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Modeling spatial and temporal variations in tourism-related employment in Michigan

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MODELING SPATIAL AND TEMPORAL VARIATIONS IN TOURISM-RELATED EMPLOYMENT IN MICHIGAN

By

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ABSTRACT

MODELING SPATIAL AND TEMPORAL VARIATIONS IN TOURISM-RELATED EMPLOYMENT IN MICHIGAN

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There were two primary focuses of this study. First, trend and seasonal patterns of monthly tourism-related employment in Michigan between January 1974 and December 1984 were identified. Second, alternative short term forecasting models for predicting monthly tourism related employment were developed and compared at both state and regional levels.

Nine study regions were formed, the state of Michigan and eight sub-regions. A general analysis and forecasting procedure was applied to each study region. Multiplicative decomposition was adopted to separate the trend and seasonal components of each series. Trend and seasonal patterns were then identified from these components. Trend models were estimated from trend components using transfer function techniques; seasonal models were estimated from seasonal components using harmonic analysis. Forecasting models were then created by combining trend and seasonal models for each region.

Michigan's tourism related employment grew by 25% over the 1974-1979 period, dropped 7% between 1980 and 1982, and subsequently recovered at a 4% annual growth rate in 1983 and 1984. Through the year statewide employment fluctuates plus or minus 6% around its annual average. Statewide seasonal patterns are stable over the eleven years period. Regional differences were found in both growth rate and seasonal fluctuations especially

between northern tourism-dependent regions and more populous southern regions.

Structural and time series models were estimated and compared based upon forecast accuracy for each region. They have the same seasonal component but different trend components (i.e. either a structural or a time series trend component). The performance of each model, therefore, depends primarily on its trend component.

All forecasting models fit the data well. Structural models based upon economic variables forecast better for three northern tourism-dependent regions. Time series models based upon time factors forecast somewhat slightly better for the other five regions. The statewide models do not generalize well to northern regions because of differences between regional and statewide patterns. Differences exist in both trend and seasonal components.

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Tourism can be defined as " the science, art, and business of attracting and transporting visitors, accommodating them, and graciously catering to their needs and wants" (McIntosh, 1977). The tourism industry is characterized by variations in size, location, functions, types of organization, and the range of services provided (Schmoll, 1977). State and regional officials have experienced an increasing interest in the potential tourism holds for generating revenues, raising the level of employment, and contributing to the overall economic development of a particular geographic area. Some areas are heavily dependent upon tourism and their levels of economic activity fluctuate with the ups and downs of tourism demand. To ease economic instability, it is necessary to have a sufficient understanding of past trends and the forces which cause change in tourism activity. Then, appropriate policies can be developed to respond to anticipated changes in the area. Therefore, systematic monitoring, tracking, and forecasting of tourism activity is highly desirable.

Tourism activity varies both spatially and temporally (Stynes and Pigozzi, 1983). For example, temporal variations can be observed in Mexican tourism to the United States which reached a peak at 3.8 million visitors in 1981, experienced a rapid decline for the next two years, and had a projected significant increase in 1984 by 21 percent and in 1985 by 9 percent (U.S.

Travel Data Center, 1984). Different geographic areas provide different types of tourism activity that may reach their peaks in different seasons. For example, Hawaii is primarily selling its water- and cultural-related tourism activity all year long, and both summer and winter tourism activity prevail in states of mid-west region, like Michigan.

Both temporal and spatial variations in tourism activity must be considered in the design of tourism plans, management policies, and marketing at the national, state, and local levels. Tourism monitoring and forecasting models are generally developed at the national or state level, although many tourism development and marketing decisions are made at the local level. An understanding of temporal variations in tourism activity in an area is needed to develop appropriate tourism plans and policies in the area.

Changes in tourism activity in an area (region or local) are sometimes difficult to track and monitor because of the lack of good tourism data. Patterns of regional or local tourism activity must often be generalized from a broader area. The applicability of national and statewide travel statistics to a regional or local level may be quite limited.

TEMPORAL VARIATIONS

Trend and seasonality are the two major temporal patterns of tourism activity. These may not be stable over time. Trend is defined as the general patterns of increase or decrease in tourism activity over time. Seasonality is defined as a regular pattern of tourism activity by season of the year.

In the short term (3-5 years), seasonal fluctuations are more obvious than trends. Trends reveal the historical pattern of the levels of tourism activity from which we may make forecasts. Tourism activity is very seasonal and often viewed as regular patterns in tourism businesses. During the winter season a significant portion of tourism facilities in Michigan are idle. For example, in Michigan's eastern upper peninsula, the occupancy rate of motel and hotel rooms in winter is only about one tenth of that in summer, i.e. 5.7% vs. 55.7%, (Michigan Department of Commerce, 1975).

Changes in trends and seasonality of tourism activity may impact decisions in the tourism industry. If a decreasing trend in tourism activity in an area is observed, appropriate policies can be designed to counteract this downward trend to avoid losing more tourism business and/or to stimulate the area's tourism industry or develop other economic sectors.

It is suspected that the patterns of seasonality, i.e. peak and valley in tourism demand, have been changing over time. For example, off-season tourism activity in northern Michigan has been much higher than previously (McIntosh, 1977). Changes in seasonal patterns of tourism activity may have a significant effect on the timing and quantity of tourism services and opportunities demanded and supplied. If tourism activity could be more evenly-spread throughout the year, tourism facilities could be more efficiently utilized. At the same time, more tourism opportunities with better quality of services could be provided to the tourists, and more stable tourism employment could be achieved (BarOn, 1973). Seasonality is not a totally uncontrollable factor in tourism management and development.

Forecasting models for trend and seasonality can help us better monitor the trend and seasonal patterns and provide forecasts to lead to appropriate decisions in tourism development.

SPATIAL VARIATIONS

Both trend and seasonal patterns of tourism activity also vary between geographical areas in a country or a state. Different geographical areas have different patterns of flow of income, employment and prevailing types of tourism activities. In Michigan, such spatial differences were demonstrated by MESC (1980), Stynes (1980) and Stynes and Pigozzi (1983). For example, in northern Michigan the northwest region is the only one experiencing a steadily increasing trend of tourism-related employment from 1974 through 1979. The region was not significantly impacted by the 1979 energy crisis (MESC, 1980).

Each region can be characterized by its location, climate, supply of tourism opportunities and related services, and prevailing types of tourism activity. Individual regional tourism plans and policies could be improved, if designed in accordance with regional patterns of tourism activity.

Trends and seasonality of local and regional tourism activity may be hidden in the patterns of aggregate statewide series. Since southern Michigan accounted for approximately 92 percent of Michigan tourism-related jobs in 1979 (MESC, 1980), patterns of activity in northern Michigan are difficult to identify from the statewide data. Thus, using statewide tourism forecasts to guide tourism development in individual counties and regions of the state may be ill-advised. Quantitative forecasting methods can help us to identify, analyze and compare the trends and seasonality of statewide and regional tourism activity across Michigan.

FORECASTING METHODS

There are three categories of quantitative forecasting methods: (1) time series methods, (2) structural methods , and (3) combined structural-time-series methods (Pindyck and Rubinfeld, 1981). Each of these three types of models has advantages and disadvantages in particular applications.

Tourism activity shows strong fluctuations by season of the year. To capture seasonal fluctuations, time series methods, such as decomposition techniques (BarOn, 1975, 1979), Box-Jenkins techniques (Guerts, 1982), and harmonic analysis (Stynes and Chen, 1985), are appropriate. Compared to time series models, structural models are more responsive to changes in activity caused by changes in population, income and other socio-economic, environmental and political variables. Structural models, such as multivariate linear models (Johnson and Suits, 1983) and gravity models (Cesario, 1969) are commonly employed to forecast recreation and tourism activity. Wander and Van Erden (1980), Fritz et al (1984), and Stynes and Chen (1985) report that combining time series and structural models achieves higher forecasting accuracy than with either of these two models used alone.

Forecasting methods should be matched with characteristics of the problem and data series. Using an appropriate forecasting method enables us to more fully exploit and utilize information of the data series and achieve study objectives. Strengths and weaknesses of different forecasting methods will be discussed more fully in Chapter II.

MICHIGAN AS AN AREA OF APPLICATION

Secondary data measuring tourism activity in Michigan will be used to examine and compare trends, seasonal patterns and forecasting models at statewide and regional levels of aggregation. Michigan has both summer and winter tourism seasons. The state also has different economic structures between regions with northern Michigan more dependent upon tourism than southern Michigan. For example, twenty out of forty one counties in northern Michigan and only one out of forty two counties in southern Michigan had more than 9 percent of their wages and salary employment attributed to tourism-related jobs (Michigan Department of Commerce, 1975). Examining and comparing spatial variations in trend and seasonal patterns of tourism activity across several regions of the state can help us better understand regional differences in tourism dependency. Finally, developing scientific and systematic forecasting procedures and models may be useful for the Michigan Travel Bureau in its effors to better monitor and forecast tourism activity in Michigan.

PROBLEM STATEMENT

Spatial and temporal variations in tourism activity are expected to exist in a large geographic area like a country or a state. If we find that differences in trend and seasonal patterns of tourism activity are significant among sub-regions of the state and between individual regions and the state, there is a clear need to develop forecasting models at both statewide and regional levels. Forecasting models enable us to better understand the trend and seasonal patterns of tourism activity and how these patterns differ across the state. Tourism forecasts can assist the development of tourism plans and policies to properly respond to the needs and wants of tourism businesses in the state and its sub-regions. Also, they can be used by the tourism industries in strategic planning and marketing.

Longitudinal studies of tourism activity across Michigan are particularly lacking. A few studies have focused on either identifying and quantifying trend and/or seasonal patterns of tourism activity in Michigan or developing statewide monitoring and/or forecasting models.

The Michigan Employment Security Commission (MESC, 1980) has established a data base of tourism related employment in Michigan and reported the data series' trend, cycle, and seasonal components between 1974 and 1979. These components were descriptively identified and graphically presented at the state and regional levels. The patterns of these three components of tourism-related employment levels and comparison of them between various regions were not completely analyzed. Also, mathematical models used to monitor and forecast the trend, cycle, and seasonal components of tourism activity in Michigan have not been estimated at the state or regional levels.

Stynes and Pigozzi (1983), using harmonic analysis, found that seasonal patterns of service employment varies across northern Michigan. Service employment was used as a surrogate for tourism-related employment, since significant positive correlations with tourism activity were found in northern Michigan.

Using monthly Michigan lodging tax revenue data a linear regression model (Holecek et al, 1983) and a combined structural-time-series model (Stynes and Chen, 1985) were developed at the state level. The linear regression model provides interim estimates of Michigan lodging activity 2-3 months ahead of when they are reported for the purpose of better tracking and monitoring lodging activity. The structural-time-series model incorporates both trend and seasonal components of the lodging activity to predict monthly lodging tax receipts.

These studies provide some evidence of regional differences in trend and seasonal patterns of tourism activity across Michigan. They also provide a basis for a more sophisticate and comprehensive approach to tourism analysis and forecasting based upon quantitative mathematical models. Lack of tourism information systematically analyzed and forecasted will hinder the efforts of the state and regional officials and business managers to develop sound tourism plans. This calls for a systematic approach to analyze and forecast tourism activity across Michigan.

STUDY OBJECTIVES

The purpose of the study is to further analyze the differences in tourism activity across Michigan by developing a systematic forecast modeling approach. The study will extend past research in four areas: (1) identifying and quantifying both trend and seasonal patterns of tourism activity across Michigan, (2) examining spatial variations in these two patterns, (3) developing formal models to forecast tourism activity in Michigan at both the state and regional levels, and (4) comparing the model structures and forecast performance of statewide and regional models.

Formally, the study objectives are:

1. Identify and quantify trend and seasonal patterns of tourism activity in the state of Michigan and its individual sub-regions.
2. Compare trend and seasonal patterns across several regions of the state.
3. Develop, estimate and evaluate alternative models for forecasting statewide tourism activity.
4. Develop, estimate and evaluate models for forecasting tourism activity at the regional level.
5. Test the generalizability of statewide models for forecasting

tourism activity at regional levels.

OVERVIEW OF THE STUDY

To achieve these objectives, this study is divided into six chapters. Following this introductory chapter, chapter II reviews relevant literature on forecasting methods and tourism forecasting studies. Research methods are summarized in Chapter III. The results are presented in the next two chapters. Chapter IV summarizes descriptive results of trend and seasonal patterns of tourism-related employment in Michigan. Differences in these two patterns between regions were investigated. Chapter V presents statewide and regional forecasting models for tourism-related employment in Michigan. The final chapter summarizes the results, limitations of the study and recommendations for future research, and concludes with major findings of the study and applications of the results to tourism planning and management.

CHAPTER II

LITERATURE REVIEW

In this chapter three types of quantitative models are introduced: (1) structural, (2) time series and (3) combined structural-time-series models. Applications of these models in tourism, and especially to Michigan tourism are reviewed. Previous findings, particularly relevant to the study, are summarized at the end of the chapter.

QUANTITATIVE FORECASTING MODELS

A model is a logical structure reflecting the information or situation revealed from the real world, and is implicit in every forecast or analysis of a social or a physical system (Theil, 1966). But why is an explicit model needed to analyze the data on hand? There are several advantages to formal models. First, during the model building process, the individual is forced to examine, identify, and account for the important relationships involved in a problem. The relationships that make up the model can be tested and validated by examining whether they are as hypothesized in the model specification stage.

Second, a statistical measure of the confidence of the individual relationships that make up the model, and of the model as a whole can be estimated. Estimation of forecast errors is important to the user of the forecasts. Third, once a model has been constructed and fitted to data, the effects of small changes in individual variables in the model can be evaluated using sensitivity analyses. This is important in both understanding and using the model (Pindyck and Rubinfeld, 1981).

Structural Models

Structural models represent the relationships between the variable of interest and those quantifiable factors that affect the behavior of this variable. The estimated relationship can be used to forecast. Using a measure Y_t of tourism activity to illustrate, a structural relationship can be written mathematically as

$$Y_t = f(X_{1t}, X_{2t}, \ldots, X_{kt}), \qquad (2.1)$$

where Y_t is the level of tourism activity at a destination in time t, and X_{kt} is the level of kth explanatory variable affecting Y_t at time t. Two types of structural models are the most common in tourism forecasting, multivariate regression models and gravity models .

Multivariate Regression Models

In a multivariate regression model, it is hypothesized that a dependent variable is a function (usually linear) of a set of explanatory variables. In the case of estimating the level of tourism activity at a destination, these explanatory variables may be external to the tourism system, such as per capita income, or internal, such as promotional expenditures.

Additive and multiplicative models are the most popular functional forms. An additive regression model can be written as

$$Y_t = b_0 + b_1 X_{1t} + b_2 X_{2t} + \ldots + b_i X_{kt} + e_t, \qquad (2.2)$$

where b_i, $i=0,\ldots,k$, are parameters to be estimated and e_t is an additive error term.

A multiplicative model can be written as

$$Y_t = b_0 X^{b1}{}_{1t} X^{b2}{}_{2t} \ldots X^{bi}{}_{kt} e_t, \qquad (2.3)$$

where e_t is a multiplicative error term and Y_t, X_{kt}, and b_i are defined as above.

In the multiplicative form, the coefficient of variable X_k represents the elasticity of the dependent variable with respect to X_k. One of several ways to estimate multivariate regression models is to use ordinary or weighted least squares on Equation (2.2) or the logarithmic transformation of Equation (2.3), the assumptions are summarized in Pindyck and Rubinfeld (1981, pp.76).

To use a structural model for forecasting, projections of each explanatory variable are required. Unless the future values of the explanatory variables can be reliably and accurately forecasted, the forecasts produced from the model will be of limited use. Forecasts from structural models are made under the assumption that the identified structural relationships between the variables will remain constant over the forecast period. The model should be re-estimated periodically to allow for changes in these structural relationships.

The multivariate regression equation should be examined for multi-collinearity, autocorrelation, or heteroscedasticity as these problems may have adverse effects on the use of the model for forecasting (Archer, 1976). Multicollinearity is often present, especially with cross-sectional data (Sheldon and Var, 1985). Although the overall forecast accuracy of the model is not thereby impaired, the effects of changes in each of the intercorrelated independent variables can not be identified and forecasted.

Autocorrelation can exist between the values of the error terms. The presence of serious autocorrelation has two implications. First, the estimated relationships that make up the model may be unreliable because coefficients and the degree of variance may be considerably under- or over-estimated. Second, the regression equation is not the best prediction of the dependent variable if serial correlation is present. Methods used to correct for serial correlation, such as transfer function techniques, will be introduced later in this chapter. Heteroscedasticity means that the error terms do not have equal variances. The presence of heteroscedasticity also tends to reduce forecast accuracy.

Explanatory variables for forecasting models should be selected based upon: (1) logical relationship to the variable of interest, (2) availability of past and/or future values, and (3) to avoid multicollinearity.

Gravity Models

Gravity models are developed from the principles of Newton's law of gravitation and similar in form to regression models. A gravity model specifies the nature of relationship, especially those concerning distance between origin and destination, in a more rigid form (Archer, 1980).

Trip generation models are sometimes developed from gravity models (Ewing, 1983). Trip generation models are used to estimate and forecast probabilities or number of trips generated from a given origin to a specified destination (Stynes, 1983). A gravity or trip generation model incorporates a number of variables like distance between origin and destination, population size and income level of a trip generating origin, and the attraction index of a destination, etc. to explain why origins (i.e. cities, states, or countries) generate different volumes of trips (Bruges, 1980). The gravity models require origin-destination data which are generally available on a cross sectional basis for a limited number of sites or regions.

Time Series Models

A time series is a series of data which are historically and systematically collected, or observed, over successive increments of time (Theil, 1966). A time series model "accounts for patterns in the past movements of a particular variable, and uses that information to predict future movements of the variable" (Pindyck and Rubinfeld, 1981, pp. 470). Time series methods are not concerned with explaining the reason why a series is what it is. All causal factors are considered in the aggregate, since only the past behavior of the variable of interest is used to be the basis of our prediction. When used to forecast, it is assumed that the pattern of underlying causal forces which has caused trend, seasonality or cyclical behavior of the data series will remain constant over the forecasting period (Makridakis and Wheelwright, 1983), and that an extrapolation of the trend, seasonal or cyclical pattern will yield an appropriate forecast (Swart, Var and Gearing, 1978). A number of time series methods have been applied in tourism, such as simple trend extension, exponential smoothing, moving averages, etc. Three time series methods will be discussed in some detail here: decomposition methods, harmonic analysis and Box-Jenkins models.

Decomposition Methods

Decomposition methods decompose a time series into a trend, a cycle, and a seasonal component. Trend is defined as the general increasing or decreasing levels of the time series over time; and seasonality defines a regular pattern of the time series by season of the year. The cycle of the time series is the periodic fluctuation with oscillations occurring between three and seven years, often called "business cycle" (Mendenhall and Reinmuth, 1974).

The general mathematical representation of the decomposition approach is:

$$Y_t = f(S_t, T_t, C_t, E_t) \tag{2.4}$$

where Y_t is the time series values (actual data) in period t. S_t is the seasonal component (or index) in period t, T_t is the trend component in period t, C_t is the cyclical component in period t, and E_t is the error or random component in period t.

A general way to present a decomposition of a mixed model of Y_t into its components, defined by Raveh (1985), is

$$Y_t=(T_tE_t+e_t)S_t+s_t, \quad t=1,...,N \tag{2.5}$$

where Y_t is the observation of the series in time t. T_t represents the trend and cyclical components in time t, S_t and s_t are the multiplicative and additive seasonal components, respectively, and E_t and e_t are the multiplicative and additive error components, respectively. The purely additive model is obtained by setting $S_t=E_t=1$ for all t, that is

$$Y_t=T_t+s_t+e_t. \tag{2.6}$$

A purely multiplicative model is obtained by setting constraints $s_t=e_t=0$ for all t, that is

$$Y_t=T_tE_tS_t. \tag{2.7}$$

A simpler mixed additive-multiplicative model with a mixed type for seasonality and a multiplicative version for the error component, adopted by Raveh (1985), is

$$Y_t=T_tE_tS_t+s_t=Z_tS_t+s_t \qquad (2.8)$$

where $Z_t=T_tE_t$ is the seasonally adjusted series.

The selection of an appropriate decomposition model form depends on the characteristics of the data series. For the case where seasonal fluctuations are independent of the trend, a purely additive model is appropriate. When fluctuations are proportional to the trend, a purely multiplicative model should be adopted. If the fluctuations are neither proportional nor independent of the level of the trend, a mixed additive-multiplicative model may be required (Raveh, 1985). For simplicity only the purely additive and multiplicative model forms will be considered here.

In the decomposition process, seasonality is first removed, then trend and finally cycle, and any residual is assumed to be randomness. Bagshaw (1985), Makridakis and Hibon (1979) and Plosser (1979) recommend this prior seasonal adjustment in the forecast procedure to produce more accurate forecasts. There are several methods for separating trend and seasonal components. The n-period moving average method, Census II method, and the classical X-11 variant of the Census (Shiskin et al., 1967) all assume a multiplicative form. A non-metric technique, called Least Polytone Analysis or LPA (Raveh, 1981), can be used to select one of the three possible model forms: purely additive, purely multiplicative and mixed.

Harmonic Analysis

Harmonic analysis is a variant of Fourier analysis which can be applied to study periodicity in a time series with regular oscillations (Rayner, 1971). Fourier analysis estimates a time series with equal intervals of observations by an infinite series of sine and cosine curves.

Harmonic analysis affords a means to quantify the seasonal component of a time series with regular periodicity over time and express them mathematically as the algebraic sum of a series of simple sine curves (Horn and Bryson, 1960). Harmonic analysis uses ordinary least squares procedures to fit a series of sine curves of varying amplitudes and frequencies to a time series. Each harmonic (one sine curve) is determined independently of the others so that the characteristics of any particular harmonic, e.g. amplitude of fluctuation, and time of peaking or trough, can be mapped and examined separately. The sum of all harmonics recreates the original time series.

The formula for the Fourier series commonly used in harmonic analysis, defined by Rayner (1971), is:

$$\begin{aligned} X_k(\theta) = X_k &= \sum_{k=0}^{N} [A_k \mathrm{SIN}(k\theta+\phi_k)] \\ &= A_0 + A_1 \mathrm{SIN}(\theta+\phi_1) + A_2 \mathrm{SIN}(2\theta+\phi_2) + \ldots + \\ &\quad A_k \mathrm{SIN}(K\theta+\phi_k) + \ldots + A_N \mathrm{SIN}(N\theta+\phi_N) \end{aligned} \tag{2.9}$$

where, X_k is the time series of interest. A_k is the amplitude for harmonic k, measuring the magnitude of the fluctuation of sine curve k around the arithmetic mean of the data series (A_0). ϕ_k is the phase angle which determines the time of the year at which the peak (and consequently trough) for harmonic k occurs. θ is a portion of the one-year period that a data point represents, measured as an angle. For example, for a series with 12 monthly data points, each month is represented by 30 degrees (360/12) if we make the simplifing assumption that all months have the same number of days. One degree roughly corresponds to one day in the year.

When the number of sine terms (frequencies) needed to perfectly fit the finite data, (i.e. 100% of variation in the series is explained). This process is called harmonic analysis, otherwise Fourier analysis.

Harmonic analysis is appropriate for a time series with equal interval observations and regular periodicity over time (Rayner, 1971). Harmonic analysis can fit a time series with N observations with a series of N/2 harmonics or sine curves. Each of the k harmonics is fitted to the data curve by (1) increasing or decreasing the value of arithmetic mean of the data series, which decides the amplitude of the kth harmonic, and (2) shifting the curve horizontally, according to the phase angle, ϕ_k, of the harmonic k, so as to change the abscissa value at which the maximum occurs (and consequently minimum) (Horn and Bryson, 1960).

Statistics, such as the amplitude, relative amplitude, phase angles, peak timing, variance explained can be produced from harmonic analysis to help in explaining the behavior of the variable of interest. For their definitions and derivation, see Rayner (1971) and Appendix A.

Box-Jenkins Models

Box and Jenkins, in 1970, postulated a time series model which is a mix of autoregressive and moving average processes. An auto-regressive process of order p, denoted as AR(p), is to generate the current observation Y_t by weighting past observations going back p periods, together with an error term in the current period. A moving average process of order q, denoted as MA(q), is to generate the current observation Y_t by weighting error terms going back q periods (Pindyck and Rubinfeld, 1981). Box-Jenkins models are sufficient to describe a wide variety of stationary series. A series is stationary when it has constant mean and variance and its underlying forces are assumed to remain constant over time, otherwise it is non-stationary (Guerts and Ibrahim, 1975). A non-stationary series can be transformed into a stationary one by differencing. The number of differences required to produce a stationary series depends on the behavior of the series. One or two differences normally suffice for most empirical series.

The general form of the Box-Jenkins model can be written as

$$\phi(B)\Delta^d Y_t = \delta + \theta(B) e_t \qquad (2.10)$$

with

$$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - \ \dots \ - \phi_p B^p$$

$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \ \dots \ - \theta_q B^q$$

where $\phi(B)$ --- the autoregressive operator and $\theta(B)$ --- the moving average operator denote polynomial function of the operator B for the autoregressive process and the moving average process respectively. B is a backward shift operator which imposes a one-period time lag each time it is applied to a variable, e.g. $Be_t=e_{t-1}$ and $BY_t=Y_{t-1}$. ϕ_p and θ_q are parameters of the autoregressive and moving average components respectively. $\Delta^d y_t$ is the degree of differencing which transforms a nonstationary series to a stationary series, e_t is a normally distributed random disturbance process with a mean equal to zero and a variance equal to σ_e^2. δ is a constant term of the autoregressive component. Equation (2.10) is sometimes referred to as an ARIMA (Autoregressive Integrated Moving Average) model of order [p,d,q].

Box-Jenkins models are generally derived in three steps: (1) identification of a tentative model for a series, (2) estimation of parameters and examination of a set of diagnostic statistics and plots, and (3) generation of forecasts. If the model is not adequate, replication of the modeling process from the first step has to be performed again until an acceptable one is obtained. Then the forecasts can be computed (Pindyck and Rubinfeld, 1981).

Advantages of using Box-Jenkins techniques are: (1) they can fit any and all kinds of data patterns; and (2) greater forecast accuracy for some types of series can be obtained. Disadvantages are: (1) it is difficult to use because of the complexity of the model-building processes and the difficulty in fully understanding the underlying theory; and (2) the accuracy depends somewhat on individual forecasters' knowledge and experience to determine the best ARIMA model (Wheelwright and Makridakis, 1985).

Structural-Time-Series Models

There are several ways of combining structural models with time series models. These include varying parameter models, simulation models and combined structural-time-series models. The combined models use a structural method to capture and measure the influence of individual explanatory variables on the dependent variable and time-series methods to capture historical patterns in the data or errors. Three approaches of the combined models will be reviewed: (1) averaging forecasts from two or more models, (2) transfer function models, and (3) decomposition-type combined models.

Averaging Forecasts from Two or More Models

The first approach is to average forecasts from two or more competing models to derive a more accurate forecast than with any individual model used alone (Fritz, Brandon and Xander, 1984). Weights, sometimes based upon variances of the individual models, are applied to each forecast to calculate the combined forecasts. A simple example serves to illustrate.

The combined forecast is

$$F_c = W_t F_1 + (1-W_t) F_2 , \qquad (2.11)$$

where F_c is the combined forecast, F_1 and F_2 are structural forecast and time series forecasts respectively, and W_t and $(1-W_t)$ are the weights calculated for F_1 and F_2 respectively. For the procedure of computing the weights, see Fritz et al.

Transfer Function Models

The second approach is a transfer function model. A transfer function model combines a linear regression model and a Box-Jenkins model. It can be used to improve the power of the linear regression model to explain and forecast the behavior of a series.

Formally, a transfer function model takes the following form:

$$Y_t = \text{(a regression model)} + \text{(an ARIMA model)}$$
$$= (a_0 + a_1 X_{1t} + a_2 X_{2t} + \ldots + a_k X_{kt}) + (\phi^{-1}(B)\theta(B)\eta_t), \quad (2.12)$$

where X_{kt} is the value of explanatory variable k at time t, η_t is a normally distributed error term at time t. $\phi(B)$ and $\theta(B)$ are defined as in Equation (2.10), and a_i, i=1,2, ..., k are the parameters of the regression component of the combined model. The procedures for estimating a transfer function model will be introduced in Chapter III.

Decomposition-Type Combined Models

The third approach incorporates both structural and temporal variables in the estimation of a decomposition-type combined model. In this approach the data series may be decomposed into a moving average series (i.e. the combined trend and cycle components) and a seasonality series (i.e. seasonal component). The structural component of the model can be estimated by using structural methods like linear regression or the transfer function modeling techniques on the moving average series. Temporal variation in the seasonality series can be captured by a time series method, such as harmonic analysis. Then, structural and temporal components are either multiplied or added together to generate a combined model according to the relationship of these two components. The decomposition-type combined model form is additive or multiplicative:

$$Y_t = F_s * F_t, \text{ or}$$
$$Y_t = F_s + F_t, \qquad (2.13)$$

where F_s and F_t are forecasts of structural and temporal components of the combined model respectively.

Some disadvantages of using these three combined modeling approaches are: (1) they are difficult to use and costly to develop; and (2) the gains in terms of accuracy do not always justify the costs involved in developing and building this kind of model (Wheelwright and Makridakis, 1985).

APPLICATIONS TO TOURISM

To develop sound forecasting models for tourism activity it is important to select a highly tourism-related data series and examine the suitability of the modeling techniques for monitoring and forecasting tourism activity. Five key issues concerning monitoring and forecasting tourism activity will be reviewed and discussed in this section. They include problems in (1) measures of tourism activity, (2) identification of trend and seasonal components of the tourism series, (3) forecast modeling of trend and seasonal components , (4) comparison of forecasting models, and (5) spatial variations in the trend and seasonal components of tourism activity.

Measures of Tourism

A number of problems complicate selecting an appropriate measure of tourism activity. These include (1) the definition of tourism, (2) the composition or structure of the tourism industry, and (3) the choice of data series to be used. The first two problems contribute to the confusion and complexity of which data series is most appropriate to estimate the level of tourism activity.

"Different data series vary significantly in accuracy, regularity, level of temporal and spatial aggregation, and their relationship to recreation and tourism" (Stynes, 1986, pp. 4). It is important to know how many sectors and activities of the tourism industry are covered in the collection procedures of the data series. Some data series measure only a single tourism sector/activity, e.g. lodging room use taxes, visits to national parks, boating and fishing registrations. Other measures encompass several tourism sectors/activities, like tourist arrivals and tourism related employment. The tourism component is not clearly separated from the local-use component of many tourism-related data series. For example, lodging tax revenues will include revenues from tourists, business travelers, and local residents who may spend a night out. These problems make the development of reliable and valid measures of tourism activity difficult.

The choice of an aggregate or individual tourism data series depends on the purpose of the study. Information from individual tourism-related sectors may or may not be consistent with each other. A wider picture of overall tourism activity generally requires data collected across a number of tourism sectors or activities.

Seasonality versus Trend

Separating trend and seasonal components of a tourism time series may help us in understanding the behavior of the tourism series and therefore better monitoring and forecasting the series. BarOn (1975) argues that changes in either trends or seasonality of a time series may be obscured by the other. This may make the commonly used techniques of comparing corresponding months of two consecutive years misleading. Understanding the seasonal patterns of the series will enable us to more clearly identify the trends.

BarOn (1972, 1973, 1979) has written extensively on the subject of applying decomposition and time series methods for forecasting international tourism, including use of these methods to monitor and forecast tourist arrivals to Israel. A time series of tourist arrivals by air to Israel over the year 1956 to 1970 was decomposed into a moving average series and a seasonality series. Then a short-term trend was estimated from the moving average series. Patterns of seasonality were identified by examining the seasonality series and then projected into the future. Forecasts of trend and seasonal components were used to produce forecasts for Israel tourism activity.

Estimation of A Trend Model

Multivariate regression methods are commonly employed to estimate tourism trends. The resulting models can be used to forecast.

A number of variables have been used to explain and predict tourism demand. Employment, income, and wealth variables were found to be influential in determining air travel volumes between U. S. urban cities and Tucson, Arizona (Leaming and Gennaro, 1974). The U. S. retail price of gasoline was found to be related to the number of visits to national parks (Johnson and Suits, 1983). Income has consistently been found to be a very important and significant determinant of the demand for tourism (Gray, 1966; Askari; 1971; Artus, 1972; Kwack, 1972; Edward, 1975; Diamond, 1977; Sauran, 1978; Little, 1980; Loeb, 1982).

