

**VISITATION TO THE NATIONAL PARKS IN THE SOUTHWEST:
THE INFLUENCE OF ECONOMIC AND CLIMATE VARIABLES**

by

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**A Thesis Submitted to the Faculty of the
DEPARTMENT OF AGRICULTURAL AND RESOURCE ECONOMICS
In Partial Fulfillment of the Requirements
For the Degree of
MASTER OF SCIENCE
In the Graduate College
THE UNIVERSITY OF ARIZONA**

2005

STATEMENT BY AUTHOR

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1 Acknowledgements

I wish to thank, first and foremost, Dr. George Frisvold, for his constant encouragement, guidance and suggestions in shaping and improving the quality of this thesis. I would like to thank Dr. Sathesh Aradhyula and Dr. Gary Thompson for their helpful and valuable suggestions in improving the quality of this thesis. Without their careful guidance, this work could never have been completed and I am greatly indebted to each of them.

I would also like to thank Dr. Gregg Garfin for his valuable suggestions and guidance on the climate related aspects of this research.

I am greatly indebted to my Guru His Holiness Sri Sri Sri Ganapathi Sachchidanada Swamiji for his constant grace and blessings. Without which I would never have reached this stage in my life.

I am grateful to the Institute for the Study of Planet Earth (Climate Assessment for the Southwest team) for providing my funding and an enjoyable, friendly environment in which to pursue my academic goals.

I am grateful to the Department of Agricultural and Resource Economics for providing me with a very friendly and encouraging environment to pursue my academic program. I have truly enjoyed this two year academic program and I will always cherish the memory of my time spent in the graduate program.

Also, I am greatly indebted to my family: my father Koteswara Rao Ponnaluru and my mother Bhagya Lakshmi Ponnaluru, my Brothers Ravichandra Ponnaluru and Dr.

Suresh Ponnaluru and to my wife Akula for their constant support and guidance, with out which I would never have reached this stage in my life.

To the Lotus feet of my Guru

His Holiness Sri Sri Sri Ganapathi Sachchidananda Swamji.

Table of Contents

LIST OF FIGURES	7
LIST OF TABLES	8
ABSTRACT	9
INTRODUCTION	10
REVIEW OF LITERATURE	14
DESCRIPTION OF DATA AND REGRESSION VARIABLES	19
DESCRIPTION OF DATA	19
DESCRIPTION OF REGRESSION VARIABLES	22
ECONOMETRIC SPECIFICATION	44
RESULTS	49
CONCLUSIONS	61
REFERENCES	63

List of Figures

Figure 2.1 MAPE and RMSPE values for the NPS model	18
Figure 3.1 Annual Visits to the Casa Grande Ruins NM.....	30
Figure 3.2 Annual Visits to the Sunset Crater Volcano NM.....	30
Figure 3.3 Graph of Visits to Tonto NM.....	31
Figure 3.4 Differences in Monthly Visits to Bandelier NM, 1999 and 2000.....	36

List of Tables

Table 3.1 List of National Parks covered in this study	37
Table 3.2 Percentage share of visits of each park among all the national.....	38
Table 3.3 Competition Index for the parks under consideration.....	39
Table 3.4 Personal income (real) of Cities (in thousands of Dollars).....	40
Table 3.5 Parks ranked according to the MPI values	41
Table 3.6 Selected Definitions of Units Administered by the National Park Service	42
Table 3.7 Definitions and Summary Statistics	43
Table 5.1 Pooled OLS models and Fixed effects models without AR(1)and PCSEs	56
Table 5.2 Pooled OLS model and Fixed effects model with AR(1) and PCSEs	57
Table 5.3 Estimated Fixed effects coefficients of the AR(1) correction and PCSEs.....	58
Table 5.4 Evaluating the forecasting efficiency of the fixed effects AR(1) and PCSE model.....	59

Abstract

This study examines factors influencing visits to the national parks of the U.S. Southwest from 1980 to 2003.

While previous studies on park visitation used OLS estimation to explain visitation, this study tested and corrected for panel heteroskedasticity, contemporaneous correlation, and autocorrelation in the data.

The results identify several environmental variables as important determinants of park visitation. These include long-term climate variables for summer and winter temperature and summer humidity, as well as indicators for reservoir levels. Important economic variables included gasoline prices, exchange rates and per capita personal income changes.

Chapter 1

1 Introduction

Nature exerts great influence on many human activities. Tourism and recreation are two activities that can be greatly influenced by climate. This is especially true of water-based recreation. National parks providing water-based recreation enjoy the lion's share of the total annual park visitation in the U.S. Southwest. These include Lake Mead National Recreation Area, Glen Canyon National Recreation Area (home of Lake Powell) and the Grand Canyon, visited by 22,673 river rafters annually (Stynes, 2003).

The national parks in this study of the Southwest include all national parks in Arizona and New Mexico, plus parks in southern California, southern Nevada, and southern Utah. These national parks attract more than 26 million visitors in total a year, with visitor spending of more than 1.3 billion dollars. The park visitation is of paramount importance to the local economies as it generates employment and revenues. According to the Money Generation Model (MGM) – an input-output model developed for the National Park Service – every 1000 visits to the parks generates 1.1 jobs and \$18,825 in personal income locally (NPS, 2003)¹.

Previous studies have identified important spatial and park physical attributes that influence park visitation demand. However, the influence of climate variability on visitation demand is not well studied. In this study we attempt to answer the research questions:

¹ MGM model is available at URL: planning.nps.gov/mgm/mgm2.htm (accessed January,2005)

- What factors affect visits to the Southwest National Parks? More specifically, how do climate / weather factors affect visitation.
- Can inclusion of climate and economic variables in the regression models that explain visitation, improve the ability to explain the variation in visitation and improve forecasts?

Importance of this study:

The National Park Service (NPS) conducts research on the visitation demand to the national parks. The NPS has identified various socio-economic factors that influence visitation (*Discovery 2000*, NPS). The NPS currently constructs visitor forecasts to individual parks based on visitation to the particular park in the previous three years. The forecasts are one-year and two-year ahead forecasts. Inclusion of climatic and economic variables in the regression models could help to explain the influence of various factors better. The NPS may find such information useful for planning and longer-run forecasting.

Visitation to national parks, though small in scale at a regional level, can be important at the community level. Local governments of communities near parks could utilize this study to assess the impacts of the fluctuations in park visitation due to climate and other associated economic factors on their economies and to plan the developmental activities accordingly.

As this study deals with the national park visitation data, Arizona Department of Tourism and the tourism agencies could find the study useful in planning.

This study can quantify the effects of drought on the tourism industry especially on national park visitation. Arizona Governor's Drought Task force could find this study of use in quantification of the losses due to drought. The Northern Arizona University Hospitality Research and Resource Center conducts research on the impacts of fluctuations in tourism on the hotel and restaurant industry in the Southwest. This study could be of use to tourism-related research.

The National Oceanic and Atmospheric Administration conducts research on climate-related issues in the country. In the Southwest, NOAA research focuses on drought. As this study could be utilized to assess the impacts of drought on tourism and park visitation, this study could be of interest to NOAA.

Methods of Analysis:

This study tries to explain the variation in the park visitation by multivariate regression analysis, accounting for the time-series cross-section nature of the data. The study area comprises of all the national parks in the states of Arizona and New Mexico and neighboring parks in California, Nevada and Utah, covering 24 years of time period from 1979 to 2002.

The dependent variable employed in the study is annual visits to Southwest national parks. Independent variables include the variables previously identified by various studies. The NPS identified lagged visits. Hanink and White (1999) employed

variables like age of the park, area of the park, a spatial competition index, a market potential index, and distance of the park from cities in their models. This study in addition to the above variables, considers climatic variables and economic variables like price of gasoline, currency exchange rates and macroeconomic indicators to explain the visitation to the parks.

Chapter 2

2 Review of Literature

Visits to national parks could be explained either by “causal” econometric models or the “forecasting” models. The causal models can be used to explain the relative importance of each of the factors influencing visits. Visits could be influenced by factors like gasoline prices, climatic factors, occurrence of extreme weather events like fires, macroeconomic factors, etc. Causal models can quantify the effects of each of these factors. The limitation of these models is that their forecasting ability is moderate. Past research on tourism demand has shown that forecasting models generally have better forecasting ability than econometric models (Witt and Witt). Forecasting models, however, will not be able to explain the importance of the above influencing factors.

Hanink and White (1999) have explained the importance of parks’ physical attributes. Their work considered 38 National parks over 3 years of time. Annual overnight stays at the parks were considered. They used the ordinary least squares (OLS) estimation without testing or correcting for problems like autocorrelation, panel heteroskedasticity, contemporaneous correlation of errors, which are typical issues with the panel data. Their study identified the variables age of park, area of the park, population of nearest metropolitan statistical area, and an index of spatial attributes as statistically significant. They identified that older parks and bigger parks attract more visits. Also, that parks spatially compete with each other. In other words, controlling for other factors, people were less likely to visit parks that were closer to other parks than parks that were more distant from other parks.

Hanink and Stutts (2002) conducted similar research on National Battlefield parks. Their study included 19 parks over 3 years. Annual visits to these parks were considered. They employed a fixed effects model and used the step wise regression technique to arrive at a better fitting model. The variables age of park, market potential index, competition index, were found to be statistically significant. Their study found that the age of the park has positive effect on visitation and the recreation facilities are not significant in attracting visitors. Again, they found that National Battlefields appear to compete for visitors.

Weiler and Seidl (2004) identified the significance of the park's designation. In the National Park Service system, "parks" are designated as National Parks, National Monuments, National Recreation Areas, National Wilderness Areas, etc. Unless stated otherwise the generic use of the word "park" refers to all of these designations.

Weiler and Seidl (2004) considered 8 park system units over 20 years of time. Total annual visitors – that include recreation visits, non recreation visits, total overnight stays and all other types of visitation were considered in the study. A fixed effects model with an intercept specific to each of the park was used. Their study identified that the variables park designation, area of the park and population of the state are statistically significant. Their study identified that the visits to the parks increase if the park is re-designated as a National Park from a National Monument.

The National Park Service (2004) has identified various potential factors that can affect visits. They can be broadly categorized into- demographic factors, technological factors, economic factors, environmental factors and cultural factors. The influence of

some of the factors can be expected to be positive and some negative. Previous year's visits have a significant influence on future year's visits. Population and age composition of the population can affect on visitation. Retired and young adult populations seek recreational activities thus increasing park visits. Gasoline prices have a negative influence on visits. Similarly air travel costs, personal ownership of vehicles, and other aspects of transportation also influence park visitation. The NPS also believes that environmental factors such as global temperatures can influence visits.

Public Use Statistics office of the National Park Service forecasts visitation to the parks for up to 2 years into the future based on the weighted average of visits from the previous three years. The forecasting model does not utilize any of the factors recognized by the NPS.

