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# The Trend of The Locational Change of The Manufacturing in Georgia 1963 to 1976*

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## 1. Introduction

The Southern United States, long regarded as an agrarian society, has now become recognized as an industrial frontier with new markets, compatible labor, and an expanding manufacturing base.[1] As a result, there have been a number of studies in recent years dealing with the location of manufacturing in the Southeastern United States. Most of these studies have focused on locational factors while others have dealt with the regional structure of manufacturing, manufacturing diffusion, and theoretical frameworks in the context of location theory and regional development theory.[2] However, there are not many studies dealing with locational changes of manufacturing in the South. It is expected that there will be significant locational changes in terms of the interregional as well as intraregional context. The analysis of such changes and the construction of models of locational changes will be of great value in regional development and regional economic planning.

The primary purpose of this paper will be to analyze the overall trends of manufacturing in Georgia, U.S.A. from 1963 to 1976 inclusive. This paper is also concerned with the application of trend surface analysis to geographical

* This paper was orginally prepared as a research paper which was developed in a quantitative method course in 1978, University of Georgia, U.S.A. The author wishes to thank Dr. James O. Wheeler for his encouragement and helpful comments.

1) SEE. Introduction part of *Southeastern Geographer*, vol. 14(1974), No. 2, p. 61.

2) Spitz, J.V., 1969, "Relative Wage Trends in Nine Southern States: The Case of Production Labor in Manufacturing," *Journal of Regional Science*, vol. 9, pp. 319~323. McGregor, J. R., 1970, "Water as a Factor in the Location of Industry in the Southeast," *Southeastern Geographer*, vol. 10, pp. 41~54. Greenhut, M.L., 1960, "An Explanation of Industrial Development in Underdeveloped Areas of the United States," *Land Economics*, vol. 36, pp. 371~379.

Wheeler, J.O., 1973, "Regional Manufacturing Structure in the Southeastern United States," *Southeastern Geographer*, vol. 14, pp. 67~83. Rabiega, W.A. and R.G. Wood, 1974, "Manufacturing Diffusion as a Growth Point Process in the Southeast," *Southeastern Geographer*, vol. 14, pp. 84~95.

research. In order to establish a theoretical framework of locational change in manufacturing, it seems important to describe the general trends exhibited by manufacturing as a whole. Therefore, this paper can be regarded as a first step in the examination of theoretical model of locational change in manufacturing.

## 2. Data and Methodology

### (1) Data

The major data used in this study are derived from the *Georgia Manufacturing Directory*, 1964, 1969, 1973 and 1977. The number employed in industry is the major criterion of the analysis. The 159 counties in Georgia are the unit areas for the data, with the approximate gravity centers of population in each county being used as control points for the trend surface analysis. These control points are digitized.

### (2) Trend Surface Analysis (TSA)

TSA attempts to decompose each observation on a spatially distributed variable into a component associated with any regional trends present in the data and a component associated with purely local effects. This separation into two components is accomplished by fitting a best-fit surface using regression techniques.[3] There are two basic models commonly applied to geographical and geological data sets. These are a power series polynomial model and a trigonometric polynomial or Fourier Series model. Both of these are variants of the general linear model.[4] The power series model is best suited to the identification of aperiodic trend components while the Fourier Series model may be best used to identify cyclical components.

The power series polynomial trend analysis will be applied to this study. Mathematically, the equation of this power series model can be formulated as follows: $Zoij = f(Xi, Yj) + Uij$

where $Zoij$: the observed value of the surface at the point $ij$

$Xi$: the coordinate on the X-axis of data point $ij$

$Yj$: the coordinate on the Y-axis of data point $ij$

$Uj$: the residual(error term) at data point $ij$

The term $f(Xi, Yj)$ indicates the trend component.

This model is a simple modification of the multiple regression model with the independent variables replaced by a combination of the map coordinates. By adding successive terms it can be used to describe linear, quadratic, cubic, quartic and higher-order surfaces which have an increasing number of extrema.[5]

### (3) Some Assumptions and Problems in Using TSA

There are some basic assumptions in using this technique. These are:[6]

1) The residuals have an expected mean value of zero.

2) The residuals are uncorrelated with a constant variance. The assumption of constant variation is that of homoscedasticity.

3) The matrix $X$ consists of non-stochastic elements and has a rank less than the number of data points.[7]

4) The residuals have a normal distribution.

It is also assumed that the data are spatially continuous.

Such assumptions demand care in applying

3) Unwin, D.J., *An Introduction to Trend Surface Analysis*, CATMOG No. 5, Geo Abstracts Ltd., p. 3.

4) Norcliffe, G.B., 1969, "On the Use and Limitation of Trend Surface Models," *Canadian Geographer*, vol. 8, p. 338.

5) Norcliffe, op. cit., footnote 4, p. 338.

6) Unwin, op. cit., footnote 3, pp. 20~31.

7) "Non-stochastic elements" means that there is no error in the various summations that make up the $X$ matrix which is equivalent to specifying that the location($Xi$, $Yi$)of the data points can be measured with only negligible measurement error."Rank less than the number of data points" means that there must be at least as many observations as there are terms in the trend surface equation.

