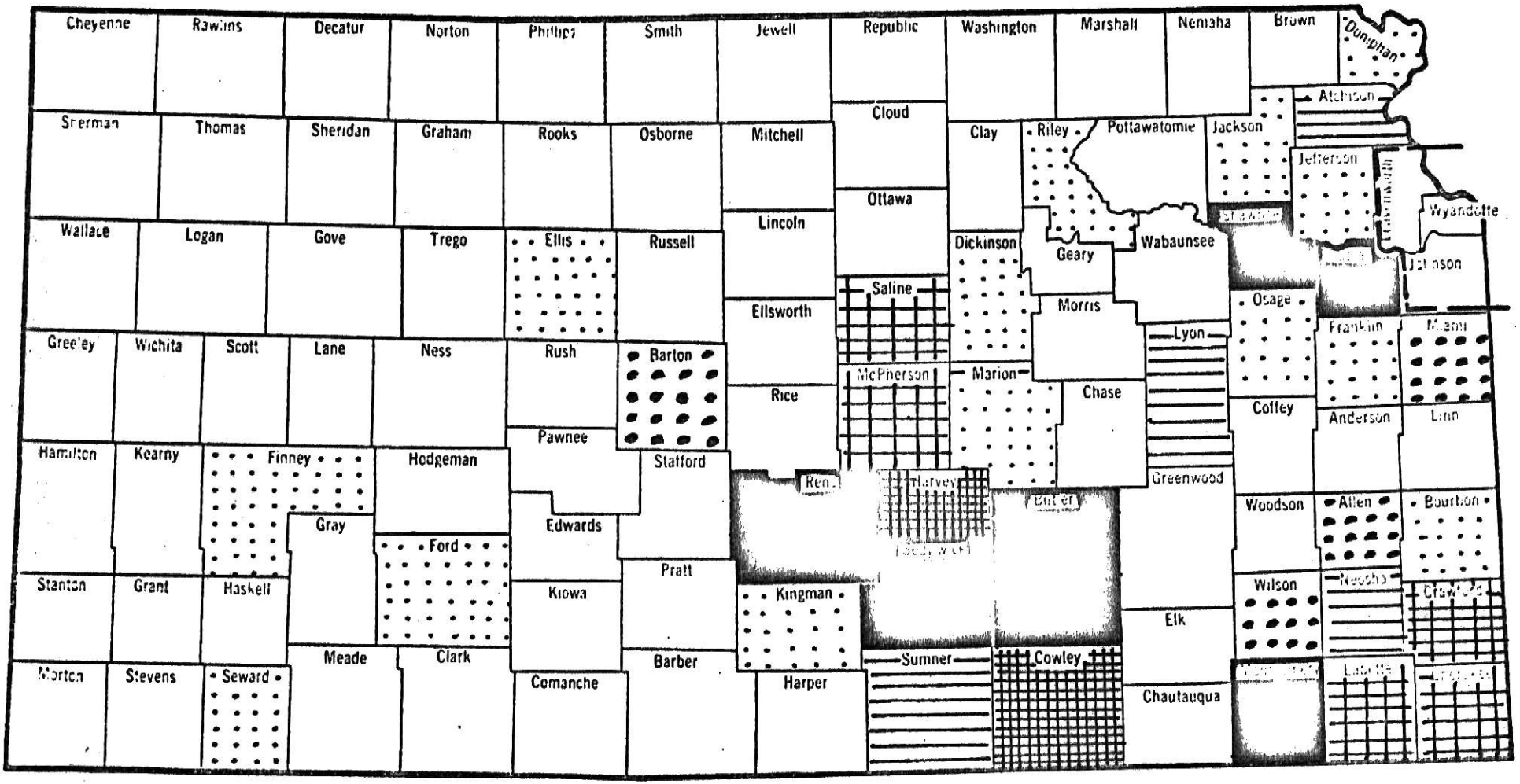
The hypothesis that there is more employment in manufacturing in counties with higher highway density was tested and supported by the nature of the regression line, coefficient of determination as well as the significance level. The semi-logarithmic function also further suggests that the number of people engaged in manufacturing would increase, relative to highway density, at an increasing rate. In other words, those counties with higher highway density will have a greater increase in the employment than counties with low density. This suggests the effect of agglomeration economies. Better connectivity among different localities will attract more plants as it was discussed in the previous chapter. In addition, the new in-coming plant will in turn attract other establishments owing to transfer economies. Transfer economies are the savings in transportation costs which accrue when firms locate close together. Therefore, the total distribution costs will be reduced and the delivered prices to consumers lowered. Demand for the goods will increase and same is the total revenue for some or all businesses. Therefore, transfer economies encourage firms to cluster. On the other hand, a reduction in procurement cost also