The future visits are forecasted using the model:

$$V_t = a_0 + a_1V_{t-1} + a_2V_{t-2} + a_3V_{t-3} + e \quad (2.1)$$

Evaluation of the forecasting performance of the models

Below, we try to evaluate the efficiency NPS forecasts in terms of standard measures of forecast accuracy of the model in terms of forecasting.

We used the measures Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSPE) as suggested by Song and Witt (2000) to calculate the efficiency of the NPS model in making predictions. Mean Absolute Percentage Error is calculated as the mean of the absolute percentage error.

$$\text{MAPE} = \frac{\sum_{t=0}^m \frac{|e_t|}{Y_t}}{m} \times 100$$

where e_t is the difference between the actual value and the predicted value, M is the length of the prediction, and Y_t is the actual value of the dependent variable.

Root Mean Square Percentage Error is calculated as:

$$\text{RMSPE} = \sqrt{\frac{1}{m} \sum_{t=1}^m \left(\frac{e_t}{Y_t} \right)^2} \times 100$$

where e_t is the difference between the actual value and the predicted value, M is the length of the prediction, and Y_t is the actual value of the dependent variable.

The smaller the value of the RMSPE and MAPE the better is the model's forecasting ability. The NPS published its forecasts for the years 1999 through 2003, with a 2 year forecasts with years 1998 through 2002 as base years. The results of our calculation of MAPE and RMSPE for the NPS model are presented in the table 2.1.

The magnitudes of the MAPE and RMSPE for the 2nd year predictions are higher than that of those of the 1st year predictions, which is expected. The limitation of the NPS model is that it cannot explain the effects of other variables like socio-economic factors, climatic, demographic and other factors on the park visitation. While more than half of the MAPE and RMSPE values for the parks' one-year ahead forecasts are less than 10%, there is a wide range in estimates. Errors for some parks, such as range Navajo National Monument, Organ Pipe Cactus National Monument and Pecos National Historic Park exceed 90%.

Figure 2.1 MAPE and RMSPE values for the NPS model

Park	1st Year Prediction		2nd Year prediction	
	MAPE	RMSPE	MAPE	RMSPE
Arches NP	4.6	5.5	8.6	9.8
Aztec Ruins NM	6.6	6.9	5.6	7.0
Bandelier NM	16.7	19.5	21.8	25.2
Bryce Canyon NP	8.9	11.0	12.7	13.2
Canyon de Chelly NM	5.8	6.5	7.5	8.3
Canyonlands NP	6.9	8.5	11.4	12.1
Capitol Reef NP	9.1	10.9	14.4	17.3
Capulin Volcano NM	7.5	8.2	11.9	13.2
Carlsbad Caverns NP	4.3	5.1	5.3	6.6
Casa Grande Ruins NM	14.2	20.2	22.6	26.0
Cedar Breaks NM	12.1	12.3	7.9	9.4
Chaco Culture NHP	16.8	18.6	23.9	28.4
Chiricahua NM	25.7	30.5	39.4	48.8
Coronado NMem	3.3	3.9	5.5	5.8
El Morro NM	6.5	8.5	10.3	10.5
Fort Bowie NHS	4.0	4.3	3.8	4.5
Fort Union NM	5.3	7.1	6.3	8.1
Gila Cliff Dwellings NM	6.4	6.8	11.3	11.7
Glen Canyon NRA	11.1	12.5	20.2	22.0
Grand Canyon NP	2.9	3.8	5.4	6.4
Hovenweep NM	20.0	25.5	34.6	35.6
Hubbell Trading Post NHS	15.7	20.1	15.1	19.5
Joshua Tree NP	8.7	9.4	11.9	13.5
Lake Mead NRA	6.4	7.8	8.5	9.4
Montezuma Castle NM	21.2	39.1	27.0	42.6
Natural Bridges NM	13.6	18.7	25.2	28.6
Navajo NM	92.4	167.3	113.5	179.0
Organ Pipe Cactus NM	96.6	172.1	139.9	223.5
Pecos NHP	174.2	370.5	203.1	385.4
Petrified Forest NP	29.1	42.5	35.7	49.1
Pipe Spring NM	19.9	23.2	34.5	37.9
Rainbow Bridge NM	26.2	34.3	38.2	57.2
Saguaro NP	8.0	10.8	15.3	18.4
Salinas Pueblo Missions NM	5.6	6.8	10.4	10.5
Sunset Crater Volcano NM	5.5	6.2	7.4	8.6
Tonto NM	11.7	16.6	19.3	23.7
Tumacacori NHP	5.1	7.1	8.0	9.3
Tuzigoot NM	6.0	7.4	11.1	12.1
Walnut Canyon NM	7.2	7.8	12.6	13.3
White Sands NM	7.0	7.6	10.7	12.3
Wupatki NM	7.5	9.0	9.6	11.6
Zion NP	4.6	6.8	7.0	7.5

Chapter 3

3 Description of Data and Regression Variables

Description of Data:

The study covers all the national parks in the states of Arizona and New Mexico and neighboring parks in California, Nevada and Utah. The list of national parks covered in the study and their locations including the Climatic Division they fall into is given in table 3.1. The data on climatic divisions is obtained from National Oceanographic Administration National Climatic Diagnostic Center (NOAA- NCDC) website (NOAA- NCDC, 2003). Annual recreation visitation to these parks is considered in the study from 1979 to 2002 over a 24 year time period.

These parks attract 26.4 million visitors on an average annually. Visitation has steadily increased at an increasing rate from 1979 to 1993 and continued to increase, however at a decreasing rate. The maximum visitation was 32.4 million in 1993 and the minimum was 18.5 million in 1979.

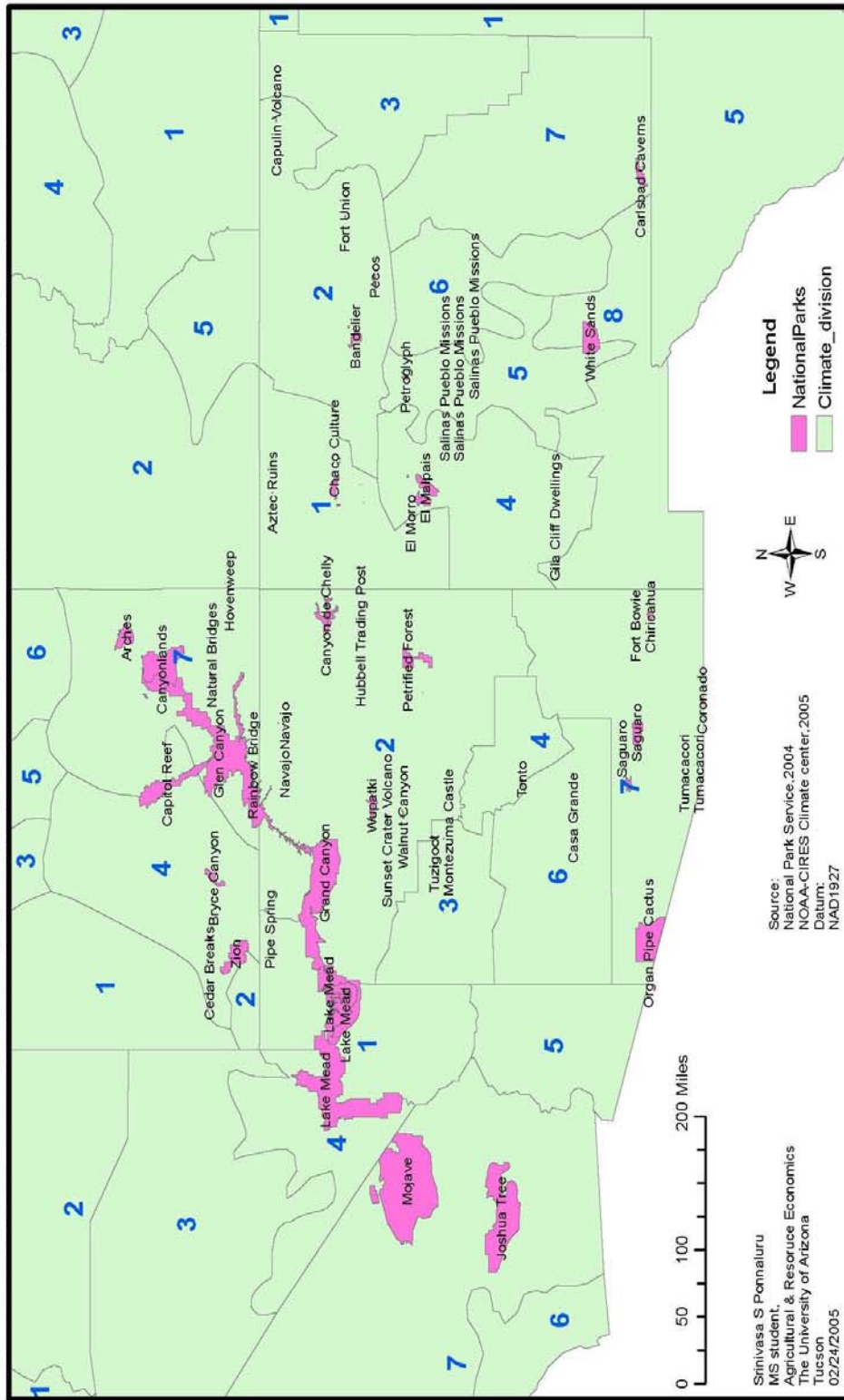
The parks Lake Mead, Grand Canyon and Glen Canyon account for at least 53% of total visits to all the parks in a year. Lake Mead alone accounts for approximately 30% of visits. Grand Canyon accounts for 15% and Glen Canyon Accounts for 10% of the total visits to all the parks in the region in a year. The share of visits of each park is given in the table 3.2. In recent years, the three parks – Lake Mead, Grand Canyon, and Lake Mead have shown decreased visitation. Parks in Utah, in general showed an increase in visitor share over time. Parks in Arizona and New Mexico showed a decrease in their share of visitors to varying degrees.

Seasonality of Park Visits:

Visitation to the parks shows interesting seasonality patterns. Monthly visitation to each of the parks is considered. The month of maximum visitation to each park is clearly spatially separated. Parks in southern Arizona and California have their visitation maxima in winter months. Parks like Tonto NM, Casa Grande Ruins NM, Saguaro NP, Tumacacori NP, Coronado NM, Fort Bowie, Chiricahua NM, Organ Pipe Cactus NP, Joshua tree NP have their visitation maxima in winter months – December – March. These parks fall into climatic divisions AZ-3, AZ-4, AZ-6, AZ-7 and CA-7. These parks have their visitation minima in the months of July and August as these parks experience very comfortable temperatures in March and excruciating heat in summer months. These parks can be conveniently branded as winter parks.

Parks in Utah falling in Climatic divisions UT-2, UT-4, UT-7 divisions and parks in AZ-2 and in all the divisions in New Mexico have their visitation maxima in June, July and August months. These parks have their visitation minima during the winter months as these parks experience low temperatures during winter. Though the summers are hot with temperatures reaching up to 110⁰ F these parks attract maximum number of visitors in the summer months. It is supposedly due to the presence of water- based recreation in the area. These parks can be branded as summer parks.

