Accurately predicting visitation as a strategic tool for management of a public park

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ABSTRACT

Public parks can provide considerable value to the population that visit them, for the community around them and the local economy. A well designed public park can attract growth in tourism, stimulate a habitat for wildlife, contribute to personal health and wellness, improve the aesthetics of an area and stimulate economic growth. Managing and operating a public park entails many complex issues such as designing an attractive green space, implementing and maintaining the park, attracting and managing visitors and obtaining financial support. Public parks need to identify factors that influence park visitation in order to more effectively manage park visitorship.. This thesis examines park visitation analyzing data of park users of The High Line in New York City to develop a model to more accurately predict visitation. The thesis focuses on the critical social and climatic variables that attract visitors to spend time in the High Line park. Understanding these factors will allow park management the ability to create a strategic plan for managing a public space that best serves its visitors and the community. More specifically, a strategic plan helps to determine who the visitors are and what activities they enjoy in the park. In conceptualizing a solution, High Line can put into practice what its visitors want to see offered in the park and which of its programming needs improvement to attract more visitors. Meeting the needs of park visitors will create a better experience for the customers and a better management strategy for operations. A multivariate regression analysis was used to establish the relationship between High Line visitation and the climatic and social variables. The climatic variables of daily average temperature and precipitation. The social variables of day of the week and season of the year were added to the structural model as

dummies. A time trend variable characterized as time in years was added to the model to show any yearly change in visitation to the park. This method has been widely applied to a number of studies testing the relationship of climatic and social variables to park visitation (Micah, Scotter and Fenech 2016). The results of this regression analysis show that the social variables of day of the week and season and the climatic variables of average temperature and precipitation had a significant affect on park visitation. The model developed can be used to forecast park visitation, quantifying the many variables that influence park visitation.

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CHAPTER I: INTRODUCTION

The High Line Park is a result of the repurposing of old railway infrastructure that was elevated to run through New York City's west side. The High Line is a linear mile and a half long public park that stretches from Gansevoort Street at its southern tip up to West 34th Street where it ramps down to the Hudson Railyards. The original structure was constructed in the 1930s to carry goods into the industrial west side of Manhattan as a response to congestion on the streets. The High Line railway eliminated 110 street crossings on 10th avenue, nicknamed Death Ave, due to so many pedestrians being run over by the freight trains. Then in the 1950s, the rise of the interstate trucking industry led to the decline of the national railway system and elevated rail systems such as the High Line. By the 1980s trains had stopped running all together and the elevated railway was left to rust. It was slated to be torn down for redevelopment and it was not until the mid-1990s when two local residents coincidentally met at a community board meeting that was discussing tearing the High Line down. The two decided that maybe the structure was worth saving and fought the odds of turning the elevated railway into a public park.

Today, the High Line Park has 3.4 acres of maintained garden space with 110,000 plantings, a walking path that takes visitors on a journey through time, art and gardens with incredible views of New York City's landmarks, including the Empire State Building, World Trade Center and the Statue of Liberty. The High Line Park has been credited with a significant economic impact on the surrounding community. The additional tax-revenue generated from the High Line is estimated at about $900 million. An estimated 38 million people have come to visit this unique public space that took $260 million dollars to build (Rainey 2014). The massive Hudson Yards development project adjoining the park has

spawned 2 billion dollars in private investment, created 23,000 construction jobs and brought 8.5 million tourists to the area. Several multinational companies have renovated space around the High Line for flagship stores attracting other business and resident facilities.

The challenges to operating an urban park are many. In New York City, space is a major challenge for the High Line, that is not only small but elevated 30 feet above the ground, causing logistics to be difficult when managing large volumes of park visitors. The High Line is 1.45 miles long and 7 acres in total with a central walkway and a long perennial border flanking the walking path. On a busy weekend in summer, the High Line can have up to 50,000 visitors creating a bottleneck on the central walkway in some sections. It can be a challenge during high volume times to keep visitors on the pathways and not spilling over into the planter beds. The current design, by the famous landscape architect Piet Oudolf, is in itself a work of art.

Faced by an unexpected number of visitors, the High Line is managing to react and adapt to its high volume visitation. Some of the major implementation challenges being faced stem from this unpredicted exponential growth of visitors to the park. The High Line has been highly successful at attracting funding and visitation but it is a challenge to manage visitation for continued operation. In 2009, when the High Line opened to the public, it estimated annual visitation to be around 350,000 persons. Those figures were increased to 1.3 million visitors that walked the High Line in the first year of operation. This has led to challenges associated with managing a high volume public space. Visitation is also inconsistent and varies based on time of day, day of the week and season of the year.

As a park in the sky, in a unique cityscape, simply growing plants and taking out the trash can also be a challenge.

Due to the rapid growth and popularity of the High Line, the caretakers of the park known as the Friends of the High Line, realized that information was needed regarding park visitation to plan for future resource allocation. Furthermore, to assess if the High Line's mission "to foster a strong community and neighborhood" was being accomplished, High Line surveyed park users and gathered daily visitation data to understand the volume and patterns of park visitors.

Despite these challenges, The High Line has continued to move forward with its vision: keep it slow, keep it safe, and make it beautiful. The High Line continues to be a main attraction in the neighborhood. According to High Line's 2015 tracking survey (Appendix A), 65% of people came to the area solely to visit the High Line. While visiting the High Line, visitors took a walk, enjoyed the flowers, took pictures, purchased food and beverage and went shopping. Therefore, an objective to increase local visitation by New Yorkers to 10% in the next year has been established. A demographics study in 2015 found that only 7% of High Line visitors came from the local community versus 60% of visitation from the tourism sector of New York City.of which roughly 30% domestic tourists and 30% international tourists visiting New York City (Line 2015).

Analyzing visitation patterns will help focus efforts for maximum and minimum visitation times, event hosting, public programming schedules, and membership and community engagement activities. The park was designed with the intent of benefiting the local community by offering a reclusive green oasis above the busy streets of west Chelsea.. In return,HighLine is planning on the continued support of the community

through contributions to raise the required revenue for park operations.. Accurately predicting park visitation and impact is vital to the continued success of the High Line. The rationale for creating a regression model to analyze park visitation is to be able to more accurately predict an increase in visitorship considering day of the week, weather, and seasonality. Past structural models for predicting park visitation found that time series methods, notably a single moving average and ARIMA produce the most accurate forecasting models (Wilmot and McIntosh 2014). This report illustrates a forecasting model for predicting park visitation including statistical programming and regression analysis

CHAPTER II: THEORY

The theory for this paper revolved around the central idea that park managers needed a tool to conduct visitor forecasting.This process starts with understanding what factors cause people to come to the park.Thus, explanatory variables for park visitation were used to develop this model. I realized that econometric analysis is a useful tool used for forcasting and prediction trends. The ideal model will accurately predict visitation by inputting selected variables into the model. I was looking for new ways to visualize and understand the visitation data.

2.1 Selecting variables

Explanatory variables used in my model to predict visitation include climatic variables of average temperature and precipitation, and the social variables of day of the week and season. These variables were selected to identify trends and to show if any correlation exists with High Line visitorship. The social variables day of the week and season are represented by dummy variables in the model. Omitting Saturday for day of the week and spring for seasonality result in the respective baseline. The dummy variables were selected to represent categories in the data. The data was gathered over time and include a time trend variable and dummy variables that represent a relationship with the dependent variable (Baker 2006). The regression results of the dummy variables shows the difference between being in a category or not. A coefficient will be generated for each day of the week and season of the year. The ideal model will accurately predict visitation by using selected variables in the model. A model equation user can enter the average daily temperature, the time trend variable, day of the week and the season and produce visitation estimates. The equation will generate a daily visitation estimate that can be used by High Line to forecast future growth and visitation trends.