Figure 4 : Employment in Manufacturing ---
Highway Density Relationship

$$\log Y = 1.158 + 0.591 X$$



Map 8 : Spatial Distribution of Employment in Manufacturing



Source : based on

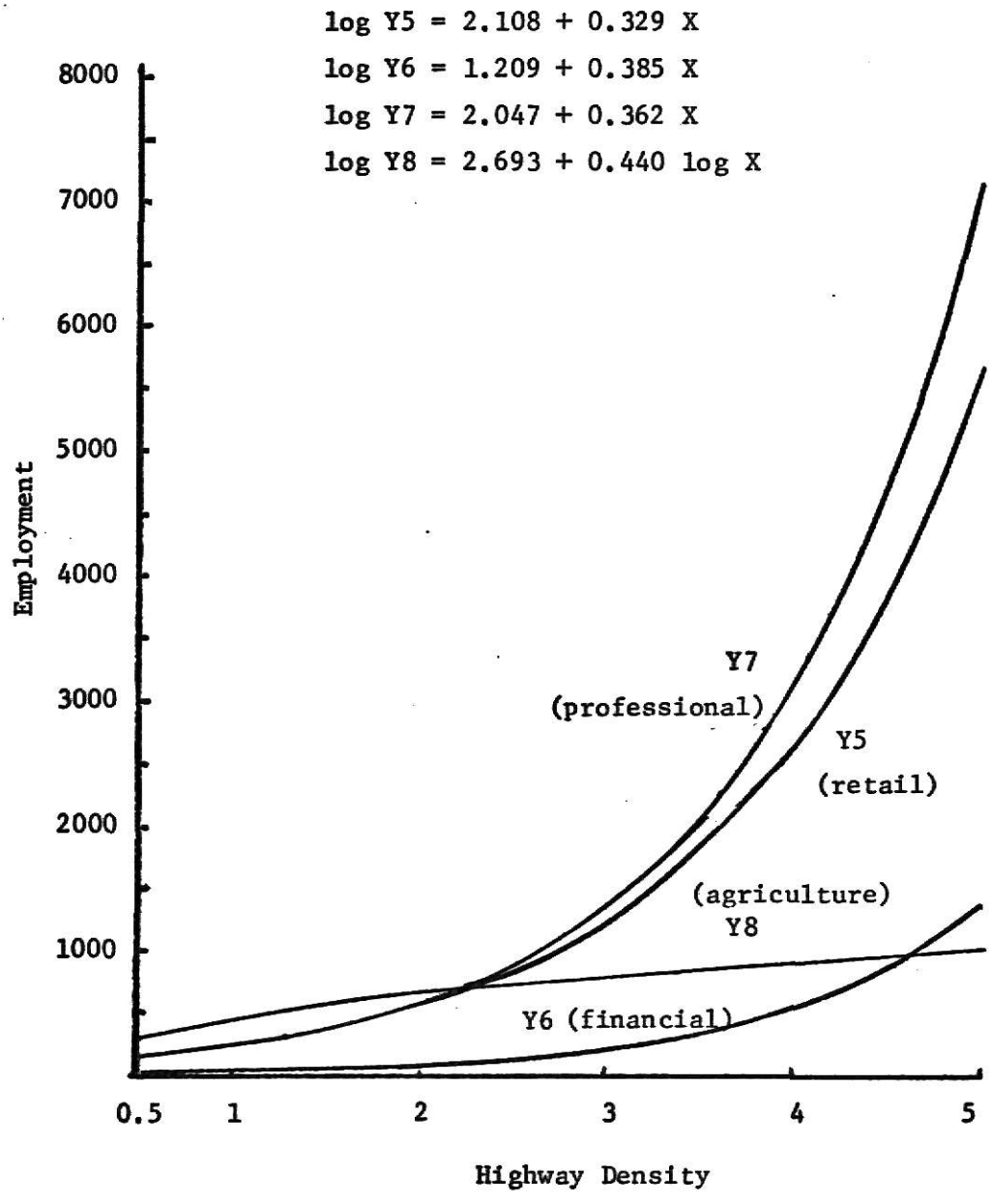
Bureau of the Census

yields transfer economies and is a further reason for higher interdependent buyers and sellers to minimize the friction in terms of time or distance which can be reduced with better connectivity.

The disequilibrium of employment in manufacturing industry is quite obvious in Kansas because a large proportion of the total manufacturing labour is located in a few counties (Map 8). There are six counties over 3500 manufacturing workers : Sedgwick (36602), Shawnee (8599), Reno (4950), Montgomery (3923), Douglas (3906), Butler (3855). These counties together with a few other have the advantage of economies of agglomeration such as economies of scale and economies of labour specialization and will be more responsive to highway development because mobility of these economies and other production factors require good connectivity in transport network. On the contrary, those counties with poor growth determinants will be at a disadvantage. Therefore, the impact of highway development will not be so obvious.

Similarly, retail industry, financial and insurance industry as well as professional and related industry are also positively correlated with highway density at an increasing rate (Figure 6). This reflects the similar kind of agglomeration experienced in manufacturing. In comparison, however, the slope of these three industries are not so responsive to highway density as manufacturing mainly because of the inelastic nature of these sectors and because of the fact that other factors also play a part in explaining the distribution of the employment of these industries.