Climate Divisions and the Location of National Parks



Definitions of variables used in the model:

Visits: This is the total number of recreation visits to a given park in a year. The National Park Service defines a recreation visit as the entry of a person onto lands or waters administered by the NPS for recreational purposes excluding government personnel, through traffic, a trades-person, and a person residing within park boundaries (NPS, 2004). The number of annual visits is not the same as the number of visitors. In the course of a trip a visitor may re-enter the park. For example, during a multi-day trip to a park, a visitor may stay outside the park, but enter it on multiple days. The NPS data treats each entry to the park as a visit. In a study of 34 national parks, Stynes (2002) reports park entries per trip ranging from 1 to 5. The data used in this study is obtained from the NPS Visitation Databases².

Explanatory variables:

Park age: Park age is the number of years since the park has been declared a national park, national recreation area, or national monument. Some parks were designated national monuments before they were designated national parks. In such cases the date when they were made national monument was used in calculating the age of the park. The data is obtained from the National Park Service History website.³

Park area: The area is measured in acres. The area is comprised of both fee acres and less than fee acres. The data are obtained from the NPS Acreage Reports database⁴.

Concessionaire facilities: It is a reasonable hypothesis that lodging facilities at a park play a major role in attracting visitors and also affect their length of stay, which

² NPS Visitation Databases found at URL : <http://www2.nature.nps.gov/stats/>

³ NPS History website found at URL: <http://www.cr.nps.gov/history/hisnps/NPSHistory/birthdays.htm>

⁴ NPS Acreage Reports database found at URL : <http://www2.nature.nps.gov/stats/>

would affect visits. In a number of parks, these facilities are provided by concessionaires, defined as private companies or individuals granted the privilege of providing facilities and services considered necessary by the NPS for accommodating visitors (NPS, 2004). Dummy variables have been employed to capture the effects of the presence of the facilities. One variable takes a value of one if there is concessionaire lodging facilities at the park and zero otherwise. The NPS defines concessionaire lodging as an element of a concessionaire operation involving facilities for overnight lodging such as hotels, motels, cabins, cottages, trailer villages, and trailer rental (NPS, 2004).

Another variable takes a value of one if there are concessionaire camping facilities at the park and zero otherwise. The NPS defines concessionaire camping as an element of a concessionaire operation involving services for overnight camping (NPS, 2004). The data on the recreational facilities at a park are collected from the NPS Monthly Visits database ⁵

Competition Index: A spatial competition index measures the effects of distance of a park from other parks on visitation. Hanink and White (1999) measure it as the sum of the inverse of the individual distances of a park from every other park. Driving distances between the parks were considered and the data were collected piece by piece from the driving directions obtained from the website of the Arizona chapter of American Automobile Association (AAA).

The competition index C_i for the i th park is

$$C_i = \sum_i^n \frac{1}{D_{ij}} \quad (3.1)$$

⁵ NPS Monthly Visitation Database is found at URL: <http://www2.nature.nps.gov/stats/>

where D_{ij} is the distance of park i from park j . Parks that are situated closer to each other could either compete with each other or substitute each other in terms of attracting visitors. The regression coefficient of the competition index casts light on such interactions among the parks. A negative value of the coefficient would suggest a competitive relationship between the parks. Similarly, a positive value would suggest a complementary relationship. Hanink and White (1995) report a negative value for the coefficient of competitive index in their study of visits to National Battlefield Parks. However the coefficient reported in their study is not significant.

Parks which are clustered closer to each other have a higher index. So a park closest to all the other parks takes the highest value. Similarly a park situated far away from the other parks takes the least value. Values of the competition index ranked from highest to the least, for the parks in this study are presented in table 3.3.

From Table 3.3 we can observe that the Sunset Crater Volcano NM has the highest competition index, followed by Wupatki NM and Walnut Canyon NM. These parks are situated very close to each other geographically. The Joshua tree NP has the lowest competition index as it is situated far away from all the parks in the study area.

As a word of warning, the competition index as constructed only measures spatial competition or complementarity between parks within the study area. Parks on the fringes of the study area are relatively closer to parks outside the study area. If one were to construct an index including all U.S. parks or all parks within 100 miles of the border of the study area, then parks on the edge of the study area would have a relatively higher

index. Future research could examine how sensitive results are to specification of this index. However, constructing different indexes is a relatively time-intensive task.

Market Potential Index: The market potential index (MPI) of park i is

$$MPI_i = \sum_j \frac{Y_j}{D_{ij}} \quad (3.2)$$

Where Y_j is the income or purchasing power of a particular market j and D_{ij} is the distance of park i from market j .

In this case the “market” is the center of a Metropolitan Statistical Area or Micropolitan Statistical Area. Krugman (1997) has discussed a more general specification where D_{ij} is raised to a power of b instead of one. Geographers have used city population as proxy for income (Hanink and White; Hanink and Stutts; Poole). In this study, Y is measured by the personal incomes of each city deflated by the Consumer Price Index. Annual data on personal income are obtained from the Regional Economic Information System of the Bureau of Economic Analysis. Personal incomes were deflated using the Consumer Price Index for the West Region which was collected from the Bureau of Labor Statistics, U.S. Department of Labor. Driving distances from the AAA website are used for distances between the parks and cities.

Table 3.4 shows the cities and their total personal incomes. Personal incomes have increased significantly over time. Ranks of each of the cities have slightly changed over time. However, the top three ranked cities Los Angeles, CA, San Diego, Phoenix, maintained their ranks from 1980 to 2002. Las Vegas, NV has improved its rank from 8th to 5th in 2003. Salt Lake City has lost its rank. Tucson, AZ has improved its rank.

Table 3.5 shows the Market potential indices of the parks. The market potential index is an inverse function of distance between the city and the park. Thus, parks closer to larger (and higher income) cities have higher index values. Saguaro NP has the highest MPI among all the parks in consideration, as it is situated close to Tucson, AZ. Similarly Joshua Tree NP has higher market potential index values because of its proximity to Los Angeles and San Diego cities. Parks like Lake Mead, Montezuma Castle, and Walnut Canyon have improved their rank due to the changes in the personal incomes of the nearby cities. Saguaro NP and Joshua Tree NP maintain their ranks because the cities of Los Angeles, Phoenix, retain their high rank in terms of personal incomes.

Gasoline prices: The price of gasoline affects the number of visitors traveling by cars and recreation vehicles (RVs). Gasoline prices can also affect the activity of boating on waters. Higher petroleum prices in general would increase gasoline and diesel prices as well as airplane fuel costs. So, the gasoline price variable may also be positively correlated with costs of air and bus travel. The national average price of unleaded regular gasoline was used in the study. The gasoline prices were deflated with adjusted Consumer Price Index for the West Region to suit the local trends. Gasoline price data were obtained from the website of the Energy Information Administration, Department of Energy.

Temperature: Temperature data is used to capture the effects of summer heat. It is reasonable to expect the effect of heat on the people's decisions to visit a given park during the summer months, as daytime high temperatures in the Southwest exceed 100⁰ F at lower elevations most days. Parks with non-water-based recreation attract lower numbers of visitors during the summer months and water based recreation parks attract

visitors in spite of heat. It might be reasonable to believe that parks closer to cities with cooler temperatures have more visits than those parks nearer to hotter cities. The temperatures of both the park and city are important in influencing the number of visitors. The temperature at the parks is calculated as a function of the distance of the park from a given city and the temperature in the city.

$$I_j = \sum_{i=1}^n w_i T_i \quad (3.3)$$

where the w_i terms are weights and the weighting function is:

$$w_i = \frac{D_{ij}^{-2}}{\sum_{i=1}^n D_{ij}^{-2}} \quad (3.4)$$

where I_j = temperature index for park j

T_i = recorded temperature in city i

D_{ij} = a Vector of distances between city i and park j

w_i = weighting function

National Park System Designation: The National Park Service administers units with different designations. Units in this study may be designated as National Parks, National Monuments, National Historic Sites, National Historic Parks, or National Recreation Areas. Table 3.6 shows the definitions of these units.

Weiler and Seidl (2004) report the significance of the change in the designation of a site from National Monument to a National Park. Weiler and Seidl (2004) report the differences between the National Parks and National Monuments. A National Park has a natural importance as well as cultural and historic relevance. While a National Monument

requires scientific and /or historic importance. Designation of the sites conveys information about the available facilities at a site. Saguaro NP and Joshua Tree NP, part of this study, were also considered in the study by Weiler and Seidl (2004) along with five other parks. Their study found that the change of the designation from National Monument to National Park has significantly increased the visitors to these parks, and the increase in the visits has not come from the decrease in visits to the alternative sites.

To account for differences in designations, three dummy variables were used. The first equals one if the unit is a national monument and zero otherwise. The second equals one if the unit is a national historic park or historic site and zero otherwise. The third equals one if the unit is a national recreation area and zero otherwise. The default in the regressions is if the unit is a national park. The national monument variable accounts for the fact that both the Saguaro National Park and Joshua Tree National Park changed from national monuments during the study period in the year 1994

Areas within National Parks may also be designated as a Wilderness. The Wilderness Act works as a zoning system to establish that certain blocks of land within units of the National Parks System are maintained permanently as wildlands free of roads, resorts, or other significant human-made intrusions. There are currently 45 national park areas that contain congressionally designated wilderness. In our study area, the following ten parks have portions that are designated Wilderness: Chiricahua National Monument, Glen Canyon National Recreation Area, Grand Canyon National Park, Organ Pipe Cactus National Monument, Petrified Forest National Park, Saguaro National Park, Bandelier National Monument, Carlsbad Caverns National Park, El Malpais National

Monument, and Joshua Tree National Park. A dummy variable was include that equals one if the park has designated wilderness area and zero otherwise.

Changes in Visitor Counting Procedures and Construction: Two parks, Casa Grande Ruins National Monument from the year 2000 and Sunset Crater Volcano National Monument from the year 1996, significantly altered their method of estimating park visits. Dummy variables were created to account for these changes. Visitation of these parks over time is presented in Fig.3.1 and Fig.3.2. A dummy variable was also included for Tonto National Monument for 1990. Visits were curtailed in that year by lengthy road construction.