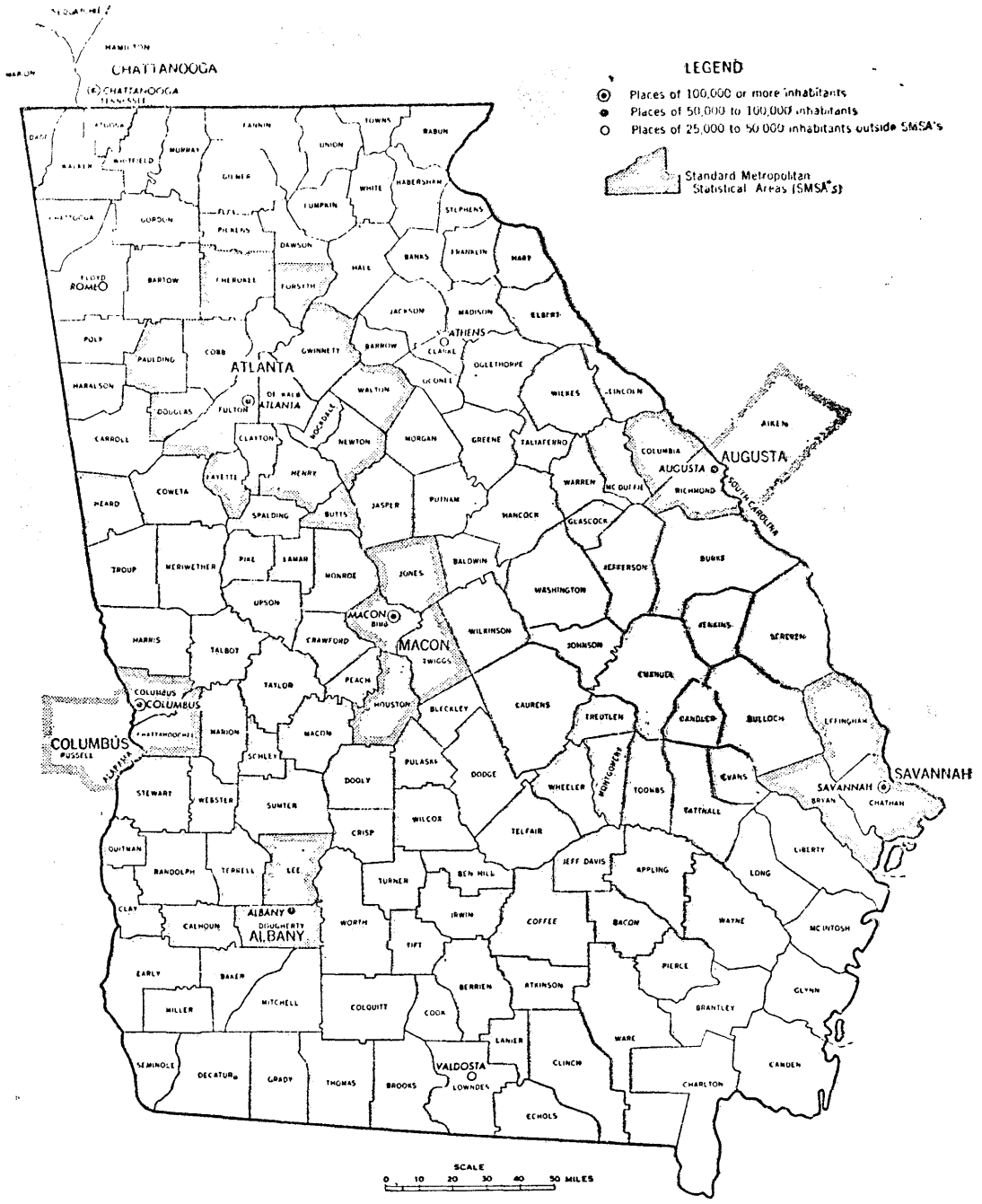


**Fig. 1. Study area and SMSA's**
(Source: U.S. Department of Commerce Bureau of the Census)

this technique to geographical research, especially in human geography. The data of human geography are seldom continuous. As a result, there are fundamental problems in applying this statistical method to social data if it is not justified. Cerny points out the problems in using social data.[8] These are uncontinuity of data, number and spacing of control points, tests for significance of surfaces, and the role of theory and fitting of confidence surfaces. Robinson also argues that point-valued data, and especially area-valued data, are difficult to

8) Cerny, J.W., 1973, "Social Data and Trend Surfaces: A Comment." *Geographical Analysis*, vol. 5, pp. 156~157.

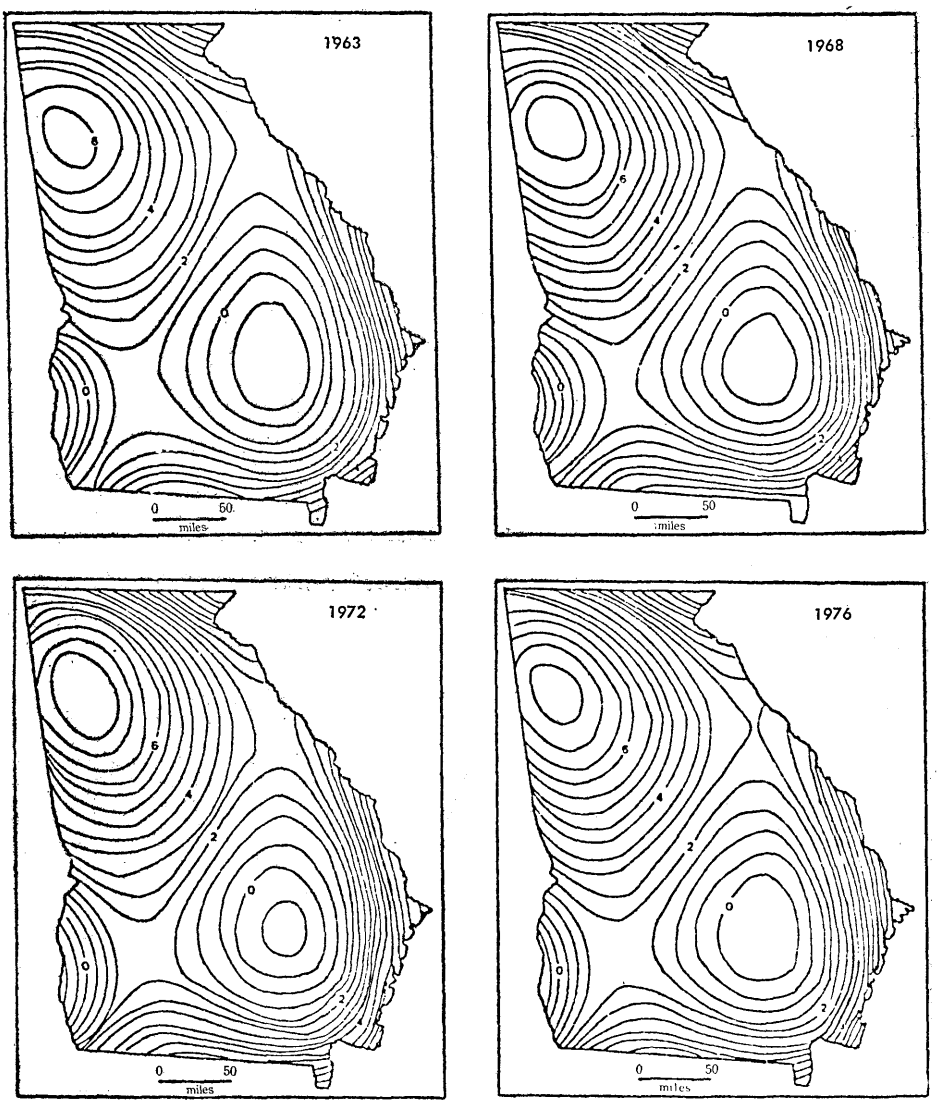


**Fig. 2. Linear Surfaces** (Number of employees in manufacturing)

justify when using a continuous function to describe inherently discontinous data.[9] Nevertheless, the possibility still exists for careful experimentation with social data.[10] Population, like light, may be profitably regarded either as a series of discontinuous quanta or as continuous. The choice is largely a matter of scale, convention and convenience.[11]

One may point out two major problems that may result from applying the TSA. They are discontinuity of data (point valued data), and the problem of applying significance tests. As mentioned above, it is difficult to justify the use of this technique in view of these problems. However, the number employed in industry can be assumed to be the representative value of each county and then as the potential of manufacturing. Even though the employment data are discontinuous over space, the manufacturing potential may be assumed to be continuous so as to examine the overall trend of manufacturing location. Significance testing

9) Robinson, G., 1970, "Some Comments on Trend Surface Analysis," *Area*, No. 3.
10) Cerny, op. cit., foonote 8, p. 159.
11) Chorley, R.J. and P. Haggett, 1965, "Trend-Surface mapping in Geographical Research," *Transactions*, vol. 37, p. 48.

