Cost of Winning: What contributing factors play the most significant roles in increasing the winning percentage of a major league baseball team?

The Honors Program
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ABSTRACT

Over the past decade, discussions of competition disparity in Major League Baseball have been brought to the forefront of many debates regarding the sport. The belief that "large market" teams such as the New York Yankees buy their championships through acquiring star talent at high prices has become a common belief of many followers of the game. This research will answer the pressing question, "What are the most significant factors that correlate to a Major League Baseball Team's winning percentage?". I used stepwise regression to identify factors significantly related to winning percentage. Interestingly enough, payroll is not a significant factor in the best model. Its high correlation with several other model variables may explain this.

INTRODUCTION

Dating back to early times, sport has been an integral part of our society and culture. Only in recent history has the idea of sports and competition been transformed into a business. Ranging from college athletics to professional sports, important business decisions must be made by both individuals and entire organizations in order to be successful in the industry. Young high school athletes must now investigate financial components of selecting a school, instead of focusing solely on the sport itself. Every day one can turn on the news and see another professional athlete in a contract dispute with his team. As sports grow increasingly popular in America, the correlation between money and sports will also be impacted. Owners continue to find new ways to make money, including team merchandise sales, which also serve as an effective marketing strategy for their sports teams. Professional sports have truly become a business, with money and financial decisions becoming an ever-growing part of daily team decisions. All these examples display particular evidence to prove how financial components of running a team are just as crucial as the athlete's performance on the field.

In any type of business, ranging from companies such as Wal-Mart and McDonald's, all the way to Major League Baseball, effectively allocating capital is critical to business success. Owners and general managers of major league baseball clubs must find the most

effective level of allocations to players, coach, and executive salaries, concession costs, stadium maintenance and staff, among countless other expenses. With this is in mind, it is important to understand the effectiveness of each of these components on the overall profitability of the team. Clubs must analyze statistics on each of these components and rank which play the most crucial role in generating the most success for the team. Knowing the correlation and impact that player salaries and other contributing factors have on win percentage is required knowledge to Major League Baseball owners. Obtaining this knowledge will greatly affect important decisions of baseball clubs as they will need to evaluate which approach they want to take for their team: either attempt to buy star players when they become available (e.g. New York Yankees) or have "home grown talent" where players are brought up through the farm systems with minimal costs (e.g. Tampa Bay Rays).

Particularly in Major League Baseball, disparity in team salaries has been portrayed by many as a major defect in the sport today, as there is no current salary cap. A salary cap allows the league to place a limit on the amount of money a club can spend on player salaries and/or team payrolls (Candela, 2011). Without one, some owners, players, reporters, and fans believe that teams with the highest overall salaries effectively have the highest winning percentages. The main appeal and virtue of all sports, whether at the high school, collegiate, or professional level of competition, is the idea that any team can win at anytime. The idea that winning is directly related to the level of funds owned by the team completely shatters this idea of contest, and playing the sport itself would prove to be irrelevant.

This study will analyze whether the overall payroll of a team is a significant factor in increasing a team's winning percentage, or are other financial or performance factors more significant. Potential factors that affect winning percentage include: performance factors, such as home and road wins and losses, fielding percentage, runs per game allowed, total earned runs allowed, earned run average of pitchers, strikeouts, walks, errors, runs per game scored, total runs scored, hits, home runs, runs batted in, stolen bases, batting average, on base percentage, slugging percentage, as well as factors with financial implications, such as total

fan attendance and stadium capacity. This study will use regression analysis to identify the most significant factors contributing to a team's winning percentage.

LITERATURE REVIEW

With this topic being such a controversial topic amongst baseball fans, there are many views and research on what factors actually impact a team's winning percentage. Conventional wisdom indicates that the higher the team salary, the greater the winning percentage, and the better the fan attendance will be. However, evidence from the Tampa Bay Rays runs contrary to this, as they are one of the few teams with an extremely low payroll, and a very high winning percentage, reaching the playoffs three times in the last four years. However, this has not resulted in increased fan attendance. It is no wonder that during the 2011 MLB Playoffs, the Tampa Bay Rays expressed sincere displeasure with their fan base, particularly related to their overall attendance. After selling out game 3 with 32,828 fans, fan attendance dropped to only 28,299 in game 4 when the Rays were ultimately eliminated. Tampa Bay's owner Stuart Sternberg showed his displeasure in a statement, "Were four years into winning. We're getting to the point where we don't control our own destiny. This is an untenable as a model" (Caple, 2011). According to the Cot's Baseball Contracts site, the Rays' payroll is lower this year than it was three years ago, and $30 million lower than last year. Ray's superstar Evan Longoria expressed this same concern with the fans three years prior in a statement, "They've wanted to watch a contender. And for us to play good baseball for three years now, and for us to be in a spot to clinch again and go to the playoffs, we're all confused as to why it's only 15,000 to 20,000 in the building" (Caple, 2011).

Despite this, the team is still winning. Mr. Sternberg's frustration comes from the recurrent idea that higher payrolls inducing more winning. Being one of the most successful teams in recent years, while at the bottom of the league in payroll year after year, leaves Sternberg questioning whether spending more money on players will help lead to a championship. He states, "When you're sitting here at this point and you lost by a run, you

know another X dollars might have changed things," Sternberg said. "Three or five million wouldn't have changed things necessarily but 15 to 30 might have. That's where we were. And for the foreseeable future that's what we've got" (Caple, 2011). This is exactly the question my study attempts to answer: does increasing a team's payroll really increase a team's ability to win, or are other factors more significant? For example, should owners focus on obtaining players who hit home runs or, players who steal bases? Or maybe hitters are not important at all and he should focus on obtaining an excellent pitching staff.

