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The efficiency of the National Football League and its impact on attendance

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"I think in the NFL knowledge is power, and you try to get the knowledge by whatever means."

- Steve Sabol, co-founder of NFL Films

"The NFL is such a large, multibillion dollar enterprise with fan loyalty because they have provided not only entertainment for sports fans, but memories, good memories, family memories to these fans, that can only bring about good will."

- Wendell Pierce, actor

"If it doesn't matter who wins or loses, then why do they keep score?"

- Vince Lombardi, former NFL coach

"How do you win? By getting average players to play good and good players to play great. That's how you win."

- Oail Andrew "Bum" Phillips, former NFL coach

"We are a bunch of fat cat Republicans who vote socialist on football."

- Art Modell, former owner of two NFL teams

PREFACE AND ACKNOWLEDGEMENTS

As a result of the thesis broker, I came across the topic of efficiency in sports and immediately knew I wanted to write my thesis on the National Football League. This thesis gave me the chance to combine two fields of interest, namely sports and finance. As an American football enthusiast, this paper gave me a great opportunity to peak behind the curtains and take a scientific perspective on the game. Since most of the games are played late in the evening or even in the middle of the night, I found myself writing most of my thesis in this time slot. Collecting the data and constructing the dataset was, besides necessary, actually fun and interesting. I am afraid no NFL game will ever be just a game to me.

I wish to thank first and foremost my thesis supervisor, Gosse Alserda for his constructive feedback and interest in this field. Furthermore, I obviously wish to thank Ingrid for her help and patience. I am also grateful to Teun and Kimberley for their views on some of the statistical aspects. In general, I wish to thank my mother and her partner for their support throughout my study.

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ABSTRACT

This paper studies the effect of efficiency on attendance in the National Football League. Efficiency is defined as a percentage of the observed number wins over the expected number of wins. A production function is constructed using the stochastic production function approach. Via this production function the number of expected wins are estimated for all franchises over the years 2001 – 2014. The efficiency scores for the years 2008 – 2014 are then used to measure the effect efficiency has on attendance using a Tobit regression. In order to check for robustness of the results both total attendance and attendance percentage are used as independent variables. I find that in both models the lagged efficiency variable has a significantly positive effect on attendance.

Keywords:

Efficiency; National Football League; Stochastic production frontier; Sports attendance

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LIST OF ABBREVIATIONS

AFC	American Football Conference
AFL	American Football League
CFL	Canadian Football League
DEA	Data Envelopment Analysis
FCI	Fan Cost Index
GM	General Manager
LAD	Least Absolute Deviations
MLB	Major League Baseball
MLS	Major League Soccer
MSA	Metropolitan Statistical Area
NBA	National Basketball Association
NFC	National Football Conference
NFL	National Football League
OLS	Ordinary Least Squares
RPCPI	Real Per Capita Personal Income
SBA	Sports Broadcasting Act
SPF	Stochastic Production Frontier
UEFA	Union of European Football Associations
VIF	Variance Inflation Factors

1. Introduction

1.1 Motivation

Super Bowl Sunday! It was February 2nd 2015, New England Patriots – Seattle Seahawks. 00:27 left on the clock, ample opportunity and just a few yards shy of eternal fame. Pete Carrol (head coach of the Seattle Seahawks) opted for a passing play instead of a running play. Passing plays have a much higher chance of being intercepted than running plays. Marshawn Lynch, the running back of the Seattle Seahawks, was in the form of his life. The whole world was expecting a running play involving Marshawn Lynch and the almost inevitable touchdown that would follow. The result of the passing play; interception by cornerback Malcolm Butler (a rookie free agent) of the New England Patriots and the end of Super Bowl XLIX resulting in a victory for the New England Patriots. What had happened? Was it luck, or were the New England Patriots simply more efficient?

The National Football League (NFL) was founded in 1920. Soon after the Second World War the American Football League (AFL) was created. The AFL quickly became a successful rival of the NFL with regards to finance, players and public interest. The two merged in 1970 to form one big league, the NFL. The NFL consists of two conferences, the American Football Conference (AFC) and the National Football Conference (NFC). At the end of the regular season, the best teams of the AFC compete for a spot in the final as the AFC representative. The same goes for the NFC. In the end, the AFC and NFC teams play each other for the holy grail in football, the Super Bowl.