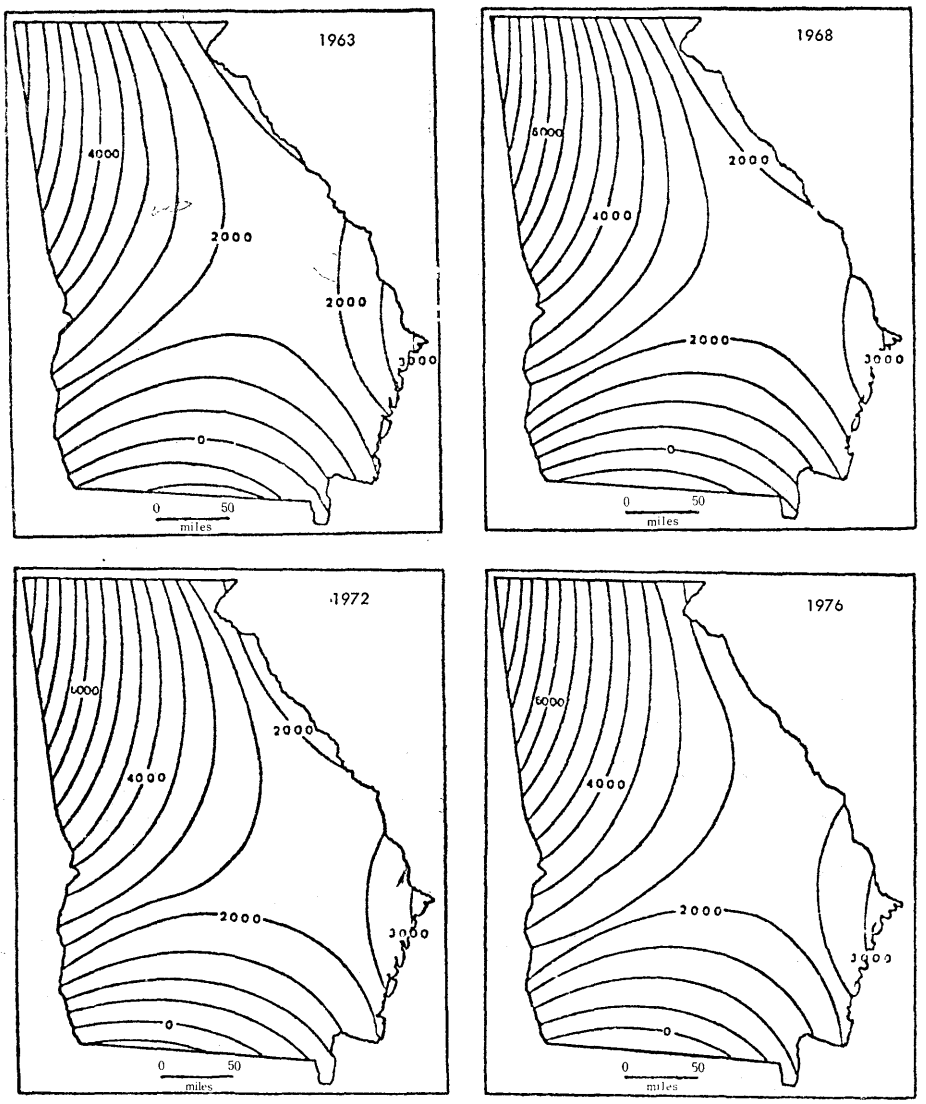


**Fig. 3. L.+Quadratic Surfaces** (Number of employees in manufacturing)

remains as the major problem. The employment data are not easily thought of as a sample. Rather, they form the total indentified and indentifiable population so that the fitted surface must be significant. "What is the population?" This problem is not limited to this study. It may be the problem of all geographic research using related quantitative techniques. Here, it is assumed that the data are the sample of underlying manufacturing potential. This does not mean that all the problems are solved. While it is realized that there are problems in the use of this technique, it is also felt that the technique is still capable of lending insight into potential trends in industrial location.

## 3. The Analysis of the Locational Change of Manufacturing

The overall trend of manufacturing employment in Georgia can be easily identified from the trend surface maps presented in Figures 1-3. The linear trend surfaces (Fig.1) indicate that the general trend of employment declines from northwest to southeast. This trend can be identified as a NW to SE component of

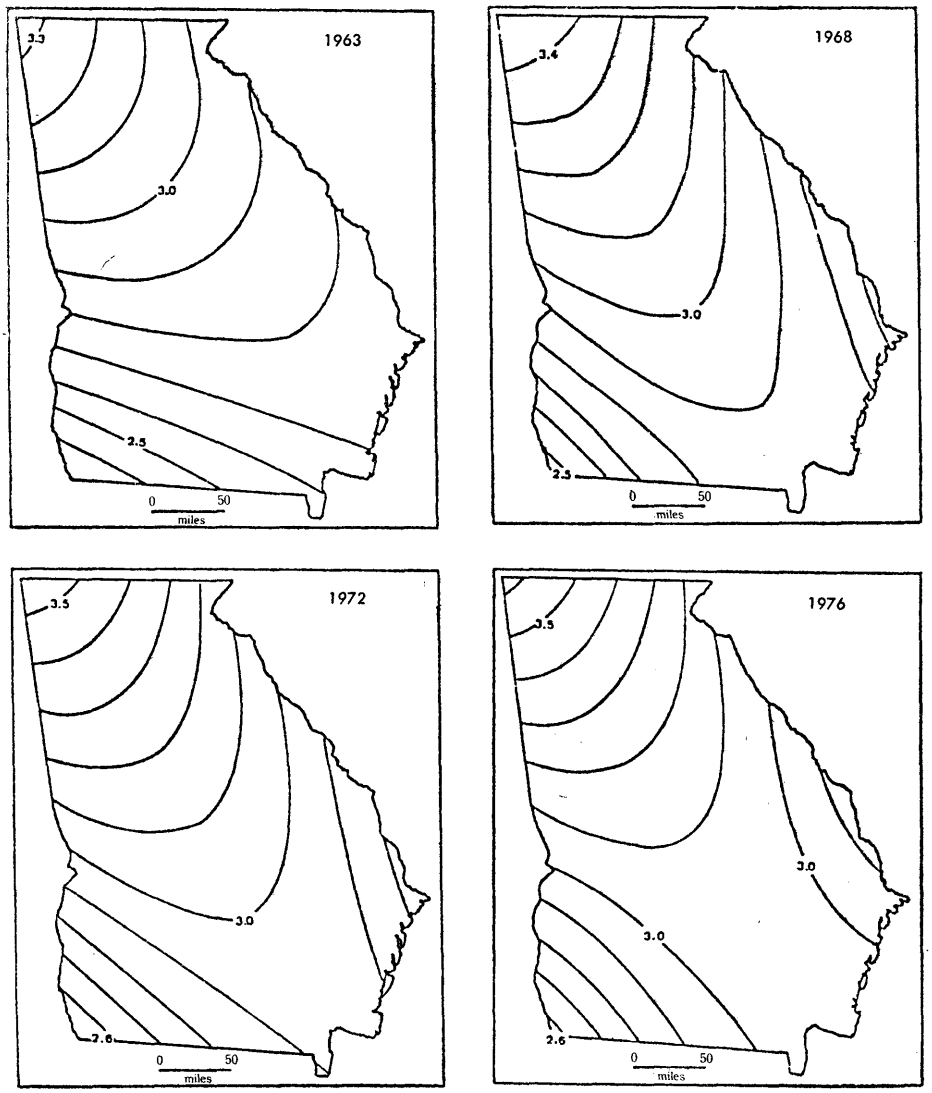


**Fig. 4. L.+Q.+Cubic Surfaces** (Number of employees in manufacturing (thousands))

decline. This basic trend does not seem to change during the thirteen year period. The second order surfaces (Fig. 2) show a ridge which emphasizes that the direction of employment declines to the south, away from the concentration of the northwest area. Chatham county appears as a minor concentration area of manufacturing employment. The third order surface (Fig. 3) adds to the general trends described by the first and second order surfaces. There are two contrasting regions emphasized in these maps; a concentrated area in the northwest central part and a depressed area in the southeast central part. There are steep increases from the southwest central region to the east and south. These maps also ndicate that there are no fundamental changes in overall trends during the 13 year period.

To this point the overall trends of manufacturing employment have been examined roughly. However, two basic questions can be raised from the above analysis: ① Are the trends examined above reasonably significant; and ② are there any significant changes in industrial location from 1963 to 1976? These two questions deserve to be examined in detail.