With a more league-based approach, Major League Baseball as an entity must monitor and evaluate the effects of disparities in spending throughout the league to maintain the competitive integrity of the sport. A major issue taking the forefront in recent years has been the idea of implementing a salary cap into Major League Baseball similar to that used in the National Football League. Bud Selig, Major League Baseball Commissioner, is faced with this challenge, which could change the sport forever. The difficulty lies with the fact that each team has varying financial situations based on many factors such as owner net worth, city size, and media market, among others. A team such as the New York Yankees has much more financial leverage than a team such as the Seattle Mariners. The market size of these two cities varies greatly, as does the winning percentage of the two teams. In Michael Lewis's (2008) study, he analyzes the growing concern of different size markets and the effect market size has on the competition in sports. Lewis highlights how popular sports are becoming in America, in particular baseball, where attendance at games increased from 55.5 million to 70 million people in only 25 years (Lewis, 2008). Analyzing all the factors that contribute to a successful franchise and weighing the importance of each can give Bud Selig a more substantial understanding of the effectiveness of the possible solutions he will implement.

Many studies, as is the case with Schwartz and Zarrow, believe that payroll is a significant factor in the winning percentage of a major league team. In their study, they identified specific errors in baseball from 1997 to 2008 and attempted to determine payrolls effect on both regular season wins and post season wins. In regards to the regular season, their findings concluded that since the free agency era, the ability to purchase talent on the

open market diminished the random elements of professional competition, leading to expanded effects of team payroll on winning percentage in regular season games (Schwartz & Zarrow, 2009). Interestingly enough, the study determined that in the postseason, there was no statistically significant relationship between wins and payroll. It even identified that neither regular season winning percentage, performance over the final month of the season, nor do a team's pitching statistics seem to be related to a team's post season success. With that said, compared to other professional sports leagues, Major League Baseball in fact has a strong competitive balance according to the study. While having a high payroll in the regular season may allow some of the same teams to be perennial playoff teams, since 2000, eight different teams have won a World Series championship (Schwartz & Zarrow, 2009). Moving forward, this study raises even more questions about disparity in baseball and whether or not certain limitations such as a salary cap or luxury tax would further improve competitive balance in baseball.

A variation of this study was analyzed in a recent Time magazine article based on the 2011 movie *Moneyball*, where each team's cost per win versus their OPS (on-base percentage plus slugging percentage) was examined to see which team plays most efficiently. In Time's research, it was discovered that perennial winners such as the New York Yankees, Boston Red Sox, and Philadelphia Phillies spend over $1.5 million dollars per victory. In correlation with these types of spending, only the Yankees and Red Sox have team OPS's above .790. Almost all of the other teams spending over $1.5 million per win have worse team OPS's than many of the lower market teams, many of which spend less than $1 million per win. Billy Beane, coach of the Oakland A's in the early 2000s overcame his lack of high payroll by seizing undervalued talent (Gregory, 2011). This has become a common practice of many teams today as many franchises do not have the type of funding to keep up with the spending of high market ball clubs. This study shows supports the idea that there can also be other factors besides payroll that exhibit strong relationships with winning percentage.

As aforementioned, one potential solution to baseballs competitive disparity that has been implemented is the luxury tax placed on teams with high player salaries. Because there

is no salary cap in baseball as there is in other sports such as football, the league places a tax on teams whose payroll exceeds $178 million for the 2011 season. The fines vary based on the number of offences, but to date there has only been four teams who have paid the tax. The league takes the money into an industry growth fund that is used to fund baseball programs in developing countries with limited availability to equipment and playing fields (Dietl, Lang, & Werner, 2008). However, some people, such as Michael Lewis (2008), argue that the luxury tax is not effective in leveling the playing field, as statistics show that only three teams with payrolls under $100 million have won a World Series in the past ten years. As discussed by Schwartz and Zarrow, while having a large payroll may not necessarily ensure a World Series victory, statistics show that it does have an extremely high correlation with the amount of playoff berths a team has (Schwartz & Zarrow, 2009).

Another potential solution that has been investigated in order to solve baseball's perceived competitive disparity issue is the idea of creating a worldwide draft. Currently, the collective bargaining agreement in place states that teams can only draft players from the United States, Canada, Puerto Rico, and other U.S. territories. With that said, players from other places around the world are not included in this draft. The problem here is the issue that major league baseball has rules dictating how much a drafted player should be compensated, yet if a player signs as a free agent, the player has more control over the team he signs with, his salary, and contract terms (Pollock, 2010). This creates league competition disparity, as teams with high payrolls are able to acquire high caliber talent from other countries such as Japan at very high prices, while lower market teams may only be able to acquire talent from the draft. A perfect example of this occurred in 2012 in the deal that brought Japanese pitching sensation Yu Darvish to the Texas Rangers. The deal for Darvish was so expensive that the Rangers had to pay $51 million to his old team the Nippon Ham-Fighters to even negotiate with Darvish and then an additional $60 million to sign him to their team (Short, 2012). These astronomical figures are unthinkable for most clubs, and continue to put low market teams at a disadvantage for acquiring talent from around the world.

Furthermore, the market and city size of a Major League Baseball team is another interesting factor in determining what best drives a team's winning percentage. Different cities have extremely large baseball cultures such as New York and Boston, while others like Tampa Bay have trouble gaining a large fan base. In J.C. Bradbury's book, he discusses this issue and concludes from his regression that variance in city size accounts for 40 percent of the variance in winning percentage, which seems to be a rather impactful component (Bradbury, 2007). The size of the city as a whole will be another component to look at to determine whether the sheer size of the city, or population, plays a role on fan attendance.

This idea is becoming a growing concern in baseball about the small market teams and their corresponding enviornments. Teams such as the Cleveland Indians, typically with a great fan base, is being limited by the city of Cleveland's economy. In addition, possibly one of the most troubling cases is the Tampa Bay Rays who only two years ago went on a "cinderella type" run all the way to the World Series. As stated by respected analyst Peter Gammons, "The Rays are stuck in a ballpark and location that Peter Ueberroth once predicted would suit only tractor pulls" (Gammons, 2010). These teams further support the idea that building a sucessful team has much more to it than simply payroll. With that said, the model that will be analyzed in this study will include fan attendence as a potential variable that may have a strong correlation with a team's winning percentage.