Population size was used with income level and travel costs to predict the demand for Turkish tourism services by Diamond (1977). A significant and positive relationship between the increase in population and tourists generated was found. The Insured Unemployment Rate (IUR) in New York was used as an indicator in a Box-Jenkins transfer function model to forecast the monthly demand for trips to Puerto Rico from United States (Wander and Van Erden, 1980).

Estimation of A Seasonal Model

Several methods have been used in tourism to quantify the seasonality of a series (e.g. decomposition methods) and model seasonal patterns (e.g. harmonic analysis and linear regression with dummy variables).

Using harmonic analysis, Oliveria (1973) identified weekly cycles of use patterns in wilderness areas and campgrounds in California. Johnson and Suits (1983) used 12 dummy variables (for months) in a linear regression model of National Park visits to capture the seasonality. Stynes and Pigozzi (1983) applied harmonic analysis to identify seasonal patterns of service employment in northern Michigan. They found that seasonality of service employment varies across northern Michigan. Stynes and Chen (1985) found that a harmonic model could explain most of the variation in Michigan monthly lodging tax data.

Spatial Variations in Tourism Activity

There is some evidence that tourism activity in different regions of Michigan may vary significantly in trend, seasonality or both. Northwest Michigan led the other regions of the state by its approximately 40 percent increase in tourism-related employment over the period of 1974-1979, followed by northeast Michigan (31%), southern Michigan (24%), and the upper peninsula (19%) (MESC, 1980). Stynes and Pigozzi (1983) found that there existed both temporal and spatial differences in service employment in northern Michigan.

It is believed that differences in the economic structure, location, seasonality and tourism facilities and resource endowment all contribute to variations in tourism activity between regions. If regional differences in tourism activity are significant, direct applications of statewide tourism forecasts may not be suitable for local and regional tourism planning and policy-making. However, tourism forecasts are particularly lacking at the local and regional levels. Thus, spatial variations in tourism activity in a state have to be carefully analyzed to better monitor and forecast tourism activity at the state, regional and county levels.

Comparison of Forecasting Models

Different types of forecasting models are appropriate in different situations. Van Doorn (1984) applied seven forecasting techniques to forecast tourist arrivals in the Netherland in 1980 and 1981. Evaluated in terms of three criteria --- simplicity, accuracy, and costs, the classical decomposition model was most acceptable to the policy-makers, followed by harmonic, generalized adaptive filtering and Box-Jenkins models. Three models estimated by multivariate regression, exponential smoothing and Census II methods respectively performed poorly for forecasting.

Combined model forms are recommended by many researchers to utilize more information of the data series and hopefully to improve accuracy in forecasting (Makridakis, Wheelwright and McGee, 1983). Combined models did outperform other types of models in several studies. Fritz et al (1984) developed a combined model for air arrivals to Florida from domestic points of departure which combined forecasts from both econometric and Box-Jenkins models using a weighting scheme. They also compared the forecast accuracy of moving average, econometric, Box-Jenkins, and combined econometric-Box-Jenkins models. The combined model performed best, followed by moving average, econometric and Box-Jenkins models.

Wander and Van Erden (1980) estimated a Box-Jenkins transfer function model to project monthly tourism demand for Puerto Rico from the United States. A regression model was developed using the Insured Unemployment Rate (IUR) in New York as the only explanatory variable. A Box-Jenkins model was then estimated on the residuals of the regression model. Then these two models were combined to predict the future values of the variable being forecasted. Compared with the univariate model in terms of forecasting accuracy, the transfer model performed better for the first six months but slightly worse for the entire 12 month period. Weller and Kurre (1987) estimated a series of Box-Jenkins transfer function models for monthly employment in Erie SMSA, Ohio. They used the Composite Index of Leading Indicators or the national employment as the explanatory variable. Transfer function models outperformed both naive and univariate Box-Jenkins models in both fitting the data and predicting future data values. They argue that transfer function modeling techniques can be applied in a small region and result in relatively accurate forecasts.

A structural model (Holecek et al, 1983) and a model combining linear regression and harmonics (Stynes and Chen, 1985) were estimated from Michigan lodging tax data. The combined model outperformed the structural model in terms of accuracy in fitting the existing data.

APPLICATIONS TO MICHIGAN TOURISM

Four studies have specifically addressed one or more of the principal problems being studied here: (1) identifying and quantifying trend and seasonal patterns of tourism activity in Michigan, (2) investigating spatial and temporal variation in tourism activity in Michigan, and (3) developing forecasting models for tourism activity in Michigan. As these four studies provide a foundation for the present study, they will be discussed in more detail.

1. Michigan Tourism Related Employment Study

The Michigan Employment Security Commission assembled monthly employment data for 9 tourism-related sectors from 1974 to 1979 to create a tourism-related employment data base (MESC, 1980). This data series was developed as an indicator of the level of tourism activity in Michigan. The nine industries chosen to represent the tourism-related employment include (1) service related to water transportation (SIC 446), (2) gasoline service stations (SIC 554), (3) boat dealers (SIC 555), (4) recreational and utility trailer dealers (SIC 556), (5) eating and drinking places (SIC 581), (6) hotels, motels and tourist courts (SIC 701), (7) rooming and boarding houses (SIC 702), (8) camps and trailer parks (SIC 703), and (9) amusement and recreational services (SIC 799). These nine sectors are considered to have strong ties to tourism and recreational activity and to be primary direct recipients of tourist dollars (MESC, 1980). The data do include jobs serving both local residents and tourists, since there is no specific industry or industry group which exclusively relates to tourism activity.

The tourism-related employment series was decomposed into trend, cycle, and seasonal components at the state and regional levels. These three components were graphically reported, but no further analysis was performed to investigate the effect of these components on tourism-related employment patterns. Simple regression modeling did identify variables related to tourism. Tourism-related employment was negatively correlated to the statewide unemployment rate, and had a positive correlation to gasoline sales, wages and salary employment, Mackinac Bridge crossings, and employment in the automobile industry (MESC, 1980, pp. 34-36).

2. A Study of Tourism Related Seasonal Employment in Northern Michigan

Stynes and Pigozzi (1983) applied harmonic analysis to identify both the temporal and spatial variations in service employment in northern Michigan from January 1969 through December 1978. Northern Michigan was chosen because of its less diversified economic system and more prevailing seasonal patterns. The service employment pattern of each of forty-four labor market areas defined by the Michigan Employment Security Commission was investigated.

The authors reported spatial differences in the timing and magnitude of seasonal service employment in northern Michigan. The highest seasonal fluctuation of service employment within the year was found in the St. Ignace labor market area (LMA) and the lowest fluctuation was found in the Marquette LMA. Service employment in the St. Ignace LMA peaks first (July 19) and more than a week before any other study area, and the latest peaks occur in the Alpena and Cadillac areas. The study also suggested that regions (or areas) could be differentiated based upon seasonal patterns of service employment.

3. Developing A Travel Activity Monitoring System for Michigan

Holecek et al. (1983) estimated a multivariate linear regression model for monitoring and tracking Michigan's lodging-industry activity. The model was used to provide interim estimates of lodging activity 2-3 months ahead of when they are reported. The model (t statistics in parentheses) is

$$Y(t) = \underset{}{826.5} + \underset{(.804)}{.288\ X_1} + \underset{(1.967)}{.478\ X_2} + \underset{(.112)}{.004\ X_3} + \underset{(1.781)}{1.115\ X_4} + \underset{(.096)}{.012\ X_5}, \qquad (2.14)$$

where all variables are expressed in thousands and defined as:

$Y(t)$ = Statewide lodging room use plus sales tax collections in period t adjusted for inflation (1979 dollars).
X_1 = Mackinac bridge crossings
X_2 = Aggregate statewide highway traffic count
X_3 = Michigan State Park day use
X_4 = Visitor counts at Michigan Travel Information Centers
X_5 = Michigan State Park camping parties
t = a count for the month, t=0 is Jan. 1979, t=1 is Feb. 1979, through t=59 is Dec. 1983.

The model explains 78 percent of variation in statewide lodging tax revenues. Highway traffic counts explain 74 percent of the variation and is the only variable statistically significant at the 5% level. These five variables show highly seasonal fluctuations in the same direction, yielding high multi-collinearity. This makes the interpretation of the effect of individual explanatory variables on the dependent variable difficult.

The model systematically over- or under-predicted monthly statewide lodging tax revenues for particular months. The authors corrected for this with monthly "adjustment factors". Since residuals of predictions are not consistent across the period of 1979-1982 and the monthly adjustment factors are computed by averaging the corresponding monthly residuals for the past four years (1979 to 1982), it is suspected that these adjustment factors will change over time and be unpredictable. This may make the final predictions of the model inaccurate.

4. A Comparison of Time Series and Structural Model for Monitoring and Forecasting Tourism Activity

Stynes and Chen (1985) extended the analysis of the Michigan tax data using time series methods. Their models, estimated from the same data, contains with trend and seasonal components.

The model is

$$Y(t)= 1,283-14.8\ t+231.5\ t^2+268.4\ SIN(30t+254) +87.3\ SIN(60t+34), \qquad (2.15)$$

where Y(t) is the lodging tax revenues in time t. The first three terms of the right hand side of the equation represent the trend and the two sine terms are the seasonal part of the model.

Twelve monthly averages of the data series were first computed by averaging values of the corresponding months across the years to eliminate the trend and cyclical components and isolate the seasonal component of the data series. Harmonic analysis was then applied to the 12 monthly averages of the data series to capture seasonal variations in lodging tax revenues. Since a plot of the data series showed a quadratic trend , a linear regression model with time factors (i.e. t and t^2) was estimated using ordinary least squares techniques on the actual data series. The harmonic model was combined with the trend model to predict monthly lodging tax receipts.

The trend model predicted the short term trend in the data, while the harmonics captured the basic seasonal patterns. Also, the relative contributions of the individual components of the model to explaining variation in the data series were identified. The combined model explained 87.5 percent of the variation in lodging activity in Michigan. The trend and harmonic components explain 8.3 and 79.2 percent respectively.

Both the structural and combined models were developed at the state level since local and regional lodging tax revenues data were not readily available. Statewide forecasts of lodging activity may not be suitable to be applied to any particular regions of the state. Also, lodging is only one of many sectors of the tourism industry. The patterns of lodging activity may not be consistent with that of overall tourism activity.

SUMMARY

My review of the literature emphasized prevailing quantitative forecasting techniques and their applications in tourism. Three general conclusions, which will guide the present study, are drawn from the literature.

1. Systematic analysis of trend and seasonal patterns of tourism time series along with analysis of factors influencing the behavior of these two patterns are useful in monitoring, tracking, and forecasting tourism activity.

2. Decomposition methods, multivariate regression methods, time series techniques, and combined structural-time-series methods are the most commonly used forecasting techniques. Decomposition methods separate a time series into its trend and seasonal components according to an additive or multiplicative relationship (Raveh, 1985).

Linear regression methods can be used to estimate trends in a series. Income, population size, retail price of gasoline, and (un)employment, are frequently used as structural variables to estimate trends in tourism activity. In time-series studies regression models often encounter problems of serial correlation which may make the estimated regression unreliable and impair subsequent forecasts. To correct for serial correlation, transfer function modeling techniques can be used. Wander and Erden (1980) and Weller and Kurre (1987) claim that transfer function models can produce better forecasts than would be possible through the use of either strcutural regression or Box-Jenkins techniques alone.

Time series methods like harmonic analysis and Box-Jenkins techniques, are best suited for short-term forecasting. Certain time series methods are better suited than others for handling seasonal series. Harmonic models can capture annual, semi-annual, quarterly and other patterns of variation in monthly time series, and are relatively easy to understand and manipulate.

Box-Jenkins models are particularly useful to forecast when the explanatory variables are not quantifiable or their existing and future values are not available. Box-Jenkins models are estimated using information of the past movements of the variable to be predicted and can be easily updated to produce the needed forecasts. In their practical applications to tourism Box-Jenkins models were not as popular as harmonic models and decomposition methods to tourism policy-makers because of their costs and complexity (Van Doorn, 1984). Stynes and Chen (1985) found that a Box-Jenkins model did not perform as well as a combined linear regression-harmonic model for Michigan lodging activity.

Many researchers recommend some kind of the combined modeling approaches for forecasting. Stynes and Chen (1985) concluded that models combining both time series and structural techniques can capture both the trend and seasonal fluctuations of the series, and may outperform each of time-series and structural models when used alone.

There is considerable evidence of significant temporal and spatial variation in tourism activity in Michigan (MESC, 1980; Stynes and Pigozzi, 1983), although tourism patterns across Michigan have not been examined in a comprehensive and systematic manner. Spatial variations in tourism activity may be due to the differences in the economic structure and/or the extent of tourism-dependency, seasonality, or the type of prevailing tourism activity (e.g. winter or summer tourism activity or both of them) between individual areas or regions in Michigan. Such differences can be used to differentiate regions (or areas) and should be accommodated in the development of statewide tourism plans.

CHAPTER III

METHODS

This chapter presents the research methods employed to achieve the study objectives. The chapter first discusses the choice of a tourism-related data series. Then, methods for forming distinct tourism regions in Michigan are introduced, and a general approach to analyzing and modeling tourism activity is presented and discussed. The general approach is divided into six phases: (1) assemble data series, (2) choose an appropriate decomposition method, (3) decompose the time series and identify its trend and seasonal patterns, (4) model the trend and seasonal components, (5) estimate a forecasting model and develop forecasts, and (6) evaluate the forecasting model.

The statewide and regional analyses will be carried out individually by following these six steps. This will achieve the first four study objectives. To achieve the fifth study objective, we will test for differences in the trends, seasonality, or both between the state of Michigan and eight individual sub-regions. Specific methods employed to accomplish each phase of the research will be introduced in order of this design.

DATA SELECTION

Several tourism-related series were preliminarily examined for their consistency and availability at the state, regional and/or county level(s). Michigan State Park day use, Michigan State Park camping parties, and Michigan lodging room use and sales taxes are collected by month and reported at the state level. These data series are not available at a regional or county level on a regular basis at the present time.

Monthly tourism-related employment data are available at both the state and county levels for the period 1974-1984, i.e. another 5 years beyond a study conducted by MESC in 1980. This data base includes nine tourism-related sectors encompassing lodging, resturants, gasoline service, water transportation, recreational equipment dealers, camps and trailer parks, and amusement and recreational services. Although seasonal patterns of tourism-related employment are not as pronounced as that of tourism activity (as indicated by State Park day use and camping and lodging use,for example), they are significant enough to reflect levels of tourism activity in individual areas of Michigan by season. Also, with 11 years of data the trend of tourism-related employment across Michigan can be identified. Therefore, the tourism-related employment series will be used in the present study.

The employment series includes jobs in the private sectors covered under unemployment compensation provision of the Michigan Employment Security Act. State and local government employees, services performed by students, certain services performed for non-profit organizations, and family employment are excluded from the employment series (MESC's Employers' Handbook, 1984). Also, problems in defining a job make it difficult to accurately estimate the number of jobs in an industry with many seasonal and part-time jobs (Muller, 1977). A full-time job is not distinguished from a part-time job, each of them is counted as one job. If one person has two jobs, he or she is counted twice in the employment series. Also, tourism-related employees serve not only tourists but also business travelers and local residents. The tourism component of the tourism-related employment series is not clearly identified and isolated from the local component. Thus, the figure of tourism-related employment should not be interpreted as the number of full-time jobs or the number of jobs created solely because of tourism activity.

STATEWIDE AND REGIONAL ANALYSES

The study objectives call for statewide and regional analysis of tourism activity. Trend and seasonal patterns of statewide and regional tourism activity will be identified and quantified (the first objective). These two patterns will be compared across regions of Michigan (objective two) to test for spatial differences.

Alternative statewide forecasting models will be developed and evaluated to achieve the third study objective. It is hypothesized that both trend and seasonal patterns of tourism activity vary among sub-regions of Michigan. To test for such spatial variations, regional forecasting models are developed and evaluated. Regional models are compared with each other and with the statewide model to identify structural differences and assess the forecast accuracy at different level of spatial aggregation (the fourth study objective). The chapter concludes with a test of the generalizability of the statewide forecasting model to the regional level (objective 5).

FORMULATION OF THE STUDY REGIONS

To examine the spatial and temporal variations of tourism activity in Michigan, distinct study regions were required. The aggregate modeling will use the state of Michigan as a whole. In addition, models will be estimated for eight sub-regions of the state. The eight study regions are (1) Wayne and Oakland counties, (2) other southern urban counties, (3) rural southern counties, (4) northwest Michigan, (5) northeast Michigan, (6) Mackinac Straits region, (7) the eastern upper peninsula, and (8) the western upper peninsula. These eight regions, when combined, yield the state as a whole (see Figure 1).

To form the study regions, harmonic analysis was applied to each of 83 county tourism-related employment series. This yielded measures of the magnitude and seasonal fluctuations of the series for each county. Sub-regions of the state were formed by grouping counties with similar magnitude and seasonal patterns of tourism-related employment (annual average, relative amplitudes of 1st and 2nd harmonics) while maintaining where possible geographically contiguous regions.

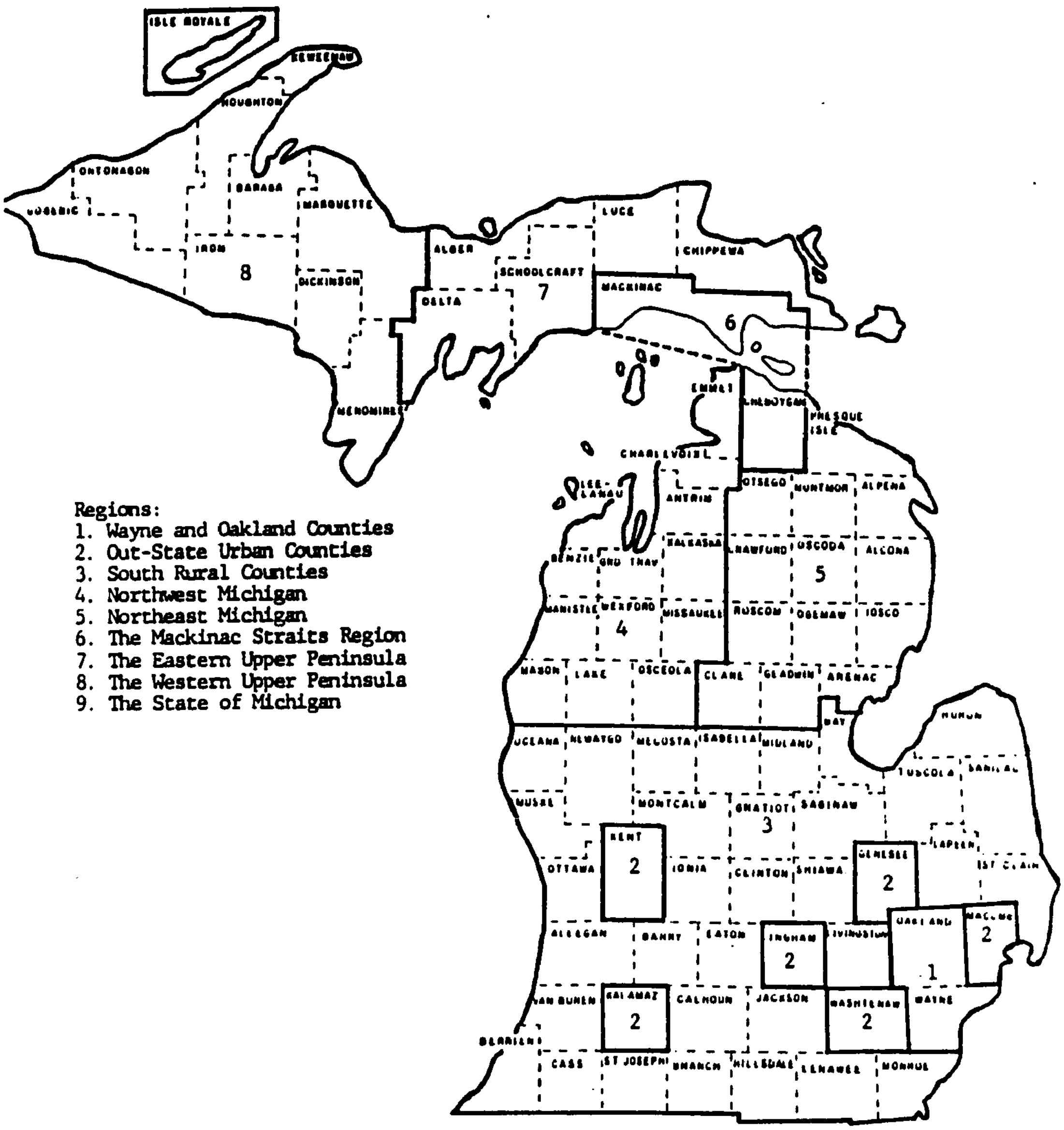

Figure 1: Study Regions of Tourism-Related Employment in Michigan.

ANALYSIS AND FORECAST APPROACH

The first four study objectives require the estimation of models for tourism activity in Michigan. The same analysis and forecast procedure will be applied to the state and each sub-region.

From the review of previous tourism studies it is concluded that trend and seasonal patterns of Michigan's tourism activity and factors affecting these two patterns should be identified, modeled and forecasted at both the state and regional levels. Combined structural-time-series forecasting methods have been selected because of their ability to capture both trend and seasonal fluctuations of a time series. Also, combined models have generally outperformed alternative models in fitting existing data and in their forecast accuracy (Wander and Erden, 1980).

Decomposition methods (BarOn, 1972, 1975, 1979; Weller and Kurre, 1987) are used to separate the trend and seasonal components of the series. Transfer function modeling techniques are then applied to the trend components. A seasonal model is estimated from the seasonal component using harmonic analysis. The trend and seasonal models are then re-combined to yield the final forecasting model.

The general approach is divided into six steps (Figure 2):

1. Assemble data series for the region. We will be dealing with 9 time series, one for the state of Michigan as a whole and employment series for eight sub-regions of the state.
2. Choose an appropriate decomposition model. We will choose from either an additive or multiplicative model.
3. Decompose the time series employing a simplified version of Census II method and then identify its trend and seasonal patterns.
4. Model trend and seasonal components and generate their forecasts.
5. Combine the seasonal and trend models to form a structural-time-series forecasting model. Produce 1-12 months ahead forecasts of the time series for the region.
6. Evaluate the combined model based upon goodness-of-fit to the data and forecast accuracy.

The first three steps analyze the trend and seasonal patterns of a data series. The next three steps develop and evaluate a forecasting model for a data series. Decomposition methods and techniques for describing the trend and seasonal patterns will be presented first, followed by procedures for estimating and evaluating the forecasting models.

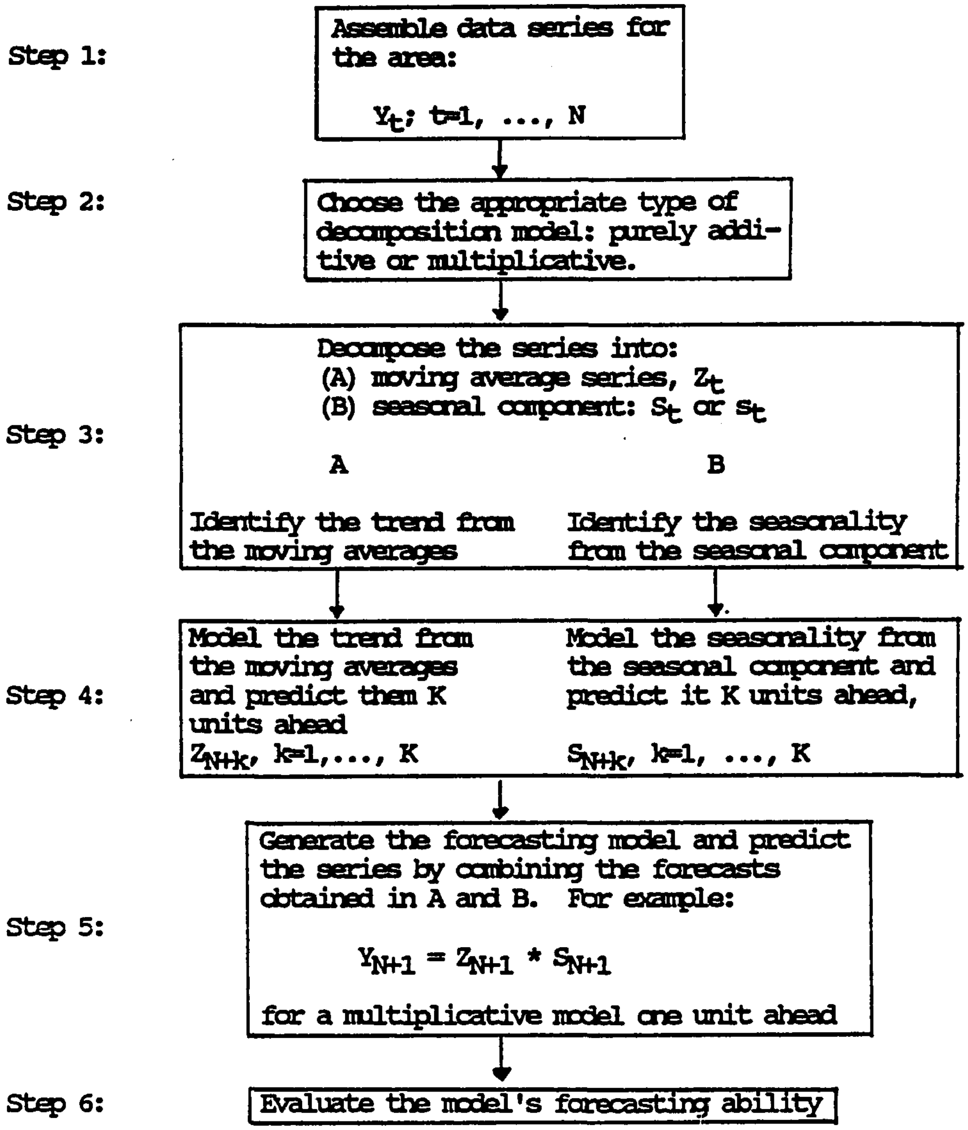

Figure 2: A flowchart of Analysis and Forecast Procedure.

Identification of Trend and Seasonal Components

Trend and seasonal patterns of tourism-related employment are identified using a decomposition procedure, either multiplicative or additive. Multiplicative and additive decomposition methods will be introduced first, followed by methods to choose one of these two decompositions for all data series to be encountered.

Decomposition Methods

After the data series for a particular region are assembled, an appropriate decomposition method, either multiplicative or additive, will be selected to decompose the data series into trend and seasonal components. The multiplicative model is $Y_t = T_t*S_t*E_t$, and the additive decomposition model is $Y_t = T_t+s_t+e_t$. T_t is the trend, S_t and s_t are the respective seasonal components, and E_t and e_t are the respective error or random components.

The first step in both decomposition methods is to calculate a series of moving averages, which will include both trend and cycle. A simplified version of the Census II method using a 12-period moving average is used to separate the trend and cycle components from the seasonal component of the time series. In the rest of this study, the trend component will represent both trend and cycle components together.

The following is a brief description of the 12-month centered moving average method (Hall and Hall, 1980). Assume the series to be adjusted is Y, which has N observations and a periodicity of 12, i.e. a monthly series with an annual seasonal period. The trend component can be derived by calculating the moving averages of Y, T(t):

$$T(t) = (1/12)*\{(1/2)[Y(t-6)+Y(t+6)] + Y(t-5)+ Y(t-4)+...+Y(t+5)\} \quad (3.1)$$

The equation describes a moving average over 12 observations centered at each observation. To calculate the multiplicative seasonal factors, S_t, the ratio, R(t), of the data series to its moving averages is first calculated:

$$R(t) = Y(t)/T(t) \quad (3.2)$$

This ratio contains the combined seasonal and error components. Then the vector R(t) may be rewritten as a matrix F(i,j) where each row i corresponds to a year and each column j to a month [i.e. t=j+12*(i-1)]. F contains N-12 elements (omitting 6 observations at the beginning and end of the series).

The multiplicative seasonal factors are calculated by averaging each column in F to eliminate random disturbances:

$$S(j) = (1/N) * \sum_{i=1}^{N} F(i,j), \text{ where } \quad i=1,...,N \text{ years} \quad j=1,...,12. \quad (3.3)$$

In the purely multiplicative model, the seasonality series is the series consisting of the 12 seasonal factors, S(j), repeated across the years. These 12 seasonal factors add up to 12.

There are two steps to compute the additive seasonal component, denoted s_t. First, we subtract the moving averages from the actual data series, that is

$$Z(t) = Y(t) - T(t) \qquad (3.4)$$

Then, compute the averages for each month across the i years of data to eliminate the random error component, that is

$$s(j) = (1/N) * \sum_{i=1}^{N} Z(i,j), \text{ where } \quad i=1, \ldots, N \text{ years}, \quad j=1, \ldots, 12. \qquad (3.5)$$

$Z_{i,j}$ is a matrix (like F(i,j) above) rewritten from Z(t) with each row i corresponding to a year and each column j to a month [i.e. t = j+12*(i-1)]. Whichever model is used, the decomposition produces two series, a trend and a seasonality series.

Choice of Additive versus Multiplicative Decomposition Method

A choice must be made between the multiplicative and additive decompositions. Although the purely additive form is rare in empirical data series and not recommended by many researchers (Wheelwright and Makridakis, 1985), it could not be ruled out based on a visual inspection of the series.

To examine which decomposition model best fits the Michigan tourism-related employment series a preliminary test was performed. The data series for each of three selected regions were used in the test: (1) the state of Michigan, (2) northwest Michigan and (3) the Mackinac Straits region. These regions were selected to represent a range of differences in the 9 series to be modeled from visual inspections of the series. The state series represents patterns typical of a region without dominant seasonality, while the northwest Michigan and Mackinac Straits regions are more typical of tourism-dependent regions with strong seasonality.

Both additive and multiplicative decompositions were calculated for each of these three regions using the period from January 1974 to December 1984. Three goodness-of-fit measures for the two models were calculated. These are introduced and discussed more fully in the section on evaluation of forecasting models later in this chapter.

The multiplicative decomposition was selected as it outperformed the additive form in the two tourism-oriented regions and is much more common in empirical studies (BarOn, 1972,1975,1979; Weller and Kurre, 1987). The two decompositions fit the statewide series about equally (Table 1).

Table 1: Evaluation of Decomposition Models by Region.

Region	Type of model	Mean Absolute Error (MAE)	Mean Absolute Percentage Error (MAPE)	Eta-Square (%)
Michigan	Mult.	1,469	0.64	99.13
	Add.	1,441	0.63	99.19
Northwest	Mult.	145	1.66	98.27
	Add.	166	1.92	97.77
Straits	Mult.	61	4.22	99.27
	Add.	100	9.15	98.31

Note:
Multi.: Multiplicative decomposition model.
Add.: Additive decomposition model.

Model Estimation

In the fourth step of the approach, the trend and seasonal models for individual regions will be estimated. Model estimation is divided into two parts: (1) estimating a seasonal model and (2) estimating a trend model. Transfer function techniques will be employed to estimate three alternative trend models. They incorporate time factors, economic driver variables, or both groups, as explanatory variables.

BarOn (1979) has argued that short-term tourism trends are difficult to forecast using econometric methods, since there are so many changes external and/or internal to the environment of a tourist destination. Seasonal patterns, on the other hand, are relatively stable over time and much easier to predict. A simple harmonic analysis procedure will be used to estimate this component.

Seasonal Model

Seasonal variations in tourism-related employment will be identified and quantified into a seasonal model using harmonic analysis. Harmonic analysis is briefly explained in pp 19-21. The harmonic model is estimated from the seasonality series, i.e. 12 seasonal factors. The harmonic model generates the seasonal component of the tourism-related employment series. With 12 points, six harmonics may be produced.

The seasonal equation with all six harmonics is:

$$\hat{S}_t = B_0 + B_1 \sin(30t + \phi_1) + B_2 \sin(60t + \phi_2) + \ldots + B_6 \sin(180t + \phi_6) \qquad (3.6)$$

where

$\hat{S}_t$: estimated seasonal component of tourism-related employment in time t,
B_i: amplitude of the i_{th} harmonic, and
ϕ_i: phase angle (in degrees) of the i_{th} harmonic, i=1, ..., 6.

To allow for random error and ease of interpretation, we will primarily look at the first (annual) and second (semiannual) harmonics. Other harmonics will be included if necessary to achieve an overall explanation of 98% of the seasonal variation.