Figure 3.1 Annual Visits to the Casa Grande Ruins NM

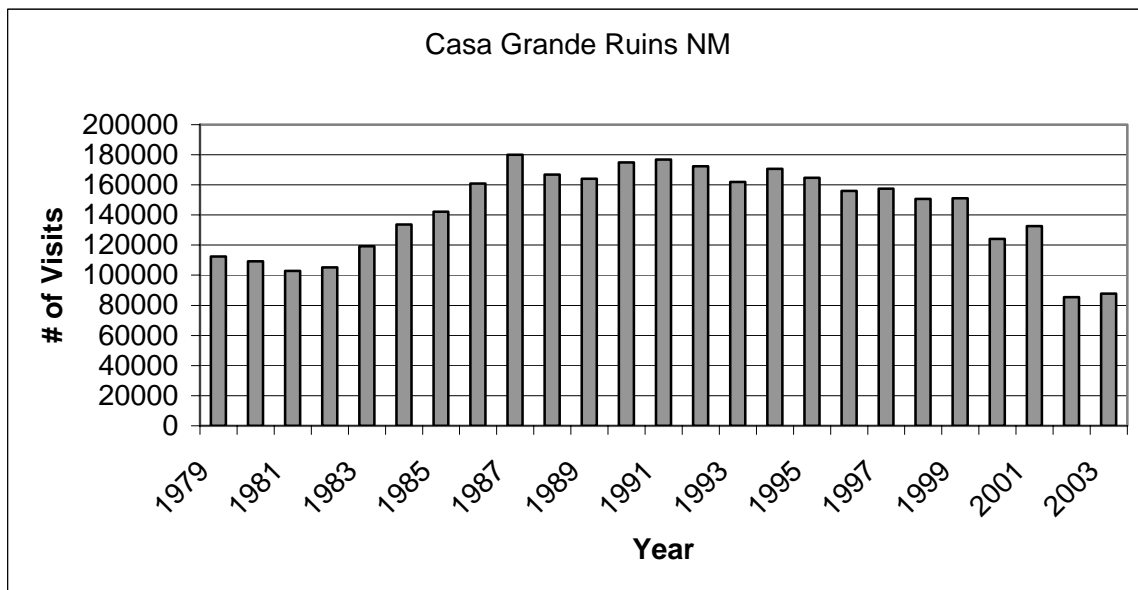


Figure 3.2 Annual Visits to the Sunset Crater Volcano NM.

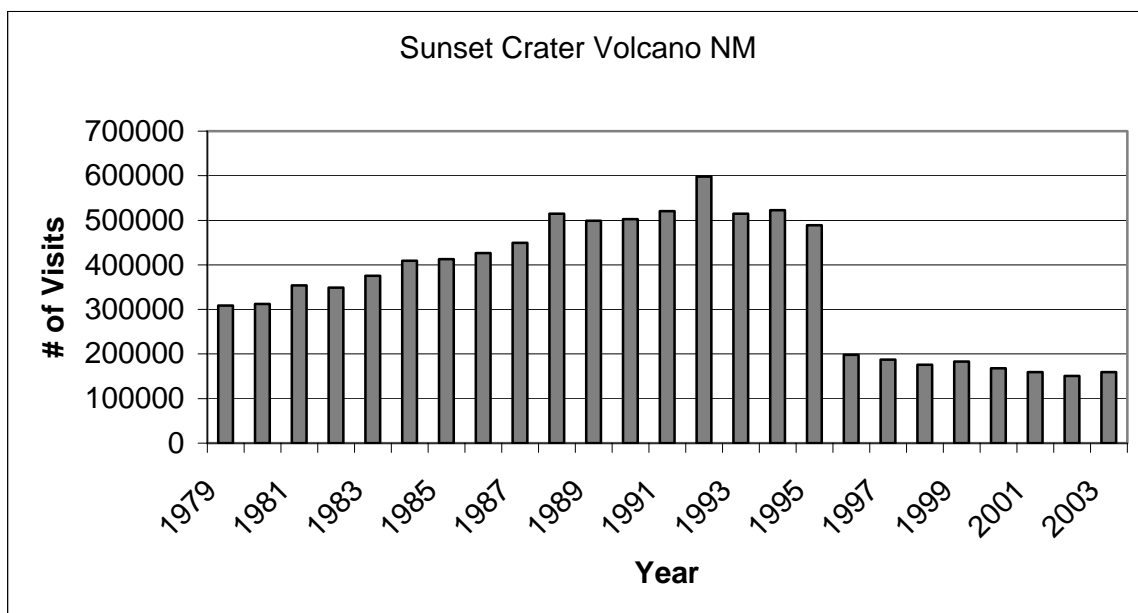
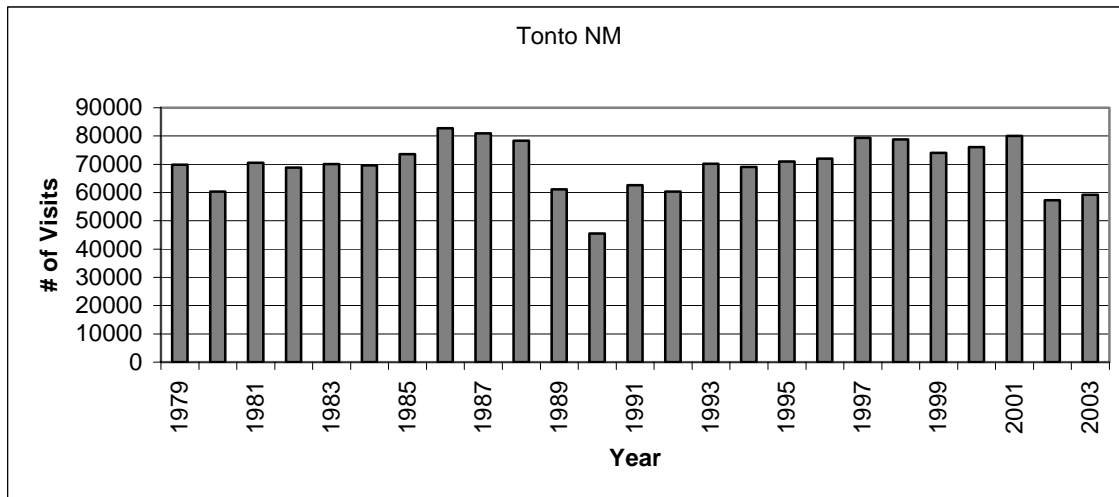


Figure 3.3 Graph of Visits to Tonto NM

State-specific fixed effects: Dummy variables were included to account for state-specific fixed effects. A park has a value of one if it is in a particular state and zero otherwise. Where parks are in more than one state, the park was assigned to the state with the most visitor entries. Dummy variables were included for Nevada, Utah, New Mexico, and California, with Arizona serving as the default. States may differ in tourist promotion, economic conditions, or other features that may attract visitors.

Exchange rate: Tourism demand studies often include the exchange rate as a measure of the relative price of traveling to one international destination versus another (Witt and Witt). Changes in exchange rates affect the cost to foreigners of visiting the United States and the costs of U.S. residents traveling abroad. The exchange rate used is the Broad Index exchange rate. The Board of Governors of the Federal Reserve System constructs the Broad Index of the Foreign Exchange Value of the Dollar. This Broad Index exchange rate is a weighted average of the foreign exchange values of the U.S. dollar against the currencies of a large group of major U.S. trading partners. This is a real index: exchange rates used in the calculations are adjusted for aggregate price inflation in the markets of partner countries (Goldberg, 2004). Data is available from the New York Federal Reserve Industry Specific Exchange Rate Historic Data files

Visits from foreign tourists decrease due to the increase in the exchange rates. If the dollar becomes more costly to purchase, the tourists from foreign countries find the travel to the U.S. destinations more expensive. On the other hand, the U.S. residents enjoy the appreciating value of the Dollar. U.S. residents find the travel to foreign destination cheaper, thus increasing the visits to foreign destinations and potentially decreasing visits to the national parks. The regression coefficient of the exchange rate is

expected to be negative representing the inverse relationship between visits and the exchange rate.

Macroeconomic factors: The market potential index captures growth in real personal income weighted by distance from parks. Vacation plans may be sensitive to economic downturns such as recessions. To capture this effect a dummy variable was constructed that equaled one in a year when real per capita personal income in the park's state fell. State-level data for personal income came from the Regional Economic Information System of the Bureau of Economic Analysis and deflated using the CPI-U for the West (Bureau of Labor Statistics).

County Natural Amenities: USDA's Economic Research Service has developed natural amenity indexes to explain differences in migration and population growth across U.S. counties (McGranahan, 1998). Counties with greater population growth tend to be those with the following characteristics:

- (a) a warm winter
- (b) more days of sunlight in winter
- (c) a more temperate summer
- (d) lower summer humidity
- (e) greater variation in topography

Raw data was collected for each county, then converted into a standardized Z-score with a mean of zero. A score of 1 would mean the county's score was 1 standard deviation above the mean, while a score of -1 would mean 1 standard deviation below

the mean. A higher score corresponds to a greater level of the amenity in the county. The warm winter index is measured by average January temperature. Because a warm winter is conceived of as positive, a value of 1 means that the January temperature is one standard deviation above the average of all U.S. counties. The humidity index is based on July relative humidity. Because humidity is considered a disamenity, lower humidity receives a higher score. So, a score of zero means average humidity, but a score of 1 means humidity one standard deviation below the mean. Average July and January temperatures were highly correlated. To account for this, the ERS study regressed July temperature on January temperature and used the residual to construct its temperate summer index. The index is higher if July temperature is cooler than predicted from the regression. These measures all come from the Area Resources Tape issued by the National Center for Health Statistics, U.S. Department of Health and Human Services. A topographic variation score was constructed based on the *National Atlas of the United States of America* (1970) where a county receives a higher standardized score if a county had a more varied topography. McGranahan (1998) provides more explanation about how this was done.

These variables were included in the regression analysis to see if a county's natural amenities affect park visits. McGranahan notes that amenity scores developed to predict net in-migration may do less well at predicting their attraction for tourism and recreation. For example, the amenity indexes are all positively associated with a county being classified as a retirement county, defined as counties where the number of residents 60 years old or older grew by 15% or more between 1990 and 2000. Warm winters, however, are negatively correlated with a county being classified as a recreation county.

ERS defines recreation counties based on the relative importance of entertainment and recreation, accommodations, eating and drinking places, and real estate in local employment and income and the percentage of housing units intended for seasonal or occasional use (Johnson and Beale). McGranahan notes, “Cold winters discourage many permanent residents, but in the context of other amenities, encourage recreational visitors (page 12).”