In addition, there are some owners that have the potential capital structure to sign big talent and necessary players, yet refuse to do so as they choose to allocate their money and revenues on expenses other than increasing their team's payroll and signing new players. A recent Sports Illustrated article by Joe Sheehan (2012) entitled "Memo to Owners: Spend Money!," highlights the spending trends of two major league baseball owners: including the Detroit Tigers owner Mike Ilitch, and Kansas City Royals owner David Glass. With the 2012 season beginning teams have many needs to fill as they attempt to bring a championship to their city. In the case of the Tigers, an injury to one of their star players left a gaping need for a power hitter for the upcoming season. Contrarily, the Royals are a team loaded with hitters and need a strong starting pitcher. So what happened? The Tigers made one of the biggest

deals in baseball history, signing superstar Prince Fielder to $214 million deal, while the Royals passed on pitcher Edwin Jackson who could have made the Royals a playoff contender for the first time since 1985. These two owners represent two different personalities, one who "wants to win more than the next dollar," and one who treats their team as if they "are the corner grocery, with the need to stay in the black for the next month, next quarter, next year the primary goal, and winning a secondary one" (Sheehan, 2012). As you can see, knowing the tendencies of owner spending on payroll is a crucial factor to a team winning, and cannot be definitively expressed in my model.

All in all, there are many studies and opinions on whether in fact winning percentage is a result of the amount of money spent on a team's payroll. A study conducted by Dave Studeman (2012), highlights the idea that within the sports realm there is no certainty. Studeman looked at this comparison from 1976 to 2011 utilizing regression analysis and correlations to determine the trends of this relationship over the time period. The following depiction from his study depicts the year-by-year correlation between payrolls and wins over this time span.

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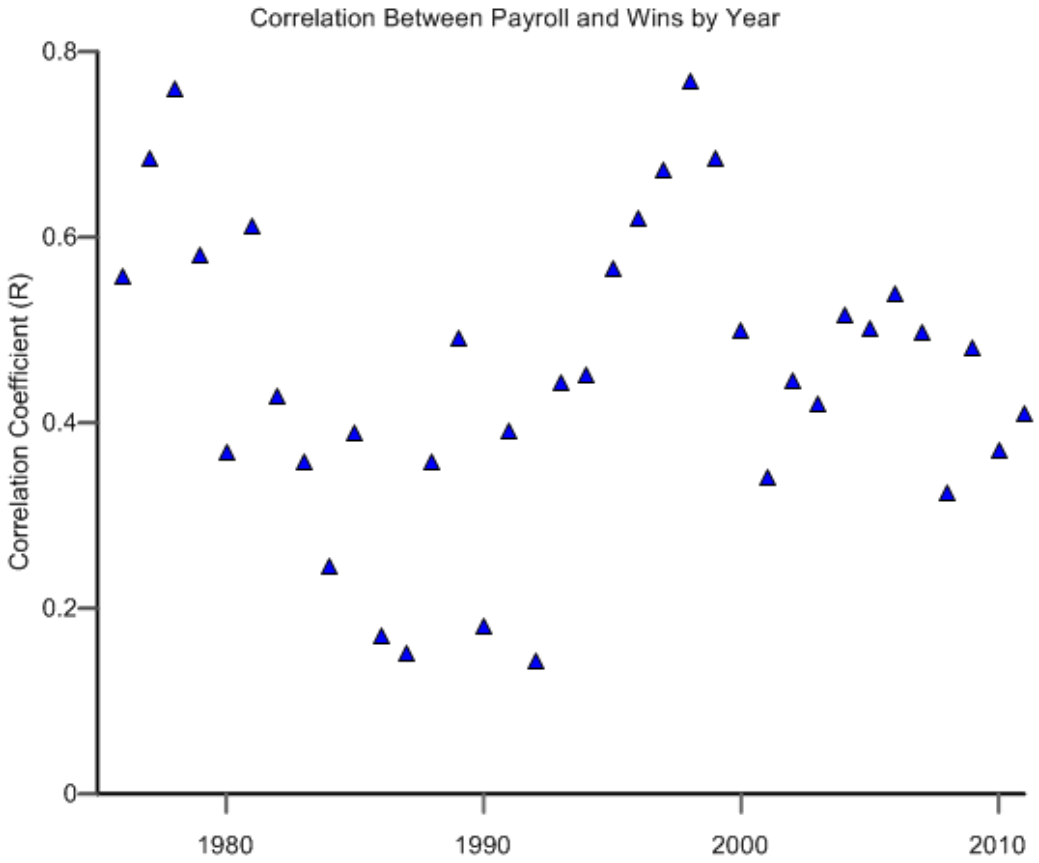

As you can see, there is no distinct or apparent trend in the results obtained from this correlation graph. In some years such as the mid to late 70's or the late 90's winning percentage seems to be extremely highly correlated with a team's payroll. These fluctuations are rational can be explained by structural changes within the game itself. For example in the latter half of the 70's, free agency was in its first few years and teams were taking advantage of new opportunities by signing top talent for high prices (Studeman, 2012). On the contrary in almost every other time span this correlation seems to be average indicating that this truly cannot be the most determining factor in winning, even today. While studies on this type of research in regards to competition disparity are constantly discussed and argued; maybe there are in fact no statistical measures to predict the mystery of sports and competition.

METHODOLOGY

Inevitably, there are countless factors that go into establishing a winning baseball team from the owners down to the players. In this study, the research attempted to answer the question of what factors are most impactful on a team's winning percentage. The model that was utilized will have winning percentage as the dependent variable. Various independent variables were analyzed in this study, including: home and road wins and losses, fielding percentage, runs per game allowed, total earned runs allowed, earned run average of pitchers, strikeouts, walks, errors, runs per game scored, total runs scored, hits, home runs, runs batted in, stolen bases, batting average, on base percentage, slugging percentage, total fan attendance and stadium capacity.