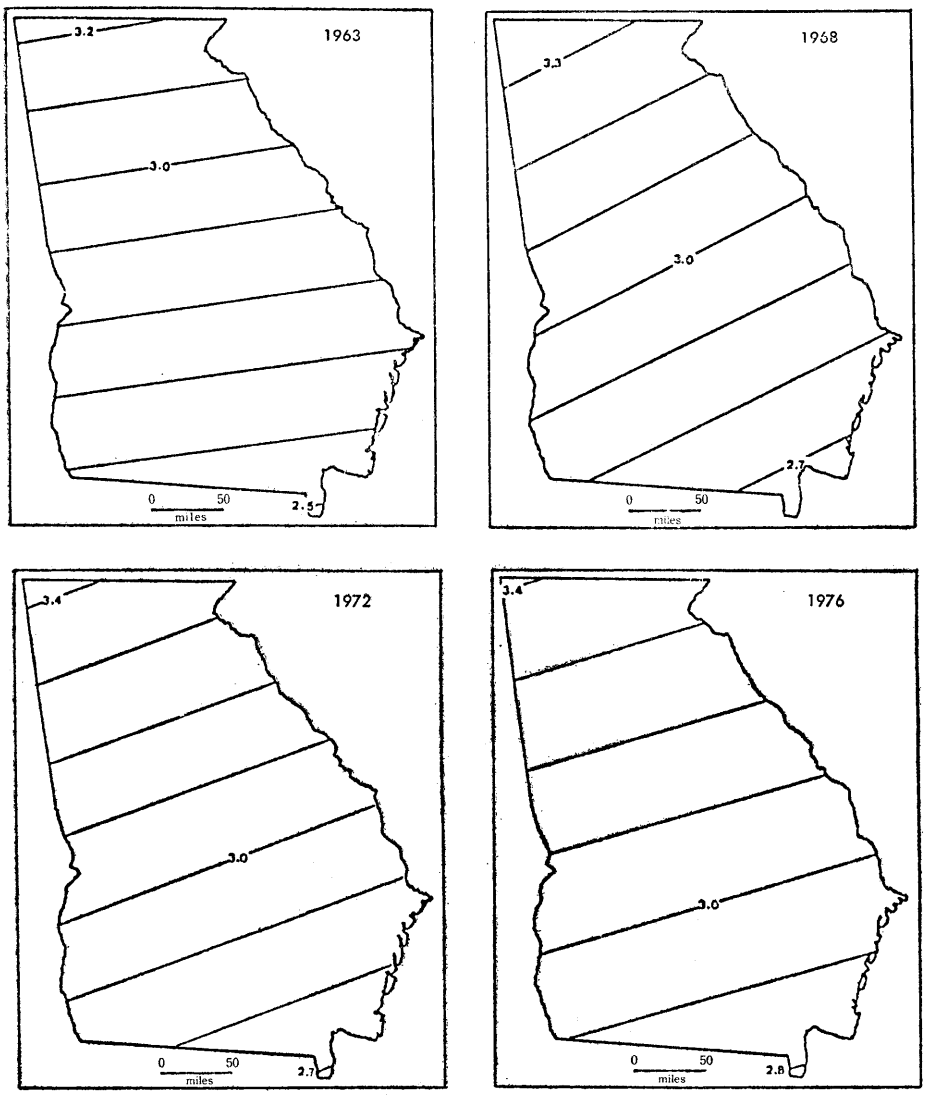


**Fig. 5. Linear Surfaces** (Data converted into log.)

First of all, attention is given to the analysis of variance and explained variation by the trend surfaces. There are some problems here because the strength of the trends is not high (Table 1). The presence of only a small trend[12] perhaps suggests that the application of the trend surface technique to social data is not successful. If we examine residuals, however, extreme values are found in metropolitan areas. These extreme values reduced the explained variation. We may discern the trends underlying this complex pattern by eliminating or reducing the effect of these extreme values. There might be two ways to eliminate this effect; one way is to convert the data into other values which reduce the extreme effect

**Table 1. Analysis of variance** (original data)

| | 1963 | | 1968 | | 1972 | | 1976 | |
|---|---|---|---|---|---|---|---|---|
| | a | b | a | b | a | b | a | b |
| L. Surface | 3.45 | 90.0 | 3.85 | 95.0 | 3.81 | 95.0 | 4.87 | 95.0 |
| L.+Q. | 6.01 | 90.0 | 6.02 | 90.0 | 5.84 | 90.0 | 7.28 | 95.0 |
| L.+Q.+C. | 11.99 | 95.0 | 11.63 | 95.0 | 11.37 | 95.0 | 13.36 | 99.0 |

a : % explained variation b : significance level (%)

12) Unwin, op. cit., footnote 3, p. 14.

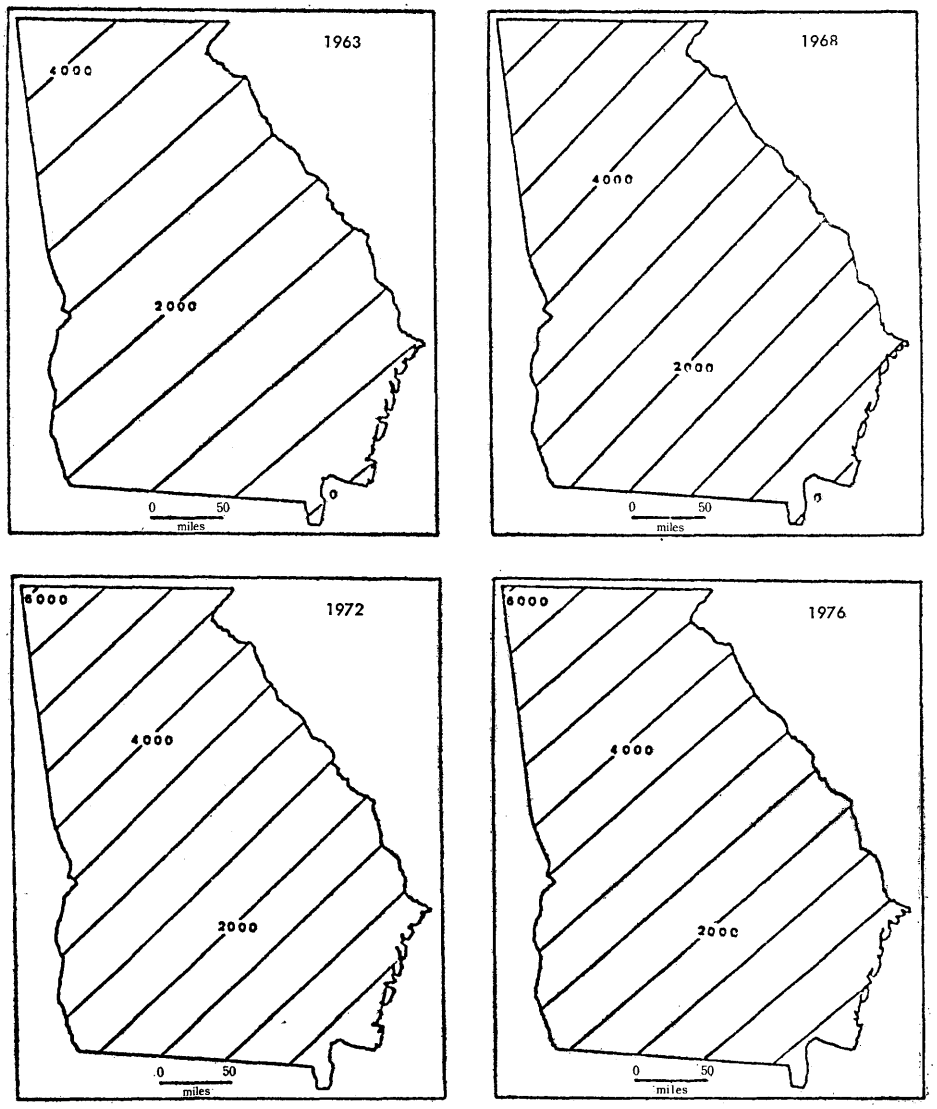


**Fig. 6. L.+Quadratic Surfaces** (Data converted into log.)

of these residuals, and the other way is to remove the data of counties which have extreme values from the original data sets.

Following the above suggestions the data were re-examined by first performing a common logarithmic transformation and second, by excluding those eight counties which had more than 8000 employees in the residuals of the third order trend surface in 1976. The map of data converted into logarithms (Fig. 4, through 6) shows the same trend as that of the absolute employment data. The basic direction of decline is northwest to southeast. The northwest-central region is still the major source of concentration, while the southwest-central region is the primary source of depression in manufacturing employment. No particular changes in trends from 1963 to 1976 can be found. However, the trends of converted data are moderate-substantial trends.[13] Significance testing reveals that these overall trends are meaningful at the 99% significance level(Table 2). The trend surface maps of data omitting the 8 counties reveal that there are

13) Unwin, op. cit., footnote 3, p. 14.