Forecasting park visitation is important to future management and effective park operations. Stymes (1983) stated that "Structural models rely upon an understanding of these casual forces in order to estimate the effects on recreation participation of changes in a set of independent variables" This structural model assumes that the relationship of the variables remain stable over time for forecasting purposes. The climatic data acquired from Central Park's weather station shows weather patterns to be relatively stable and can therefore be used for accurate forecasting purposes. In addition, it is well documented that weather can have both a positive and negative impact on park visitation. For example, research has shown that the climatic variables of rain and heavy wind tend to decrease park visitation (Micah, Scotter and Fenech 2016). It makes sense that people are much less likely to engage in outdoor activities when it is considered a bad weather day. Also, excessively cold or hot temperatures will likely decrease visitation. It is clear that weather affects visitation patterns and season directly affects park visitorship. Previous studies have shown that social variables such as day of the week and cultural holidays may have an even greater or equal impact on visitation then the weather (Micah, Scotter and Fenech 2016).

2.2 Econometric Framework

Regression analysis is widely used because of its ability to quantify results and put numbers to support data and theoretical models. Regression analysis is one of the most widely used techniques for predicting park visitation. The National Park Service has used regression analysis to predict an number of outdoor recreational variables in past studies. Although general patterns in visitation data were previously analyzed by High Line staff, a regression analysis was not conducted to quantify these trends and produce slope coefficients. The objective of this paper is to generate a forecasting model that would provide numerical estimates of park visitation more accurately. The regression analysis will

provide statistical based predictions to support a park visitorship model. Regression analysis provides a way to estimate the relationship of the dependent and independent variables quantifying the relationship of the variables (Studenmund 2011). The statistical software Gretl was chosen to analyze High Line data and conduct a more complex multi-variant analysis. This will help support better informed decisions for improving park operation and management such as predicting future visitation and infrastructure needs.

Econometric methods are designed to help predict future economic trends such as sales and profits for businesses. It is postured that the proposed model can use the same technique to predict future visitation trends in a public park. The visitor data collected will act as a good predictor of the future visitation pattern due to the relative consistency of the selected variables. Furthermore, five years of data with over 2000 data entries results in a high degrees of number for freedom and good data set.

The conceptual model developed for this analysis considered all these variables to identify variables that could be quantified. Therefore, the variables average daily temperature, daily precipitation, day of the week, season and time trend year were ultimately used for the regression model. A total of twelve independent variables were identified. Excluding the dummy for day of the week leaves six variables, then adding the three seasonal variables of summer, fall and winter brings the number of variables to nine. Two explanatory variables for average temperature and precipitation were added, then the last addition of a time trend equals twelve explanatory variables. In supporting the objective to accurately predict park visitation these twelve variables make sense for the model. It is anticipated that this conceptual model will help identify new ways to visualize and understand High Line visitor data.

The 2015 visitor survey gave the High Line new insights about what the customer's value in the park. Those data help create visitor driven experiences and support the mission of being an inclusive public space for everyone. Each park user can have a slightly different experience, or a reason for visiting, but management needs to know what activity brings visitors back to the park and be able to accurately predict how many people will visit. The survey conducted by the High Line was similar to a 2008 comprehensive survey of Central Park that was conducted over a one year period by the Central Park Conservancy. The Central Park survey's purpose was to learn more about the park's visitorship in efforts to use the information gathered for future park planning purposes. As the Central Park Report Preface mentions, it is important to know who is visiting and for what reason, and furthermore, what are the visitor perceptions and attitudes about the park (Conservancy 2011).

Many explanatory variables influence park visitation and good prediction models take these factors into consideration. Strategically planning a public park considers new functionality and equity. Accommodation can be made in the public park for use by a farmer's market, family entertainment areas and public art space. High Line has an opportunity to put in place a maintenance and operation plan for the final section of Elevated Park that opens in 2018. Furthermore, incorporating good prediction models into the management plan allows the park to function with increased efficiency and maintain a safer space for the public. In addition, public parks have the capability to dramatically alter how urban planning and how new infrastructure is created. The repurposing of existing infrastructures is important in today's changing business climate. Elevated green infrastructures such as the High Line have the ability to balance both economic and

environmental success. High Line has the potential to merge social equity with economic development and creating green infrastructure. Having the data and metrics to support the success of these parks will be important in quantifying their value.

CHAPTER III: LITERATURE REVIEW

The objective of this literature review is to research different facets of public park visitation as a strategic tool for operation and management. Operating a public park entails many complex issues such as designing an attractive green space, implementing and maintaining the park, creating programming, attracting and managing visitors and obtaining financial support. There is a growing need for public parks to be able to identify factors of economic value as well as social value for itspublic space, Factors that support the local economy and the equitability that result in increased visitation and consistent financial support from the local community.. This thesis will focuses on a public park, The High Line in New York City. The main objective of the thesis is to accurately predict visitation to the New York City Public Park, the High Line. Understanding the factors that influence people, especially local park users to visit the park and more specifically what activities are they engaging in during their visit.

It is important to understand and quantify visitation and use the information for future park management and operation purposes. Research included learning more about other examples of successful urban parks such as New York's Central Park, Brooklyn's Prospect Park and Millennium Park in Chicago for comparative analysis. All these parks have a similar quality about them. They are found in densely populated urban areas. In addition, information on visitor perceptions of and support for management of urban parks, visitation patterns, the role and innovative value of urban parks such as human, environmental and cultural aspects is available. Accessibility both in physical access to the park and accessibility across sociocultural boundaries. Park services and amenities, weather patterns, flower blooming periods and public programs were referenced.

3.1 The value of urban parks

Public parks can provide considerable value to the population that visit them, for the community around them, and the local economy. A well designed public park can attract growth in tourism, stimulate a habitat for wildlife, contribute to personal health and wellness, improve the aesthetics of an area and stimulate economic growth. Public parks are at the heart of what makes a city great. The fortuitous start of American public parks began with Frederick Law Olmstead and Calvert Vaux in 1858 and the daunting task of building a public park on the island of Manhattan. This public space would come to be known as New York's world famous Central Park. During the time of Central Park's inception, America was just beginning to understand the value urban parks would have on the city and population that surround them. Thus, Central Park began the general public's realization of the integral role public parks play in shaping both the physical and social spaces of society.

According to San Francisco State University report about the modern urban park, "Access to outdoor resources has been shown to improve physical and psychological health, increase spiritual rejuvenation, reduce crime and promote a healthy, balanced sense of community" (Roberts and Roa 2014). Further, in a city of concrete, steel and automobiles, public parks provide carbon sequestering trees, fresh air, shade and a safe space for outdoor activities, social interaction and respite. Over the decades, the role of urban parks has evolved in response to urban populations and concepts of sustainability. "More and more we see parks becoming an essential component of the social fabric and ecological landscape of urban centers" (Roberts and Roa 2014). Prospect Park, Brooklyn's answer to Manhattan's Central Park, was designed as a natural landscape with no showy

flowers or gardens. In May 1996, research was conducted on user perceptions of Prospect Park.

The study showed the primary reason people visited Prospect Park was to escape into nature and enjoy a relaxing environment (Low, 2005). In Central Park the user study showed that visitors valued art and cultural programming in the Park. Park patrons also benefit their personal health and wellness by taking a break calming their minds or jogging on the park's greenways. Public parks are a measure of social equity and provide a social service to all citizens.

The High Line landscape plantings are essentially an American prairie-inspired park with over 600 different perennials and grasses half of which are native to the United States. The habitat value of the park to the community is also notable. However this value is often less noticeable and underappreciated. The wild-seeded landscape, native plants, trees and shrubbery are maintained using sustainable agricultural practices. In his January 9th, 2017 Blog, Wild Plant Culture, Jared Rosenbaum (2017) states that "Assembling diverse, multifunctional ecologically appropriate plant communities is one of the most critical practices of our time"

The park's greenery contribute oxygen and sequesters carbon, keeping it locked up in the soil by the perennial grasses. The green habitat is home to many birds and pollinators adding ecological services to the surrounding area. Strips of prairie such as The High Line represents in its garden form, can slow soil erosion, reducing run-off and sequester carbon.

3.2 Visitor perspectives of public parks

Several studies have looked at visitor perspectives for public parks, particularly why people visit the park and how often. Visitor perceptions of crowding, how long a

visitor stays and how far the visitor traveled to get to the park. Managing crowds in a park is a challenge to park operations with both safety and overuse issues. This impacts people when they visit, how often and their satisfaction with the park. Crowding perceptions were analyzed by Arnberger and Brandenburg in 2007 on national parks that are on the border of urban-rural areas. This study found similar data to the High Line 2015 visitor survey about crowding perceptions. The Arnberger and Brandenburg 2007study, shows that the parks receive local, regional and international tourist visitation.