All professional teams pay a fee to the NFL in order to participate in the league. This is why they are mostly referred to as franchises as opposed to the more general term clubs or teams. In exchange for this fee, the NFL either acts as the sole agent for the teams (e.g. negotiating television rights fees) or as part of the interdependent trifecta that is formed by the owners, players and the NFL. Due to the successful launch of the AFL, the NFL adopted a very uniformed way of thinking. The league wanted to make sure it was bigger in size, better in terms of players and larger in fan base than any other possible future competitor. It is the equality that the NFL strives for that makes the league even more interesting.

In this paper, I study the efficiency of football franchises competing in the National Football League. The study is extended by looking closer at the effect efficiency has on attendance. Attendance in this case, should be seen as a proxy for revenue or revenue generating possibilities for the franchises. The vast majority of revenue for the franchises comes from the television and media rights fees, which are evenly shared. This pool has grown from $47 million in 1970 to a staggering $4 billion in 2013. The NFL even goes so far in trying to maximize equality, that even ticket sales are split at a 60/40 home/visitor rate. However, some revenue streams such as parking, concession and luxury club seat revenues are not shared. In order for these unshared revenues to grow, it is necessary for fans to be in the stadium.

1.2 Relevance

Efficiency in this sense means playing as close to a team's potential as possible, given their unique set of input variables such as sacks[1], average yard per rush and average yards per pass. This is scientifically interesting as sports are more and more intertwined with science. As the stakes are getting higher, science takes the emotion out of the equation and implements reason. Even though professional football is a multibillion dollar industry, it is a relatively small field of study compared to sports such as basketball and baseball. Aaron Schatz (2005) made a striking comparison: "If baseball research is now about where mathematics was in 1900, football research is about where the Arabs were when they invented algebra."

From a social perspective, studying the efficiency of NFL teams is interesting as according to Quinn (2012), in 2009 more people identified themselves as NFL fans than did so for MLB (Major League Baseball). This is reflected in the total revenue generated, where the NFL's estimated revenue was 9.0-10.0 billion dollar for the 2012 – 2013 season compared to the MLB's estimated 8.0-8.5 billion (Gaines, 2014). Even though the MLB is gaining ground, the NFL surely knows how to capitalize on its position, having dominated the other three big leagues[2] for years now.

This paper contributes to current literature by linking efficiency in the NFL to revenue generation possibilities for the franchises. The NFL is rather unique when it comes to its, somewhat socialist, economic structure. It understands that its existence as a league is dependent on multiple teams willing to participate. This is why all franchises pool and share roughly two thirds of generated revenue (Vrooman, 2012). As opposed to the Champions League in Europe, the NFL distributes all generated media revenue evenly across the franchises. There is however, still some room to generate individual revenue as the NFL distinguishes between national and local revenue. Gate revenue, which is local revenue, doubled since 1993 and comprised 21.7% of total NFL revenue according to Vrooman (2012).

[1] Successfully downing the quarterback behind the line of scrimmage (the imaginary starting line) and ending the play.
[2] National Basketball Association, Major League Baseball and National Hockey League.

The Atlanta Falcons are in this regard a prime example. They have announced to lower the prices for their concession stands dramatically in hope of convincing more fans to move from their couch into the stadium. After their move into the new stadium in 2017, they will offer all you can drink soda for 2 dollar and beer for 5 dollar (Colangelo, 2016). With this new policy they hope to increase the number of fans attending events. Furthermore, the Atlanta Falcons hope to create goodwill and get current stadium fans to spend more.

1.3 Research question

The research question is stated as follows: "*What is the impact of the efficiency of the National Football League franchises on attendance?*".

The purpose of this thesis is to study which franchises of the NFL produce efficient given their input variables. Later on I will review the impact of this efficiency on attendance. Both total attendance and attendance as a percentage of maximum stadium capacity are used as independent variables to show robustness of the results. Unfortunately, as the NFL is identified as a non-profit organization, it is not obliged to provide insight into its finances. This also holds for the franchises. Since the vast majority of revenue is shared equally among the 32 franchises, it is more interesting to look at the non-pooled local revenue generated by the matches. As revenue numbers are not available, I therefore analyse total attendance and attendance as a percentage of maximum stadium capacity as a proxy for revenue generation. By including attendance relative to the maximum capacity, this could even out the effect larger stadiums might have and improves comparability. I expect efficiency to have a significant positive effect on attendance and therefore I form the following main hypothesis:

1. H_0: The efficiency of NFL franchises has no significant impact on attendance.

Subsequently, in order to check if the league is as egalitarian as the NFL strives for I also form the following sub-hypotheses:

- 1.1 H_0: There is no significant difference in the number of expected wins between AFC and NFC franchises.
- 1.2 H_0: There is no significant difference in efficiency between AFC and NFC franchises.
- 1.3 H_0: There is no significant difference in total attendance between AFC and NFC franchises.
- 1.4 H_0: There is no significant difference in attendance percentage between AFC and NFC franchises.

The rest of this paper is as follows: chapter two describes the theoretical framework providing a theoretical background for the research question and the hypotheses. The third chapter entails the methods used in this study. In the fourth chapter the nature and the origin of the data is discussed including some summary statistics. In the fifth chapter the results are examined in order to answer the research question and the hypotheses. The final chapter consists of the conclusion, the limitations of this study and suggestions for further research.

2. Theoretical Framework

In this chapter I frame the previously stated research question and hypotheses by linking them to several theoretical aspects relating to economics and sports. First of all, there is the age-old tale of separation of ownership and control. The owner does not necessarily has its goals aligned with the manager, leading to possible shirking behaviour (Coase, 1937). Secondly, I discuss the role of sports teams in the public domain and the effect they have on society. Study has shown that people go to great lengths to publicly identify with winning sport teams, spending large amounts of money on merchandise and other items showing their support for the team (End, 2001). It seems plausible that due to the era of the internet this has only increased further with the use of social media. The third section addresses the economic structure of the NFL. Broadcasting rights are sold for vast amounts to the highest bidder and are therefore a major revenue stream for teams. The fourth and final section is reserved for reviewing efficiency measuring methods used in other literature.

2.1 The separation of ownership and control

2.1.1 The nature of the firm

In 1937, Ronald Coase wrote "The nature of the firm" in which he posed an explanation of why firms produce themselves or turn to the market and buy. The market is efficient and therefore produces at the lowest cost. Coase noted however, that using the market for any good comes along with extra costs, transaction costs. Examples of these transaction costs are information costs, bargaining costs and policy costs (Coase, 1937). First, one must assess the quality of the good before purchasing. This could be summarized in a quality report. These costs are an example of information costs. After the decision has been made to purchase the good, the negotiating begins. Prices and contracts are drawn and sent back and forth until an understanding between the two parties has been reached. These costs can be seen as bargaining costs. Finally, policies must be made on how to handle these products, trade agreements or even company secrets resulting in policy costs. No owner of any company can do everything by themselves, meaning they have to hire capable staff to do this for them in return for a salary.

2.1.2 Sports franchises as a firm

Now a new problem arises. The owner may have different views or incentives as opposed to the employee, leading to agency problems. The employee might exhibit shirking behaviour. He does not have a genuine incentive to work as hard as he could in the best interest of the owner.

In a simpler world, shirking would not exist. The owner could and would constantly check the employee. However, as Coase (1937) explains, constantly checking employees is costly in the real world. This leads to agency problems throughout virtually all sectors of the economy, both public and private. No exception is made for sports teams. In fact, sports teams can be seen as though they are producing firms. The owner either buys, trades or drafts the necessary raw materials (e.g. players) in order to produce a certain good (e.g. wins or entertainment). Wins and entertainment are most likely highly correlated, at least for the fans rooting for their home team in the stadium. Close games might be of higher entertainment value than blow outs. However, this all becomes irrelevant if the home team loses as entertainment than transforms into disappointment. The owner sells these goods to the general public in order to make a profit, just like any other business.

Still, the objectives of an owner or general manager (GM) or head coach may also not be perfectly aligned. Think of a GM that wants to keep making a profit on the short rush and the head coach that wants to invest money in the form of new players in order to perform better on the long run. This problem could lead to a less efficient head coach, which in turn could lead to less games won.

There is an obvious relation between winning and profit (Scully, 1989). Wins increase exposure, media coverage and air time, not to mention win premiums offered by sponsors or leagues. Therefore, the last thing the owner needs is an inefficient team. Or to paraphrase the late great Dutch soccer player Johan Cruijff; “A bag of money has never scored a goal.”.