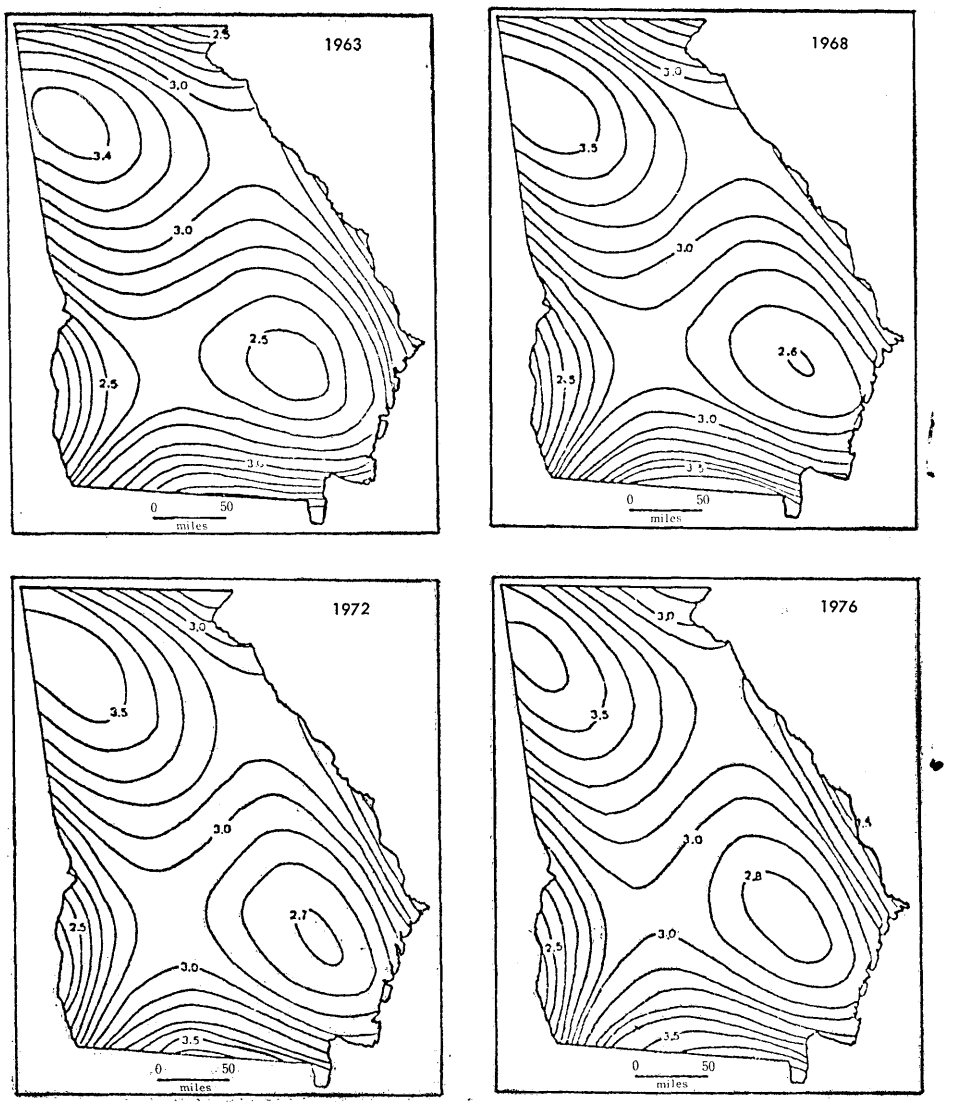


**Fig. 7. L.+Q.+Cubic Surfaces** (Data converted into log.)

**Table 2. Analysis of variance** (converted and reduced data)

| year / order | 1963 | | 1968 | | 1972 | | 1976 | |
|---|---|---|---|---|---|---|---|---|
| | a | b | a | b | a | b | a | b |
| Data converted into logarithms | | | | | | | | |
| L. | 7.64 | 99.0 | 7.10 | 99.0 | 7.00 | 99.0 | 6.15 | 99.0 |
| L.+Q. | 9.04 | 99.0 | 9.10 | 99.0 | 8.78 | 95.0 | 8.78 | 95.0 |
| L.+Q.+C. | 20.66 | 99.9 | 20.74 | 99.9 | 17.24 | 99.9 | 19.85 | 99.9 |
| Data excluding 8 counties | | | | | | | | |
| L. | 8.63 | 99.0 | 8.76 | 99.9 | 7.16 | 99.0 | 8.80 | 99.9 |
| L.+Q. | 12.47 | 99.0 | 11.98 | 99.0 | 10.76 | 99.0 | 12.57 | 99.9 |
| L.+Q.+C. | 21.98 | 99.9 | 20.45 | 99.9 | 17.90 | 99.9 | 19.62 | 99.9 |

a : % explained variation  b : significance level (%)

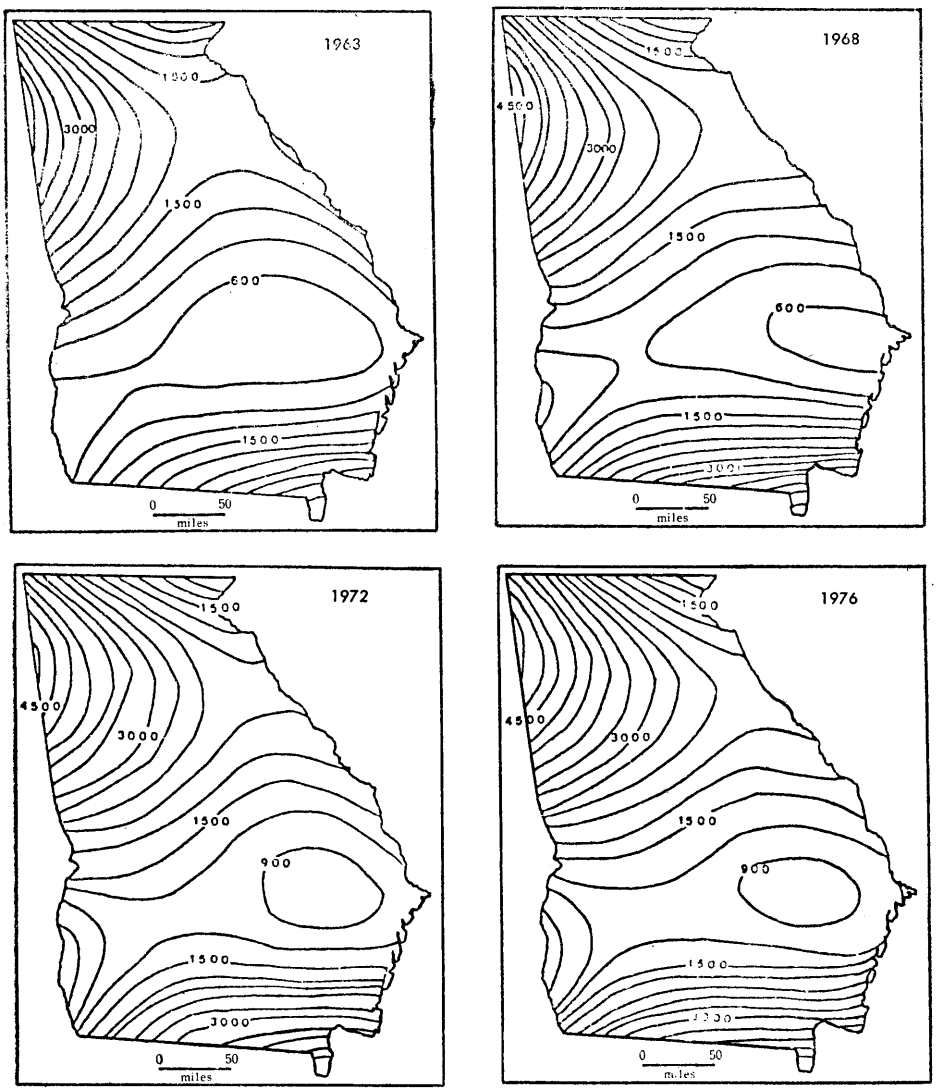


**Fig. 8. L+Q.+Cubic Surfaces** (Data except 8 counties)

no fundamental changes in the overall trends as examined above (Fig. 7). The trends are also moderate and substantial, and these are meaningful at the 99.9% significance level as well. From the analysis of the converted data we can summarize the overall trend of manufacturing employment as a NW(concentration) vs SE (depression) component, with a NW to SE direction of decline.