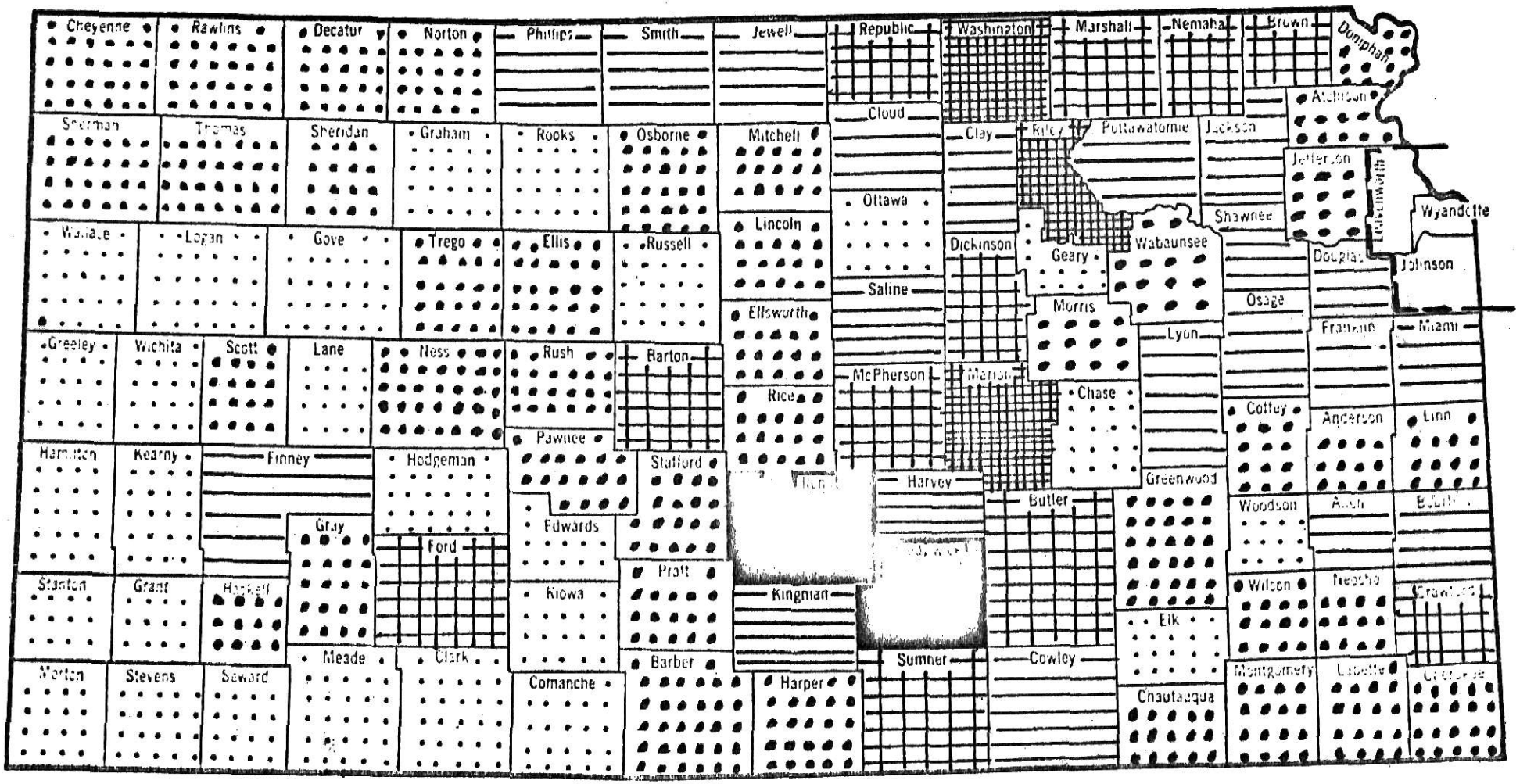
Figure 5 : Employment in Different Industries --- Highway Density Relationship



Agricultural Industry

One interesting finding is the relationship between highway density and the employment level of agriculture. The slope of the regression model indicates that employment will increase but at a decreasing rate. According to the data of the Bureau of the Census, agricultural activity includes farming, horticultural services, and other agribusiness industries. The location of some of these activities such as agricultural services or agribusiness industries are subject to certain location principles. For instance, agricultural services require a threshold market which can be enlarged by better accessibility and connectivity to different areas. Therefore, more agricultural services will be found in the higher level of the hierarchy of network. Secondly, the decline of agriculture laborers is mainly in crop growing. Employment in agricultural services, meat production and dairy products are still increasing though slowly.[18] The development of these activities depend quite much on good transport network. Livestock, for instance, will lose more weight if the delivery to the central market takes a long time. Moreover, according to the information of government publication, most of the shipments of crops and farm products are centered in several cities such as Hutchinson, Salina, Witchita, Topeka and a few other.[19] Therefore, it is reasonable to expect that counties with these cities will have more people in agricultural services. Finally, highway density encourages population growth and urbanization, counties with more population will have more employment in agricultural industry though the proportion of it to the