2.1.3 Publicly owned clubs

Combining the topics of the separation of ownership and control and sports, Robert McMaster wrote a paper in 1997, in which he posed supporters to be of influence on the output of soccer teams. If that indeed is the case, they could be seen as an input variable in the production function of the team. Theory suggests in such a case to make them part of the club by issuing them property rights (e.g. shares in the club) (McMaster, 1997). This is to be done, in order to circumvent the agency problem.

However, the author acknowledges that this is by no means certain. Individuals might not exercise their stockholder rights because they feel too much affection for the club instead of seeing it as a business transaction. Some European soccer clubs are publicly owned, such as Ajax in the Netherlands, Manchester United in the United Kingdom and Juventus in Italy.

In the NFL, the only franchise not privately owned is the Green Bay Packers. All shares are owned by members of the local community for which they receive no dividend. Interestingly enough the Green

Bay Packers are to this day the only non-profit franchise in the NFL and holder of the most NFL championships.

2.2 Sports in the public domain

The NFL is largely tax exempted thanks to the Sports Broadcasting Act of 1961 (SBA). According to Congress, the collective bargaining of pooled rights fees is justified because of the interdependence of sports teams in a league. The league solely exists by virtue of teams willing to compete in a league. Furthermore, Congress argues that social welfare benefits from competitive balance (Vrooman, 2012). But what exactly are those social welfare benefits?

2.2.1 Winning and losing

Stadtmann (2006) studied the effects winning and losing had on the stock price of Borussia Dortmund, a German soccer club. He finds that both corporate governance as well as sports related variables are important drivers of the stock price. This is not that much of a shock, as the results on the pitch sometimes have a direct effect on the clubs financial results. For instance, in the UEFA Champions League for soccer in the 2016 – 2017 season, a win in the group stage generated €1.5 million in revenue. The total amount of prize money to be divided is around €1.3 billion (UEFA, 2016). One can see that a win in such a case could have a direct impact on the stock price. However, what is actually more interesting is the following.

A similar study done by Brown & Hartzell (2001) finds that investors asymmetrically respond to wins and losses. Match performance significantly affects share prices, trading volume and volatility. Playoff games seem to have an even larger effect on returns than regular season games. Even though games are mostly played when the market is closed, information is not incorporated straight away. This is not rational as the information is publicly available, straight away and most of the times even broadcasted live. Some capitalize on these results, others do not. One can argue that it is likely that individuals who bought the stocks out of love for their (local) team are the ones who do not capitalize on the results. If so, is that truly socially beneficial? Investing is a zero sum game, where one sells and another buys. One makes a profit and the other loses. Large investors only interested in the stocks for profit rather than the love for the franchise are probably making money of the backs of fans, shifting capital from the individual to the institutions. This means that the individual is worse off than before, which is not socially beneficial.

2.2.2 Identification

Another psychological effect was documented by End, Dietz-Uhler, Harrick, & Jacquemotte in 2002. They asked college students to list sports teams with which they most identified in order of personal preference. The authors found a positive relationship between their favourite team and the success of that team (End, Dietz-Uhler, Harrick, & Jacquemotte, 2002). One of the consequences of this behaviour is that people who identify themselves more with sports teams, experience the glorious feeling of victory and agonizing pain of defeat with regards to their favourite team more strongly.

This effect is not limited to mood alone according to Hirt, Zillmann, Erickson, & Kennedy (1992). They find that sports fans' judgments, regarding their own personal capabilities, are affected by team performance. Lever already wrote an article in 1969 in which she tried to clarify the enormous role soccer plays in Brazil. She mentions that Brazilian workplace productivity was affected by soccer game results. When Corinthians from Sao Paolo would win, production would rise with 12.3 percent (1969). This indicates that people would indeed be psychologically affected by the results of their favourite team.

There are studies that provide similar evidence for the United States as well. In their research note from 2002, Coates & Humphreys provide evidence that winning the Super Bowl would increase real per capita personal income (RPCPI) in that city with roughly $140. This would imply that when e.g. the New England Patriots would win the Super Bowl, RPCPI in Boston would rise with $140. One of their explanations is that increased productivity could be the cause of the increase in personal income. Another explanation is that it could simply be an anomaly in the chosen model (Coates & Humphreys, 2002). However, Coates and Humphreys are not the only one to find such results.

