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SEASONAL EMPLOYMENT PATTERNS
IN NORTHERN MICHIGAN

By

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ABSTRACT

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This research identifies and compares seasonal employment patterns in northern Michigan between 1970 and 1978, and discusses the geographic and economic implications of these patterns. Seasonal variations in employment are defined as changes in employment occurring in similar timing, duration, and intensity from year to year, related to social, economic, and climatic factors.

Monthly employment estimates from 1970 through 1978 for each of four industrial groups (durables, nondurables, government, services) for thirty-four labor markets in northern Michigan constitute the data base. Harmonic analysis is applied to these monthly time series to objectively measure periodic fluctuations in employment and to examine variations over space and time.

Northern Michigan's service sector experiences the largest annual fluctuations while durables, nondurables, and government exhibit weaker seasonal fluctuations. The amount of seasonal change in service employment is positively correlated with tourism opportunities in the labor market. Variations in seasonal employment patterns throughout northern Michigan are found to be related to the occurrence of tourism, the industry mix, and distance from major economic centers.

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CHAPTER I

INTRODUCTION

Scope and Purpose of the Study

The population, economic structure, relative location, and resource base of an area will strongly influence, and be influenced by, the spatial and temporal distributions of economic activities (Haggett, Cliff, and Frey, 1977). One indicator of economic activity is employment, and it may be assumed that a change in employment reflects a change in the underlying economic structure (Perloff et al., 1960). Thus, an understanding of changes and patterns of employment may lead one to a realization of the basic economic system of a region. Accordingly, the focus of this study is upon employment as an indicator of a region's economic activities.

There are two major purposes of this study: (1) to determine spatial and temporal patterns of seasonal employment; and (2) to explain the processes generating these patterns. This will be done by examining the periodic fluctuations of employment levels within the year (seasonal variations) for industrial and service sectors in northern Michigan, and relating these seasonal elements and their geographic patterns to selected locational variables. In this way, patterns of spatial processes will be defined as they relate to seasonal employment and specific economic activities.

Attention to seasonal employment is not only warranted in itself as a factor of economic change, but it is also related to complex economic conditions. Within the regional economic setting the behavior of seasonal employment has fundamental economic and geographic implications. For example, a reduction in the seasonal fluctuations in employment can lead to a more stable community as a result of increased regional economic efficiency (Thompson, 1965). For these reasons, it is necessary to examine short term fluctuations in employment levels, seasonal movements, as well as their interrelated processes.

Economic Change and Seasonal Fluctuation

Economic change is often portrayed as a *time series*, defined according to Mendenhall and Reinnuth (1974) as a sequence of measurements taken on a variable process over time. The time series is generally considered the addition of four meaningful components: the trend, cycle, seasonal, and irregular (random) movements. For example, the actual time series illustrated in Figure 1a can be explained by the summation of these four movements. Each of these movements are related to different phenomena. The first of these is the *trend*, which defines the steady increase or decrease of a variable over time and is therefore represented as a "linear trend" (Figure 1b). The *cycle* of the time series is the periodic fluctuation with oscillations occurring between three and seven years, often called the "business cycle" (Figure 1b). The *seasonal* components are the periodic fluctuations which have peaks at the same time (or times) each year (Figure 1b). The final movement is the *irregular* variation, which is the oscillation

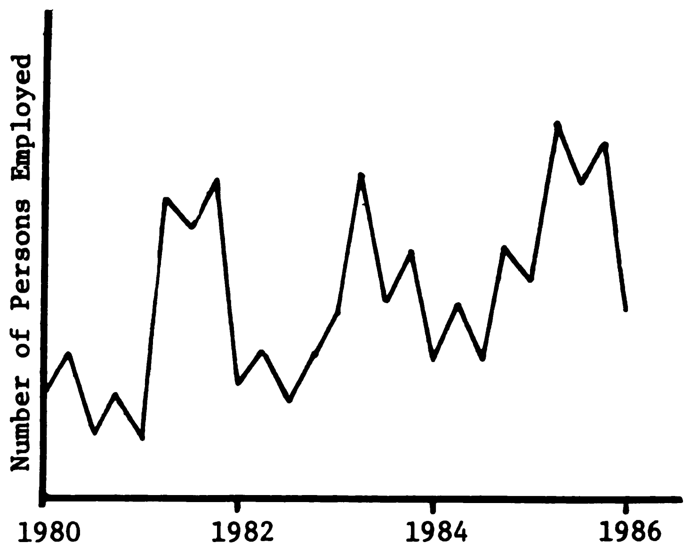

Figure 1a. Sample Employment Time Series.

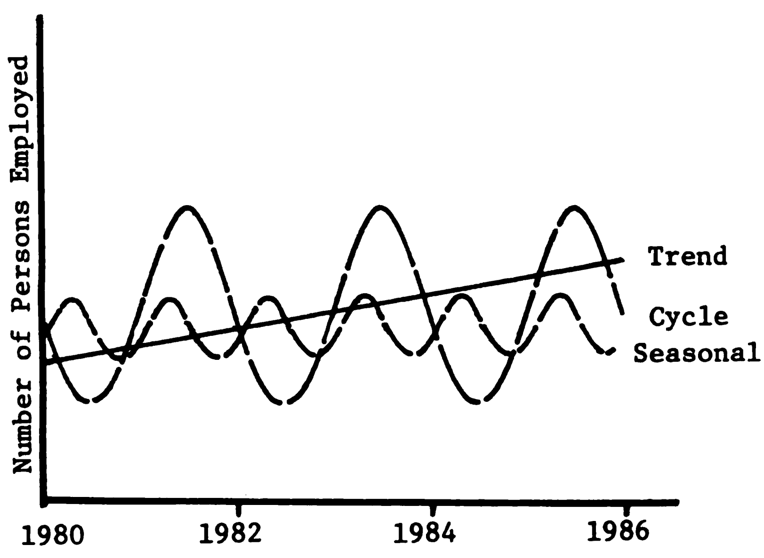

Figure 1b. Trend, Cycle, and Seasonal Curves for Sample Employment Time Series.

of a time series due to strictly local or episodic events. When these four components are aggregated, they recreate the original time series in Figure 1a.

Various economic time series have been examined to understand factors related to general economic change and instability (Neter and Wasserman, 1956). Greig (1949) discusses the problems of business instability and analyses of economic change as primary objectives in economic research. The dominant emphasis has been upon investigations of aggregate phenomena, such as, gross national product and trends in labor and income. Less attention has been given to the details of economic change, behaviors of individual industries, their markets, and, in particular, short term fluctuations in business activities (Bonin, 1968). Furthermore, Thompson (1965:133) observes that the economic literature "exhibits a very uneven interest" in economic instability, with the greatest attention focused upon long term fluctuations.

The focus of this study is the timing and spatial patterns of seasonal variations within a set of regional employment time series. Seasonal variations, or fluctuations, in employment are defined as changes in employment levels recurring in similar timing, duration, and intensity from year to year (Bourque and Brabb, 1960); a persistent periodic fluctuation within the year. Some of the forces associated with seasonal variations are repetitious social, economic, and climatic patterns. Autumn lumbering of coniferous trees, winter ski vacations, automobile style changes, December retail surges, and summer camping trips, are some familiar examples. The variability of these seasonal fluctuations is related to variations in both supply and demand factors, as well as external and internal forces of a region.

An Introduction to Harmonic Analysis

In order to clarify the concept of seasonality and introduce the methods employed in this study, a brief example is presented here.[1] Average monthly employment levels in the service industries for the Escanaba labor market area in Michigan's upper peninsula are illustrated in Figure 2. The January value is the average for the nine Januaries from 1970 through 1978; the February value is the average for the nine Februaries, and so on. Figure 2 clearly shows the fluctuating employment levels throughout the year in the services industrial group.

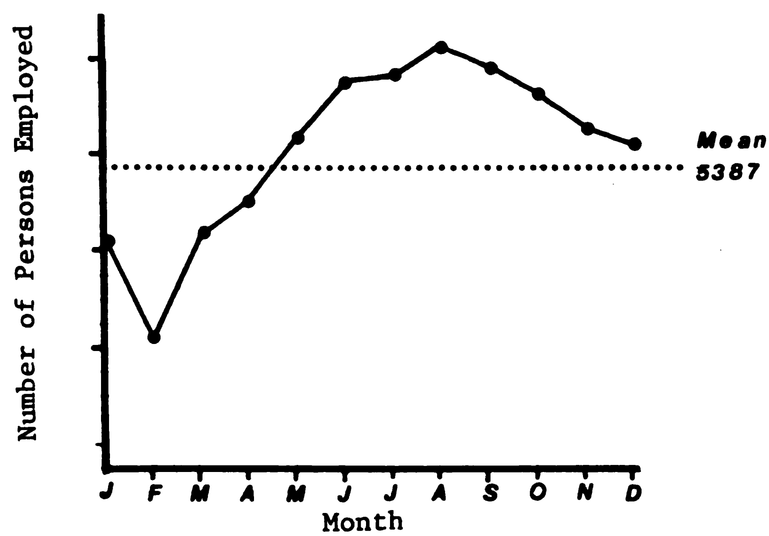

Figure 2. Average Monthly Employment, Escanaba Labor Market, Service Industries (1970 through 1978).

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[1]A more detailed development of harmonic analysis is found in Chapter III.

Peak employment occurs in late August and the lowest employment is in February. These fluctuations in the time series are the seasonal variation in employment.

The mean employment over the nine year period is 5,387. This average employment value, of course, tells us nothing about fluctuations throughout the year. Recognizing that there are seasonal elements, or periodic behaviors, within the year, questions arise regarding the measurement of seasonality, and the classification and comparison of different regions based upon seasonal characteristics in employment. How do we measure these fluctuations in employment levels? What are the magnitudes of variations above and below the mean? Do annual or semiannual oscillations predominate? Are different time series indicative of different temporal or spatial processes? Measures of the magnitudes, variance, and timing of seasonal oscillations must be developed in order to answer these questions.

Harmonic analysis is one method which affords a means to an objective description of seasonal patterns by analyzing the periodicity of the data (Conrad and Pollack, 1958). The primary assumption of this analysis is that the observed phenomena exhibit oscillations at regular intervals. The method fits a series of trigonometric functions to an observed set of data by the method of least squares. The observed curve is replicated by the summation of sine and cosine curves of varying frequencies and amplitudes.

The application of an harmonic analysis to the monthly service employment of the Escanaba labor market results in the curves in Figure 3a, illustrating the first and second frequencies, or harmonics. A curve of the first frequency has one maximum and one minimum. A curve of the second frequency has two maxima and two minima. By summing these two curves of varying frequencies, we arrive at the more complex curve in Figure 3b, which explains most of the seasonal variation in the monthly employment time series for Escanaba. (Note the similarity between the two curves of Figure 2 and Figure 3b.) Reversing this summation is essentially the function of harmonic analysis; from a complex original time series we can isolate each of the individual harmonics.

A set of harmonics can be determined for every observed time series; the observed data equalling the sum of the estimated trigonometric functions. Each of the harmonics has two component parts known as amplitude and phase angle. The amplitude of the first harmonic is the amount the maximum (minimum) is above (below) the mean (distance ba or bc in Figure 3a). The time of year the peak (e) occurs is determined from the phase angle (distance de' in Figure 3a). With the harmonic analysis not only are the amplitude and timing determined, but we can also establish the amount of variation in the observed data (the monthly averages) which is explained by each estimated harmonic.

The first harmonic of service employment in Escanaba has an amplitude of 445 above and below the mean; the peak employment occurs August 21; and 84% of the total variance is explained by the first harmonic. The second harmonic has an amplitude of 128, the peak timing

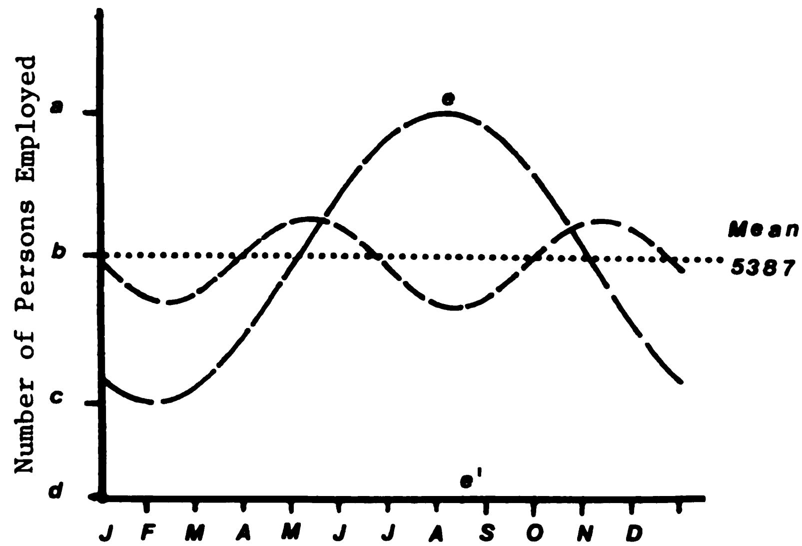

Figure 3a. First and Second Harmonic Curves of Monthly Employment, Escanaba Labor Market, Service Industries (1970 through 1978).

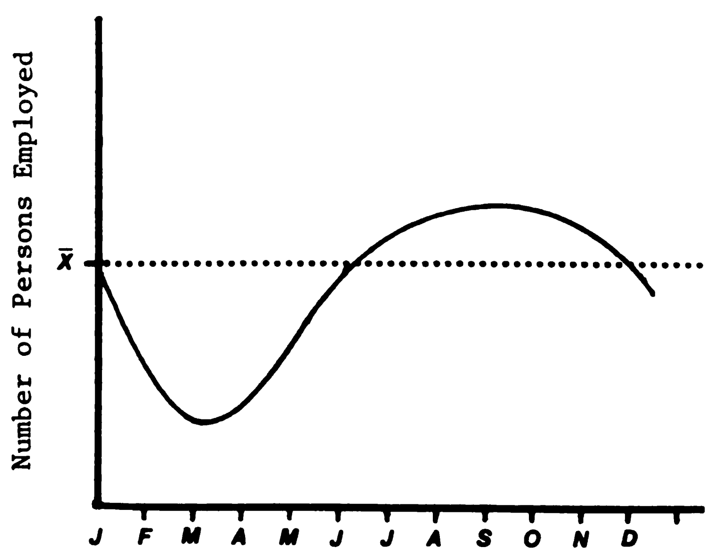

Figure 3b. Summation of First and Second Harmonic Curves of Monthly Employment, Escanaba Labor Market, Service Industries (1970 through 1978).

occurs May 29 and (six months later) November 29; and 7% of the variance is explained. From these measures of the first two harmonics, we can clearly define the temporal distributions of employment in the labor markets. The amplitudes reproduce the magnitude of the variations or fluctuations within the year; the timing gives an exact date of peak employment; the variance determines the predominant frequency within the time series and suggests "unexplained" variance (84% + 7% = 91% explained). Most of the seasonal employment in Escanaba is attributable to annual variations with secondary semiannual influences.

This harmonic analysis presents only the temporal seasonal patterns of the service industries in only one labor market. In order to understand the regional economic factors and geographic implications related to seasonal employment, it will be necessary to do this same analysis for several labor markets.

Regional Economic Concepts

The underlying spatial patterns and process of economic change within the regional, economic settings are "intertwined in a maze" of interactions and interdependencies (Isard, 1960:3). As individual activities, industries operate within, and, as a result of, this larger economic system. Oscillations in different economic activities are often examined in terms of their relationships to the economic base and industrial mix of a locality. An understanding of these factors as they relate to regional economic concepts will account for much of the seasonal variability of employment over time and space.

