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The National Hockey League: An Econometric Analysis of Attendance

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ABSTRACT

The National Hockey League (NHL) and professional sports as a whole are interesting to study when econometric models are applied. First, a thorough examination of current literature concerning both professional sports and econometrics will be reviewed. In addition, a full description of the data and its accompanying sources are discussed. Then, through the use of an ordinary least squares (OLS) regression and hypothesis testing, the role of attendance throughout the NHL as a function of win percentage is empirically tested. Using a demand equation for the attendance of hockey games over the past 15 years, this paper will focus on determining the significance that a team's adjusted win percentage has on attendance. Specifically, a simple linear demand equation is modeled and tested for heteroscedasticity and significance at a 5 percent level. After running this regression model and performing the appropriate hypothesis tests, a team's adjusted win percentage can finally be analyzed to conclude its overall impact on attendance at NHL games. Ultimately, a team's adjusted win percentage does have a significant impact on NHL attendance. Lastly, the paper will conclude with a summary of the paper's findings and various conclusions from the regression model that are able to further advance our knowledge in the fields of econometrics and professional sports.

THE NATIONAL HOCKEY LEAGUE:
AN ECONOMETRIC ANALYSIS OF ATTENDANCE

INTRODUCTION

The process of economic analysis and econometrics is interesting and insightful when applied to the field of professional sports. According to Allen Sanderson and John Siegfried, two renowned sports economists, “Competitive balance, and specifically winning percentage, is thought to affect attendance of fans through its influence on winning and fans’ response to winning. It is well established that home attendance rises when a team wins more games or matches and declines when it loses” (Sanderson and Siegfried, 2003, p. 255). Many notable articles have been written in this field looking specifically at Major League Baseball (MLB), the National Football League (NFL), and the National Basketball Association (NBA). Of particular relevance are the articles by Sanderson and Siegfried (2003), Humphreys (2002), and Meehan, Jr., Nelson & Richardson (2007). However, little attention has been paid to the National Hockey League (NHL). Using available data from the past 15 years and the work from various professional economists, the role of overall win percentage in the NHL can be analyzed to see its effects on attendance.

More specifically, using previous literature concerning influences on attendance at sporting events, the following question can be explored: Does a team’s adjusted win percentage in any given year directly influence the number of fans who choose to attend hockey games in the NHL? Current economic theory put fourth by Sanderson and Siegfried (2003), Humphreys (2002), and Meehan et al. (2007) states that as a team’s winning percentage increases, the number of fans who attend their games increases. Therefore, by examining the differences in team winning percentages and comparing them to the league average for any given year, it can be determined if a team's winning percentage directly affects the demand for hockey games.

CURRENT RESEARCH ON SPORTS ECONOMETRICS

There is an abundance of literature on the econometrics of professional sports leagues. There are three studies that relate closely to my specific research question. First, Sanderson and Siegfried (2003) present a general overview of important topics related to competitive balance and other sports economics theories. Next, Humphreys (2002) discusses the use of an alternative measure of competitive balance, the competitive balance ratio, which measures a league's season-to-season change in the disparity between winners and losers. Lastly, Meehan, Jr. et al. (2007) employ the difference between home and visiting team-winning percentages across the MLB to analyze the effect that many factors, including winning percentage, have on attendance.

Sanderson and Siegfried

Sanderson and Siegfried (2003) present basic theories about competitive balance in their article "Thinking About Competitive Balance", from the *Journal of Sports Economics*. Sanderson and Siegfried mention five distinctive factors that have considerable influence over competitive balance that they and other scholars have found: Differences in population and preferences, willingness to act on differences in fan tastes, differences in player tastes, the trade-off between winning and uncertainty, and the character of the events themselves (Sanderson and Siegfried, 2003). In addition, they also delve into the issues that institutional arrangements play with regard to competitive balance. These issues include topics such as: payroll caps and luxury taxes, revenue sharing, number of teams, and relocation restrictions, just to name a few. Overall, throughout the article Sanderson and Siegfried are able to shed light on various topics that can be explained through empirical analysis (Sanderson and Siegfried, 2003).

Sanderson and Siegfried's article fits in well with my research topic. According to Sanderson and Siegfried, "Competitive balance is thought to affect attendance of fans through its influence on winning and fans' response to winning. It is well established that home attendance rises when a team wins more games or matches and declines when it loses" (Sanderson & Siegfried, 2003). This is just one of the many pieces of information that will weave its way through this paper. By utilizing the article's ability to analyze various economic measures, including winning percentage, I will be able to strengthen the evidence for my own research.

Humphreys

Humphreys (2002) may be the most closely related journal article to my research. Found in the *Journal of Sports Economics*, "Alternative Measures of Competitive Balance in Sports Leagues" provides new insight to an alternative measure of competitive balance in professional sports and specifically the MLB. His new method of defining competitive balance, the competitive balance ratio (CBR), is summed up nicely by Larsen, Fenn, & Spenner (2006):

> Humphreys (2002) presents yet another measure of competitive balance, the competitive balance ratio (CBR). He argues that the CBR is a more accurate indicator of competitive balance over time than other measures. The CBR is a ratio of the average of a given team's standard deviations of win/loss ratio across seasons divided by the average of the

> standard deviation of winning percentages for the league during the same number of seasons. The ratio is a number between 0 and 1, with 1 being perfect competitive balance over time and 0 being no competitive balance over time (p. 376).

The most significant finding from this article is the fact that the CBR, or rather Humphreys' unique model of competitive balance, is significant at the five percent level. This means that in Humphrey's model the CBR is a significant determinant to the number of fans that attend MLB games. Ultimately, according to Humphreys, "… more competitive balance will increase demand for attendance, other things being equal" (Humphreys, 2002, p. 144).

While my research does not specifically use the CBR, Humphreys estimates a multiple linear regression equation using ordinary least squares (OLS) estimates. My research is modeled after this method since I employ many aspects of Humphreys' model to conduct my own research. His model is a demand equation for sporting events, with attendance as the dependent variable acting as a function of a vector of variables that affect the demand for attendance at MLB games over the past 100 years. This is very similar to the equation I'm currently using to analyze attendance in the NHL, making this journal article an excellent fit with my research.

Meehan, Nelson & Richardson

In "Competitive Balance and Game Attendance in Major League Baseball" from the *Journal of Sports Economics*, Meehan, Jr., et al. (2007) examine the effects of competitive balance on attendance in the MLB for the 2000 – 2002 seasons. Using the "difference between the winning percentages of the home and visiting teams as a measure of competitive balance," they are able to effectively develop a model of the demand for MLB games (Meehan, Jr., et al., 2007, p. 563). They employ a large number of variables including: a team's daily attendance, average rainfall, day and night games, day of the week, average temperature, location (inside v. outside), and number of games behind in the league standings, just to name a few. The key conclusion from this article is that individual game competitive balance influences attendance at MLB games in a positive manner (Meehan, Jr. et al., 2007, p. 565). In other words, as the difference in winning percentages between any two teams decreases, attendance increases since the outcome of the each individual game becomes more uncertain.

This article is particularly relevant to my research for many reasons. First, it models a multiple linear regression equation using panel data over a number of years with attendance as the dependent variable. In addition, this article provides an empirical test of the hypothesis that individual game attendance in the MLB is positively correlated to the degree that the outcome is uncertain. But perhaps most importantly, Meehan, Jr. et al. found, among other conclusions, that "…an increase in the team's winning percentage had a positive and significant impact on attendance…" (2003, p. 572). This paper attempts to test this same hypothesis for the NHL.

Overall, these three journal articles from the *Journal of Sports Economics* have offered a unique perspective on the topic of competitive balance while also adding value to this topic. Various key subjects and points of economic theory were both taken and derived from these articles to strengthen the arguments put forth in my research. Although these three articles focus mainly on the MLB, key characteristics can be taken from each article and be applied to the NHL. Ultimately, these three articles serve as a foundation for my current research and were inspirational to the project.