Davis & End (2010) take it even one step further. They show that not just a Super Bowl victory increases RPCPI in the home town. Even the winning percentage of the local franchise has a significant positive effect on RPCPI in its city. Even after controlling for variables such as hosting or winning the Super Bowl, population growth or other sports franchises winning percentages, the effect remains (Davis & End, 2010). This would mean that franchises with higher winning percentages would be more beneficial to their local community. Even more so, franchises who do not produce technically efficient, are in that case less beneficial than they could be. Another interesting result is that the marginal increase in per RPCPI becomes less with every additional win during the season. This would promote a league structure in which equality is key, as the first additional win reaps the highest economical gains for the host towns.

2.2.3 Criticism

Still, not all economists are as convinced of the significance of the contributions to social welfare, if there are any. The evidence presented by Coates & Humphreys (2002) was questioned by Matheson in his article in 2005. He reported an increase in personal income of less than half found by Coates & Humphreys adding that these findings were not statistically significant at the 5% level (Matheson, 2005).

In their 2003 working paper, Baade & Matheson refute the argument for increased productivity being the cause of the increased personal income. They bring forth the argument that championships are often celebrated parades in their home town, often leading to the temporarily closings of business. Furthermore, tragically enough championships have seem to be seen by some as an opportune moment for rioting (Baade & Matheson, 2003). Other studies on the effects on football related events on local personal income (Baade & Matheson, 2000) (Coates & Humphreys, 2003), have failed to find positive effects.

2.3 Economic structure

The league had a rocky start in the beginning of the years, when numerous teams joined and exited due to various reasons. Later came the threat of the AFL which gained ground quickly. Thanks to the merger in 1970, the NFL remains as the only professional football league in the United States. Since it can be seen as a producing firm, its economic structure and market needs to be clarified as well. There are generally four market forms, namely; monopoly, oligopoly, monopolistic competition and perfect competition. The NFL is arguably a monopoly (Vrooman, 2012), as it meets all of the following key features:

- *A sole supplier.* The NFL is the only professional football league in the United States.
- *Price setter.* It can pretty much dictate broadcasting rights fees negotiations.
- *High entry barriers.* Forming another football league comes with enormous extra costs.
- *Homogenous product.* Even though every game is different, in the eyes of the consumer the NFL always delivers the same good.

The NFL is the sole supplier of its product, football. As a monopolist, the NFL has enormous bargaining power since the consumer has nowhere else to go when it comes to professional football. When it comes to sports in a broader sense, the NFL might have some form of competition from the other Major Leagues, baseball, hockey and basketball. Still, the NFL regular season normally starts around September and ends in December. MLB regular season usually runs from April until October, whereas the NHL regular season runs from October until April. The NBA regular season roughly starts at the end of October and ends midway April. This way, all four Major Leagues are never simultaneously at play in regular season. It should also be noted that the NFL season has far less games than the other leagues. There are only 16 games to be played during the NFL regular season whereas there are 82 in the NBA and NHL and even a staggering 162 in the MLB.

The competition of other sports teams within the same metropolitan statistical area (MSA) even becomes more questionable in the light of the paper by Spenner, Fenn, & Crooker (2010). They find evidence that NFL attendants display characteristics of rational addiction. This way, other sports teams might be considered complementary as opposed to substitutional goods as it satisfies the need for sports. Even among the franchises themselves there is little competition. Apart from the New York[3] and San Francisco[4] MSA, all other franchises operate relatively in their own market.

2.3.1 The NFL as a monopoly

Because of the popularity of the sport and the bargaining power of the NFL as a result of the monopoly, the broadcasting networks find themselves with the back against the wall during negotiations. This is largely due to the SBA of 1961, granting them antitrust immunity to negotiate television rights fees collectively as opposed to individually on a franchise level. Due to the fact that the NFL considers itself a non-profit trade association made up of and financed by its members, the league was always considered tax exempt (Weinreich, 2012). In 2015, following public criticism, the NFL voluntarily gave up its tax exempt status (Erb, 2015).

The SBA paved the way for the astronomical annual 3.7 billion dollar national television rights contract that ran until 2011 (Vrooman, 2009). Another example is that of team owners threatening to move or actually moving out of town in order to gain more subsidies or access to a bigger fan base. This explains how the industry has been able to be so enormous. The NFL has been extremely able to capitalize on its monopoly position.