Spatial Patterns of Seasonal Magnitude

Some important concepts related to differences in seasonal patterns are found in economic base models. Simply stated, economic base defines activities which export goods or services from a region as basic, and activities whose goods or services are consumed locally as nonbasic (Tiebout, 1962). The basic activities determine growth of a community as they bring in additional income which stimulates an increase in more nonbasic activities (the multiplier effect) resulting in greater employment. Economic units produce for both the local and export markets. Assuming wages and investments constant, the major short run changes in the local economic system come from changes of exports and imports (Nourse, 1967). Therefore, we may expect different locations to experience different seasonal employment patterns related to the composition of exports and imports.

Fluctuations in different types of industrial activity will have different effects upon regional employment cycles. Certain basic activities are related to a national market, and, in turn, affect local retail and service sectors. In this way, some of the variations in basic activities (i.e., demand for exports) throughout the year will indirectly affect even local service and government employment. The magnitudes of seasonal fluctuations in basic activities will be reflected in the magnitudes of nonbasic activities.

In regions of high tourism, such as northern Michigan, we can expect service industries to behave as basic industries. This has been proposed by a number of authors (Gray, 1970; Strang, 1970; BarOn, 1978; International Union of Travel Organizations, 1972). As a result of the tourism industry, which is highly seasonal, part of the local population is temporary, or seasonal. It is a local population in terms of location only; in actuality, the local market is imported. For this reason, tourism may be considered a basic industry which will significantly affect the overall level of activity within a locality, especially in the nonbasic, service industries. Consequently, those places dependent upon tourism and related service industries will experience greater seasonal fluctuations in employment as a result of the seasonal population.

One additional factor which will affect the magnitudes of seasonal fluctuations in employment is the location of the industries within a region. As a result of distance and accessibility, those labor markets farthest from major economic centers (Detroit and Chicago) will have fewer interactions with those centers. Thus, fewer tourists, or populations, will travel to these distant markets resulting in smaller impacts upon tourism and service industries. For these reasons, the more remote areas within the study region are expected to exhibit smaller seasonal magnitudes, or fluctuations, in employment.

The actual amount of industries within an area is also a factor affecting the amount of seasonal variations in employment. It is generally argued that increased city size brings greater industrial diversification, where some balance of industries contributes to overall seasonal stability. "Even unbalanced, random diversification is likely to affect a substantial reduction in local seasonal instability" (Thompson, 1965:147). The amplitudes of seasonal employment are therefore expected to be relatively smaller in the more populated and central economic places as a result of their more diversified industrial composition. Related to their less diversified industrial composition and dependency upon a highly seasonal export activity, places with singular industrial activities, such as tourism-dependent areas, will have high amplitudes. Thus, the spatial patterns of seasonal employment magnitudes will reflect patterns of the industrial nature of a region.

Spatial Patterns of Seasonal Timing

Different processes determine patterns of supply and demand for different types of industries. Where industries such as forestry and agriculture are supply-oriented, we may expect seasonal employment to reflect temporal fluctuations in supply, perhaps related to climatic conditions. For demand-oriented industries such as retail and food services, employment patterns will reflect variations in demand throughout the year. Although these variations in factors of supply and demand are difficult to determine, it is important to realize that different temporal processes exist within each industry.

Pigozzi (1980) argues that the transmission of information within a system of cities, during periods of less than a year, has elements of spatial diffusion. These spatial-temporal transmission paths are evident in an urban hierarchy, regardless of whether they are related to forces external to the regional system or within. A conceptual model thus emerges, where changes in the urban system are related to "regional, structural, and temporal components" (Pigozzi, 1980:1). Similarly, but in a smaller and less economically complex region, we can expect patterns of seasonal employment to exhibit temporal behaviors.

It is proposed that the peak timing of seasonal employment will vary spatially. Related to concepts of distance-decay and diffusion, similar behaviors occur in "proximate places" (Bannister, 1975:178). As distance increases from the major population centers, the peak timing of employment will change, reflecting the diffusion of central influences into these areas. Although it is difficult to anticipate an hierarchical direction of these behaviors due to the dominance of different economic factors, the larger cities are expected to be central points within the timing patterns related to their economic influences upon rural areas.

Thus, complex geographic and economic concepts such as economic base, industrial diversification, and spatial diffusion processes can perhaps explain the variability of employment among regions and industries. Seasonal variations in employment are expected to occur over spatial as well as temporal dimensions. As an example, harmonic analysis can be applied to the service employment time series of the Manistique labor market, adjacent to Escanaba in Michigan's upper peninsula (see Figure 5). The curves of the first two harmonics, or frequencies, for the monthly series (Figure 4a) are presented in Figure 4b. These curves show differences between the two labor market areas of Escanaba and Manistique (Table 1). Although the amplitude for Escanaba's first harmonic is larger than Manistique's, the mean is also larger. By calculating the relative amplitude, we can compare the

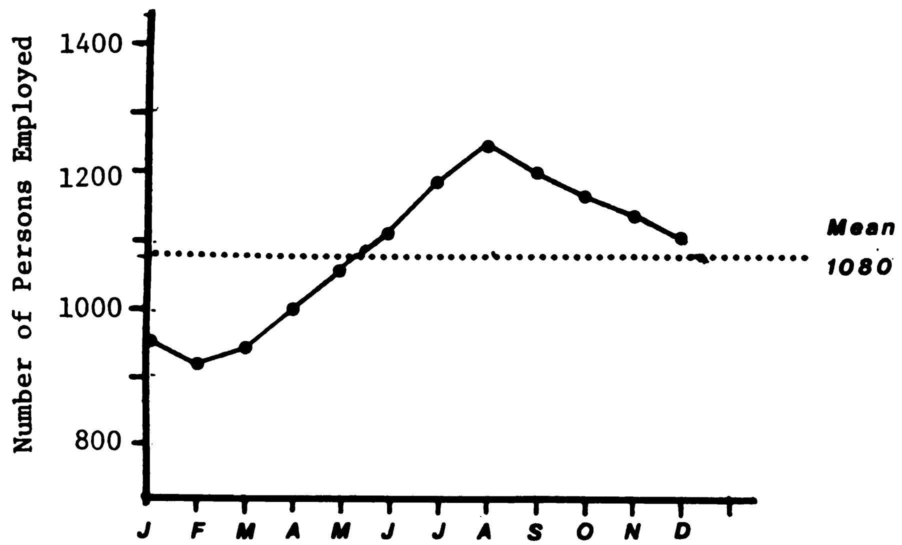

Figure 4a. Average Monthly Employment, Manistique Labor Market, Service Industries (1970 through 1978).

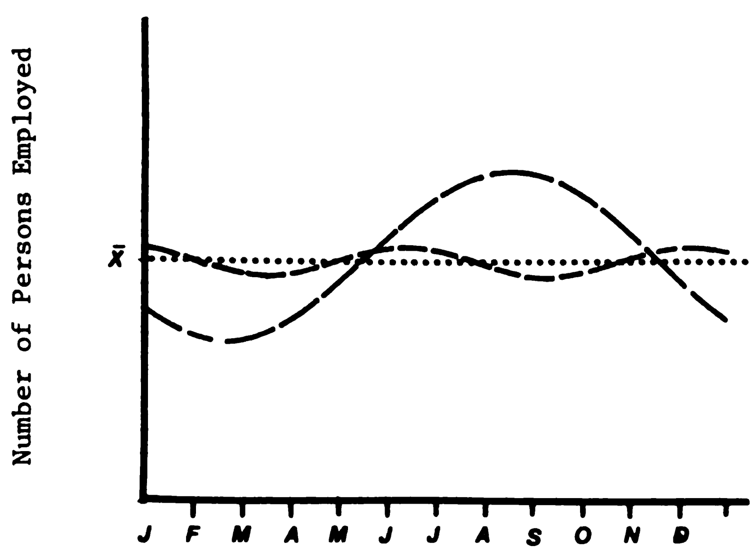

Figure 4b. First and Second Harmonic Curves of Monthly Employment, Manistique Labor Market, Service Industries (1970 through 1978).

Table 1. Harmonic Measures of Monthly Employment for Escanaba and Manistique Labor Markets, Service Industries

Labor Market	Mean Employment	Actual Amplitude	Relative Amplitude	Percent Variance	Peak Timing
		-------- First Harmonic --------			
Escanaba	5,387	445	8.3	84	August 21
Manistique	1,080	213	19.7	97	August 17
		-------- Second Harmonic --------			
Escanaba		128	2.4	7	May 29/Nov 29
Manistique		23	2.1	1	June 14/Dec 14

magnitudes of seasonal impacts among different locations.[1] The relative amplitude for Manistique is more than twice that of Escanaba, showing Manistique service employment experiences more extreme seasonal employment fluctuations. Although only a slight variation in the timing of peak employment occurs (August 17 versus August 21), by examining the timing of other adjacent labor markets, specific spatial-temporal patterns are expected to emerge and such patterns would be evidence of spatial processes.

Thus, the questions being addressed in this thesis are: What specific patterns of seasonal employment exist among different labor markets and industries throughout northern Michigan? What regional factors account for the variability of amplitudes, variance, or timing? Are seasonal variations related to certain economic or locational

[1]Relative Amplitude $= \frac{\text{Amplitude}}{\text{Mean}} \cdot 100.0 =$ percent change in employment.

influences? It is the intent of this research to identify spatial patterns of seasonal employment in northern Michigan and some of the economic factors associated with these patterns.

Organization of the Thesis

Chapter I has summarized the scope and purpose of the study within the temporal and geographic settings. A brief example of the characteristics of seasonality and the methodological approach were also presented. The regional economic concepts and spatial processes being addressed are further clarified in the following chapters. Chapter II discusses the data base and the study region, followed by statements of the specific objectives and hypotheses. The procedures are clarified in Chapter III, including a more detailed explanation and derivation of the method of harmonic analysis, its appropriateness to the study, and further clarification of the hypotheses and the methods employed to test them. The results and implications of the analyses of the employment time series are discussed in Chapter IV. The hypotheses are evaluated and relationships among seasonal patterns, both geographic and economic, are examined. The final chapter summarizes the findings and limitations of the research and suggests further avenues of inquiry into the phenomena of seasonality.

CHAPTER II

DATA, OBJECTIVES, HYPOTHESES

Introduction

Geographic research can be classified into two fundamental research questions (Johnston, 1978:2). Are places different in terms of the phenomena there? Are there relationships between phenomena in different places? Regardless of ideology, philosophy, or methodological preference, all geographic research is an attempt to answer these questions. Within the context of this analysis we ask: Are the labor markets in northern Michigan different in terms of the seasonal employment? And, are there linkages between seasonal employment in different places? If there are specific spatial patterns of seasonal employment, what are the underlying factors which contribute to these patterns? These are the important questions which guide this study. The following sections present the data base, the specific objectives, and the working hypotheses of the inquiry.

Data and Study Region

The study region, northern Michigan (Figure 5), contains economic activities with local, regional, and national markets. The economy of the region is less diversified than Michigan's more metropolitan southern lower peninsula. Northern Michigan has major tourism

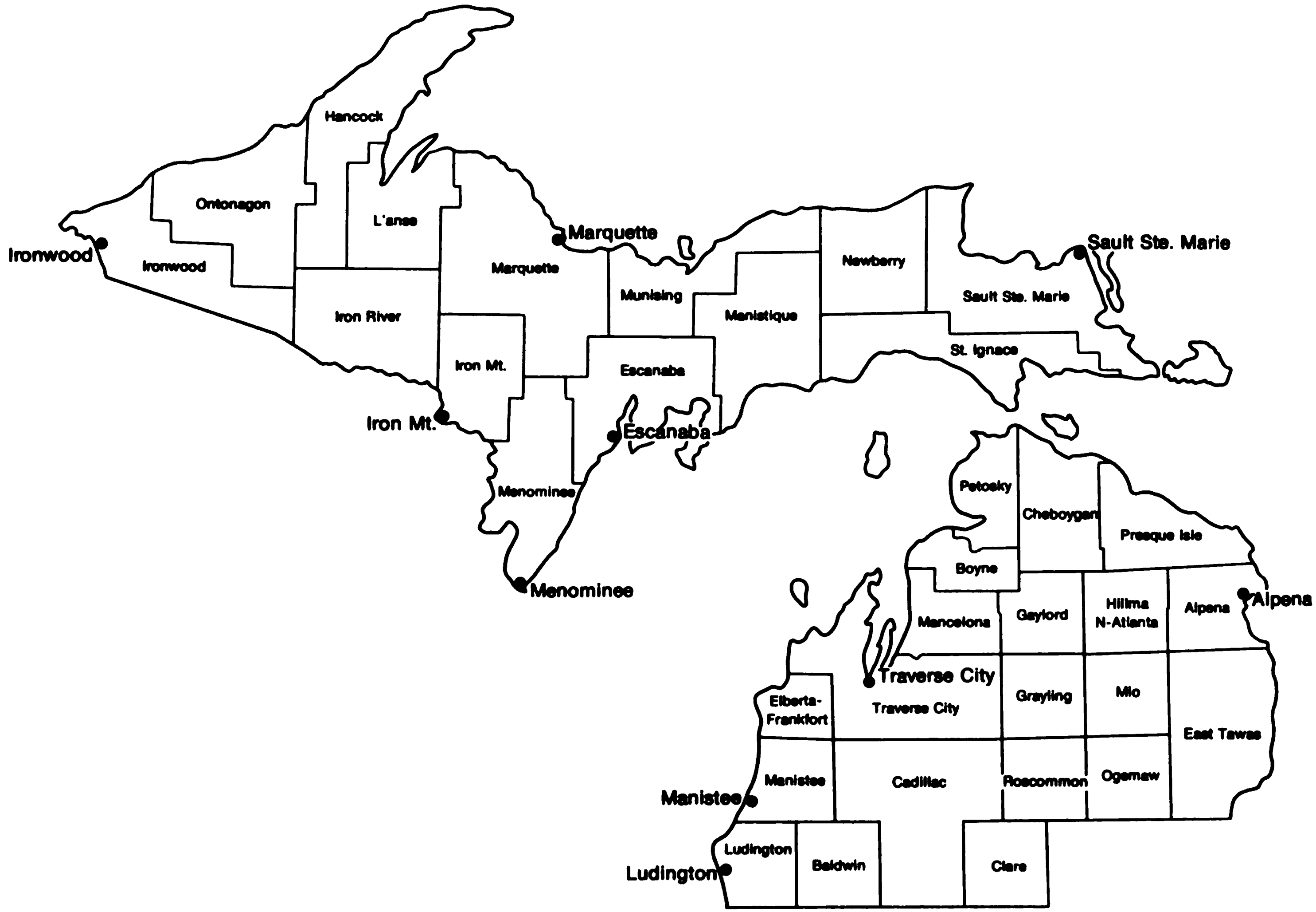

Figure 5. Labor Market Areas Within the Northern Michigan Study Region. (Source: Michigan Employment Security Commission, 1979.)

developments and therefore presents an opportunity for exploring the impact of seasonal populations upon local economics by investigating seasonal employment patterns. The exclusion of the larger metropolitan areas to the south is due to the emphasis upon areas where there are identifiable seasonal elements in employment. The strict periodic behavior of these seasonal patterns permits the use of harmonic analysis. (The southern counties are too complex, both industrially and temporally to use this method.)

Within the State of Michigan there are a total of sixty-four labor market areas (LMA) defined by the Michigan Employment Security Commission (MESC). In the southern half of the lower peninsula, these are primarily metropolitan counties, while the northern labor markets (northern lower peninsula and upper peninsula) are nonmetropolitan counties or pairs of counties. This analysis will focus upon the thirty-four labor market areas illustrated in Figure 5.