To accomplish this research, I utilized a multiple regression equation that includes all of the different factors contributing to winning percentage, and the relevance of each to winning percentage. The equation model will be as follows:

Winning Percentage = b_0+ b_1 (total payroll) +b_2 (home wins) + b_3 (home losses) + b_3 (road wins) + b_4 (road losses) + b_5 (fielding percentage) + b_6 (runs per game allowed) + b_7 (total earned runs allowed) + b_8 (earned run average of pitchers) +b_9 (strikeouts) + b_{10} (walks) + b_{11} (errors) + b_{12} (runs per game scored) + b_{13}(total runs scored) + b_{14} (hits) + b_{15} (home runs) + b_{16} (runs batted in) +b_{17} (stolen bases) + b_{18} (batting average) + b_{19} (on base percentage) + b_{20} (slugging percentage) + b_{21}(total fan attendance) + b_{22} (stadium capacity)

Where b stands for the respective coefficients of each variable that will be determined from the regression analysis.

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The purpose of a regression analysis was to investigate the relationship between variables. In this case, my regression model attemped to understand the causal effect of all of the independent variables previously mentioned on the dependent variable of winning

percentage. The regression allows the user to estimate the quantitative effect of the causal variables upon the variable they influence and assesses the statistical significance of the estimated relationships, or the degree of confidence that the true relationship is close to the estimated relationship (Skykes, 1991).

In the beginning stages of attempting to discover the most prevalent and influential factors on a major league baseball team's winning percentage, a large sample of data and statistics must first be collected. For each of the 30 major league teams, data was collected over a 10 year span dating back to 2002 ranging from financial data, on the field performance measures, and environmental factors. The original set of variables that would be identified and measured as contributors to winning percentage included: total payroll, home wins and losses, road wins and losses, city size (population), fan attendance, stadium capacity, errors, fielding percentage, runs allowed per game, total earned runs, earned run average for pitching staff, strikeouts, walks, runs per game scored, total runs scored, hits, home runs, runs batted in, stolen bases, batting average, on base percentage, and slugging percentage. These factors were all components that I believed to be significant to the success of a typical major league baseball team, and would serve as the best predictors of winning percentage.

With the variables and data entered into an Excel document, the next step was to create a stacked file to be analyzed using the regression functionality of Excel. Stacking the data simply require moving each of the ten years of statistics to one master file from which the regression would. The first problem that I encountered in attempting to analyze the data was the limitation in Excel that only allows for 16 variables to be considered in the regression. Originally, I was considering 24 variables in my model, yet due to this constraint, the next step was to eliminate eight of the variables that were least significant to predicting winning percentage, creating a more focused model. The first four variables that were eliminated from the model were home wins, home losses, road wins, and road losses. Because these variables directly depict winning percentage (in other words by adding up home and road wins/losses you can derive the winning percentage) they can be disregarded from the model.

Furthermore, the problem still exists that I must eliminate four more variables from the model so that the variables can be run through Excels regression tool. The first step in completing this task was to create a correlation matrix for the data. A correlation matrix can be created using Excel, and provides statistical measurements for the relationships between two variables. Correlations can range from +1 to -1 where a +1 relationship means that both variables move in the same direction together, while -1 shows a perfectly inverse relationship. A correlation of zero represents that there is no relationship. A correlation matrix uses these principles and compares all of the variables to each other, creating a table to be analyzed (Cherry, 2012). Creating a matrix in regards to this study identify variables that are so closely related that one of them can be removed from the model.

After analyzing the correlation matrices, it was determined that runs scored per game, total runs scored, earned run average, and total earned runs could be removed from the model. From there, the regression analysis was run based on the 16 variables that would impact winning percentage.

After running the standard regression model, the capabilities to utilize a stepwise regression program became a variable where all of the original variables could be run, excluding home/road wins and losses.

Finally, after analyzing the results from the stepwise regression, more questions were raised from the results and a new model placing total payroll as the dependent variable was created. This new model was created to determine which of the same factors used in the original model would be most significant in regards to impacting a team's payroll. With the results from these two models complete, conclusions can be drawn for owners to determine what factors influence winning percentage, and what variables are most important to invest in.

RESULTS

The first obstacle to obtaining definitive results for our model was the need to determine the final four variables to be removed from the model. It is important to eliminate variables that have a strong correlation with each other. If two variables are highly correlated, one variable could be removed while its "identity" remains encompassed and accounted for in the interrelated variable. In order to establish which of these variables are most closely related, a correlation matrix must be created with all the variables as indicated below:

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Table 1: Correlation Matrix 1

	Win Pct.	*Total Payroll*	*Road-W*	*Road-L*	*Fan Attendance*	*RPG Allowed*	*Total ER*	*ERA*	*RPG Batting*	*Total Runs*	*Hits*	*HR*	*RBI*	*SB*	*BA*	*OBP*	*SLG*
Win Pct.	1.0000																
Total Payroll	0.4132	1.0000															
Road- W	0.8444	0.3600	1.0000														
Road-L	-0.8492	-0.3702	-0.9908	1.0000													
Fan Attendance	0.5182	0.7591	0.4487	-0.4619	1.0000												
RPG Allowed	-0.6488	-0.2610	-0.5563	0.5682	-0.3483	1.0000											
Total ER	-0.6176	-0.2395	-0.5341	0.5457	-0.3188	0.9874	1.0000										
ERA	-0.6336	-0.2456	-0.5562	0.5675	-0.3279	0.9871	0.9975	1.0000									
RPG Batting	0.5701	0.3003	0.4568	-0.4475	0.3263	0.1098	0.1349	0.1160	1.0000								
Total Runs	0.5701	0.3007	0.4566	-0.4470	0.3269	0.1095	0.1351	0.1158	0.9998	1.0000							
Hits	0.3846	0.2554	0.3240	-0.3206	0.3089	0.1685	0.1956	0.1754	0.7943	0.7951	1.0000						
HR	0.4115	0.2259	0.3682	-0.3497	0.2097	0.1254	0.1370	0.1185	0.7122	0.7122	0.3620	1.0000					
RBI	0.5718	0.3067	0.4598	-0.4498	0.3280	0.1077	0.1323	0.1127	0.9960	0.9961	0.7808	0.7344	1.0000				
SB	0.1316	0.0819	0.1516	-0.1514	0.0548	-0.1473	-0.1327	-0.1368	-0.0353	-0.0339	-0.0186	-0.1364	-0.0485	1.0000			
BA	0.4121	0.2592	0.3237	-0.3207	0.3246	0.1353	0.1627	0.1503	0.7909	0.7912	0.9830	0.3391	0.7746	-0.0015	1.0000		
OBP	0.5374	0.3249	0.4230	-0.4172	0.3631	0.0449	0.0718	0.0551	0.8782	0.8778	0.7894	0.4874	0.8690	-0.0272	0.8162	1.0000	
SLG	0.4915	0.2386	0.4015	-0.3868	0.2651	0.1544	0.1738	0.1564	0.9128	0.9126	0.7304	0.8624	0.9207	-0.1065	0.7286	0.7616	1.0000