Usually, monopolies are deemed to be undesirable. As the monopolist is the only supplier, consumers cannot switch to the competition. This gives the monopolist no real incentive to act in the consumers best interest or evolve in order to gain a competitive advantage. Under perfect competition, supply and demand meet at the lowest social cost, or at the most efficient point. In a monopoly, prices rise above and output falls below this optimal level (Posner, 1975). In the case for

[3] New York Giants and New York Mets respectively.
[4] San Francisco Giants and Oakland Raiders respectively.

the NFL, this would imply that NFL franchise owners are profit-maximizing. Still, is it possible that team owners are not profit maximizers, but win maximizers?

2.3.2 The invariance proposition

In 1956, Simon Rottenberg wrote an article in which he posed the invariance proposition. Although this study was done on the labour market for baseball players, the same should apply for the NFL given their similarity. He showed that, free agency for players would yield the same talent distribution as the reserve system that tied players to one particular club for life. The difference however, was that free agency would weaken monopsonistic[5] exploitation of players allowing for them to approach their marginal revenue product (Rottenberg, 1956). In other words, allowing players to switch freely from team to team does not affect the distribution of talent amongst teams. It does however, allow for the players to gain better terms of employment, resulting in a positive social outcome. According to the invariance proposition the competitive balance the NFL strives for, is not impeded.

2.3.3 The sportsmen effect

The article by Rottenberg (1956) is said to have been the spark for a lot of further research in the field of the economics of sports. Szymanski & Késenne (2004) showed that the invariance proposition does not hold in the open European market of soccer and that gate revenue sharing actually leads to less competitive balance. Vrooman (2009) argues none matters, as for both open and closed markets the assumption of profit-maximizing owners is implied. He states it is more likely for sports-owners to be win maximizers (*sportsmen)*, prevailing wins over profit, as already argued by Sloane in 1971. Even though Sloane's analysis focussed on British soccer, he states most of the features apply equally to other leagues (Sloane, 1971). Vrooman further states that, if owners are *sportsmen*, revenue sharing increases competitive balance. If the owners do not mind spending heaps of cash on players, these players will gladly increase their piece of the pie. The fact that they have roughly 60% of the revenue shares indicates that they do. Since the monopsony power of the league has dwindled, the NFL has turned to their monopoly power regarding the broadcasting rights to increase their revenue (Vrooman, 2009). And with great success. NFL national TV rights in 2013 have grown 80-fold since 1970 and at a compound 12% annual rate since 1947 making up roughly 50% of total revenue for the NFL (Vrooman, 2012). These are staggering numbers, as of yet not matched by any other of the big leagues. The NFL is more than capable of exercising its negotiation power.

[5] A multitude of suppliers, but only one buyer.

However, it does raise the question whether this all puts a strain on the *sportsmen effect* as not only the shared portion of revenue has grown enormously but also the unshared portion of revenue. As local venue revenue is unshared with the rest of the league, 27 out of the 32 teams have asked for and gotten, new or renovated stadiums over the 1995 – 2012 time period. These new stadiums have shifted their focus to the more lucrative, unshared revenue generating, luxury seats. This creates a fracture in the uniformity, as the franchises in the larger markets generate more unshared revenue than those in smaller, tougher markets. The new stadiums could provide a particular set of franchises with a competitive advantage over those with older stadiums. This is something the NFL has sought to avoid. Furthermore, if owners are not the *sportsmen* they are deemed to be, it might give them an incentive wanting to relocate their team to a larger marketable area.

2.4 Efficiency in sports

A topic not yet touched upon, is that of efficiency. As stated previously, sports teams can be seen as individual firms producing a good. With the right combination of inputs, such as coaching staff, supporting staff and players, they can produce wins. These wins translate into a greater fan base, a possible higher attendance rate and a higher brand awareness. This mix should subsequently lead to higher revenue streams. However, when discussing efficiency, it needs to be clear what definition of efficiency is used. Throughout this paper, efficiency means playing as close to the expected frontier as possible. This means producing as much output as possible (wins), as is to be expected. Given their unique team characteristics, franchises should be able to produce a certain number of wins. If they fail to achieve that number, they are considered to be, at least to some extent, inefficient. There are several ways one can estimate efficiency and two of the most commonly used methods are discussed in the following paragraphs.