Civilian labor force estimates of wage and salary employment by LMA were obtained from the MESC. The bases for these estimates are monthly sample surveys of local employers in each LMA reported under the Michigan Employment Security Act (MESC, 1979). The MESC closely monitors 'critical' industries within the labor markets in order to strengthen the reliability of the estimates.

The MESC classifies all wage and salary industries (excluding agriculture) into four major industrial groups: "Durables, Nondurables, Government, and Nonmanufacturing." Table 2 presents the industries included in these groups. The "Nonmanufacturing" sector will be

Table 2. Industries Included in the Four Industrial Sectors

Wage and Salary Employment
1. Durables
Lumber and Wood Products
Furniture and Fixtures
Metals
Nonelectrical Machinery
Electrical Machinery
Other Durables
2. Nondurables
Food and Kindred Products
Textiles
Paper and Allied Products
Printing and Publishing
Chemicals and Petroleum
Other Nondurables
3. Government
Federal
State
Local
4. Nonmanufacturing[a]
Construction
Transportation, Communication, Utilities
Wholesale Trade
Retail Trade
Finance, Real Estate, and Insurance
Services
Mining

[a]The nonmanufacturing group will be referred to as "services."

referred to as the "Services" industries throughout this study to reflect the dominant activity in that sector, especially in the study area.

Monthly employment estimates from 1970 through 1978 for each of the four industrial groups for each LMA constitute the data for the analysis. The monthly estimates are averaged over a nine year period to yield a single series of twelve monthly averages for each industry and LMA. This nine year average permits us to isolate the seasonal components. Thus, there are five time series of twelve monthly averages for each LMA; a set of monthly observations for each of four industries, and one monthly series aggregated over the four industries. There are thirty-four LMA's in the study region; hence there are 170 time series (34 x 5).

Research Design

Characteristics of the northern Michigan climate, resource, and economic base account for the presence of seasonal elements in employment patterns (Battelle Labs, 1969; Ragatz, 1970). It is recognized that there are complex interrelationships among industrial activities within and beyond a region. The following objectives and hypotheses are proposed to illuminate specific relationships among seasonal employment patterns, industrial structure, and location.

Objectives

Most authors agree that all industries experience some degree of seasonality (Thompson, 1965). The identification of the short term employment fluctuations and quantification of their periodic properties are the first objectives in this research. The application of harmonic analysis to each data series yields well-defined, objective measures of seasonality for each labor market and industrial group.

> Objective 1:
>
> Measure the seasonal employment fluctuations within the labor market areas, between 1970 and 1978, for each industrial group.

By comparing the amplitudes, variance, and timing of employment, for each industrial group and LMA geographically, spatial patterns will emerge reflecting employment structure and spatial process. Areas of greater and lesser amplitudes of employment fluctuations will indicate the relative magnitudes of seasonal patterns. Variations in peak timing of employment will show relative temporal differences in seasonal employment among the locations.

> Objective 2:
>
> Examine the spatial patterns of the harmonic measures of relative amplitude, variance, and timing, among the industries and labor markets.

With the emergence of specific seasonal patterns throughout the study region, factors related to these patterns can be identified, such as environmental characteristics, changing populations, tourism opportunities, and different types of industries. By employing correlation analysis between selected variables and the harmonic measures, the strength of these associations can be determined.

Objective 3:

Relate the identified seasonal measures to selected locational variables.

The identification of the spatial and temporal distributions of employment, and their association with physical and social variables presents several implications for regional planning and development. Kuznets (1933), Greig (1949), and more recently, Ragatz (1970), Stynes (1978), Baron (1978), and Rottmann (1979) call for greater attention to investigations of seasonality in analyses of economic activities. Variations in activities, equipment, raw materials, and labor supplies throughout the year create costs which accrue to various social groups as well as to society as a whole (Kuznets, 1933). In addition to the short term impacts of seasonal fluctuation, seasonality also assumes importance as a factor of long term economic growth and change.

Objective 4:

Discuss the practical geographic and economic implications of seasonal employment patterns and the related factors affecting these patterns.

Hypotheses

Variations in the types of industries, the resource base, and locations, will influence the spatial patterns of seasonal employment. It is proposed that the industry mix within a locality is a factor affecting the seasonality of employment. The greater the industrial diversification, the more economically stable the area. Consequently, places with large populations will have greater and more diverse employment and thus smaller variations in employment during the year. Places of specialized economic functions or singular industries will have highly seasonal employment if the primary industry is a highly seasonal one. The null hypothesis is that there are no differences in the measures of relative amplitude and variance among labor markets, for all industrial employment. This hypothesis will be tested by comparing, statistically and visually, the measures of relative amplitude and variance of the first harmonic. Isoline maps of these measures will facilitate the spatial comparisons and delineation of seasonal patterns for the aggregate industrial time series for each labor market.

> Hypothesis 1:
> The aggregate seasonal employment patterns (relative amplitude and variance of the first harmonic) for all industries will vary among labor markets throughout the study region.

A fundamental proposition of this analysis is that seasonality varies over both space and time, suggesting the presence of spatial economic processes. Where industries are close to the sources of supply or demand, changes in these factors will be felt sooner than in those places farthest away. Location will significantly affect timing of employment related to hierarchical economic relationships among places. Variations in peak timing will center upon the major population areas as a result of their influence within the regional economy. This variability of temporal patterns occurring over space would lend support to the existence of a spatial diffusion component to process in the regional economy. The null hypothesis is that there are no consistent variations in timing within the study region. This hypothesis will be tested bv mapping the peak timing of employment in order to illustrate the direction of changes in peak employment among the labor markets.

> Hypothesis 2:
>
> The peak timing of seasonal employment for all industries will vary among labor markets throughout the study region.

Changes in the rates of production, and therefore levels of employment, are related to differences in supply and demand factors for different industries. Although it cannot be specified here whether changes in supply or demand occur first, it is recognized that seasonal patterns will vary among industries due to these interactions. The null hypothesis is that there are no differences in the measures of relative amplitude, variance, and timing among the four industrial groups. This hypothesis will be tested by the application of a t-test to seasonal measures. Both the Difference of Means and the Mean Difference will be applied to the harmonic measures in order to identify statistically significant differences in seasonality among industries.[1] In addition, descriptive statistics will give some indication of the variation in seasonal employment patterns among industries.

---

[1]Statistical Package for the Social Sciences (Nie, Hull, Steinbreuner, and Bent, 1975).

Hypothesis 3a:

Seasonal employment patterns (amplitude, variance, and timing) will vary among the four industrial groups.

We can assume that the manufacturing sectors (durables and nondurables) are composed primarily of basic activities, where fluctuations in employment will reflect changes in regional and national markets. The nonmanufacturing sectors (government and services) cater primarily to the local populations, and therefore will reflect changes in these populations. It is expected that the manufacturing industries will exhibit lower magnitudes of seasonal employment fluctuations because the stable use of machinery and equipment throughout the year will increase efficient operations. Nonmanufacturing industries will have large amplitudes related to the tourism economy of northern Michigan and the impact of the seasonal populations. The null hypothesis is that the magnitudes (relative amplitude and variance) of the manufacturing and nonmanufacturing industries are equal, with no variations among sectors. This hypothesis will be tested by examining the harmonic measures for each industrial group averaged over all of the labor markets.

Hypothesis 3b:

The durables and nondurables sectors will have lower relative amplitudes and variance of the first harmonic than the government and service sectors.

We can expect the durables sector to exhibit the smallest employment fluctuations due to their greater investments in heavy machinery. Furthermore, their close association and dependence upon the automobile industries in Michigan would be revealed in annual tendencies, reflecting the annual cycle of automobile production. The nondurables are primarily resource-oriented activities, highly dependent upon raw materials which are subject to marked seasonal variations in availability. Such factors as the spring birthing of livestock, harvests of wheat, and autumn lumbering, will affect temporal variations in the availability of supplies for the nondurables. In addition, these industries have more variable markets than the durables which would affect their annual or semiannual tendencies. For these reasons the durables are expected to exhibit smaller fluctuations in employment, although greater variation will be explained by the first harmonic than for the nondurables. The null hypothesis is that there are no differences in the relative amplitude and variance of the first harmonic between the durables and nondurables sectors. This hypothesis will be tested by examining the harmonic measures of relative amplitude and variance averaged over all of the labor markets for each industrial group.

> Hypothesis 3c:
>
> The durables sector will have smaller relative amplitude and greater variance explained by the first harmonic than the nondurables sector.

Although the government sectors are generally within the nonmanufacturing industries, they are often affected by changes beyond the locality, due to employment policy set at both state and federal levels. The service industries are almost entirely dependent upon the local population. Where places are highly tourism dependent, the changing local population will therefore have greater impact upon the service sector. It is expected that the relative amplitudes and variance of the first harmonic will be highest for the service sector. The null hypothesis is that there are no differences in the relative amplitude and variance of the first harmonic between the government and service sectors. This hypothesis will be tested by examining the harmonic measures of relative amplitude and variance averaged over all of the labor markets for each industrial group.

> Hypothesis 3d:
>
> The government sector will have smaller relative amplitude and less variance explained by the first harmonic than the service sector.

The northern Michigan labor markets are dominated by tourism and related services as they provide most of the employment in these regions (Michigan Department of Commerce, 1976). Renaud (1969) points out that as the population changes in a tourist area, the amount of services in employment will change. There is hypothesized a direct relationship between the seasonal population and the employment in services in the local area. As stated in Hypothesis 3d, the service sectors are therefore expected to exhibit the greatest fluctuations in employment and have the highest annual tendencies. For this reason more specific attention is given to the seasonal patterns of employment in services in this analysis.

Due to the relationship between the nonmanufacturing industries and tourism, it is expected that the magnitudes of seasonal fluctuations in government and services will be directly related to the number of tourism opportunities in an area. Such a relationship would reveal the impact of the changing local population upon the local economy. The more dependent an area is upon tourism, the higher the impact upon seasonal employment. In addition, the more tourism in an area, the less likely manufacturing will occur due to their locationally incongruent characteristics. The null hypothesis is that there are no relationships between the magnitudes of seasonal fluctuations, in either government or services, and tourism, or manufacturing. This hypothesis will be tested by applying correlation analysis to measures of relative amplitude and variance of the first harmonic, and selected tourism and economic indicators defined in the following chapter.

> Hypothesis 4a:
> The measures of relative amplitude and variance of the first harmonic for the government and service sectors will be directly related to tourism and indirectly related to manufacturing.

It is expected that similar relationships will occur between specific tourism indicators and the magnitudes of the second harmonic for the service and government sectors. If tourism is significantly related to fluctuations in the nonmanufacturing industries, then it is proposed that the ski resorts and other winter sports activities will impact the semiannual fluctuations in employment of the government and service sectors. The null hypothesis is that there are no relationships between the semiannual peaks and the winter tourism indicators. This hypothesis will be tested by correlation analysis also.

<u>Hypothesis 4b</u>:

The measures of relative amplitude and variance of the second harmonic for the government and service sectors will be directly related to the winter tourism in an area.

As a result of the relationships between tourism and seasonal change in services, specific spatial patterns of seasonal employment in the service sector can be anticipated. The highly specialized activities of tourism result in volatile local economies. These specialized areas will appear with the highest relative amplitudes. The very remote locations will show low relative amplitudes due to their distance from the southern population centers (Chicago and Detroit) and corresponding small seasonal population change. The more accessible remote areas will therefore exhibit higher relative amplitudes than those areas least accessible. In addition, the timing of peak employment in services is expected to vary among the labor markets. Major tourism areas will be points of early timing, while the more remote areas are expected to exhibit later timing. Furthermore, areas of winter sports resorts should have later timing than summer resorts. The null hypothesis is that there is no spatial variation in the relative amplitudes and peak timing of the first harmonic for the service sector among the labor markets. This hypothesis will be tested by constructing isoline maps of the relative amplitude and variance and examining these for spatial patterns within the study region.

Hypothesis 4c:

The service employment patterns of relative amplitude and peak timing will vary among the labor markets throughout the study region.

Analyses of the above hypotheses will determine differences between places in their seasonal variations in employment, and will define linkages between these seasonal variations and the spatial patterns. The following chapter explains in detail the procedures for quantifying seasonal phenomena and the methods employed for evaluating each hypothesis.

CHAPTER III

PROCEDURES AND METHODS

Introduction

The discussion of time series movements in Chapter I defined seasonality as a periodic phenomenon, with temporal patterns repeated from year to year. Understanding the periodicity of employment time series within the year is essential to recognizing seasonal patterns. By examining each of the frequencies contributing to this behavior, specific measures of seasonality can be determined and correlated with locational variables. Consequently, the essential periodicity of seasonal employment can be related to spatial influences. Harmonic analysis provides a method by which the components of this periodicity can be objectively defined. The first section of this chapter offers a detailed explanation of the method of harmonic analysis; and formally defines the measures of amplitude, variance, and timing. The second section will briefly explain the methods employed for the analysis of the seasonal patterns, thereby further clarifying the hypotheses from the previous chapter.

Harmonic Analysis

Early work in physics, music, and engineering introduced various applications for the analysis of time series. Important publications have appeared since the early 1800s when Joseph Fourier proved that any periodic function can be represented by a sum of sine and cosine curves.[1] This technique is called Fourier Analysis and has been applied to a variety of research in astronomy (Speight, 1965), and engineering (Blackman and Tukey, 1958); with geographic applications being primarily in the areas of climatology (Horn and Bryson, 1960; Sabbagh and Bryson, 1962), geomorphology (Goldstein, 1964), and more recently in economic geography (Bassett and Haggett, 1971; Bennett, 1974, 1979).

Horn and Bryson (1960) performed an harmonic analysis on monthly rainfall data for weather stations throughout the United States. By analyzing the harmonics of the annual, semiannual, and triannual variations, they were able to objectively map and identify cyclical precipitation patterns. Bassett and Haggett (1971) applied a variety of methods for the analysis of unemployment time series in order to classify, compare, and forecast regional unemployment in southwest Wales. Further studies in geography include work by Bennett (1979) who has produced a comprehensive synthesis of spatial-time series theory, methods, and applications. Other fields in the social sciences have found techniques of time series analysis particularly appropriate for studying various types of data, such as social change (Mayer and Arney, 1974), business cycles (Hamermesh, 1969), and recreational use (Beaman and Smith, 1974).

Mayer and Arney (1974) identify four main purposes of time series analysis:

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[1]Rayner (1971) provides a thorough description of the historical development of time series analysis techniques.

1. Establish the principle characteristics of a time series.
2. Determine the nature of the system generating the time series.
3. Forecast future values of a time series.
4. Specify relationships between different time series.

This study focuses upon the identification of the basic characteristics of the Michigan employment time series (first purpose above) in order to determine the temporal variability of seasonal employment. Fourier methods are applied to separate a time series into its component parts and analyze each of these individually (Panofsky and Brier, 1968). In addition, the analysis is an exploratory effort to begin to identify some of the underlying relationships which generate the time series, and how different time series interact or are related [(2) and (4) above]. There is no attempt to forecast in this study (third purpose above).

The major objective of Fourier analysis is to study periodicity within a time series. The basic assumption is that the data exhibit regular oscillations over time (Rayner, 1971). An examination of the northern Michigan employment data indicates that there is general conformity to this assumption.[1]

The formula for the Fourier series commonly used in harmonic analysis is:

$$Y = A_o + A_1\sin(\theta + \phi_1) + A_2\sin(2\theta + \phi_2) + \ldots + A_k\sin(k\theta + \phi_k) + \ldots + A_N\sin(N\theta + \phi_N). \qquad (1)$$

[1]Note that southern Michigan has been excluded from this study for this very problem; the metropolitan counties of the south show more complex temporal behavior.