Local park users were the most frequent visitors who commonly felt the space was more crowded than did the regional or tourists. However, both local and regional visitors that visit on a regular basis said the park was crowded. High use can result in overcrowded perceptions especially in urban areas with large numbers of residential areas near the park. This may lead to a reduction in park visitation by the local community. Neighborhood park users might also vary visitation times to off peak hours if sensitive to crowding. The study on crowding perceptions by Arnberger and Brandenburg in 2007, showed that park management can use displacement techniques to move visitors efficiently inside the park. Displacement techniques can be divided into two categories special and temporal. Encouraging local residents to come at times when less tourists are present in the park is an example of displacement. For example, encouraging locals to come for a morning walk or jog in the park before the park gets crowded,or by holding community based programing on lower visitation days such as Tuesday, and hosting these events at less crowded spots in the park. Visitor perceptions of crowdedness in the park can also be overcome by signage and navigational tools. If park users can navigate the space better, this creates better flow and fewer bottlenecks. Better mapping and digital applications and social media can be

powerful tools to assist park users in successfully navigating the park (Arnberger and Brandenburg 2007).

Parks offer a wide variety of opportunities to interact with nature and for outdoor recreation. Popular park amenities include walking paths, fitness areas, playing fields, water features and gyms. Cohen, et al, learned that walking loops had the most weekly use in neighborhood parks for adults and seniors, followed by gym facilities and fitness or exercise areas, with male adolescents' using gym facilities the most (Cohen, et al 2016). Most local visitors cite their reasons for coming to an urban or neighborhood park are related to physical activity; walking, jogging, walking the dog or hiking (Arnberger and Brandenburg 2007, Stack and Miller 2009, Cohen, et al 2010). Water features and multi-purpose playing fields also garnered frequent visits, with organized sports drawing the most people (Cohen, et al 2010). The importance of urban parks for quality of life issues for the increasingly urbanized population is critical for planners to consider. In addition to recreation and leisure with children, parks offer a place to relax from city stresses and are valued for their restorative and spiritual nature. Access is one of the variables that influence park visitation and can be defined as "the ability of people to get to and navigate with in a park." Access can include both physical and social spatial elements. Access includes the number and locations of entry points, handicap accessibility, safety, welcoming to different cultures, and what programs are available that serve all in an equitable way.

Research shows that park-driven public programming can affect park visitation. Interestingly, both users and non-users of urban parks in Portland, Oregon associate the proximity of a park to neighborhood social health (Bauer et al 2013), as opportunity for social interaction is another perceived value to such parks. Much public park programming

is targeted at youth such as summer recreation, ball fields, and after school programming. Teen nights and outdoor classroom educational experiences are also becoming common trends. Cultural programs such as preforming arts, heritage festivals and live music can increase park visitation. Research by the National Recreation and Park Association reported that parks build communities and serve residents across all social economic levels. It showed that "Parks are such an essential component of livable and sustainable communities that it is difficult to imagine a truly livable and sustainable community without parks, trails and other outdoor recreation resources and the positive changes such parks create for the entire neighborhood" (Public Parks: The Key to Livable Communities 2011). A diverse community with equitable public space is a strong community.

3.3 Weather and Seasonality

Weather, or the conditions of the atmosphere can be classified as temperature, solar energy, wind and precipitation surrounding an area at a certain time and place. Weather has long been recognized to have an impact on the type and amount of outdoor activity pursued and the number of persons visiting a park. Therefore, average daily temperature can be used as an explanatory variable to predict daily park visitation. Daily maximum temperature is most important for peak and seasonal visitation, however excessive heat or precipitation negatively impacts visits during peak season (Hewer et al 2016). Daily precipitation impacts on visitation are mixed. Hewer et. Al. showed that daily precipitation affected daily visits negatively. However, precipitation may simply delay a visit until the precipitation ends or visit earlier than the expected precipitation.

Seasonally, park visits decline in the winter when it is cold outside and are highest in the spring and summer when warmer weather brings out visitors to vacation, walk on trails, and do leisure activities with their families such as picnic and take children to

playgrounds (Roemmich and Johnson 2014). Springtime is also when plants and flowers bloom which also attracts visitors to view the beauty of a park surroundings seasonally. As the climate changes and the pattern of extended and warmer weather continues, park visitation is expected to be impacted in several ways that would affect park management. Visitors may increase the number of trips and/or length with drier warmer weather and peak and shoulder season visitation may be extended (Loomis and Richardson 2006, Buckley and Flushed 2011, Dawson and Scott 2010).

3.4 Summary

There are multiple factors that influence park visitation. Previous studies have attempted to quantify this by observing and surveying outdoor visitation patterns of park users. Explanatory variables for visitation patterns range from accessibility, location, programming and weather. In general, most people visit their neighborhood parks to enjoy leisure activities and be physically active. However, urban parks are also seen by visitors as having a positive influence on psychological and mental health. Parks evoke a sense of place in people and foster a strong connection with the natural world. The role of social interaction needs further exploration as parks look at ways to increase park visitation and maintain the satisfaction of existing users. Managing the future flow of people and resources is an ongoing challenge for park management. More information and research is needed to assist park management in learning what visitors want, in tracking and developing programs that meet their user base in an equitable way. Public parks are a central part of a community providing immense value to the quality of life and the equitability of an entire city.

CHAPTER IV: METHODS

This chapter provides an overview of the methods used to analyze, quantify and predict visitation for High Line Park. The methods contain four distinct sections; background research, the High Line 2015 survey, visitation and weather data collection and analysis. Regression analysis is completed using Gretl statistical software to create the model for forecasting park visitation. Patterns were identified in data sets to fulfill the primary objective of predicting visitation as a tool for operation and management. The data used for analysis were collected from September 21, 2009 to September 21, 2015 encompassing six years of High Line park operation.

4.1 Background Research

Due to the rapid growth and popularity of the High Line, the caretakers of the park known as the Friends of the High Line, realized that information was needed about park visitation to plan for the future and to evaluate if the organization was meeting its mission: of fostering a strong community and neighborhood. Background information was gathered on the history of public parks. Articles and professional journals were referenced that studied the history of public parks and what factors have historically influenced park visitation. In addition, sociocultural theory of parks as an equitable public space was analyzed by examining cultural attitudes of visitors to determine what people value in a public park. The vision established by the Friends of the High Line is that it is a park for all, with everyone to feel welcome here.

4.2 Survey

In 2015, the Friends of the High Line conducted tracking survey to better understand its visitors. This survey gave insight into the factors that influence High Line Park visitation. This survey was used in analysis of High Line park customer data. The

customers in this case are the daily visitors to the park who engage in a variety of economic and outdoor activities.

High Line uses visitation data to identify strategic planning priorities such as public outreach, visitor services and operational requirements. (Ganser 2016) The High Line has examined its customers and developed a model for creating visitor estimates. The current High Line algorithm takes into account key factors known about park users including length of visit, day of the week and the seasonality. The average park user visits for an estimated 30 to 40-minute interval. The day of the week is taken into consideration because weekends tend to be busier then weekdays with Saturday being the peak visitation day. In addition, tourism is higher on weekends for New York City. The time of day is also considered when estimating the daily park visitors, 10:00 am to 5:00 pm is considered the high volume. The number of visitors along each section of the High Line was also taken into consideration.

The survey sampled 2,132 respondents in 4 fielding periods. The survey was conducted on-site at various locations along the High Line following the random sampling strategy of every 5th person. The four fielding periods were conducted at various locations with in the park at different times of the day as well as days of the week. Data were logged via iPad with offline survey software. A refusal log was also recorded of parties that were approached but declined to complete the survey. The gender, age, and ethnicity were recorded to the best of the High Line staff knowledge. A shorter non-English version was also offered to non-English speaking respondents to capture their attitudes and behaviors toward the park in more detail as well as collect key demographics. This survey was referenced for theory and formation of the regression model used in this analysis.