From this matrix, I identified six variables that showed a strong relationship with each other. These inputs included runs scored per game, total runs scored, runs batted in, runs allowed per game, earned run average, and total earned runs allowed. The next step in eliminating four of these variables is to determine which of these variables have the strongest relationship or impact on a team's winning percentage. By pulling from the data in the matrix, it was determined that runs scored per game and total runs scored were encompassed through runs batted in, which showed a stronger relationship with winning percentage than the others. In addition, the data showed that earned run average and total earned runs allowed were not as significant as runs allowed per game. As a result, the two variables that remained in the model were runs batted in and runs allowed per game while the others were eliminated.

To further investigate the significance of these six variables and ensure that the correct inputs are included in the model, the values from the correlation were converted to t-stat values using the following conversion formula:

$$t=\frac{r_{x1y}\sqrt{n-2}}{\sqrt{1-r_{x1y}^2}}$$

As seen below, a similar matrix was developed using the values obtained from the formula.

Table 2: Correlation Matrix 2

	Win Pct.	*Total Payroll*	*Road-W*	*Road-L*	*Fan Attendance*	*RPG Allowed*	*Total ER*	*ERA*	*RPG Batting*	*Total Runs*	*Hits*	*HR*	*RBI*	*SB*	*BA*	*OBP*
Win Pct.																
Total Payroll	7.8325															
Road- Wins	27.214	6.661905														
Road-Loss	-27.76	6.878422	-126.1													
Fan Attendance (Total)	10.46	20.13247	8.6672	-8.99												
RPG Allowed	-14.72	4.667603	-11.56	11.92	-6.414836668											
Total ER	-13.56	4.258267	-10.91	11.242	-5.805592888	107.75966										
ERA	-14.14	4.373313	-11.55	11.898	-5.991183149	106.25387	244.58									
RPG Batting	11.978	5.434326	8.8653	-8.637	5.958699924	1.9068089	2.3502	2.016								
Total Runs	11.978	5.441919	8.8604	-8.627	5.971147086	1.9019509	2.353	2.013	868.4398							
Hits	7.1924	4.560343	5.9128	-5.842	5.607418859	2.9508744	3.4424	3.076	22.57123	22.6307						
HR	7.793	4.002377	6.8356	-6.444	3.702833521	2.1811385	2.3871	2.060	17.51227	17.5137	6.703					
RBI	12.031	5.56193	8.9372	-8.693	5.993602662	1.8704979	2.3033	1.957	191.3188	195.541	21.57	18.68				
SB	2.292	1.417979	2.6468	-2.644	0.94729058	2.5711838	2.3118	-2.384	-0.608968	0.58531	0.321	2.377	-0.838			
BA	7.807	4.632214	5.9052	-5.845	5.924002457	2.357879	2.8465	2.623	22.31434	22.3328	92.44	6.222	21.14	-0.025		
OBP	11	5.929438	8.059	-7.924	6.72811086	0.776525	1.2419	0.952	31.69494	31.6334	22.19	9.635	30.31	-0.469	24.38	
SLG	9.743	4.241953	7.5667	-7.24	4.746291447	2.6969661	3.0475	2.733	38.57836	38.5297	18.45	29.40	40.73	-1.848	18.36	20.29

In reviewing the outputs from the new matrix, the results were confirmed through the t-stat values associated with winning percentage. Consistent with the previous conclusion, runs batted in and runs allowed per game remain in the model, while the other four variables were removed.

With the variables and inputs defined, a regression analysis was run and the results were sorted based on ascending P-values:

Table 3: Regression 1 Results

	Coefficients	*t Stat*	*P-value*
Runs/Game Allowed	-0.08841932	-16.94312418	5.54799E-45
RBI	0.000505619	6.516248447	3.27534E-10
HR	0.000576289	3.102890093	0.002109516
Walks	-9.79662E-05	-3.094455313	0.002168386
Fan Attendance (Total)	9.18959E-09	2.310968319	0.021550836
Stolen Bases	0.000123855	2.272631524	0.0237957
Batting Average	2.31411985	2.137985895	0.033371407
Slugging Percentage	-0.75874036	-2.073797718	0.038999233
Errors	-0.001126866	-1.659810953	0.098056234
Hits	-0.000207211	-1.588107328	0.113374722
Total Payroll	-1.13998E-10	-1.572172591	0.117023907
Intercept	6.555707657	1.555588776	0.120919549
Fielding Percentage	-6.092224229	-1.44964163	0.14826185
Stadium Capacity	-2.09532E-07	-0.567218591	0.571013743
Strikeouts	8.49967E-06	0.432767788	0.665511935
OBP	0.116280602	0.367707907	0.713364928

The regression statistics show that the input variables for this model are extremely effective in predicting a team's winning percentage. The adjusted R square value of .8533 shows that 85% of what comprises a team's winning percentage is accounted for by the variables in the model, which is a significant portion. To determine if a variable is in fact significant, its corresponding P-value must be less than .05. As seen in the regression outputs above, runs per game allowed and runs batted in are the top two most significant indicators of a team's winning percentage. All of the variables below slugging percentage in the chart above would be removed from the model as they serve to be insignificant variables. In addition, it is

important to notice that while some variables are very significant predictors, not all are positively associated with winning percentage. For example, while runs per game allowed is the most significant variable from the regression results, it also depicts a very high negative t-stat, which determines that the more runs an opponent scores, the more likely a team is going to lose games.