Equation (1) in summation form is:

$$Y = \sum_{k=0}^{N} \left[A_k \sin(k\theta + \phi_k) \right] \tag{2}$$

where Y is the time series, A_k is the amplitude for frequency k, A_o is the arithmetic mean, and ϕ_k is the phase angle which determines the values of θ at which the extremes of Y occur.[1] Equation (2) can then be expressed by trigonometric identities, with the following summation of a series of sine and cosine functions,

$$Y = \sum_{k=0}^{N} \left[A_k \sin(\phi_k)\ \cos(k\theta) + A_k \cos(\phi_k)\ \sin(k\theta) \right]. \tag{3}$$

With Fourier analysis the sine and cosine terms are fitted to an observed set of data until their aggregation provides a perfect fit. When this process is limited to a finite number of terms (frequencies) it is called harmonic analysis.[2] With a discrete set of data, having N observations, the number of computable harmonics is N/2, or (N - 1)/2 for odd N. With 12 monthly means of employment observations, six harmonics can be extracted. The first harmonic will have a frequency of one (one maximum and one minimum) within the basic interval of twelve months. The second harmonic will have a frequency of two (two maxima

[1]The harmonic method presented here and applied in the analysis is from Conrad and Pollack (1950).

[2]Panofsky and Brier (1968) discuss the differences between Spectral, Fourier, and Harmonic analysis.

and two minima per year), and so on, with the sixth harmonic having a frequency of six (six maxima and six minima).

From equation (3) the coefficients for the series are defined by,

$$a\{k\} = A_k \sin(\phi_k) \qquad \text{and,} \qquad \{b\}k = A_k \cos(\phi_k). \tag{4}$$

Then for discrete data, with 12 observations, equation (3) becomes,

$$Y = \sum_{k=0}^{12/2} \left[a\{k\}\cos(k\theta) + b\{k\}\sin(k\theta) \right]. \tag{5}$$

From this the coefficients are determined, where,

$$a\{k\} = 2/12 \left[\sum_{k=0}^{6} \sin\left(\frac{2\pi jk}{12}\right) \right] \text{ and, } b\{k\} = 2/12 \left[\sum_{k=0}^{6} \cos\left(\frac{2\pi jk}{12}\right) \right] \tag{6}$$

where j is the monthly observation of the twelve month time series.

The sine curve [equation (2)] may be fitted to the data by: (1) increasing or decreasing the ordinate value of employment (amplitude), and (2) shifting the curve horizontally so as to change the abscissa value when the maximum and minimum employment occur (phase). For each frequency (harmonic) the amplitude, A_k, measures the maximum level of employment above (and below) the yearly mean, A_o. The time of year, T_k, during which the maximum occurs is determined from the phase angle, ϕ_k, and is referred to as the "timing" of harmonic k.

The amplitude, A_k, can be obtained by combining the coefficients, where,

$$A_k = (a^2\{k\} + b^2\{k\})^{\frac{1}{2}}. \tag{7}$$

The relative amplitude, R_k, is the amplitude expressed as a percentage of the mean,

$$R_k = A_k/A_o \cdot 100.0. \tag{8}$$

And the phase angle, ϕ_k, is defined by,

$$\phi_k = \text{Arctangent } \frac{a(k)}{b(k)} . \tag{9}$$

From the phase angle, the timing, T_k, (based upon a 360° interval) can be computed,

$$T_k = \frac{\phi_k}{k} + \frac{90.0}{k}. \tag{10}$$

T_k is then converted to the exact date during the year, using 360° equals 365 days.

The type of variation which predominates (annual, semiannual, etc.) will be revealed by comparing the amplitudes. Those harmonics, or frequencies which are most important in explaining the observed curve will have the largest amplitudes; the less important frequencies will have smaller amplitudes. The sum of the six harmonics will explain 100 percent of the variation in the time series.

The variance explained by the kth harmonic is,

$$\sigma_k^2 = \frac{A_k^2}{2} = \frac{[a^2(k) + b^2(k)]^{\frac{1}{2}}}{2} . \tag{11}$$

The total variance for the six harmonics is,

$$\sigma^2 = \sum_{k=0}^{6} A_k^2 \tag{12}$$

The percentage of the total variance explained by each harmonic k is,

$$V_k = \frac{A_k^2 \cdot 100.0}{\sum\limits_{k=0}^{6} A_k^2} \tag{13}$$

In summary, the above equations applied to a series of discrete points which exhibit periodicity, as in the monthly employment time series, will determine the harmonic measures of relative amplitude, R_k, variance, V_k, and timing, T_k, for each frequency.[1] The analysis of the timing of peak employment will delineate characteristics of spatial process not easily determined from other methods. In this way, the seasonal fluctuations will be quantified and can be compared and analyzed over spatial and temporal dimensions.[2]

Methods of Analysis

Seasonal employment patterns throughout northern Michigan are hypothesized to vary both temporally and spatially. Different industries as well as different places will exhibit variable employment fluctuations throughout the year. After the harmonic measures have

[1]The harmonic analysis is performed by a FORTRAN program which is included in the Appendix.

[2]For a more detailed explanation of harmonic analysis, see for example: Rayner (1971), Panofsky and Brier (1968), Conrad and Pollack (1950).

been determined comparisons of seasonal patterns can be made among the industries and labor markets. Furthermore, relationships between selected locational variables and the harmonic measures of relative amplitude, variance, and timing can be defined by means of correlation analysis. This section will clarify each of the methods used to evaluate the hypotheses, which are restated within the context of time series notation.

The employment time series of twelve monthly means can be expressed by, X^j_{iM}, where j is the industry, 1 through 4 (durables, nondurables, services, and government); i is the labor market, 1 through 34; and M is the nine year (1970 through 1978) average monthly series. For each X^j_{iM} there are three harmonic measures for each of six frequencies k,

R^j_{ki} = the relative amplitude of industry j, location i;

V^j_{ki} = the percentage variance explained by k, for industry j, location i; and

T^j_{ki} = the date of peak timing for industry j, location i.

The monthly series for all industries, 1 through 4, within location i, is,

$$X^{\cdot}_{iM} = \sum_{j=1}^{4} X^j_{iM}$$

And for frequency k, for all industries in i,

$R^{\cdot}_{ki}$ = the relative amplitude;

$V^{\bullet}_{ki}$ = the percentage variance; and

$T^{\bullet}_{ki}$ = the peak timing.

In addition to the harmonic measures for the aggregate industrial employment in each labor market, the average harmonic measure within the entire study region for each industry is also computed. Where,

$$\frac{\sum_{i=1}^{34} R^{j}_{ki}}{34} = \bar{R}^{j}_{k}$$ = the average relative amplitude for frequency k industry j, for the study region; and

$$\frac{\sum_{i=1}^{34} V^{j}_{ki}}{34} = \bar{V}^{j}_{k}$$ = the average percentage variance explained by frequency k, industry j, for the study region.

The general hypotheses stated in Chapter II are presented below. In the discussion following, these hypotheses are restated in the time series notation expressed above.

Hypothesis 1:

The magnitudes of seasonal employment (relative amplitude and variance of the first harmonic) for all industries will vary among labor markets throughout the study region.

Hypothesis 2:

The peak timing of seasonal employment for all industries will vary among labor markets throughout the study region.

Hypothesis 3:

Seasonal employment patterns (amplitude, variance, timing) will vary among the four industrial groups.

Hypothesis 3b:

The durables and nondurables sectors will have lower relative amplitudes and variance of the first harmonic than the government and service sectors.

Hypothesis 3c:

The durables sector will have smaller relative amplitude and greater variance explained by the first harmonic than the nondurables sector.

Hypothesis 3d:

The government sector will have smaller relative amplitude and less variance explained by the first harmonic than the service sector.

Hypothesis 4a:

The measures of relative amplitude and variance of the first harmonic for the government and service sectors will be directly related to tourism and indirectly related to manufacturing.

Hypothesis 4b:

The measures of relative amplitude and variance of the second harmonic for the government and service sectors will be directly related to winter tourism.

Hypothesis 4c:

The service employment patterns of relative amplitude and peak timing will vary among the labor markets throughout the study region.

It is expected that the patterns of seasonal measures for the aggregate industrial employment within each labor market will reflect both the industrial structure and relative locations of those places. By constructing isoline maps of measures, R'_{1i}, V'_{1i}, and T'_{1i}, for each location i, the spatial patterns of seasonal fluctuations will illustrate the orientation of magnitudes, and the direction of changes in the peak timing of the first harmonic. Hypothesis 1 and 2 can be restated as:

Hypothesis 1:

$A^{\bullet}_{1i}$ and $V^{\bullet}_{1i}$ will vary among location i, for each series $X^{\bullet}_{iM}$.

Test: Cartographic.

Hypothesis 2:

$T^{\bullet}_{1i}$ will vary among location i, for each series, $X^{\bullet}_{iM}$.

Test: Cartographic.

By disaggregating the industrial time series for each labor market and applying an harmonic analysis to the monthly time series of each industrial sector (durables, nondurables, government, and services), locational and industrial variations in seasonality will be determined. This more detailed analysis of the individual time series, X^{j}_{iM}, will examine specific factors affecting differences in seasonal patterns among the industries. Differences in the means of the three harmonic measures, as well as the mean difference will be tested by the application of a two-tailed t-test, with alpha equal to .05. Hypothesis 3 examines the variations in seasonality among the different industrial sectors. Where j and m are the individual sectors, 1 through 4, Hypothesis 3a is restated:

Hypothesis $3a_1$:

$R^{j}_{1} \neq R^{m}_{1}$, $j \neq m$ Test: t-test.

Hypothesis $3a_2$:

$V^{j}_{1} \neq V^{m}_{1}$, $j \neq m$ Test: t-test.

Hypothesis $3a_3$:

$T^{j}_{1} \neq V^{m}_{1}$, $j \neq m$ Test: t-test.

It is expected that the magnitudes of the first harmonic will differ between the manufacturing (durables and nondurables) and the nonmanufacturing (government and service) sectors due to differences in both supply and demand factors. By computing the mean harmonic measures for each sector over all 34 labor markets, comparisons between industries can be made. Where 1 and 2 are the manufacturing sectors (durables and nondurables), and 3 and 4 are the nonmanufacturing sectors (government and services), Hypothesis 3b is presented;

Hypothesis $3b_1$:

$\bar{R}_1^{1,2} < \bar{R}_1^{3,4}$ Test: t-test.

Hypothesis $3b_2$:

$\bar{V}_1^{1,2} < \bar{V}_1^{3,4}$ Test: t-test.

Within the manufacturing industries, durables and nondurables are expected to have different seasonal magnitudes of the first harmonic, again related to variations in factors of supply and demand. Hypothesis 3c is evaluated by examining the average harmonic measures of relative amplitude and variance, where durables is industry 1 and nondurables is industry 2.

Hypothesis $3c_1$:

$\bar{R}_1^1 < \bar{R}_1^2$ Test: t-test.

Hypothesis $3c_2$:

$\bar{V}_1^1 > \bar{V}_1^2$ Test: t-test.

Within the nonmanufacturing sectors, the government and service industries are expected to exhibit different seasonal magnitudes.

Similar to hypothesis 3c, the following hypothesis examines these measures, where government is industry 3, and services is industry 4.

Hypothesis $3d_1$:

$\overline{R}_1^3 < \overline{R}_1^4$ Test: t-test.

Hypothesis $3d_2$:

$\overline{V}_1^3 < \overline{V}_1^4$ Test: t-test.

The final statistical method is correlation analysis, which summarizes the relationship between two variables by indicating the degree to which variation in one variable is related to variation in another (Taylor, 1977). The Pearson product-moment correlation computes the correlation coefficient, r_{xy}, which measures the strength of the relationship between the variable x and the variable y. By determining the correlation coefficient for certain seasonal measures and selected variables over locations, strength of relationships between spatial and temporal patterns of seasonal employment are measured. The following variables were selected as tourism and economic indicators because they accurately represent levels of tourism and recreational developments within the labor markets. Furthermore, variables representing both summer and winter activities will help to clarify relationships among these activities and seasonal employment fluctuations.

- Seasonal Cabins (SEAC). Total number of owner-occupied units, which are occupied for less than six months during the year, within each labor market, 1975.

- Ski Areas (SKIA). Total number of ski tows (chair and rope) within each labor market, 1978-1979.

- Skier Days (SKID). A measure of actual visits to all ski areas within each labor market, during 1978.
- Boat Launchings (BOAT). The estimated number of boat launchings which took place within each labor market during 1978.
- Public Land (PUBLD). Percentage of land acreage owned by the Michigan Department of Natural Resources and the U.S. Forest Service, 1973.
- Retail Earnings (RETAIL). Percentage of total labor and proprietors' earnings in retail trade, 1976.
- Manufactures Earnings (MANUF). Percentage of total labor and proprietors' earnings, 1976.
- Service Earnings (SERV). Total percentage of total Michigan labor and proprietors' earnings, 1976.
- Mean Employment (MEAN). Average yearly employment for each industry between 1970 and 1978 by labor market area.

Specific relationships are examined by calculating the correlation coefficients between the above variables and the harmonic measures for each industry, and determining the statistical significance with alpha equal to .05. The null hypothesis is, H_o: $r_{xy} = 0.0$; and the alternative hypothesis for Hypothesis 4 are given below.

Hypothesis $4a_1$:

Where j = government and services,

R^j_{1i} and V^j_{1i} will be directly related to SEAC, BOAT, PUBLD, RETAIL, SERV.

H_1: $r_{xy} > 0.0$.

Hypothesis $4a_2$:

R^j_{1i} and V^j_{1i} will be inversely related to MANU.

H_1: $r_{xy} < 0.0$.

Hypothesis 4b:

Where j = government and services

R^j_{2i} and V^j_{2i} will be directly related to SKID AND SKIA.

H_1: $r_{xy} > 0.0$.

As a result of the relationships expected from Hypotheses 4a and 4b, the service sectors will exhibit specific spatial seasonal patterns of relative amplitude and timing of the first harmonic. Isoline maps of these measures will illustrate the variability of these seasonal patterns. The final hypothesis is expressed as the following.

Hypothesis 4c:

R^4_{1i} will vary among locations i, for each X^4_{iM}.

T^4_{1i} will vary among locations i, for each X^4_{iM}.

Test: Cartographic.

The procedures and methods will determine the patterns of seasonal variations in the northern Michigan employment time series. Relationships between these patterns and both the economic and geographic setting of industries and labor markets are also assessed. Thus, the objectives of identifying, comparing, and examining the interrelationships of seasonal patterns will be addressed. Chapter IV presents the results of the analysis and evaluates each of the hypotheses stated above.

CHAPTER IV

ANALYSIS AND RESULTS: THE VARIABILITY OF SEASONAL EMPLOYMENT PATTERNS

Employment throughout northern Michigan is expected to exhibit fluctuations which "produce distinct patterns of interaction and interdependence" (Jeffrey, 1974:114). The delineation of seasonal employment behaviors provides a basis for investigating these patterns over both spatial and temporal dimensions. The following sections summarize the results; the seasonal patterns, the general conclusions for all industrial employment throughout the study region, and conclusions for the four industrial groups. This is accomplished by addressing each of the hypotheses. Also, the nonmanufacturing sectors are examined in greater detail due to their prevalence and impact upon the northern Michigan economy.