DATA DESCRIPTION

The ultimate goal of my paper is to answer the proposed research question: Does a team's winning percentage in any given year directly influence the number of fans who choose to attend hockey games in the NHL? However, to discuss the effect win percentage plays in the NHL with any certainty, the proposed research question had to be modeled by a multiple linear regression equation and estimated using ordinary least squares (OLS). After reviewing current economic theory from Sanderson and Siegfried (2003), Humphreys (2002), Meehan, Jr. et al. (2007), and many other sports economics articles, I determined a suitable demand equation that modeled attendance for hockey games based on multiple factors. Overall, attendance is modeled as a function of adjusted win percentage, population, income, ticket price, and a dummy variable to account for the player's strike that took place during the 1994-1995 season. Therefore, the original regression equation took this form:

$$ATT = \beta_0 + \beta_1 WINP + \beta_2 POP + \beta_3 Y + \beta_4 P + \beta_5 D + u$$

However, after reviewing the results of the regression analysis and the previous literature more closely, I determined that a lagged dependent variable would be another suitable variable to add to the regression equation. Therefore, a lagged dependent attendance variable was added to the previous equation. Moreover, the dummy variable (D) was omitted from the previous equation due to the addition of the new lagged dependent attendance variable. This is because the lagged dependent attendance variable represents the previous season's attendance and the first year of the data set was the year of the lockout. Therefore, there was no longer a need for the dummy lockout variable since the new data doesn't include the 1994 – 1995 season. The new data set covers only the 1996 – 2010 seasons, which represents a total of 15 years. Consequently, the new regression equation models attendance as a function of adjusted win percentage, population, income, ticket price, and a lagged dependent attendance variable. The new regression equation to be estimated is:

$$ATT = \beta_0 + \beta_1 WINP + \beta_2 POP + \beta_3 Y + \beta_4 P + \beta_5 LATT + u$$

The data used for the regression equation is considered to be pooled panel data. For the purposes of this paper, data from each of the 30 teams in the NHL was gathered for any given year between the 1996 – 2010 seasons, encompassing a total of 15 seasons and 399 different observations. Therefore, each team in any given year represents cross-sectional data, but all 30 teams put together over 15 years represents both time-series and cross-sectional data, which is otherwise known as panel data.

According to Jeffrey Wooldridge, "Some data sets have both cross-sectional and time series features. A panel data (or *longitudinal* data) set consists of a time series for *each* cross-sectional member in the data set" (Wooldridge, 2009, p. 9). Yet, the key characteristic that distinguishes a pooled data set from a pooled cross section is that the *same* cross-sectional units are followed over the given time period. Therefore, observing the same unit over time allows a few advantages over the traditional cross-sectional or even pooled cross-sectional data sets (Wooldridge, 2009, p. 10 – 12).

The first advantage to focus on is the fact that by having multiple observations on the same data units allows us the benefit to control for certain unobserved characteristics of both fans and sports franchises. Another advantage of panel data sets is they often allow us the opportunity to study the results of lags in behavior. This case holds true whether we are talking about crime in different cities from one year to the next or in different hockey teams from year to year (Wooldridge, 2009, p. 10– 12).

Table 1 below shows the sources of the data from each variable. In addition, a more thorough analysis is discussed next.

Table 1: Variables in Regression Equation[1]

Variable	**Source**
Attendance (ATT)	ESPN and Andrew's Dallas Stars Page
Adjusted Win Percentage (WINP)	NHL and HockeyDB.com
Population (POP)	BEA and Statistics Canada
Income (Y)	BEA and Statistics Canada
Ticket Price (P)	Andrew's Dallas Stars Page and Team Marketing Report
Lagged Attendance (LATT)	ESPN and Andrew's Dallas Stars Page

NOTE: BEA = Bureau of Economic Analysis

The dependent variable in this case is "ATT" or attendance. This variable was taken from two sources. First, from ESPN average annual attendance per team was taken for the 2001 – 2010 seasons (ESPN, 2011). Second, average annual attendance data per team from 1996 – 2000 was taken from Andrew's Dallas Stars Page. Andrew's Dallas Stars Page is run by Mark Stepneski, the manager of the ESPN Dallas website. However, this original data is not biased or skewed in any way even though it comes from a website dedicated to the Dallas Stars. Stepneski cites the original data as coming from the Team Marketing Report, which is a paid

[1] Each NHL season takes place over a period of seven months, but in two different years. For simplicity purposes, the year in which a season ended is used to describe that specific season.

subscription service that is a leader in the publishing of sports marketing and statistical information (Stepneski, 2008a). This data has an annual frequency and is expressed in terms of the number of people attending each game for each team.

The next variable in the equation is "WINP", which stands for win percentage. More specifically, this variable is the *adjusted win percentage* per team in any given season. The adjusted win percentage per team can be calculated by taking a team's win percentage in any given year and subtracting the league average win percentage for the same year. An equation for the adjusted win percentage may modeled as:

$$\boldsymbol{Adjusted\ Win\ Percentage} = \overline{\boldsymbol{Team\ Win\ Percentage}} - \overline{\boldsymbol{League\ Win\ Percentage}}$$

Overall, this regressor is one of the most important in the regression equation. I attempt to prove that adjusted win percentage is a significant positive determinant to overall attendance at hockey games.

However, it is important to note why adjusted win percentage is used instead of strictly the win percentage. In the NHL, standings are determined by points, not wins, which changes the nature of the "win percentage" statistic. According to the NHL, teams are awarded two points for a win and only one point for either a tie (discontinued statistic) or an overtime loss (NHL, 2011). This means that if a game goes into overtime, the winner will still get two points *and* the loser will get one point towards their overall standings. In games where there is overtime, a total of three points are available for that game, not just two points. Therefore, since some games have three available points and others have only two available, the average win percentage across the league for any given year is not always equal to 0.500, or 50 percent. By taking a team's adjusted win percentage we can compare winning percentage both across teams and across time. Basically, we are seeing how much individual team results deviate from the average win percentage for the entire league for any given year. Over the duration of my data set, only three years (1996, 1998, and 1999) had a league average win percentage equal to exactly .500.

The data for this variable was taken from two different sources. First, the official website of the NHL had the win percentage data from 1998 – 2010 (NHL, 2011). Second, the data from 1996 – 1997 was taken from HockeyDB.com, a well-known and reputable hockey statistical database website (Hockey Database, n.d.). Once all the data was collected, the equation above was used in deriving the adjusted win percentage data for each team during the 15 years. This data has an annual frequency and is expressed as a ratio or a percentage.

Population is the next variable in the equation defined as “POP”. The population data is the average population per city using its metropolitan statistical area (MSA) for the city in which each team is located. The data for cities in the United States was found from the Bureau of Economic Analysis (BEA) website (Bureau of Economic Analysis, 2011b). The data for the Canadian cities was found from Statistics Canada, Canada’s official statistics and demographics database (Statistics Canada, 2011b). One piece of information to keep in mind regarding the population data is there are multiple teams within the same MSA. This means that a particular MSA is so large it encompasses more than one team; therefore some teams use the same population figures. These teams in New York include: the New York Islanders, New York Rangers, and New Jersey Devils. The multiple teams in the Los Angeles market include: the Los Angeles Kings and Anaheim Ducks. This data has an annual frequency and is expressed in terms of number of people.

Another variable in the multiple linear regression equation is "Y", the average household income per city using the MSA. Again, the income data for cities in the United States were found using the BEA (Bureau of Economic Analysis, 2011a). Additionally, data for the Canadian cities was found from Statistics Canada (Statistics Canada, 2011a). The Canadian data was in Canadian dollars, which then was converted from the Canadian dollar amount to US dollars by using the exchange rate for the given years from the United States Federal Reserve (Federal Reserve, 2012).

Moreover, the Canadian data was already in real values, but the data from the United States was still in nominal terms. Therefore, I used a simple inflation calculator from the Bureau of Labor Statistics (BLS) to obtain the real values for all ticket prices from the United States (Bureau of Labor Statistics, 2011). The BLS has an easy to use calculator on their website where the figures were plugged in the nominal income from a particular MSA and picked the year the income data was originally from. Then, the BLS calculator gave the new income figures in real (2010) terms based on the last year in the data set. Once this step was complete, I now had consistent data in real terms of US dollars for all MSAs in both Canada and the United States. Now, the income variable was in consistent values and ready to be run using OLS. This data has an annual frequency and is expressed in terms of US dollars.

The next to last variable in the equation is "P" or the average ticket price per team per game. This regressor had the most impact in determining the range of the data set because average annual ticket price data per NHL team was only publically available back to the 1994 – 1995 season. This data was found from the Andrew's Dallas Stars Page (Stepneski, 2008b).

Again, however, the data found on Andrew's Dallas Stars Page originally came from the Team Marketing Report.

All the ticket price data was in nominal US dollars; therefore no currency conversion using the exchange rate was needed. However, the same calculation using the BLS inflation calculator was used to determine the real ticket prices for each team over the 15-year period (Bureau of Labor Statistics, 2011). After this transformation, the values for ticket prices were in real terms and ready to be run in the regression. This data has an annual frequency and is expressed in terms of US dollars.

The last variable in the data set is the lagged dependent variable for attendance (LATT). This variable is exactly the same as the dependent attendance variable except that it is lagged by one year for every team during the 15 seasons. Again, just as with the case of the previous dependent attendance variable, the data from the 1996 – 1999 seasons were taken from Andrew's Dallas Stars Page, which was originally from the Team Marketing Report (Stepneski, 2008a). Data for the 2000 – 2010 seasons were taken from ESPN. This data is expressed as the average attendance per game, per team. This data has an annual frequency and is expressed in terms of the number of people attending each game for each team averaged over a specific year.