After testing my inputs through the Excel regression analysis tools and obtaining the aforementioned results, I continued to test my model through a more systematic process referred to as a stepwise regression using the SAS system program. This system is a step-by-step progression that involves automatic selection of independent variables that best correlate with the dependent variable. This process allows for more input variables than in Excel, and as a result, total runs scored, total earned runs, runs per game batting, and earned run average were included in this model. As the system evaluates the data, it goes through each variable to determine if it is a significant indicator of winning percentage. If the corresponding values were found to be significant, they are included in the model; if not, these variables were eliminated and do not appear in the final results. The following are the output results from running the stepwise regression:

Table 4: Stepwise Regression Results

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.53808	0.02577	20.88	<.0001
TotalAttend	1	7.027374E-9	2.597685E-9	2.71	0.0072
RPG	1	-0.11850	0.02052	-5.77	<.0001
TotalER	1	0.00090434	0.00032941	2.75	0.0064
ERA	1	-0.10857	0.04890	-2.22	0.0272
Walks	1	-0.00012187	0.00003032	-4.02	<.0001
RPGBat	1	0.39774	0.17239	2.31	0.0217
TR	1	-0.00198	0.00106	-1.86	0.0635
HR	1	0.00019632	0.00006927	2.83	0.0049
SB	1	0.00012842	0.00005330	2.41	0.0166

To maintain continuity between the standard regression analysis previously conducted and the stepwise analysis, the outputs from the stepwise regression had to be altered slightly. When the stepwise regression produces its results, the corresponding outputs are based on F values, or the fixation index. An F-test is simply another statistic that helps to identify which components of a model are most correlated with the dependent variable. In this case, I am looking to get the P-values of each variables so the regression must be conducted again using the nine variables that the stepwise regression deemed to be significant: total attendance, runs per game, total earned runs allowed, earned run average, walks, runs scored per game, total runs scored, home runs, and stolen bases.

After running the regression model with this new group of variables the following statistics were determined:

Table 5: Stepwise Regression: P-value

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Runs/Game Allowed	-0.1185	0.02052	-5.77	0.0001
Walks	-0.00012187	0.00003032	-4.02	0.0001
Home Runs	0.00019632	0.00006927	2.83	0.0049
Total Earned Runs	0.00090434	0.00032941	2.75	0.0064
Total Atendence	7.03E-09	2.60E-09	2.71	0.0072
Stolen Bases	0.00012842	0.0000533	2.41	0.0166
Runs/Game Scored	0.39774	0.17239	2.31	0.0217
ERA	-0.10857	0.0489	-2.22	0.0272

The preceding chart is sorted based on ascending P-value scores, which allowed me to determine the level of significance of each variable. As the results show, runs per game allowed, walks and home runs are the three most significant determinants of a team winning baseball games. This model further supports the conclusion of the stepwise regression, as each of the variables included did in fact turn out to be significant, while maintaining a strong adjusted R-squared value of .8545.

Cost of Winning: **What contributing factors play the most significant roles in increasing the winning percentage of a major league baseball team?**
Patrick Tartaro

Potentially the most intriguing outcome recognized from this data analysis is the fact that a team's payroll was found to be insignificant in all of the models tested. In the original model tested, the regression results showed team payroll having an insignificant P-value of 0.117023907, and in the stepwise regression analysis, team payroll did not even make it into the model. This outcome is surprising and goes against the conventional wisdom that when teams spend more money, they will be more successful. This discovery raises even more questions in regards to which factors teams are spending the most money on, and if in fact they are allocating these resources in ways that put the teams in the best position to win.

To begin analyzing this idea, another regression was run to determine which of the variables used in the previous models are significant in determining a team's payroll. In other words, the model will show which of these inputs teams are spending the most money on. The same sixteen variables were utilized as were used in the first regression analysis run. The following are the regression outputs computed for this model:

Table 6: Payroll Regression Analysis

	Coefficients	*t Stat*	*P-value*
Fan Attendance (Total)	34.48497952	13.51714834	1.74698E-32
SLG	-851997001	-2.877564566	0.004311726
HR	431780.169	2.845715206	0.004753857
Strikeouts	29160.04939	1.832257996	0.067960023
RBI	120990.5963	1.79496298	0.073722813
Win Pct.	-75687221.42	-1.572172591	0.117023907
Errors	-753049.9127	-1.359122406	0.175186098
Intercept	4572291741	1.330000649	0.184585179
Fielding Percentage	-4532085966	-1.322672613	0.187008354
Runs/Game Allowed	-6309570.838	-1.048422773	0.29533526
SB	40453.25118	0.904100721	0.366708258
OBP	175112199.7	0.679984115	0.497068419
Stadium Capacity	-171.5555876	-0.569959211	0.569155951
BA	349896179.2	0.393682649	0.694110754
Walks	7188.471323	0.274118251	0.78419302
Hits	26292.41535	0.246241233	0.805673376

After reviewing the results obtained from the data analysis, it can be seen that fan attendance, slugging percentage, and home runs were the only significant factors that help to comprise a team's payroll. The output shows a P-value of 1.74698E-32 for fan attendance, which is extremely significant and logical, as the more fans who attend games, owners receive additional revenue, which can in turn be spent on player salaries. The other two variables make sense as well in that most fans want to see the "big" hits such as home runs, triples, and doubles when they attend games, so it is reasonable to believe that these variables would be significant in the model. With that said, the outputs show that winning percentage is slightly insignificant, which is an unexpected outcome. Conventional wisdom would state that winning more games would draw more revenues for the team, which in turn could be used on payroll. While this is surprising, it is a common occurrence with many clubs today as highlighted by the Tampa Bay Rays.