Trend Model

Procedures for estimating trend models for the individual regions can be divided into three steps: (1) estimating alternative linear regression models, (2) checking auto-correlation of each model, and (3) adding transfer components.

Estimating Linear Regression Models

Three alternative linear regression models will be tested and evaluated for each study region: (1) a time-series regression model, (2) a structural regression model, and (3) a structural-time-series regression model. These three linear regression models are tested to see which type of independent variable (time series, structural or both) can best capture the trends of the series under certain conditions. These three models will be discussed in turn.

(1) The hypothesized time-series regression model is:

$$\hat{T}_t = A_0 + A_1\ t + A_2\ t^2 + A_3\ t^3 \qquad (3.7)$$

where

$\hat{T}_t$: estimated trend component of tourism-related employment in period t,
A_i: parameters of the equation, and
t: 0=January, 1974, 1 February, 1974, ..., 131=December, 1984.

This time-series regression model uses three time factors (i.e. t, t^2, and t^3) to fit the trend component of tourism-related employment series encountered. Time (t) is used to capture the changing patterns of tourism and recreation activity and tastes and preferences of tourists. t^2 and t^3 are chosen because a plot of the statewide tourism-related employment data series (Figure 3) suggests a non-linear (quadratic or cubic) function.

(2) The hypothesized structural regression model is:

$$\hat{T}_t = A_0 + A_1\ MAUNEMP_t + A_2\ POP_t + A_3\ MAGAS_t + A_4\ MAINC_t \qquad (3.8)$$

where

$MAUNEMP_t$: seasonally adjusted statewide unemployment rate in period t,
POP_t: population size in period t (in 100,000 of persons),
$MAGAS_t$: seasonally adjusted U. S. gasoline retail price index in period t,
$MAINC_t$: seasonally adjusted statewide personal income in period t (in billion of dollars),
A_i: parameters of the equation.

The rationale for using structural variables to capture the variations of the trends of tourism-related employment in

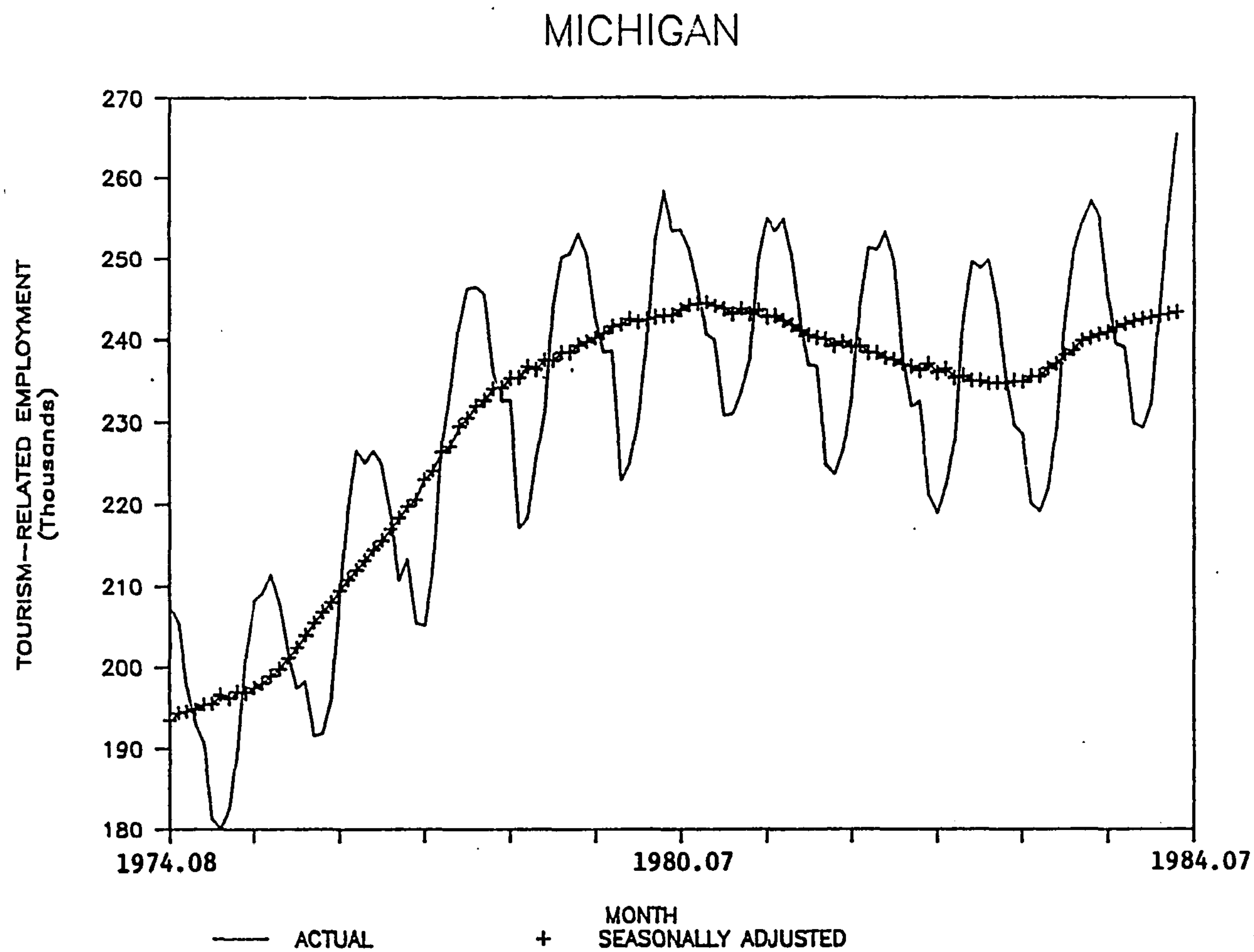

Figure 3: Statewide Tourism-Related Employment in Michigan, 1974-84.

Michigan is provided here. It is hypothesized that same economic phenomena in Michigan (such as the 1975 recession, the subsequent recovery and periods of gasoline shortage) are reflected in not only tourism related employment but also other economic measures, e.g. unemployment, population size, retail price of gasoline and personal income, etc. The assumption made here is that the other economic variables can be used as the explanatory variables to estimate a forecasting model for tourism-related employment. The relationship between these individual explanatory variables and the volume of tourism activity is supported by studies reviewed in the previous chapter (MESC 1980; Diamond 1977; Johnson and Suits 1983; and Loeb 1982).

The four independent variables are summarized in Table 2. The monthly statewide unemployment rate in Michigan had a negative linear correlation with the monthly level of tourism-related employment (R = -0.49) for the period 1974-1979 (MESC 1980). In 1979, jobs in tourism-related sectors accounted for 7.0 percent of total employment in Michigan (MESC, 1980). It is reasonable to hypothesize that the higher the statewide unemployment the lower the tourism-related employment. Monthly statewide unemployment data are available from a monthly federal publication (Employment and Earnings, U.S. Bureau of Labor Statistics). Quarterly predictions of statewide employment are produced by University of Michigan's econometric forecasting model (Shapiro and Fulton, 1985).

The size of population of a tourist-generating area has a positive relationship to the levels of tourism activity in a tourist-destination area , which in turn impacts tourism-related

Table 2: Independent Variables of the trend model.

Variable	Time period	Level	Source
Unemployment Rate	Monthly	State	Employment and Earnings, U.S. Bureau of Labor Statistics.
Population	Annual	County	Current Population Reports, U.S. Bureau of the Census.
Personal Income	Quarterly	State	Michigan Statistical Abstract.
Retail Gasoline Price Index	Monthly	U. S.	Monthly Labor Review, U.S. Bureau of Labor Statistics.

* Variables available on an annual or quarterly basis were estimated on a monthly basis by simple linear interpolation between the quarterly or annual figures.
* Except population, all other variables are seasonally adjusted using the 12-month centered moving average technique.

employment levels in that area (Diamond, 1977). Population size may capture the share of tourism-related employment serving locals or visiting friends and relatives. The larger the population size of the area, the higher the expected level of tourism-related employment. Population size data are available annually from the Current Population Reports, U.S. Department of Commerce, Bureau of the Census. Monthly estimates are obtained by linear interpolation. This data series cannot account for seasonal fluctuations in population which could be a factor in some areas.

The retail price of gasoline is an indicator of travel costs. Changes in the retail price of gasoline are expected to influence frequencies of travel and length of stay (Johnson and Suits, 1981). It is hypothesized that the higher the retail price of gasoline, the lower the volume of tourism activity and in turn tourism-related employment in Michigan. The monthly retail gasoline price index for all urban consumers is published in the Monthly Labor Review by the U. S. Bureau of Labor Statistics.

Personal income has been consistently found to be an influential determinant of tourism demand. Sauran (1978) reported that in some studies the income elasticities of tourism activity are greater than unity. It is hypothesized that the higher the personal income the higher the volume of tourism activity and in turn the level of tourism-related employment. Past values of personal income by quarter are available from the Michigan Statistical Abstract, and the predicted quarterly values are provided by the University of Michigan (Shapiro and Fulton, 1985). Monthly estimates are obtained by linear interpolation.

Each of the variables except population size are seasonally adjusted using the 12-month centered moving average technique. It should be noted that the population size variable is the only independent variable that changes across regions. The other independent variables are measured at the national or state level and dot not vary between regions. Although these independent variables are not perfect proxies of regional variables, they will be used in the model because local or regional tourism activities are not independent of national and/or statewide economic phenomena.

(3) The hypothesized structural-time-series regression model is:

$$\hat{T}_t = A_0 + A_1\ MAUNEMP_t + A_2\ POP_t + A_3\ MAGAS_t + A_4\ MAINC_t + A_5\ t + A_6\ t^2 + A_7\ t^3 \quad (3.9)$$

where all components are defined as earlier. In this model, three time factors and four independent variables are included to see whether or not combining these two types of variables can improve the model's performance. These two groups of variables may be complementary or substitute for each other.

<u>Checking Autocorrelation of the Regression Models</u>

Autocorrelation of a regression model will be identified by examining the value of the Durbin-Watson statistic (DW). If DW is not close to 2.00, there exist problems in positive or negative autocorrelation, which may adversely affect the model's forecast accuracy (Pindyck and Rubinfeld, 1981). From some preliminary analyses, auto-correlation problems are anticipated.

Transfer function techniques can correct for this problem.

Estimating Transfer Function Models

Three transfer function models will be estimated:

(1) the hypothesized time-series-ARMA(p,q) transfer function model:

$$\hat{T}_t = A_0 + A_1\ t + A_2\ t^2 + A_3\ t^3 + \phi^{-1}(B)\theta(B)\eta_t \qquad (3.10)$$

(2) the hypothesized structural-ARMA(p,q) transfer function model:

$$\hat{T}_t = A_0 + A_1\ MAUNEMP_t + A_2\ POP_t + A_3\ MAGAS_t + A_4\ MAINC_t + \phi^{-1}(B)\theta(B)\eta_t, \text{ and} \qquad (3.11)$$

(3) The hypothesized structural-time-series-ARMA(p,q) transfer function model:

$$\hat{T}_t = A_0 + A_1\ MAUNEMP_t + A_2\ POP_t + A_3\ MAGAS_t + A_4\ MAINC_t + A_5\ t + A_6\ t^2 + A_7\ t^3 + \phi^{-1}(B)\theta(B)\eta_t \qquad (3.12)$$

where n_t are error terms assumed to be independent and normally distributed with a constant variance, $N(0,\sigma^2)$, and $\phi(B)$ and $\theta(B)$ are defined as in Equation (2.10). All other components of these transfer function models are as defined earlier.

To add transfer components to a regression equation, the unconditional residuals (E_t) will be computed first; that is:

$$E_t = T_t - \hat{T}_t \quad (3.11)$$

where T_t and $\hat{T}_t$ are the actual and estimated trend values respectively.

Then, we apply Box-Jenkins procedures to the residual series to identify the order (p,d,q) of the autoregressive-integrated-moving-average error process (i.e. ARIMA(p,d,q) model) for the E_t series. Since the values of the trend series are seasonally adjusted, this residual series is usually stationary and can be modeled as low order ARMA process, i.e. as a process with $p<2$ and $q<2$ (Pindyck and Rubinfeld, 1981). An autoregressive-moving-average error model of order (p,q), ARMA(p,q), is:

$$E_t = \phi_1 E_{t-1} + \ldots + \phi_{t-p} E_{t-p} + V_t + \ldots + \theta V_{t-q} \quad (3.12)$$

V_t are the forecast errors of the unconditional residuals. This is the error we make if we compute a forecast of the unconditional errors, E_t, by applying only the autoregressive part of the ARMA(p,q) model. There are two different kinds of residuals associated with the transfer function model, i.e. E_t and V_t. E_{t-p} are values of E_t lagged p periods and V_{t-q} are values of V_t lagged q periods. ϕ_p and θ_q are coefficients of E_t and V_t respectively.

The primary tools for selecting the probable ARMA(p,q) model for E_t are the total autocorrelation and partial autocorrelation functions. The autocorrelation function (ACF) is a measure of how much correlation there is between neighboring data points in a series. The partial autocorrelation function (PACF) is a measure of how much correlation there is between the current observation and the N_{th} lagged observation after netting out the effects of any other observations. For a detailed introduction of ACF and PACF see Box and Jenkins (1970).

In this identification stage we compare the shapes of the sample ACF and sample PACF with the theoretical ACF and PACF of various members of the ARMA class. Generally, spikes in the ACF indicate moving average terms, and the PACF can be used to infer the order of the autoregressive process. For example, if the PACF has significant spikes at lags 1 and 2, a second-order autoregressive model would be used. For a detailed theoretical rationale for this identification procedures refer to Box and Jenkins (1970).

Finally, we estimate the transfer function model. After alternative ARMA(p,q) models for each trend model are identified, alternative transfer function models can be estimated. The estimation procedure used here is a variant of a generalized least squares algorithm whose objective is to find the parameter estimates in a most efficient manner. All parameters of the model are estimated simultaneously. The procedure incorporates the estimate of the ARMA(p,q) model for the unconditional residual from the past observation into the regression model to predict the current observation. A more complete discussion of this estimation algorithm can be found in Cochrane and Orcutt (1949, pp. 32-61).

Transfer function models will be estimated with data for the dependent and independent variables from July 1974 to June 1983. After three transfer function models are estimated, they will be compared with each other in terms of model structures, ability to fit the observed data and forecast accuracy. Centered moving averages of tourism-related employment data between July 1974 and June 1983 will be used to evaluate the goodness-of-fit of the estimated trend models. Cases from July 1983 to June 1984 will be used to evaluate the forecasting performance of the alternative trend models. This completes the discussion of methods for estimating trend and seasonal components. Forecasting models are completed by recombining the trend and seasonal parts (step 5 of Figure 1).

The Combined Forcasting Model

In the fifth step the selected trend model and the estimated seasonal model are combined together to generate a forecasting model for each study region. Forecasting models for individual study regions are used to predict tourism-related employment in future months. The proposed forecasting model for region i is (in the multiplicative form):

$$\hat{Y}_{i,t} = \hat{T}_{i,t} * \hat{S}_{i,t} \qquad (3.13)$$

where $\hat{Y}_{i,t}$ is estimated monthly tourism-related employment in region i in period t, $\hat{T}_{i,t}$ is the trend model for region i in period t, and $\hat{S}_{i,t}$ is the seasonal (harmonic) model for region i in period t.

Forecasting Procedure

After a forecasting model is estimated, the model will be used to predict the levels of tourism-related employment for the next 12 months from July 1983 to June 1984. The assumption made for forecasting is that the trend and seasonal patterns captured in the model remain constant over the forecasting period.

The forecasting procedure has three steps: (1) forecast the future trend values, (2) forecast the future seasonal factors, and (3) combine the trend and seasonal forecasts to generate the complete forecasts.

First, to predict the future trend values, actual moving averages of the independent variables from July 1983 to June 1984 will be entered into the model. It is assumed that the independent variables can be perfectly forecasted. This allows us to better identify the sources of forecast errors of the model, i.e. trend, seasonal or both components, because the forecast errors attributed to the errors in predicting the independent variables can be eliminated. During the forecasting period, the trend model will not be updated by reinserting the actual moving averages of the dependent variable into the computation process to produce forecasts. The predicted trend value of a month (e.g. July 1983) will be used to produce the trend forecast for the following month

(August 1983). The lead time for the individual trend forecasts is from 1 (for July 1983) to 12 (for June 1984).

Second, the future seasonal factors are simply generated from the seasonal model given the corrresponding time (t) values. It is assumed that these seasonal patterns captured by the seasonal model do not change during the forecasting period.

Finally, the corresponding monthly trend and seasonal forecasts are multiplied together to generate the complete monthly forecasts of tourism-related employment. Forecast accuracy of the model to predict for the next 12 months will be evaluated with the holdout cases from July 1983 to June 1984.

It should be noted that the actual values of the dependent variable from July 1983 to December 1983 are used in the trend model estimation, due to their presence in the 12-month centered moving average technique to calculate the moving averages.

Evaluation of the Forecasting Models

In the final step, the forecasting models will be evaluated and compared . Three criteria will be used to evaluate the performance of the forecasting models: (1) signs of the coefficients, (2) fit to the data, and (3) forecast accuracy. Signs of the coefficients of the model should be as hypothesized in the model specification stage. Fit to the data refers to how well the model can fit the data series from July 1974 to June 1983. Forecast accuracy refers to how well the model can predict cases that are not included in the model estimation procedure.

Statistics for measuring "goodness-of-fit" of a non-linear model are mean absolute error (MAE), mean absolute percentage error (MAPE), root mean square error (RMSE) and eta-square (eta^2). The smaller the MAE, MAPE and RMSE and the closer to one the eta^2 is, the better the model fits the data.

Formal definition of these statistics are presented after introducing some notation. Let a series of observations taken at equally-spaced time intervals (e.g. months) be denoted as Y_t, where t=1,2,...,N, and N is the total number of observations. Let $\bar{Y}$ denote the mean of the series Y_t. Let P_t denote the series of predicted values for the series Y_t.

Mean absolute error (MAE) is the average of difference between the predicted values and the actual data values, defined formally as:

$$MAE = \frac{\sum_{t=1}^{N} |Y_t - P_t|}{N} \tag{3.14}$$

MAE is selected instead of mean squared error (MSE) as it is easier to interpret and avoids giving undue influences to a few large errors.

Root mean square error (RMSE) is defined as:

$$RMSE = \sqrt{\frac{\sum_{t=1}^{N} (Y_t - P_t)^2}{N}} \tag{3.15}$$

It is the root squared of the average of squared differences between the predicted values and the actual data values.

Mean absolute percentage error (MAPE) is defined as:

$$MAPE = \frac{\sum_{t=1}^{N} |Y_t - P_t|/Y_t}{N} * 100.0 \qquad (3.16)$$

It measures errors in proportion to the observed values.

Eta-Square, eta^2, measures the amount of variance of the dependent variable explained by a non-linear model. Eta$_2$ is

$$Eta^2 = 1 - \frac{\sum_{t=1}^{N} (Y_t - P_t)^2}{\sum_{t=1}^{N} (Y - \bar{Y})^2} \qquad (3.17)$$

A measure of forecast accuracy is Theil's UII statistic. Theil (1966) proposed two forecast accuracy measures, UI and UII. The UII measure is prefered to the UI measure because it gives more meaningful information about the accuracy of forecasting models (Bliemel, 1973). Theil's UII statistic is defined as:

$$UII = \sqrt{\frac{\sum_{t=1}^{N} (Y_t - P_t)^2}{\sum_{t=1}^{N} (Y_t)^2}} \qquad (3.18)$$

If UII=0, the forecast is perfect. A forecast with UII=1 is only as accurate as a forecast of no change. If UII>1, the forecast is worse than one of no change.

Each of these five measures (i.e. MAE, RMSE, MAPE, eta^2 and UII) may be applied to measure goodness-of-fit or to assess the accuracy of forecasts. In the latter case, the formulas are applied to the holdout sample of cases. Different measures of forecast accuracy are used to capture different characteristics of the forecast errors (Makridakis, et al., 1983). Also, different readers may be interested in different forecast accuracy measures for some particular purposes.

The measures of MAE and MAPE are easy to interpret. Theil's Statistic-UII is frequently employed to measure forecast accuracy (Theil, 1966; Geurts and Ibrahim, 1975; Fujii and Mak, 1980; Guerts, 1982). The Theil's UII and RMSE measures penalize a forecast much more for extreme deviations than it does for small ones because of squaring errors. In contrast, both the MAE and MAPE measures treat all errors equally, or give the same weight to each error.

Comparison of the Forecasting Models

By applying thees forecasting procedure to individual study regions, regional models can be derived. All forecasting models will be compared in terms of the structures of trend and seasonal components, forecast accuracy, and sources of forecast errors. In the comparison of trend models, we examine independent variables entering the equation, the signs of the coefficients, the structure of the error model, and variance explained. In the comparison of seasonal models, we examine the magnitudes of harmonics and variance explained. Forecast accuracy of the forecasting models will be examined using MAE, MAPE, RMSE, eta^2 and Theil's UII statistic. Sources of forecast errors in each forecasting model will be identified by examining forecast accuracy of the trend and seasonal components separately.

GENERALIZABILITY OF THE STATEWIDE MODEL TO THE REGIONAL LEVEL

The fifth study objective is to test how well statewide models forecast at the regional level. It is suspected that the statewide model may not accurately predict future changes in tourism-related employment in each sub-region of Michigan. The differences between the predicted statewide and regional patterns may be due to differences in trend, seasonality, or both.

The proposed methods to test for such differences are to substitute the trend, seasonal, or both components, of the statewide model for the corresponding component(s) of a regional model to forecast tourism-related employment in that particular region. Four models for each sub-region of Michigan will be tested.

Let the statewide model be represented as

$$\hat{Y}_S = \hat{T}_S * \hat{S}_S \quad \text{and} \tag{3.19}$$

the model for region i as

$$\hat{Y}_i = \hat{T}_i * \hat{S}_i, \tag{3.20}$$

where $\hat{Y}_S$ and $\hat{Y}_R$ are the statewide and regional predicted values and $\hat{T}_S$, $\hat{S}_S$, $\hat{T}_i$ and $\hat{S}_i$ are the statewide and regional predicted trend and seasonal components for the state as a whole and region i, respectively.

To account for differences in the size of the trend component across regions the statewide and regional trend components have to be normalized first. Thus, changes in the respective regional trend index series can be compared between regions on the same basis since thay all start from 1.00 for July 1974. The seasonal component is already standardized as an index series, i.e. a seasonality series with 12 seasonal factors.

Define the predicted statewide index series for the trend as

$$\hat{T}'_S = \hat{T}_S/(T_S \text{ for July 1974}) \qquad (3.21)$$

and a predicted trend index for region i as

$$\hat{T}'_i = \hat{T}_i/(T_i \text{ for July 1974}), \qquad (3.22)$$

where T_S and T_i are the actual statewide and regional trend components. The base month for each component series is July 1974.

The four alternative index series models for sub-region i are:

$$(1) \quad Y^1_i = \hat{T}'_i * \hat{S}_i \qquad (3.23)$$

$$(2) \quad Y^2_i = \hat{T}'_i * \hat{S}_S \qquad (3.24)$$

$$(3) \quad Y^3_i = \hat{T}'_S * \hat{S}_i \qquad (3.25)$$

$$(4) \quad Y^4_i = \hat{T}'_S * \hat{S}_S \qquad (3.26)$$

where Y^j_i is the estimated regional index series for region i using model j, j=1,2,3,4.

In the first model, regional estimates of both the trend and seasonal components are used. In the second model, the statewide seasonal component substitutes for regional seasonal component. In the third model, the regional trend is replaced by a statewide trend, and in the last model, both trend and seasonal components are the statewide estimates.

Forecast accuracy of these four index series models will be evaluated and compared for each sub-region to see which model performs best in predicting the actual index series, Y'_i, defined as

$$Y'_i = T'_i * S_i \tag{3.27}$$

where

$$T'_i = T_i/(T_i \text{ for July 1974}) \tag{3.28}$$

T'_i is the actual trend index series for region i starting from 1.00 for July 1974. S_i are the actual regional seasonality series. Notice that Y'^i will not start from 1.00 from July 1974 unless the seasonal factor for July is also 1.00.

The number of tourism-related jobs in a region is obtained by multiplying the predicted index values by the level of tourism-related employment in the base month (July 1974). Comparisons of the four models will provide measures of the errors made in applying the statewide model (patterns of tourism activity) at regional levels.

SUMMARY

Data selected to investigate tourism activity across Michigan are monthly tourism-related employment series from 1974 to 1984. Nine study regions including the state of Michigan and eight sub-regions are formed. These sub-regions were formed by grouping counties with similar magnitude and seasonal patterns of tourism-related employment and (with one exception) adjacent geographic locations.

A general research approach for analyzing and forecasting tourism activity in the individual study regions is proposed. A multiplicative decomposition is adopted to decompose the data series into a trend and a seasonality series. Trends are identified from the changes in annual averages in tourism-related employment, and seasonality is identified from the variations of the seasonality series over a 12 months period. Trend and seasonal patterns for each study region will be identified and quantified to achieve the first study objective. These two patterns will be compared between regions to achieve the second study objective.

In the forecasting procedure, trend and seasonal models will be developed for each study region. Three approaches will be tested to estimate the trend models: (1) time-series, (2) structural, and (3) structural-time-series models. Transfer function techniques will be used to reduce autocorrelation problems. The three trend models will be evaluated and compared with each other. Harmonic analysis will be applied to the seasonality series to generate a seasonal model. The seasonal model produces monthly

seasonal factors for the corresponding months of the year. The trend and seasonal models will be combined together to generate combined forecasting models for tourism activity in a study region. Accuracy of the forecasting models will be evaluated. Following this forecasting procdure, statewide and regional forecasting models will be compared with each other in terms of the structures and accuracy (study objectives 3 and 4).

Finally, the generalizability of the statewide forecasting model to the regional level will be tested (study objective 5). This will be carried out by substituting the trend, seasonal, or both components of the statewide model for the corresponding component(s) of a regional model. Four alternatives will be evaluated for each sub-region of Michigan.

CHAPTER IV

TREND AND SEASONAL PATTERNS

This chapter reports the trend and seasonal patterns of tourism-related employment in Michigan and its individual sub-regions (the first objective) and spatial differences in the trend and seasonal patterns between study regions (the second objective). Trend patterns will be presented first, followed by seasonal patterns.

TRENDS

Trends were identified from the changes in annual averages of tourism-related employment from 1974 to 1984. The annual averages are computed by averaging the 12 monthly tourism-related employment figures for the year. Changes over time are represented as an index starting from the base year (1974) to 1984. Statewide trend patterns will be presented first, followed by regional trends.

Statewide Trends

Michigan's tourism-related employment increased by about 57,700 jobs (30 percent) from 1974 to 1984, while Michigan's overall employment increased by 279,000 jobs (7.8 percent) over the same period. Tourism-related employment had a larger growth rate than Michigan's total employment (30% vs 7.8%), resulting in an increase in tourism's share of the state's jobs from 5.4 percent in 1974 to 6.3 percent in 1984.

Statewide tourism-related employment was not immediately affected by the energy crisis in 1979 but did decline with the 1980-82 economic recession in the state. Tourism-related employment in Michigan grew by 25 percent over the 1974-1979 period, dropped 7 percent between 1980 and 1982, and subsequently recovered at a 4 percent annual growth rate in 1983 and 84 (Table 3). Cumulative percentage changes in tourism-related employment in Michigan for the period 1974-1984 using 1974 as the base year are plotted in Figure 4.

Examination of the distribution of jobs within the nine individual tourism-related sectors and changes in the distribution of jobs in these 9 sectors may be helpful to understand the changing patterns of tourism activity in Michigan over time. From 1974 to 1984 the distribution of jobs in the 9 tourism- related sectors has remained relatively stable (Table 4). Eating and drinking places and hotel/motel sectors provide the majority of tourism-related jobs in Michigan (about 85% in 1984) and account for more than 99% of the growth since 1974. Eating and drinking places led the other sectors in creating new jobs (51,000) since 1974, followed by hotel/motel sector with 13,000 new jobs. The gas service sector lost about 3,500 jobs between 1974 and 1984. The hotel and motel sector experienced the highest growth (64%), followed by amusements (41%). Jobs in the recreational vehicle and utility sector declined by 33% from 1974 to 1984.

Table 3: Trends in Tourism-Related Employment in Michigan, 1974-84.

Year	Average[a] Annual Jobs	Ratio to[b] 1974 values	Cumulative Percentage[c] Changes from 1974
1974	203,942	1.00	0
1975	209,223	1.03	3
1976	222,856	1.09	9
1977	238,893	1.17	17
1978	252,154	1.24	24
1979	254,384	1.25	25
1980	249,097	1.22	22
1981	244,349	1.20	20
1982	241,583	1.18	18
1983	249,421	1.22	22
1984	258,596	1.27	27

a. Average of 12 monthly figures for each year.
b. Column 2 divided by 203,942.
c. Column 3 minus 1.00.

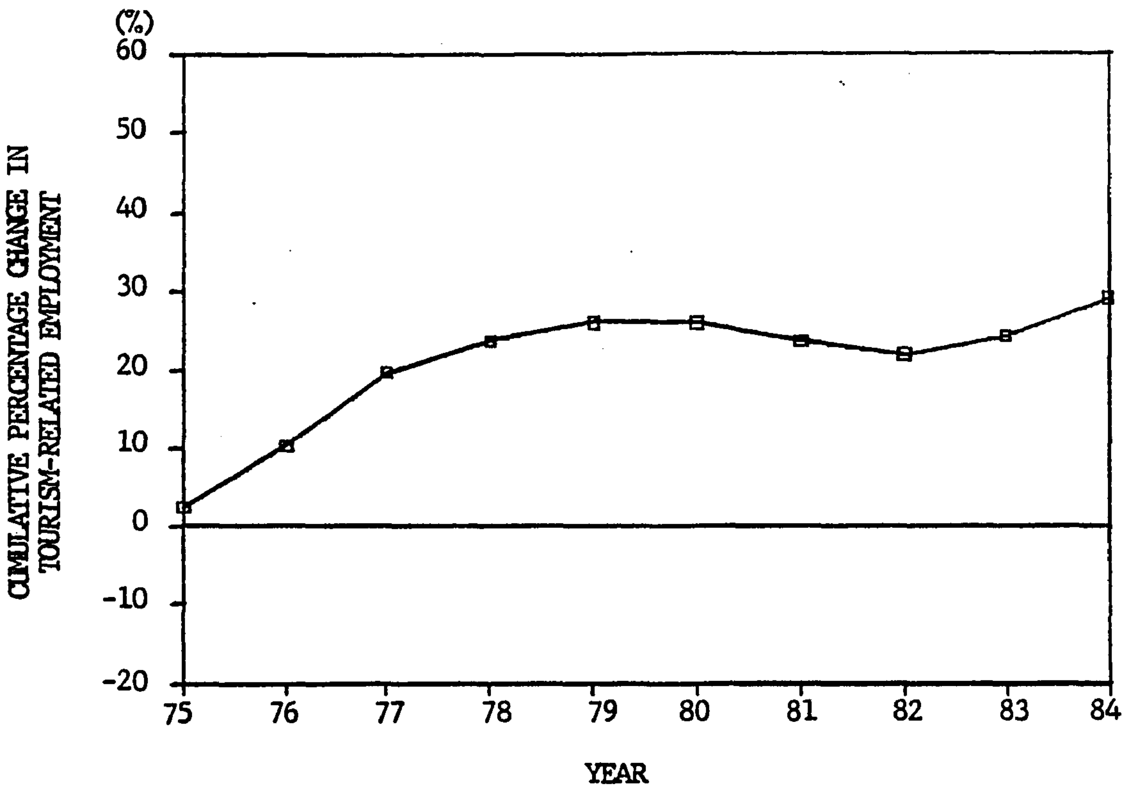

Figure 4: Cumulative Percentage Changes in Tourism-Related Employment in Michigan between 1974 (Base Year) and Subsequent Years.

Table 4: Distribution of Jobs in Tourism-Related sectors in Michigan, 1974-84.