In addition to describing each variable in the data set and their sources, below in Table 2 is a concise summary of each regressor for quick reference when referring to any variables throughout this paper.

Table 2: Summary of Variables in Regression Equation

Variable	**Summary**
Attendance (ATT)	Average game attendance per team per year
Adjusted Win Percentage (WINP)	Team win percentage in given year minus the league average win percentage for same year
Population (POP)	Average annual population per city (MSA) containing a NHL team
Income (Y)	Average annual income per city (MSA) containing a NHL team
Ticket Price (P)	Average game ticket price per team per year
Lagged Attendance (LATT)	Previous year's average game attendance per team per year

One last note about the data set is that not all teams have been in the city they are currently playing in today. Therefore, according to Andrew's Dallas Stars Page, accompanying data was available for each team when they were not in their current city. Each variable reflects this change in city, especially the income and population data, but there are only three teams of the 30 current teams that are actually affected. One example is the case of the Phoenix Coyotes. During the 1996 – 1997 season the team was moved from Winnipeg (formerly the Winnipeg Jets) to Phoenix and became the Phoenix Coyotes. Consequently, the data from 1995 – 1996 is of Winnipeg, not from Phoenix. The two other teams are the Colorado Avalanche and the Carolina Hurricanes. The Avalanche moved from Quebec (formerly the Quebec Nordiques) in 1996, while the Hurricanes (formerly the Hartford Whalers) were moved from Hartford, CT in 1998 (Stepneski, 2008c).

Lastly, it is very informative to present a table of summary statistics, such as minimum and maximum values, means, and standard deviations for each variable. Having such a table makes it easier to interpret the coefficient estimates in the empirical analysis section discussed later in the paper (Wooldridge, 2009, p. 682).

Table 3 below shows the summary statistics for each variable in the regression equation.

Table 3: Summary Statistics

	Attendance (ATT)	Adjusted Win % (WINP)	Population (POP)	Income (Y)	Ticket Price (P)	Lagged Attendance (LATT)
Minimum	8,188	-0.250	124,260	$30,487	$25.81	8,188
Maximum	22,247	0.299	19,069,796	$67,418	$117.49	22,247
Mean	16,674	0.002	5,514,646	$41,226	$51.24	16,600
Standard Deviation	2,268	0.092	5,332,284	$6,389	$11.37	2,289

NOTE: Statistics represent the league as a whole, over the 15-year time period (1996 – 2010)

EMPIRICAL ANALYSIS

Originally, as noted above, the first regression equation used to find the most significant determinants on attendance in the NHL was the equation containing a dummy variable for the 1994 – 1995 partial lockout season, but excluded a lagged dependent attendance variable. The equation was only sufficient at first, until I learned about the problem with omitting key variables. Usually a key variable is omitted because the data for the specific variable is unavailable. However, in my case the data for the lagged attendance variable was available. The problem with omitting a key variable that actually belongs in the true regression model is that it *generally* causes OLS estimates to become biased (Wooldridge, 2009, p. 89).

Therefore, it is crucial that we look for ways to solve, or at minimum to mitigate, the bias caused by omitted variables in the original equation. One way of accomplishing this task is by the use of a "proxy variable" in place of the omitted variable. According to Wooldridge, "Loosely speaking, a proxy variable is something that is related to the unobserved variable that we would like to control for in our analysis" (Wooldridge, 2009, p. 306).

In some cases we at least have a vague notion about which factor that is unobserved that we would like to attempt to control. This enables us to choose the correct proxy variable(s). However, there are many more applications in which we suspect that one or more of the independent regressors are in some way correlated with the omitted variable, but we have no idea as to which proxy variable would be best suited in place of the omitted variable. In these cases, just as in the case of my current equation, we can include a control variable equal to the value of the dependent variable from an earlier time period (Wooldridge, 2009, p. 310). In my case, I chose to take a one-year lag of attendance to control for these unobserved factors.

Overall, using a lagged dependent variable in a panel data set increases the number of observations, which increases the accuracy of the regression results. In addition, "…it also provides a simple way to account for historical factors that cause *current* differences in the dependent variable that are difficult to account for in other ways" (Wooldridge, 2009, p. 310). For example, some cities with NHL teams have had high attendance in the past. Many of the same unobserved factors contribute to both high current and past attendance. By including a lagged dependent variable in the regression equation, we are better able to capture some otherwise "unobservable" factors (Wooldridge, 2009, p. 310 – 312). This idea is discussed further during the "regression results" section below.

An equation had to be modeled to test the current hypothesis and accurately find an answer to the proposed research question. Using current economic theory put fourth by Sanderson and Siegfried (2003), Humphreys (2002), and Meehan, Jr. et al. (2007), an appropriate demand equation for attendance was derived. Their research, along with the work of others, helped ensure this equation was sound and made sure it included all relevant variables, including a lagged dependent variable for reasons previously discussed. Below is the new multiple linear regression equation:

$$ATT = \beta_0 + \beta_1 WINP + \beta_2 POP + \beta_3 Y + \beta_4 P + \beta_5 LATT + u$$

Modeled from the three previously discussed articles, attendance was placed as the dependent variable. Then, an OLS regression was used to estimate each variable's coefficient (β_1 through β_5) to determine the magnitude by which each variable influences attendance.

Heteroscedasticity

Before the regression analysis results could be analyzed, it was first important to conclude the presence or absence of heteroscedasticity. Heteroscedasticity is defined as a non-constant variance of the error term, given the explanatory variables (Wooldridge, 2009, p.839). Under the classical assumptions, with homoscedasticity – constant variance of the error term – OLS is the Best Linear Unbiased Estimator (BLUE). When the data is homoscedastic, the OLS results are unbiased and efficient. The efficiency is lost, however, in the presence of heteroscedasticity. Two tests were used to determine if heteroscedasticity was present. The first was the Breusch-Pagan test and the second was White's test.

The results from both of these tests are listed in Table 4 below.

Table 4: Heteroscedasticity Test Results[2]

Test	Hypothesis	NR^2	Critical Value[3]	Decision Rule	Decision
Breusch-Pagan Test	$H_0: \sigma_i^2 = \sigma_i^2$ $H_1: \sigma_i^2 \neq \sigma_i^2$	41.62	11.07	Reject H_0 if $NR^2 > c$	Reject H_0
White's Test	$H_0: \sigma_i^2 = \sigma_i^2$ $H_1: \sigma_i^2 \neq \sigma_i^2$	44.00	31.41	Reject H_0 if $NR^2 > c$	Reject H_0

NOTE: NR^2 = Number of Observations (N) * R^2 (from $\hat{u}^2$ regression)
The Breusch-Pagan Test used 5 degrees of freedom
White's Test used 20 degrees of freedom

After analyzing the results from both the Breusch-Pagan and White's Test, it is clear that heteroscedasticity is present in the data set. Therefore, White's t-statistics and standard errors must be used when running any hypothesis tests on the regression equation's estimated coefficients.

Hypothesis Testing

To determine if the coefficient on any variable is statistically significant, a hypothesis test is needed for each variable in question. The hypothesis test is set up the same way for each coefficient. First, a null and alternative hypothesis is presented. Next, the student t-statistic and critical value are determined. A decision rule is then made and lastly it is determined if the estimated coefficient on the variable was statistically significant. As previously mentioned, since

[2] All hypothesis tests were performed at a 5% level
[3] NR^2 is distributed chi-square with degrees of freedom equal to the number of regressors, excluding the intercept

heteroscedasticity is present in the dataset, White's standard errors and t-statistics are used throughout the hypothesis tests.

Refer to Table 5 below to see the results of the hypothesis testing.

Table 5: Hypothesis Testing[5]

Variable	Hypothesis	Student T – Statistic	Critical Value[4]	Decision Rule	Decision
Intercept	H_0: $\beta_0 = 0$ H_1: $\beta_0 \neq 0$	4.90	1.96	Reject H_0 if $\lvert t \rvert > c$	Reject H_0
Adjusted Win % (WINP)	H_0: $\beta_1 = 0$ H_1: $\beta_1 \neq 0$	6.04	1.96	Reject H_0 if $\lvert t \rvert > c$	Reject H_0
Population (POP)	H_0: $\beta_2 = 0$ H_1: $\beta_2 \neq 0$	-1.97	1.96	Reject H_0 if $\lvert t \rvert > c$	Reject H_0
Income (Y)	H_0: $\beta_3 = 0$ H_1: $\beta_3 \neq 0$	-0.23	1.96	Reject H_0 if $\lvert t \rvert > c$	Do not reject H_0
Ticket Price (P)	H_0: $\beta_4 = 0$ H_1: $\beta_4 \neq 0$	0.49	1.96	Reject H_0 if $\lvert t \rvert > c$	Do not reject H_0
Lag Attendance (LATT)	H_0: $\beta_5 = 0$ H_1: $\beta_5 \neq 0$	21.97	1.96	Reject H_0 if $\lvert t \rvert > c$	Reject H_0

Regression Results

After running the necessary hypothesis tests using the results from the OLS regression it is very clear which estimated coefficients are statistically significant. By referring to Table 6 below, we see that the intercept, adjusted win percentage, population, and lagged attendance variables are significant at the 5 percent level. However, income and ticket prices are not statistically significant determinants of attendance. Moreover, although a variable's estimated coefficient may be statistically significant, this does not automatically imply any economic meaning.