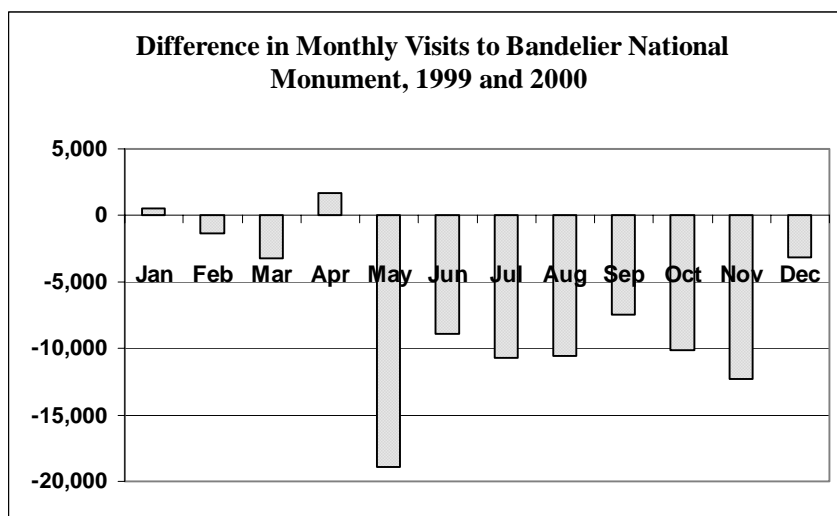
Reservoirs and reservoir levels: Two of the parks considered have large reservoirs. The Glen Canyon National Recreation Area has Lake Powell and The Lake Mead National Recreation Area has Lake Mead. Prolonged drought reduces the levels of these reservoirs and can reduce access to boating marinas. A variable was created to capture the changes in reservoir levels relative to capacity. An index was constructed that takes on a value of 1 at a lake’s historic peak elevation. Other years are represented as a percent of that peak. (Weighting measures by surface area had little effect on later regression results because surface areas differ by less than 4%). Data for Lake Powell elevation come from the Historic Data files of the Bureau of Reclamation Upper Colorado Division Water Resources Group. Data for Lake Mead elevation come from Historic Data files of the Bureau of Reclamation Lower Colorado Division.

Forest Fires: On May 4, 2000, fire personnel at Bandelier National Monument, National Park Service, ignited a prescribed fire, but the fire got out of control. By May 10, the Cerro Grande Prescribed Fire, carried by high winds, entered Los Alamos Canyon and spread towards Los Alamos, New Mexico. More than 18,000 residents of the towns of Los Alamos and White Rock were in the fire's path and were evacuated. By May 11,

the fire had burned 18,000 acres, destroying 235 homes, and damaging many other structures (National Park Service, 2000).

Fig.3.4. shows the changes in monthly visits to the Bandelier NM in year 2000 from 1999. A large drop can be noticed in the month of May 2000 due to the fire. It can also be noted that the visits have decreased two months prior to the occurrence of fire. In the study, a dummy variable has been employed to capture the effects this fire. Thus the variable would take a value of 1 for the Bandelier NM for year 2000 and zero otherwise. This dummy variable can account for the effects of fire.

Figure 3.4 Differences in Monthly Visits to Bandelier NM, 1999 and 2000



Source: NPS, Public Use Statistics

Table 3.1 List of National Parks covered in this study

Name of the Park	Location	Climate Division
Arches NP	Utah	UT 7
Aztec Ruins NM	New Mexico	NM 1
Bandelier NM	New Mexico	NM 2
Bryce Canyon NP	Utah	UT 4
Canyon de Chelly NM	Arizona	AZ 2
Canyonlands NP	Utah	UT 7
Capitol Reef NP	Utah	UT 4
Capulin Volcano NM	New Mexico	NM 2
Carlsbad Caverns NP	New Mexico	NM 7
Casa Grande Ruins NM	Arizona	AZ 6
Cedar Breaks NM	Utah	UT 4
Chaco Culture NHP	New Mexico	NM 1
Chiricahua NM	Arizona	AZ 7
Coronado Nmem	Arizona	AZ 7
El Malpais NM	New Mexico	NM 4
El Morro NM	New Mexico	NM 4
Fort Bowie NHS	Arizona	AZ 7
Fort Union NM	New Mexico	NM 2
Gila Cliff Dwellings NM	New Mexico	NM 4
Glen Canyon NRA	Utah	UT 7
Grand Canyon NP	Arizona	AZ 2
Hovenweep NM	Utah	UT 7
Hubbell Trading Post NHS	Arizona	AZ 2
Joshua Tree NP	California	CA 7
Lake Mead NRA	Nevada, Arizona	NV 4, AZ 1
Mojave National preserve	California	CA 7
Montezuma Castle NM	Arizona	AZ 3
Natural Bridges NM	Utah	UT 7
Navajo NM	Arizona	AZ 2
Organ Pipe Cactus NM	Arizona	AZ 6
Pecos NHP	New Mexico	NM 2
Petrified Forest NP	Arizona	AZ 2
Petroglyph NM	New Mexico	NM 5
Pipe Spring NM	Arizona	AZ 1
Rainbow Bridge NM	Utah	UT 7
Saguaro NP	Arizona	AZ 6
Salinas Pueblo Missions NM	New Mexico	NM 6
Sunset Crater Volcano NM	Arizona	AZ 2
Tonto NM	Arizona	AZ 4
Tumacacori NHP	Arizona	AZ 7
Tuzigoot NM	Arizona	AZ 3
Walnut Canyon NM	Arizona	AZ 2
White Sands NM	New Mexico	NM 5, NM 8
Wupatki NM	Arizona	AZ 2
Zion NP	Utah	UT 4

Table 3.2 Percentage share of visits of each park among all the national parks in the study area

S.No.	Park	% share of visits
1	Lake Mead NRA	29.75
2	Grand Canyon NP	13.46
3	Glen Canyon NRA	9.55
4	Zion NP	7.32
5	Joshua Tree NP	3.69
6	Bryce Canyon NP	3.11
7	Petrified Forest NP	3.00
8	Montezuma Castle NM	2.72
9	Carlsbad Caverns NP	2.64
10	Saguaro NP	2.64
11	Canyon de Chelly NM	2.29
12	White Sands NM	2.21
13	Arches NP	2.20
14	Capitol Reef NP	1.88
15	Cedar Breaks NM	1.85
16	Sunset Crater Volcano NM	1.44
17	Bandelier NM	1.09
18	Canyonlands NP	0.98
19	Organ Pipe Cactus NM	0.87
20	Wupatki NM	0.87
21	Rainbow Bridge NM	0.80
22	Hubbell Trading Post NHS	0.69
23	Casa Grande Ruins NM	0.56
24	Walnut Canyon NM	0.45
25	Tuzigoot NM	0.40
26	Natural Bridges NM	0.38
27	Chiricahua NM	0.28
28	Tonto NM	0.28
29	Chaco Culture NHP	0.27
30	Navajo NM	0.26
31	Aztec Ruins NM	0.26
32	Coronado Nmem	0.25
33	Tumacacori NHP	0.23
34	El Morro NM	0.22
35	Capulin Volcano NM	0.20
36	Gila Cliff Dwellings NM	0.18
37	Pipe Spring NM	0.16
38	Pecos NHP	0.16
39	Salinas Pueblo Missions NM	0.14
40	Hovenweep NM	0.09
41	Fort Union NM	0.06
42	Fort Bowie NHS	0.03

Table 3.3 Competition Index for the parks under consideration

Park	Competition Index
Sunset Crater Volcano NM	0.276
Wupatki NM	0.268
Walnut Canyon NM	0.247
Hubbell Trading Post NHS	0.209
Navajo NM	0.195
El Morro NM	0.194
Canyon de Chelly NM	0.193
Glen Canyon NRA	0.188
Petrified Forest NP	0.185
Montezuma Castle NM	0.184
Hovenweep NM	0.175
Grand Canyon NP	0.172
Saguaro NP	0.170
Tuzigoot NM	0.169
Natural Bridges NM	0.167
Chaco Culture NHP	0.164
Rainbow Bridge NM	0.163
Pipe Spring NM	0.163
Aztec Ruins NM	0.162
Fort Bowie NHS	0.161
Arches NP	0.160
Casa Grande Ruins NM	0.159
Chiricahua NM	0.158
Zion NP	0.155
Pecos NHP	0.153
Tonto NM	0.153
Cedar Breaks NM	0.151
Bryce Canyon NP	0.147
Tumacacori NHP	0.144
Salinas Pueblo Missions NM	0.141
Bandelier NM	0.140
Canyonlands NP	0.139
Capitol Reef NP	0.130
Coronado Nmem	0.129
Fort Union NM	0.124
Lake Mead NRA	0.121
Organ Pipe Cactus NM	0.113
Gila Cliff Dwellings NM	0.112
Carlsbad Caverns NP	0.104
White Sands NM	0.102
Capulin Volcano NM	0.095
Joshua Tree NP	0.095

Table 3.4 Personal income (real) of Cities (in thousands of Dollars)

City	1980	1980Rank	2002	2002 Rank
Los Angeles-Long Beach-Santa Ana, CA (MSA)	140,072,198	1	223,695,126	1
San Diego-Carlsbad-San Marcos, CA (MSA)	24,994,269	2	54,841,669	2
Phoenix-Mesa-Scottsdale, AZ (MSA)	20,123,534	3	53,809,951	3
Riverside-San Bernardino-Ontario, CA (MSA)	19,203,376	4	45,641,973	4
Las Vegas-Paradise, NV (MSA)	6,295,715	8	24,132,299	5
Salt Lake City, UT (MSA)	7,562,032	5	15,452,100	6
Oxnard-Thousand Oaks-Ventura, CA (MSA)	7,217,884	6	14,621,706	7
Tucson, AZ (MSA)	5,872,549	9	12,026,700	8
Albuquerque, NM (MSA)	5,637,287	10	11,597,730	9
Fresno, CA (MSA)	6,654,532	7	10,581,527	10
Bakersfield, CA (MSA)	5,342,909	11	8,486,454	11
El Paso, TX (MSA)	3,773,223	13	7,575,695	12
Santa Barbara-Santa Maria-Goleta, CA (MSA)	4,510,699	12	7,418,058	13
Provo-Orem, UT (MSA)	1,812,598	14	4,249,892	14
Santa Fe, NM (MSA)	839,429	18	2,391,703	15
Prescott, AZ (MSA)	721,004	21	2,126,194	16
Las Cruces, NM (MSA)	799,402	19	1,989,260	17
Yuma, AZ (MSA)	894,579	16	1,857,461	18
Lake Havasu City-Kingman, AZ Micropolitan SA	542,210	24	1,784,152	19
El Centro, CA (MSA)	1,050,269	15	1,609,377	20
Flagstaff, AZ (MSA)	702,246	22	1,593,145	21
Sierra Vista-Douglas, AZ Micropolitan SA	794,084	20	1,441,666	22
Farmington, NM (MSA)	841,784	17	1,330,557	23
St. George, UT (MSA)	217,617	36	1,079,824	24
Roswell, NM Micropolitan SA	491,459	26	740,102	25
Hobbs, NM Micropolitan SA	679,311	23	677,571	26
Carlsbad-Artesia, NM Micropolitan SA	498,162	25	659,557	27
Alamogordo, NM Micropolitan SA	434,553	29	652,225	28
Gallup, NM Micropolitan SA	437,436	28	609,967	29
Clovis, NM Micropolitan SA	439,996	27	583,322	30
Payson, AZ Micropolitan SA	329,193	30	576,046	31
Pahrump, NV Micropolitan SA	127,513	42	483,814	32
Los Alamos, NM Micropolitan SA	276,321	32	480,517	33
Espanola, NM Micropolitan SA	204,030	37	433,136	34
Nogales, AZ Micropolitan SA	193,790	38	384,412	35
Safford, AZ Micropolitan SA	291,814	31	375,437	36
Taos, NM Micropolitan SA	149,078	39	349,011	37
Cedar City, UT Micropolitan SA	145,166	41	343,578	38
Silver City, NM Micropolitan SA	260,056	34	324,037	39
Las Vegas, NM Micropolitan SA	148,755	40	319,846	40
Bishop, CA Micropolitan SA	220,604	35	259,665	41
Price, UT Micropolitan SA	267,031	33	250,623	42
Deming, NM Micropolitan SA	115,252	44	234,872	43
Portales, NM Micropolitan SA	121,383	43	232,179	44
Heber, UT Micropolitan SA	83,016	45	198,135	45