Sector	1974 Jobs	1974 PCT	1984 Jobs	1984 PCT	Jobs 84-74	% Change
Eat and Drink	144,764	71.1	196,702	73.3	51,308	35
Hotel/Motel	19,607	9.6	32,221	12.0	12,614	64
Gas Service	24,745	12.2	21,247	7.9	-3,498	-14
Amusements	9,903	4.9	13,976	5.2	4,073	41
Boat Dealers	1,584	0.8	1,279	0.5	-287	-18
Camps & Trailer	1,041	0.5	1,063	0.4	22	2
Water Transp.	1,140	0.6	1,062	0.4	-78	-7
RV & Utility	811	0.4	543	0.2	-268	-33
Room & Board	0	0.0	114	0.0	114	0
Total	203,595	100.0	267,595	100.0	64,000	31

Regional Trends

Statewide patterns are dominated by southern Michigan which accounted for 89% of tourism-related employment in 1984 and contributed approximately 86 percent of the statewide increase over the 1974-1984 period (Table 5). With the exception of the eastern upper peninsula, northern regions of the state had a 27 percent or more increase in tourism-related jobs over the 11 year period. The eastern upper peninsula has experienced a loss in tourism-related employment since 1978. The Mackinac Straits region experienced the highest growth (54%), followed by the western upper peninsula (46%) and out-state urban counties (44%). In 1984 most northern regions experienced slight increases in tourism-related employment while Wayne and Oakland counties had a 6% increase (Table 6).

Individual study regions of southern Michigan have trend patterns similar to those of the state of Michigan (Figure 5), but vary in the magnitude of these changes. In northern Michigan, trends in individual regions vary significantly (Figure 6). This may be due to regions responding differently to economic conditions in the state and/or experiencing different patterns of growth and development.

Northeast Michigan is the only region which showed a relatively flat pattern with no decline and little growth during the 1974-1984 period. Tourism-related employment in northwest Michigan and out-state urban counties grew by 6% during the 1979-80 gasoline shortage. Tourism-related employment in Wayne and Oakland counties, and southern rural counties remained stable from

Table 5: Trends of Tourism-Related Employment in Michigan 1974-84, by region.

Year	Michigan	Wayne & Oakland	Out-State Urban	South Rural	Northwest Michigan	Northeast Michigan	Mackinac Straits	Eastern Upper Peninsula	Western Upper Peninsula
				Annual Averages					
1974	203,942*	79,633	49,073	41,053	8,071	4,604	1,136	2,523	4,187
1975	209,223	80,156	51,053	43,709	8,619	4,843	1,272	2,572	4,689
1976	222,856	84,644	56,845	46,636	9,272	5,340	1,330	2,787	4,828
1977	238,893	91,697	62,646	50,447	9,868	5,587	1,530	2,817	5,082
1978	252,154	96,048	64,776	52,128	10,513	5,771	1,675	2,442	6,052
1979	254,384	95,984	67,736	51,936	10,983	5,732	1,584	2,054	5,871
1980	249,097	96,579	68,019	52,093	10,485	5,758	1,526	1,947	5,686
1981	244,349	94,467	65,865	51,529	10,424	5,824	1,640	1,944	5,981
1982	241,583	91,648	66,238	50,624	10,423	5,845	1,717	1,974	5,924
1983	249,421	93,475	68,182	50,777	10,760	5,865	1,771	2,171	5,938
1984	258,596	98,263	70,586	52,525	10,774	5,869	1,754	2,101	6,118

* Numbers are not equal to the sum of the annual averages of 8 sub-regions because tourism-related jobs in the non-profit organizations are not included in tourism-related employment in the individual counties.

Table 6: Changes in Tourism-Related Employment, 1974-84, by Region.

Year	Michigan	Wayne & Oakland	Out-State Urban	South Rural	Northwest Michigan	Northeast Michigan	Mackinac Straits	Eastern Upper Peninsula	Western Upper Peninsula
				Cumulative Percentage					
1974*	0	0	0	0	0	0	0	0	0
1975	3	1	4	6	7	5	12	2	12
1976	9	6	16	14	15	16	17	10	15
1977	17	15	28	23	22	21	35	12	21
1978	24	21	32	27	30	25	47	-3	45
1979	25	21	38	27	36	25	39	-19	40
1980	22	21	39	27	30	25	34	-23	36
1981	20	19	34	26	29	26	44	-23	43
1982	18	15	35	23	29	27	51	-22	41
1983	22	17	39	24	33	27	56	-14	42
1984	27	23	44	28	33	27	54	-17	46

* 1974 is the base year.

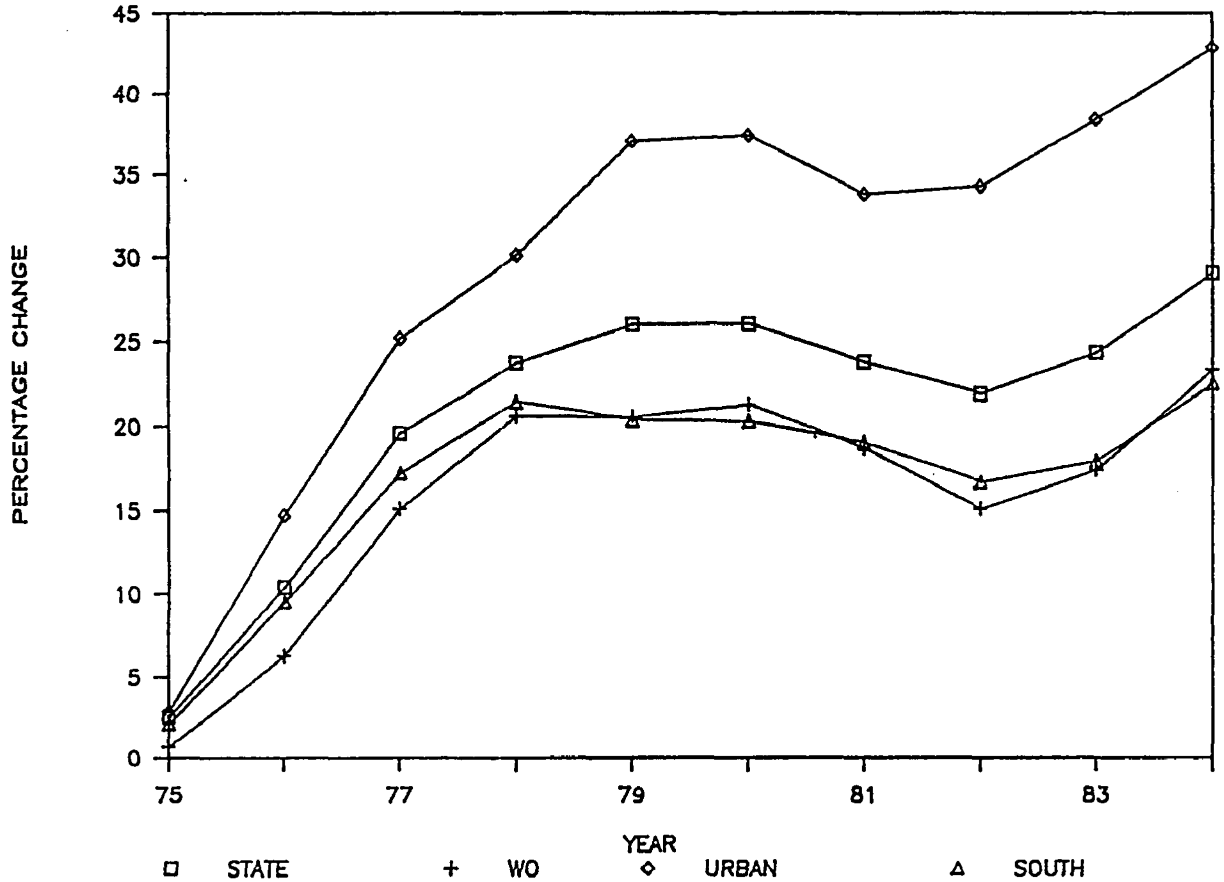

Figure 5: Cumulative Percentage Changes in Tourism-Related Employment in the State of Michigan and Southern Regions Between 1974 (Base Year) and Subsequent Years.

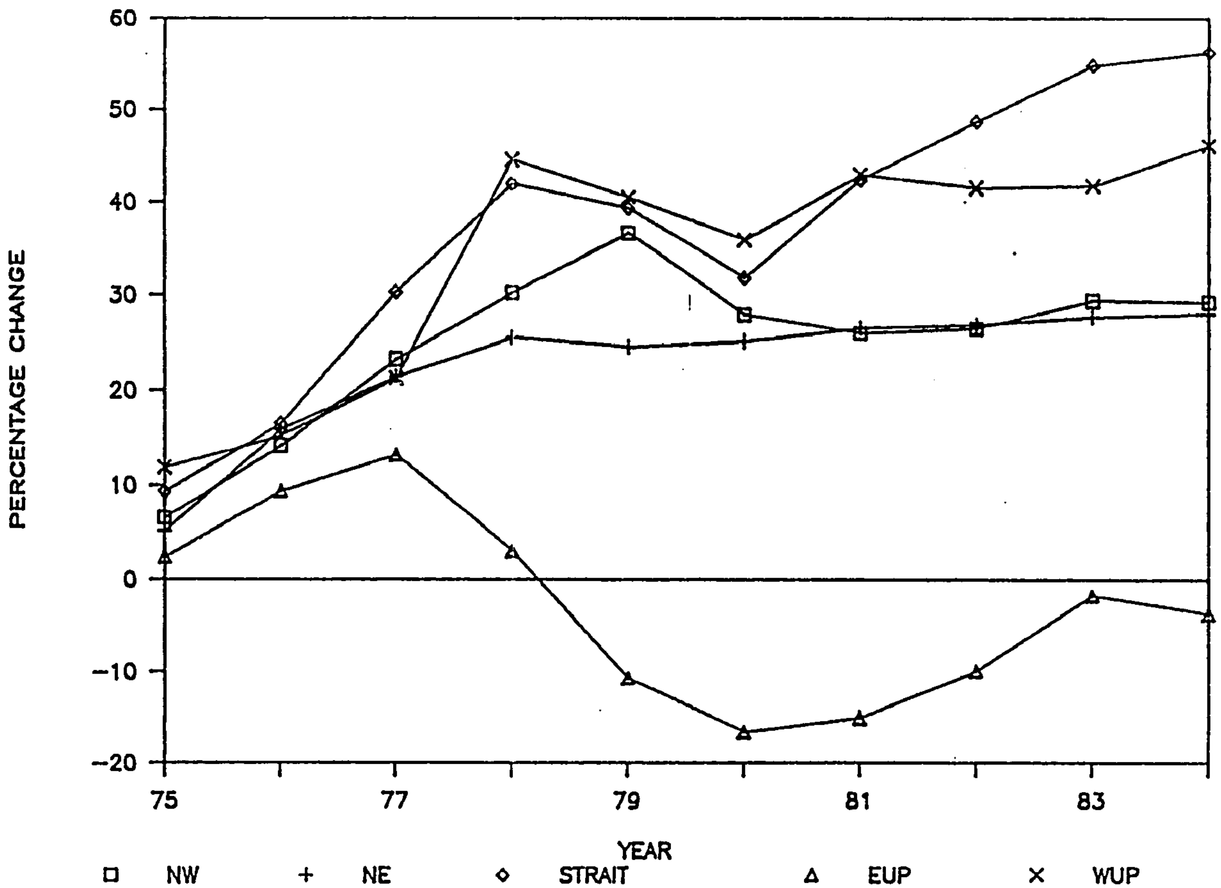

Figure 6: Cumulative Percentage Changes in Tourism-Related Employment in Northern Regions of Michigan Between 1974 (Base Year) and Subsequent Years.

1978 to 1980 and then declined from 1981 to 1983. By contrast, the Mackinac Straits region and the eastern upper peninsula experienced significant declines in tourism-related employment in 1979, followed by increases from 1981 to 1983.

Northern Michigan experienced larger relative changes in tourism-related employment than the state as a whole over the study period. The turning points of the trend series were reached two years earlier in the north than in southern counties, presumably due as much to gasoline price increases as to the recession.

It should be noted that significant variations exist between counties within a region (Table 7). For example, although all counties in the eastern upper peninsula experienced a loss in tourism-related employment, these losses ranged from 3% for Chippewa to 46% for Alger. The increase in tourism-related jobs in the Wayne and Oakland region was almost all in Oakland county.

SEASONALITY

Seasonal patterns of tourism-related employment were identified and quantified from the seasonality series of 12 monthly seasonal factors. In the preliminary analysis, seasonal factors for each year from 1974 to 1983 were calculated and examined for each study region. It was found that, during this time period, regional seasonal patterns have remained relatively stable. The individual monthly seasonal factors across the years deviate from their respective means by nor more than plus or minus 2.3% for Wayne and Oakland counties and 10% for the Mackinac Strait region

Table 7: Changes in Tourism-Related Employment in Michigan, 1974-84, by Region and by County.

Region	County	Jobs* 84-74	%** Change	Region	County	Jobs 84-74	% Change
Wayne &	Wayne	429	1	Northwest	Antrim	50	9
Oakland	Oakland	18,200	69	Michigan	Benzie	166	72
					Charlevoix	91	11
Other	Genesee	2,957	38		G. Traverse	1,373	75
Urban	Ingham	1,597	21		Kalaska	6	3
Counties	Kalamazoo	2,527	51		Lake	-8	-7
	Kent	5,985	52		Leelanau	86	25
	Macomb	5,165	44		Manistee	111	29
	Washtenaw	3,283	58		Mason	-29	-4
					Missaukee	18	16
South	Allegan	255	26		Osceloa	15	8
Rural	Barry	-52	-14		Emmet	20	2
	Bay	254	10		Wexford	160	25
	Berrien	-159	-4				
	Branch	-34	-6	Northeast	Alcona	67	53
	Calhoun	86	2	Michigan	Alpena	-24	-3
	Cass	-191	-32		Arenac	156	39
	Clinton	156	49		Clare	-35	-6
	Eaton	165	24		Crawford	202	60
	Gratiot	-35	-5		Gladwin	222	131
	Hillsdale	-96	-18		Iosco	79	17
	Huron	112	19		Montmorency	91	65
	Ionia	-43	-6		Ogemaw	99	44
	Isabella	349	29		Oscoda	-12	-10
	Jackson	1,083	38		Otsego	73	11
	Lapeer	491	83		P. Isle	36	26
	Lenawee	208	16		Roscommon	323	63
	Livingston	1,254	127				
	Mecosta	249	55	Mackinac	Cheboygan	323	64
	Midland	603	55	Straits	Mackinac	294	46
	Monroe	213	12				
	Montcalm	126	18	Eastern	Alger	-140	-46
	Muskegon	888	31	Upper	Chippewa	-17	-3
	Newaygo	227	68	Peninsula	Delta	-153	-15
	Ottawa	1,966	73		Luce	-54	-26
	Saginaw	1,514	31		Schoolcraft	-58	-18
	Sanilac	-37	-10				
	Shiawassee	1,514	31	Western	Baraga	-5	-4
	St. Clair	62	3	Upper	Dickison	196	47
	St. Joseph	533	55	Peninsula	Gogebic	325	75
	Tuscola	1	0		Houghton	171	31
	Van Buren	182	25		Iron	24	9
					Kewenaw	19	38
					Marquette	1,058	62
					Menominee	194	49
					Ontonagon	-52	-25

* *Actual change in tourism-related jobs*

** Percentage change in tourism-related jobs.

(Table 8). Thus, the nine-year averages of monthly seasonal factors were computed to estimate seasonal factors for each study region and these are asuumed constant over time.

Statewide Seasonality

At the statewide level of aggregation, Michigan's tourism-related employment has relatively small seasonal fluctuations. Seasonal factors range from a low of .93 in February to a high of 1.06 in June and August (Table 9). Based on an annual average of 258,596 statewide tourism-related jobs in 1984, this translates into a difference of 33,600 jobs between February and June (or August).

To identify which sectors contribute most to the seasonal fluctuations of tourism-related employment in Michigan, seasonal patterns of the 9 tourism-related sectors were examined using 1984 figures (Table 10). Annual seasonal fluctuations in tourism-related employment is measured by the difference between March employment and August employment. It was found that eating and drinking places contributed most to the annual seasonal fluctuations (20,591 jobs or 56.7%), followed by the amusements sector (8,200 jobs or 22.6%). Camps and trailer parks sector led the other sectors in the magnitude of seasonal fluctuations of jobs within individual sectors. August employment in this sector (2,246 jobs) was almost 3 times higher than March employment (599 jobs).

Table 8: Stability of monthly seasonal factors by region, 1974.07-1983.06.

Month	Michigan	Wayne & Oakland	Out-state Urban Counties	Southern Rural	Northwest Michigan	Northeast Michigan	Mackinac Straits	Eastern Upper Peninsula	Western Upper Peninsula
	-----------------	-----------------	-----------------	Coefficient of Variation [a]	-----------------	-----------------	-----------------	-----------------	-----------------
January	0.009	0.011	0.011	0.012	0.019	0.019	0.059	0.055	0.030
February	0.009	0.009	0.013	0.016	0.020	0.021	0.039	0.059	0.031
March	0.008	0.003	0.012	0.014	0.032	0.023	0.063	0.065	0.026
April	0.012	0.023	0.016	0.009	0.028	0.021	0.100	0.043	0.015
May	0.007	0.014	0.017	0.011	0.021	0.019	0.045	0.056	0.023
June	0.008	0.013	0.017	0.013	0.015	0.024	0.057	0.064	0.011
July	0.008	0.008	0.016	0.012	0.017	0.017	0.033	0.025	0.025
August	0.009	0.011	0.016	0.013	0.016	0.010	0.043	0.021	0.029
September	0.008	0.009	0.017	0.012	0.018	0.015	0.042	0.027	0.020
October	0.004	0.007	0.011	0.012	0.012	0.015	0.070	0.052	0.021
November	0.009	0.013	0.011	0.012	0.020	0.014	0.032	0.067	0.026
December	0.006	0.010	0.009	0.015	0.024	0.018	0.058	0.070	0.028

a. Coefficient of variation = (standard deviation/mean).

Table 9: Seasonal Factors for Tourism-Related Employment in Michigan, 1974-84.

Month	Seasonal factors
January	0.93
February	0.93
March	0.95
April	0.98
May	1.03
June	1.06
July	1.05
August	1.06
September	1.04
October	1.01
November	0.98
December	0.98
1984 Tourism Related Employment	258,596

Table 10: Seasonal Patterns of Tourism-Related Employment in Michigan by Sector, 1984.

Sector	March	%	August	%	Aug-Mar	%	(Aug-Mar)/Mar % Change
Eat & Drink	184,932	76.7	204,983	74.0	20,591	56.7	11
Hotel/Motel	22,465	9.3	25,618	9.3	3,153	8.7	14
Gas Service	20,516	8.5	21,827	7.9	1,311	3.6	6
Amusements	10,250	4.3	18,450	6.7	8,200	22.6	80
Boat Dealers	1,049	0.4	1,567	0.6	518	1.4	49
Water Transp.	682	0.3	1,364	0.5	682	1.9	100
Cams & Trailer	599	0.2	2,246	0.8	1,647	4.5	275
RV & Utility	495	0.2	618	0.2	123	0.3	25
Room & Board	78	.0	170	0.1	92	0.3	118
Total	240,526	100.0	276,843	100.0	36,317	100.0	15

Regional Seasonality

Tourism-related employment in each of the eight regions peaks in either August or September. It reaches its trough in January for eight southern metropolitan counties; in April for northwest Michigan; and in February for the other four regions (Table 11). Patterns of seasonal fluctuations of tourism-related employment in individual regions are plotted in Figure 7. In northwest Michigan and the western upper peninsula , a slight increase in tourism-related employment from December to February is observed, presumably due to winter tourist activities in these areas.

Patterns of seasonality in tourism-related employment are much more evident for northern regions than for southern regions. For example, in northwest Michigan tourism-related employment fluctuates from a high of 27% above the annual average (seasonal factor=1.27) in August to an April low of 16% below the annual average (seasonal factor of 1-.16=.84). The Mackinac Straits region shows the largest seasonal fluctuations in tourism-related employment. In these counties, August employment (seasonal factor=1.92) is almost four times higher than February employment (seasonal factor=0.38). Southern regions, on the other hand, experience relatively low seasonal fluctuations in tourism-related employment. This is likely due to the more diversified economy, fewer seasonal residents, and larger local population bases to sustain employment in tourism-related sectors throughout the year.

Table 11: Seasonal Factors for Tourism-Related Employment in Michigan, 1974-84, by Region.

Month	Michigan	Wayne & Oakland	Other South Urban	South Rural	Northwest Michigan	Northeast Michigan	Mackinac Straits	Eastern Upper Peninsula	Western Upper Peninsula
January	0.93	0.94	0.96	0.91	0.91	0.87	0.39	0.65	0.97
February	0.93	0.95	0.95	0.90	0.89	0.85	0.38	0.65	0.96
March	0.95	0.96	0.97	0.93	0.87	0.86	0.39	0.66	0.95
April	0.98	1.00	1.00	0.98	0.84	0.89	0.51	0.75	0.93
May	1.03	1.03	1.04	1.04	0.97	1.01	1.13	1.07	0.98
June	1.06	1.04	1.04	1.07	1.11	1.11	1.57	1.29	1.03
July	1.05	1.03	1.01	1.08	1.24	1.19	1.91	1.47	1.07
August	1.06	1.03	1.01	1.09	1.27	1.20	1.92	1.50	1.09
September	1.04	1.02	1.02	1.06	1.12	1.12	1.58	1.38	1.04
October	1.01	1.00	1.01	1.01	1.00	1.02	1.13	1.07	0.99
November	0.98	0.99	0.99	0.97	0.88	0.97	0.62	0.82	0.97
December	0.98	1.00	0.99	0.97	0.90	0.92	0.49	0.74	1.01
1984 Tourism Related Employment	258,946	98,263	66,960	51,119	9,090	5,869	1,754	2,878	6,118

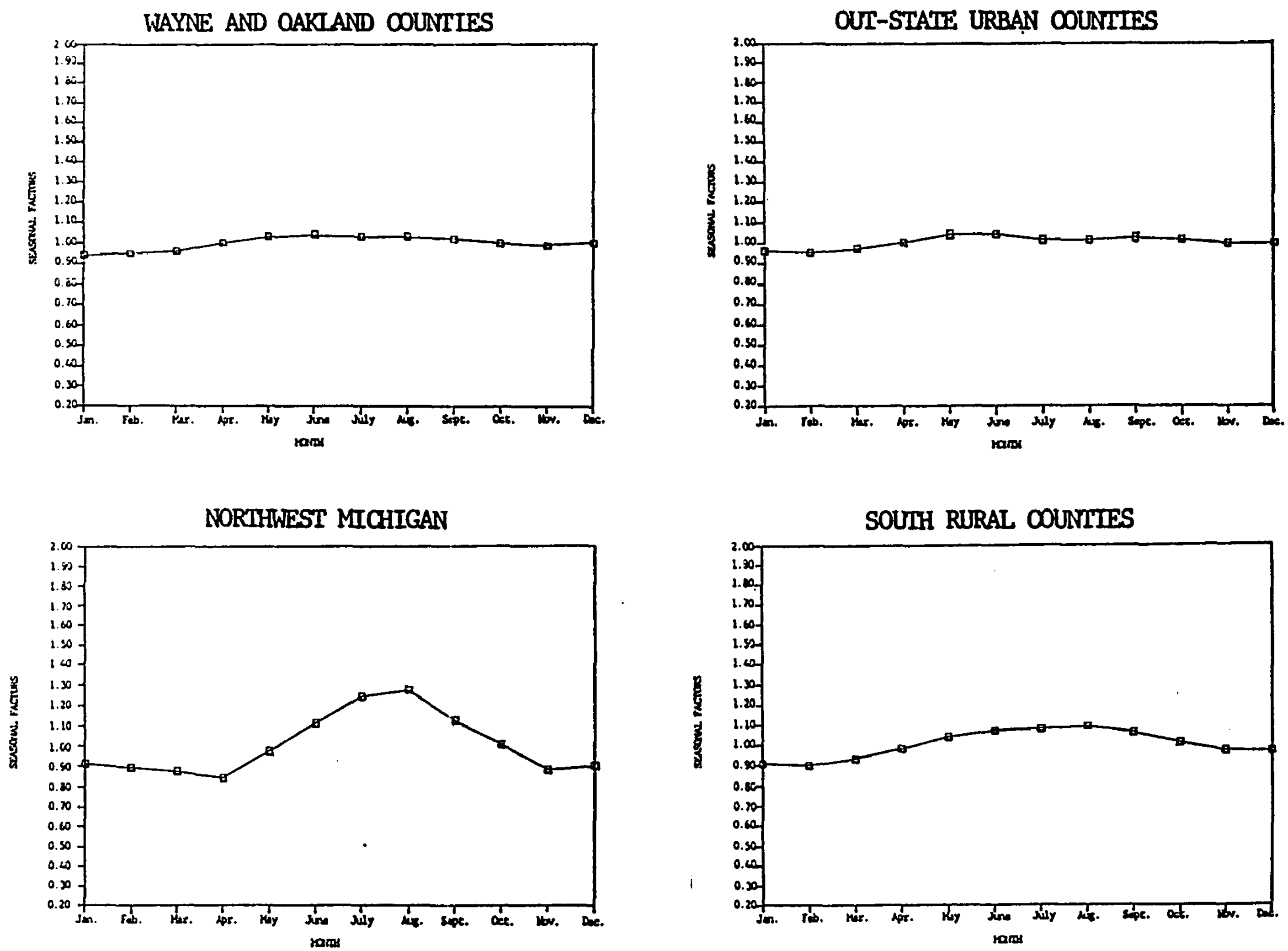

Figure 7: Seasonal Patterns of Tourism-Related Employment in Michigan, 1974-84, by Region.

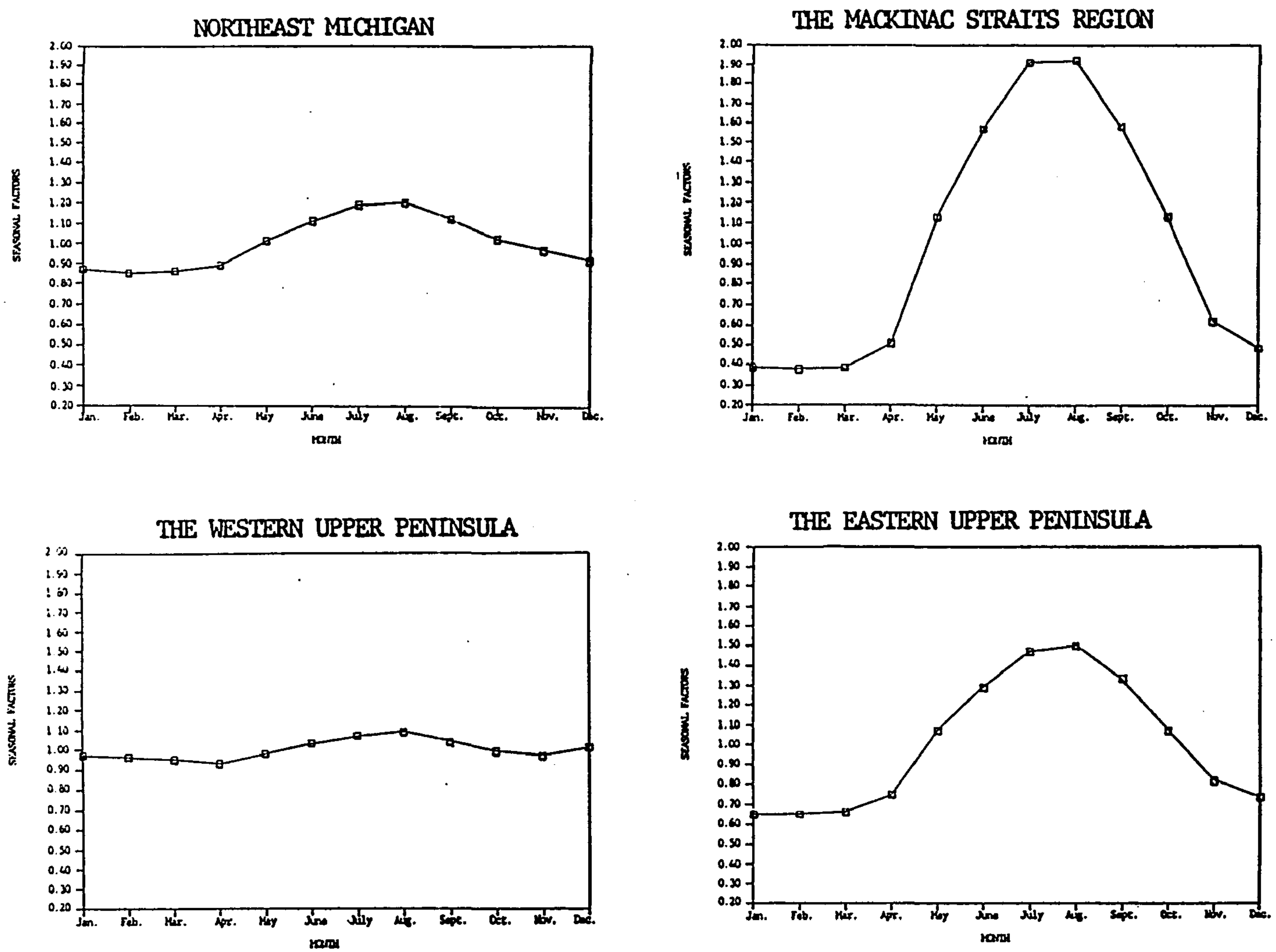

Figure 7: (Continued).

SUMMARY

Trend and seasonal patterns of tourism-related employment exhibit significant differences across the state of Michigan. Southern regions generally follow statewide trend patterns and had a tourism-related job increase of 23 percent or more between 1974 and 1984. Significant variations in the trend patterns between northern regions are observed. The region with the highest growth in tourism-related employment is the Mackinac Straits region (54%), followed by the western upper peninsula (46%) and out-state urban counties (45%). Seasonal fluctuations in tourism-related employment is lowest in southern rural counties, which are less populated and have relatively low levels of tourism activity. The highest seasonal variation in tourism-related jobs is in Mackinac Straits region which is highly dependent upon tourism and related industries. Thus, regions differ in trend, seasonal, or both patterns of tourism activity, which makes these regions distinguishable from each other. To further test spatial variations in the trend and seasonal patterns of tourism-related employment in the state of Michigan, statewide and regional forecasting models will be developed and reported in the next chapter.

CHAPTER V

FORECASTING MODELS

This chapter presents forecasting models for the state of Michigan as a whole and its 8 sub-regions (study objectives 3 and 4). The generalizability of the statewide model to sub-regions of the state (objective 5) is also tested. The forecasting models predict monthly levels of tourism-related employment. To develop a forecasting model each regional series was decomposed into trend and seasonal components using a multiplicative decomposition. A transfer function procedure was applied to the trend component to estimate trend models. The seasonal model was generated from the results of harmonic analysis on the seasonal component. Trend and seasonal models were then recombined into a monthly forecasting model for each study region. The ability of the statewide model to forecast at the regional level was investigated and will be reported in the last section of the chapter. The statewide model will be presented and discussed first, followed by regional forecasting models.

STATEWIDE FORECASTING MODEL

Three trend models were estimated: (1) a time-series-ARMA(p,q) transfer function model, (2) a structural-ARMA(p,q) transfer function model and (3) a structural-time-ARMA(p,q) transfer function model. Forecast accuracy of each trend model was evaluated. The seasonality component was estimated using harmonic analysis.

Statewide Trend Models

The three transfer function models differ in the composition of explanatory variables of the regression component. The residuals of their respective regresssions are modeled and forecasted by the same Box-Jenkins techniques. The pure time series model is estimated as a third degree polynomial with time, time-squared, and time-cubed as the independent variables. Explanatory variables in the structural model are population size, unemployment rate, retail price of gasoline, and personal income. All seven variables are tested in the combined structural-time-series model.

Estimation procedures for a transfer function model are demonstrated first for the structural model. First, a structural regression equation is estimated using ordinary least squares applied to the trend component of the monthly statewide tourism-related employment series (July 1974 to June 1983). The estimated models will be presented together with standard errors in parentheses, adjusted R-square, Durbin-Watson statistic (DW), and mean absolute percentage error (MAPE) of the equation.

<u>Structural Models</u>

The structural ordinary least squares (OLS) regression model is:

$$\hat{T}_t = \underset{(-73,451)}{-802,206} + \underset{(792)}{10,395} * PSTATE_t - \underset{(213)}{157} * MAUNEM_t - \underset{(11)}{86} * MAGAS_t + \underset{(51)}{1,295} * MAINC_t \qquad (5.1)$$

$$R^2 = 0.964 \quad MAPE= 1.05 \quad DW = .008$$

where $PSTATE_t$ is the population size of the state of Michigan in month t. Other variables in the equation are defined on pp. 60. The unemployment coefficient is not significant at the 5% level, but its negative sign is as hypothesized. All other coefficients are significant at the 5% level and the signs of coefficients are as hypothesized. The model explains 96% of the variation in the trend series. The mean absolute percentage error (MAPE) is 1.05. The Durbin-Watson statistic is close to zero, indicating the presence of serious positive serial correlation. This may impare forecast accuracy of the regression model. The transfer function model corrects for this problem.