Seasonal Patterns of All Industrial Employment

By aggregating the four industry time series of average monthly employment levels, the time series of all wage and salary employment within the study region is determined. The application of an harmonic analysis to this aggregate series results in the two harmonics presented in Table 3 and illustrated in Figure 6. Clearly, the employment levels within northern Michigan for all industries experience a marked annual

Table 3. Harmonic Measures of Monthly Employment for All Industries in Northern Michigan

First Harmonic			Second Harmonic		
Relative Amplitude	Percent Variance	Peak Timing	Relative Amplitude	Percent Variance	Peak Timing
5.50	97	Aug 24	.70	2	June 2/Dec 2

cycle, with greater than 97% of the variation in the time series explained by the first harmonic. This singular oscillation peaks August 24, and is lowest February 24, perhaps reflecting the tourism economy of the northern region where seasonal populations are highest in the summer months and lowest in the late winter. Disaggregation of this time series by location and industrial sector in sections to follow will help clarify some of the factors affecting these distinct seasonal fluctuations in employment in northern Michigan.

Magnitudes of Seasonal Variation

It was hypothesized that the seasonal measures for all industrial employment, $R^{\cdot}_{1i}$ and $V^{\cdot}_{1i}$ would vary among locations i (Hypothesis 1). Figure 7 depicts the relative amplitudes in 5% intervals throughout the study region. The greatest variation occurs in the eastern upper peninsula, while the western areas have the least variation in amplitudes. The larger population centers of Ironwood, Menominee, Marquette, Saulte Ste. Marie, Alpena, Traverse City, Manistee, and Ludington, all experience relative amplitudes lower than or equal to the relative

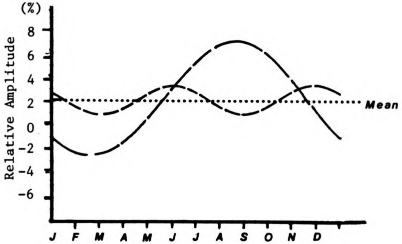

Figure 6. First and Second Harmonic Curves of Monthly Employment, Northern Michigan, All Industries, (1970 through 1978). (Relative amplitude is the change in the number of persons employed, expressed as a percentage of the annual mean.)

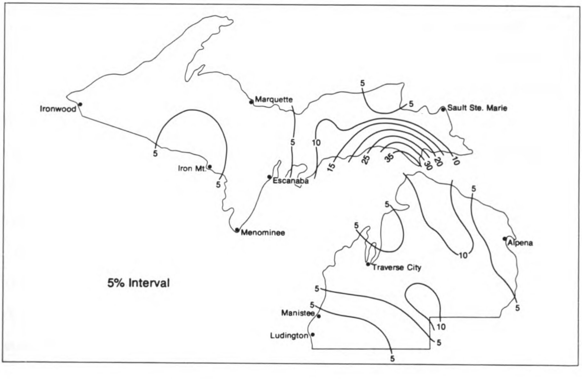

Figure 7. Relative Amplitude of the First Harmonic of Monthly Employment for All Industries.

amplitude ($R_1^{\cdot}$) for all employment in the study region (Table 3). The greater stability of these areas is related to their industrial diversification and role as central places. The increased number of industries and central place functions distributes the employment levels more uniformly over time, reducing seasonal fluctuations. The behavior of the more specialized places, as in the eastern upper peninsula and the northern lower peninsula exhibits relative amplitudes greater than a 14% change from the mean.

The spatial patterns of the percent variance explained by the first harmonic are illustrated in Figure 8 with isolines of 10% intervals. The western upper peninsula has the most notable variations, with the first harmonic variance decreasing significantly westward while variance of the second harmonic increases. These differences in variations explained by the harmonics between the western upper peninsula and the remainder of the study region suggest differences in both locational and industrial influences upon seasonal variations. The western upper peninsula is less dominated by tourism having a greater percentage employed in the primary industries such as mining, lumbering, and agriculture. Consequently, the influences of these supply-oriented industries and perhaps their intermediate markets in Wisconsin and Minnesota might affect the different annual and semiannual tendencies in employment. Furthermore, the western upper peninsula is more isolated from the major economic centers of Detroit and Chicago. Fewer interactions therefore occur between the distant upper peninsula labor markets and these centers to the south, resulting in significantly different seasonal employment behaviors.

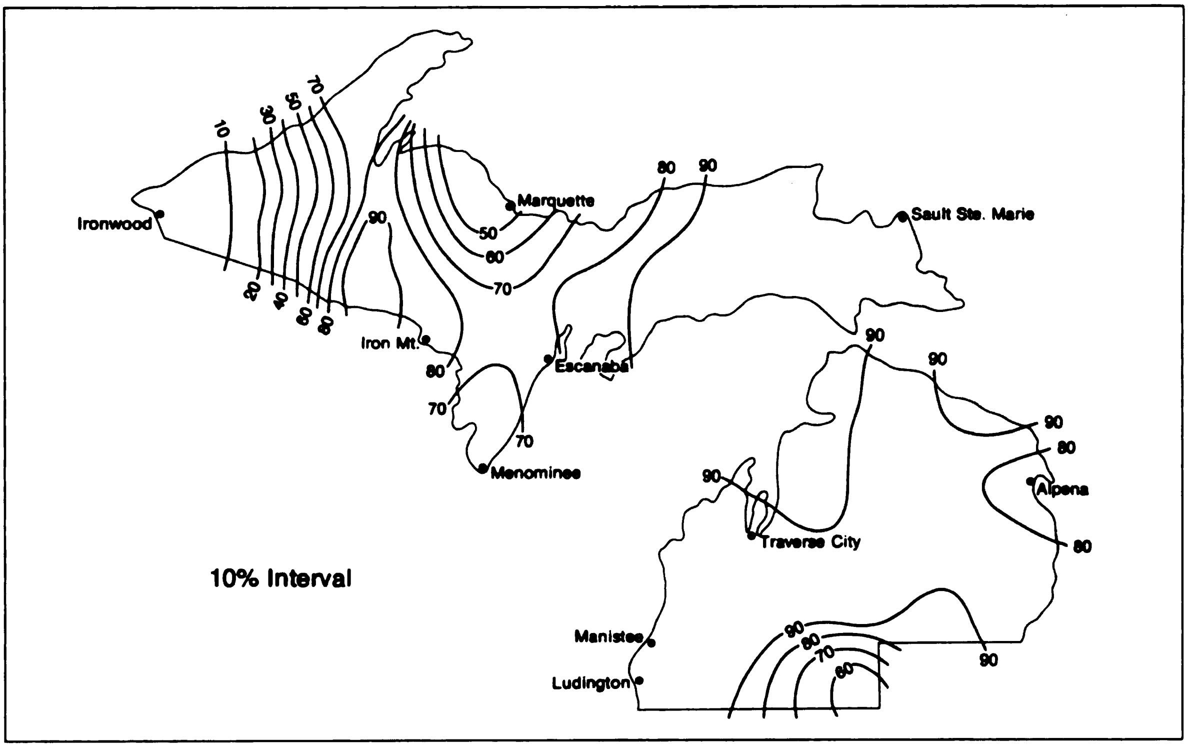

Figure 8. Variance Explained by the First Harmonic of Monthly Employment for All Industries.

The southern portion of the study area has annual variations decreasing in the direction towards Detroit. The more industrialized and metropolitan areas to the southeast appear to have variable influences upon the seasonal employment in the southern labor markets of the study region. Overall, the areas with the least spatial variation in relative amplitude and variance are those places with a high percent variance explained by the first harmonic. Furthermore, these same places experience the highest relative amplitudes as in the eastern upper peninsula and the northern lower peninsula. It is proposed that the tourism economy of these regions is the primary factor affecting the variability of $R^{\bullet}_{1i}$ and $V^{\bullet}_{1i}$, which will be discussed further in the following sections.

We can conclude from the patterns illustrated in Figures 7 and 8 that distinct seasonal employment patterns exist for both $R^{\bullet}_{1i}$ and $V^{\bullet}_{1i}$ supporting Hypothesis 1. These patterns appear to be related to the types of industries and locations of the labor market areas. While patterns of relative amplitudes and variance represent variations in seasonal magnitudes over space, there is no evidence of variations in temporal behaviors. Differences in timing of peak employment among locations would indicate that interactions between economic activities take place over both space and time.

Peak Timing of Seasonal Variation

The peak timing of employment for the first harmonic in intervals of twenty-five days are illustrated in Figure 9. It was hypothesized that $T^{\bullet}_{1i}$ would vary among locations i (Hypothesis 2). The resulting patterns of timing support this hypothesis with the western upper peninsula having the greatest variability. The Ironwood and Marquette places are central areas within the timing patterns. Temporal rings are created around these central places suggesting temporal markets and their interactions with the peripheral areas. Alpena, Ludington, and the northern point of the lower peninsula experience some change in peak employment. Examining these patterns with intervals of less than twenty-five days might reveal short term patterns within the lower regions.

Throughout the upper peninsula, Marquette experiences the latest peak timing, perhaps reflecting its distance from Detroit and Chicago. Similar to the patterns of relative amplitude and variance,

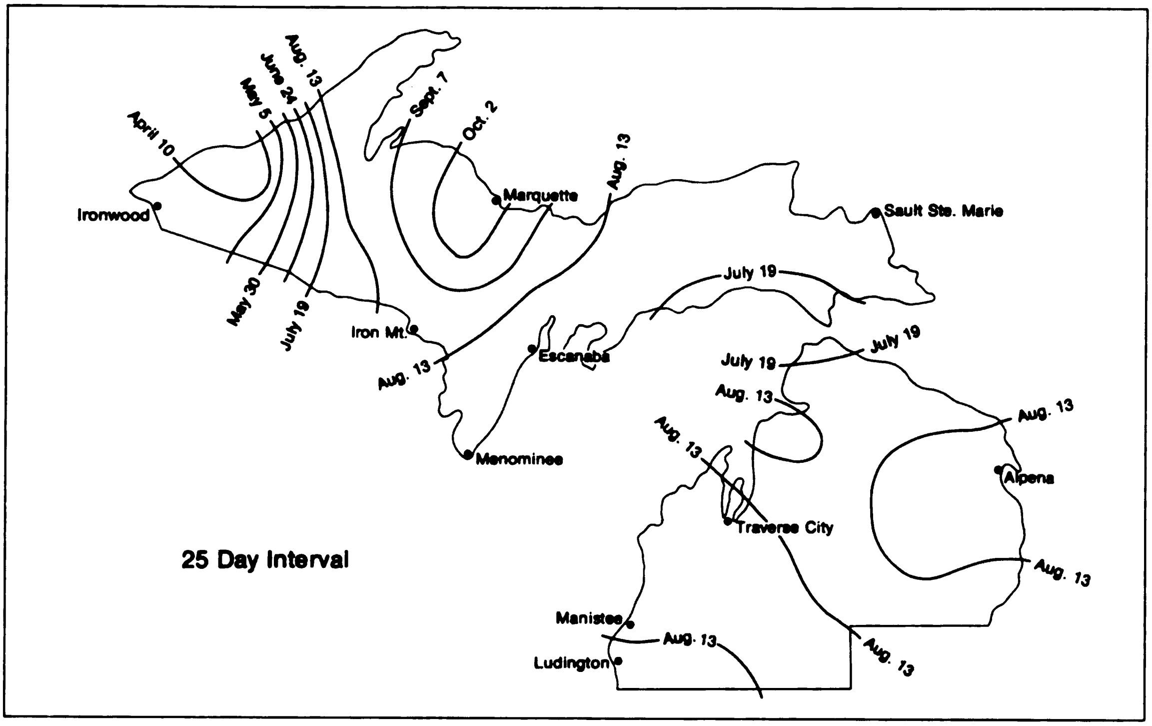

Figure 9. Peak Timing of the First Harmonic of Monthly Employment for All Industries.

the timing of the first harmonic is distinctly different in the western upper peninsula. Although no proof is offered at this time, this might be related to differences in the industrial structure and the influences of the Wisconsin and Minnesota regions.

Although the data does not provide a basis for specifying the interrelationships, spatial patterns of timing emerge within the northern Michigan region. The notion that economic impulses are transmitted over space is supported, with a sequence of peak employment times occurring between central places and their peripheral areas. Bannister (1976) notes that the more urban an economic system is, the greater the occurrence of impulses transmitted from larger to smaller places. In agricultural areas, the demand impulses emanate from small and move to large places. The early peak timing in employment for some of the remote areas as the west upper peninsula lends support to this hypothesis, reflecting the primarily nonindustrial nature of northern Michigan.

For the industrial employment time series, $X^{\cdot}_{iM}$, the measures of $T^{\cdot}_{1i}$ were found to vary among locations i, supporting the second hypothesis. These patterns of timing further support the proposition that economic interactions occur over spatial and temporal dimensions. Although it has been suggested that different types of industries might exhibit different seasonal patterns related to variations in economic factors, the seasonal characteristics of the individual industries have not been defined. The following section presents the results of the harmonic analysis of the time series for each industrial sector and labor market, in order to examine locational and industrial differences in seasonal employment fluctuations.

Seasonal Patterns of the Individual Industries

As supply and demand change from industry to industry, the magnitudes and timing of seasonal employment fluctuations will vary. These variations in the seasonal patterns of the different sectors will determine, in part, seasonal variations among places associated with those industries. Hypothesis 3a proposed that for each individual time series, X^{j}_{1M}, the first harmonic measures of relative amplitude, R^{j}_{1M}, variance, V^{j}_{1M}, and timing, T^{j}_{1M}, would vary among industries j. In order to test these hypotheses, two-tailed t-tests were employed to examine (1) the differences between means, and (2) the mean difference, for each of the harmonic measures between industries. The resulting probabilities of accepting the null hypothesis that (1) industry means are equal (Table 4a), and (2) that the mean difference equals zero (Table 4b) are determined. Table 4a does not include the peak timing as these measures cannot be averaged accurately within the basic interval of the harmonics or frequencies.

For the relative amplitude of the first harmonic, $\overline{R}_1^j$, both government and services are significantly different from durables and nondurables showing that varied fluctuations exist between the manufacturing and nonmanufacturing industries. Services has significant differences in the variance of the first harmonic, $\overline{V}_1^j$, while government differs only from nondurables. The results of the t-test for the difference of means support, in part, Hypothesis 3a. Similar patterns occur in Table 4b, probabilities for the mean difference null hypothesis. Again, services and government have significant differences from the other industries for relative amplitude, variance, and timing, lending further support to Hypothesis 3a.

The results of the t-tests in Table 4a show the industrial sectors to have less significant differences in harmonic measures than the results presented in Table 4b. This latter test is more sensitive to the various measures among LMA's, which would be averaged in the difference of means test. Thus, the probabilities in Table 4b suggest that locational differences exist in seasonality among the labor markets. In particular, the service and government sectors

Table 4a. Probability of Accepting the Null Hypothesis That Industry Means of Amplitude and Variance Are Equal

	Relative Amplitude			Percent Variance		
Industry	Durables	Nondurables	Government	Durables	Nondurables	Government
	First Harmonic					
Nondurables	.14	--	--	.31	--	--
Government	.00	.06	--	.00	.29	--
Services	.00	.06	.37	.02	.00	.00
	Second Harmonic					
Nondurables	.21	--	--	.36	--	--
Government	.05	.94	--	.04	.00	--
Services	.37	.44	.21	.01	.01	.00

Table 4b. Probability of Accepting the Null Hypothesis That the Mean Difference of Amplitude and Variance Is Equal to Zero

Industry	Relative Amplitude			Percent Variance			Peak Timing		
	Durab	Nondurab	Govern	Durab	Nondurab	Govern	Durab	Nondurab	Govern
	First Harmonic								
Nondurables	.15	--	--	.30	--	--	.30	--	--
Government	.34	.04	--	.02	.25	00	.00	.00	--
Services	.00	.00	.00	.00	.00	.00	.16	.75	.00
	Second Harmonic								
Nondurables	.26	--	--	.35	--	--	.14	--	--
Government	.04	.94	--	.00	.00	--	.01	.00	--
Services	.39	.39	.23	.06	.00	.00	.00	.39	.00

have the most distinct seasonal behaviors, while durables and nondurables have similar behaviors with small seasonal fluctuations.