Table 3.5 Parks ranked according to the MPI values

Park	1980	1980Rank	2002	2002Rank
Saguaro NP	12457375	1	25529214	1
Joshua Tree NP	1608121	2	3016166	2
Lake Mead NRA	1026952	4	2308147	3
Casa Grande Ruins NM	1056209	3	2296014	4
Montezuma Castle NM	817644	6	1732809	5
Tuzigoot NM	822421	5	1720050	6
Tonto NM	753330	7	1563435	7
Walnut Canyon NM	734944	9	1519281	8
Tumacacori NHP	742499	8	1513201	9
Organ Pipe Cactus NM	720495	10	1460613	10
Sunset Crater Volcano NM	708109	11	1458888	11
Wupatki NM	676285	12	1386444	12
Zion NP	658403	13	1329925	13
Coronado Nmem	647063	14	1296624	14
Pipe Spring NM	628010	15	1264440	15
Grand Canyon NP	623022	16	1256823	16
Cedar Breaks NM	615990	17	1232486	17
Fort Bowie NHS	581190	18	1161935	18
Chiricahua NM	577700	19	1157290	19
Glen Canyon NRA	567075	20	1142511	20
Petrified Forest NP	560427	21	1120874	21
Bryce Canyon NP	559744	22	1112109	22
Hubbell Trading Post NHS	521939	23	1035927	23
Navajo NM	516942	24	1033935	24
Rainbow Bridge NM	485743	26	972282	25
El Malpais NM	491605	25	971716	26
Canyon de Chelly NM	481461	27	954798	27
Capitol Reef NP	472388	29	930743	28
Aztec Ruins NM	481205	28	927321	29
Chaco Culture NHP	460349	30	904906	30
Natural Bridges NM	455430	33	902706	31
Hovenweep NM	456562	32	899135	32
White Sands NM	457519	31	894147	33
Arches NP	443818	34	876235	34
Salinas Pueblo Missions NM	439609	35	864485	35
Bandelier NM	436268	36	852751	36
Pecos NHP	433568	37	852351	37
Gila Cliff Dwellings NM	430197	38	844492	38
Canyonlands NP	422101	39	831591	39
Carlsbad Caverns NP	381947	40	729291	40
Fort Union NM	368679	41	721634	41
Capulin Volcano NM	312856	42	609049	42

Table 3.6 Selected Definitions of Units Administered by the National Park Service

<p><i>National Park:</i> Usually a large natural place having a wide variety of attributes, at times including significant historic assets. Hunting, mining and consumptive activities are not authorized.</p>
<p><i>National Monument:</i> The Antiquities Act of 1906 authorized the President to declare by public proclamation landmarks, structures, and other objects of historic or scientific interest situated on lands owned or controlled by the government to be national monuments.</p>
<p><i>National Historic Site:</i> Usually, a national historic site contains a single historical feature that was directly associated with its subject. Derived from the Historic Sites Act of 1935, a number of historic sites were established by secretaries of the Interior, but most have been authorized by acts of Congress.</p>
<p><i>National Historical Park:</i> This designation generally applies to historic parks that extend beyond single properties or buildings.</p>
<p><i>National Recreation Area:</i> Twelve National Recreational Areas (NRA) in the system are centered on large reservoirs and emphasize water-based recreation. Five other NRAs are located near major population centers.</p>

Table 3.7 Definitions and Summary Statistics

Variable	Brief Definition	Mean	Std Dev	Minimum	Maximum
LNVISIT	Natural Log of Visits	12.18	1.52	8.50	16.10
LNAREA	Natural Log of Area of Park	9.08	2.84	3.69	14.20
LNAGE	Natural Log of Age of Park in Years	4.06	0.40	2.64	4.57
CAMPING	Dummy Variable. value=1 if camping is available at a park	0.10	0.29	0	1
LODGING	Dummy Variable. value=1 if lodging is available at a park	0.12	0.32	0	1
NMON	Dummy Variable. Value=1 if park is designated National Monument	0.62	0.48	0	1
NHP	Dummy Variable. Value=1 if park is designated National Historic Place	0.12	0.32	0	1
NRA	Dummy Variable. Value=1 if park is designated National Recreation Area	0.05	0.21	0	1
WILD	Dummy Variable. Value=1 if the park is a designated wilderness area			0	1
SUNSET	Dummy Variable. Value=1 for year1996,Sunset Crater Volcano NP	0.01	0.09	0	1
CASA	Dummy Variable. Value=1 for year2000,Casa Grande Ruins NP	0.00	0.04	0	1
TONTO	Dummy Variable. Value=1 for year1990, Tonto NM	0.00	0.03	0	1
NV	Dummy Variable. Value=1 if park is situated in Nevada.	0.02	0.15	0	1
NM	Dummy Variable. Value=1 if park is situated in New Mexico.	0.26	0.44	0	1
CA	Dummy Variable. Value=1 if park is situated in California	0.02	0.15	0	1
UT	Dummy Variable. Value=1 if park is situated in Utah	0.21	0.41	0	1
CERRO	Dummy Variable. Value=1 for year2000 and Bandeleir NM	0.00	0.03	0	1
RESLEVEL	Dummy Variable. Value is 0 for non reservoir parks and takes value between 0and 1 for reservoir parks. If reservoir level is at its historic peak then the value=1.	0.05	0.21	0	1
YDROP	Dummy Variable. Value=1 if there is a drop in State per capita income in a year	0.31	0.46	0	1
T0POGZ	Topographic diversity index:	0.48	0.66	-0.44	1.84
CINDEX	Competition Index	0.16	0.04	0.09	0.28
LNMPI	Natural Log of Market Potential Index	13.68	0.61	12.65	17.06
LNGAS	Natural Log of price of Gasoline	5.11	0.24	4.78	5.66
LNXRATE	Natural Log of Exchange rate	4.66	0.10	4.54	4.88
JULTEMP	July temperature Index (Normalized Z score)	0.26	1.20	-2.72	2.06
JANTEMP	January temperature Index (Normalized Z score)	0.21	0.65	-0.56	1.59
HUMID	Humidity Index (Normalized Z score)	1.96	0.59	-0.82	2.87
LNTI	Natural log of July Temperature index (weighted monthly average temperature)	4.52	0.05	4.35	4.65

Chapter 4

4 Econometric specification

The Panel data model to explain the visitation is estimated as:

$$Y_{it} = \alpha + X'_{it}\beta + W'_i\gamma + Z'_t\delta + u_{it} \quad (4.1)$$

where Y_{it} is the number of visits to a park i in year t , X_{it} is a vector of independent variables that vary by park and vary over time, W_i is a vector of variables that vary by park, but are constant over time, Z_t is a vector of variables that vary over time, but are the same for each park, u_{it} is a stochastic error term, and β , γ and δ are vectors of regression coefficients to be estimated. The static W_i variables represent fixed attributes of individual parks, such as area or existence of concessionary lodging or camping, the spatial competition index, and state dummy variables. They also include the ERS amenity index variables for topographic variation and for long-term climate. The Z_t variables include national economic variables such as the price of unleaded gasoline and the real exchange rate. The X_{it} variables include park age, the log(market potential index), reservoir levels, the current July temperature index, the state-level recession variable, the national park and national monument designation variables (because some parks changed designation over the study period), as well as specific dummy variables for park-year combinations of changes in visitation estimation, road construction and fire.

An alternative to equation (4.1) above is a fixed effect specification such that

$$Y_{it} = \alpha_i + X'_{it}\beta + Z'_t\delta + u_{it} \quad (4.2)$$

This specification differs from (4.1) above in that the α_i intercepts are allowed to vary by park. There is a single α intercept in (4.1). The fixed effect specification has dummy variables for each park, while the static W_i variables must be omitted from the regression. Static (or very slowly moving) variables must be omitted from the fixed effects specification because they will be perfectly collinear with the park-specific dummy variables.

The estimator:

The model mentioned above could be estimated by Ordinary Least Squares (OLS) or Feasible Generalized Least Squares (FGLS) estimators. Ordinary Least Squares estimation assumes that the disturbances are spherical in the data. Violation of this assumption leads to inefficient estimators, which is undesirable.

Panel data commonly exhibits panel heteroskedasticity and autocorrelation. Panel heteroskedasticity is a situation where the error variances are same within the unit and different across the units. This arises due to the difference between the natures of cross section units. Panel errors could be contemporaneously correlated. Errors of unit i at time t will often be associated with errors of unit j at time t

The assumptions of Panel data could be summarized as:

Panel heteroskedasticity:

$$E(u_{it}^2) \neq E(u_{jt}^2) \text{ for } i \neq j$$

$$E(u_{it}^2) = E(u_{it+1}^2)$$

$$E(u_{it}^2) = \sigma_{ii}^2$$

Contemporaneous Correlation:

$$E(u_{it} u_{jt}) = \sigma_{ij}$$

$$u_{it} = \rho_i u_{i,t-1} + \varepsilon_{it}$$

Where:

$$E(\varepsilon_{it}) = 0$$

$$E(u_{i,t-1} \varepsilon_{jt}) = 0$$

$$E(\varepsilon_{it} \varepsilon_{jt}) = \phi_{ij}$$

$$E(\varepsilon_{it} \varepsilon_{js}) = 0 \quad \text{for } i \neq j \text{ and } t \neq s$$

$$E(u_{i0}) = 0$$

$$E(u_i u_j) = \sigma_{ij} = \frac{\phi_{ij}}{(1 - \rho_i \rho_j)}$$

Due to these non-spherical error terms, the standard errors of the OLS estimates are consistent but inefficient. Beck and Katz (1995) identified that the OLS estimates with Panel Corrected Standard Errors (PCSE) are superior to the Feasible Generalized Least Squares (FGLS) for the TSCS data. The OLS estimates would be:

$$\beta = (X'X)^{-1}X'Y$$

The Panel Corrected Standard Errors of the estimates are the square roots of the diagonal terms of:

$$\text{Cov}(\hat{\beta}) = (X'X)^{-1}\{X'\Omega X\}(X'X)^{-1}$$

$$\text{where } \Omega = \Sigma \otimes I_T$$

Ω is a block diagonal matrix of dimension $NT \times NT$ with an $N \times N$ matrix of contemporaneous covariances, Σ on the diagonal. The typical element of Σ can be estimated from OLS residuals, for unit i at time t as:

$$\hat{\Sigma}_{i,j} = \frac{\sum_{t=1}^T e_{i,t} e_{j,t}}{T}$$

where e'_t is a $1 \times N$ matrix of residuals for the N groups at time t .