Below in Table 6 are the complete results from the OLS regression estimate.

[4] This regression is distributed t with degrees of freedom equal to the number of observations
[5] All hypothesis tests were performed at a 5% level

Table 6: Ordinary Least Squares (OLS) Regression Results for Attendance

Variable	Estimate of Coefficient	Standard Error	Student T Statistic
Intercept	3868.17322*	789.95	4.90
Adjusted Win Percentage (WINP)	4371.19081*	724.11	6.04
Population (POP)	-0.00002125*	0.00	-1.97
Income (Y)	-0.00195	0.01	-0.23
Ticket Price (P)	2.69352	5.54	0.49
Lag Attendance (LATT)	0.77457*	0.04	21.97

NOTE: *Indicates significance at 5% level (α = 0.05)
The r^2 value for this model is 0.7415
N = 399 Observations

The first coefficient to take note of is the one associated with the intercept. While at the 5 percent level it is deemed significant, this does not mean much other than the estimated regression line should not run through the origin. Ultimately, the regression line should start at 3,868 fans, meaning regardless of any other variables, a minimum of 3,868 fans will attend hockey games, according to my model.

The second coefficient that is significant, adjusted win percentage (WINP), is the main focus of this paper. Literature from Sanderson and Siegfried (2003), Humphreys (2002), and Meehan, Jr. et al. (2007) has already proven empirically throughout the MLB that as a team's win percentage increases, attendance also increases as a result. According to my OLS regression, the estimate for the coefficient on the adjusted win percentage (WINP) is roughly 4,371 fans. This means that as the adjusted win percentage increases by 0.100, that team will, on average, increase attendance at any given game by 4,371 people. For example, if the Detroit Red Wings went from being a 0.500 team (winning 41 out of 82 games) to a 0.600 team (winning 50 out of 82 games), they would see an average increase of 4,371 fans in any given game. This fact is significant and empirically helps support the conclusion that increases in win percentage lead to increases in overall attendance.

Proportionately, this figure represents a significant increase in attendance. For a team with continually high attendance figures, the percentage increase in attendance isn't quite as substantial, but nonetheless it is meaningful overall. For example, take the 2010 attendance of the Chicago Blackhawks – the largest average attendance of any team in 2010. In 2010, the Chicago Blackhawks has an average attendance of 21,356 fans per game (ESPN, 2011). According to my model, the increase of 0.100 in adjusted win percentage would result in a 20 percent increase in attendance. However, on the other extreme, the Atlanta Thrashers had an average game attendance in 2010 of 13,607 fans (ESPN, 2011). Given the increase of 0.100 in adjusted win percentage, or an average of 4,371 fans, the Atlanta Thrashers would see an increase in their average fan base of 32 percent.

The numbers above paint a quite descriptive picture of just how much influence adjusted win percentage has on the average attendance at hockey games. For one last comparison we should take a look at the league as a whole. On average, over the past 15 years all the teams in the NHL have averaged 16,675 fans, as referenced in the Summary Statistics Table (Table 3) on page 17. Given a 0.100 increase in adjusted win percentage, the league as a whole would see an increase in attendance equal to roughly 26 percent. Therefore, adjusted win percentage is quite a significant determinant of attendance in NHL games!

As was the case with the intercept, the population (POP) variable is deemed statistically significant at the 5 percent level. However, given the value of the estimated coefficient,

-0.00002125, this variable has no economic significance, especially since it is measured in number of people. This is an example of where a variable's estimated coefficient is statistically significant, but the overall value is not economically meaningful. Moreover, after running the OLS regression, it turns out that both income (Y) and ticket prices (P) are not statistically significant at the 5 percent level. Overall, neither income nor the price of tickets is a significant determinant of attendance in the NHL, according to this model.

The lagged dependent attendance variable (LATT) is the last variable in the regression model. According to the hypothesis test, this variable is significant at the 5 percent level. Although the variable's estimated coefficient is small, the economic meaning is much larger. Often a lagged dependent variable has the ability to catch some unobserved variation in the data set. In this case, the lagged dependent attendance variable helps to account for other unobserved variables, such as fan preference to attend hockey games rather than attending substitute sporting and entertainment events.

In their book The Business of Sports, Scott Rosner and Kenneth Shropshire discuss this same idea. "In addition to different preferences for winning, fans who live in different areas may differ in their willingness to act on those preferences" (Rosner and Shropshire, 2011). Moreover, Sanderson and Siegfried (2003) noted something quite similar in their own study:

> So, too, is this true for winning sporting contests. Residents in some locations may be willing to pay more to have a more successful local team (e.g., per capita willingness and ability to support a winning ice hockey team is undoubtedly greater in Ontario than in Florida), especially if there are few other recreational, entertainment, and/or cultural amenities close at hand" (p. 154).

By including a lagged dependent variable in the regression equation, these otherwise "unobserved" effects can be effectively captured.

CONCLUSION

Ultimately, after running the regression model and estimating the variables' coefficients, we are able to draw many conclusions about the variables that influence overall attendance for NHL games. First, the data shows that regardless of any other variables incorporated in my model, on average, roughly 3,868 fans will attend NHL games. This is significant because this assumption disregards the average ticket prices, average household income or any other factors.

Another, and perhaps the most significant, influence on attendance in the NHL is a team's "adjusted win percentage". For the most part, the more a team wins, the higher a team's win (and adjusted win) percentage, and the more fans a team will have on average per game. Specifically, on average a team will see a 4,371 fan increase as their adjusted win percentage increases by 0.100. Most importantly, the answer to the proposed research question can finally be answered. Again, the question at hand is: Does a team's adjusted win percentage in any given year directly influence the number of fans who choose to attend hockey games in the NHL? According to my model and the results previously discussed above, a team's adjusted win percentage *does* have a direct influence on attendance at NHL games.

Additionally, from the regression it is apparent that although the estimate of the population variable is significant, it has no economic significance. Moreover, both the price of tickets and the average household income in cities with NHL teams are not significant determinants of attendance at NHL games, according to my model.

The last variable, the lagged attendance variable, is both statistically and economically significant. Although the actual value on the estimated coefficient is small (0.77457), it holds a much larger economic meaning. As discussed in previous sections, a lagged dependent variable is able to control for various unobservable factors that may be taking place, such as fan taste or preference to watch hockey in a certain city. In this case, by adding a lagged dependent variable we can see how much of an effect a previous year's attendance has on the current year. Overall, by adding the variable to the regression equation, I have been able to obtain more accurate predictions for each of the variables' coefficients.

By using theory put fourth by Sanderson and Siegfried (2003), Humphreys (2002), and Meehan et al. (2007), I was able to estimate a demand attendance equation for the number of fans attending NHL games and analyze the data using OLS. Overall, my results provide insight into the many factors that influence attendance throughout the NHL.

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APPENDICIES

Appendix I – SAS Program Editor

```
options ls=100;
proc print data=work.nhl;
var ATT WINP POP Y P LATT;
run;
proc reg data=work.nhl;
model ATT = WINP POP Y P LATT/spec acov;
**spec tells SAS to do White's test;
**acov tells SAS to calculate White standard errors and t-statistics;
output out=ATTu residual=uhat;
run;
data uhat;
set ATTu;
uhatsq=uhat*uhat;
u1=lag1(uhat);
u2=lag2(uhat);
u3=lag3(uhat);
u4=lag4(uhat);
run;
**Breusch-Pagan Test;
proc reg;
model uhatsq = WINP POP Y P LATT;
run;
**Breusch-Godfrey Test for first order autocorrelation;
proc reg;
model uhat = WINP POP Y P LATT u1;
run;
**Breusch-Godfrey Test for higher order autocorrelation;
proc reg;
model uhat = WINP POP Y P LATT u1 u2 u3 u4;
run;
**Calculates the ACF and the Q-Statistic;
proc arima;
identify var=uhat nlag=6;
run;
** ATT;
** Title:                Attendance;
** Measures:             Average Game Attendance per Team;
** Source:               ESPN and Team Marketing Report;
** Frequency:            Annual;
** Range:                1995-2010;
** Units:                Number of People;
** ;
** WINP;
** Title:                Adjusted Winning Percentage;
** Measures:             Team Winning Percentage minus League Average Winning
                         Percentage;
** Source:               NHL and HockeyDB.com;
** Frequency:            Annual;
** Range:                1995-2010;
** Units:                Ratio;
**;
** POP;
** Title:                Population;
```

```
** Measures:              Average Population per City using Metropolitan
                          Statistical Area (MSA);
** Source:                Bureau of Economic Analysis(BEA) and Statistics
                          Canada;
** Frequency:             Annual;
** Range                  1995-2010;
** Units:                 Number of People;
** ;
** Y;
** Title:                 Adjusted Income;
** Measures:              Average Income per City using Metropolitan
                          Statistical Area (MSA)adjusted for inflation;
** Source:                Bureau of Economic Analysis(BEA) and Statistics
                          Canada;
** Frequency:             Annual;
** Range:                 1995-2010;
** Units:                 Dollars (Index Year = 2010);
** ;
** P;
** Title:                 Adjusted Ticket Price;
** Measures:              Average Ticket Price per Team per Game;
** Source:                Team Marketing Report;
** Frequency:             Annual;
** Range:                 1995-2010;
** Units:                 Dollars (Index Year = 2010);
**;
** LATT;
** Title:                 Lagged Dependent Attendance;
** Measures:              Average Game Attendance per Team - lagged one period
                          (year);
** Source:                ESPN and Team Marketing Report;
** Frequency:             Annual;
** Range:                 1995-2010;
** Units:                 Number of People;
```