2.4.1 Stochastic production frontier

One of the most widely used ways to measure efficiency is to use a stochastic production frontier (SPF) often in the shape of the Cobb-Douglas function, made famous by Charles Cobb and Paul Douglas (1928). The SPF finds its starting point in the works by Aigner, Lovell, & Schmidt (1977)and Meeusen and Van den Broeck (1977). One of the unique qualities is that deviations from the maximum attainable output are not only ascribed to inefficiency, but the method also accounts for random factors such as luck (Greene, 2008).

Gerald Scully (1974) was one of the first to use this method when analysing pay and performance in the MLB. With the use of the Cobb-Douglas form of the SPF he was able to determine the marginal revenue product of players allowing this to be compared to their salary. Another notable work of that time is the work of Zak, Huang, & Siegfried (1979). In their paper, they used the Cobb-Douglas SPF to analyse various inputs used in the NBA, allowing them to compare potential output and average team efficiency between teams. Furthermore, the authors used this method to analyse the "home-court advantage", showing home-teams are not favoured by the referees but simply excel at home.

Since then, the SPF has been used in many studies covering the MLB, NFL and NBA. Hofler & Payne (1996) for example, used this method in their paper discussing how close NFL teams were playing to their offensive potential. They use the method again one year later in their paper when measuring efficiency in the NBA (Hofler & Payne, 1997). In both these papers, Hofler & Payne focus solely on the effect of players' input variables on wins. Brian Goff (2013) however, extends the use of a SPF by using it to explain the contributions of different managerial levels in both the MLB and NFL on franchise wins.

2.4.2 Data envelopment analysis

Another method employed is that of the data envelopment analysis (DEA). This alternative to the SPF was developed by Charnes, Cooper, & Rhodes (1978) in their paper on measuring the efficiency of decision making units. This influential work has since then been used in various fields of research and so too in the fields of sports research.

Hadley, Poitras, Ruggiero, & Knowles (2000) use the DEA in order to measure the performance of NFL teams and head coaches. They show the importance of having an efficient head coach for NFL franchises. The authors argue that efficient head coaches can account for three to four additional victories in a season. As the regular season in the NFL consists of only 16 games, they truly are a valuable asset for a franchise.

Dieter Haas (2003) measures the technical efficiency of Major League Soccer (MLS) franchises in the United States using the DEA and players' and head coaches' wages as input variables. He finds that efficiency scores were highly correlated with team performance in the MLS and that inefficiency is for the largest part caused by the suboptimal scale of production. Karl Einolf (2004) studies the MLB and NFL using the DEA to measure franchise payroll efficiency, showing that MLB franchises tend to be less efficient than their NFL colleagues.

It is clear that both the SPF and the DEA are useful and employed in a wide array of research. From operations research to sports research and from football to soccer, efficiency can be measured using these methods.

3. Methodology

As in most other sports, a team wins when it outscores its opponents. In order to measure the efficiency of an NFL franchise, the number of wins is regressed on a vector of team-specific production determining characteristics. With regards to the productive efficiency, a panel dataset comprises variables for all aspects of the game namely for offense, defence and special teams. Concerning the effect of efficient production on attendance, a second panel dataset is used consisting of some socioeconomic and productive variables such as real per capita personal income, real fan cost index prices and production efficiency.

3.1 Efficiency

Hofler & Payne (1996) studied the offensive efficiency of National Football League teams with a Cobb-Douglas production model using the stochastic production frontier (SPF) methodology. Though the SPF model is largely used in a cross-sectional data production context, the authors employ this model for their panel data in order to obtain more robust results for every franchise's inefficiency. Using several determinants for offensive production (e.g. average yards rushing, number of interceptions or average yards passing), they estimate the following general production function:

$$Y_{jt} = \beta X_{jt} + v_{jt} \tag{1}$$

Here Y is the actual production (e.g. scoring) of a given team j in a given time t. X_{jt} is a row vector of team-specific production determining variables of team j in a given year t. β is a column vector of regression coefficients. The error term is defined as v_{jt}. The production frontier is represented as follows:

$$Y_{jt} = \beta X_{jt} + v_{jt} + u_{jt} \tag{2}$$

All variables are defined as above and u_{jt} is introduced as the inefficiency term which are non-negative random variables unrelated to v_{jt}. There are several other key assumptions to be made when considering this stochastic production frontier model:

- No multicollinearity for v_{jt}.
- Independence of elements for v_{jt}.
- Homoscedasticity for v_{jt}.
- Approximately normal distribution with mean 0 for v_{jt}.