PCSE take into consideration the panel heteroskedastic and contemporaneous correlation of error terms. OLS estimates with PCSE are superior to the FGLS estimates computed by the Parks Method. The Parks method takes the autocorrelation AR1 process into consideration in the estimation. It consists of transforming the data to make the disturbances spherical and estimating the parameters on the transformed data by OLS. This method cannot be employed if the number of cross section is greater than the number of time periods (Greene; Beck and Katz, 1995). Beck and Katz (1995) estimate the over confidence introduced into the estimates. FLGS estimates have very low standard errors due to over correction.

A total of four models have been estimated which include:

- Pooled OLS models with and without AR1 correction and Panel Corrected Standard Errors.
- Fixed effects models with and without AR1 correction and Panel Corrected Standard Errors.

Correction for the first order autocorrelation in the data has been done by the Cochrane-Orcutt procedure.

Calculation of Point Elasticities:

The point elasticity ($\epsilon_{visits,x}$) of annual Visits to the parks with respect to a variable x is given by:

$$\epsilon_{visits,x} = \frac{d(\ln y)}{d(\ln x)}$$

For example, the elasticity of visits with respect to temperature is given by:

$$\epsilon_{visits,ti} = \frac{d(\ln visits)}{d(\ln TI)} = \beta_{11}$$

The elasticity of visits with respect to the variables is presented in a table 5.5 in the Results chapter.

Chapter 5

5 Results

Table 5.1 reports estimation results for two pooled OLS specification. The first includes static park characteristic and climate variables. The second specification includes park-specific fixed effects. A number of hypothesis tests were conducted concerning the error structure and specification of the model. These included Lagrange multiplier tests for cross section heteroskedasticity and contemporaneous correlation (diagonal covariance matrix), tests for autocorrelation and likelihood ratio tests of the null hypothesis that static park or climate effects or fixed effects are not significant.

The Lagrange multiplier test for cross-section heteroskedasticity is done by estimating the restricted model under the null hypothesis of no heteroskedasticity. The loglikelihood function for normally distributed sample of observations is

$$\ln L = -\frac{n}{2} \ln(2\pi) - \frac{1}{2} \sum_{i=1}^n \left[\ln \sigma_i^2 + \frac{1}{\sigma_i^2} (y_i - X_i' \beta)^2 \right]$$

$$\sigma_i^2 = \sigma^2 f_i(\alpha)$$

where α is a vector of unknown parameters.

Under assumption of no heteroskedasticity, $\alpha = 0$.

LM test statistic would be:

$$LM = \left[\frac{\partial \ln L}{\partial \gamma} \right]' \left\{ -E[H]^{-1} \right\} \left[\frac{\partial \ln L}{\partial \gamma} \right]$$

$$\text{where } \gamma = \left(b, \frac{e'e}{n}, 0 \right)$$

The statistic is a Chi-square statistic with degrees of freedom equal to the number of restrictions.

The results from the LM test for cross section heteroskedasticity for the Pooled OLS model with static variables indicate the presence of heteroskedasticity. The Chi-square statistic is 841.6 with 41 degrees of freedom. The null hypothesis of no cross-section heteroskedasticity is rejected (p value <0.000). LM test statistics for the fixed effects model also indicate cross section heteroskedasticity. The LM test statistic is 422.02 with 41 degrees of freedom. The null hypothesis of no heteroskedasticity can be flatly rejected (p-value <0.000).

The Breush–Pagan-Godfrey Lagrange multiplier test for the diagonal covariance matrix is done under the null hypothesis of no contemporaneous autocorrelation.

The LM test statistic is:

$$LM = T \left(\frac{e'X_0 (X_0'X_0)^{-1} X_0'e}{e'e} \right)$$

where X_0 is the original X matrix augmented by lagged OLS residuals.

The LM test statistic for the Pooled OLS model is 9819.7 with 861 degrees of freedom.

The p-value is (< 0.000). The null hypothesis of a diagonal variance covariance matrix is rejected. The LM test statistic for the fixed effects model is 4176.8 with 861 degrees of freedom. The null hypothesis of a diagonal variance covariance matrix is rejected (p-value <0.000) even for this model, indicating the presence of contemporaneous correlation.

The presence of autocorrelation in the data is tested by the construction of Durbin Watson test statistic. This test assumes that the autocorrelation process in the data is identical across all the cross sections. The Durbin Watson statistic is constructed as:

$$D = \frac{\sum_{t=2}^n (u_t - u_{t-1})^2}{\sum_{t=1}^n u_t^2}$$

Which is the ratio of sum of squared differences in successive error terms to the sum of squares of the error terms. The above equation on simplification gives:

$$D \approx 2 \left(1 - \frac{\sum u_t u_{t-1}}{\sum u_t^2} \right)$$

Defining the $\frac{\sum u_t u_{t-1}}{\sum u_t^2} = \rho$ the 1st order correlation coefficient gives the range of D as

bound between 0 and 4 as the value of ρ lies between -1 and 1.

The Durbin-Watson test is carried out by comparing the calculated value against the critical values – the lower limit D_L and the upper limit D_U . If the calculated value D is less than the D_L the null hypothesis is rejected. If the D is greater than the D_U then the null hypothesis is not rejected. If the value of D lies between D_L and D_U then the test is indecisive.

The values of D_L and D_U for the fixed effects model are 1.554 and 1.991 respectively. We can observe that the calculated D value is 0.423, which implies existence of autocorrelation in the data. The values of D_L and D_U for the pooled OLS static variable model are 1.859 and 1.9374 respectively. The calculated D value is 0.0366

which is less than the D_L indicating the presence of autocorrelation. The null hypothesis of no autocorrelation has been rejected. Weiler and Seidl (2004) also report autocorrelation in their data.

Finally, for the static-variable model we test the null hypothesis that the static variables are not significant and for the fixed effects model that the fixed effects coefficients are all equal. The first test hypothesis is tested using a likelihood ratio test. The test statistic is $-2 \ln(\text{likelihood function of the restricted model}) - \ln(\text{likelihood function of the unrestricted model})$ and has a Chi-squared distribution. For the static model, the statistic is 1258.52 with 16 degrees of freedom (Table 5.1). The fixed effects model, the statistic is 306.8300 with 41 degrees of freedom. In both cases, the null hypothesis is soundly rejected ($P < 0.000$).

The results of a number of hypothesis tests suggest that OLS is not appropriate for estimating national park visits. The results from the Lagrange multiplier test for panel heteroskedasticity, LM test results for contemporaneous correlation, the Durbin Watson test for autocorrelation indicate the presence of panel heteroskedasticity, contemporaneous correlation and autocorrelation in the data. The OLS standard errors in the presence of these phenomena are biased. Conclusions based on these biased standard errors could be erroneous.

Table 5.2 reports results of the static-variable and fixed effects models with corrections for first order autocorrelation (AR (1)) and using panel corrected standard errors (PCSEs). In the static-variable specification, a park's attributes affects visitation. Visits to parks were increasing in the area of the park Similarly, the age of the park, and

existence of concessionaire camping and lodging have positive coefficients, indicating that the visits to parks increase with these variables. The coefficients are statistically significant. The signs of the coefficients are as expected and in conformity with the findings of the previous studies.

Coefficients of variables for Park designation (National Monument, National Historic Park, Wilderness area) are positive. However they are not statistically significant National Recreational Areas have a negative and statistically significant coefficient. Parks with designated Wilderness Areas have a positive coefficient statistically significant at the 90% level.

The geographic variables, the topographical diversity index and competition index have positive coefficient values. The competition index coefficient is not quite significant at the 10% level. This provides somewhat weak evidence of a complementary relationship between the parks. Previous studies have identified a competitive relationship between parks.

The economic variables market potential index has positive coefficient, but is not statistically significant. The price of gasoline, foreign exchange rate, and the variable indicating the drop in state per capita income are all negative indicating that the visits to parks decrease with increase in these factors. All the coefficients are significant statistically.

The long term climatic variables – July month temperatures and January month temperatures, July humidity have negative and statistically significant coefficients. Negative coefficient of January temperatures indicates that the visits decrease with higher temperatures in winter. The variable JULTEMP takes higher values if July temperatures

are more temperate. Specifically, it is higher if they are more temperate than expected based on a regression of July temperature on January temperature. The negative coefficient on the index means that visits are *lower* in areas where July climate is more temperate than expected, given January temperatures.

The coefficient of July humidity index is negative, but the interpretation of the effects should be treated carefully. The HUMID index increases as the actual relative humidity *decreases*. The negative coefficient suggests that park visits are increasing with humidity. This may be a relationship that only holds in the relatively arid Southwest, where relative humidity levels are among the lowest in the country. Relatively high humidity levels for the Southwest will still be relatively dry. The mean of the humidity index is nearly 2, meaning that the sample average humidity of Southwest parks is nearly 2 standard deviations below the national average. In the Southwest, extremely low humidity may reflect very dry, desert conditions, while relatively more humidity may reflect presence of more grasslands and forests.

The results from the fixed effects models in table 5.2 are similar to the results from the Pooled OLS model with static variables. However the magnitude of the coefficients in fixed effects model is more than the coefficients of Pooled OLS models with static variables.

The fixed effects model appears to perform better compared to the models with static variables. The Goodness of fit is higher for the fixed effects specification. The R-squared (between observed and predicted values) for the static variable model is 0.945 for the static variable model, but 0.9941 for the fixed effects model.

For the static-variable model, the autocorrelation coefficient $\rho = 0.97352$, which is close to one. Beck and Katz (2004) warn that a ρ close to one is an indicator that the data is non-stationary and that

“While estimation of TSCS models with unit root data is just beginning to be studied, our experience from single time series analysis tells us that we cannot simply use stationary methods to analyze such data (p.25).”

The variables RESLEVEL and CERRO explain the effects of changes in reservoir levels and the effects of fire on visits respectively. The coefficient of the reservoir level variable is 5.0076, indicating that the visits to the parks increase with an increase in the water levels. For every 1% increase in water levels would increase the visits by as much as 5%. The variable CERRO represents the effects of fires. The coefficient is negative, indicating that the visits decrease with the occurrence of fires.