Map 9 : Spatial Distribution of Employment in Agriculture



Source : based on
Bureau of the Census

total employment in agriculture

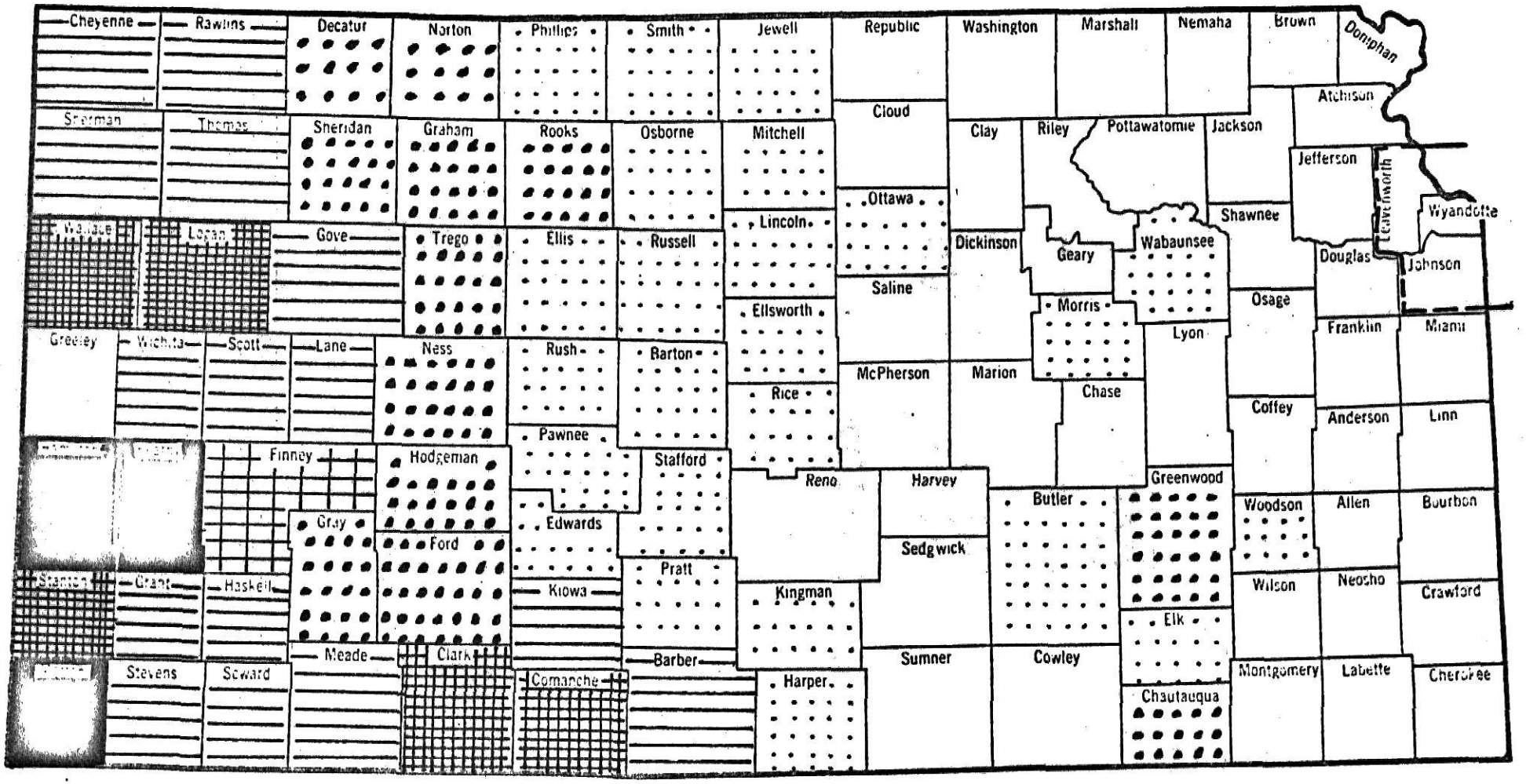
under 500	500 -- 750	750 -- 1000	1000 -- 1250	1250 -- 1500	Over 1500	counties not included

total employment of all sectors is smaller in these counties.

However, it should be noted that the actual increase, as shown by the curve in Figure 5 is very smaller. One unit change of highway density only lead to an increase of 0.44 units in employment in this sector. Indeed, the increase is actually at a decreasing rate and implies that the trend will be levelled off. This reflects the decline of farm operators but the population is maintained to certain extent by the slight increase of employment in agricultural services, meat production and dairy products. This trend of development is consistent with other projections of the Kansas economy done by other studies.[20]

Map 10 shows the spatial variation of average farm size of each county. Generally speaking, most of the large farms are found in the western part of the study area especially the South West Region. Average farm size in Hamilton, Kearny and Morton is over 1,500 acres. On the other hand, small farms are generally found in the east section of the State where highway density is higher. Therefore, one may visualize that the average farm size and highway density are negatively correlated. As the regression model shows, the farm size declines at a decreasing rate. This suggests the elasticity of farm size to the impact of highway in counties with low highway density but in those with higher density, the impact of the highway becomes relatively small mainly because of the fact that given certain level of urban pressures, the size of farm still has to be maintained to a level in order to be economically feasible. Therefore, it is expected that farm size will " level off " in response to higher highway density.