4.3 Collection Methods

The visitation data were collected by High Line rangers using a count and predict protocol and algorithm. On weekends, rangers would count visitors using a hand counter at one hour intervals in 8 zones along the park. These entries were then recorded on the High Line observations and field notes form. Observations were then plugged into a proprietary algorithm and weekday algorithm to get the total number of daily visitors. Furthermore, these estimates were adjusted yearly and seasonally. The explanatory variables that were considered in the algorithm include average length of the visit, day of the week, time of the day, number of visitors along each section of the park and the local weather in the park.

Weather data were obtained from the Central Park Weather station for the years 2009-2015, to match the High Line visitation data. The weather data include daily observations of the average, minimum and maximum temperature observed and amount of daily precipitation. These weather observations were collected from Central Park Weather Station which is two miles from the park and accurately represents weather at the High Line Park. In the future, a weather station at the High Line park could give even more accurate readings. Temperature and precipitation data were purchased through MDA Information Systems, a company that specializes in providing weather data for forecasting business solutions. Both weather data and visitation data were then combined into an Excel document then imported into Gretl for statistical analysis.

4.4 Multivariate Regression

The Model was structured as a multivariate regression using OLS modeling in Gretl. The data set (n=2192) include six years of data in multiple categories. The climatic variables include the average daily temperature and precipitation. The social variables include day of the week and season and an annual time trend variable. Day of the week and

season were dummy variables with Saturday and Spring as the baseline respectively. A time trend variable (year) was added to the regression to compensate for the annual visitation increase at the High Line. This generated a visitation equation illustrated as follows.

Vhl=B1 AT(-)B2 P(-) B3 Mon(-) B4 Tu(-) B5 W(-) B6 Th(-) B7 F(-) B8 Su (-) B9 Fa(-)B10 Wi(-)B11 Sum(+)B12 Time

The data used for this regression model were collected by Friends of the High Line staff from times series September 21, 2009 to September 21, 2015. A total of six years of temperature and visitation data were analyzed. For consistency purposes the data set starts on the autumnal equinox September 21st to give an even picture of seasonality. The dependent variable analyzed in this model is Daily Park Visitation. Daily Park Visitation is defined as the sum of visitors to the High Line on a given day. I believe Park visitation is influenced by the climatic variables of weather and choose a regression model to quantify this relationship. As temperature increases in Fahrenheit, the model would expect park visitation to increase as well. This is true up to a certain temperature, then visitation will likely fall as it becomes too hot for people to engage in outdoor activities. This indicates more of a non-linear function for the climatic variables of average temperature and precipitation. Furthermore, an ideal temperature range where visitation is maximized may be between 60 and 70 degrees Fahrenheit. The lowest visitation will be when it is cold outside during the winter season. Due to the uncertain variable relationship of average temperature and perceipitation to park visitation , two models were developed for analysis. The first model illustrating linear relationships between the dependent and independent variables. The second model added the quadratic function of Average Temperature and

Precipitation in the regression equation. The regression results will display the forecasting performance of linear and non-linear models. The day of the week will also affect park visitation and more people are likely to visit the park on the weekends when they have more leisure time. Theoretically, the model expects to see a positive relationship to park visitation of the weekends and a negative relationships with the weekdays Monday through Thursday.

For this model, Park visitation is regressed against twelve independent variables. Day of the week and season are dummy variables, average temperature and precipitation are quadratic variables and the time trend is an annual variable. The amount of rain in inches on any given day will negatively affect park visitation. The question High Line needs to answer is how much will rain affect visitors? How much will visitation drop if it is raining outside? What activities or services could High Line provide that would increase visitation on bad weather days? The results of the regression analysis will show how temperature, precipitation and day of the week influence park visitation. An OLS regression was chosen as the best structural model based on past studies that examined visitation of national recreation areas (Stymes 1983). In addition, the regression analysis will explain how much of the variability was explained by the independent variables for this model. Adding more explanatory variables to the model for future analysis such as population and tourism levels could be helpful in more accurately predicting visitation for High Line Park. Saturday was picked as the baseline day of the week and was omitted from the regression model. Saturday is the day of the week with the highest visitation on the High Line. The expectation is that every other day of the week to have a negative

relationship with our baseline. The regression model will show how park visitation deviates from our baseline Saturday.

Average temperature will have a positive relationship with High Line visitation. It is nice outside, the weather is warmer, plants are blooming and people are more likely to engage in outdoor activities such as visiting a park. Precipitation will have a negative relationship with High Line visitation, if it is raining people will choose an alternative activity to visiting the park. Day of the week with have a -/+ relationship as some days of the week will be favorable to visiting the park while others will not. Weekends will be more busy then weekdays with Tuesday being the least busy. Furthermore, visitation will be less in winter and fall then in spring or summer.

CHAPTER V: DATA

The regression analysis was estimated using data from the measureable characteristics for this visitation model. They include calendar date, average temperature (Fahrenheit), precipitation (inches), number of visitors (visitation), and day of the week, year and season. Table 5.1 is a sample of the full data set used to run the regression analysis.

Table 5.1 Sample Data Table

Date	Avg Temp	Precip	Visitation	Day	Year	Season
6/22/2015	78.5	0	24,400	Monday	2015	Summer
6/23/2015	82.5	0.02	15,400	Tuesday	2015	Summer
6/24/2015	76	0	40,000	Wednesday	2015	Summer
6/25/2015	74	0	30,400	Thursday	2015	Summer
6/26/2015	75	0	32,912	Friday	2015	Summer
6/27/2015	64.5	1.12	20,347	Saturday	2015	Summer
6/28/2015	67.5	0.29	34,886	Sunday	2015	Summer

The data used for the regression analysis are the combination of the visitation data and weather data. The full data can be used as a quick reference guide for High Line management. For example, if a manager wanted to look at last year's programming schedule to understand why visitation was high or low on a certain day, this table can display the characteristics of that day and can be used to help explain the visitation number Various types of data collected were included in the regression analysis to help determine factors that influence increased park visitation. Visitation data were collected by High Line staff to determine an estimate of the number of visitors that came to High Line. Weather data on temperature and precipitation were collected. The task of combining the visitation data with the acquired weather data was an objective of this research. This paper uses

climatic, social and visitation data to create a forecasting model for park visitation to as a tool to drive operational and management decisions.

5.1 High Line Visitation equation

$V_{hl}=B_1$ AT(-)B_2 P(-) B_3 Mon(-) B_4 Tu(-) B_5 W(-) B_6 Th(-) B_7 F(-) B_8 Su (-) B_9 Fa(-)B_{10}Wi (-)B_{11} SU+B_{12}Time

Simplified equation:

$V_{hl}=B_1$ AvgTemp-B_2 Precip- B_{3-8} day of week- B_{9-11} Season+B_{12}Time

The visitation equation shows the relationship between the independent and dependent variables. It will be used to calculate the visitation estimate of the park. Many descriptive data elements were gathered for this study.

5.2 Park visitation descriptive tables and figures

Table 5.2: Yearly visitation High Line Park (2009-2016)

2009	2010	2011	2012	2013	2014	2015	2016
1.35 Mil	2.03 Mil	3.5 Mil	4.5 Mil	4.8 Mil	6.2 Mil	7.3 Mil	8.5 Mil

Table 5.2 illustrates the annual High Lines Visitorship estimates from 2009 through 2016. Since opening to the public in the summer of 2009, an estimated 38 million people have visited the High Line Park.

Table 5.3: High Line Annual Growth Rate

2009	2010	2011	2012	2013	2014	2015	Average Growth
opened	16%	83%	20%	8%	30%	22%	30%

The average annual growth rate is 30%, with the largest surge in growth occurring in 2011, which experienced 83% growth rate from the previous year.

Based on the visitation numbers and growth rates the following visitation forecast was estimated with trend line. The limitations of the linear trend forecast may be reached if variables in the data are non linear in nature. Other forecasting models might do a better job at finding the best fit trend line then a simple linear trend model.