DISCUSSION

All in all, this study set out to answer an extremely prevalent question in the world of major league baseball today: is a team's total payroll the greatest predictor for a team's winning percentage, or are other alternative factors more significant? In recent years, it has been the common belief of almost all major league baseball followers that the more money a team spends on players, the more successful the team will be. If one were to look historically at the past World Series winners, one might think the answer to this question is obvious. Furthermore, over the last 16 years, of the World Series winners, 62.5% of them were top ten in the league in payroll. While, 64% of the worst five teams in baseball over the last five years have been within the bottom ten teams in payroll (Stransky, 2011). While these figures make this question seem crazy, the results from this study may surprise many people in the baseball world.

It is important to note that when conducting a statistical analysis, in particular when dealing with a topic such as sports, there are countless factors that play large roles in the outcome of a team's season. Human nature is an almost impossible measure to quantify

empirically, and as a result the outcomes produced by this model are based on quantitative statistics associated with major league baseball teams. A variety of factors including injuries, team chemistry, coaching tendencies, among many others are virtually immeasurable and would clearly alter the results concluded throughout this study.

With that said, this study used a model that included 16 variables, ranging from fan attendance to batting average in the attempt to determine which factors were significant, and which were not. After the regression analysis was completed on the variables included in the first model using Excel, it was determined that the following factors were the only significant variables in regards to winning percentage.

Table 7: Regression Analysis 1 Rankings

Rank		*Coefficients*	*t Stat*	*P-value*
#1	Runs/Game Allowed	-0.08841932	-16.94312418	5.54799E-45
#2	RBI	0.000505619	6.516248447	3.27534E-10
#3	HR	0.000576289	3.102890093	0.002109516
#4	Walks	-9.79662E-05	-3.094455313	0.002168386
#5	Fan Attendance (Total)	9.18959E-09	2.310968319	0.021550836
#6	SB	0.000123855	2.272631524	0.0237957
#7	BA	2.31411985	2.137985895	0.033371407
#8	SLG	-0.75874036	-2.073797718	0.038999233

The outcomes from the first regression analysis are fairly consistent with what one could expect, except for the absence of total payroll which will be discussed later. Runs per game allowed by teams are consistent with the age-old belief in almost all sports that "defense wins championships." It is completely logical that when a team gives up less runs than their opponent, they are more likely to win games as evident by the extremely significant P-value. Some of the other variables are more interesting to see, including walks, fan attendance, and stolen bases, which all have very similar P-values. A high number of walks indicate a high significance level with winning baseball games. As my high school baseball coach used to

say, "A leadoff walk scores over 80% of the time." If this is true, then it makes sense that the more times a team puts runners on base for "free," the more likely chance they have of scoring more runs and winning games. Similarly, stolen bases seems like another logical indicator of getting wins, as the more stolen bases a team has, the more likely they are to be in "scoring position" when a player gets a hit.

One of the more surprising results from this regression analysis is the high significance of fan attendance on a team's ability to win. It is interesting to see that fan attendance is substantially more significant than other variables naturally seen as being extremely important, such as batting average or strikeouts. I believe the significance of this variable comes from the issue discussed before about human competitive nature, in particular professional athletes. To be a successful athlete, throughout one's career dating back to little league, an athlete always has fans watching games and evaluating their performance. It can be assumed that the miniscule percentage of these players who are good enough to make to the major leagues thrive under pressure and enjoy displaying their exceptional talents to the public. Also, it is a competitor's natural instinct to practice and play harder when they feel something is on the line or people will be evaluating them. This is depicted well by the Tampa Bay Ray's star Evan Longoria who expressed his displeasure with fans in recent years as fan attendance has been very low despite the team winning many games. This model suggests that if these types of teams do not maintain a solid fan attendance, performance in the future may be impacted.

In addition to the simple regression model conducted using Excel, I conducted a second regression using an SAS System program that conducts a stepwise regression analysis. With this type of analysis, I can input all of the original 20 variables selected, and the analysis added only the variables that are significant indicators of winning percentage. The results from this analysis are as follows:

Table 8: Stepwise Regression Rankings

Rank		*Coefficients*	*t Stat*	*P-value*
#1	Runs/Game Allowed	-0.1185	-5.77	0.0001
#2	Walks	-0.00012187	-4.02	0.0001
#3	Home Runs	0.00019632	2.83	0.0049
#4	Total Earned Runs	0.00090434	2.75	0.0064
#5	Total Attendance	7.03E-09	2.71	0.0072
#6	Stolen Bases	0.00012842	2.41	0.0166
#7	Runs/Game Scored	0.39774	2.31	0.0217
#8	ERA	-0.10857	-2.22	0.0272

After running this second regression analysis, again we see many of the same significant variables as previously determined. The results from running the two regressions are extremely similar, in that five of the eight variables from the previous model are seen as significant in this model as well. The only variables that are included in the second regression, but not in the first, are total earned runs, runs per game scored, and earned run average, as all of these were removed from the previous model due to high correlations with other variables.

Ultimately, the five most significant factors in increasing the winning percentage of a major league baseball team in order are:

Table 9: Final Results vs Winning Percentage

Rank	
#1	Runs/Game Allowed
#2	Walks
#3	Home Runs
#4	Fan Attendance (Total)
#5	Stolen Bases

As mentioned previously, all of these contributing factors make logical sense in their association with winning percentage, but their significance over other variables may be

surprising to some around the baseball world. One would be hard pressed to find a baseball analyst who would state that fan attendance is the fourth most contributing factor to a team winning games throughout a season.

With this information now known, owners and general managers whose focus is to bring championships to their cities should focus most of their time obtaining players whose skill set matches the variables expressed above. In looking at the results, it seems that the two most significant factors affecting winning percentage come from the defensive side of the game, in particular, pitching. Knowing this, I believe it would best suit a major league baseball team to primarily allocate their team's resources in obtaining pitchers who allow the fewest runs per game. Players such as the Tampa Bay Ray's Jeremy Hellickson, who allowed only 64 runs in 189 innings pitched and cost the team only $418,400 when the league average salary reached a staggering $3.44 million (Baseball's Average Salary Hits $3.4m, 2012). In addition, it was found that pitchers who allow the fewest walks to their opponents should be targeted as well. A player that resembles this most closely is Doug Fister, who allowed one of the league's best 37 walks in 216 innings and only cost the Seattle Mariners $436,500 in 2011 (2011 Leage Pitching).