Recognizing that industries have variable seasonal patterns, it is important to address these differences in order to begin to understand some of the processes involved. As presented in Chapter III, for each industry, an average harmonic measure is computed over all thirty-four LMA's. These measures of relative amplitude, $\overline{R}^j_1$, and variance, $\overline{V}^j_1$, of the first harmonic are presented in Table 5. With these measures we can examine the variability of seasonal employment among the industries and throughout the study region. The following sections identify and discuss the differences in these average harmonic measures for each industry; and define, if any, the relationships between the seasonal patterns and locational variables.

Table 5. Average Harmonic Measures of Monthly Employment by Industry in Northern Michigan

Industry	Mean Employment	Relative Amplitude (%)	Percent Variance	Cumulative Variance First Two Harmonics (%)
	----------- First Harmonic ------------			
Durables	873	4.8	63	
Nondurables	409	7.3	56	
Government	1,585	4.2	51	
Services	2,793	13.6	80	
	----------- Second Harmonics -----------			
Durables		2.2	13	76
Nondurables		3.4	17	73
Government		3.4	34	85
Services		2.7	7	87

Manufacturing: Durables and Nondurables

Between 1960 and 1970 manufacturing industries increased considerably in the Upper Great Lakes regions, while primary industries began to decline. In the decade since 1970, tertiary industries experienced very large gains in this region, while manufacturing continues to decline (Michigan Employment Security Commission, 1979). The only gains in employment in the durables sectors have occurred in metals, machinery, and transportation attributed to advantages in labor, maintenance costs, and lack of urban diseconomies throughout the region (Battelle Labs, 1969). The nondurables sectors have experienced rather steady employment levels for the last decade and are expected to show only marginal increases relative to durables. The food and paper industries, the largest employers, are expected to increase slightly in the future, while the textiles and chemicals, which employ substantially fewer numbers, are expected to decline in this region in the 1980s (MESC, 1979).

Within the State of Michigan, 30% of all jobs are in manufacturing, 24% durables and 6% nondurables. Within the study region, manufacturing accounts for 22% of the employment, 15% durables and 7% nondurables. The durables sectors are the dominant activities in manufacturing, of which over 80% are related to the automobile industry. As the auto industry is sensitive to changes in demand throughout a national market, we can expect the durables industries to also feel the impacts of changes in the national markets.

Hypothesis $3b_1$ proposed that the relative amplitude of the first harmonic for the manufacturing industries, $\bar{R}_1^{1,2}$, would be less than for the nonmanufacturing industries, $\overline{R}_1^{3,4}$. The government sector has the lowest average relative amplitude, contrary to Hypothesis $3b_1$ (Table 5). Only service has a higher relative amplitude than either durables or nondurables, in part supporting this hypothesis. Hypothesis $3b_2$ proposed that the variance of the first harmonic, $\overline{V}_1^{1,2}$, would be less than $\overline{V}_1^{3,4}$. Again, both durables and nondurables have a higher variance than the government, while services has the greatest variation explained by the first harmonic, partially supporting Hypothesis $3b_2$.

While durables and nondurables have higher relative amplitudes and variance of the first harmonic, it is interesting to note that the cumulative variance of the first two harmonics are lowest for these two sectors. This would indicate that the manufacturing industries have more variable influences upon seasonal employment fluctuations not attributable to a single annual or semiannual tendency. The lower average magnitude of fluctuations for the manufacturing industries indicates these industries are more seasonally stable throughout the year.

Hypothesis $3c_1$ proposed that the average relative amplitude, for durables $\overline{R}_1^1$, would be less than, for nondurables $\overline{R}_1^2$. This hypothesis is supported with an $\overline{R}_1^1$ of 4.8% and an $\overline{R}_1^2$ of 7.3%. In addition, Hypothesis $3c_2$ is supported with $\overline{V}_1^1$ (63%) greater than $\overline{V}_1^2$ (56%). The higher relative amplitudes in the nondurables for the first harmonic shows these industries to have greater annual fluctuations, while the lower variance suggests more variable influences upon these industries. The nondurables sector is more dependent upon primary industries such as agriculture and lumbering which experience highly seasonal fluctuations in supply. These variations in supply seem to affect the seasonality of employment in the nondurables. The durables sector has small annual fluctuations while most of the variation in the series is explained by the first harmonic. It is thought that these lower amplitudes are perhaps related to the greater investments in machinery and other fixed capital, where severe fluctuations would result in gross inefficiencies. Furthermore, the marked annual tendency of the durables points to its close relationship with the automobile industries, which generally operate on an annual cycle, with demand highest in the spring and lowest in the late summer.

Nonmanufacturing: Government and Services

The nonmanufacturing industries are expected to experience the largest gains in employment in Michigan for both the long term and short term outlook (MESC, 1979). The dominant growth components are in the retail and specific service fields.[1] Demand for business and health services are expected to remain strong, with the most rapid gains in retail, finance, and real estate. The public sector (government) is expected to gradually increase through the 1980s at both the local and state levels. Thus, the importance of the tertiary industries and their patterns of economic activities will have increasing impact upon the localities within northern Michigan.

Seventy percent (70%) of all Michigan jobs are in nonmanufacturing, 18% in government and 52% in services. Within the study area

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[1]These specific services do not refer to the general industrial sector, but to specific activities within the service category under nonmanufacturing in Table 2.

nonmanufacturing accounts for 78%, with 28% in government and 50% in services. The service sector clearly dominates the economic structure of the northern Michigan region. While durables and nondurables are goods producers regulated by supply and generally exogenous markets, activities such as retail, finance, communications, and education are geared toward the local population. The tourism and recreation industries are highly dependent upon seasonal populations. Changes in the tourism markets will be primary factors affecting local and service sectors which cater to these changing local populations. Seasonal fluctuations in nonmanufacturing employment are, therefore, closely related to fluctuations in the local tourism industries, the population and their lifestyles.

Hypothesis 3b proposed that the nonmanufacturing sectors would have higher relative amplitudes and variance explained by the first harmonic than the manufacturing industries. Although this holds true for the service sector, the government sector has the lowest average relative amplitude and variance of the first harmonic. Furthermore, government exhibits a marked semiannual fluctuation with an average of 34% variance explained by the second harmonic, more than twice that of the other three sectors. The increased hiring of education and postal employees in the fall, and the increased hiring for state and local recreation areas in the spring might account for this semiannual tendency in the government sector. Although the relative amplitudes of both harmonics are small indicating low seasonal fluctuations, greater than 85% of the variation in the data is explained by these first two harmonics. Thus, the government industries have fewer variable influences than either the durables or nondurables sectors.

Hypothesis $3d_1$ proposed that the average relative amplitude for service, $\bar{R}_1^4$, would be more than for government, $\bar{R}_1^3$. This hypothesis is supported with an $\bar{R}_1^3$ of 4.2%, and an $\bar{R}_1^4$ of 13.6%. In addition, Hypothesis $3d_2$ is also supported with $\bar{V}_1^3$ (51%) less than $\bar{V}_1^4$ (80%). Clearly, the service sector exhibits, on the average, the largest annual fluctuation in employment with greater than 80% of the variation in the data explained by the first harmonic and an average change in employment of 13.6% above and below the mean during the year. It is proposed that this singular fluctuation in employment for services is related primarily to the tourism markets of northern Michigan.

Specific relationships between seasonal patterns and tourism are proposed to exist throughout northern Michigan. These relationships define the economic as well as locational influences upon seasonality in government and service sectors. Hypothesis 4a proposed that the tourism variables defined in Chapter III (pages 44-45) would be positively related to R_{1i}^j and V_{1i}^j for government and services. The resulting correlation coefficients for the government industries are presented in Table 6. Only SEAC and SERV are significantly related to the measures R_{1i}^3 and V_{1i}^3, supporting, in part, Hypothesis $4a_1$. As annual fluctuations in government increase, there is an increase in seasonal cabins and service earnings.

Table 7 presents the correlation coefficients for the harmonic measures of the service sector and tourism variables. As hypotheisized, there are positive relationships between R_{1i}^4 and SEAC, PUBLD, RETAIL,

Table 6. Correlation Coefficients for Relationships Between the Harmonic Measures of Monthly Employment and Locational Variables, Government Industries[a]

Variables	SEAC	SKIA	SKID	BOAT	PUBLD	RETAIL	MANUF	SERV	MEAN
					First Harmonic				
Relative amplitude	(.43)[b]	-.04	(.44)	.00	-.10	-.20	-.06	(.36)	.04
Percent variance	(.43)	.10	.09	.03	.28	.10	(-.51)	-.05	.20
					Second Harmonic				
Relative amplitude	-.05	-.11	(.62)	.01	(-.31)	-.21	.23	.28	-.04
Percent variance	(-.31)	.21	.13	.12	(-.30)	-.02	(.38)	.11	-.11

[a]Variables are defined in Chapter III, pages 44-45.

[b]Parentheses indicate correlation coefficients significantly different than 0.

Table 7. Correlation Coefficients for Relationships Between the Harmonic Measures of Monthly Employment and the Locational Variables, Service Industries[a]

Variables	SEAC	SKIA	SKID	BOAT	PUBLD	RETAIL	MANUF	SERV	MEAN
	First Harmonic								
Relative amplitude	(.64)[b]	.27	-.18	-.03	(.45)	(.46)	-.23	(.33)	(-.31)
Percent variance	.28	.29	-.27	.13	.05	(.34)	.12	.21	.31
	Second Harmonic								
Relative amplitude	(.38)	.09	.19	-.20	.29	.22	-.14	.14	-.11
Percent variance	-.28	(.42)	(.41)	.27	.01	-.20	-.05	-.15	.18

[a] Variables are defined in Chapter III, pages 44-45.

[b] Parentheses indicate correlation coefficients significantly different than 0.

and SERV. The influence of tourism upon the local employment is most significant for the service industries. The tourism variables have the strongest relationships with the seasonal measures of the service sector. The negative relationship between the MEAN (Mean employment in services) and R_{1i}^{4}, and the positive relationship between SERV (percentage of total state earnings in services) and R_{1i}^{4} are further evidence of the impact of tourism industries upon seasonal fluctuations in services. As the mean employed in services increases, the fluctuations decrease suggesting the diversification effect upon seasonal stability. Furthermore, as the importance of services increases for a locality, the fluctuations in service employment increase. Thus, the smaller and more specialized, highly tourism dependent areas, exhibit the greatest seasonal amplitudes in service employment. In addition, the positive relationship between MEAN and V_{1i}^{4} indicates the singular annual influence of tourism and service employment upon seasonal variations.

Hypothesis $4a_2$ proposed that R_{1i}^{j} and V_{1i}^{j} would be inverselty related to MANU for the government and service sectors. This hypothesis is only partly supported with negative relationships between V_{1i}^{3} and MANU. This suggests the influence of industrial diversity upon seasonal stability, where more manufacturing results in less annual variations reflecting greater stability throughout the year.

Hypothesis 4b proposed that R_{2i}^{j} and V_{2i}^{j} would be positively related to SKID and SKIA for the government and service sectors. Only R_{2i}^{3} is positively related to SKID, while V_{2i}^{4} is positively related to both SKIA and SKID, supporting this hypothesis. As the winter activities increase there is an increase in demand for public services, again related to the seasonal populations and their impacts upon local economies. The largest semiannual fluctuations for government and services occur in those places with large numbers of ski activities. In addition, the positive relationship between both R^4_{1i}, R^4_{2i}, and SKID indicates that the areas with strong annual fluctuations also have strong semiannual fluctuations. Thus, the highly tourism dependent economies appear to experience the greatest seasonal employment fluctuations in the nonmanufacturing industries.

Having defined some of the relationships between seasonal characteristics and tourism and related variables, it is important to examine these seasonal patterns as they vary throughout the study region. By delineating the spatial patterns of relative amplitude and timing of the first harmonic for services we can examine some of the geographic influences upon seasonal patterns and define specific places which experience marked seasonal fluctuations. The final hypothesis examines variations in R^4_{1i} and T^4_{1i}, where it was hypothesized that these measures would vary among locations i.

Figure 10 illustrates the isolines of relative amplitudes in 10% intervals for the service sector. The more specialized areas with their singular dependence upon tourism show high amplitudes related to their industrial structure and location. Places with predominantly tourism industries as in the eastern upper peninsula, where the Mackinac Island resort is, and the northern lower peninsula where there are numerous second home developments have the highest fluctuations within the year. The more remote or less tourist areas in the western

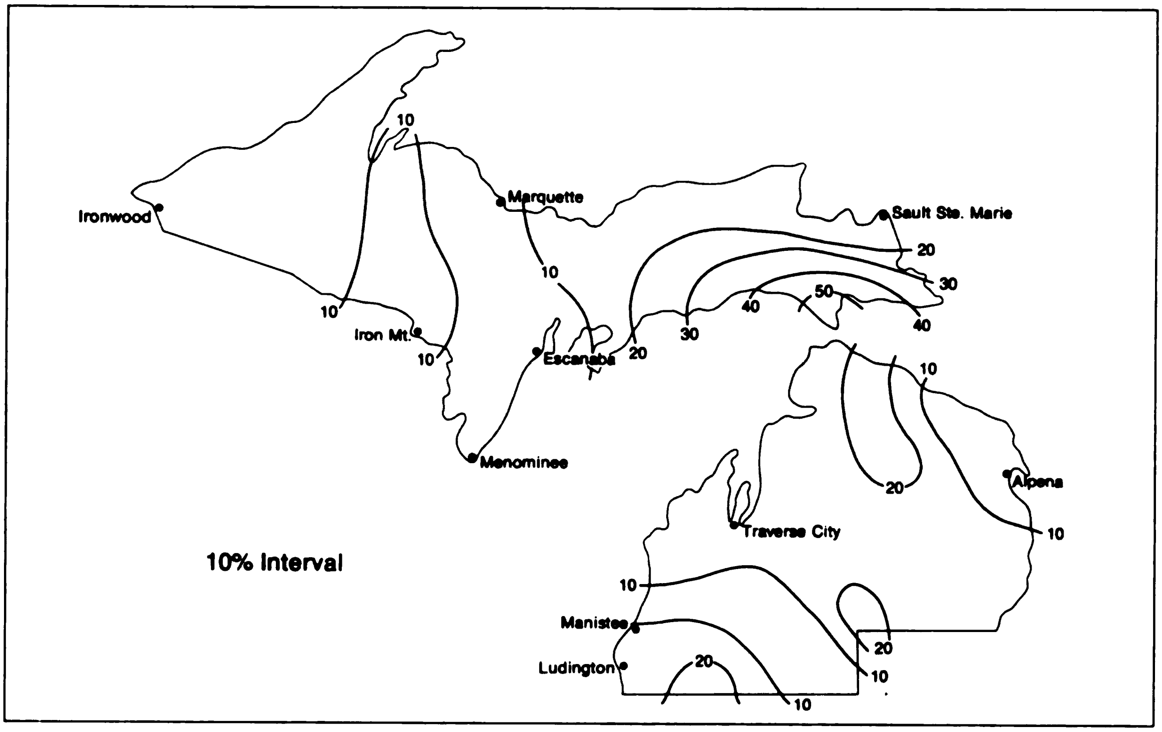

Figure 10. Relative Amplitude of the First Harmonic of Monthly Employment for Service Industries.

upper peninsula and the eastern lower peninsula have smaller fluctuations, generally less than 13.6%, the mean for services. In addition to the occurrence of less tourism, the smaller fluctuations also suggest the impact of distance upon the seasonal amplitudes. The smaller seasonal populations in the western upper peninsula appear to have less impact upon the relative amplitudes of the service industries in those places.