Map 10 : Spatial Distribution of
Average Farm Size (in acres)



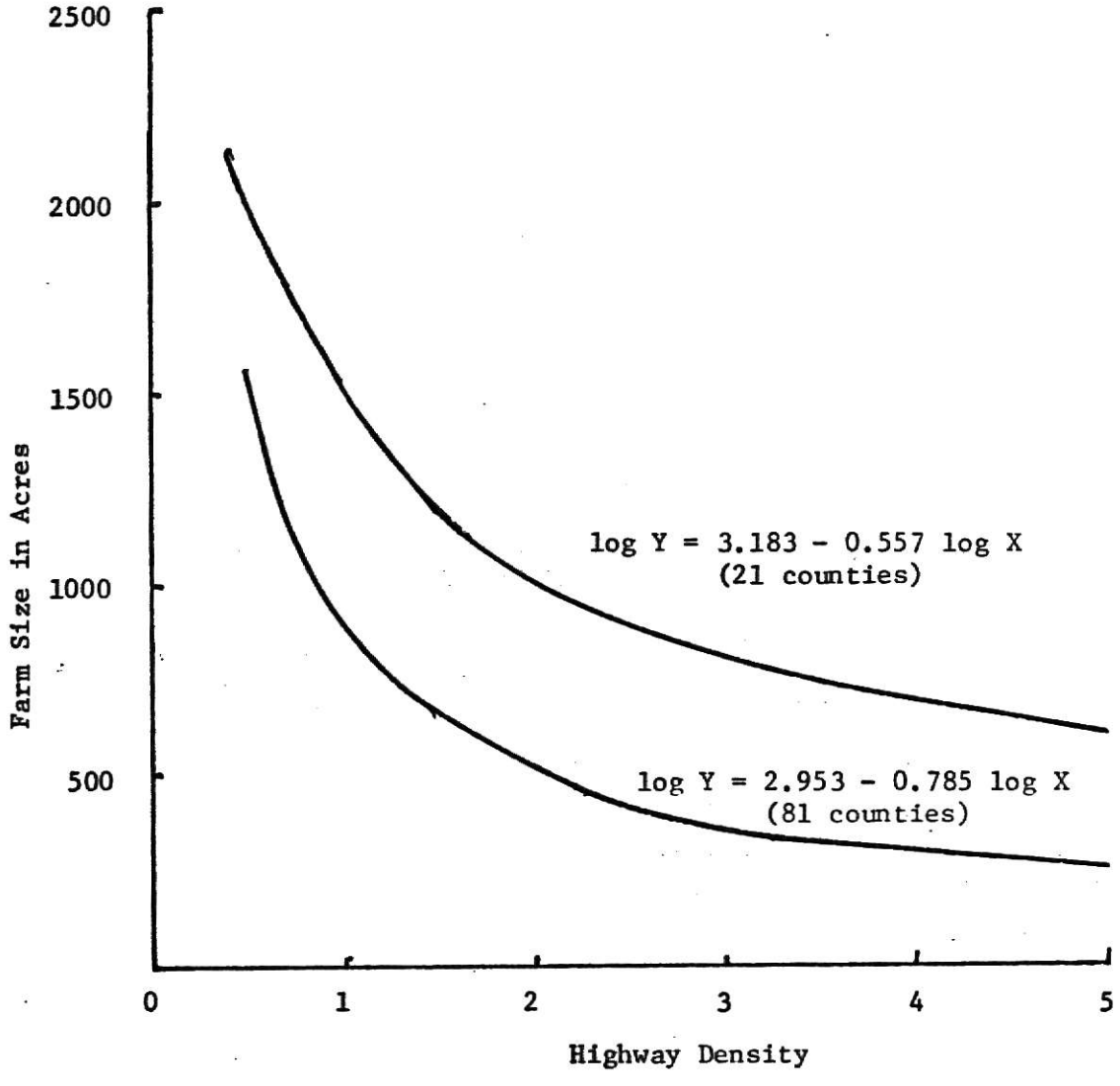
Source : based on
Bureau of the Census

Acres

under 500	500 -- 750	750 -- 1000	1000 -- 1250	1250 -- 1500	1500 -- 1750	over 1750