On the offensive side of the plate, teams should focus on players who hit the most home runs and steal the most bases. The correlation between home runs and wins can easily be seen by the top three teams who hit the most home runs in 2011: the Yankees, Rangers, and Red Sox, all perennial playoff teams. While finding a player who hits home runs is one of the more expensive tasks for a general manager in the major leagues, there are in fact players such Giancaro Stanton of the Florida Marlins who hit 34 home runs and only cost his team $416,000. In addition, stolen bases is another attribute a manager should look for when acquiring talent for his ball club. A player who matches the qualities portrayed by Drew Stubbs of the Cincinnati Reds should be particularly interesting for teams, as he stole 40 bases in 2011 while accumulating 15 home runs at a salary of only $450,000 (2011 Major League Baseball Standard Batting, 2011). From the data compiled from the study, and the availability

of cheap players who demonstrate the skills described above, it is in fact possible for teams to win games without extremely high payrolls.

Finally, because fan attendance was one of the significant factors that motivate a baseball team to win, owners and the marketing sector of the clubs must seriously focus on providing a unique and enjoyable experience in their ballparks. People come to see baseball games not only for the game itself, but for the experience. The age old song, "Take me out to the ball game" encompasses this idea of an enjoyable fan experience. More so now than in the past, new ballparks are being created that have activities for children and adults to do before, during, or after games. For example, the New York Mets home Citi Field has video games, a wiffle ball field, and pitching practice than fans can partake in while at the game. As the regression results show, fan attendance is a very significant factor in winning games, so funds must be allocated appropriately, just as they would for a big time superstar.

This whole study attempts to get to the bottom of the age old question, what does it take to win? Traditionally it is believed that the team who spends the most money, wins the most games. As previously mentioned, this is not the case. With this learned the question then arises of what factors actually contribute to a team's payroll. To find this, another regression analysis was conducted with team payroll as the dependent variable with the same independent variables as previously used. The following were the only significant variables associated with a team's payroll:

Table 10: Final Results vs Payroll

Rank	
#1	Fan Attendance (Total)
#2	SLG
#3	HR

These results in regards to total payroll would make sense to most baseball analysts. The idea that fan attendance contributes significantly to a team's payroll is extremely logical due to the

fact that the more fans who attend games, the more revenues that is brought in by the club through ticket sales and concession stands. With this additional revenue, owners have the ability to increase the amount of money they are willing to spend on buying players for their team. Similarly, slugging percentage and home runs are also reasonable results as players who hit home runs and extra base hits tend to be the most expensive players in the league. Last year's home run champion Jose Bautista of the Toronto Blue Jays is set to make $14 million next year, and runner up Curtis Granderson of the Yankees is set to make $10 million (2011 Major League Baseball Standard Batting, 2011). Typically, fans love seeing exciting players who hit home runs and leg out triples, so owners in turn are willing to pay more for these hitters.

Finally, there are limitations for this study including a variety factors that may not be measurable in a quantitative manner. The impact of coaching on a team's ability to perform at high levels clearly plays a tremendous role on a team's ability to accumulate wins throughout a baseball season. Different factors regarding coaches cannot be measured in a systematic way including the coach's experience in the league, tenure with the team, total number of wins including individual winning percentage for their career, as well as the salary they received. Even a coaches personality, past coaching experiences, assistants, and their ability to gain the support of the players on their club all play roles on the actions of a baseball manager. This types of factors are important in regards to the cost of winning, in that if a team has a coach such as Billy Bean who can train and groom talent, they can pass up buying high priced star talent. If a coach is not suitable to manage players with undervalued skill, then the club may have to spend more money finding players who are already solidified in the league at higher costs. While these factors deal a lot with human nature and are virtually immeasurable, it is still important to note that this study does not include these types of variables in the model.

Similarly, other such limitations include the financial decisions and actions of the ownership as they have ultimate control over where to allocate the teams financial resources. Some owners, like is the case with the Steinbrenner's and the Yankees, have a win now

mentality, and will spend as much money as it takes to bring the best talent and coaches to the Bronx. Others in the league have a low budget mentality due to playing in small markets where they are more likely to develop players in the farm systems and groom them into stars at relatively cheaper prices.

Moreover, the demographics of where a particular team exists are other functions of winning percentage that would be difficult to quantitatively identify and examine. The climate and region where a team plays may provide an important correlation to winning percentage. Some teams play in cold rainy weather during late August, while other teams experience warm weather almost year round. It is much more difficult for players to hit in cold weather, and as a result teams in cold weather regions may tend to focus on their pitching staffs, while warm weather clubs may attempt to compile a high quality lineup. In addition, the Colorado Rockies, who play almost a mile above sea level, have different air pressures, causing teams to hit balls a greater distances, which further indicates the importance of examine the regions in which teams play. A study conducted by Zahari and Mustafa (2007), they determined that while climate did not have a strong influence on winning it could play some role in the process (Zahari, 2007). While this factor may not have as big an impact on winning percentage as others in that on a given night two teams play in the same game environment, it is important to recognize this factors impact on a club will be and how they will allocate its resources on certain players.

CONCLUSION

All in all, while the results show what statistical areas owners should allocate most of their resources to win the most games, nothing in sports is guaranteed. As much analysis is done, nothing can truly depict how many games a team will win in a season due to the incredible uncertainty of human nature and potential accidents. Teams who spend all their money on increasing fan attendance and buying shutdown pitchers do not guarantee championships. With that said, this study set out to determine the best model for owners to allocate their financial resources in the most economic way possible to position their club for

success. It also disproved the common belief that the more money a team spends on its players, the more successful they will be, which will help Pirate fans rest easier when they walk into Yankee stadium for a matchup with the Bronx Bombers

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