Appendix II – SAS Output

The SAS System 16:01 Monday, April 16, 2012 1

Obs	ATT	WINP	POP	Y	P	LATT
1	17155	-0.024	11692693	34359	48.00	17174
2	16977	0.026	11771038	35238	55.97	17155
3	16908	-0.104	11915815	36220	55.00	16977
4	15804	0.006	12086776	38226	58.05	16908
5	14461	-0.019	12253223	38207	58.48	15804
6	13512	-0.123	12398950	39173	62.38	14461
7	11646	-0.104	12525736	40226	49.27	13512
8	13988	0.047	12634977	40084	44.23	11646
9	14988	-0.066	12717433	40364	47.62	13988
10	15106	0.041	12761175	42092	32.80	14988
11	16363	0.114	12713660	44365	31.89	15106
12	17193	0.067	12692603	44191	41.17	16363
13	16990	-0.002	12768395	45191	44.21	17193
14	15168	-0.018	12874797	42784	43.50	16990
15	15263	-0.159	4281905	41566	63.15	17206
16	13368	-0.196	4432950	41169	48.80	15263
17	13476	-0.081	4555490	39850	47.71	13368
18	15121	-0.053	4673146	38924	40.25	13476
19	15550	-0.008	4947012	39169	45.08	15121
20	16229	0.034	5119641	39533	45.79	15550
21	15824	-0.092	5267527	39226	42.03	16229
22	14626	-0.094	5385586	39553	49.31	15824
23	13607	-0.055	5475213	37101	48.51	14626
24	17361	0.055	4230795	41423	73.07	14301
25	15551	-0.120	4265564	42963	71.44	17361
26	15098	0.055	4302696	44561	64.44	15551
27	16300	0.055	4337751	46758	62.16	15098
28	16323	-0.080	4369743	47713	62.33	16300
29	15433	0.012	4402611	51628	60.77	16323
30	15404	0.091	4443310	52124	59.74	15433
31	15029	-0.002	4459011	50829	60.88	15404
32	15133	0.105	4458187	50204	62.45	15029
33	16211	-0.106	4458891	51488	57.38	15133
34	14764	-0.094	4473477	54142	59.36	16211
35	15384	0.018	4503921	54784	57.16	14764
36	17039	0.150	4544705	56309	62.41	15384
37	17388	-0.006	4588680	53553	54.94	17039
38	13848	-0.055	1197885	30618	48.11	15503
39	16912	0.069	1194167	30999	41.30	13848
40	15635	0.043	1186175	31982	50.19	16912
41	17982	0.055	1178462	32544	50.63	15635
42	17955	-0.007	1173102	32606	46.94	17982
43	17840	0.073	1169159	33335	49.73	17955
44	16765	-0.025	1163528	33765	44.13	17840
45	13776	-0.093	1158368	33636	44.99	16765
46	15290	-0.011	1154212	34178	40.93	13776
47	16910	0.114	1139328	34397	32.16	15290
48	18690	0.132	1130913	35463	31.62	16910
49	19950	-0.006	1125965	36437	32.98	18690
50	18531	-0.002	1124055	37957	37.03	19950
51	18529	0.049	1123804	37469	36.43	18531

Obs	ATT	WINP	POP	Y	P	LATT
52	18000	-0.018	821628	35224	38.83	19306
53	17089	-0.047	838061	35467	36.42	18000
54	16847	-0.091	854822	35971	29.30	17089
55	16202	-0.061	871918	36244	34.08	16847
56	15322	-0.055	889357	36123	35.27	16202
57	16623	-0.080	951395	36177	40.46	15322
58	15719	-0.043	970423	36682	33.85	16623
59	16239	-0.075	989831	36941	36.36	15719
60	16580	0.044	1009628	37062	42.09	16239
61	19289	0.071	1079310	40777	44.26	16580
62	19289	0.028	1154900	43907	49.80	19289
63	19289	0.018	1187300	44548	60.86	19289
64	19289	0.041	1220400	46536	56.73	19289
65	19289	-0.012	124260	44205	59.73	19289
66	11967	-0.030	666317	36034	48.61	11822
67	13680	-0.035	694496	37048	55.74	11967
68	9086	-0.049	721528	38936	55.76	13680
69	8188	0.024	750079	40504	49.93	9086
70	12401	-0.013	776786	40926	59.95	8188
71	13346	0.012	804436	42794	50.80	12401
72	15052	0.030	835602	42319	34.28	13346
73	15682	-0.160	863488	40332	37.65	15052
74	12086	-0.066	889313	39263	36.67	15682
75	15596	0.126	953157	39954	28.28	12086
76	17386	-0.020	998979	40838	39.87	15596
77	16663	0.006	1045871	40551	35.34	17386
78	16572	0.034	1090408	40380	39.01	16663
79	15240	-0.073	1125827	38007	38.38	16572
80	20391	0.073	8693383	38109	55.37	20818
81	19397	0.002	8782253	39174	59.64	20391
82	18356	-0.055	8862719	40529	58.86	19397
83	17330	-0.073	8949190	42055	57.58	18356
84	16274	-0.049	9035654	41986	55.72	17330
85	14997	-0.092	9117732	43574	58.57	16274
86	15569	0.060	9192501	43305	57.66	14997
87	14795	-0.050	9245135	42916	56.37	15569
88	13253	-0.170	9286162	42493	57.72	14795
89	13318	-0.161	9362080	43384	41.38	13253
90	12727	-0.124	9398855	45041	36.68	13318
91	16814	-0.018	9451936	45488	35.33	12727
92	22247	0.077	9515636	46880	53.08	16814
93	21356	0.122	9580567	44379	46.80	22247
94	16017	0.134	1910680	38137	43.74	14395
95	16061	0.160	1959552	39352	54.40	16017
96	16060	0.079	2012227	40807	65.93	16061
97	16061	0.098	2061091	42651	64.49	16060
98	18010	0.060	2118555	43854	74.83	16061
99	18007	0.195	2172223	47258	77.70	18010
100	18007	0.079	2223954	48532	45.28	18007
101	18007	0.108	2276250	46957	48.19	18007
102	18007	0.081	2297441	45800	48.69	18007

Obs	ATT	WINP	POP	Y	P	LATT
103	18007	0.022	2353518	46779	41.62	18007
104	17612	0.022	2399620	48599	40.47	18007
105	16842	0.024	2449476	47938	40.06	17612
106	15429	-0.136	2500384	49392	41.29	16842
107	13947	0.018	2552195	46611	40.62	15429
108	18136	-0.177	1642112	39073	53.21	17457
109	17744	-0.111	1659344	39178	52.03	18136
110	17369	-0.152	1678827	38829	48.22	17744
111	16796	-0.106	1714463	38464	45.02	17369
112	16401	-0.112	1737170	38931	46.36	16796
113	14823	-0.067	1759348	38546	46.11	16401
114	15543	0.004	1779822	39276	48.54	14823
115	15416	-0.079	1801848	37999	47.66	15543
116	15572	-0.098	4501154	34818	39.94	16729
117	15997	0.142	4627649	36093	39.05	15572
118	16449	0.165	4770420	37851	58.18	15997
119	16893	0.195	4917993	39637	60.04	16449
120	17001	0.097	5059956	39769	64.42	16893
121	17001	0.121	5196188	42050	69.48	17001
122	18527	0.024	5354623	41563	46.19	17001
123	18532	0.145	5476578	40204	45.16	18527
124	18355	0.062	5582033	39509	44.26	18532
125	17829	0.126	5816407	41001	37.04	18355
126	17914	0.095	5999411	41950	38.24	17829
127	18038	0.036	6156652	41999	37.32	17914
128	17680	-0.051	6301085	44400	38.42	18038
129	17215	-0.024	6447615	41764	35.66	17680
130	19928	0.299	4399746	36240	49.85	19780
131	19976	0.081	4433102	36795	51.45	19928
132	19983	0.128	4440400	37884	58.43	19976
133	19983	0.067	4441717	39901	63.64	19983
134	19983	0.134	4447649	39901	63.61	19983
135	19995	0.152	4457471	41518	64.51	19983
136	20058	0.182	4479232	41491	65.02	19995
137	20058	0.139	4486067	40691	67.22	20058
138	20065	0.136	4492756	41021	65.92	20058
139	20079	0.199	4494398	39489	46.65	20065
140	20066	0.132	4484542	39222	45.36	20079
141	18912	0.146	4456582	39005	41.03	20066
142	19865	0.126	4423781	40211	47.36	18912
143	19546	0.061	4403437	37927	46.60	19865
144	12335	-0.085	862597	32845	28.74	13124
145	16044	0.002	879849	33072	31.82	12335
146	16245	-0.012	897446	33541	36.70	16044
147	16251	-0.024	915395	33796	39.02	16245
148	15802	0.012	933703	33683	42.59	16251
149	15612	0.042	937845	33733	42.91	15802
150	16593	0.036	956602	34205	33.60	15612
151	16658	0.029	975734	34446	34.79	16593
152	17678	0.014	995249	34559	42.24	16658
153	16832	0.022	1034945	39263	47.01	17678