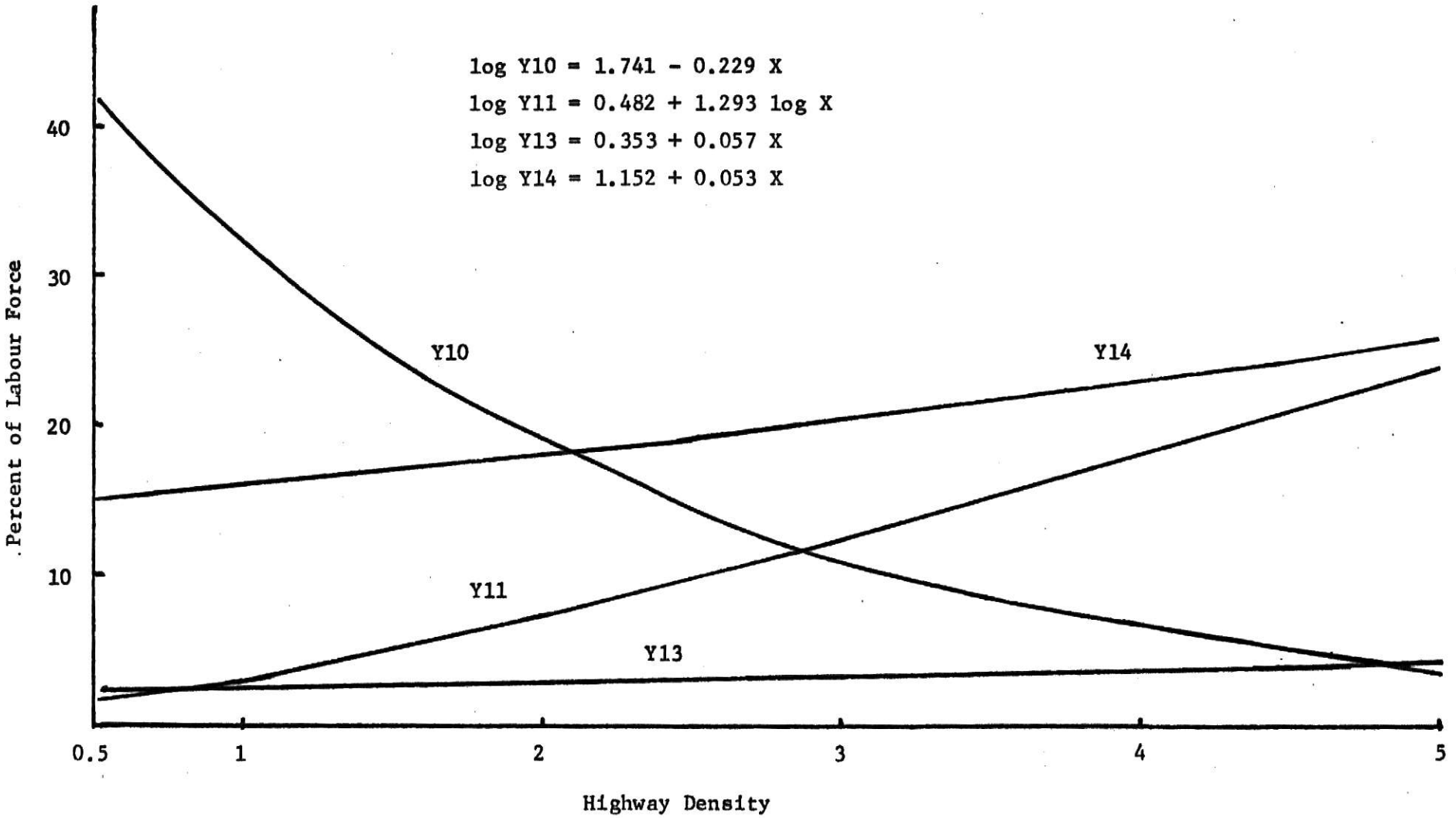
counties not included

Figure 6 : Average Farm Size --- Highway Density Relationship



On the other hand, the percentage of employment in agriculture will decline at a decreasing rate while the percent of labour force in other industries increase (Figure 7). This indicates the significant role of secondary and tertiary industries in counties with higher density of highway. Similar to the nature of slopes in employment in secondary and tertiary industries, the regression equations of the percent of labour force in these two sectors also indicate an increase at an increasing rate. However, this should not be emphasized because the rate is very low and the curves are very close to linear (Figure 8).

Figure 7 : Percent of Labour Force of Different Sectors



Chapter 6

IMPLICATION OF HIGHWAY DEVELOPMENT TO POLICY FORMULATION AND PLANNING

An understanding of the relationship between highway density and spatial variation of socioeconomic dimensions is essential for analysis of the problem of development in many counties and for formulation of policies and strategies to maintain their well being and functioning.