Further support of the spatial variability of seasonal patterns for services is illustrated in the isolines of twenty-five day intervals for timing in Figure 11. Significant changes occur westward in the upper peninsula, with little variability in the remainder of the region.

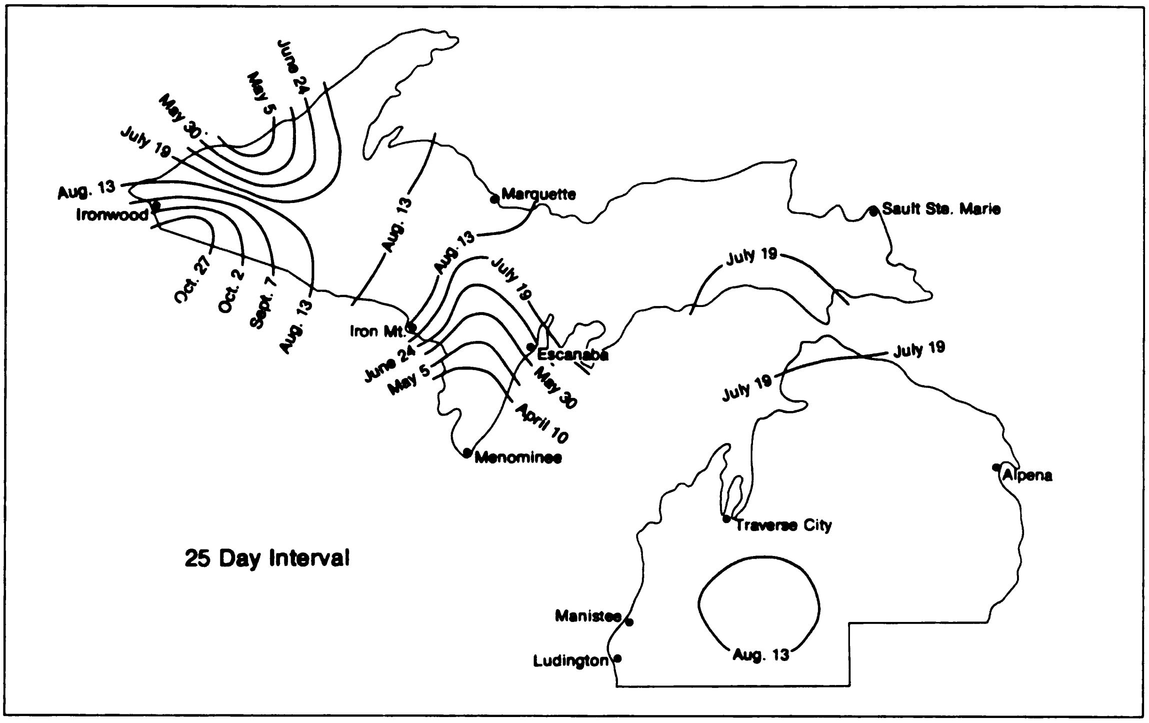

Figure 11. Peak Timing of the First Harmonic of Monthly Employment for Service Industries.

These western areas have the lowest fluctuations attributable to a variety of influences with very different timing among places. However, the tourism areas to the east and south have very high fluctuations attributable to primarily annual influences, but with very similar timing among places. Thus, places with singular economic functions such as tourism, exhibit seasonal instability with little variation in the timing of peak employment. Interactions between these places do not appear to occur along temporal paths. However, further analysis of the peak timing at smaller intervals and among more specific industries might delineate variations in temporal employment behaviors not evident in Figure 11.

CHAPTER V

CONCLUSIONS

Summary of Objectives

The first objective of this study was to measure seasonal employment fluctuations within the northern Michigan labor markets between 1970 and 1978. The application of harmonic analysis to the monthly employment time series produced descriptive measures of the periodic behavior of seasonal employment. Analysis of these harmonic measures revealed spatial and temporal patterns of seasonal employment.

The second objective of this analysis was to examine these patterns of seasonality among different industries and locations. Analysis of the employment time series for the aggregate and individual industries showed that seasonal employment variations occur over space and time. The greatest variations among industries were seen in the first two harmonics, with the first harmonic measures for individual industries significantly different. The harmonic measures (relative amplitude and variance) for each industry averaged over the thirty-four labor markets showed the service sectors experienced the largest annual fluctuations in employment during the year. Government had the lowest annual and highest semiannual tendencies, while both durables and nondurables exhibited weaker seasonal fluctuations in employment.

Geographically, the amount of seasonal fluctuation in employment (relative amplitude) for all industries is lowest in the more populated and major economic centers of the study region due to their greater employment diversification. Variance of the first harmonics were found to be significantly different in the western upper peninsula and the southern lower peninsula. These differences were related to distance from the major centers of Detroit and Chicago. For the service sectors seasonal fluctuations were lowest in the more remote areas of the western upper peninsula due to both distance and the low occurrence of tourism. Conversely, those places with highest fluctuations in employment were the central areas of the lower peninsula and eastern upper peninsula, which are highly dependent upon tourism and related industries.

The timing of peak employment provided the exact dates of highest employment along a harmonic or frequency. The spatial patterns of these measures support the theoretical concepts related to spatial diffusion of economic activities. The centrality of specific centers within the timing patterns for all industries suggests interactions among places along temporal dimensions. These patterns appear to be influenced by the economic structure and locations of the labor markets. The western upper peninsula emerges with very distinct timing patterns, significantly different from the remainder of the study region. This may be due to ties with Wisconsin and Minnesota, and the industrial mix of the labor markets themselves. The timing patterns of the service sector reveal significant differences again in the western upper peninsula, while the remainder of the study area exhibits little variation in timing using twenty-five day intervals.

The third objective of this study was to relate the seasonal measures among industries to selected locational variables with emphasis on tourism and recreation. Results support the hypotheses that there are significant positive relationships between the magnitudes of seasonal employment and the number of tourism opportunites within an area. The relative amplitudes of government and services are directly related to the incidence of recreation and tourism within a locality. These relationships suggest two important conditions affecting seasonal instability. As areas become more specialized and less economically diverse, the magnitudes of seasonal peaks increase. The locationally incongruent characteristics of the service and manufacturing sectors lead to highly specialized tourism economies. These tourism dependent areas are therefore bound to experience high seasonal instability regardless of other factors. The second condition affecting seasonal instability is related to concepts of economic base and the importance of tourism within a locality. Changing local populations have significant impact upon the level of economic activity, where influences beyond a region will affect changes in the tourism market. These relationships present a complex economic structure where repercussions from external changing demands are felt, to different extents, within the study area. For these reasons, the service sectors are important as basic industries within northern Michigan, and changes in their activities significantly affect the overall level of economic activity within the northern region.

The final objective of this study was to discuss the geographic and economic implications of the impacts of seasonal employment fluctuations. There are considerable economic inefficiencies resulting from seasonal instabilities. These are evident in the uneven flows of capital, investments, stocks, and income and the end result may be stagnation. The upper peninsula and parts of the northern lower peninsula, along with similar areas throughout the Great Lakes, have been identified as economically depressed regions due to inefficient and insufficient economic development (Michigan Department of Commerce, 1976). The persistent and severe seasonal employment fluctuations related to specialized tourism economies contribute to this problem. The locations of industries, their sources of supply and demand, and local conditions are also related to the problems of seasonal instability. The resolution of the negative impacts of seasonal fluctuation within a locality is possible via planning and development strategies. The first step, however, is the objective identification of seasonal employment patterns and their related geographical influences.

Limitations of the Study and Future Research

Although the harmonic method provides a means for quantifying the periodicity of employment, certain limitations to both the process and the data utilized are recognized. A basic assumption necessary to the interpretation of the harmonics was that the function repeat itself completely and the data is therefore periodic (Conrad and Pollack, 1958). If the employment time series were not genuinely periodic, then the harmonics do not accurately reflect the temporal variations throughout the year and interpretation of the harmonic curves would result in incorrect statements regarding seasonal patterns. Thus, the method can only be applied in areas, like the study region, where strict periodicity can be assumed.

The study period covered a time-span of only nine years, while the harmonic method assumes a potentially infinite periodic series. Other time periods may show different periodic fluctuations as a result of changes in custom, resources, or technology. For example, changes in life style may result in different tourism markets altering the movements of seasonal populations, thus affecting the seasonal patterns of the service and government sectors.

The use of a nine-year monthly average could result in problems of interpretation of the seasonal patterns. As the economic structure of a region changes, both in the short-run and long-run, activities within individual sectors will change. This might result in upward or downward trends in seasonality for a given month. Thus, changing amplitudes or timing are not accounted for in the nine-year average. For example, since 1970 the popularity of winter sports increased in northern Michigan (Rottmann, 1979). As these winter activities are increasing we can expect the magnitudes of seasonal fluctuation to be affected due to the relationship between relative amplitude and tourism. Thus, an upward trend in amplitude for the winter months is not accounted for. No measure of increasing or decreasing seasonality over time is incorporated in this study.

The harmonic method offers no means for statistical inferences, or determination of the statistical significance of the trigonometric estimates. Because the original data is only a sample of the universe, questions arise as to how reliable the amplitudes are at a given frequency. No satisfactory test for significance of the harmonics is available. For these reasons the single application of the method remains primarily descriptive (Rayner, 1971).

As a result of aggregating the employment data for wage and salary industries into four industrial groups certain problems emerge. Although all of the industries were found to exhibit seasonal fluctuations, this might be attributed to specific sectors within any one group. The durables industries are the most homogeneous sectors in terms of their markets (automobile) and goods produced and are therefore similar among sectors. However, the nondurables show extreme variability over space and among sectors posing problems when aggregating the sectors into one industrial group. Generalizations regarding the seasonality of nondurables are difficult and often unreliable due to the very small sample size and the variations among specific sectors.

The service group also contains diverse sectors which might present problems with interpretation of the seasonal employment patterns. For example, a closer look at the breakdown in employment is recommended for areas where there are high levels of mining and construction employment, as these categories are regretably contained in the service group. This is especially important for the labor markets of the western upper peninsula.

Further analyses of employment data must take into account these limitations. Research could investigate the greater than nine year time period to arrive at seasonal measures related to past and future changes in factors affecting employment. The percentage of change or variance in the amplitudes from year to year could be examined to define more accurate seasonal measures and establish trends in seasonality.

By identifying the employment levels of selected industries in terms of location quotients, or minimum requirements, the effects of tourism and the amount of services as they relate to different seasonal patterns could be more clearly defined. Analysis of changes over time in magnitudes of variance and amplitude related to changes in the economic structure would clarify some of the relationships of seasonal employment to the local economy. Further investigation of input-output relationships among industries, the effects of diversification upon seasonal stability, and characteristics of the tourism market would all help to clarify seasonal behaviors. Analysis of different time series would further define relationships between employment and other economic conditions. In addition, further attention to the temporal behavior of employment would reveal the nature of the underlying processes generating seasonal change. Relating timing patterns to the timing of demand and supply factors, and their associations with location, would clarify the impacts and importance of seasonal phenomena.

This study has presented a viable method for objectively identifying seasonal employment patterns along spatial and temporal dimensions. The results of the analysis have identified specific economic and locational variables which influence and are influenced by seasonal characteristics. One important aspect of this study has been the inclusion of temporal behaviors within the analysis of geographic and regional economic patterns. Analysis of temporal distributions gives us more detailed reference points for measuring dynamic economic change, facilitates the modelling of our space-economy, and leads to the understanding of spatial process. Certainly, neither reality nor space are independent of time.

APPENDIX

FORTRAN IV PROGRAM FOR HARMONIC ANALYSIS

FORTRAN IV PROGRAM FOR HARMONIC ANALYSIS

```
      DIMENSION X(12),S(12),A(12),P(12),V(12), R(12),Y(12),D(12)
      DIMENSION PA(12),PS(12),PM(12),PM1(12)
      PRINT 110
C***CALCULATE THE TWELVE MONTHLY MEANS FOR THE STUDY PERIOD
    1 DO 5 K=1,12
    5 Y(K)=0.0
      DO 10 I=1,12
    6 READ 7, LMA,IND,IYR,(X(J),J=1,12)
    7 FORMAT(1X,I2,1X,I1,1X,12F6.0)
      IF(LMA.EQ.0.0) GO TO 195
      DO 15 K=1,12
   15 Y(K)=Y(K)+X(K)
   10 CONTINUE
   20 X(J)=Y(J)/12.0
      PRINT 111,LMA,IND
      PRINT 112
      PRINT 113
      PRINT 114,(X(J),J=1,12)
      PRINT 115
      PRINT 116
      N=12
      XN=N
      I=N/2+1
      PI=3.1415927
      Q=(2.0*PI/XN)
      V1=0.0
      DO 100 K=1,I
      XK =K-1
      S1=0.0
      C1=0.0
      X1=0.0
C***CALCULATE THE MEAN FOR THE TWELVE MONTHLY VALUES,MEAN=O
      DO 30 J=1,N
   30 X1=X1+X(J)
   31 Q=X1/XN
C***CALCULATE THE COSINE COEFFICIENTS, C(K)
      DO 35 J=1,N
      XJ=J-1
   35 C1=C1+X(J)*COS(Q*XJ*XK)
      IF(K.EQ.0) GO TO 38
   37 C(K)=(2.0/XN)*C1
      GO TO 39
   38 C(K)=(1.0/XN)*C1
 C***CALCULATE THE SINE COEFFICIENT,S(K)
   39 DO 40 J=1,N
```

```
      XJ=J-1
   40 S1=S1+X(J)*SIN(Q*XJ*XK)
   41 S(K)=(2.0/XN)*S1
C***CALCULATE THE ACTUAL AMPLITUDE, A(K)
   45 A(K)=SQRT((C(K)**2)+S(K)**2))
      IF(K.NE.1) GO TO 46
C***SET VALUES TO  0.0 FOR THE ZERO (0) HARMONIC
      R(K)=0.0$D(K)=0.0$P(K)=0.0$PA(K)=0.0$PS(K)=0.0$PM(K)=0.0$PM1(k)=0.
C***THE AMPLITUDE OF THE ZERO HARMONIC DIVIDED BY 2 EQUALS THE MEAN
      A(K)=A(K)/2.0
      GO TO 100
C***CALCULATE THE RELATIVE AMPLITUDE, R(K)
   46 R(K)=(A(K)/O)*100.0
C***CALCULATE THE PHASE ANGLE,P(K)
   56 P(K)=ATAN(C(K)/S(K))
C***CONVERT PHASE RADIANS,P(K), TO PHASE DEGREES, D(K)
      D(K)=P(K)*57.296
C***SET MINUS PHASE P(K) TO PLUS PHASE, MULTIPLY BY MINUS 1
      IF(P(K).LT.0.0) GO TO 60
      GO TO 63
   60 D(K)=-1.0*(D(K))
C***DETERMINE THE QUADRANT FOR THE PHASE ANGLE ALONG THE BASIC INTERVAL
   63 IF(C(K).GT.0.0.AND.S(K).GE.0.0) GO TO 70
      IF(C(K).GE.0.0.AND.S(K).LT.0.0) GO TO 71
      IF(C(K).LE.0.0.AND.S(K).LT.0.0) GO TO 72
      IF(C(K).LT.0.0.AND.S(K).GE.0.0) GO TO 73
C***CALCULATE THE PHASE ANGLE,PA(K)
   70 PA(K)=D(K)
      GO TO 75
   71 PA(K)=180.0-D(K)
      GO TO 75
   72 PA(K)=180.0+D(K)
      GO TO 75
   73 PA(K)=360.0-D(K)
C***CALCULATE THE PHASE SHIFT,PS(K)
   75 PS(K)=-(PA(K)/XK)
C***CALCULATE THE PHASE MAXIMUM OF Y, PM(K)
      PM(K)=(PS(K)+(90.0/XK))
C***CALCULATE THE PHASE MAXIMUM PM1(K), BETWEEN 0 and 360
      PM1(K)=PM(K)+(360.0/XK)
C***CALCULATE THE TOTAL VARIANCE, V1
   80 V1=V1+(A(K)**2)
  100 CONTINUE
C***CALCULATE THE PERCENT VARIANCE EXPLAINED BY K, V(K)
      DO 105 K=1,I
      XK=K
      K1=K-1
      IF(K.NE.1) GO TO 102
      V(K)=0.0
```

```
      GO TO 105
  102 V(K)=(A(K)**2/V1)*100.0
  105 PRINT 117,K1,C(K),S(K),PA(K),R(K),A(K),PM(K),V(K)
      PRINT 119
      DO 101 K=1,7
      K1=K-1
  101 PRINT 120,K1,P(K),D(K),PS(K),PM1(K)
  110 FORMAT(*-HARMONIC ANALYSIS, STATE OF MICHIGAN*)
  111 FORMAT(*-LABOR MARKET AREA*1X,I2,4X,*INDUSTRY*,1X,I2)
  112 FORMAT*0*,*MEAN
  113 FORMAT(2X,*MEAN      JANUARY  FEBRUARY MARCH   APRIL   MA
     6Y      JUNE     JULY     AUGUST   SEPTEMBER  OCTOBER NOVEMBER DE
     6CEMBER*)
  114 FORMAT(*0*,9X,12F10.2)
  115FORMAT(*0*,*       HARMONIC     COSINE      SINE       PHASE
     6      RELATIVE       ACTUAL          PHASE      PERCENT*)
  116 FORMAT(*                         COEFF         COEFF          ANGLE
     6  AMPLITUDE     AMPLITUDE    MAXIMUM    VARIANCE*)
  117 FORMAT(*0*,7X,I2,8X,F10.3,6(4X,F10.3))
  119 FORMAT(*0*,*   HARMONIC   PHASE RAD    PHASE DEG    PHASE SHI
     6FT     PHASE MAX 1*)
  120 FORMAT(*0*,7X,I2,8X,F10.3,3(4X,F10.3))
      GO TO 1
  195 CONTINUE
  200 END
```