A transfer function model is estimated by first computing the unconditional residuals (E_t) and then applying Box-Jenkins techniques to this series. The total and partial autocorrelation functions of E_t with lags of 1 to 24 were examined to determine the orders (p and q) of the autoregressive and moving-average processes (Figure 8). The autocorrelation decays geometrically from its starting value. This indicates the moving-average part of the error model should be of order 1. The partial

Figure 8: Total and Partial Autocorrelation Functions for the Structural Regression Model for Tourism-Related Employment in Michigan, 1974.07-1984.06.

Autocorrelations		Partial Autocorrelations		LAG	AC	PAC
	*********		*********	1.	0.945	0.945
	********	******		2.	0.826	-0.622
	*******			3.	0.688	0.033
	******			4.	0.562	0.040
	*****			5.	0.467	0.046
	****			6.	0.402	0.035
	****			7.	0.355	0.020
	***			8.	0.318	0.008
	***			9.	0.277	-0.007
	**			10.	0.215	-0.032
	*	*		11.	0.114	-0.059
		*		12.	-0.011	-0.052
*				13.	-0.134	-0.033
**				14.	-0.227	-0.013
***				15.	-0.271	0.004
***				16.	-0.268	0.011
**				17.	-0.237	0.007
**				18.	-0.199	0.001
**				19.	-0.171	-0.009
**				20.	-0.165	-0.017
**				21.	-0.179	-0.019
**				22.	-0.204	-0.014
**				23.	-0.229	-0.007
**				24.	-0.235	0.005

auto-correlation function has significant spikes at lags 1 and 2, indicating a second-order autoregressive interpretation of the E_t series. This suggests two possible error models: ARMA(2,1) and ARMA(1,1).

These two transfer function models were estimated using the Time Series Processor Statistical Package (Hall and Hall, 1980). Estimation procedures are described on pp. 64-65.

The estimated structural-ARMA(2,1) transfer function model is:

$$\hat{T}_t = \underset{(64{,}390)}{248{,}878} - \underset{(697)}{74} * PSTATE_t - \underset{(10.6)}{6.3} * MAUNEM_t + \underset{(2.2)}{1.3} * MAGAS_t - \underset{(39)}{8} * MAINC_t + \underset{(0.0035)}{1.92} * E_{t-1} - \underset{(0.0024)}{0.92} * E_{t-2} + V_t + \underset{(0.1023)}{0.68} * V_{t-1} \qquad (5.2)$$

$$R^2 = 0.999 \quad MAPE= 0.04 \quad DW = 1.99.$$

where E_{t-1} and E_{t-2} are the unconditional errors in period t-1 and t-2, and V_t and V_{t-1} are the forecast errors of the E_t series in period t and t-1, respectively. Although this model explains 99.9% of the variations in the statewide trend series with a mean absolute percentage error of 0.04 and no serial correlation (Durbin-Watson statistic is close to two), none of the structural variables are significant at the 5% level. Except for the unemployment variable, the signs of coefficients are opposite to those hypothesized. This model is therefore rejected.

The estimated structural-ARMA(1,1) transfer funtion model is:

$$\hat{T}_t = \underset{(65,210)}{-419,072} + \underset{(702)}{6,949} * PSTATE_t - \underset{(39)}{57} * MAUNEM_t - \underset{(4.3)}{1.7} * MAGAS_t +$$

$$\underset{(54)}{300} * MAINC_t + \underset{(0.0088)}{0.97} * E_{t-1} + V_t + \underset{(0.1039)}{0.88} * V_{t-1} \qquad (5.3)$$

$$R^2 = 0.999 \quad MAPE= 0.11 \quad DW = 1.97.$$

This model incorporates all four independent variables and a first-order autoregressive and first-order moving-average error model, i.e. ARMA(1,1). The model explains 99.9% of the variance of the statewide trend series with a MAPE of 0.11 and no serial correlation (DW = 1.97). The signs of the coefficients are as hypothesized. Statewide population size and personal income levels have positive coefficients, while statewide unemployment and U. S. retail price of gasoline have negative coefficients. All variables, except unemployment and gasoline price index, are significant at the 5% level. All variables are retained in the trend model for forecasting and comparison purposes.

Pure time series models

The same procedure was repeated for the pure time series models. Although the signs of the coefficients of the estimated time-series-ARMA(1,1) model are as hypothesized, the model has a strong negative serial correlation (DW= 3.8). Thus, this model is not presented here. On the other hand, the estimated time-series-ARMA(2,1) transfer function model is:

$$\hat{T}_t = \underset{(8,617)}{109,516} + \underset{(423)}{5,207} * t - \underset{(6)}{66} * t^2 + \underset{(0.03)}{0.27} * t^3 + \underset{(0.0032)}{1.77} * E_{t-1} -$$

$$\underset{(0.0023)}{0.78} * E_{t-2} + V_t + \underset{(0.1017)}{0.63} * V_{t-1}. \qquad (5.4)$$

$$R^2 = 0.999 \quad MAPE= 0.04 \quad DW = 1.99.$$

This model includes three powers of time and a second-order autoregressive and first-order moving-average error model, i.e. ARMA(2,1). It explains almost 100% of the variation in the statewide trend series with a MAPE of 0.04. No serial correlation problem is observed. All coefficients are significant at the 5% level.

Structural-time-series models

In the structural-time-series-ARMA(2,1) model the coefficients of t, t^2 and t^3 are significant at 5% level while the coefficients of structural variables are insignificant. This model is no better than the pure time-series-ARMA(2,1) model and the structural-ARMA(1,1) model in terms of measures for goodness-of-fit to the existing data and simplicity of the model and thus not reported here. In the statewide trend models the group of four structural variables and the group of three time factors can roughly substitute for each other when these two sets of variables are entered together.

Forecast Accuracy of Statewide Trend Models

The structural-ARMA(1,1) and the time-series-ARMA(2,1) transfer function models were then compared in terms of forecast accuracy. These two models were used to produce one to twelve months ahead forecasts from July 1983 to June 1984. For a detailed description of forecasting procedure see pp. 67. These forecasts are also compared with those of the structural regression model and the time-series regression model (Table 12). The mean absolute error of the time-series regression model is about 35 times larger than that of the time-series transfer function model (Table 13). There is not much improvement in forecast accuracy of the structural transfer function model over the structural regression model.

Among the four models tested, the time-series-ARMA(2,1) transfer function model performs best in terms of all four measures of forecast error, followed by the structural-ARMA(1,1) transfer function model. These two models will be used as alternative trend models to build the forecasting models for Michigan.

Table 12: Forecasts of the Statewide Trend Models for Tourism-Related Employment in Michigan, 1983.07-1984.06.

Month	Time-Series Transfer	Time-Series Regression	Structural Transfer	Structural Regression	Actual Trend Values
1983.07	240,079	230,319	239,927	241,784	240,042
1983.08	240,953	229,624	240,271	242,963	240,874
1983.09	241,821	228,911	240,661	244,426	241,734
1983.10	242,695	228,179	241,017	245,791	242,758
1983.11	243,583	227,430	241,522	247,594	243,912
1983.12	244,494	226,662	241,922	249,083	245,079
1984.01	245,434	225,876	242,293	250,882	246,100
1984.02	246,411	225,072	242,532	251,979	246,938
1984.03	247,431	224,250	242,739	252,743	247,647
1984.04	248,499	223,411	242,957	253,163	248,089
1984.05	249,620	222,554	243,129	253,867	248,344
1984.06	250,798	221,679	243,380	255,259	248,635

Table 13: Forecast Accuracy of the Statewide Trend Models for Tourism-Related Employment in Michigan, 1983.07-1984.06.

Model	MAE	RMSE	MAPE (%)	Statistic-UII
Time-Series-ARMA(2,1)	537	802	0.22	0.0033
Time-Series Regression	18,849	19,673	7.67	0.0803
Structural-ARMA(1,1)	3,151	3,645	1.28	0.0371
Structural Regression	4,115	4,356	1.67	0.0178

Statewide Model for Sasonality

The seasonal model was estimated from the statewide seasonality series using harmonic analysis. Statistics for all 6 harmonics for the state of Michigan are presented in Table 14. The first harmonic explains more than 95 percent of the variation in the seasonality series. Tourism-related employment in Michigan shows an obvious annual cycle. The seasonal fluctuations in tourism-related employment across the year are relatively low, varying by plus or minus 6.5 percent of the annual average or about 16,000 jobs. The annual cycle peaks August 1, and reaches its low point on February 1.

The first (annual), second (semiannual) and 4th (quaterly) harmonics are included in the seasonal model, capturing more than 98 percent of the variation in the seasonality series. This model generates the seasonal component of tourism-related employment in Michigan and is:

$$\hat{S}_t = 1 + 0.06 * SIN(30*t+255) + 0.01 * SIN(60*t+169) + 0.01 * SIN(120*t+238) \quad (5.5)$$

The model predicts the 12 monthly seasonal factors within plus or minus 2 percent (Table 15). All four measures of forecast error are small, e.g. MAPE= 0.95. It should be noted that MAE and RMSE are small because these 12 seasonal factors vary around 1.00. When comparing forecast accuracy of the trend and seasonal models, MAPE and Statistic-UII should be used since they are relative measures.

Table 14: Harmonic Measures of Tourism-Related Employment in Michigan, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.06	255	6.5	95.2	Aug. 1
2	.01	169	1.0	2.3	
3	.01	139	.6	.8	
4	.01	238	.8	1.3	
5	.00	237	.3	.3	
6	.00	270	.2	.1	

Table 15: Forecasts of the Statewide Seasonal Model for Tourism-Related Employment in Michigan, 1983.07-1984.06.

Month	Actual Seasonal	Seasonal Forecast	Seasonal Error	Absolute Percentage Error (%)
1983.07	1.06	1.05	0.01[a]	0.81[b]
1983.08	1.07	1.05	0.02	1.86
1983.09	1.06	1.04	0.02	1.72
1983.10	1.01	1.01	0.00	0.48
1983.11	0.98	0.99	-0.01	1.19
1983.12	0.98	0.98	0.00	0.42
1984.01	0.94	0.94	0.00	0.48
1984.02	0.93	0.93	-0.00	0.45
1984.03	0.94	0.96	-0.02	1.80
1984.04	0.98	0.97	0.01	0.60
1984.05	1.03	1.02	0.01	0.71
1984.06	1.07	1.06	0.01	0.87

a. Column 2 minus column 3.
b. |col 4/col 2|*100.

Measures for goodness-of-fit and forecast accuracy of the model:

Eta-square = 0.97
Mean absolute error (MAE) = 0.0096
Root mean square error (RMSE) = 0.0111
Mean absolute percentage error = 0.95
Statistic-UII = 0.0110

Statewide Forecasting Models

Since a multiplicative decomposition was adopted, the trend and seasonal models are multiplied together to generate alternative forecasting models for Michigan's tourism-related employment. The structural forecasting model is:

$$\hat{Y}_t = \hat{T}_t * \hat{S}_t$$
$$= [\ -419{,}072 + 6{,}949 * PSTATE_t - 57 * MAUNEM_t - 1.7 * MAGAS_t + 300 * MAINC_t + 0.97 * E_{t-1} + V_t + 0.88 * V_{t-1}] * [\ 1 + 0.06 * SIN(30*t+255) + 0.01 * SIN(60*t+169) + 0.01 * SIN(120*t+238)\ ] \quad (5.6)$$

This model explains 99.9% of the variations in tourism-related employment in Michigan for the period from August 1974 to June 1983 (Figure 9).

The time-series forecasting model is:

$$\hat{Y}_t = \hat{T}_t * \hat{S}_t$$
$$= [109{,}516 + 5{,}207 * t - 66 * t^2 + 0.27 * t^3 + 1.77 * E_{t-1} - 0.78 * E_{t-2} + Vt + 0.63 * V_{t-1}] * [1 + 0.06 * SIN(30*t+255) + 0.01 * SIN(60*t+169) + 0.01 * SIN(120*t+238)] \quad (5.7)$$

This model explains 98.4% of the variations in tourism-related employment in Michigan for the same period. The plot of the forecasts of this model is similar to Figure 9.

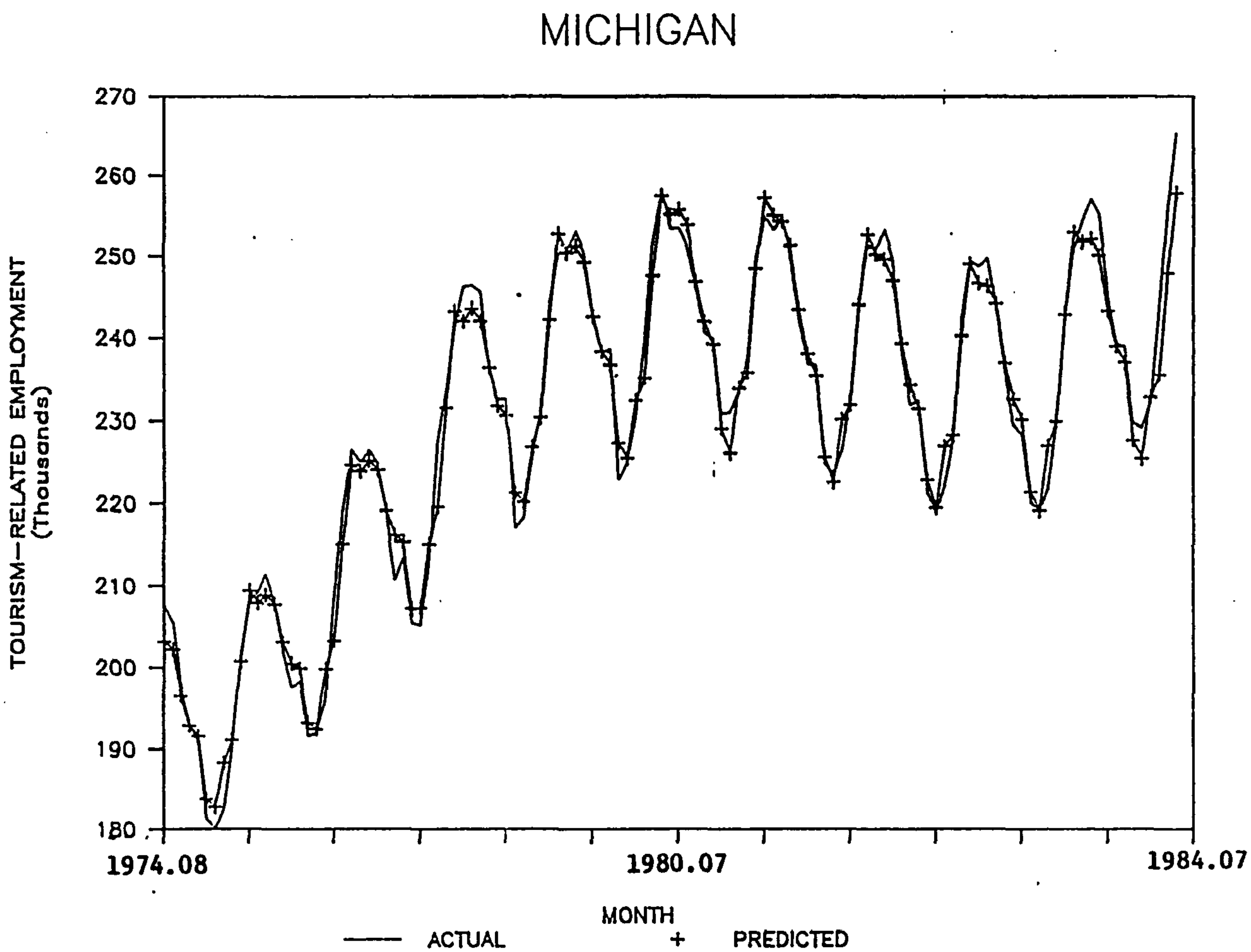

Figure 9: Actual and Predicted Tourism-Related Employment in Michigan, 1984.08-1984.06.

Forecast Accuracy of the Statewide Models

One to twelve-months ahead forecasts of the structural forecasting model for statewide tourism-related employment for the months from July 1983 to June 1984 were produced (Table 16). The projections follow the actual statewide patterns quite closely, but consistently underpredict. The errors are not more than 3.0% for any month and their average (MAPE) is 1.54. The model forecasts well up to 12 months ahead, but there are signs that the model may be deteriorating over time. The majority of forecast errors can be attributed to the errors in predicting the trend component. The mean absolute percentage error is 1.28 for the trend model, 0.95 for the seasonal model, and 1.54 for the combined forecasting model.

To improve the forecast accuracy adaptive forecasting was employed. Adaptive forecasting is defined as updating the model by reinserting the most recent available data for the dependent and independent variables into the model to forecast for the following period(s) (Pindyck and Rubinfeld, 1981). This technique is expected to provide better forecast(s) because of the more up-to-date information used in the adaptive process.

Using adaptive forecasting the MAPE of the forecasts is reduced from 1.54 to 0.93 for the same forecasting period. The percentage error of the 12-months ahead forecast for June 1984 is three time higher than that of the one-month ahead forecast.

Table 16: Comparison of 1-12 Months Ahead and 1-month Ahead Forecasts of the Structural Forecasting Model for Tourism-Related Employment in Michigan, 1983.07-1984.06.

Month	Actual Statewide Values	1-12 Months Ahead* Forecast Error	1-12 Months Ahead* Absolute Percentage Error (%)	1-month Ahead** Forecast Error	1-month Ahead** Absolute Percentage Error (%)
1983.07	254,697	2,443	0.99	2,443	0.96
1983.08	257,183	4,885	1.90	4,659	1.81
1983.09	255,127	4,406	1.73	3,437	1.35
1983.10	245,421	3,165	1.29	1,990	0.81
1983.11	239,431	-79	0.03	-2,260	0.94
1983.12	239,094	3,012	1.26	578	0.24
1984.01	229,854	3,196	1.39	-226	0.10
1984.02	229,244	2,684	1.17	-915	0.40
1984.03	232,410	121	0.05	-4,452	1.92
1984.04	243,917	7,257	2.98	2,492	1.02
1984.05	256,340	7,685	3.00	2,359	0.92
1984.06	265,429	7,274	2.74	1,883	0.71

* Four measures for 1-12 months ahead forecast accuracy are:
Mean absolute error (MAE) = 3,850
Root mean square error (RMSE) = 4,568
Mean absolute percentage error (MAPE) = 1.54
Statistic-UII = 0.0186

** Four measures for 1-month ahead forecast accuracy are:
Mean absolute error (MAE) = 2,308
Root mean square error (RMSE) = 2,660
Mean absolute percentage error (MAPE) = 0.93
Statistic-UII = 0.0108

One to twelve months ahead forecasts of the time-series forecasting model for the same time period were also produced using the same forecasting procedure (Table 17). The percentage errors are not more than 1.88 for any months and their average (MAPE) is 0.77. This is lower than that for the structural forecasting model (1.54). The majority of forecast errors can be attributed to the errors in predicting the seasonal component. The MAPE is 0.22 for the trend model, 0.95 for the seasonal model and 0.77 for the forecasting model.

Adaptive forecasting did not improve the forecast accuracy of this model. The MAPE for the 1-12 months ahead forecasts (0.77) is smaller than that for the 1-month ahead forecasts (0.89).

Table 17: Comparison of 1-12 Months Ahead and 1-month Ahead Forecasts of the Time-Series Forecasting Model for Tourism-Related Employment in Michigan, 1983.07-1984.06.

		1-12 Months Ahead*		1-month Ahead**	
Month	Actual Statewide Values	Forecast Error	Absolute Percentage Error (%)	Forecast Error	Absolute Percentage Error (%)
1983.07	254,697	2,283	0.90	2,283	0.90
1983.08	257,183	4,170	1.62	4,261	1.66
1983.09	255,127	3,199	1.25	3,307	1.30
1983.10	245,421	1,480	0.60	1,561	0.64
1983.11	239,431	-2,121	-0.89	-2,391	1.00
1983.12	239,094	504	0.21	53	0.02
1984.01	229,854	259	0.11	477	0.21
1984.02	229,244	-939	-0.41	-1,599	0.68
1984.03	232,410	-4,367	-1.88	-4,671	2.01
1984.04	243,917	1,860	0.76	1,949	0.80
1984.05	256,340	1,048	0.41	2,165	0.84
1984.06	265,429	-594	-0.22	1,575	0.59

* Four measures for 1-12 month ahead forecast accuracy are:
Mean absolute error (MAE) = 1,902
Root mean square error (RMSE) = 2,322
Mean absolute percentage error (MAPE) = 0.77
Statistic-UII = 0.0094

** Four measures for 1-month ahead forecast accuracy are:
Mean absolute error (MAE) = 2,188
Root mean square error (RMSE) = 2,548
Mean absolute percentage error (MAPE) = 0.89
Statistic-UII = 0.0104

REGIONAL FORECASTING MODELS

Given the evidence in Chapter 4 that trend and seasonal patterns of tourism-related employment do vary spatially in Michigan, we proceed to further examine these variations through formal modeling at the regional level. The same forecasting procedure carried out at the state level is now repeated for each region. Regional trend models will be presented first, followed by regional seasonal models and finally regional forecasting models.

Regional Trend Models

Three alternative trend models were estimated for each study region from the regional moving average series . The specifications of these three alternative trend models are presented on pp. 63. Both time-series and structural regression models were estimated for each study region, followed by transfer functions.

Structural Transfer Function Models

All four structural variables are included in each of the structural regression models (Table 18). Their relationships to the dependent variable are as hypothesized.

Some of these four independent variables are not included in the regional structural transfer function models. Each of these independent variables excluded from the models has a relationship to the dependent variable opposite to that hypothesized or is

Table 18: Structural Trend Models for Tourism-Related Employment in Michigan, 1974.07-1983.06, by Region.

Region	Model Type	Constant	POP	MAUNEM	MAGAS	MAINC	AR(1)[d]	AR(2)[e]	MA(1)[f]	R^2	D-W
Michigan	R[a]	-802205.65	10394.51	-157.12	-85.57	1295.27				0.964	0.08
		(73451.27)	(792.71)	(212.93)	(10.62)	(51.11)					
	T-F[b]	-419072.28	6949.34	-57.56	-1.73	300.41	0.97		0.84	0.999	1.97
		(65120.54)[c]	(702.22)	(38.77)	(4.31)	(54.32)	(0.009)		(0.10)		
Wayne & Oakland	R	-249718.37	8365.67	-217.67	-22.97	858.79				0.930	0.09
		(36476.94)	(953.96)	(111.65)	(5.19)	(55.72)					
	T-F	95327.75		-1.31	-1.20	0.81	1.88	-0.88	0.58	0.999	1.99
		(3187.65)		(6.82)	(1.43)	(25.27)	(0.01)	(0.01)	(0.10)		
Out-State Urban Counties	R	-301945.27	15149.34	46.39	-21.90	207.22				0.975	0.08
		(23413.24)	(1059.36)	(60.21)	(3.01)	(22.59)					
	T-F	-115501.31	7587.43			46.35	0.98		0.93	0.999	1.99
		(31084.56)	(1365.56)			(1.79)	(0.01)		(0.10)		
South Rural	R	-72764.80	4412.14	-185.73	-19.62	120.17				0.914	0.09
		(13195.52)	(527.81)	(51.27)	(2.97)	(18.61)					
	T-F	20062.57	1122.55	-34.40	-1.70	9.05	0.97		0.98	0.999	1.99
		(12861.69)	(488.98)	(10.85)	(1.25)	(15.86)	(0.01)		(0.10)		
Northwest Michigant	R	-17719.62	11624.93	-67.54	-7.94	-1.61				0.963	0.33
		(1782.24)	(892.17)	(6.48)	(0.49)	(5.69)					
	T-F	9446.01		-9.33	-1.67	6.58	0.97		0.99	0.999	1.96
		(378.73)		(2.62)	(0.30)	(3.76)	(0.01)		(0.10)		
Northeast Michigan	R	-11740.23	8701.62	-20.20	0.66	-14.27				0.986	0.25
		(563.16)	(317.10)	(2.17)	(0.17)	(1.85)					
	T-F	3120.05	1372.28			-1.80	0.97		0.96	0.999	2.04
		(1379.26)	(655.68)			(1.71)	(0.01)		(0.10)		

Table 18: (Continued)

Region	Model Type	constant	POP	MAUNEM	MAGAS	MAINC	AR(1)[d]	AR(2)[e]	MA(1)[f]	R^2	D-W
Mackinac Straits	R	-2444.09	9839.78	5.58	-1.62	16.49				0.942	0.16
		(707.51)	(2419.43)	(2.04)	(0.14)	(0.97)					
	T-F	1305.42			-1.13	4.54	0.96		0.99	0.997	1.94
		(116.13)			(0.12)	(1.28)	(0.02)		(0.10)		
Eastern Upper Peninsula	R	-5209.56	3795.94	43.68	-4.23	6.89				0.814	0.15
		(1991.62)	(922.05)	(6.69)	(0.39)	(2.13)					
	T-F	-8560.32	3698.86		-0.79		1.00		0.95	0.997	1.90
		(5870.02)	(1014.84)		(0.22)		(0.00)		(0.10)		
Western Upper Peninsula	R	4817.55	-1979.43	-33.62	-3.01	46.75				0.911	0.09
		(1474.27)	(1308.20)	(8.33)	(0.57)	(3.64)					
	T-F	6149.20	-565.68	-0.21	-0.20	3.13	1.83	-0.84	0.82	0.999	1.96
		(1007.91)	(979.34)	(0.93)	(0.19)	(3.37)	(0.01)	(0.01)	(0.11)		

a. Regression model.
b. Transfer Function model.
c. Standard error in the parentheses.
d. AR(1): First-order autoregression, E_{t-1}.
e. AR(2): Second-order autoregression, E_{t-2}.
f. MA(1): First-order moving-average, E_{t-1}.

statistically insignificant at 5 % level. Each of the structural transfer function models explains at least 99.7 percent of variance in the dependent variable.

In most structural models, population size of the study region and statewide personal income levels have positive coefficients and statewide unemployment and U. S. retail price of gasoline have negative coefficients. Statewide personal income and population size of the study region have a negative coefficient in the model for northwest Michigan and the western upper peninsula. All components of the error model part of each structural equation are statistically significant at 5% level. Wayne and Oakland counties and the western upper peninsula are the only two regions having a second-order autoregressive term. Each of the other structural models has an ARMA(1,1) transfer function structure.

Time-Series Transfer Function models

Three time variables (time, time-squared, and time-cubed) are included in both a regression model and a transfer function model for each study region (Table 19). Both t and t^3 have positive coefficients. The quadratic time variable is negatively related to the dependent variable. Most of the coefficients of these regional trend models are significant at the 5% level. Each model has an ARMA(2,1) transfer function structure. The inclusion of the error part of the transfer function model to correct for the autocorrelation problem did not change the respective signs of coefficients of individual time variables,

Table 19: Time-Series Trend Models for Tourism-Related Employment in Michigan, 1974.07-1983.06, by Region.

Region	Model Type	Constant	t	t^2	t^3	AR(1)[d]	AR(2)[e]	MA(1)[f]	R^2	D-W
Michigan	R[a]	173981.93	1809.39	-12.72	0.010				0.960	0.03
		(1840.58)	(126.85)	(2.42)	(0.013)					
	T-F[b]	109515.66	5207.49	-66.14	0.268	1.77	-0.78	0.63	0.999	1.99
		(8617.51)[c]	(422.73)	(6.26)	(0.029)	(0.003)	(0.002)	(0.10)		
Wayne & Oakland	R	73347.28	517.26	-1.76	-0.013				0.931	0.03
		(854.13)[c]	(58.87)	(1.12)	(0.006)					
	T-F	46372.13	1943.79	-24.29	0.095	1.74	-0.76	0.53	0.999	1.99
		(4457.21)	(221.87)	(3.33)	(0.015)	(0.005)	(0.004)	(0.10)		
Out-State Urban Counties	R	41407.43	563.43	-3.78	0.004				0.956	0.03
		(59.52)	(11.85)	(-4.18)	(0.005)					
	T-F	32754.59	1067.88	-12.41	0.048	1.81	-0.83	0.99	0.999	1.99
		(1944.29)	(9.76)	(1.78)	(0.009)	(0.009)	(0.006)	(0.10)		
South Rural	R	37651.25	393.57	-3.51	0.007				0.953	0.04
		(346.18)	(23.86)	(0.45)	(0.002)					
	T-F	28866.96	892.46	-11.79	0.049	1.72	-0.75	0.86	0.999	1.99
		(1546.34)	(79.84)	(1.22)	(0.006)	(0.007)	(0.005)	(0.10)		
Northwest Michigan	R	6134.40	97.18	-0.96	0.003				0.898	0.02
		(124.40)	(8.57)	(0.16)	(0.001)					
	T-F	2245.08	290.00	-3.84	0.016	1.72	-0.74	0.60	0.999	1.96
		(966.00)	(44.84)	(0.64)	(0.003)	(0.007)	(0.005)	(0.10)		
Northeast Michigan	R	4116.66	58.86	-0.70	0.003				0.984	0.09
		(26.72)	(1.84)	(0.03)	(0.0001)					
	T-F	3899.28	69.93	-0.86	0.003	1.38	-0.48	0.94	0.999	2.00
		(60.16)	(3.46)	(0.06)	(0.0003)	(0.04)	(0.02)	(0.11)		

Table 19: (Continued).

Region	Model Type	Constant	t	t^2	t^3	AR(1)[d]	AR(2)[e]	MA(1)[f]	R^2	D-W
	R	937.26	23.61	-0.30	0.001				0.882	0.04
Mackinac Straits		(33.87)	(10.11)	(0.04)	(0.0002)					
	T-F	859.78	27.51	-0.35	0.002	1.61	-0.65	0.83	0.999	1.99
		(166.59)	(8.70)	(0.13)	(0.0006)	(0.08)	(0.05)	(0.13)		
	R	2456.34	60.29	-1.34	0.007				0.879	0.04
Eastern Upper		(53.45)	(3.68)	(0.07)	(0.0004)					
Peninsula	T-F	2309.18	66.64	-1.41	0.008	1.72	-0.76	0.77	0.999	2.00
		(192.38)	(10.88)	(0.18)	(0.0009)	(0.04)	(0.03)	(0.11)		
	R	3839.79	46.15	-0.23	-0.0002				0.900	0.03
Western Upper		(102.35)	(7.05)	(0.13)	(0.0007)					
Peninsula	T-F	3488.76	71.07	-0.70	0.0023	1.85	-0.88	0.73	0.999	1.99
		(267.74)	(16.48)	(0.28)	(0.0015)	(0.05)	(0.03)	(0.11)		

a. Regression model.

b. Transfer function model.

c. Standard error in parentheses.

t is equal to time (month).

d. AR(1): First-order autoregression, E_{t-1}.

e. AR(2): Second-order autoregression, E_{t-2}.

f. MA(1): First-order moving-average, V_{t-1}.

but did increase the percentage of variance explained up to 99.9% in each of regional trend series.

Structural-Time-Series Transfer function models

The models with both structural and time variables are no better than the time-series and the structural transfer function models in terms of measure for goodness-of-fit to the existing data and the simplicity of the model , and are therefore not presented here. As was the case with the statewide model, using both the group of three time factors and the group of four independent variables as the explanatory variables of the transfer function models did not enhance the power of the model to fit the existing data. The group of three time variables and the group of structural variables can roughly substitute for each other.

Forecast Accuracy of Regional Trend Models

For each sub-region, the forecast performance of the time series and the structural trend models for the months from July 1983 to June 1984 were evaluated. Differences between sub-regions were also investigated.

The time-series models have smaller mean absolute errors for southern Michigan while the structural models have smaller errors for northern Michigan (Table 20). Northern regions have larger percentage changes in tourism-related employment over time than southern regions. These changes are better predicted by changes in national, statewide and regional economic phenomena which are

Table 20: Forecast Accuracy of Transfer Function Models for Tourism-Related Employment Trends, 1983.07-1984.06, by Region.