Table 5.1 Pooled OLS models and Fixed effects models without the AR(1) correction and PCSEs

Variable Name	Pooled OLS with Static Variables		OLS with Fixed effects	
	Estimate	t-statistic	Estimate	t-statistic
LNAREA	0.17573	12.31		
LNAGE	0.58604	8.093	0.4284	4.6730
CAMPING	1.1242	8.710		
LODGING	1.1396	9.540		
NMON	-0.60484	-7.141		
NHP	-0.63632	-5.257		
NRA	-5.1242	-0.5663		
WILD	0.46508	4.947		
SUNSET	-0.13278	-0.5182	-1.1234	-13.9800
CASA	-0.10109	-0.2053	-0.5705	-4.1770
TONTO	-0.72774	-1.055	-0.4792	-2.5530
NV	0.58185	2.323		
NM	-0.82658	-9.196		
CA	-0.55084	-1.717		
UT	-0.28757	-2.803		
TYPOGZ	0.43245	8.639		
CINDEX	3.8325	3.247		
LNMPI	0.39039	6.967	0.1288	1.7180
YDROP	-0.76027E-01	-1.576	-0.0508	-3.7530
LNGAS	-0.30884E-01	-0.2774	-0.3794	-7.6460
LNXRATE	-1.0189	-4.371	-0.7607	-11.3100
JULTEMP	-0.38388	-9.506		
JANTEMP	-0.81471	-11.02		
HUMID	-0.62481	-5.337		
CERRO	-0.13993	-0.2028	-0.2082	-1.1090
RESLEVEL	4.9438	0.5370	3.6259	1.4570
LNTI	-1.6179	-1.960	-0.5792	-1.9540
Intercept	16.206	4.317		
R ²	0.8042		R ²	0.9863
Log Likelihood Function	-1032.72		Log Likelihood Func.	306.8300
Durbin Watson Statistic	0.0366		Durbin Watson Statistic	0.4234
Estimated ρ	0.97352		Estimated ρ	0.7634
LM test for cross-section heteroskedasticity	χ^2 Test Statistic	841.56	χ^2 Test Statistic	422.0200
	D.F.	41	D.F.	41
	P value	0.0000	P value	0.0000
Breusch-Pagan LM test for diagonal covariance matrix	χ^2 Test Statistic	9819.7	χ^2 Test Statistic	4176.8000
	D.F.	861	D.F.	861
	P value	0.0000	P value	0.0000
Likelihood Ratio test for null hypothesis of no static variable or fixed effects	χ^2 Test Statistic	1258.52	3937.62	
	D.F.	16		41
	P value	0.0000		0.0000

Table 5.2 Pooled OLS regression with Static Variables and Fixed effects model with the AR(1) and PCSEs

Variable Name	Pooled OLS with AR(1) correction, PCSEs, Static Variables		Pooled OLS with AR(1) correction, PCSEs, Fixed effects	
	Coefficient Estimate	t-statistic	Coefficient Estimate	t-statistic
LNAREA	0.23835*	5.265		
LNAGE	0.67699*	3.848	0.65638*	3.57
CAMPING	1.3101*	5.532		
LODGING	1.2189*	3.604		
NMON	3.08E-02	0.4743		
NHP	9.52E-02	0.3487		
NRA	-4.6536*	-2.528		
WILD	0.48925***	1.645		
SUNSET	-0.87585*	-10.88	-0.97237*	-16.35
CASA	-0.44142*	-6.225	-0.49552*	-7.5
TONTO	-0.29964*	-3.96	-0.29519*	-3.523
NV	0.67661			
NM	-0.96390**	1.715		
CA	-1.1226*	-3.496		
UT	-0.14333	-0.3617		
TYPOGZ	0.44528*	2.85		
CINDEX	5.3003	1.634		
LNMPI	0.19429	1.625	0.11109	0.865
YDROP	-2.28E-02*	-2.474	-0.029088*	-2.566
LNGAS	-0.13906*	-2.221	-0.22765*	-3.286
LNXRATE	-0.43804*	-3.947	-0.49906*	-4.101
JULTEMP	-0.44939*	-4.411		
JANTEMP	-0.82775*	-3.359		
HUMID	-0.90129*	-3.05		
CERRO	-0.24653*	-3.669	-0.23621*	-3.296
RESLEVEL	4.416*	2.385	5.0076*	2.62
LNTI	-0.35317***	-1.738	-0.36643	-1.467
Intercept	9.7942*	4.660		
Buse R ²	0.3728		R2	0.9307
Buse Raw Moment R ²	0.9692			0.9988
R ² between observed and predicted values	0.9450			0.9941
Log Likelihood Function	684.133		Log Likelihood Function	769.82
Durbin Watson Statistic	1.9358		Durbin Watson Statistic	1.7683
Estimated ρ	0.97352		Estimated ρ	0.76344

Dependent Variable: Invisit (log of annual visits to park i in year t) 42 Parks 24 Years (1980-2003)

* significant at 99% level, ** significant at 95% level, *** significant at 90% level

Table 5.3 Estimated Fixed effects coefficients of the AR(1) correction and PCSEs

Park	Coefficient Estimate	t-statistic
Arches NP	14.466	7.901
Aztec Ruins NM	11.977	6.573
Bandelier NM	13.505	7.471
Bryce Canyon NP	14.477	7.879
Canyon de Chelly NM	14.289	7.829
Canyonlands NP	13.854	7.494
Capitol Reef NP	14.148	7.738
Capulin Volcano NM	11.76	6.611
Carlsbad Caverns NP	14.349	7.933
Casa Grande Ruins NM	12.66	6.666
Cedar Breaks NM	14.074	7.604
Chaco Culture NHP	11.923	6.575
Chiricahua NM	12.008	6.503
Coronado Nmem	12.326	6.591
El Morro NM	11.646	6.411
Fort Bowie NHS	10.438	5.552
Fort Union NM	11.19	6.116
Gila Cliff Dwellings NM	11.512	6.366
Glen Canyon NRA	11.117	4.24
Grand Canyon NP	15.892	8.634
Hovenweep NM	10.927	6.006
Hubbell Trading Post NHS	13.603	7.287
Joshua Tree NP	14.592	7.557
Lake Mead NRA	11.995	4.481
Montezuma Castle NM	14.107	7.573
Natural Bridges NM	12.224	6.747
Navajo NM	11.86	6.5
Organ Pipe Cactus NM	13.344	7.104
Pecos NHP	12.142	6.579
Petrified Forest NP	14.243	7.792
Pipe Spring NM	11.547	6.234
Rainbow Bridge NM	12.878	7.052
Saguaro NP	14.099	6.577
Salinas Pueblo Missions NM	11.222	6.204
Sunset Crater Volcano NM	13.832	7.481
Tonto NM	11.85	6.369
Tumacacori NHP	11.689	6.285
Tuzigoot NM	12.566	6.687
Walnut Canyon NM	12.782	6.84
White Sands NM	14.235	7.802
Wupatki NM	13.167	7.135
Zion NP	15.3	8.25

Table 5.4 Evaluating the forecasting efficiency of the fixed effects AR(1) and PCSE model

MAPE and RMSPE for Fixed effects model predictions		
Logvisits		
Park	MAPE	RMSPE
Arches NP	2.742951	2.743969
Aztec Ruins NM	3.186367	3.697322
Bandelier NM	1.166755	1.168837
Bryce Canyon NP	1.738565	1.739316
Canyon de Chelly NM	3.021935	3.049945
Canyonlands NP	3.887583	3.890826
Capitol Reef NP	1.42593	1.426855
Capulin Volcano NM	1.078221	1.419092
Carlsbad Caverns NP	2.497846	2.811253
Casa Grande Ruins NM	0.956808	0.962823
Cedar Breaks NM	2.088604	2.093057
Chaco Culture NHP	1.302104	1.622948
Chiricahua NM	1.845574	1.984963
Coronado Nmem	3.042071	3.043878
El Morro NM	1.46377	1.620326
Fort Bowie NHS	0.908197	0.90929
Fort Union NM	3.384023	3.749438
Gila Cliff Dwellings NM	1.11545	1.121773
Glen Canyon NRA	0.194064	0.219058
Grand Canyon NP	1.801513	1.803621
Hovenweep NM	4.052487	4.056277
Hubbell Trading Post NHS	0.782838	0.785751
Joshua Tree NP	2.575557	2.591205
Lake Mead NRA	0.678988	0.679045
Montezuma Castle NM	0.630697	0.632355
Natural Bridges NM	1.626493	1.626777
Navajo NM	1.520803	1.854225
Organ Pipe Cactus NM	2.643163	2.654335
Pecos NHP	2.29869	2.58682
Petrified Forest NP	0.789388	0.796519
Pipe Spring NM	3.527869	3.529174
Rainbow Bridge NM	2.286123	2.831691
Saguaro NP	0.162568	0.225677
Salinas Pueblo Missions NM	1.603851	1.604962
Sunset Crater Volcano NM	0.474187	0.514254
Tonto NM	0.222617	0.265406
Tumacacori NHP	0.373194	0.373874
Tuzigoot NM	1.493756	1.496536
Walnut Canyon NM	0.220375	0.256391
White Sands NM	1.173428	1.623509
Wupatki NM	1.823227	1.876974
Zion NP	2.765333	2.77252

The forecasting efficiency of the fixed effects model has been evaluated by the construction of the MAPE and RMSPE. The model has a percentage error ranging from 1% to 5% which denotes good forecasting ability of the model. These results are not, strictly speaking, forecasts because they are in-sample predictions rather than predictions of future periods. Future research could examine the out-of-sample performance of the model. For example and out-of-sample forecast for 2004 could be compared with the NPS forecast for 2004.

Chapter 6

6 Conclusions

Visitation to the national parks in the Southwest is of great importance to the economies. This study tries to explain the importance of the climatic and economic factors influencing the visits to the national parks. The study area includes all the national parks in the states of Arizona, New Mexico and neighboring parks in the states of Utah, California and Nevada. This study covers a total of 42 national parks from 1980 to 2003.

The previous studies on visitation to national parks used the OLS estimator to explain visitation. In this study, we tested for the presence of panel heteroskedasticity, contemporaneous correlation and autocorrelation in the data. Results of the tests indicate the presence of all the phenomena tested for in the error structure. OLS estimate standard errors are biased due to the above phenomena. Any conclusions based on these standard errors could be erroneous. The issue of panel heteroskedasticity and contemporaneous correlation is corrected by the use of Panel Corrected Standard Errors (PCSE) and the issue of autocorrelation was corrected by the Cochrane Orcutt procedure for AR(1) process.

The static-variable specification included long-term climate variables. Regression results suggest that visits decline with higher long-term January temperatures, but increase with humidity. This latter result may be due to the fact that our study was confined to the Southwest, which has very low humidity. Extremely low humidity is associated with desert, as opposed to forest and grassland environments.

The regression model helps to identify the significant factors that affect visitation to the national parks. The impact of each factor on the visitation can be measured in

terms of the elasticity. The elasticity of visits with respect to price of gasoline is -0.227. This means that if there were an increase in the gas price by a 10%, visits to the parks would go down by nearly 2.3%. If the exchange rate increases by 1%, the visits would decrease by 0.4%. In years when per capita personal income falls, visits fall by 2.9%. The results suggest visits fall 4.5-5.0% for every 1% drop in reservoir levels. Since reaching a peak level in 1983, levels at Lake Mead have fallen by 5.79%. Since reaching a peak level in 1983, levels at Lake Powell have fallen by 2.1%. Finally, the results suggest that, controlling for other factors, the Cerro Grande fire accounted for a drop of 66,150 visits to Bandelier National Monument in 2000, equivalent to a 21% decrease.

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