Obs	ATT	WINP	POP	Y	P	LATT
154	16839	-0.124	1102900	41699	54.43	16832
155	16828	-0.018	1127600	42264	62.48	16839
156	16839	-0.039	1156500	44818	55.06	16828
157	16839	-0.183	1176300	43125	59.71	16839
158	13278	0.061	4547191	35628	44.58	14198
159	14703	0.051	4652414	36238	47.08	13278
160	14696	-0.116	4750249	36500	51.24	14703
161	18500	-0.024	4836853	37934	62.08	14696
162	15982	0.073	4932004	37671	61.36	18500
163	14679	-0.123	5025806	39134	58.74	15982
164	16084	-0.159	5120256	39511	52.45	14679
165	15428	-0.105	5212602	39627	38.61	16084
166	15936	-0.072	5280671	39184	34.35	15428
167	16014	-0.039	5443159	41850	37.11	15936
168	15370	-0.033	5466743	44026	46.57	16014
169	15436	-0.037	5465183	44158	52.81	15370
170	15621	0.010	5501752	45245	53.47	15436
171	15146	-0.091	5547051	42764	48.76	15621
172	13556	-0.098	11692693	34359	51.42	15414
173	12297	-0.083	11771038	35238	55.06	13556
174	13019	0.030	11915815	36220	47.22	12297
175	12794	-0.079	12086776	38226	54.52	13019
176	16519	0.048	12253223	38207	62.33	12794
177	15813	0.036	12398950	39173	66.52	16519
178	16314	0.054	12525736	40226	55.62	15813
179	17570	-0.056	12634977	40084	57.03	16314
180	17883	-0.035	12717433	40364	53.83	17570
181	17840	-0.014	12761175	42092	47.40	17883
182	16859	-0.142	12713660	44365	48.36	17840
183	16606	-0.122	12692603	44191	46.57	16859
184	16488	-0.075	12768395	45191	47.97	16606
185	17313	0.055	12874797	42784	47.20	16488
186	18015	-0.080	3024111	45943	53.88	18328
187	18501	0.047	3053303	45588	54.61	18015
188	18531	-0.023	3078253	45638	57.39	18501
189	18575	-0.045	3132772	46210	54.20	18531
190	18470	0.077	3167666	47300	54.02	18575
191	18568	0.043	3204196	47396	58.36	18470
192	18568	-0.014	3237612	48478	62.28	18568
193	18415	-0.049	3269814	45811	61.28	18568
194	18233	0.049	3326447	33004	40.87	16964
195	21002	-0.022	3392976	33232	49.72	18233
196	20772	0.030	3460835	33704	58.73	21002
197	20741	-0.043	3530052	33959	56.40	20772
198	20206	-0.019	3600653	33846	56.95	20741
199	20105	-0.098	3426350	33897	47.23	20206
200	18990	0.005	3494877	34370	38.21	20105
201	20673	-0.062	3564775	34613	42.63	18990
202	20555	0.038	3636070	34726	47.14	20673
203	21273	0.010	3635571	31692	51.46	20555
204	21273	-0.008	3723000	31971	59.76	21273

Obs	ATT	WINP	POP	Y	P	LATT
205	21273	0.079	3765400	32303	68.52	21273
206	21273	0.010	3818700	33368	65.31	21273
207	21273	-0.024	3859300	32980	72.18	21273
208	16600	-0.098	1293463	37567	55.06	16202
209	15824	-0.037	1317580	38984	53.54	16600
210	14789	-0.104	1343263	38599	52.82	15824
211	13228	-0.081	1363834	38528	50.84	14789
212	13168	0.026	1386743	38502	49.06	13228
213	14428	0.089	1450538	38994	40.38	13168
214	15259	0.114	1489156	40144	42.89	14428
215	14910	0.000	1524920	40027	46.34	15259
216	15010	-0.020	1556368	40906	47.99	14910
217	14979	0.049	1582264	38656	48.36	15010
218	16219	0.024	17544499	42407	57.26	16379
219	16398	0.142	17681708	43744	63.07	16219
220	17321	0.152	17835528	45407	57.56	16398
221	16695	0.140	18007924	46702	60.85	17321
222	15206	0.103	18192429	46838	58.88	16695
223	15642	0.152	18352743	49000	62.94	15206
224	15926	0.054	18490029	49132	66.27	15642
225	14859	0.127	18590085	47916	64.79	15926
226	15060	0.081	18671320	47332	63.11	14859
227	14230	0.059	18798114	49692	59.13	15060
228	14176	0.095	18825633	52655	57.49	14230
229	15564	0.049	18901167	54254	64.99	14176
230	15790	0.089	18968501	55332	58.09	15564
231	15546	0.067	19069796	52037	48.05	15790
232	11356	-0.171	17544499	42407	59.26	12574
233	12495	-0.065	17681708	43744	55.19	11356
234	12025	-0.067	17835528	45407	63.28	12495
235	11258	-0.146	18007924	46702	49.74	12025
236	9748	-0.171	18192429	46838	83.35	11258
237	11332	-0.208	18352743	49000	81.04	9748
238	14549	0.060	18490029	49132	54.04	11332
239	14931	-0.026	18590085	47916	52.83	14549
240	13456	0.026	18671320	47332	51.46	14931
241	12609	-0.081	18798114	49692	48.27	13456
242	12886	0.004	18825633	52655	48.20	12609
243	13640	-0.073	18901167	54254	50.97	12886
244	13773	-0.185	18968501	55332	55.86	13640
245	12735	-0.079	19069796	52037	58.57	13773
246	18200	-0.010	17544499	42407	50.52	18194
247	18188	0.085	17681708	43744	46.98	18200
248	18200	0.032	17835528	45407	78.70	18188
249	18200	-0.085	18007924	46702	76.99	18200
250	18200	-0.030	18192429	46838	43.91	18200
251	18200	-0.080	18352743	49000	42.70	18200
252	18039	-0.086	18490029	49132	43.21	18200
253	18148	-0.037	18590085	47916	45.55	18039
254	18081	-0.056	18671320	47332	61.34	18148
255	18142	0.000	18798114	49692	47.60	18081