Region	Model Type	MAE	RMSE	MAPE (%)	Statistic-UII
Michigan	Time-Series	537	802	0.22	0.0033
	Structural	3,151	3,645	1.28	0.0149
Wayne & Oakland	Time-Series	891	1,333	0.92	0.0118
	Structural	1,216	1,594	1.25	0.0166
Out-State Urban Counties	Time-Series	395	462	0.59	0.0070
	Structural	703	818	1.05	0.0124
South Rural	Time-Series	204	244	0.40	0.0048
	Structural	995	1,071	1.96	0.0212
Northwest Michigan	Time-Series	270	372	2.94	0.0403
	Structural	75	95	0.82	0.0103
Northeast Michigan	Time-Series	69	97	1.17	0.0164
	Structural	30	36	0.50	0.0061
Mackinac Straits	Time-Series	58	77	3.29	0.0433
	Structural	20	25	1.11	0.0145
Eastern Upper Peninsula	Time-Series	331	405	11.33	0.1381
	Structural	51	67	1.95	0.0228
Western Upper Peninsula	Time-Series	4	5	0.06	0.0008
	Structural	22	30	0.42	0.0050

captured by structural variables.

The western upper peninsula has the smallest MAPE of the time-series trend models, and the eastern upper peninsula has the largest MAPE. The MAPE of the individual structural models range from 0.42 for the western upper peninsula to 1.96 for southern rural counties. One to twelve months ahead structural (trend) forecasts are presented in Appendix B.

Regional Models for Seasonality

The seasonality series of tourism-related employment in each study region of Michigan was modeled using harmonic analysis. The first two harmonics explain at least 94% of variance in the seasonality series for each study region. The statistics for the first two harmonics are presented in Table 21. All 6 harmonics for individual regions are reported in Appendix B. Each of study regions shows a strong summer season peaking in August. For each region the first harmonic explains 70 percent or more of the seasonal variation of tourism-related employment. The Mackinac Straits region leads the other regions in the relative magnitude of the seasonal fluctuations (RA1=90.9 and RA2=17.9), followed by the eastern upper peninsula. In contrast, the lowest seasonal fluctuations in tourism-related employment is found in out-state urban counties (RA1=3.3 and RA2=1.8).

The first and second harmonics are included in every seasonal model. Together, they can explain 94 percent or more of the variance in the seasonality series. Some of the other four harmonics appear(s) in the respective seasonal models for the

Table 21: Selected Harmonic Measures of Tourism-Related Employment in Michigan, 1974-1984, by Region.

Study Region	First Harmonic			Second harmonic			Percent Variance Explained by 1st & 2nd (VAR1+VAR2)
	Relative Amplitude (RA1)	Percent Variance (VAR1)	Peak Timing	Relative Amplitude (RA2)	Percent Variance (VAR2)	Peak Timing	
Michigan	6.5	95.2	Aug. 1	1.0	2.3	June 5/ Dec. 5	97.5
Wayne & Oakland	4.1	82.6	Aug. 5	1.5	11.5	May 22/ Nov 22	94.1
Out-State Urban Counties	3.3	71.8	Aug. 9	1.8	21.1	May 17/ Nov 17	92.9
South Rural	9.1	96.8	Aug. 1	1.0	1.3	June 5/ Dec. 5	98.1
Northwest Michigan	17.9	79.7	Aug. 6	8.9	19.5	July 30/ Jan. 30	99.2
Northeast Michigan	17.0	95.6	Aug. 8	3.4	3.9	July 19/ Jan. 19	99.4
Mackinac Straits	80.9	94.8	Aug. 2	17.9	4.6	July 28/ Jan. 28	99.4
Eastern Upper Peninsula	43.8	96.2	Aug. 5	8.2	3.4	July 28/ Jan. 28	99.6
Western Upper Peninsula	5.9	71.5	Aug. 19	3.3	22.5	July 25/ Jan. 25	94.0

state of Michigan, eight urban counties, and the western upper peninsula. This shows that in these individual regions tourism-related employment has not only a strong annual pattern but also other patterns of variation over a one year period (Table 22).

Forecast Accuracy of Regional Seasonal Models

Monthly seasonal factors for each region do not fluctuate much over time, and can be accurately predicted by the seasonal models (Table 23). Errors in predicting seasonal factors for southern Michigan and the western upper peninsula are smaller than those for the northern regions.

Although the seasonal model for the Straits region can explain 98% of the variation in seasonal factors for the forecast period, it has the largest error among regions, followed by northwest Michigan. This is because a high value of goodness-of-fit measure (eta^2) can be obtained if a series has large fluctuations across the year(s) and its predictions can closely follow the actual patterns of the series. Also, during the period of July 1983 to June 1984, the observed seasonal factors are lower in summer but higher in winter than predicted from the previous 9 years.

Table 22: Seasonal Models for Tourism-Related Employment in Michigan, 1974-1984, by Region.

Region	Constant	1st harmonic	2nd harmonic	3rd harmonic	4th harmonic	5th harmonic	Variance Explained (%)
Michigan	1.00	0.06*SIN(30*t+255) (95.2%)	0.01*SIN(60*t+169) (2.3%)		0.01*SIN(120*t+238) (1.3%)		98.8
Wayne & Oakland	1.00	0.04*SIN(30*t+259) (82.6%)	0.02*SIN(60*t+198) (11.5%)		0.01*SIN(120*t+230) (3.7%)		97.8
Out-State Urban Counties	1.00	0.03*SIN(30*t+264) (71.9%)	0.02*SIN(60*t+207) (21.1%)	0.01*SIN(90*t+100) (3.1%)	0.01*SIN(120*t+238) (3.4%)		99.5
South Rural	1.00	0.09*SIN(30*t+256) (96.8%)	0.01*SIN(60*t+170) (1.3%)				98.1
Northwest Michigan	1.00	0.18*SIN(30*t+250) (79.7%)	0.09*SIN(60*t+62) (19.5%)				99.2

Note: Numbers in the parentheses are the percentage of variance in the seasonality series explained by the Nth harmonic of the model.

Table 22: (Continued).

Northeast Michigan	1.00	0.17*SIN(30*t+247) (95.6%)	0.03*SIN(60*t+81) (3.9%)				99.5
Mackinac Straits	1.00	0.81*SIN(30*t+253) (94.8%)	0.18*SIN(60*t+68) (4.6%)				99.4
Eastern Upper Peninsula	1.00	0.44*SIN(30*t+251) (96.2%)	0.08*SIN(60*t+67) (3.4%)				99.6
Western Upper Peninsula	1.00	0.06*SIN(30*t+236) (71.5%)	0.03*SIN(60*t+72) (22.5%)		0.01*SIN(120*t+234) (2.4%)	0.01*SIN(150*t+206) (2.0%)	98.4

Note: Numbers in the parentheses are the percentage of variance in the seasonality series explained by the Nth harminic of the model.

Table 23: Forecast Accuracy of Seasonal Models for Tourism-Related Employment in Michigan, 1983.07-1984.06, by Region.

Region	MAE	RMSE	MAPE (%)	Statistic-UII	Eta-Square
Michigan	0.0096	0.0111	0.95	0.0110	0.95
Wayne & Oakland	0.0100	0.0122	0.99	0.0121	0.91
Out-State Urban Counties	0.0099	0.0113	0.97	0.0112	0.90
South rural	0.0099	0.0123	0.97	0.0122	0.96
Northwest Michigan	0.0268	0.0332	2.50	0.0323	0.96
Northeast Michigan	0.0293	0.0327	2.93	0.0323	0.87
Mackinac Straits	0.0620	0.0683	7.76	0.0598	0.98
Eastern Upper Peninsula	0.0252	0.0321	2.55	0.0303	0.99
Western Upper Peninsula	0.0098	0.0127	0.98	0.0126	0.95

Forecasting Models for Each Region

The regional trend and seasonal models are multiplied together to generate the forecasting models for each study region. Each region has two forecasting models. One is the structural forecasting model and the other is the time series forecasting model. The structural and time series forecasting models are reported in Table 24 and Table 25, respectively.

Forecast Accuracy of Regional Forecasting Models

All regional structural forecasting models perform quite well in fitting the observed regional tourism-related employment (Figure B1.1 to Figure B1.8) and in forecasting monthly employment for the period July 1983-June 1984 (Table B2.1 to Table B2.8). Regional trend and seasonal patterns captured by the regional structural models are assumed to remain stable over the forecasting period. Among all structural models the model for the western upper peninsula has the smallest mean absolute percentage error (1.02) and Statistic-UII (0.0129). The model for Mackinac Straits region has the largest values of these two forecast error measures, MAPE (7.75%) and Statistic-UII (0.0637). Generally, models for northern regions have larger relative forecast errors than those for southern regions (Table 26).

The majority of the forecast errors can be attributed to the errors in predicting the seasonal components for northern regions, and to the errors in predicting the trend components for southern regions (see Table 20 and Table 23). For example, for

Table 24: Structural Forecasting Models for Tourism-Related Employment in Michigan, by Region.

Region	Forecasting model
Michigan	$[\,-419072.28 + 6949.34 * \mathrm{PSTAT}_t - 57.56 * \mathrm{MAUNEM}_t - 1.73 * \mathrm{MAGAS}_t + 300.41 * \mathrm{MAINC}_t + 0.97 * E_{t-1} + V_t + 0.84\, V_{t-1}\,] *$ $[\,1.00 + 0.06 * \mathrm{SIN}(30*t+255) + 0.01 * \mathrm{SIN}(60*t+169) + 0.01 * \mathrm{SIN}(120*t+238)]$
Wayne & Oakland	$[\,95327.75 - 1.31 * \mathrm{MAUNEM}_t - 1.20 * \mathrm{MAGAS}_t + 0.81 * \mathrm{MAINC}_t + 1.88 * E_{t-1} - 0.88 * E_{t-2} + V_t + 0.58 * V_{t-1}\,] *$ $[\,1.00 + 0.04 * \mathrm{SIN}(30*t+259) + 0.02 * \mathrm{SIN}(60*t+198) + 0.01 * \mathrm{SIN}(120*t+230)]$
Out-State Urban Counties	$[\,-115501.31 + 7587.43 * \mathrm{PURB}_t + 46.35 * \mathrm{MAINC}_t + 0.98 * E_{t-1} + V_t + 0.93 * V_{t-1}\,] *$ $[\,1.00 + 0.03 * \mathrm{SIN}(30*t+264) + 0.02 * \mathrm{SIN}(60*t+207) + 0.01 * \mathrm{SIN}(90*t+100) + 0.01 * \mathrm{SIN}(120*t+238)\,]$
South Rural	$[\,20062.57 + 1122.55 * \mathrm{PSOU}_t - 34.40 * \mathrm{MAUNEM}_t - 1.70 * \mathrm{MAGAS}_t + 9.05 * \mathrm{MAINC}_t + 0.97 * E_{t-1} + V_t + 0.98 * V_{t-1}\,] *$ $[\,1.00 + 0.09 * \mathrm{SIN}(30*t+256) + 0.01 * \mathrm{SIN}(60*t+170)\,]$
Northwest Michigan	$[\,9446.01 - 9.33 * \mathrm{MAUNEM}_t - 1.67 * \mathrm{MAGAS}_t + 6.58 * \mathrm{MAINC}_t + 0.97 * E_{t-1} + V_t + 0.99 * V_{t-1}\,] *$ $[\,1.00 + 0.18 * \mathrm{SIN}(30*t+250) + 0.09 * \mathrm{SIN}(60*t+62)\,]$

Table 24: (Continued).

Northeast Michigan	$[\ 3120.05 + 1372.28 * PNE_t - 1.80 * MAINC_t + 0.97 * E_{t-1} + V_t + 0.96 * V_{t-1}\ ] *$ $[\ 1.00 + 0.17 * SIN(30*t+247) + 0.03 * SIN(60*t+81)\ ]$
Mackinac Straits	$[\ 1305.42 - 1.13 * MAGAS_t + 4.54 * MAINC_t + 0.96 * E_{t-1} + V_t + 0.99 * V_{t-1}\ ] *$ $[\ 1.00 + 0.81 * SIN(30*t+253) + 0.18 * SIN(60*t+68)\ ]$
Eastern Upper Peninsula	$[\ -8560.32 + 3698.86 * PEUP_t - 0.79 * MAGAS_t + 1.00 * E_{t-1} + V_t + 0.95\ V_{t-1}\ ] *$ $[\ 1.00 + 0.44 * SIN(30*t+251) + 0.08 * SIN(60*t+67)\ ]$
Western Upper Peninsula	$[\ 6149.20 - 565.68 * PWUP_t - 0.21 * MAUNEM_t - 0.20 * MAGAS_t + 3.13 * MAINC_t + 1.83 * E_{t-1} - 0.84 * E_{t-2} + V_t +$ $0.82 * V_{t-1}] * [\ 1.00 + 0.06 * SIN(30*t+236) + 0.03 * SIN(60*t+72) + 0.01 * SIN(120*t+234) + 0.01 * SIN(150*t+206)\ ]$

Note: PSTAT: Population size of the state of Michigan.
PURB: Population size of other urban counties.
PEUP: Population size of eastern upper peninsula.
PSOU: Population size of south rural counties.
PNE: Population size of northeast Michigan.
PWUP: Population size of western upper peninsula.

Table 25: Time Series Forecasting Models for Tourism-Related Employment in Michigan, by Region.

Region	Forecasting model
Michigan	$[\ 109515.66 + 5207.49 * t - 66.14 * t^2 + 0.268 * t^3 + 1.77 * E_{t-1} - 0.78 * E_{t-2} + V_t + 0.63 * V_{t-1}\ ] *$ $[\ 1.00 + 0.06 * SIN(30*t+255) + 0.01 * SIN(60*t+169) + 0.01 * SIN(120*t+238)]$
Wayne & Oakland	$[\ 46372.13 + 1943.79 * t - 24.29 * t^2 + 0.095 * t^3 + 1.74 * E_{t-1} - 0.76 * E_{t-2} + V_t + 0.53 * V_{t-1}\ ] *$ $[\ 1.00 + 0.04 * SIN(30*t+259) + 0.02 * SIN(60*t+198) + 0.01 * SIN(120*t+230)]$
Out-State Urban Counties	$[\ 32754.59 + 1067.88 * t - 12.41 * t^2 + 0.048 * t^3 + 1.81 * E_{t-1} - 0.83 * E_{t-2} + V_t + 0.99 * V_{t-1}\ ] *$ $[\ 1.00 + 0.03 * SIN(30*t+264) + 0.02 * SIN(60*t+207) + 0.01 * SIN(90*t+100) + 0.01 * SIN(120*t+238)\ ]$
South Rural	$[\ 28866.96 + 892.46 * t - 11.79 * t^2 + 0.049 * t^3 + 1.72 * E_{t-1} - 0.75 * E_{t-2} + V_t + 0.86 * V_{t-1}\ ] *$ $[\ 1.00 + 0.09 * SIN(30*t+256) + 0.01 * SIN(60*t+170)\ ]$
Northwest Michigan	$[\ 2245.08 + 290.00 * t - 3.84 * t^2 + 0.016 * t^3 + 1.72 * E_{t-1} - 0.74 * E_{t-2} + Vt + 0.60 * V_{t-1}\ ] *$ $[\ 1.00 + 0.18 * SIN(30*t+250) + 0.09 * SIN(60*t+62)\ ]$

Table 25: (Continued).

Northeast Michigan	$[\ 3899.28 + 69.93 * t - 0.86 * t^2 + 0.003 * t^3 + 1.38 * E_{t-1} - 0.48 * E_{t-2} + V_t + 0.94 * V_{t-1}\ ] *$ $[\ 1.00 + 0.17 * SIN(30*t+247) + 0.03 * SIN(60*t+81)\ ]$
Mackinac Straits	$[\ 859.78 + 27.51 * t - 0.35 * MAINC_t + 0.002 * t^3 + 1.61 * E_{t-1} - 0.65 * E_{t-2} + V_t + 0.83 * V_{t-1}\ ] *$ $[\ 1.00 + 0.81 * SIN(30*t+253) + 0.18 * SIN(60*t+68)\ ]$
Eastern Upper Peninsula	$[\ 2309.18 + 66.64 * t - 1.41 * t^2 + 0.008 * t^3 + 1.72 * E_{t-1} - 0.76 * E_{t-2} + V_t + 0.77\ V_{t-1}\ ] *$ $[\ 1.00 + 0.44 * SIN(30*t+251) + 0.08 * SIN(60*t+67)\ ]$
Western Upper Peninsula	$[\ 3488.76 + 71.07 * t - 0.70 * t^2 + 0.0023 * t^3 + 1.85 * E_{t-1} - 0.88 * E_{t-2} + V_t + 0.73 * V_{t-1}\ ] *$ $[\ 1.00 + 0.06 * SIN(30*t+236) + 0.03 * SIN(60*t+72) + 0.01 * SIN(120*t+234) + 0.01 * SIN(150*t+206)\ ]$

Note: PSTAT: Population size of the state of Michigan.
PURB: Population size of other urban counties.
PEUP: Population size of eastern upper peninsula.
PSOU: Population size of south rural counties.
PNE: Population size of northeast Michigan.
PWUP: Population size of western upper peninsula.

Table 26 : Forecast accuracy of time series and structural forecasting models for tourism-related employment, 1983.07-1984.06, by region.

Region	Model Type	MAE	RMSE	MAPE (%)	Statistic-UII
Michigan	Time Series	1,902	2,322	0.77	0.0094
	Structural	3,850	4,568	1.54	0.0186
Wayne & Oakland	Time Series	1,224	1,502	1.25	0.0157
	Structural	1,456	1,893	1.48	0.0197
Out-state Urban Counties	Time Series	562	711	0.84	0.0107
	Structural	861	976	1.29	0.0147
South Rural	Time Series	607	724	1.19	0.0142
	Structural	1,246	1,345	2.48	0.0264
Northwest Michigan	Time Series	410	448	4.42	0.0474
	Structural	245	309	2.48	0.0327
Northeast Michigan	Time Series	132	157	2.20	0.0264
	Structural	191	207	3.24	0.0346
Mackinac Straits	Time Series	126	155	8.02	0.0763
	Structural	114	129	7.75	0.0637
Eastern Upper Peninsula	Time Series	300	403	11.59	0.1301
	Structural	88	107	3.25	0.0346
Western Upper Peninsula	Time Series	51	71	0.84	0.0117
	Structural	62	79	1.02	0.0129

the Mackinac Straits region, mean absolute percentage error (MAPE) for the seasonal model is 7.76% and for the trend model is 1.11%. The forecasting model has a MAPE of 7.75%. For southern rural counties, MAPE for the trend model is 1.96, for the seasonal model is 0.97, and for the forecasting model is 2.48. Thus, forecast errors for southern rural counties are attributable more to errors in predicting the trend component than the seasonal component.

Forecast accuracy of each regional time series model is also evaluated. All time series models can predict within plus or minus 2.20%, except the models for three tourism-dependent regions, i.e. northwest Michigan, the Straits region and the eastern upper peninsula. For southern rural counties, the Mackinac Straits region and the western upper peninsula, the majority of forecast errors can be attributed to the errors in predicting the seasonal components. Errors in predicting the trend components dominate the other five sub-regions. Structural models perform better for Northwest Michigan, the Mackinac Straits region and the eastern upper peninsula. Time series models perform better for the other five sub-regions.

Since forecasting models tend to deteriorate over time, it is recommended that the forecasting performance of these models be monitored over time. If obvious changes in trend, seasonal or both patterns are observed, the forecasting models should be updated or re-estimated.

GENERALIZABILITY OF THE STATEWIDE MODELS TO THE REGIONAL LEVEL

To complete the fifth and last study objective the ability of the statewide model to forecast at the regional level was tested. The test was performed by substituting the trend, seasonal, or both components of the statewide structural model for the corresponding component(s) of a regional structural model. The resulting models were then used to forecast monthly tourism-related employment in each region for the months from July 1983 to June 1984. The forecast accuracy of four models for each sub-region was evaluated. Each model predicts the values of a tourism-related employment index in the region, which can then be translated into the actual number of tourism-related jobs.

The procedures are demonstrated first for northwest Michigan (NW). Statewide trned forecasts and regional observations and trend forecasts were normalized using July 1974 as the base month (Table 27-28). Four index-series models (Equations 3.23 to 3.26 on pp. 73) were generated and evaluated. The composition of these four models are: (1) NW's trend and NW's seasonal components, (2) NW's trend and statewide seasonal components, (3) statewide trend and NW's seasonal components, (4) statewide trend and statewide seasonal components.

Forecast accuracy of these models were compared. The first model with both regional components performs best. Its monthly absolute error is not more than 5% (Table 29) and it has the smallest mean absolute error for the index, 0.021. This is translated into 186 jobs, i.e. 0.021 * 8,862, (Table 30).

Table 27: Normalization of Statewide Trend Model Component.

Month	Trend Forecasts	Forecasted Trend Index
1983.07	239,927	1.243[a]
1983.08	240,271	1.245
1983.09	240,661	1.247
1983.10	241,017	1.249
1983.11	241,522	1.251
1983.12	241,922	1.253
1984.01	242,293	1.255
1984.02	242,532	1.257
1984.03	242,739	1.258
1984.04	242,957	1.257
1984.05	243,129	1.260
1984.06	243,380	1.261

a. Column 2 divided by 192,998 (July 1974).

Table 28: Normalization of Northwest Michigan Model Components.

Month	Trend Forecasts	Forecasted Trend Index	Actual Trend Values	Actual Trend Index	Actual Seasonal Factor	Actual Regional Index
1983.07	9,166	1.034[a]	9,148	1.300[b]	1.240	1.612[c]
1983.08	9,169	1.035	9,182	1.305	1.270	1.657
1983.09	9,182	1.036	9,221	1.310	1.116	1.462
1983.10	9,189	1.037	9,263	1.316	0.996	1.311
1983.11	9,221	1.039	9,295	1.321	0.884	1.167
1983.12	9,236	1.042	9,323	1.325	0.898	1.190
1984.01	9,258	1.045	9,321	1.324	0.907	1.201
1984.02	9,277	1.047	9,276	1.318	0.889	1.172
1984.03	9,287	1.048	9,232	1.312	0.874	1.146
1984.04	9,293	1.049	9,183	1.305	0.844	1.101
1984.05	9,294	1.049	9,136	1.298	0.996	1.293
1984.06	9,316	1.051	9,106	1.294	1.110	1.436

a. Column 2 divided by 7,038 (July 1974).
b. Column 4 divided by 7,038 (July 1974).
c. Column 5 multiplied by Column 6.

Table 29: Forecasts of Tourism-Related Employment Index in Northwest Michigan, 1983.07-1984.06, by Model.

		Models			
Month	Actual Regional Index	1 RT*RS	2 RT*SS	3 ST*RS	4 ST*SS
1983.07	1.612	1.627	1.369	1.553	1.307
1983.08	1.657	1.634	1.368	1.561	1.307
1983.09	1.462	1.481	1.359	1.415	1.299
1983.10	1.311	1.282	1.312	1.226	1.255
1983.11	1.167	1.167	1.298	1.116	1.241
1983.12	1.190	1.164	1.281	1.112	1.223
1984.01	1.201	1.197	1.230	1.142	1.174
1984.02	1.172	1.185	1.231	1.130	1.174
1984.03	1.146	1.133	1.263	1.080	1.204
1984.04	1.101	1.134	1.286	1.080	1.224
1984.05	1.293	1.261	1.351	1.203	1.289
1984.06	1.436	1.481	1.404	1.411	1.338

Note:
RT: Regional trend component; RS: Regional seasonal component.
ST: Statewide trend component; SS: Statewide seasonal component.

Table 30: Forecast Accuracy of Four Models for Northwest Michigan, 1983.07-1984.06.

	Models			
Forecast	1 RT*RS	2 RT*SS	3 ST*RS	4 ST*SS
	----- Mean Absolute Error -----			
Index	0.021	0.111	0.060	0.108
Number of Jobs	186[a]	987	530	955

Note:
RT: Regional trend component; RS: Regional seasonal component.
ST: Statewide trend component; SS: Statewide seasonal component.

a. Row 1 multiplied by 8,862 (July 1974).

Substituting statewide seasonality for regional seasonality (model 2) results in larger forecast errors than sustituting statewide trends for regional trends (model 3). Forecast error of the pure statewide model is 4 times higher than the pure regional model. Monthly differences between the four sets of forecast errors are larger in the summer months than in the winter months. This is because monthly differences between regional and statewide seasonal factors are larger in the summer months than in the winter months. Forecasts of the pure regional model and the statewide-trend/regional-seasonality model follow the patterns of tourism-related employment in northwest Michigan during the forecasting period of July 1983 and June 1984, while it is not the case for forecasts of the regional-trend/statewide-seasonality model and the pure statewide model (Figure 10). This shows that northwest Michigan has similar trends as the state but different seasonality. Statewide seasonality patterns are not suitable to guide tourism planning and development in northwest Michigan. On the other hand, if a larger forecast error is acceptable, the model composed of the statewide trend and the seasonality of a subregion (like northwest Michigan) is recommended. Using this type of models we can save the costs of estimating the regional trend models which require more regional data and complex estimation methods. In contrast, seasonal factors can be estimated with one year of regional data.

This procedure was repeated for the other sub-regions of Michigan. Forecast accuracy of four models within the region and across the regions were compared. As expected, the pure regional model performs best in all regions, while the pure statewide

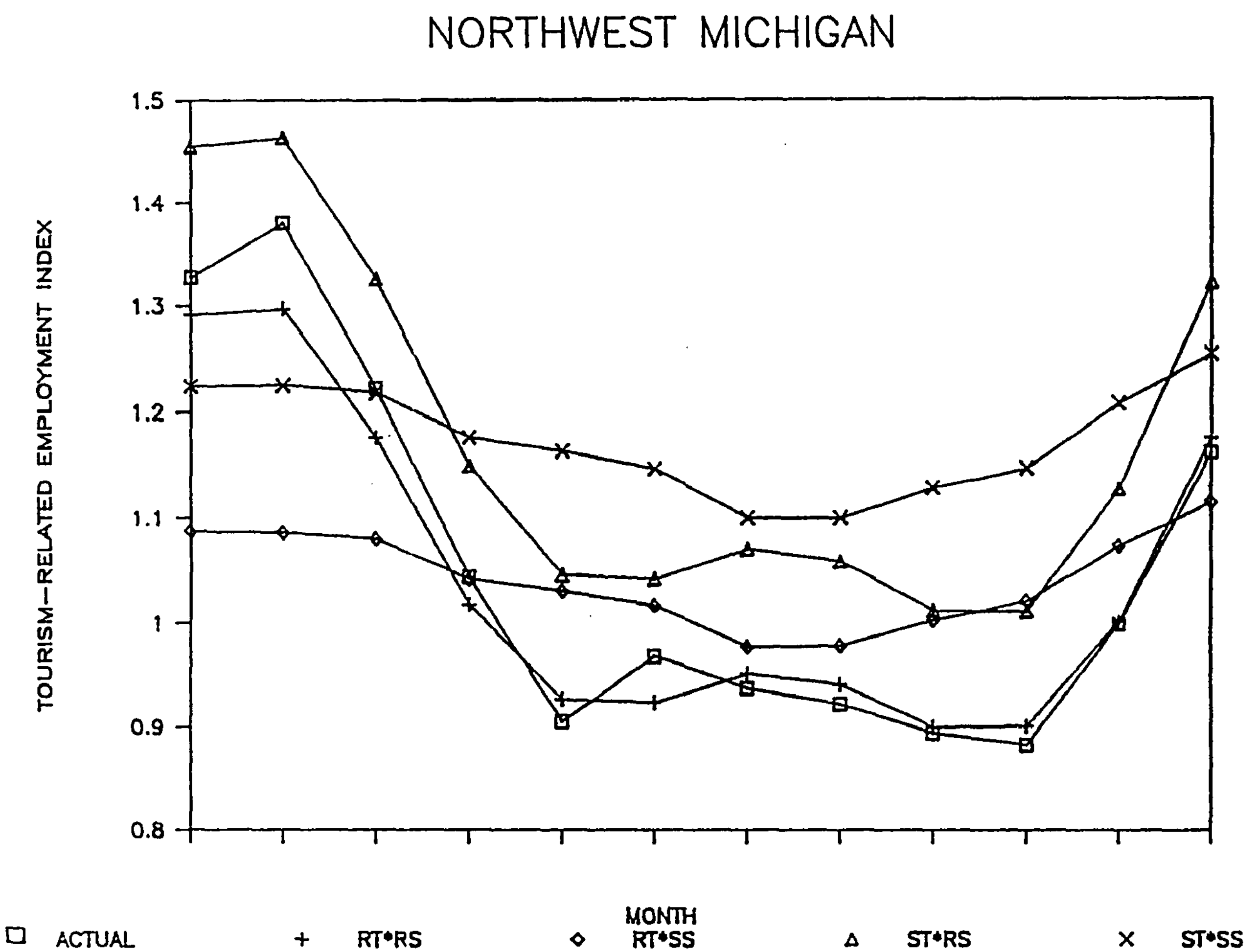

Figure 10: Actual and Predicted Index for Tourism-Related Employment in Northwest Michigan, 1983.07-1984.06, by Model.

model performs worst. This shows that patterns of statewide tourism-related employment do not generalize well to regional levels. Over the period examined, southern regions have experienced similar seasonal patterns as the state but large differences in trends. For each of these regions, larger forecast errors are observed when substituting the statewide trend component for the regional trend component (model 3) than when substituting the statewide seasonal component for the regional seasonal component (model 2). For example, for out-state urban counties, the regional-trend/statewide-seasonality model performs as well as the pure regional model and almost five times better than the model with statewide trend and regional seasonal components. Model 2 has a low value of mean absolute error for the employment index ,0.021, (Table 31) and corresponding actual number of tourism-related jobs, 1,026, (Table 32).

Northern regions, especially the Mackinac Straits region, show large differences in both trend and seasonal patterns from the state of Michigan. All of the northern regions' index-series models have larger forecast errors than southern regions' models. The Mackinac Straits region has the largest forecast errors of all four models across all sub-regions of Michigan. Except for the western upper peninsula, substituting statewide seasonal component for regional seasonal component (model 2) results in larger forecast errors than substituting statewide trend component for regional trend component (model 3) for all northern regions.

Table 31: Forecast Accuracy of Four Models of Tourism-Related Employment Index, 1983.07-1984.06, by Regions.

Region	Models: 1 RT*RS	2 RT*SS	3 ST*RS	4 ST*SS
	---- Mean Absolute Error, Job Index ---			
Wayne & Oakland	0.032	0.048	0.057	0.063
Out-State Urban Counties	0.015	0.021	0.130	0.130
South Rural	0.040	0.043	0.055	0.053
Northwest Michigan	0.021	0.111	0.060	0.108
Northeast Michigan	0.012	0.088	0.028	0.089
Mackinac Straits	0.057	0.785	0.314	0.796
Eastern Upper Peninsula	0.022	0.246	0.258	0.322
Western Upper Peninsula	0.008	0.038	0.189	0.189

Note:
RT: Regional trend component; RS: Regional seasonal component.
ST: Statewide trend component; SS: Statewide seasoanl component.

Table 32: Forecast Accuracy of Four Models for Number of Tourism-related Employment Jobs, 1983.07-1984.06, by Regions.

Region	Models 1 RT*RS	2 RT*SS	3 ST*RS	4 ST*SS
	-- Mean Absolute Error, Number of Jobs --			
Wayne & Oakland	2,623	3,956	4,707	5,207
Out-State Urban Counties	738	1,026	6,252	6,251
South Rural	1,826	1,976	2,521	2,411
Northwest Michigan	186	987	530	955
Northeast Michigan	64	475	153	478
Mackinac Straits	131	1,814	725	1,840
Eastern Upper Peninsula	91	1,038	1,086	1,356
Western Upper Peninsula	36	168	838	838

Note:
RT: Regional trend component; RS: Regional seasonal component.
ST: Statewide trend component; SS: Statewide seasoanl component.

* The number of tourism-related jobs for the base month (July 1974) is 83,086 for Wayne and Oakland counties, 48,067 for other urban counties, 45,438 for south rural counties, 8,862 for northwest Michigan, 5,392 for northeast Michigan, 2,312 for Mackinac Straits region, 4,210 for the eastern upper peninsula, and 4,440 for the western upper peninsula.

SUMMARY

Structural and time series forecasting models for tourism-related employment were developed for the state of Michigan and 8 sub-regions. Each forecasting model consists of a trend model and a seasonal model which were estimated separately and then multiplied together.

Statewide and regional models differ in their structures, accuracy, and sources of forecast errors. All or some of these four structural variables are included in the individual structural trend models if they have the signs of coefficients as hypothesized. All three time variables are included in each time series model. Error models can capture the part of the trend component not explained by the economic variables or the time variables.