Figure 5.1: Peak High Line Visitation Day vs Temperature

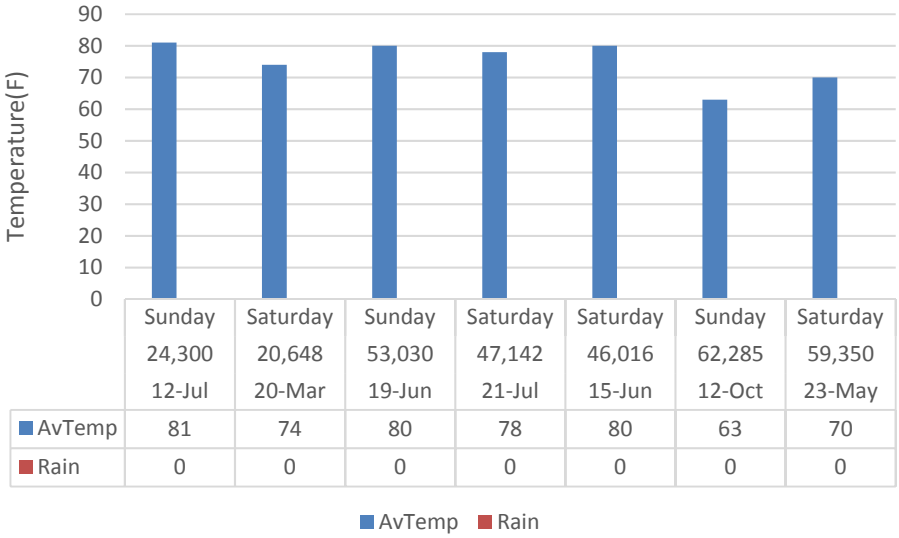

Figure 5.1 shows the peak visitation day for each year of operation (2009-2015). For each year's peak visitation day, there was no recorded precipitation and the average daily temperature was between (63-81) degrees Fahrenheit. Furthermore, each peak visitation day fell on a Saturday or Sunday supporting the theory of higher weekend visitation.

Figure 5.2: High Line Visitorship Monthly Comparison (2009-2015)

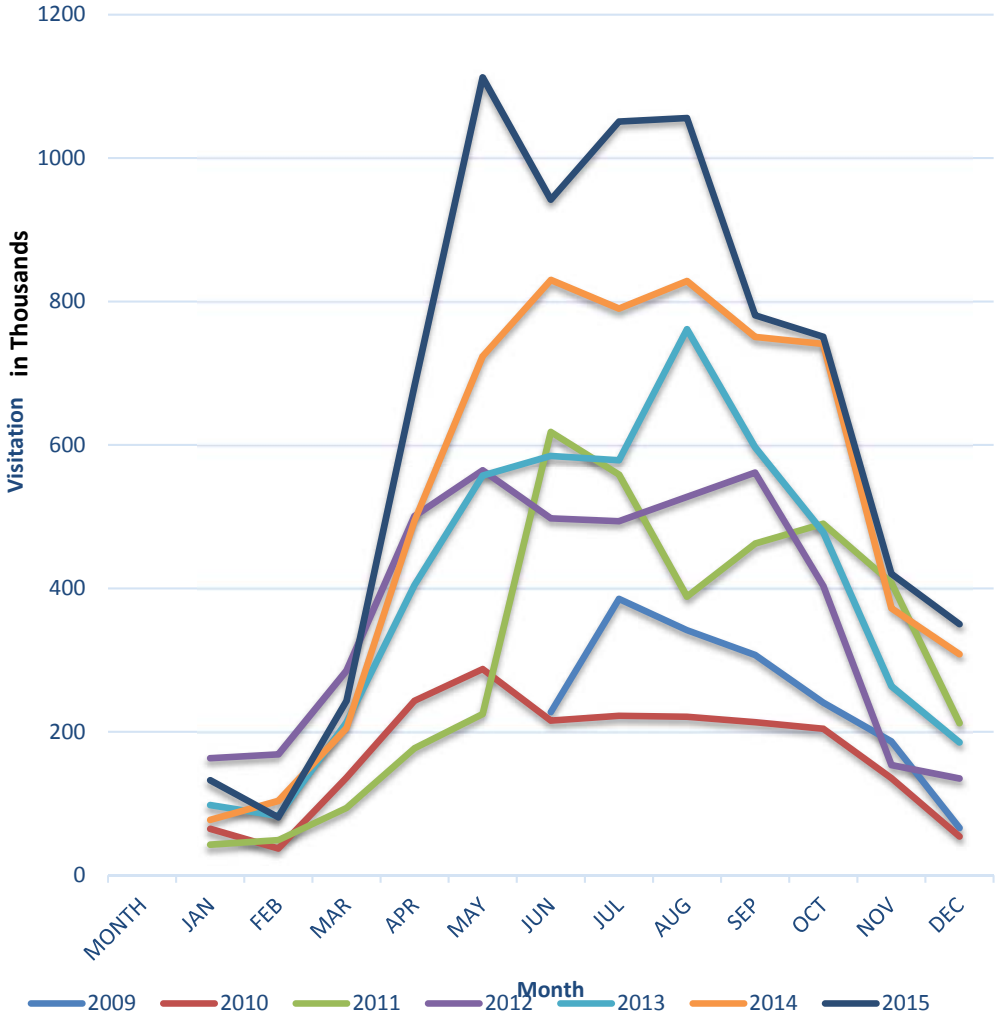

Figure 5.2 shows monthly visitation in all years of park operation. Figure 5.2 illustrates that the peak visitation for 2011 was in June and peak visitation for 2015 was in May.

Typically, summer accounts for the highest visitation but that trend may be changing. More visitors are coming to the park earlier in the season with additional visitation spikes in early fall and visitation slowly declines into the fall and winter season. Highline can possibly expect an increase in visitation earlier in the year if the seasons are warmer sooner in the year. Temperature has a more significant impact on visitation than purely season.

Figure 5.3: High Line Visitation (2009-2015) Temperature/Visitors

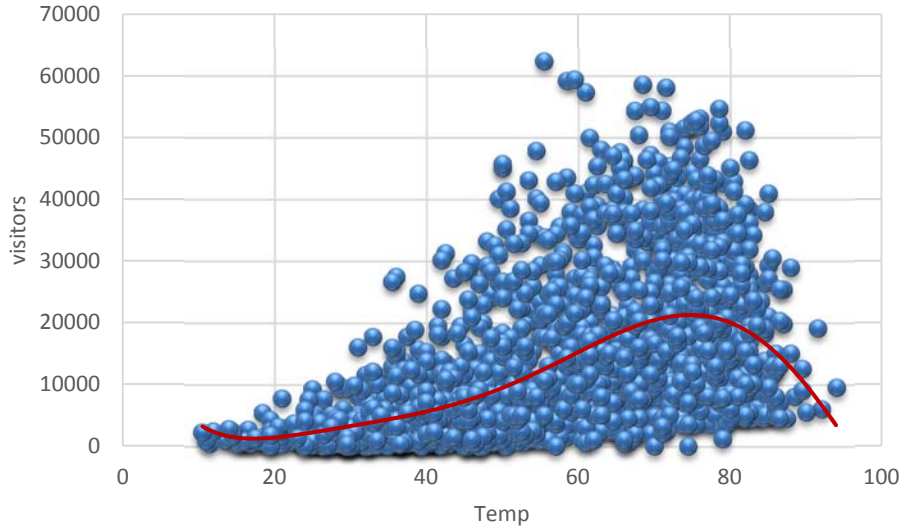

Figure 5.3 shows that temperature and visitation has a large distribution indicating that other variables may impact visitation more than climatic ones. Each blue dot represents a data point of (x) temperature and (y) visitation from 2009-2015. The red trend line indicates that the temperature data follows a polymorphic trend.