Second, attention is given to the other question: Are there any significant changes in industrial location from 1963 to 1976? It is true that there seems to be no fundamental changes in the basic trends of manufacturing from 1963 to 1976. However, at some point during the thirteen year period there does seem to be some significant change. By comparing each map of 1963, 1968, 1972 and 1976 (Fig. 1 through 6), two components of location change can be identified. The concentrated area of manufacturing experienced a great growth during the period 1963 to 1968, while the depressed area experienced little change during the same period. On the contrary, since 1968, the concentrated area has increased slightly, while the depressed area has experienced cont-

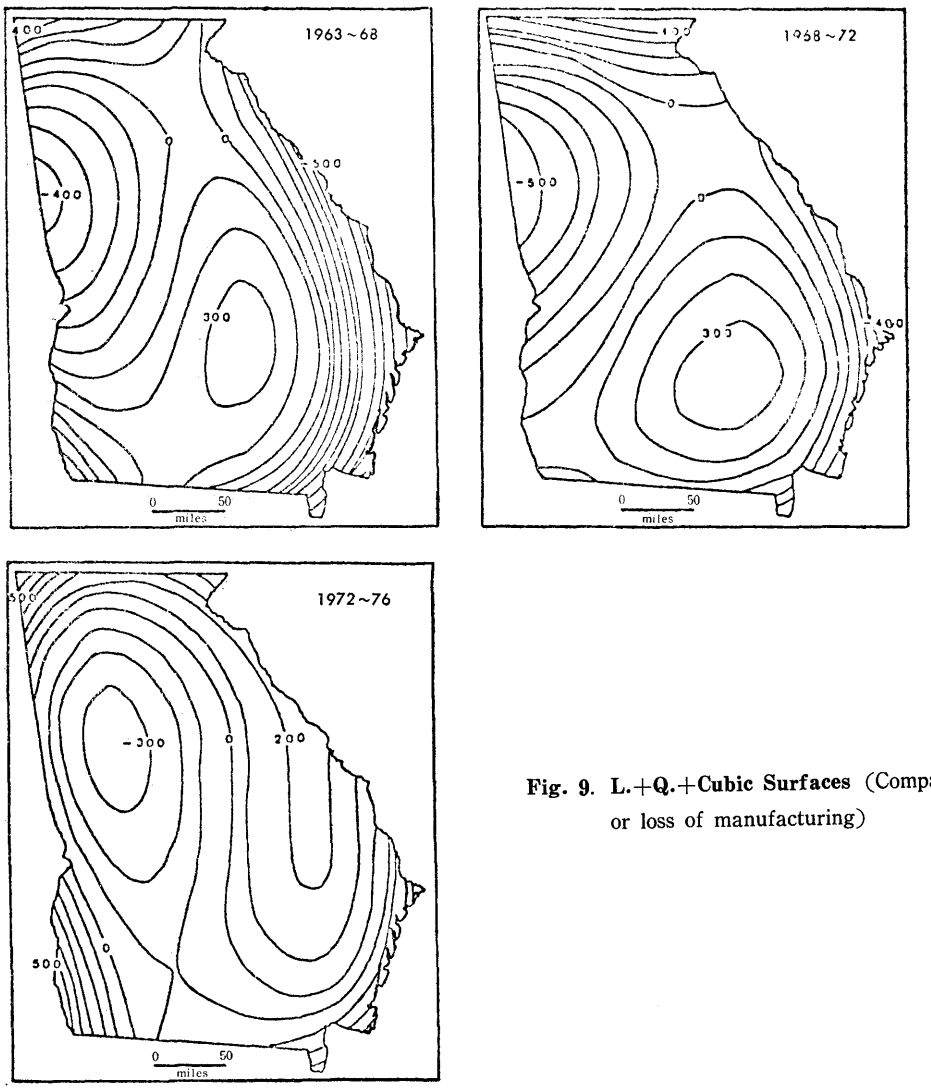


**Fig. 9. L.+Q.+Cubic Surfaces** (Comparative gain or loss of manufacturing)

inuous growth. This result suggests a process in which there was a concentration in the major industrial area during the years 1963 to 1968, followed by one in which there was decentralization or diffusion during the period 1968 to 1976.

In order to clarify the change in trends, the data of comparative change in manufacturing need to be examined.[14] The trends of comparative change in manufacturing can be summarized as NW (decreasing) to SE (increasing) from the trend surface map in Figue 8. The major trend revealed by these maps appears to be almost opposite to that of Fig. 3,

14) The analysis of comparative change is based on V.R. Fuchs. V.R. Fuchs, *Changes in the Location of Manufacturing in the United States since 1929*, (New Haven : Yale University Press, 1962), pp. 39~40.

Comparative Change : $Y_i - X_i \frac{Y}{X}$

where Yi number of employment (manufacturing) in terminal year in county.
Xi number of employment (manufacturing) in initial year in county.
Y number of employment (manufacturing) in terminal year in Georgia.
X number of employment (manufacturing) in initial year in Georgia.

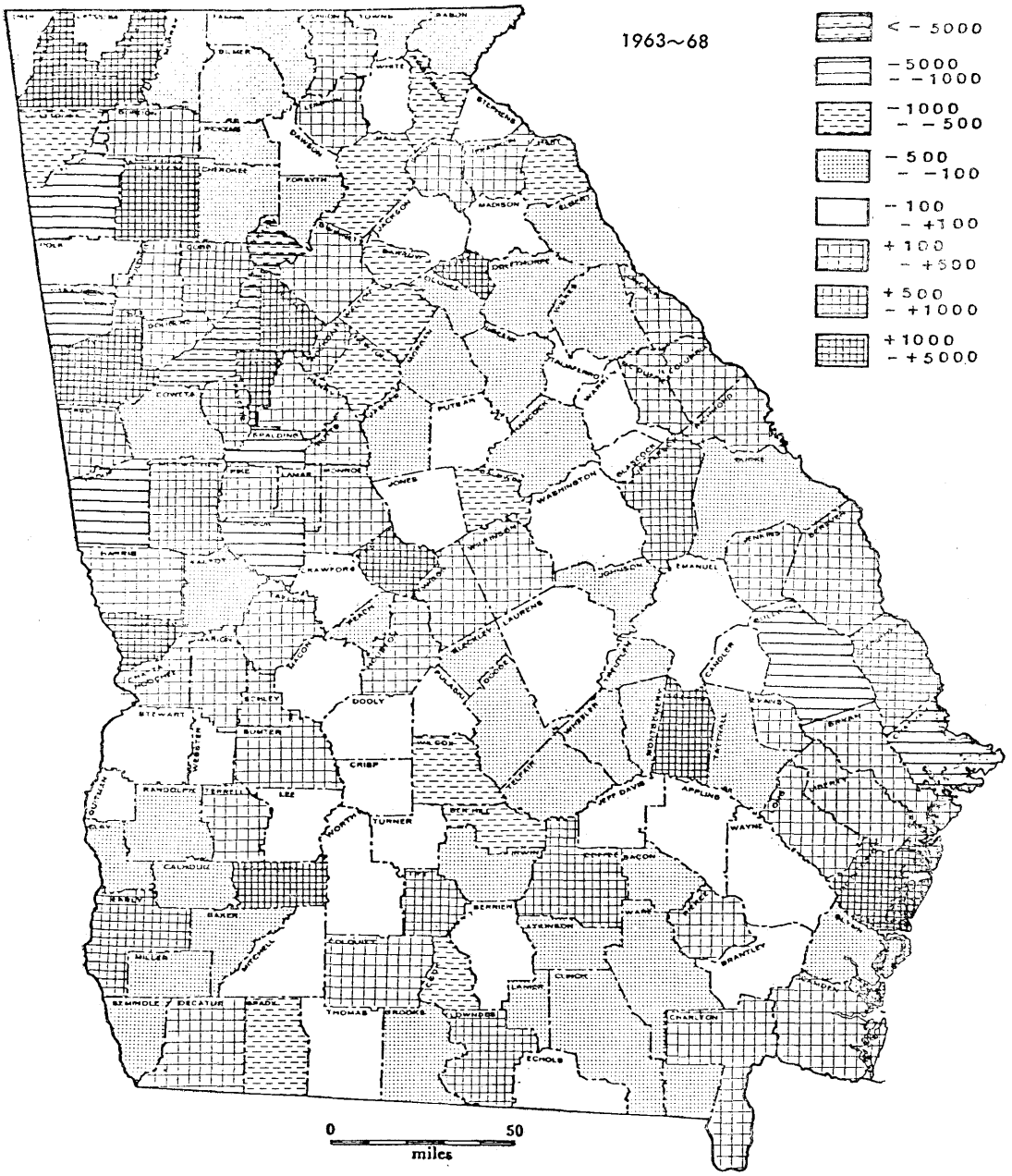


**Fig. 10. Residuals of L.+Q.+Cubic Surfaces** (Comparative change 1963 to 1968)

Fig. 6 and Fig. 7. This can be interpreted as a diffusion process from the concentrated region to the depressed region. But it is difficult to say that this process is meaningful, because the explained variation and significance test shows only negligible trends. This confirms the point that it is not easy to determine significant trends in changes during the thirteen year period by using TSA.