The statewide seasonal model includes the first, second and fourth harmonics. The state of Michigan has a strong summer season and smaller semiannual and quarterly patterns of seasonal fluctuations in tourism-related employment across the year. In each regional seasonal model, the first and second harmonics can explain 94 percent or more variance in the regional seasonality series. Some of the other four harmonics are also included in the individual seasonal models. Differences in the structures between seasonal models show how regions differ from each other in seasonal patterns of tourism-related employment.

All Structural forecasting models accurately fit the data and most of them can forecast within 3.25% error in average, except for the Mackinac Straits region (7.75%), for the next 12

months from July 1983 to June 1984. The transfer function models deteriorate slowly over time. Forecast accuracy of the trend models is improved using adaptive forecasting. Seasonal models for those tourism-dependent regions did not perform well because these regions experienced large changes in their seasonal factors over the period examined. Generally, seasonal (trend) models contribute most forecast errors of structural forecasting models for northern (southern) regions. All time series models can forecast within 2.20% error, except the models for northwest Michigan, the Mackinac Straits region and the eastern upper peninsula. The structural models perform better than time series models for northwest Michigan, the Mackinac Straits region and the eastern upper peninsula. The time series models perform better for the other five sub-regions.

Finally, the statewide structural models do not generalize well to regional levels over the period examined. The state of Michigan differs from its individual sub-regions in trend, seasonal, or both patterns of tourism-related employment. This result again suggests that sub-regions are distinguishable from each other in the patterns of tourism activity, and each region needs to have its own forecasting model to guide tourism planning and management in the region.

CHAPTER VI

CONCLUSIONS

This study was designed to (1) identify and quantify temporal and spatial patterns of tourism activity in Michigan, (2) test alternative methods associated with the development of tourism forecasting models, and (3) examine the generalizability of statewide models to regional levels.

Methods employed to select the decomposition approach, to identify the seasonal patterns of tourism activity and the relationships underlying fluctuations in the trends of tourism activity over time, and to select techniques for forecast model-building were introduced and discussed in Chapter III. Statewide and regional trend and seasonal patterns of tourism-related employment were empirically analyzed and reported in Chapter IV. In Chapter V, patterns of tourism-related employment in each study region were specified as a structural and a time series forecasting models. Each model consists of a transfer function model of the trend and a harmonic model of seasonality. The models were subsequently used as forecasting equations to predict monthly tourism-related employment in each of the study regions. The forecasting performance of each model was evaluated using four measures of forecast accuracy. Finally, the ability of the statewide models to forecast at the regional levels was tested.

Chapter III, IV, and V report results relevant to these study objectives. All five study objectives were successfully achieved.

This concluding chapter summarizes the study, addresses major study limitations, provides recommendations for future research, discusses important findings of the study and suggest possible applications of the study results.

SUMMARY OF THE STUDY

The first objective of this study was to identify and quantify trend and seasonal patterns of tourism activity in the state of Michigan and its individual sub-regions. Data used here are monthly tourism-related employment series (1974-84) systematically collected and reported by Michigan Employment Security Commission. The application of multiplicative decomposition to the data series for each study region produced a trend and a seasonality series. Trend and seasonal patterns were identified from these series for each study region.

The second objective of this analysis was to compare trend and seasonal patterns across several regions of the state. Analysis of the behavior of these trend and seasonality series for the state and individual sub-regions revealed that patterns of tourism-related employment in individual study regions differ with each other in trend, seasonality, or both.

The third and fourth objectives of this study were to develop, estimate and evaluate alternative models for forecasting tourism activity in the state as a whole and individual sub-regions. A structural forecasting model composed of a structural transfer function model of the trend and a harmonic model of seasonality were developed for each of the study regions. Similar models using pure time series specifications were also estimated and compared with the statewide models. Both types of trend models performed quite well and had no serial autocorrelation problem. The harmonic model accurately fit the seasonal patterns over the period examined and predicted the future seasonal patterns within 3% of error, except for the Straits region. Statewide and regional forecasting models differ with each other in structure, accuracy and sources of forecasting errors.

For each study region, the trend and seasonal models were combined to produce monthly forecasts for tourism-related employment in each region. Forecast errors of structural models average 3.30% or less for the next 12 monthly observations (July 1983-June 1984), except the model for the Straits region. Forecast eroors of time series models average 2.20% or less, except the models for the three most heavily tourism-dependent regions. Forecast errors increase with increases in the lead time for forecast but can be decreased by using adaptive forecsting. Relative forecast errors of models for northern Michigan are larger than those for southern regions. For the structural forecasting models, most of forecast errors are contributed by forecast errors of seasonal models for northern Michigan, while they are evenly shared by forecast errors of both trend and seasonal models for southern regions. This is because the percentage changes in seasonal factors for tourism-related employment are larger in northern Michigan than in southern Michigan over the period forecasted.

The final objective of this study was to test the generalizability of statewide models to the regional level. The structural models were used for these tests. Four alternative models were obtained by substituting statewide trend, seasonal, or both components for the corresponding component(s) of the individual regional structural models. They were then used to forecast future levels of tourism-related employment in individual sub-regions of Michigan. Regional models based on statewide trend, seasonal or both components have larger errors than the estimated regional models. It is concluded that patterns of statewide tourism-related employment do not generalize well to the regional level. To reduce the costs of developing regional models the model consisting of the statewide trend component and the regional seasonal component is recommended for Wayne and Oakland counties and southern rural counties. The regional models should be used for the other six sub-regions of Michigan.

STUDY LIMITATIONS AND FUTURE RESEARCH

Several limitations to the data utilized, the isolation of tourism component from the data, the stability of the models, and the applications of the study results should be recognized. Research approaches to overcome these limitations are recommended.

First, the study period covered a time-span of only eleven years (1974-84). With only eleven years of data the cyclical component of the series could not be identified, since it takes about 5 to 7 years to complete a business cycle. Thus, cyclical and trend components were combined and interpreted as a trend component in the present study. Study of the characteristics and underlying forces of the cycle could not be performed. The analysis of the business cycle may provide some important information, such as the length of a cycle, fluctuation patterns of the cycle, and the relationships of the cycle to other components of the series.

The second limitation concerns the definition of tourism-related jobs. The patterns of tourism-related employment can only be applied to the employment of the private tourism-related sectors, since employees of state and local government and family business related to tourism activity are not included in the employment series. Also, the number of tourism-related jobs do not represent the number of full-time jobs solely created by tourism activity, since a half-time or a full-time job is counted as a job and tourism related employees serve not only tourists but also other travelers, and local residents. The tourism component and its importance to overall tourism-related employment in a region was not clearly understood.

It is recommended that the tourism component of tourism-related employment should be clearly isolated and identified. Two approaches to extract the tourism component from tourism-related employment data series are recommended here. One is to take the lowest level of tourism-related employment over the year as serving local residents. The difference between the lowest level of employment and the levels for other months could be treated as the tourism component of tourism-related employment. The assumption made here is that tourism-related services demanded by local permanent populations only create a certain number of jobs which are stable over the year. The usefulness of this approach was proved by O'Donnell (1970). Another approach proposed by Stynes (1986) involves developing a general model for the employment serving local populations. The tourism component of tourism-related employment can be derived by subtracting the prediction of the model from the reported level of employment.

The third limitation concerns the definition of tourism. The composition of tourism industry has not been well defined. The tourism-related employment statistics used in this study do not encompass all of the jobs in tourism-related businesses. Whether the results for the 9 tourism-related series would also hold for other tourism series is an open question.

It is recommended that the trend and seasonal patterns of other tourism-related data series (e.g. hotel/motel and eating and drinking places tax revenues, and gasoline sales) should be examined and compared with those of tourism-related employment data series (or hotel/motel employment data series if available). Differences in patterns of these data series can show the ranges of fluctuations in trend and seasonality of tourism activity. If such differences are significant, how to incorporate two or more tourism-related data series into one model in order to produce better tourism forecasts becomes an interesting research topic.

Fourth, trend and seasonal patterns of aggregate tourism-related employment may not be consistent with those of the individual sectors. The lack of data disaggregated by region for individual sectors restricts attempts to examine the differences in the behavior between the aggregate employment series and employment series for individual sectors. Information, such as which sector(s) contribute most to the fluctuations in the series and changes in the relative importance of the individual sectors to the overall tourism-related employment levels, may be helpful in interpreting patterns of tourism activity in each region.

It is recommended that the trend and seasonal patterns of the individual tourism-related sectors, especially hotel/motel and eating and drinking places should be identified for each region and compared. Valuable information may be obtained from such comparisons. Regional planners can determine which sectors have the potential in creating new jobs in the region based upon their grwoth in employment together with other economic development factors. Business managers can better develop marketing and management plans to compete with their competitors in other regions if they know the trend and seasonal patterns of tourism-related businesses in their own region and the other regions. Information on differences in the trend and seasonal patterns between the individual sectors and their aggregate enable researchers to determine whether the present aggregate trend and seasonal patterns can represent these patterns of tourism activity in the region, and, if not, which sector(s) can do better.

The fifth limitation concerns the predictive ability of the seasonal model. The nine-year monthly averages of seasonal factors were used to represent the seasonal patterns over time, since generally these seasonal factors have been relatively stable for the past nine years (1974:07-1983:06). During this period some changes in seasonal factors for the individual regions were observed. However, no effort was devoted to understanding and capturing these changes. The seasonal model developed here provided reasonably accurate fit to past data but may not be able to capture changes in the future.

Models which permit the twelve seasonal factors to change over time should be developed and compared with the fixed models here. Three approaches for developing seasonal models are recommended. One is to develop a transfer function model using all or some of six harmonics as the independent variables in an additive form. The error model should predict part of seasonal variations not captured by these harmonics. Another approach is to develop seasonal Box-Jenkins models. Finally, a simple moving average or exponential smoothing model for the seasonal factors may suffice. Comparing these alternative models with the seasonal model in this study may enable researchers to better understand the changing patterns of seasonality.

Sixth, regional trend and seasonal patterns are not always consistent with those of each county within the region. County planners and managers should be careful in taking and interpreting these regional patterns as the county's patterns to develop tourism plans for the county. The only regional variable used in the study is population size. Variations in the regional employment series may be better captured using more variables at the regional or local levels.

A research effort should be directed toward collecting data for a number of regional or local variables in addition to population size. Variables, such as weather index for travel, distance to and economic environment of the major market areas, and a tourism attraction index for the area are candidates to improve regional models. These variables can be helpful in not only differentiating counties to form more homogeneous sub-regions of the state but also in explaining trends and seasonal patterns of tourism activity. They are also useful in examining differences in these two patterns between the individual counties and the region as a whole and between regions. Continuing research is therefore necessary to monitor patterns of tourism activity in the region and its counties.

The last study limitation concerns the stability of the forecasting models over time. The economic structure of a tourism destination changes over time, the economic environment of the market areas at the national, state and regional levels change, the taste and preference of visitors changes, and weather conditions affecting the seasonality change. Therefore the trend and seasonal patterns of tourism activity in an area are likely to change over time. There is no assurance that the underlying forces of the trends and seasonality are stable over time. If changes in the trend and seasonal patterns of tourism activity are not acknowledged, forecasts may lead planners and managers to develop inappropriate tourism development and management plans and related policy. Therefore, cautious interpretation and application of the findings and the forecasting models of the study to some time beyond a certain time limit (like two years) are highly recommended. The usefulness of the models for forecasting should be carefully monitored over time, and the forecasting models should be updated and re-tested periodically.

CONCLUSIONS AND DISCUSSIONS

Five major conclusions can be drawn from the study. They are: (1) the relative magnitudes of fluctuations in trends and seasonality of tourism-related employment in Michigan do vary across regions; (2) both the economic variables and the time variables perform well in capturing the fluctuations in the trends of tourism-related employment; (3) the statewide forecasting models do not generalize well to the regional level; (4) decomposing a time series enables us to better identify and model the trend and seasonal patterns of tourism activity; and (5) transfer function techniques, harmonic analysis and the combined forecasting methods should receive more attentions in tourism forecasting.

First, spatial and temporal variations in tourism-related employment do exist in Michigan. Patterns in the individual regions change over time. This suggests that tourism activity should be carefully monitored and tracked to better understand past tourism patterns. Understanding historical patterns is essential to projectthem into the future. Different patterns of tourism-related employment between study regions are identified, showing that regions are distinguishable by trend, seasonal, or both patterns. This finding suggests that statewide tourism plans for Michigan must accommodate regional variations. Each study region should have its own plans for tourism development. This study provides forecasting models to forecast tourism-related employment in individual study regions. Such forecasts can be useful inputs to guide statewide and regional tourism development.

Second, time series factors and economic variables can successfully track the trends of tourism activity. Generally, economic variables perform slightly better than time variables in capturing fluctuations in tourism activity in the most tourism-dependent regions. Economic variables may capture the fluctuations of economic phenomena which in turn impact tourism businesses better than time series variables. It is hypothesized that tourism businesses are quite sensitive to the fluctuations in the economic enviroment of the nation, the state, and the region. If possible, economic variables at the national, state and region levels should be included in the model for tourism activity.

Third, predictions from statewide forecasting model should not be generalized to the local level without first checking the consistency of the respective patterns of tourism activity in the state and its sub-regions. If tourism patterns of the state and the sub-region are sigificantly different, using statewide forecasts to guide local tourism planning and management may result in inaccurate expectations on the levels of tourism activity, inappropriate and inefficient uses of local tourism resources, and finally instability of local economic situations. This suggests that tourism patterns of an area should be carefully identified and monitored. Regional planners and managers should understand the patterns of tourism businesses in their own regions and know the differences in the patterns between regions to enable themselves to make better tourism development and management plans. On the other hand, local variations in the patterns of tourism activity in the region should be considered in developing the regional tourism plans. If local variations are sigificant, it may call for a closer examination of tourism patterns across the region to group those counties with highly homogeneous tourism patterns into a region for further study.

The fourth conclusion is decomposing a time series is useful in better identifying and modeling the behavior of the time series. Multiplicative decomposition models outperform additive decomposition models in fitting the data especially for tourism-dependent regions. Èhis provides strong empirical support for their use recommended by BarOn (1972;1975) and Wheelwright and Makridakis (1983;1985). Researchers can clearly identify the trend and seasonal patterns and separate their respective effects on the overall behavior of the series. The underlying forces of the trends and seasonality can be carefully examined in order to better quantify and model these forces to capture the trends and seasonality of the series. From the forecasts of the trend and seasonal models planners and managers can know the future changes in the volume of tourism activity are due to fluctuations in trend, seasonality, or both. For each case, appropriate plans can be developed to deal with the foreseen situations.

The last conclusion is the transfer function techniques, harmonic analysis and methods of combining structural and time series models are applicable in tourism forecasting. The transfer function techniques employed in the study have a strong theoretical basis (Pindyck and Rubinfeld, 1981). Such techniques did perform well in not only identifying the relationships of independent variables and dependent variable but also correcting for the autocorrelation problems encountered in the pure regression models to increase the "goodness-of-fit" and predictive ability of the model. Also, the transfer function model is easily updated. These findings provide strong empirical support for their use recommended by Wander and Erden (1980) and Weller and Kurre (1987).

The harmonic model of seasonality performs well, particularly if no other variables are available to fully explain the variations in the seasonality series and predict future seasonal patterns. Variables like temperature, precipitation and snowfall for a given month can be used to explain the monthly seasonal fluctuations but are hard to accurately predict for the forecasting purposes. In this situation, descriptive measures of the periodic behavior of the seasonal patterns produced by harmonic analysis can be modeled and used to accurately predict future sesonal patterns. These measures enable planners and managers to determine the existence of a single or multiple tourism seasons, the peak timing of the season, and the relative importance of individual seasonal fluctuations in a year.

This study has demonstrated how the methods of combining structural and time series models can be used to develop forecasting models to successfully track and forecast the behavior of the series. The trend and seaonal patterns of the series were successfully modeled using transfer function techniques and harmonic analysis respectively. Through the processes of developing these models forces underlying the fluctuations in the trends and periodic patterns of the seasonality were better identified and understood.

The excellent performance of the combined forecasting methods observed in the present study provide further support for the potential uses of such methods on the other types of data series to help better identify and quantify the behavior of the series. It is believed that information provided by the combined forecasting model can help managers and planners better understand the patterns of tourism activity in an area, and consequently improve tourism planning and management decisions.

APPLICATIONS OF RESULTS

How can these results be directly applied to decision-making or to the management and development of tourism businesses in the state or a region? The first obvious use would be to employ the forecasting models to produce short-term predictions of tourism-related employment. These short-term predictions would, for example, help tourism planners of the state foresee future changes in the volume of tourism activity in the state as a whole and its individual sub-regions and then to efficiently allocate available resources to promote tourism businesses in regions with high potential growth in tourism-related employment. Also, with these predictions regional planners and managers can better supply tourism opportunities and services to meet the demand of tourism activity in the region. If a downward trend of tourism activity in a region is predicted, planners and managers can act together to develop appropriate plans to sustain and/or stimulate tourism businesses in the region. Knowing the seasonal patterns of tourism-related employment across the regions help business managers in better coordinating advertising, inventory and staff programs to compete with competitors in the region and in the other competitive regions.

Although the forecasting models look complicated and sophisticated, they are relatively easy to manipulate to produce forecasts. For example, the forecast equations can be programmed onto a LOTUS 1-2-3 spreadsheet file. In this form users only need to enter the predicted values of independent variables to produce forecasts. Forecast accuracy depends on the lead time of forecasts, i.e. the lead time equals 3 when forecasting for the next 3 months without using new observed values of the dependent variable. The larger the lead time of a forecast the larger the forecast error. Forecast errors can be reduced by updating the model. Users plug the new observed values of dependent and independent variables into the spreadsheet file and then the whole model is updated immediately without additional costs of re-estimating the whole equation. This simple procedure for updating the model is one of the characteristics of the transfer function model. A transfer function model can automatically re-calculate the values for the autoregressive and moving average components of the error model once the new values of dependent and independent variables are entered. It should be noted that the whole model needs to be re-estimated after a certain period of time or whenever there occur unusual situations of tourism activity.

Another use of the models is to perform the sensitivity analysis. From this analysis how much impact of changes in the individual independent variables on the dependent variable can be understood, when other variables are held constant.

The other use of the models is to track and monitor the impact of a (statewide or regional) tourism promotion program on tourism activity in an area, such as "Say Yes to Michigan" campaign. The predictions of the modls can be used as the control data because they are produced assuming that all underlying forces of the dependent variable are constant over time. By comparing the observations and predictions the magnitude of the impact of a campaign can be better understood and justified.

The study is part of efforts of the Travel, Tourism, Recreation and Resource Center at Michigan State University to collect, analyze, and disseminate tourism-related information to help the tourism industry in the state. This analysis provides useful information that will help in better understanding the patterns of tourism activity in the state. The analysis and modeling procedures employed in this study provide a useful framework to track, monitor and forecast tourism activity at the state, regional and local levels. With the identified tourism patterns and tourism forecasting models for tourism activity in the state, the center can better assist planners and business managers in developing appropriate tourism development and management plans for their areas.

The study provides useful information on temporal and spatial variations in tourism related employment in Michigan. These information enable planners and managers to better understand the patterns of tourism activity in various regions of the state. Predictions of the models are helpful in designing future tourism development plans. It is further hoped that these procedure and methods for analyzing and forecasting tourism activity can stimulate more research in the procedure and methods employed to better monitor and forecast tourism activity.

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APPENDIX A

DEFINITIONS OF HARMONIC STATISTICS MEASURES

The formula for the Fourier series commonly used in harmonic analysis, defined by Rayner (1971), is:

$$X_k = [A_k SIN(k\theta+\phi_k]$$
$$=A_0+A_1 SIN(\theta+\phi_1)+A_2 SIN(2\theta+\phi_2)+...+$$
$$A_k SIN(k\theta+\phi_k)+...+A_N SIN(N\theta+\phi_k) \quad (A.1)$$

X_k is the time series, A_k is the amplitude for harmonic k. A_k measures the magnitude of the fluctuation of sine curve k around the arithmetic mean of the data series (A_0). ϕ_k is the phase angle which determines the time of the year at which the peak (and consequently trough) for harmonic k occurs. θ is a portion of the study period and measured as an angle for each of the data point in the series, i.e. θ=360/N, N=1,2,...,k, assumed that 360 degrees (days) is equivalent to one year period.

An alternative expression of Equation (A.1) can be obtained through the use of the trifonometric relationship

$$\sin(w+z) = \sin(z)\cos(w)+\cos(z)\sin(w) \quad (A.2)$$

Equation (A.1) may therefore be rewritten as

$$X_k = [A_k\sin(\phi_k)\cos(k_\theta)+A_k\cos(\phi_k)\sin(k_\theta)] \quad (A.3)$$

When a_k and b_k are defined as

$$a_k = A_k\sin(\phi_k), \text{ and} \quad (A.4)$$
$$b_k = A_k\cos(\phi_k), \quad (A.5)$$

Equation (A.3) becomes

$$X_k = [a_k\cos(k_\theta)+b_k\sin(k_\theta). \qquad (A.6)$$

Then, A_k and O_k can be computed from a_k and b_k, since

$$\cos^2(w) + \sin^2(w) = 1. \qquad (A.7)$$

The amplitude, A_k, is defined by,

$$A_k = (a_k{}^2+b_k{}^2)^{1/2}. \qquad (A.8)$$

The relative amplitude, R_k, is defined by,

$$R_k = (A_k/A_0)*100.0. \qquad (A.9)$$

The phase angle, ϕ_k, is defined by,

$$\phi_k = \pi + \text{arctangent}\left(\frac{|b_k|}{|a_k|}\right) \qquad (A.10)$$

The exact date of peak, T_k, can be computed,

$$T_k = \{(360/k)-[(\phi_k/k)-(90.0/k)]\}*(365/360)+14 \qquad (A.11)$$

under the assumption that the first data point starts from January 15.

The variance explained by harmonic k, σ_k^2 , is defined by,

$$\sigma_k^2 = \frac{A_k^2}{2} = \frac{(a_k^2 + b_k^2)^{1/2}}{2} \tag{A.12}$$

And the total variance explained by the six harmonics is,

$$\sigma^2 = \sum_{t=1}^{N} \sigma_k^2 \tag{A.13}$$

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

$$V_k = \frac{\sigma_k^2}{\sigma^2} \tag{A.14}$$

APPENDIX B

SUMMARY TABLES AND FIGURES FOR CHAPTER V

Table B1.1: Harmonic Measures of Tourism-Related Employment in Wayne and Oakland Counties, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.04	259	4.1	82.6	Aug. 5
2	.02	198	1.5	11.5	
3	.01	155	.5	1.3	
4	.01	230	.9	3.7	
5	.00	260	.3	.5	
6	.00	270	.3	.4	

Table B1.2: Harmonic Measures of Tourism-Related Employment in Out-State Urban Counties, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.03	264	3.3	71.9	Aug. 9
2	.02	207	1.8	21.1	
3	.01	100	.7	3.1	
4	.01	238	.7	3.4	
5	.00	262	.2	.3	
6	.00	270	.2	.2	

Table B1.3: Harmonic Measures of Tourism-Related Employment in South Rural Counties, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.09	256	9.1	96.8	Aug. 1
2	.01	170	1.0	1.3	
3	.01	152	1.0	1.1	
4	.01	240	.7	.6	
5	.00	244	.4	.2	
6	.00	270	.2	.0	

Table B1.4: Harmonic Measures of Tourism-Related Employment in Northwest Michigan, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.18	250	17.9	79.7	Aug. 6
2	.09	62	8.9	19.5	
3	.00	205	.3	.0	
4	.00	299	.3	.0	
5	.02	170	1.7	.6	
6	.00	270	.1	.0	

Table B1.5: Harmonic Measures of Tourism-Related Employment in Northeast Michigan, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.17	247	17.0	95.7	Aug. 8
2	.03	81	3.4	3.9	
3	.00	212	.5	.1	
4	.01	299	1.0	.3	
5	.00	160	.2	.0	
6	.00	90	.2	.0	

Table B1.6: Harmonic Measures of Tourism-Related Employment in the Mackinac Straits Region, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.81	253	80.9	94.8	Aug. 2
2	.18	68	17.9	4.6	
3	.04	48	4.3	.3	
4	.02	276	1.6	.0	
5	.04	202	4.4	.3	
6	.00	90	.2	.0	

Table B1.7: Harmonic Measures of Tourism-Related Employment in the Eastern Upper Peninsula, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.44	251	43.8	96.2	Aug. 5
2	.08	67	8.2	3.4	
3	.01	82	1.5	.1	
4	.01	272	1.3	.1	
5	.02	215	2.1	.2	
6	.00	90	.0	.0	

Table B1.8: Harmonic Measures of Tourism-Related Employment in the Western Upper Peninsula, 1974-84.

Harmonic i	Amplitude A_i	Phase Angle ϕ_i (degrees)	Relative Amplitude	Variance Explained	Peak Timing
0	1.00				
1	.06	236	5.9	71.5	Aug. 19
2	.03	72	3.3	22.5	
3	.01	179	.9	1.5	
4	.01	234	1.1	2.4	
5	.01	206	1.0	2.0	
6	.00	270	.2	.1	

Table B2.1: Forecasts for Tourism-Related Employment in Wayne and Oakland Counties, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	93,582	93,612	1.03	1.03	96,562	95,992[a]	570[b]	0.59[c]
1983.08	93,797	93,847	1.04	1.02	97,355	95,397	1958	2.01
1983.09	94,026	94,061	1.04	1.02	97,353	96,154	1199	1.23
1983.10	94,405	94,254	1.01	1.01	94,678	94,834	-156	0.16
1983.11	94,955	94,431	0.99	1.00	93,919	94,885	-966	1.03
1983.12	95,518	94,587	0.99	0.99	94,098	93,886	212	0.23
1984.01	96,044	94,732	0.94	0.95	90,398	89,701	697	0.77
1984.02	96,552	94,860	0.94	0.94	90,609	89,252	1357	1.50
1984.03	97,011	94,969	0.95	0.97	91,848	92,098	-250	0.27
1984.04	97,413	95,062	1.00	0.99	97,559	94,196	3363	3.45
1984.05	97,762	95,146	1.04	1.03	101,517	98,081	3436	3.38
1984.06	98,089	95,228	1.06	1.05	103,576	100,272	3304	3.19

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.2: Forecasts for Tourism-Related Employment in Out-State Urban Counties, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	64,999	64,939	1.02	1.00	65,942	65,097[a]	845[b]	1.28[c]
1983.08	65,220	65,063	1.02	1.01	66,205	65,637	568	0.86
1983.09	65,431	65,193	1.04	1.03	67,625	66,850	775	1.15
1983.10	65,661	65,323	1.02	1.00	67,119	65,454	1,665	2.48
1983.11	65,914	65,444	1.01	1.00	66,219	65,285	934	1.41
1983.12	66,202	65,573	1.00	1.00	65,875	65,389	486	0.74
1984.01	66,488	65,640	0.96	0.96	63,579	63,175	404	0.63
1984.02	66,734	65,684	0.95	0.95	63,263	62,435	828	1.31
1984.03	66,924	65,727	0.96	0.97	64,226	63,785	441	0.69
1984.04	66,980	65,770	0.99	1.00	66,499	65,717	782	1.18
1984.05	66,957	65,816	1.03	1.04	69,209	68,559	650	0.94
1984.06	66,954	65,862	1.05	1.04	70,601	68,645	1,956	2.77

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.3: Forecasts for Tourism-Related Employment in South Rural Counties, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	49,418	49,333	1.10	1.09	54,147	53,727[a]	420[b]	0.78[c]
1983.08	49,733	49,353	1.10	1.08	54,615	53,245	1,370	2.51
1983.09	50,057	49,402	1.07	1.05	53,604	52,026	1,578	2.94
1983.10	50,342	49,430	1.01	1.02	50,805	50,420	385	0.76
1983.11	50,550	49,546	0.98	0.98	49,476	48,696	780	1.58
1983.12	50,738	49,602	0.97	0.94	48,993	46,857	2,136	4.36
1984.01	50,889	49,655	0.92	0.91	46,850	45,405	1,445	3.08
1984.02	50,986	49,713	0.91	0.91	46,601	45,031	1,570	3.37
1984.03	51,085	49,749	0.94	0.93	47,932	46,171	1,761	3.67
1984.04	51,123	49,789	0.98	0.98	50,022	48,618	1,404	2.81
1984.05	51,109	49,792	1.03	1.03	52,482	51,409	1,073	2.05
1984.06	51,112	49,844	1.07	1.07	54,573	53,539	1,034	1.89

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.4: Forecasts for Tourism-Related Employment in Northwest Michigan, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	9,148	9,166	1.29	1.25	11,766	11,445[a]	321[b]	2.73[c]
1983.08	9,182	9,169	1.33	1.25	12,233	11,494	739	6.04
1983.09	9,221	9,182	1.18	1.13	10,830	10,419	411	3.79
1983.10	9,263	9,189	1.00	0.98	9,249	9,025	224	2.43
1983.11	9,295	9,221	0.86	0.89	8,024	8,229	-205	2.55
1983.12	9,323	9,236	0.92	0.89	8,579	8,196	383	4.46
1984.01	9,321	9,258	0.89	0.91	8,305	8,428	-123	1.48
1984.02	9,276	9,277	0.88	0.90	8,174	8,341	-167	2.04
1984.03	9,232	9,287	0.86	0.86	7,922	7,977	-55	0.70
1984.04	9,183	9,293	0.85	0.86	7,822	7,982	-160	2.05
1984.05	9,136	9,294	0.97	0.95	8,855	8,875	-20	0.23
1984.06	9,106	9,316	1.13	1.12	10,293	10,423	-130	1.26

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.5: Forecasts for Tourism-Related Employment in Northeast Michigan, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	5,870	5,862	1.14	1.19	6,694	6,953[a]	-259b[b]	3.87[c]
1983.08	5,882	5,866	1.17	1.19	6,844	6,967	-123	1.79
1983.09	5,895	5,868	1.10	1.13	6,453	6,602	-149	2.30
1983.10	5,908	5,872	1.00	1.04	5,887	6,088	-201	3.42
1983.11	5,926	5,874	0.96	0.96	5,668	5,641	27	0.47
1983.12	5,940	5,877	0.92	0.91	5,456	5,339	117	2.15
1984.01	5,939	5,878	0.91	0.87	5,393	5,132	261	4.83
1984.02	5,923	5,880	0.90	0.85	5,321	4,999	322	6.05
1984.03	5,906	5,881	0.88	0.85	5,179	5,019	160	3.08
1984.04	5,895	5,882	0.93	0.90	5,510	5,317	193	3.50
1984.05	5,887	5,883	1.05	1.00	6,188	5,894	294	4.75
1984.06	5,875	5,884	1.14	1.11	6,733	6,549	184	2.73

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.6: Forecasts for Tourism-Related Employment in the Mackinac Straits Region, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	1,774	1,774	1.84	1.94	3,264	3,444[a]	-180[b]	5.52[c]
1983.08	1,781	1,777	1.84	1.93	3,272	3,432	-160	4.88
1983.09	1,786	1,780	1.59	1.57	2,842	2,790	52	1.83
1983.10	1,790	1,784	1.19	1.07	2,134	1,909	225	10.56
1983.11	1,785	1,787	0.63	0.68	1,133	1,208	-75	6.61
1983.12	1,778	1,791	0.51	0.47	908	846	62	6.77
1984.01	1,775	1,795	0.44	0.39	775	704	71	9.14
1984.02	1,773	1,797	0.41	0.35	736	634	102	13.91
1984.03	1,767	1,798	0.42	0.38	751	688	63	8.41
1984.04	1,762	1,799	0.52	0.60	920	1,073	-153	16.60
1984.05	1,757	1,801	1.08	1.04	1,905	1,874	31	1.64
1984.06	1,754	1,803	1.51	1.58	2,655	2,844	-189	7.13

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.7: Forecasts for Tourism-Related Employment in the Eastern Upper Peninsula, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	2,943	2,963	1.47	1.49	4,328	4,414[a]	-86[b]	1.98[c]
1983.08	2,944	2,966	1.51	1.50	4,441	4,437	4	0.10
1983.09	2,945	2,971	1.36	1.32	4,007	3,929	78	1.96
1983.10	2,949	2,977	1.15	1.07	3,399	3,184	215	6.32
1983.11	2,951	2,982	0.83	0.85	2,443	2,541	-98	4.02
1983.12	2,951	2,987	0.74	0.72	2,180	2,154	26	1.20
1984.01	2,950	2,992	0.63	0.66	1,852	1,968	-116	6.24
1984.02	2,945	2,996	0.63	0.63	1,851	1,893	-42	2.29
1984.03	2,934	2,997	0.65	0.66	1,902	1,973	-71	3.71
1984.04	2,917	2,995	0.76	0.78	2,211	2,345	-134	6.08
1984.05	2,897	2,996	1.06	1.02	3,073	3,056	17	0.55
1984.06	2,883	3,002	1.29	1.30	3,726	3,898	-172	4.61

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

Table B2.8: Forecasts for Tourism-Related Employment in the Western Upper Peninsula, 1983.07-1984.06.