Obs	ATT	WINP	POP	Y	P	LATT
256	18200	0.053	18825633	52655	46.28	18142
257	18200	0.016	18901167	54254	51.07	18200
258	18172	0.036	18968501	55332	49.64	18200
259	18076	0.022	19069796	52037	51.46	18172
260	13245	-0.250	998718	39964	44.78	9879
261	15377	-0.222	1018692	40239	43.88	13245
262	16751	0.006	1039066	40811	44.05	15377
263	17219	0.128	1059848	41121	42.66	16751
264	17509	0.054	1081044	40983	48.89	17219
265	17793	0.140	1063664	41045	53.01	17509
266	16919	0.048	1084937	41618	50.12	17793
267	17198	0.157	1106636	41912	47.85	16919
268	17759	0.093	1128769	42049	60.44	17198
269	19474	0.132	1130761	37046	44.09	17759
270	19372	0.083	1183400	37282	48.32	19474
271	19821	0.018	1200400	37813	54.09	19372
272	18949	-0.051	1218500	39355	49.62	19821
273	18269	0.012	1239100	40055	52.77	18949
274	17345	0.128	5586177	36373	56.42	17160
275	19311	0.136	5602154	37455	66.60	17345
276	19519	0.079	5615600	38694	70.57	19311
277	19612	0.067	5640015	40733	69.69	19519
278	19141	0.115	5665210	40734	73.69	19612
279	19576	0.085	5693275	42405	76.72	19141
280	19569	0.066	5722541	42728	66.31	19576
281	19325	0.120	5755874	43001	67.62	19569
282	19375	0.087	5787788	43110	65.87	19325
283	19653	0.059	5850621	43722	59.28	19375
284	19282	-0.216	5880912	45605	58.54	19653
285	19556	0.024	5912678	45834	56.65	19282
286	19545	0.047	5940496	47466	61.24	19556
287	19535	-0.024	5968252	46075	60.25	19545
288	11316	-0.024	2744046	30487	33.10	13013
289	15604	0.014	2855711	31373	42.55	11316
290	15405	0.000	2963714	32587	53.24	15604
291	15548	0.049	3074532	34020	52.08	15405
292	14991	0.024	3178349	34080	50.18	15548
293	14224	0.024	3278661	35594	47.69	14991
294	13161	0.054	3388445	35755	36.36	14224
295	13229	-0.056	3496957	35114	37.12	13161
296	15469	-0.115	3600163	34889	36.15	13229
297	15582	-0.063	3884588	36642	29.60	15469
298	14988	-0.148	4046571	37815	26.72	15582
299	14820	-0.049	4175595	37127	40.45	14988
300	14875	-0.075	4287323	36762	38.06	14820
301	11989	0.091	4364094	34452	37.45	14875
302	16239	0.122	2480098	32586	57.19	16108
303	16691	0.020	2471209	33488	63.13	16239
304	15069	0.098	2460208	34909	64.00	16691
305	14825	0.049	2449747	36344	58.59	15069
306	15444	0.012	2438518	36906	55.30	14825

Obs	ATT	WINP	POP	Y	P	LATT
307	16336	0.060	2429023	38058	59.65	15444
308	14895	-0.104	2418223	38507	57.19	16336
309	14749	-0.136	2408973	38436	55.91	14895
310	11877	-0.176	2400193	38327	48.08	14749
311	15804	-0.203	2372328	38734	39.60	11877
312	16424	0.083	2361482	40857	38.50	15804
313	17076	0.067	2357141	41460	47.41	16424
314	16975	0.047	2355391	43271	52.29	17076
315	17078	0.055	2354957	42298	55.55	16975
316	17190	-0.213	1622579	44532	43.89	17190
317	17420	-0.114	1652864	46358	42.90	17190
318	17101	-0.024	1684121	49702	55.61	17420
319	17149	-0.012	1708031	52184	54.40	17101
320	17291	0.005	1722965	56173	56.98	17149
321	17468	0.054	1739669	67418	58.14	17291
322	16994	0.079	1745147	59599	45.72	17468
323	17351	-0.087	1728245	54381	46.40	16994
324	15836	0.105	1723138	53496	45.19	17351
325	16831	0.047	1737313	55802	35.69	15836
326	17422	0.095	1754557	58712	34.71	16831
327	17411	0.104	1778432	60065	39.73	17422
328	17488	0.156	1810646	59308	43.78	17411
329	17558	0.128	1839700	55169	43.07	17488
330	18806	-0.012	2651219	34600	58.68	19489
331	16807	0.014	2662281	35275	66.69	18806
332	18415	0.098	2673687	36720	59.44	16807
333	18247	0.030	2679865	38034	57.84	18415
334	18591	0.170	2689480	37822	58.52	18247
335	19518	0.103	2701634	39088	55.43	18591
336	18485	0.073	2719279	39024	58.51	19518
337	18570	0.072	2733818	39531	50.58	18485
338	18560	0.026	2743862	39780	49.38	18570
339	14213	-0.209	2773155	39425	43.18	18560
340	12520	-0.063	2791682	40811	29.69	14213
341	17610	-0.073	2806368	40781	25.81	12520
342	18554	0.004	2818688	42955	30.43	17610
343	18883	-0.012	2828990	40728	37.90	18554
344	18892	0.037	2226036	31544	31.09	19934
345	17419	-0.061	2256460	32360	40.20	18892
346	13868	-0.232	2297251	33365	56.52	17419
347	11511	-0.213	2336822	34530	48.16	13868
348	13600	-0.196	2369105	34606	45.26	11511
349	14907	-0.165	2404273	35943	49.94	13600
350	15366	-0.104	2442189	35778	44.73	14907
351	16545	0.035	2483575	35838	35.47	15366
352	17820	0.117	2522780	36085	41.85	16545
353	20509	0.004	2638814	37461	47.88	17820
354	19876	0.010	2684639	38573	46.56	20509
355	18692	-0.122	2711222	38258	44.50	19876
356	16497	-0.155	2730007	39075	42.90	18692
357	15497	-0.073	2747272	37632	35.76	16497

Obs	ATT	WINP	POP	Y	P	LATT
358	15729	-0.012	4263759	34882	52.27	15733
359	15704	-0.077	4349034	34782	64.21	15729
360	15710	-0.079	4436015	34933	54.45	15704
361	16765	0.091	4524735	34857	54.68	15710
362	19158	0.085	4615230	34403	88.54	16765
363	19255	0.024	4682897	34120	82.51	19158
364	18338	0.085	4776555	34261	53.50	19255
365	19240	0.066	4872086	34167	57.45	18338
366	19377	0.099	4969528	33947	65.68	19240
367	19408	-0.008	5113149	33422	53.25	19377
368	19487	-0.002	5435500	33548	52.08	19408
369	19434	-0.049	5535700	33706	89.45	19487
370	19312	-0.063	5634500	34619	77.40	19434
371	19260	-0.110	5741400	33395	117.49	19312
372	17795	-0.018	1831665	36543	50.59	13932
373	17320	-0.022	1868298	36438	49.09	17795
374	16986	-0.110	1905664	36597	48.28	17320
375	15803	-0.146	1943778	36517	47.23	16986
376	14642	-0.019	1982653	36041	50.66	15803
377	17017	0.024	1986965	35745	57.62	14642
378	17713	0.048	2026704	35893	47.60	17017
379	18396	0.102	2067238	35795	47.07	17713
380	18631	0.087	2108583	35564	57.75	18396
381	18630	0.004	2116581	31800	58.49	18631
382	18630	0.083	2231500	33075	62.01	18630
383	18630	-0.018	2279500	33589	72.30	18630
384	18630	0.053	2337200	34898	63.07	18630
385	18810	0.067	2391300	33775	62.05	18630
386	15155	0.043	4438045	43970	48.21	14159
387	15672	-0.035	4498247	44565	50.16	15155
388	15275	0.061	4562952	45948	70.51	15672
389	17281	-0.085	4632500	47664	68.98	15275
390	14480	0.097	4723005	48500	51.96	17281
391	15534	0.060	4821031	50940	47.31	14480
392	16493	-0.007	4927274	51987	44.07	15534
393	15787	0.029	5014571	51322	49.47	16493
394	14720	-0.170	5086376	51425	50.62	15787
395	13905	-0.130	5229267	54233	41.26	14720
396	13929	-0.130	5265012	56169	40.12	13905
397	15472	0.018	5313033	56702	38.96	13929
398	18097	0.102	5377936	58732	42.34	15472
399	18277	0.177	5476241	56984	44.75	18097

The REG Procedure
Model: MODEL1
Dependent Variable: ATT ATT

Number of Observations Read	399
Number of Observations Used	399

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	1522581551	304516310	225.43	<.0001
Error	393	530873164	1350822		
Corrected Total	398	2053454715			

Root MSE	1162.24881	R-Square	0.7415
Dependent Mean	16675	Adj R-Sq	0.7382
Coeff Var	6.97020		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	3868.17322	642.99832	6.02	<.0001
WINP	WINP	1	4371.19081	667.87639	6.54	<.0001
POP	POP	1	-0.00002125	0.00001234	-1.72	0.0858
Y	Y	1	-0.00195	0.00996	-0.20	0.8449
P	P	1	2.69352	5.42818	0.50	0.6200
LATT	LATT	1	0.77457	0.02756	28.11	<.0001

Parameter Estimates

Variable	Label	DF	---Heteroscedasticity Consistent-- Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	789.94699	4.90	<.0001
WINP	WINP	1	724.10835	6.04	<.0001
POP	POP	1	0.00001077	-1.97	0.0492
Y	Y	1	0.00855	-0.23	0.8197
P	P	1	5.53581	0.49	0.6268
LATT	LATT	1	0.03525	21.97	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: ATT ATT

Heteroscedasticity Consistent Covariance of Estimates

Variable	Label	Intercept	WINP	POP
Intercept	Intercept	624016.23953	120191.51363	-0.001090769
WINP	WINP	120191.51363	524332.90514	0.0012274662
POP	POP	-0.001090769	0.0012274662	1.160424E-10
Y	Y	-4.125606402	-0.548681789	-2.142739E-8
P	P	-894.9903141	-244.1340422	-0.000013751
LATT	LATT	-22.76889992	-5.832085271	1.1655706E-7