Figure 5.4: Visitation vs Precipitation

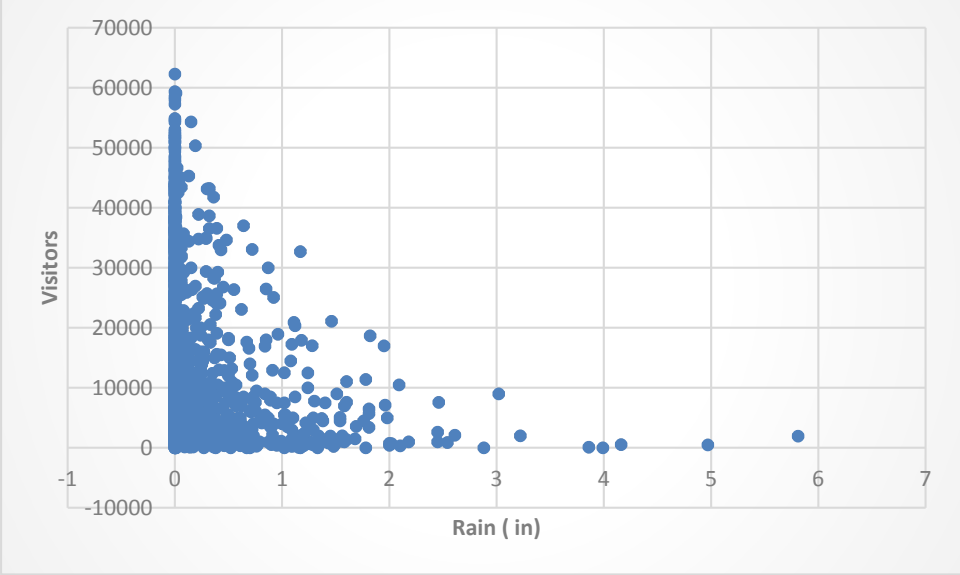

Figure 5.4 illustrates the dramatic effect precipitation has on park visitation. If it's raining, the park can expect visitation to drastically drop by thousands of visitors. Each additional inch of rainfall causes visitation to decreases significantly to the point that visitation reaches zero when rain reaches 4+ inches of precipitation. Most data points are clustered around the y-axis where rainfall is equal to zero. Precipitation is modeled has a nonlinear function and not many observations were observed in excess of 2 inches.

Figure 5.5: Visitation vs Day of the Week

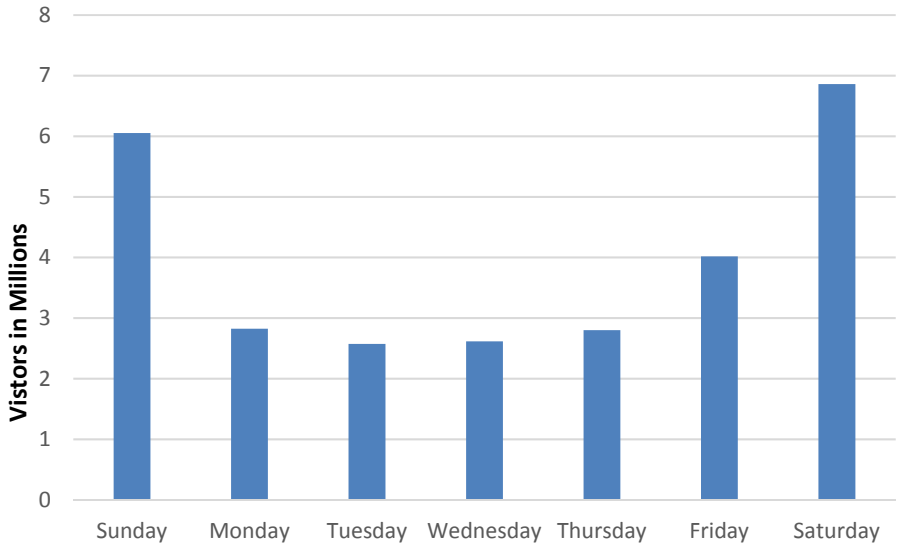

Figure 5.5 shows the total amount of visitation in millions for each day of the week from 2009 to 2015 with Saturday being the peak followed by Sunday. Monday through Thursday demonstrate a similar weekday trend but Tuesday is the slowest visitation day for the High Line Park. Day of the week seems to have a large impact on visitation. Weekdays in the park reflect a local demographic with workers from near-by construction sites visiting the park for lunch and commuters using the High Line as a greenway on their way to work. Weekends in the park see tourists visiting the High Line and also locals who bring their visitors from out of town.

Figure 5.6: Visitation vs Season

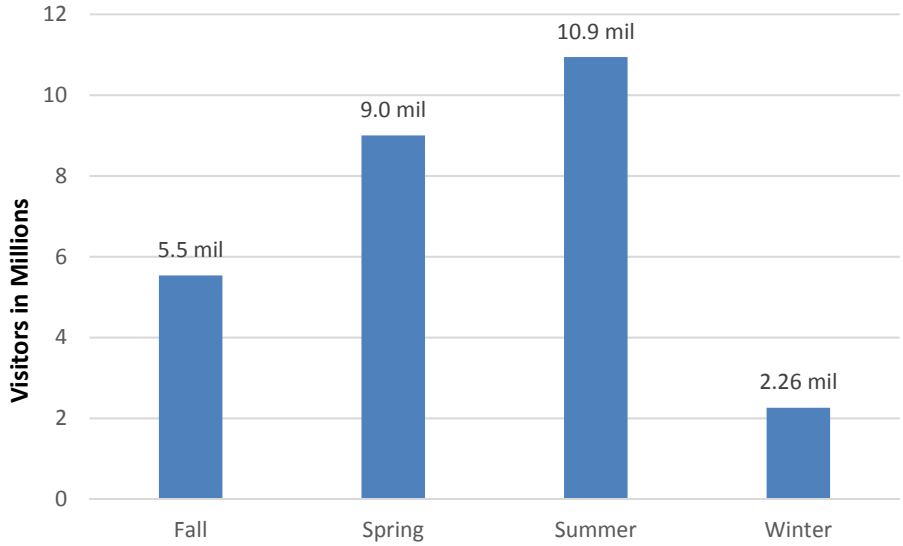

Figure 5.6 shows the total number of park users that have visited to the High Line each season. Over 10 million visitors came in the summer and 9 million in the spring. Summer and spring are comparable with no significant difference between the seasons. It appears visitation is shifting earlier in the spring as spring visitation numbers are increasing to summer levels. (Figure 5.3)

CHAPTER VI: RESULTS

The results from the multivariate regression illustrate how the model supports the theory about park visitation on the High Line. The model quantifies the visitation trends that High Line park was observing and allows staff to manage resources more efficiently. The model can be used for staffing plans and to determine the best dates for future public programming events and can accurately forecast High Line visitation. The standard error of the regression was 7,123.A second model was estimated using the quadratic function of the climatic variables. This model was not selected due to its higher standard error, lower R-squared and less accurate fit for forecasting visitation then the linear OLS model.

6.1 Regression Estimates

V_{hl}=330 AT(-)4666 P(-)13166M(-)13914 Tu(-)13490 W(-)12956 Th(-)8949 F(-)2703 Su (-)363 Fa(-)3390 Wi(-)1702 Su(+)2782Time

Table 6.1 below shows regression estimates of the High Line park daily visitation. In reviewing the independent variable, day of the week, all coefficients were negative in relationship to the baseline Saturday. These findings support the theory of Saturday being High Line's busiest day. In reviewing the independent variables for seasons, fall and winter had negative coefficients supporting the theory that spring is the busiest time of year. It is worth noting that fall did not produce a significant coefficient. High Line is witnessing more park visitors coming in the spring resulting in visitation numbers being relatively high earlier then the historic peak visitation season of summer. Significant p-values were produced for average daily temperature, precipitation, day of the week, summer, winter and time variables. A p-value of 0.4321 was recorded for Fall and was the highest p-value. The R-squared value for the model is 0.66, explaining 66% of the variation of park visitation by the explanatory variables. The Slope coefficients can be explained as follows.The average

temperature coefficient can be interpreted that for each average daily temperature increase High Line will see 330 additional visitors, keeping all other variables constant. A 10 degree temperature increase would change the visitation rate by 3300. Although the impact of temperature appears as the smallest coefficient in the model its impact is still noticeable and statistically significant. I would consider temperature a large impact variable. Precipitation can be interpreted for each inch of precipitation received High Line will see 4,666 less visitors, keeping all other variables constant. Precipitation was a large impact variable greatly reducing visitation in the park. Monday in the park High Line can expect park visitation to decrease by 13,166 from our baseline Saturday, holding all other variables constant. Tuesday in the park High Line can expect park visitation to decrease by 13,914 from our baseline Saturday holding all other variables constant. Wednesday in the High Line can expect park visitation to decrease by 13,490 from our baseline Saturday, holding all other variables constant. Thursday in the park High Line can expect park visitation to decrease by 12,956 from baseline Saturday holding all other variables constant. Friday in the park High Line can expect park visitation to decrease by 8,949 from our baseline Saturday, holding all other variables constant. Sunday in the park can expect park visitation to decrease by 2,679 from our baseline Saturday, holding all other variables constant. Fall at the High Line park can expect park visitation to decrease by 363 from our baseline Spring, holding all other variables constant. Winter in the High Line can expect park visitation to decrease by 3589 from our baseline Spring holding all other variables constant. If it is summer in the park can expect park visitation to decrease by 1702 from our baseline Spring, holding all other variables constant. Each year visitation increases by almost one million visitors to the park, this equates to an average of 2703 persons.