Population Distribution and Economic Development

It is generally recognized that one of the problems that constantly plague the economic health of many counties in the State is the distribution of population. Some counties have experienced a continuous decline in population while some other have a continuous increase. The factors for this trend are several such as change of mechanization of agriculture production, better economic opportunities in larger centers, change of function of the central place in the county and so on. However, one general pattern that can be observed is that counties with larger urban centers generally have gained population while those that lost population are the rural counties which according to the Bureau of the Census, have no population centers with more than 2500 people. More specially, during the last two decades, only a few counties with urban centers over 5000 lost population. Therefore, in policy terms, effort should be directed

to encourage the development of such centers because they are crucial for the county to maintain certain level of economic activity which has an impact on consolidating the population in the county. In this case, strategy should be developed in such a way that highway construction should be emphasized to hook up with the potential center such as the county seat. This will help to concentrate economic activities and to strengthen the functioning of the center and gradually enlarge the market area and maximize urban threshold level. This concentration is of importance to the consolidating the county population and also consistent with, though at different scale, the strategy of development proposed by some economists. [21] However, in some rural counties, instead of connecting the rural area to the center, the policy calls for the connection with the major highway even outside the county. Such development would, indeed, alter the space relationship between counties and reduce the relative advantage of the original center because instead of internal integration, the interaction with outside transport system will increase and may reduce the size of market area of the center which is already small. If the county has good resources, such as those in the Far South West Region which is rich in mineral resources, better highway connectivity would help the development both population and economical of the Region as it is now enjoying. [22] Otherwise, it will lead the county to a disadvantage position.

Economic equilibrium theory states that the spread effect of development will transmit the growth process from the growth center widely throughout the economic landscape and minimize the differentials of

economic development. Hick, for instance, argues that there are three ways in which this process of " evening out " takes place.[23] First, the demand generated outside the center for goods and services will enable peripheral areas to grow rich. Second, the movement of labour to the center in response to new employment opportunities will, in the long run, result in a rise of wages and income there. Third, the need for input from the periphery will promote a compensatory movement of the capital accumulated in the center, seeking out profitable investment opportunities. Though Myrdal and Hirschman argue the effectiveness of such spread effects in a national and regional scale, [24] it is generally agreed that the spread effects exerted by the development of a growth node are most effective in areas close to the center itself. In this case, if the urban centers in the neighboring counties have possessed certain level of population and economic development, their growth policies should be developed to increase the linkages with the center and direct the flow of growth impulse to these counties. The growth of Butler, Reno and Harvey Counties is one example.

Growth Control

The previous discussion on development is based on the assumption that urban growth is preferable. However, this assumption may not be always true. On the contrary, the issue of control growth is one of the most discussed topic in planning in many counties across the nation particularly on the east and west coasts as a response to the problems

of rapid growth in the last two decades. Though the problem of urban sprawl, loss of farmland or change of structure of agricultural activities do not occur significantly in Kansas, the implication of highway development to urbanization, farm size and possible change of the function of a county is essential for policy formulation for those counties planning to manage growth and preserve their agricultural land. In many cases, highway development policy may be contradictory with other policy such as preservation of agricultural land. In this case, the practice of preferential assessment, tax exemption and even tax deferral for the preservation purpose is made ineffective or invalidated because if the highway construction has raised the value or increased the urban pressure on the farm, the owner may take the advantage of tax benefits and wait for the day to sell his properties. The payment of back taxes can be easily recovered by charging a little more on the land. Moreover, the disruption of new highway construction, in some cases, makes farmers anxious to sell their land early for its conversion to urban use. Therefore, in growth control, these aspects should be taken into consideration and the policy should be coordinated with other planning strategies or policy may be formulated to delay the provision of highway until other development plan can be well set up if the urban growth rate is too fast in the county.

Chapter 7

CONCLUSION

This study investigates the relationship between highway development as determined by highway density and socio-economic profiles for counties in the State of Kansas. The meaning of highway density is expressed in terms of population density, urban residence, agglomeration of population, and employment in different sectors. The hypothesis constructed is based mainly on economic concepts and on the assumption that the cost of overcoming distance is basic to human activity. Activities tend to locate where the friction costs are minimized and the process of growth tends towards a geographical pattern minimizing the total cost of distance to the economy. Moreover, better connectivity can mobilize the growth determinants and enlarge the market area which is essential to the functioning of the center and further development of counties.

Relationship are sought between various measure of socio-economic indices and highway density. Correlation and regression analysis is used to test the hypotheses generated in the study. Cross-section analysis reveals the importance of highway density as a variable to explain the variation of socio-economic indices. Generally, the independent variable has a higher correlation with population density, employment of different sectors and farm size. The negative correlation between farm size and highway density indicates the impact of the latter to the former.

On the other hand, it has been found that the response of

socio-economic indices with highway density varies. The rate of change indicates that some dependent variables increase at an increasing rate while some at an decreasing rate and this reflects the different nature of association between socio-economic dimensions with highway density. In addition to this, the residual of farm size suggests that there is also regional variation of correlation between the dependent and independent variable. Submodels of farm size do improve the power of explanation of the spatial variation.