Heteroscedasticity Consistent Covariance of Estimates

Variable	Label	Y	P	LATT
Intercept	Intercept	-4.125606402	-894.9903141	-22.76889992
WINP	WINP	-0.548681789	-244.1340422	-5.832085271
POP	POP	-2.142739E-8	-0.000013751	1.1655706E-7
Y	Y	0.0000730651	0.0014602717	0.0000630549
P	P	0.0014602717	30.645242079	-0.039809159
LATT	LATT	0.0000630549	-0.039809159	0.0012426704

Test of First and Second
Moment Specification

DF	Chi-Square	Pr > ChiSq
20	44.00	0.0015

The REG Procedure
Model: MODEL1
Dependent Variable: uhatsq

Number of Observations Read	399
Number of Observations Used	399

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	3.702125E14	7.404251E13	9.16	<.0001
Error	393	3.17761E15	8.085521E12		
Corrected Total	398	3.547822E15			

Root MSE	2843505	R-Square	0.1043
Dependent Mean	1330509	Adj R-Sq	0.0930
Coeff Var	213.71556		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	9702101	1573130	6.17	<.0001
WINP	WINP	1	-1602305	1633996	-0.98	0.3274
POP	POP	1	-0.04058	0.03019	-1.34	0.1797
Y	Y	1	-44.31171	24.37393	-1.82	0.0698
P	P	1	-664.17934	13280	-0.05	0.9601
LATT	LATT	1	-378.55542	67.42341	-5.61	<.0001

The REG Procedure
Model: MODEL1
Dependent Variable: uhat Residual

Number of Observations Read	399
Number of Observations Used	398
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	1479594	246599	0.18	0.9817
Error	391	529317480	1353753		
Corrected Total	397	530797075			

Root MSE	1163.50898	R-Square	0.0028
Dependent Mean	-0.69220	Adj R-Sq	-0.0125
Coeff Var	-168088		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	227.12832	681.94736	0.33	0.7393
WINP	WINP	1	44.47771	669.89435	0.07	0.9471
POP	POP	1	-0.00000126	0.00001244	-0.10	0.9191
Y	Y	1	-0.00012314	0.01001	-0.01	0.9902
P	P	1	0.68823	5.47206	0.13	0.9000
LATT	LATT	1	-0.01513	0.03109	-0.49	0.6267
u1		1	0.05961	0.05704	1.05	0.2966

The REG Procedure
Model: MODEL1
Dependent Variable: uhat Residual

Number of Observations Read	399
Number of Observations Used	395
Number of Observations with Missing Values	4

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	4409590	489954	0.36	0.9536
Error	385	525077532	1363838		
Corrected Total	394	529487122			

Root MSE	1167.83464	R-Square	0.0083
Dependent Mean	0.86177	Adj R-Sq	-0.0149
Coeff Var	135516		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	Intercept	1	224.54187	718.21467	0.31	0.7547
WINP	WINP	1	9.04886	678.82440	0.01	0.9894
POP	POP	1	-0.00000186	0.00001264	-0.15	0.8833
Y	Y	1	-0.00060054	0.01014	-0.06	0.9528
P	P	1	1.65806	5.55574	0.30	0.7655
LATT	LATT	1	-0.01650	0.03504	-0.47	0.6379
u1		1	0.06069	0.05829	1.04	0.2984
u2		1	0.03087	0.05474	0.56	0.5731
u3		1	0.01149	0.05295	0.22	0.8283
u4		1	-0.06756	0.05236	-1.29	0.1977

The ARIMA Procedure

Name of Variable = uhat

Mean of Working Series 4.33E-12
Standard Deviation 1153.477
Number of Observations 399

Autocorrelations

```
Lag   Covariance   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1    Std Error

 0     1330509      1.00000   |                    |********************|          0
 1    61983.387     0.04659   |                  . |*.                  |   0.050063
 2    29825.356     0.02242   |                  . | .                  |   0.050171
 3     5551.514     0.00417   |                  . | .                  |   0.050196
 4   -91888.180     -.06906   |                  .*| .                  |   0.050197
 5    41753.268     0.03138   |                  . |*.                  |   0.050435
 6     102566       0.07709   |                  . |**                  |   0.050484
```

"." marks two standard errors

Inverse Autocorrelations

```
Lag   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

 1     -0.04362   |                  .*| .                  |
 2     -0.03377   |                  .*| .                  |
 3     -0.00622   |                  . | .                  |
 4      0.07586   |                  . |**                  |
 5     -0.03013   |                  .*| .                  |
 6     -0.07639   |                  **| .                  |
```

Partial Autocorrelations

```
Lag   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1

 1      0.04659   |                  . |*.                  |
 2      0.02029   |                  . | .                  |
 3      0.00221   |                  . | .                  |
 4     -0.06999   |                  .*| .                  |
 5      0.03787   |                  . |*.                  |
 6      0.07756   |                  . |**                  |
```

The ARIMA Procedure

Autocorrelation Check for White Noise

To Lag	Chi-Square	DF	Pr > ChiSq	--------------------Autocorrelations--------------------					
6	5.83	6	0.4421	0.047	0.022	0.004	-0.069	0.031	0.077

Appendix III – SAS Log

```
NOTE: WORK.NHL data set was successfully created.
options ls=100;
proc print data=work.nhl;
var ATT WINP POP Y P LATT;
run;

NOTE: There were 399 observations read from the data set WORK.NHL.
NOTE: PROCEDURE PRINT used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds


proc reg data=work.nhl;
model ATT = WINP POP Y P LATT/spec acov;
**spec tells SAS to do White's test;
**acov tells SAS to calculate White standard errors and t-statistics;
output out=ATTu residual=uhat;
run;


NOTE: The data set WORK.ATTU has 399 observations and 7 variables.
NOTE: PROCEDURE REG used (Total process time):
      real time           0.06 seconds
      cpu time            0.04 seconds


data uhat;
set ATTu;
uhatsq=uhat*uhat;
u1=lag1(uhat);
u2=lag2(uhat);
u3=lag3(uhat);
u4=lag4(uhat);
run;

NOTE: There were 399 observations read from the data set WORK.ATTU.
NOTE: The data set WORK.UHAT has 399 observations and 12 variables.
NOTE: DATA statement used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds


**Breusch-Pagan Test;
proc reg;
model uhatsq = WINP POP Y P LATT;
run;

**Breusch-Godfrey Test for first order autocorrelation;

NOTE: PROCEDURE REG used (Total process time):
      real time           0.03 seconds
      cpu time            0.03 seconds


proc reg;
model uhat = WINP POP Y P LATT u1;
run;

**Breusch-Godfrey Test for higher order autocorrelation;

NOTE: PROCEDURE REG used (Total process time):
      real time           0.03 seconds
      cpu time            0.03 seconds


proc reg;
model uhat = WINP POP Y P LATT u1 u2 u3 u4;
```

```
run;

**Calculates the ACF and the Q-Statistic;

NOTE: PROCEDURE REG used (Total process time):
     real time           0.03 seconds
     cpu time            0.01 seconds


proc arima;
identify var=uhat nlag=6;
run;

** ATT;
** Title:            Attendance;
** Measures:            Average Game Attendance per Team;
** Source:            ESPN and Team Marketing Report;
** Frequency:            Annual;
** Range:            1995-2010;
** Units:            Number of People;
** ;
** WINP;
** Title:            Adjusted Winning Percentage;
** Measures:            Team Winning Percentage minus League Average Winning Percentage;
** Source:            NHL and HockeyDB.com;
** Frequency:            Annual;
** Range:            1995-2010;
** Units:            Ratio;
**;
** POP;
** Title:            Population;
** Measures:            Average Population per City using Metropolitan Statistical Area (MSA);
** Source:            Bureau of Economic Analysis(BEA) and Statistics Canada;
** Frequency:            Annual;
** Range            1995-2010;
** Units:            Number of People;
** ;
** Y;
** Title:            Adjusted Income;
** Measures:            Average Income per City using Metropolitan Statistical Area (MSA);
**            adjusted for inflation;
** Source:            Bureau of Economic Analysis(BEA) and Statistics Canada;
** Frequency:            Annual;
** Range:            1995-2010;
** Units:            Dollars (Index Year = 2010);
** ;
** P;
** Title:            Adjusted Ticket Price;
** Measures:            Average Ticket Price per Team per Game;
** Source:            Team Marketing Report;
** Frequency:            Annual;
** Range:            1995-2010;
** Units:            Dollars (Index Year = 2010);
**;
** LATT;
** Title:            Lag Dependent Attendance;
** Measures:            Average Game Attendance per Team - lagged one period (year);
** Source:            ESPN and Team Marketing Report;
** Frequency:            Annual;
** Range:            1995-2010;
** Units:            Number of People;
```