Table 6.1 Regression Estimate of High Line Park Daily Visitation

Climatic variables	coefficient	Standard error	t-ratio	p-value
AvgTemperature	330.186	15.3677	21.49	<0.001
Precipitation	−4665.66	373.817	-12.48	<0.001

Social Variables	coefficient	Standard error	t-ratio	p-value
DAY of WEEK				
Monday	-13166.2	569.021	-23.14	<0.001
Tuesday	-13913.7	569.625	-24.43	<0.001
Wednesday	-13490.4	569.786	-23.68	<0.001
Thursday	-12956.0	569.391	-22.75	<0.001
Friday	-8949.14	569.422	-15.72	<0.001
Sunday	-2702.58	569.416	-4.746	<0.001
SEASON				
Fall	-363.191	462.222	-0.7858	0.4321
Winter	-3589.83	577.657	-6.214	<0.001
Summer	-1702.16	492.090	-3.459	<0.001
Time	2782.38	89.0001	31.26	<0.001

Statistics based on the rho-differenced data:

Table 6.2: Fitted visitation vs actual plus residual

DATE	Visitation	Fitted	Residual
8/15/2015	46302	38810.03	7491.97
8/16/2015	37882	36767.82	1114.18
8/17/2015	25400	26964.56	-1564.56
8/18/2015	29400	23213.09	6186.91
8/19/2015	15300	25154.58	-9854.58
8/20/2015	26000	25477.16	522.84
8/21/2015	36551	27212.23	9338.77
8/22/2015	49431	37159.1	12271.9
8/23/2015	39211	34456.52	4754.48
8/24/2015	24400	24818.36	-418.36
8/25/2015	28000	24566.13	3433.87
8/26/2015	29000	23173.47	5826.53
8/27/2015	29700	23212.52	6487.48
8/28/2015	44774	26559.03	18214.97

Table 6.2 shows the actual visitation numbers estimated by High Line and the fitted values from the regression model. This data was included in the estimation model and illustrates the accuracy of the predicted values from the model.

Figure 6.1: Actual and Fitted Visitation versus Average Temperature

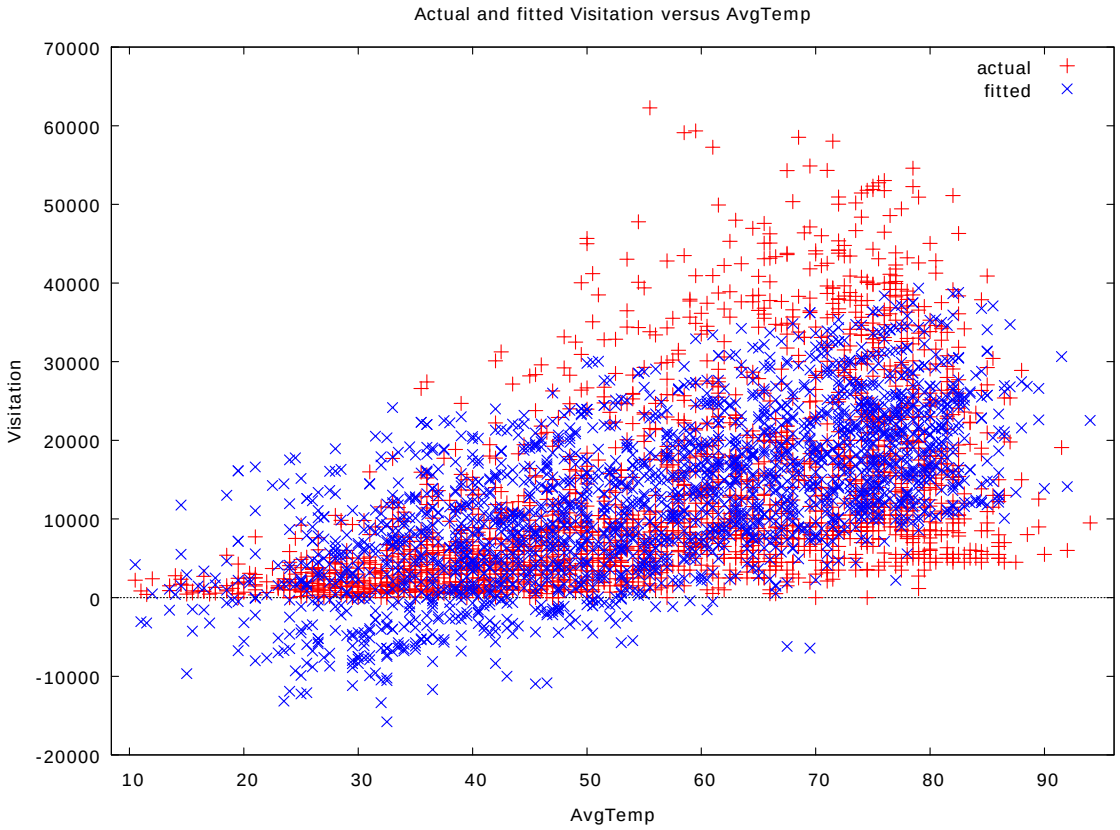

Figure 6.1 shows the results of the linear regression model with actual visitation data and predicted values based on the model. In this graph Visitation our dependent variable is plotted against our independent variable Average Temperature.