Nevertheless, the analysis of residuals helps to understand major changes and problem areas. There have been great changes in the Atlanta Standard Metropolitan Statistical Area. Fulton and Cobb counties have experienced the greatest losses, while Dekalb county has experienced the greatest gain. It should be pointed out that there are some difficulties in applying the TSA to a large scale, given the extreme variation within the metropolitan area. The northwest part of the Atlanta SMSA

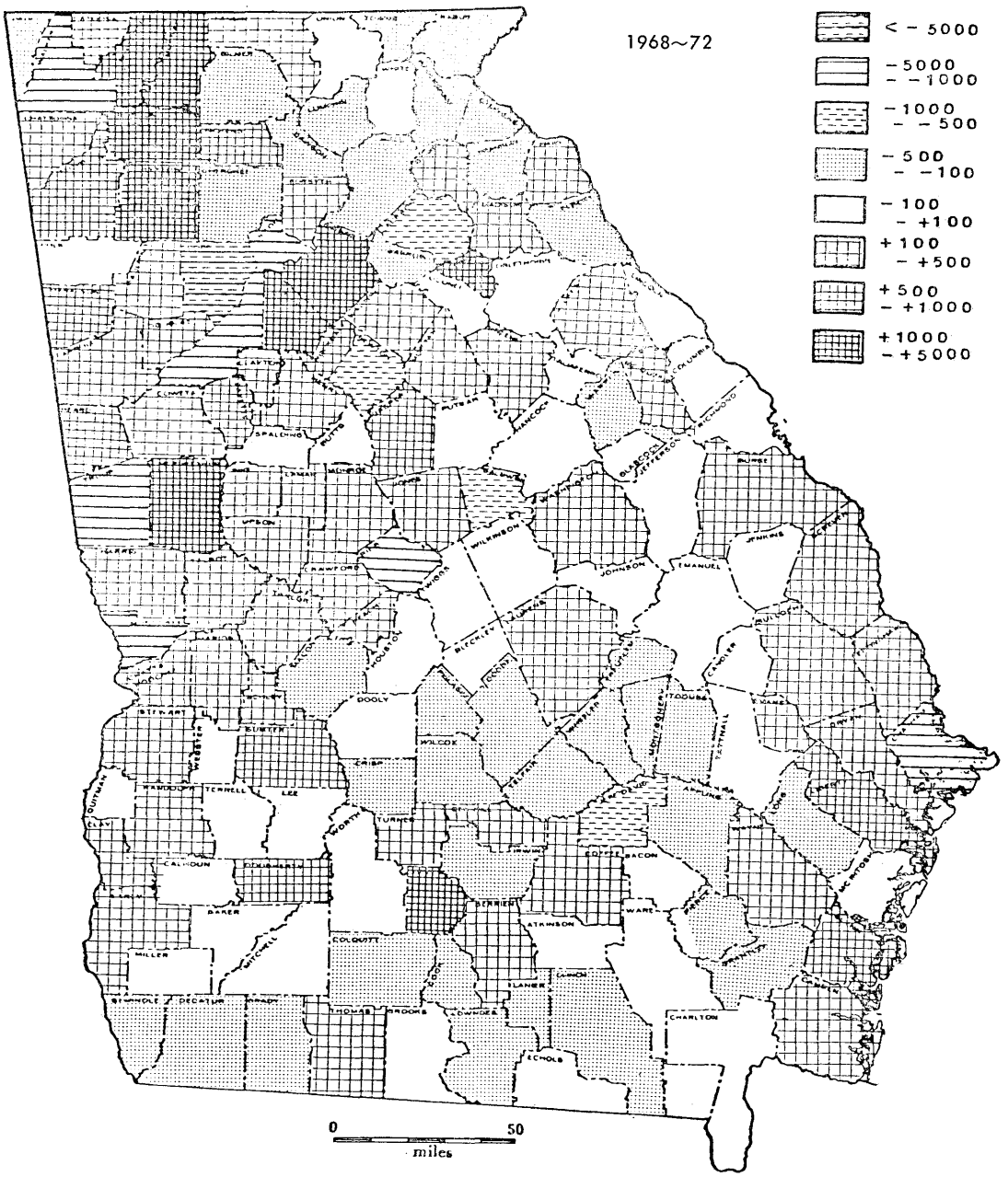


**Fig. 11. Residuals of L.+Q.+Cubic Surfaces** (Comparative change 1968 to 1972)

has certainly lost its share, while the southeast part has clearly gained. This causes one to conclude that NW Georgia has declined while SE Georgia has grown. The residual maps of third-order surfaces (Fig. 9 through 12) tell us that there is an interregional as well as an intraregional change within the Atlanta SMSA. This result suggests that further detailed study in the metropolitan area should be done to identify clearly the contents and the processes of changes in manufacturing location.

## 4. Concluding Remarks

The application of the trend surface technique to employment data has posed two basic problems in this study: discontinuity of data and significance testing. These problems can