Based on the empirical findings and the implication of the result, suggestions on highway policy have been made and two aspects of the issue were examined. On the development side, concentration of development encouraged by highway convergence to a center seems to be more appropriate as a strategy in the infant stage of development. However, up to certain level of population agglomeration and to certain degree of economic development, inflow of growth impulse will give more momentum to the county. On the growth control side, highway location may help to affect the spatial development desired and the degree of growth. However, it should be noted that the validity of these suggestions depends much on local factors. Moreover, the implication of the finding of this study is nothing more than a reference for policy formulation and by no means the role of the study is regarded as a policy tool.

As it has been pointed out before, the pattern of socio-economic structure cannot be fully explained by one variable. Other may be included to explain each dependent variable if in-depth analysis of

each of them is desired. The study of farm size, for instance, may include climate, soil, technological variables and so on. It is also understood that each type of concept or theory explains the space economy in a different way and with different emphasis. In this paper, one variable was chosen. This enables the research to simplify the construction of concepts about the relationship between highway development and socio-economic structure and to articulate the concept, theory or implication related more clearly. Indeed, in spite of the diversity among economic, social, political, resource endowment and history of the study area, the simple regression models do work well in depicting statistically the relationship and the concept derived from them also appears to be valid. However, it should be clear that the finding reported here is not intended in other states without relevant studies of the same characteristics in those states. Moreover, it is also not the intention of the researcher to claim that the results are in any sense the most preferred test of the relationship. Rather they are intended to be suggestive and to provide evidence for the issue of development in planning.

FOOTNOTES

[1]Albert O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1958) pp. 83 - 97.

[2]For detail, refer to Randall W. Scott (ed.), Management and Control of Growth Vol. I, II (The Urban Land Institute, Washington, D.C., 1975).

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[4]John Heads, " Comment: The Role of Transportation in Regional Economic Growth " , in E.Tyrchniewicz and O. Tangri (ed.) Transportation and Regional Development (University of Manitoba, 1970).

[5]R.C. Einsweiler et al., " Comparative Descriptions of Selected Municipal Growth Guidance Systems : A Preliminary Report " in Randall W. Scott (ed.) Management and Control of Growth Vol II (ULI, Washington D.C., 1975) p.284.

[6]Horst Siebert, Regional Economic Growth : Theory and Policy (International Textbook Company, 1969) p. 140.

[7]Refer to definition.

[8]M.J. Emerson, Urban and Regional Economics : Structure and Change (Allyn and Bacon, Inc., 1975)

[9]Ibid. p. 67.

[10]Ibid. p. 70.

[11]Refer to definition.

[12]E.S. Dun, The Location of Agricultural Production (Gainesville, Univ. of Florida Press, 1954), Chapter 2.

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[13]Economic rent : It is the surplus income that can be obtained from one unit of land above that which can be obtained from an inferior unit of land.

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L.O. Sorenson, Wheat, Milo, Corn and Soybeans Shipped from Kansas Elevators, June 1, 1971 - May 31, 1972 : To Where and How (Department of Agricultural Economics, Manhattan, Kansas)

[20]M.J. Emerson, Op. Cit., Chapter 8.

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[23] J.R. Hicks, Essays in World Economics (Oxford, Oxford Univ. Press, 1959)

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AN ANALYSIS OF THE RELATIONSHIP BETWEEN HIGHWAY DISTRIBUTION AND SPATIAL DEVELOPMENT IN THE STATE OF KANSAS

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AN ANALYSIS OF THE RELATIONSHIP BETWEEN HIGHWAY DISTRIBUTION AND SPATIAL DEVELOPMENT IN THE STATE OF KANSAS

The major purpose of this study is to analyze the relationship between highway development determined by highway density and socio-economic profiles for the counties in the State of Kansas. Hypotheses constructed are based mainly on economic concepts and on the assumption that the cost of overcoming distance is basic to human activity. Activities tend to locate where the friction cost is minimized. Better connectivity can help to mobilize growth determinants and also to enlarge the market area which is essential to the functioning of the urban center and its respective county.

Correlation and regression models are used throughout to demonstrate the relationship between socio-economic indicators and highway density. Given the diversity among economic, social, political and resource endowment of the study area, the simple regression models have been shown that they work well in depicting the relationship and reveal the importance of highway density to explain the geographical variation of socio-economic structure. They would also be useful in assisting regional planners in predicting various development in each county.

The analysis shows that highway density has a higher correlation with some variables such as population density, employment of different sectors and farm size. The negative relationship between farm size and highway development indicates the impact of the latter to the former. On the other hand, the rate of change between variables also varies.

Some dependent variables increase at an increasing rate while some at a decreasing rate. This reflects the different response and nature of association between socio-economic dimensions and highway density.

Based on the empirical findings, suggestions on highway development policy have been made and two aspects of the issue were examined. On the development side, concentration of development encouraged by highway convergence to a selected center of the county seems to be an appropriate strategy to help the county to maintain, at least, its present socio-economic status. However, in a county with growth potential, this strategy is less prominent. On the growth control side, highway location may be used to influence the direction of development and control the degree of growth of counties especially those with a high growth rate.