Figure 6.2: Visitation forecast model

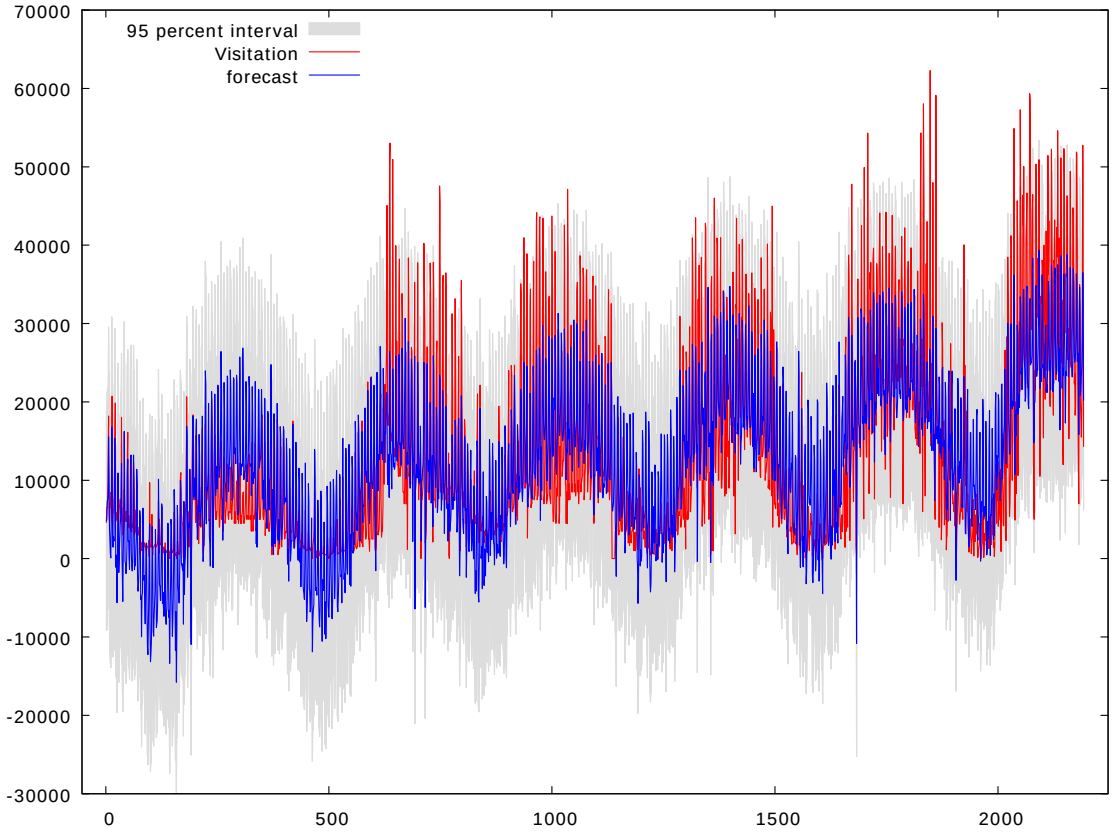

Figure 6.2 illustrates the visitation forecast trend of High Line visitation. The red is the actual visitation data and the blue is the forecasted visitation trend based on the model. The peaks and valleys of this graph illustrate the strong seasonal nature of High Line visitorship. The model is good at accurately predicting park visitation. The model shows that both the social and the climatic variables had a significant impact on visitation.

Figure 6.3: High Line Visitation Forecast

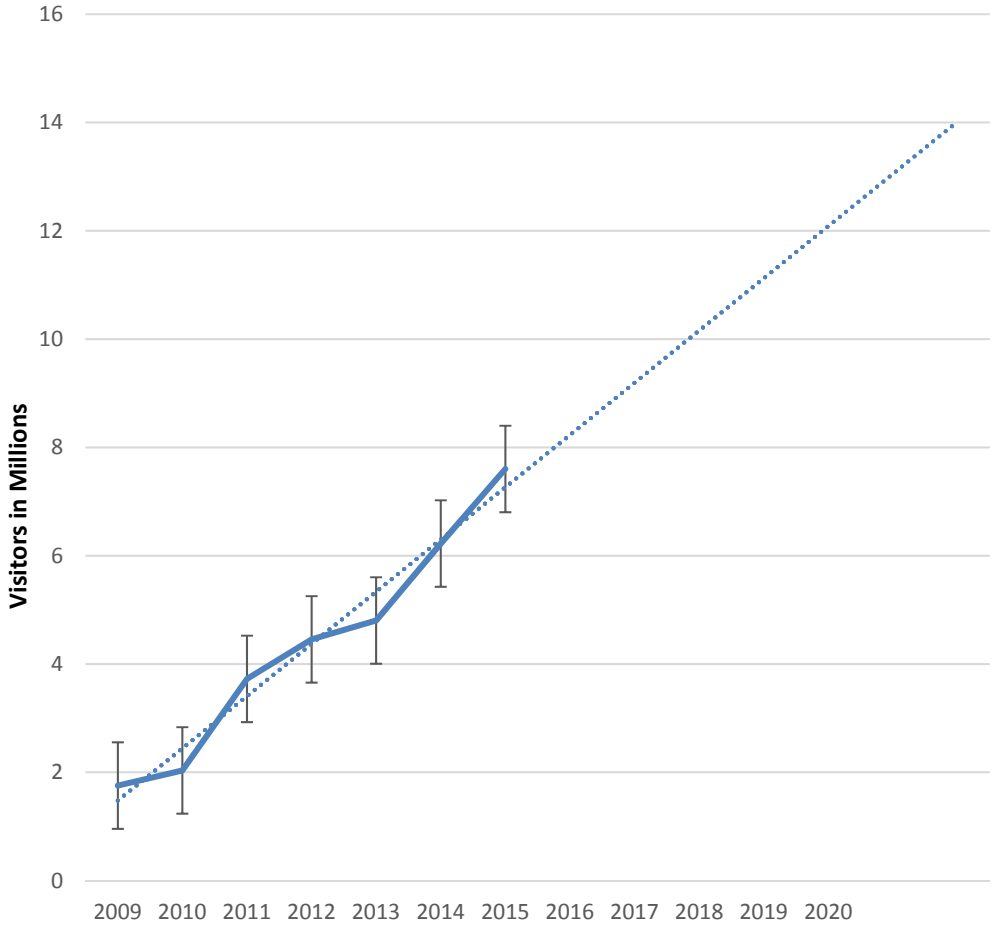

Figure 6.3 indicates that the High Line will reach 10 million visitors by 2018 and up to 14 million annual visitors by 2020.

6.2 Forecast Model Illustration

The benefit of the forecast model can be illustrated in the following example. On Monday morning the park manager looks at the weekly weather forecast. The week is forecasted to beunusually warm for February with temperatures in the 70s. The manager plugs in the value of 70 into the visitation model and adds the other variables such as what day of the week it is, what season it is and if it is going to rain or not and get an estimate of how a sudden increase in temperature may effect park visitation. High Line can then use this information to create a weekly operations and staffing plan. Operation plans will

delegate work tasks needed to maintain the park. The staffing plan will include necessary personal to operate the park including gardeners, custodians, maintenance technicians and park rangers. Efficient staffing and resource allocation can reduce costs by providing staff when staff is needed most and reducing staff in the off season.

The model may also give insight to what day of the week and which season to host events. The High Line staff is planning events two years in the future and may want to get a sense of what the anticipated visitation may be like at that time. This model can be used to accurately predict future visitation, helping the High Line to make informed decisions about its programming, special events and staffing. For example, questions such as, "Will additional staff be needed to manage the large crowds and pedestrian traffic in order to keep the park safe for all of its visitors?" will have data to inform decisions important to address crowds and contribute to the continued success of the park. As programs are planned often years in advance, forecasting visitation numbers is important because the data can drive the decisions. The park wants to avoid overcrowding at events and be able to accommodate the public as safely as possible.

CHAPTER VIII: CONCLUSION

The model concludes that the explanatory variables of temperature, precipitation, day of the week season had a significant effect on park visitation. The overall objective to develop a model to more accurately predict park visitation resulted in many insights on how to manage the park visitors at the High Line. An illustration of value for the forecast model was presented. The major findings of this research suggest regression analysis is a useful tool to support a park visitation model.

The data set variables for this model does support the ability to predict High Line park visitation. The visitation equation is an accurate method of predicting the High Line's visitation. However, there may be ways to further improve the model's accuracy. I would recommend adding some type of interaction term to this model in efforts to take a closer look at how seasonality effects park visitation numbers. One challenge with the current model is that it assumes each day of the year is equal and does not properly weigh in the seasonality. In winter, the park might get a thousand additional visitors based on the time trend but in summer maybe get more like three thousand. Using an interaction term to account for the seasonality may create a more accurate model. An interaction term could be added by multiplying the time trend variable with the dummy season variables. The interaction term between an explanatory variable and an environmental variable suggests that the effect of the variable has been moderated or changed by the environmental variable. Interactions with dummy variables can be useful as additional predictors for estimation strategies beyond the simple OLS model.

The time trend variable selected was a yearly trend that represents each year and the respective visitation increase by 2,702 persons per day for each year. For example for 2011 visitation, which is year 2 the model adds 5,404.visitors to each day in the calculation.

As a future study, it would be interesting to add a phenology characteristic to the model by incorporating bloom times or leafing out periods creating a natural calendar for use by park management. Looking forward, the research data collected by High Line can be used not only to manage park visitation but to help establish best practices for predicting future visitation. Commitment to the development of an enhanced data collection network will facilitate continued understanding and impact of the challenges faced by the High Line.

The High Line, at its foundation was a voyage into the unknown with its vision of repurposing public space for all to enjoy. Nobody could have foreseen the dramatic effect the park has had on the entire city and that it would become one of the main tourist attractions in New York City. This study has contributed to High Line by better understanding its visitorship over its seven years of operating. Tracking visitation drives the organization forward and helps identify critical operational decisions that meet organizational goals. The High Line captures a sense of America's industrial past while providing a glimpse into the future of successful urban park design.

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