MONTH	ACTUAL REGIONAL TREND	TREND FORECAST	ACTUAL REGIONAL SEASONAL	SEASONAL FORECAST	ACTUAL REGIONAL SERIES	REGIONAL FORECAST	REGIONAL FORECAST ERRORS	REGIONAL ABS ERROR (%)
1983.07	5,950	5,952	1.08	1.07	6,427	6,396[a]	31[b]	0.49[c]
1983.08	5,976	5,981	1.10	1.08	6,545	6,470	75	1.14
1983.09	6,006	6,006	1.06	1.05	6,323	6,314	9	0.15
1983.10	6,038	6,026	1.01	1.01	6,057	6,062	-5	0.08
1983.11	6,062	6,043	0.97	0.97	5,872	5,867	5	0.09
1983.12	6,077	6,057	1.02	1.00	6,190	6,041	149	2.41
1984.01	6,092	6,068	0.97	0.97	5,915	5,864	51	0.87
1984.02	6,108	6,076	0.96	0.96	5,885	5,837	48	0.81
1984.03	6,121	6,080	0.96	0.95	5,846	5,804	42	0.72
1984.04	6,122	6,083	0.94	0.92	5,747	5,601	146	2.53
1984.05	6,120	6,085	0.96	0.98	5,861	5,978	-117	2.00
1984.06	6,120	6,086	1.04	1.03	6,353	6,289	64	1.00

a. Column 3 multiplied to column 5.
b. Column 6 minus column 7.
c. Column 8 divided by column 6.

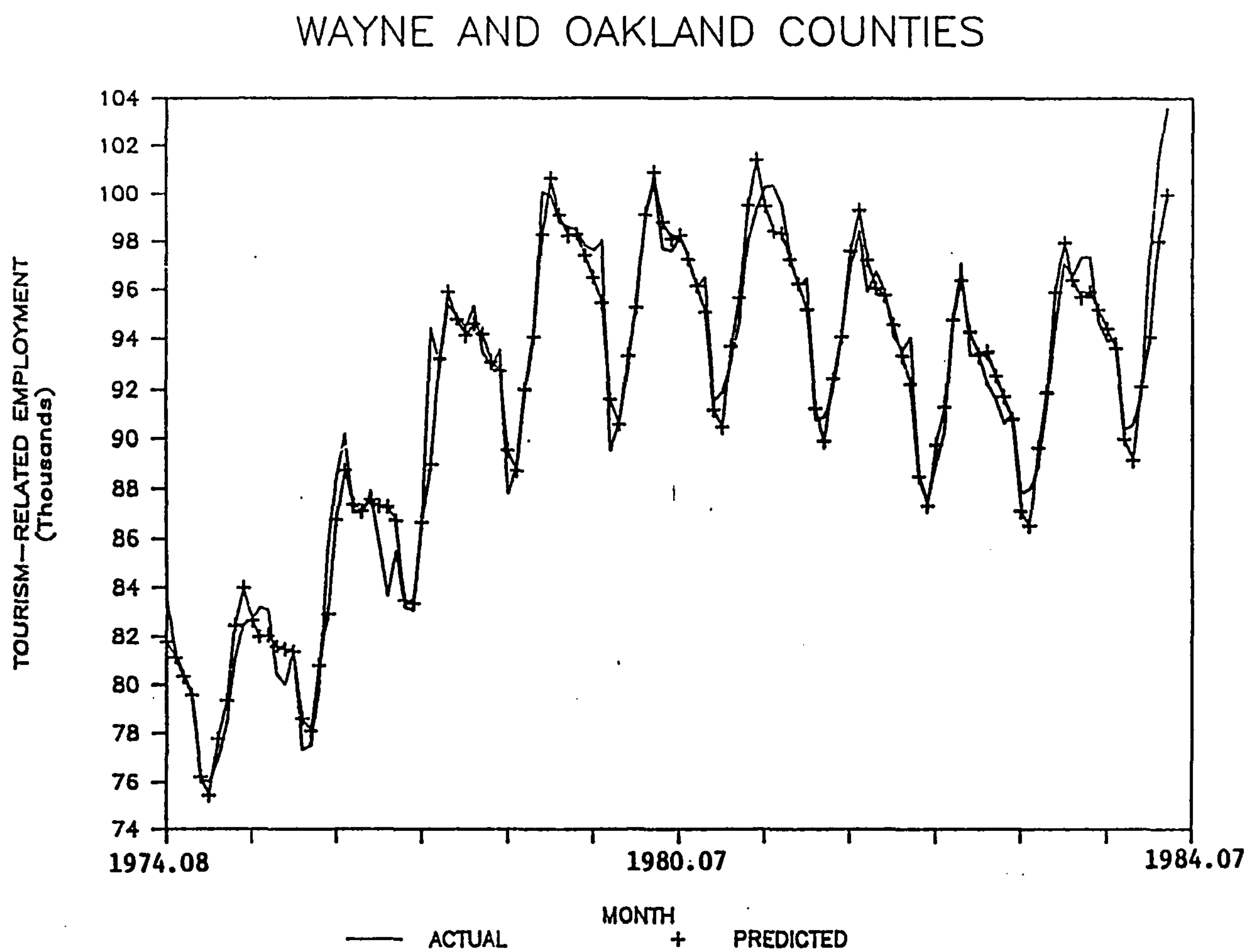

Figure B1.1: Actual and Predicted Tourism-Related Employment in Wayne and Oakland Counties, 1974.08-1984.06.

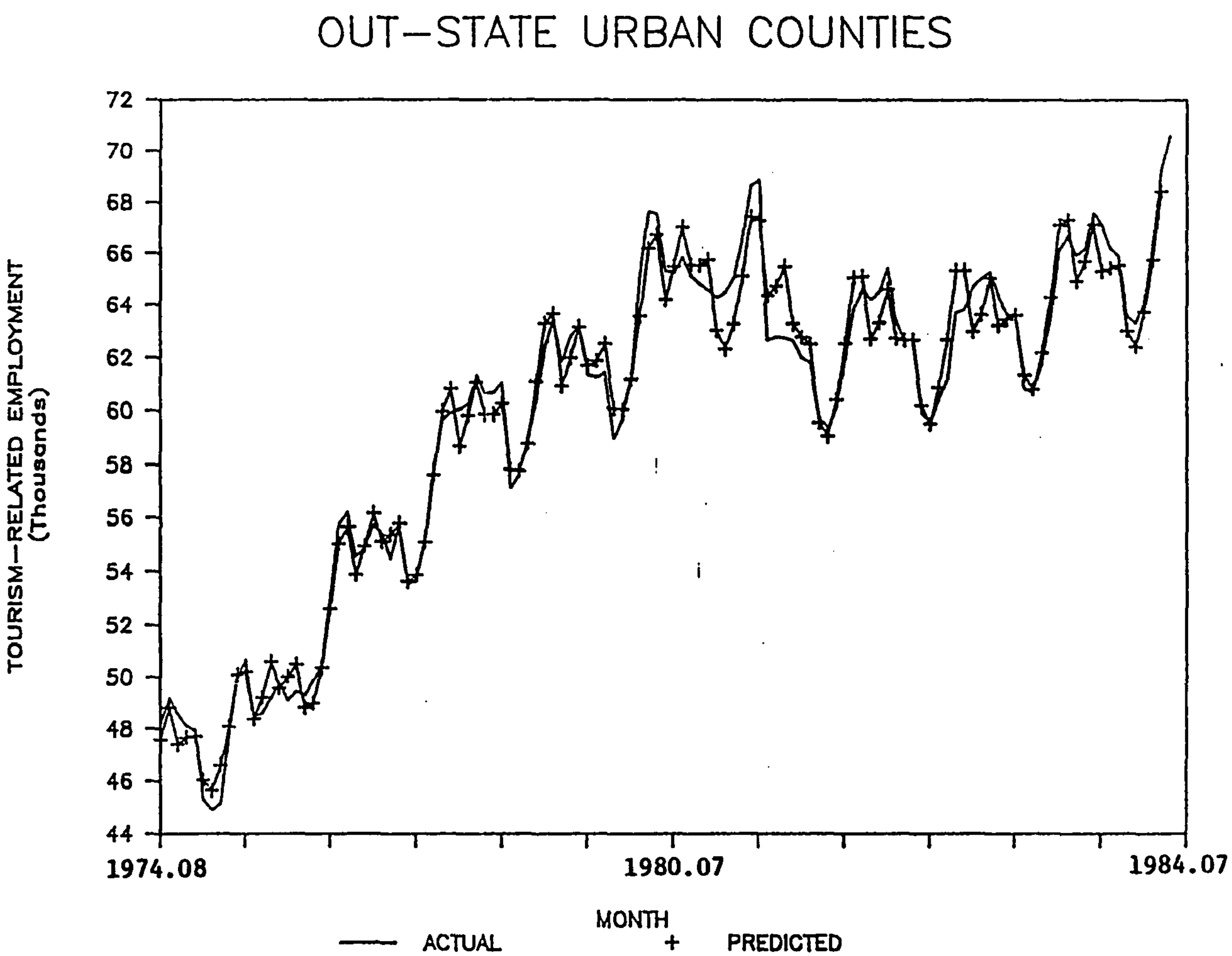

Figure B1.2: Actual and Predicted Tourism-Related Employment in Out-State Urban Counties, 1974.08-1984.06.

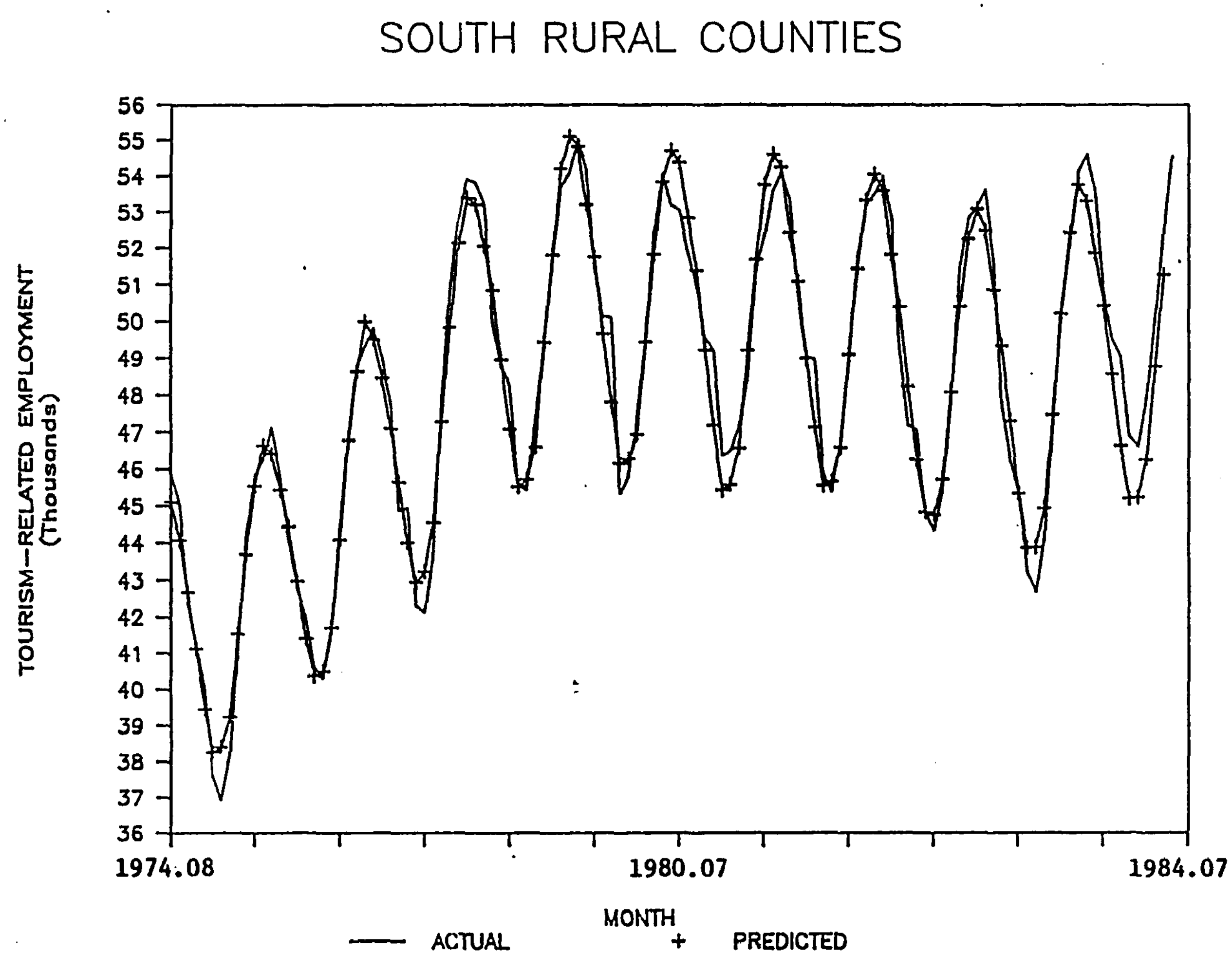

Figure B1.3: Actual and Predicted Tourism-Related Employment in Southern Rural Counties, 1974.08-1984.06.

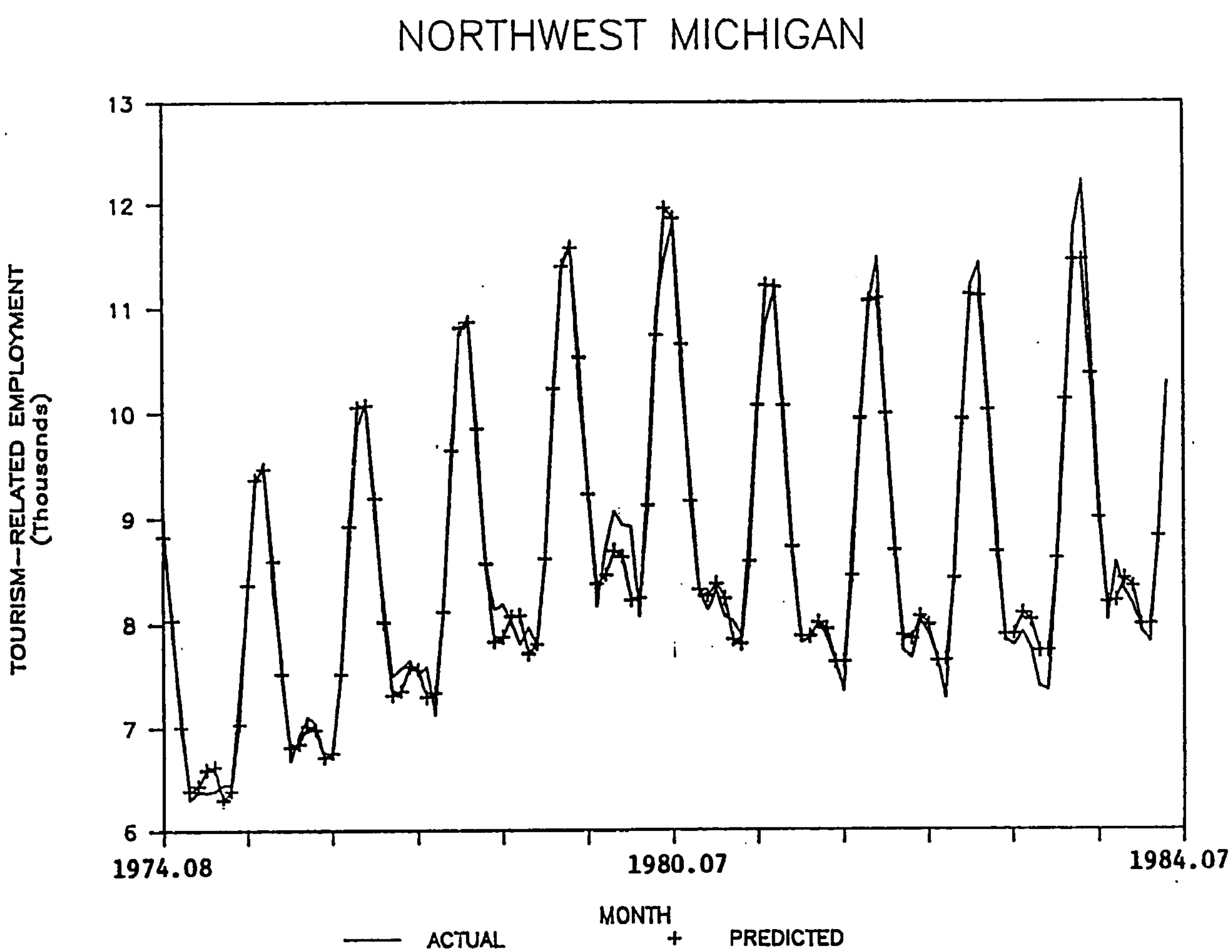

Figure B1.4: Actual and Predicted Tourism-Related Employment in Northwest Michigan, 1974.08-1984.06.

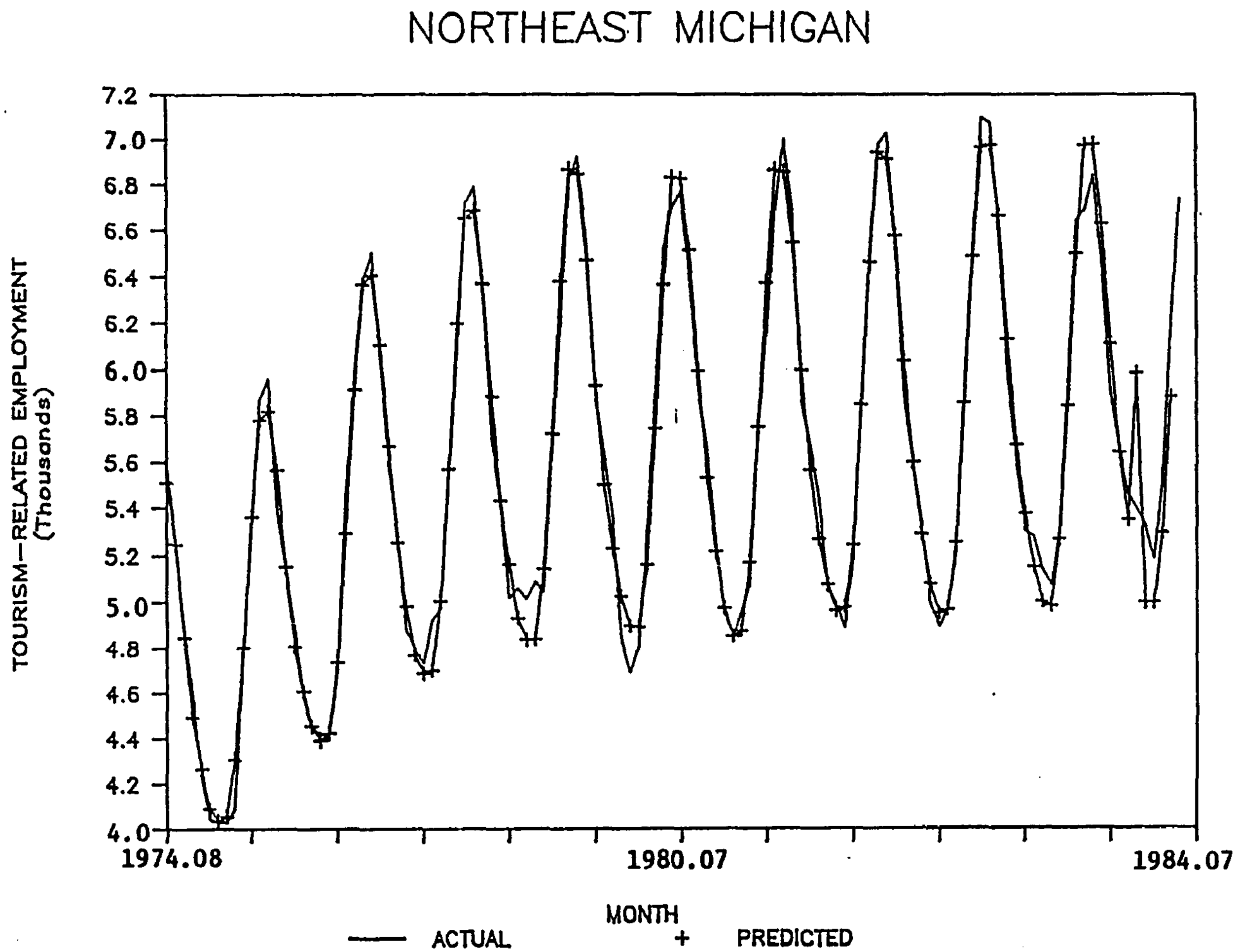

Figure B1.5: Actual and Predicted Tourism-Related Employment in Northeast Michigan, 1974.08-1984.06.

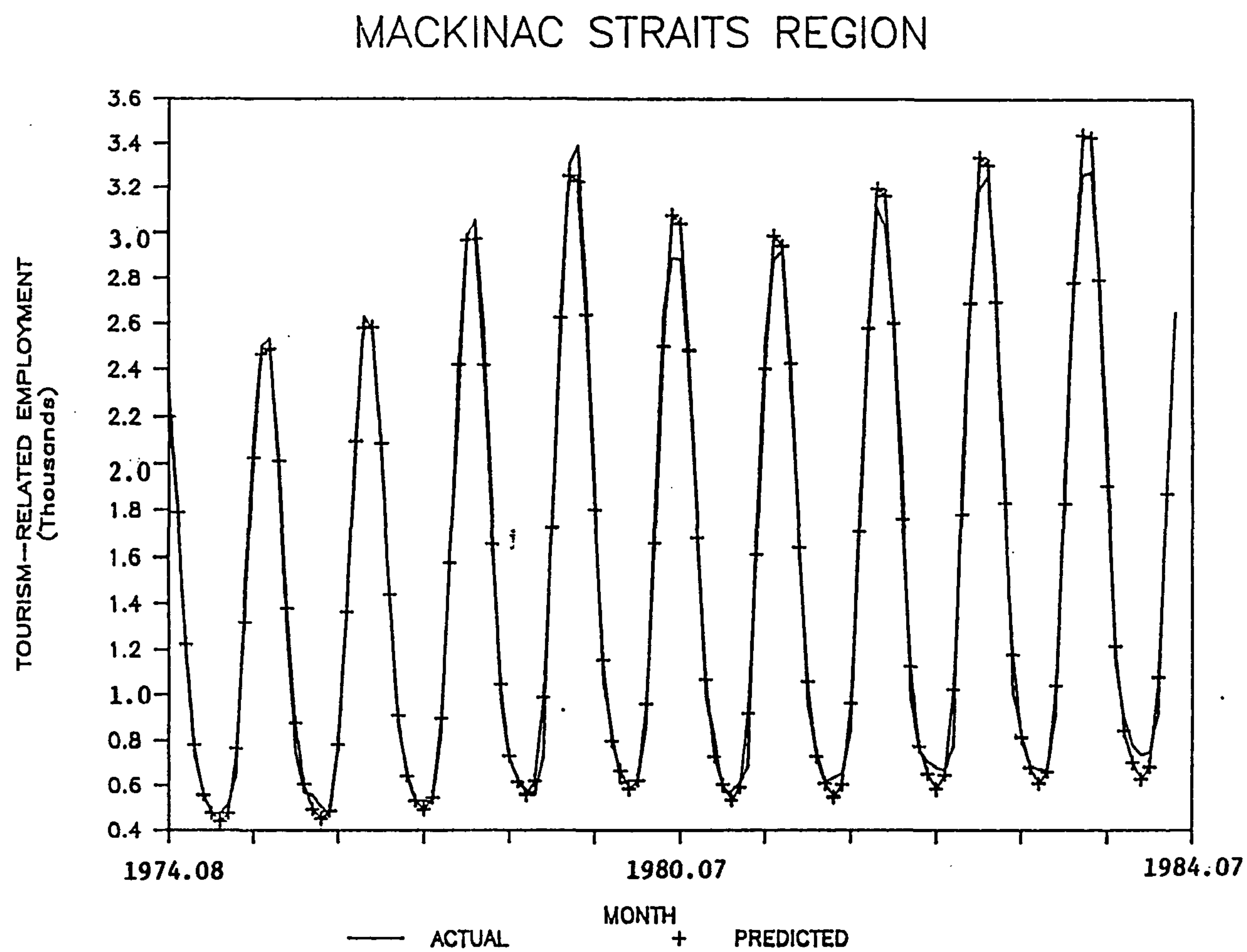

Figure B1.6: Actual and Predicted Tourism-Related Employment in the Mackinac Straits Region, 1974.08-1984.06.

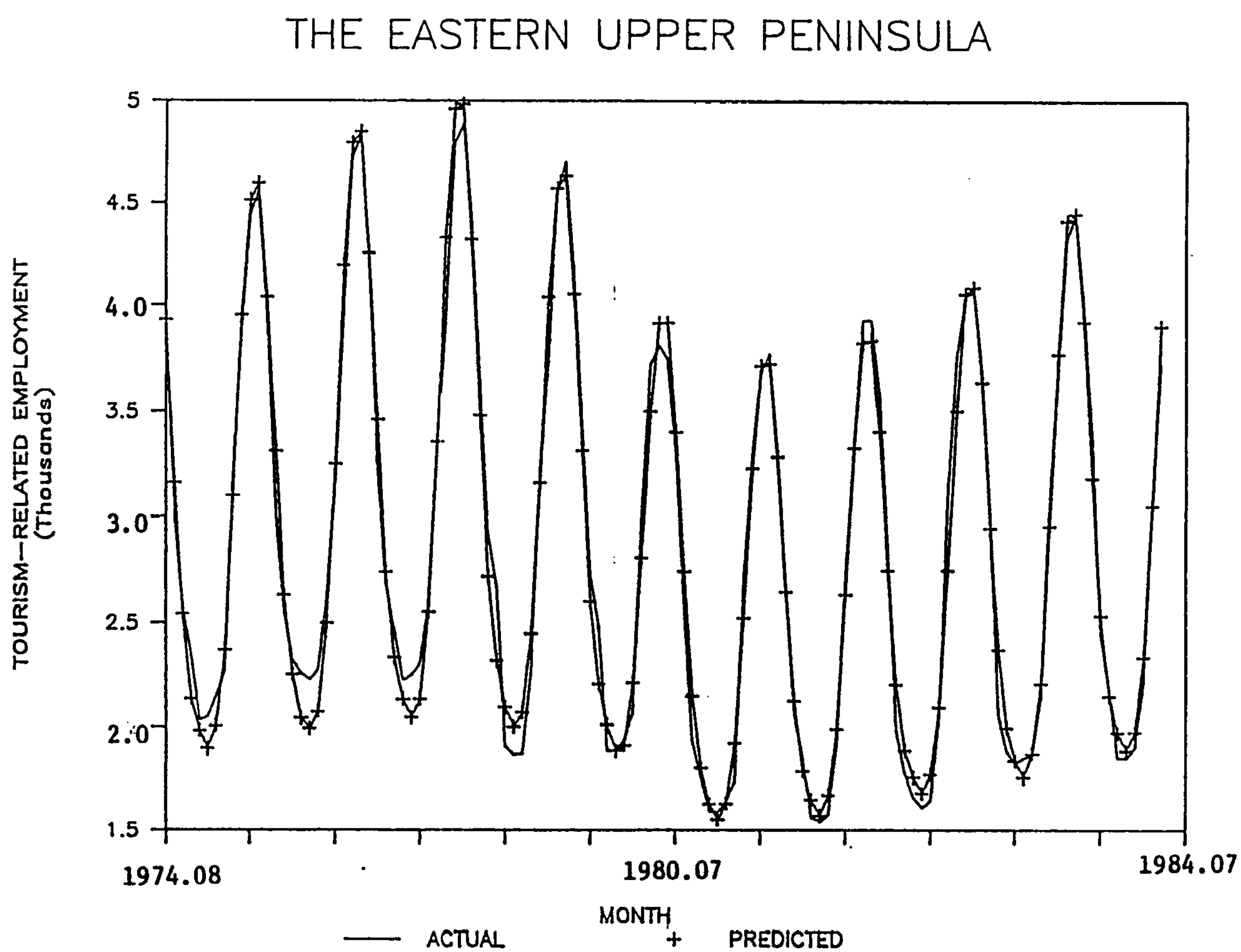

Figure B1.7: Actual and Predicted Tourism-Related Employment in the Eastern Upper Peninsula, 1974.08-1984.06.

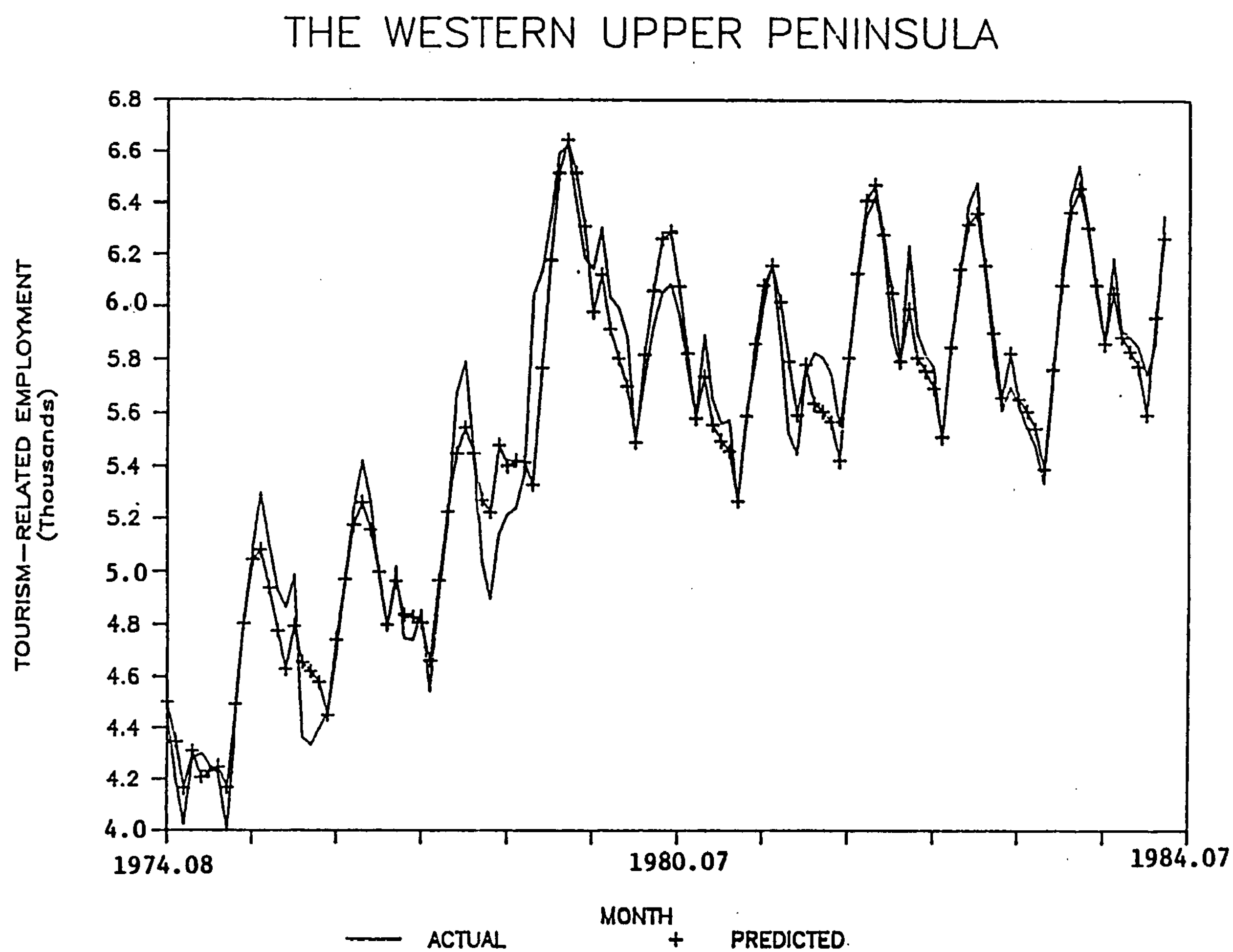

Figure B1.8: Actual and Predicted Tourism-Related Employment in the Western Upper Peninsula, 1974.08-1984.06.