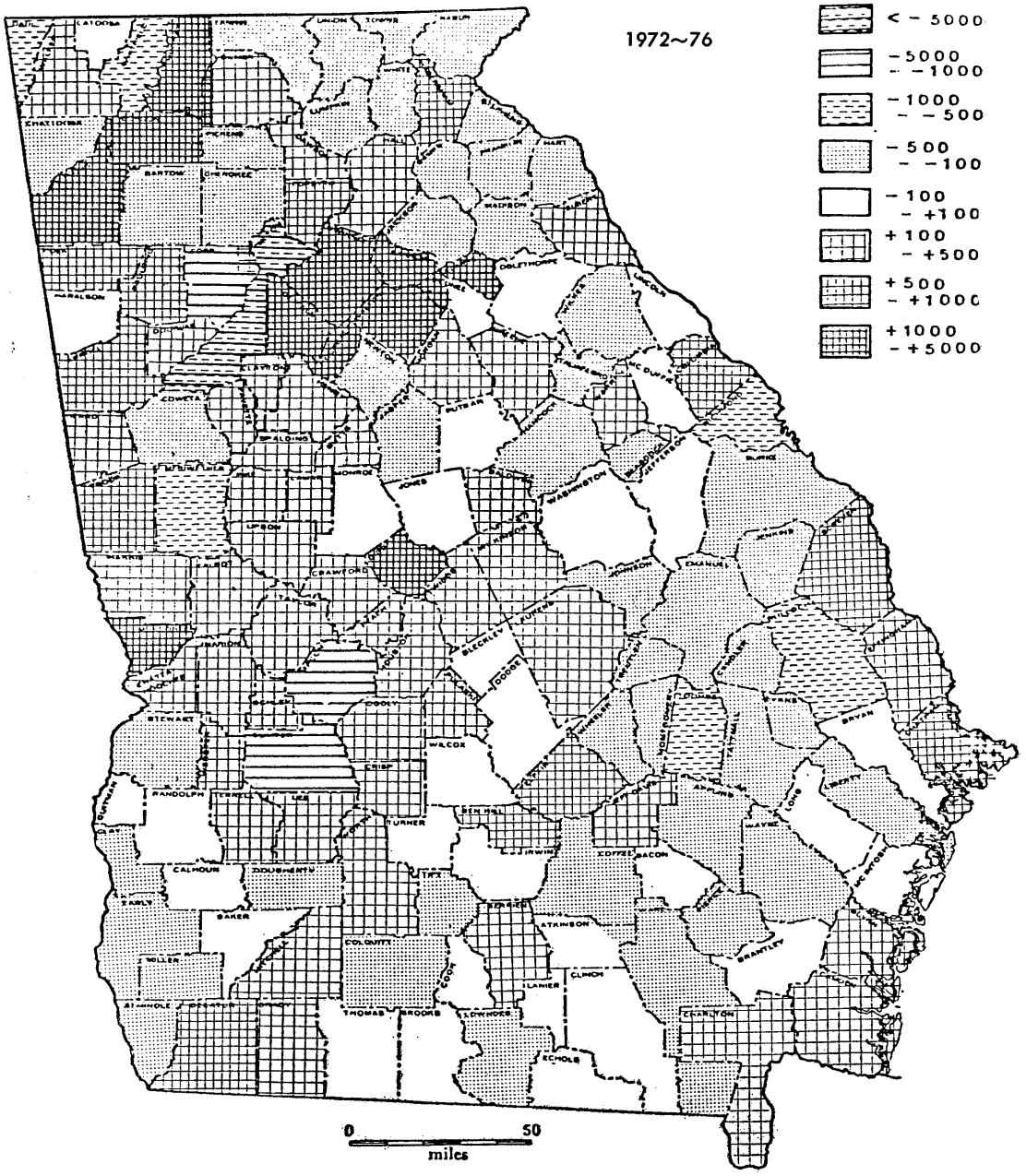


**Fig. 12. Residuals of L.+Q.+Cubic Surfaces** (Comparative change 1972 to 1976)

be overcome by justifying and recognizing the underlying problems. However, careful attention in using data and in deciding the scale of study should be given for successful analysis. The opportunity exists to apply this technique to social data where appropiate data exist at an appropriate scale, and where the underlying problems are justified and accounted for.

The major results of this analysis can be summarized as follows:

First, there is a directional decline of manufacturing employment from northwestern to southeastern Georgia.

Second, The northwest-central part and the southeast-central part of Georgia can be identified as the major concentrated and the major depressed areas, respectively.

Third, most of the concentration areas have diffused their shares to the surrounding areas or to the other areas. In other words, the metropolitan areas have experienced interregional changes as well as intraregional changes during the 13 year period.

Fourth, the analysis of residuals indicates the problem areas and suggests further intensive study in the Atlanta SMSA at a smaller scale to clarify locational changes in manufacturing.

Finally, the period of 1968 to 1972 seems to be an important turning point. Before this period, the concentration of manufacturing in the major industrial area was emphasized, while the decentralization or diffusion process began after this period.

The above findings, especially the identification of two processes of change, will be useful to further study of the evolution of manufacturing in terms of regional growth theory,[15] the concept of spatial margins to profitability,[16] and Pred's behavioral matrix concept.[17] The process of locational change can be examined in the context of regional growth, while the other two concepts are related to the evolution of industrial location patterns.

——University of Georgia, Ph. D. Course——

15) The study of locational changes should be done with regard to regional manufacturing growth. The following two works are related to this aspect.
Boventer, E.V., 1975, "Regional Growth Theory", *Urban Studies*, Vol. 12, (1975) pp. 1~29.
Richardson, H.W., 1973, *Regional Growth Theory*, Mcmillan, p. 264

16) Smith, D.M., 1971, *Indusrial Location*, John Wiley and Sons, Inc., New York, pp. 184~186.

17) Pred, A., *Behavior and Location*, Part I and II, Lund Studies in Geography, No. 127(1967), No. 28(1969).

# Georgia 製造業의 立地的 變化의 傾向에 대하여

朴 杉 沃*


## 要 約

本考는 美 Georgia 에서의 1963~1976 年 사이의 製造業의 總體的 傾向을 分析하였으며, 또 分析方向은 製造業의 立地要因, 地域構造, 擴散보다는 그 立地的 變化에 촛점을 맞추었다. 製造業의 立地的 變化 및 立地變化 model 設定은 地域開發 및 地域計劃에 매우 有用할 것이다.

資料는 1964, 1969, 1973, 1977 年의 Georgia 製造業名簿에서 구하였으며, 製造業 從事者數가 分析의 主對象이다. Georgia 의 159郡이 硏究對象地域이며, 各 郡의 人口의 中心點이 Trend Surface Analysis 의 座標로 使用되었다.

本考에서는 傾向을 分析하기 위한 技法으로 靜態的인 傾向要因을 밝히는 데 가장 유용한 power series model 을 使用하였다. 그러나 TSA 를 이용하는 데 있어, 여기서 사용한 資料가 非連續的이고 標本(sample)이 아닌데 有意檢證을 할 수 있느냐가 問題가 된다. 이러한 TSA 使用의 問題點에도 不拘하고 地圖分析 및 殘差分析에 의해 工業立地의 대체적 傾向을 볼 수 있으리라 본다.

Georgia 에서의 總體的 傾向은 Fig. 1~3 에서 쉽게 볼 수 있다. Fig. 1 의 一次 傾向面에서 就業(employment)의 傾向이 北西—南東으로 傾斜진 것을 보여 준다. 이 基本的인 傾向은 13年 동안 별 變化가 없는 것 같다. 各 次數의 傾向面들을 살펴볼 때 다음 두 가지의 疑問點이 提起된다. 即, 各 次數의 傾向이 果然 意味있는가, 또 1963~1976 年 사이에 工業立地의 重大한 變化가 있었는가가 바로 그것이다.

첫번째의 경우, 變數分析과 傾向面의 說明量을 볼 때 傾向이 强하지 않다(Table 1). 그 原因은 殘差에 있어서 metropolitan 地域에서 過大値를 나타내어 說明量을 歪曲시키기 때문이다. 이 効果를 없애는데에는 資料를 log 化시키고 過大値를 보이는 郡을 빼는 方法이 있는데 本考의 경우 1976 年 3 次 傾向面에서 從事者 8,000 人 以上의 8 個郡을 除外시켰다.

Fig. 4~6 은 log 化된 傾向面인데 主傾向은 變化가 없다. 有意檢證 結果 99 % 의 有意水準에서 이러한 總體的 傾向은 意味가 있었다(Table 2). 8 個郡을 除外하더라도 根本的인 變化는 없었다(Fig. 7).

둘째로, 1963~1976 年 사이의 製造業의 基本傾向에는 根本的인 變化가 없으나 各年度의 地圖를 對比해 보면 立地變化의 要素가 認知될 수 있다. 製造業 集中地域은 1963~1968 年 동안 상당한 成長을 하였으나 落後地域은 同期間中에 별 變化가 없었다. 이와 反對로 1968 年 以後 集中地域은 약간의 成長이 있은 反面 落後地域은 계속적인 成長이 있었다. 이 結果 1963~1968 年 사이에 主要工業地域의 集中이 있었으며, 1968~1976 年 사이에는 分散 내지 擴散이 있었음을 나타낸다.

이 傾向의 變化를 明確히 알기 위해서는 製造業의 相對的 變化를 考察할 필요가 있다. Fig. 8 에서 보듯이 相對的 變化의 傾向은 NW 에서의 減少와 SE 에서의 增加로 縮約될 수 있다. 이것은 集中된 地域으로부터 落後된 地域으로의 擴散過程으로 解釋될 수 있다. 그러나 檢證結果가 보여 주듯 이러한 過程이 意味있을 것인가는 TSA 만으로는 不足하다고 생각되나 殘差分析은 主要變化와 問題地域을 理解하는 데 도움을 준다(Fig. 9~11). 또한, 立地變化를 보다 明確히 보려면 보다 작은 scale 로 Atlanta SMSA 를 硏究해야 함을 示唆한다.


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