*****

BIBLIOGRAPHY

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Amedeo, D., and R. Golledge. 1975. An Introduction to Scientific Reasoning in Geography. New York: John Wily & Sons, Inc.

Archer, Bryan, H., and C. B. Owen. 1972. "Towards a Tourist Regional Multiplier." Journal of Travel Research, 11(2):9.

Bannister, Geoffrey. 1975. Population Change in Southern Ontario." Annals of the Association of American Geographers, 65:177-188.

________. 1976. "Space Time Components of Urban Population Change." Economic Geography, 52:228-240.

Ashby, L. 1964. "The Geographical Distribution of Employment: An Examination of the Elements of Change." Survey of Current Business, 44:13-20.

BarOn, R. R. V. 1978. "Analysis of Trends and Seasonality and Forecasting Using Tourism Information Systems." International Symposium on Tourism and the Next Decade. George Washington University, March 11-15, 1978.

Bassett, K., and P. Haggett. 1971. "Time Series Analysis of Unemployment in Southwest Wales." In Elements of Spatial Structure. Edited by A. Cliff, P. Haggett, J. Ord, and R. Davies. Cambridge University Press, 1975.

Battelle Memorial Institute Columbus Laboratories. 1969. Industries Suited for the Upper Great Lakes. Report Prepared for the Upper Great Lakes Regional Commission.

Beaman, J., and S. Smith. 1974. "A Scheme for Decomposing Park Attendance Loading Curves and Related Analysis Methodologies." Canadian Outdoor Recreation Demand Study Technical Note 8.

Bennett, R. J. 1974. "Process Identification for Time Series Modelling in Urban and Regional Planning." Regional Studies, 8:157-174.

________. 1979. Spatial Time Series. London: Pion Press.

Blackman, R., and J. Tukey. 1958. The Measurement of Power Spectra From the Point of View of Communications Engineering. New York: Dover Press.

Bonin, J. M. 1968. "Seasonality and Economic Analysis." The Southern Economic Journal, 34(3):383.

Bourque, P., and G. Brabb. 1960. Seasonality in Washington State Employment. Department of Business, University of Washington, Seattle.

Borts, G. H. 1960. "Regional Cycles of Manufacturing Employment in the United States: 1914-1953." Journal of the American Statistical Association, 55:151-211.

Borts, G. H., and J. L. Stein. 1962. "Regional Growth and Maturity in the U.S.: A Study of Regional Structural Change."

Brown, A. J., and E. Burrows. 1977. Regional Economic Problems. London: George Allen & Unwin, Ltd.

Carson, J. E. 1963. "Analysis of Soil and Air Temperatures by Fourier Techniques." Journal of Geophysical Research, 68:2217-2232.

Chambers, E. J. 1961. Economic Fluctuations and Forecasting. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Choi, K. E. 1967. Seasonal Employment in Louisiana Employment, 1947-1964. Division of Business and Economic Research. No. 5. Louisiana State University.

Cliff, A., P. Haggett, J. Ord, K. Bassett, and R. Davies. 1975. Elements of Spatial Structure; A Quantitative Approach. Cambridge, England: Cambridge University Press.

Conrad, V., and L. W. Pollack. 1950. Methods in Climatology. Cambridge, Mass.: Harvard University Press.

Croxten, F., and D. Cowden. 1955. Applied General Statistics. New York: Prentice-Hall.

Cunnyham, J. 1963. "Spectral Analysis of Economic Time Series." Working Paper No. 14. U.S. Department of Commerce, New York.

Cutler, A. T., and J. E. Hants. 1971. "Sensitivity of Cities to Economic Fluctuations." Growth and Change, 2(1):23-28.

Data Research Center. 1975. Seasonal Population of the Grand Traverse Area. Traverse City, Michigan.

Davis, H. C. 1974. "Seasonal Economic Instability in Canadian Metropolitan Areas." Review of Regional Studies, 5(1):76.

Davis, H. T. 1941. The Analysis of Economic Time Series. Bloomington, Ind.: Principia Press.

Domoy, F. M. 1977. An Employment Analysis of the Michigan Ski Industry. Research Report No. 329. East Lansing: Michigan State University Agricultural Experiment Station.

Dunn, E. S. 1960. "A Statistical and Analytical Technique for Regional Growth Analysis." Papers of the Regional Science Association, 6:97.

Elliott, C. 1979. "Indicators of Seasonal Tourism in Tennessee." Symposium on Tourism and the Next Decade. George Washington University, March 11-15, 1979.

Friedmann, J., and W. Alonso. 1964. Regional Development and Planning: A Reader. Cambridge, Mass.: MIT.

Fuchs, V. R. 1959. "Changes in U.S. Manufacturing Since 1929." Journal of Regional Science, Spring 1959.

Fusfield, D. R. 1968. "Population Growth and Employment in the Service Industries." The Southern Economic Journal, 35(1):73.

Goldstein, A. 1964. "Optical Correlation for Certain Types Discrimination." Photogammatic Engineering, 30:639-646.

Granger, C. W. 1966. "The Typical Spectral Shape of an Economic Variable." Econometrica, 34:150-161.

Granger, C. W., and M. Hatanaka. 1964. Spectral Analysis of Economic Time Series. Princeton, N.J.: Princeton University Press.

Gray, Peter H. 1970. International Travel-International Trade. Lexington, Mass.: Heath Lexington Books.

Greig, B. G. 1949. Seasonal Fluctuations in Women's Clothing Industry in New York. New York: Columbia University Press.

Haggett, P., A. Cliff, and A. Frey. 1977. Locational Analysis in Human Geography. Vol. 1, Locational Models. New York: John Wiley & Sons, Inc.

Hall, H. B., and R. E. Hall. 1979. Time Series Processor, version 2.8. East Lansing: Michigan State University.

Hamermesh, D. S. 1969. "Spectral Analysis of the Relation Between Gross Employment Change and Output Changes." Review of Economic Statistics, 51:62.

Heilbroner, R. L. 1968. Understanding Micro-Economics. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

Hewings, G. 1977. Regional Industrial Analysis: An Introduction to Regional Science. London: Methuen and Co.

Horn, L. H., and R. A. Bryson. 1960. "Harmonic Analysis of the Annual March of Precipitation Over the U.S." Annals of the American Association of Geographers, 50(1):157.

Isard, W. 1960. Methods of Regional Analysis, An Introduction to Regional Science. Cambridge: MIT Press.

________. 1975. Introduction to Regional Science. Englewood Cliffs, N.J.: Prentice-Hall, Inc.

International Union of Travel Organizations. 1972. "Study on the Economic Impact of Tourism of National Economics and International Trade." Geneva.

Jeffrey, D. 1974. "Regional Fluctuations in Unemployment Within the U.S. Urban Economic System: A Study of the Spatial Impact of Short Term Economic Change." Economic Geography, 50:111-123.

Jenkins, G. M., and D. J. Watts. 1969. Spectral Analysis. San Francisco: Holden-Day.

Johnston, Ronald J. 1978. Multivariate Statistical Analysis in Geography. New York: Longman Group, Ltd.

Kartman, A. E. 1975. "Seasonality in the San Diego Economy." Annals of Regional Science, 40(1).

King, L. J., E. Cassetti, and D. Jeffrey. 1969. "Economic Impulses in a Regional System of Cities: A Study of Spatial-Temporal Interaction." Regional Studies, 3:213.

King, L., E. Cassetti, D. Jeffrey, and J. Odland. 1972. "Spatial-Temporal Patterns in Employment Growth." Growth and Change, 3:37-42.

Kuznets, S. 1933. Seasonal Variations in Industry and Trade. New York: National Bureau of Economic Research.

Lane, Theodore. 1966. "The Urban Base Multiplier: An Evaluation of the State of the Art." Land Economics, 42(3):339.

Marans, R. W., and J. D. Wellman. 1976. "Waterfront Living: A Report on Permanent and Seasonal Residents in Northern Michigan." University of Michigan Institute for Social Science Research, Ann Arbor.

Maxwell, J., and R. Richardson. 1974. "Seasonal Tourism Indicator: A Refined Application of U.S. Labor Department Data for Measuring Tourism and Recreation." Fifth Annual Conference on TTRA, Williamsburg, Virginia.

Mayer, T. F., and W. R. Arney. 1974. "Spectral Analysis and the Study of Social Change." Sociological Methodology, 1973-1974.

Michigan Department of Commerce. 1975. Tourist and Growth Study, A Report to the Upper Great Lakes Regional Planning Commission. Programs and Administration Division, Travel Bureau.

Michigan Department of Commerce. 1976. "Tourist Industry Growth Study: A Report to the Upper Great Lakes Regional Planning Commission." Prepared by the Programs and Administration Division of the Travel Bureau.

Michigan Employment Security Commission. 1970-1978. Civilian Labor Force Employment and Unemployment Estimates.

Michigan Employment Security Commission. 1979. Annual Planning Report. Research and Statistics Division. Labor Market Analysis Division, Detroit, Michigan.

Michigan Department of Natural Resources. 1977. Recreational Boating Survey. Waterways Division, Lansing, Michigan

Mendenhall, W., and J. Reinmuth. 1974. Statistics for Management and Economics. Mass.: Duxberry Press.

Momiyama, M. 1977. Seasonality in Human Mortality. University of Tokyo Press.

Needlemen, L. (ed.). 1968. Regional Analysis: Selected Readings. Middlesex, England: Penguin Books, Inc.

Neff, P., and A. Weifenback. 1949. Business Cycles in Selected Industrial Areas. Berkeley: University of California Press.

Nerlove, M. 1964. "Spectral Analysis of Seasonal Adjustments Procedures." Econometrica, 32(3):241.

Nie, N., C. Hull, K. Steinbreuner, and D. Bent. 1975. SPSS: Statistical Package for the Social Sciences, N.Y. : McGraw-Hill.

Norton, R. 1979. City Life Cycles and American Urban Policy. New York: Academic Press, Inc.

Nourse, H. O. 1968. Regional Economics: A Study of the Economic Structure, Stability, and Growth of Regions. New York: McGraw-Hill Book Co.

Ontario Ministry of Industry and Tourism. 1976. The Importance of Tourism to the Ontario Economy. Tourism Policy and Research Section.

Panofsky, H. A., and G. W. Brier. 1968. Some Applications of Statistics to Meteorology. University of Pennsylvania.

Perloff, H. S., E. Dunn, E. Lampard, R. Muth. 1960. Regions, Resources, and Economic Growth. Baltimore: Johns Hopkins Press.

Pigozzi, B., Wm. 1979. "A Set of Urban Employment Forecasting Models with Structural and Temporal Implications." Ph.D. dissertation, Department of Geography, Indiana University.

______. 1980. "Interurban Linkages Through Polynomially Constrained Distribution Lags." Paper presented to the Association of American Geographers Annual Meeting, April 13, 1980, Louisville, Kentucky.

Ragatz, R. 1970. "Vacation Homes in Northeastern United States: Seasonality in Population Distribution." Annals of the American Association of Geographers, 60:447-455.

________. 1970. "Vacation Housing: A Missing Component in Urban and Regional Theory." Land Economics, 46:118-126.

Rayner, J. N. 1971. An Introduction to Spectral Analysis. London: Pion Press.

Renaud, B. M. 1972. "The Influence of Tourism Growth on the Production Structure of Island Economies." Review of Regional Studies, 2(3):41.

Richardson, H. W. 1969. Regional Economics, Location Theory, Urban Structure, and Regional Change. New York: Praeger Press.

Rottmann, K. 1979. "Trends in Seasonality of Michigan State Park Use." Master's thesis. Department of Park and Recreation Resources. Michigan State University.

Sabbagh, M., and R. Bryson. 1962. "Aspects of Precipitation Climatology of Canada Investigated by the Method of Harmonic Analysis." Annals of the American Association of Geographers, 52.

Sant, Morgan. 1973. The Geography of Business Cycles. London, England: London School of Economics and Political Science, Paper No. 5.

Saunders, C. T. 1936. Seasonal Variations in Employment. London: Longmans Green Co.

Smart, J. J. 1964. Problems of Space and Time. New York: The Macmillan Co.

Smith, Edwin S. 1931. Reducing Seasonal Unemployment. New York: McGraw-Hill Book Co.

Speight, J. G. 1965. "Meander Spectra of the Anabunga River." Journal of Hydrology, 3:1-15.

Strang, W. A. 1970. Recreation and the Local Economy, An Input-Output Model of Recreation-Oriented Economy. Graduate School of Business Administration, University of Wisconsin, Madison.

Stynes, D. 1978. "The Peaking Problem in Outdoor Recreation: Measurement and Analysis." Paper presented to the National Recreation and Park Association Congress, October 15, 1978.

Taylor, P. J. 1977. Quantitative Methods in Geography. Boston, Mass.: Houghton Mifflin Co.

Tiebout, C. 1962. The Community Economic Base Study. Supplementary Paper No. 16. Washington, D.C.: Committee for Economic Development.

Thompson, W. R. 1965. A Preface to Urban Economics. Baltimore: Johns Hopkins Press.

Verway, D. I. 1979. Michigan Statistical Abstract. Division of Research. School of Business Administration, Michigan State University, East Lansing.

Webb, S., and A. Freeman. 1912. Seasonal Trades. London: Constable and Co., Ltd.

Zelinsky, W. 1958. "A Method for Measuring Change in the Distribution of Manufacturing Activity: U.S. 1939-1949." Economic Geography, April 1958.