Another method used for measuring efficiency, is that of the data envelopment analysis (DEA). Dieter Haas (2003) used the DEA method to analyse the efficiency of the 12 MLS franchises using the year

2000 data. He notes that the DEA method has some favourable qualities over the SPF. For instance, when production processes involve multiple inputs and/or outputs, DEA provides a single measurement for efficiency and does not need to assign pre-specified weights to either the inputs or outputs. However, Haas (2003) does acknowledge the downside of the DEA method. Measurement problems can be caused by statistical noise. Unfortunately, this statistical noise cannot be separated from inefficiency, leading to biased results. Another problem is that DEA measures relative efficiency within a sample, not allowing for conclusions in an absolute sense and therefore not suited for this study.

In their article, Collier, Johnson, & Ruggiero (2011) propose a correction to the standard SPF model in order to correct for an endogeneity problem. Endogeneity would be a violation of the assumptions for the SPF model and should therefore be corrected for. Endogeneity would become a factor as the efficiency of one franchise, would be dependent on the inefficiency of another. Therefore, Collier et al. minimize the sum of absolute deviations, instead of minimizing the squared residuals as with the ordinary least squares (OLS) approach. In their eyes, this leads to a more unbiased estimator. Instead of using the OLS, DEA or SPF, they turn to the Least Absolute Deviations (LAD) method. In general, this LAD model will be explained as follows:

In general, the output sought to be produced by any franchise is wins (W). In order to do so, they use a vector $X \equiv (x_1,\ldots,x_m)$ of m inputs. This production function is formalized as:

$$W_{jt} = f(X_{mjt}) \tag{3}$$

Team j data are represented by W_j and $X_j = (x_{1j},\ldots,x_{mj})$ for $j = 1,\ldots,n$ at time t. However, inefficiency is now not accounted for. In order to allow for deviations from this frontier the following inefficiency term ε is introduced, leading to the following equation:

$$W_{jt} = f\left(X_{mjt}\right) + \varepsilon_{jt} \tag{4}$$

This is the standard production function model. Still, as mentioned before, this does not take into account the influence other franchises their efficiency or inefficiency has on a franchise its wins. The proposed alteration by Collier et al. (2011), minimizing the sum of absolute deviations, would then result in the following equation:

$$min \sum_{j_t} \left[y_{j_t} - f(X_{m_{jt}})\right] \tag{5}$$

Here, y is the observed number of wins for team j at time t. The production function is shown by the function of vector X with input variable m for team j at time t. Collier et al. use the 2009 NFL season data as input variables. They show that OLS and DEA give downward biased technical efficiency results. By using the LAD model, five franchises previously deemed to be inefficient are now scored efficient. Furthermore, shifts in rankings appear as well, showing scores are affecting franchises in various numbers.

It should be noted that this downward bias possibly is not always be that severe. Sometimes leagues do not have round schedules in which every franchise always plays every other franchise in that league. The NFL is such an example of the absence of a round schedule, since there are 16 games to be played during regular season with in total 32 teams in the league.

Following all of the above, this study turns to the SPF method, as is shown in Equation (1) and (2), to conduct its research. This leads to the following equation for the production frontier:

$$Y_{jt} = \beta_0 + \sum_{i=1}^{n} \beta_i X_{jt} + v_{jt} + u_{jt} \tag{6}$$

The dependant variable Y_{jt} is the actual number of wins for team j at time t. β_0 is the intercept and β_i (i = 1, …, n) is the corresponding coefficient for the control variable of vector X for team j at time t. v_{jt} are random variables and u_{jt} are non-negative random variables unrelated to v_{jt}, to account for team-specific inefficiencies. The key assumptions belonging to this approach are as stated earlier. The distribution of u_{jt} is assumed to be independent identical distributed as truncations at 0 of the N(μ,σ_u^2) distribution (Hofler & Payne, 1997). The winning percentage W/E(W) (actual wins/expected wins) is checked to see how efficient a franchise has produced in a given year. If this number is below 1 they have not been fully efficient. The SPF method ascribes deviations from the maximum attainable output not only to inefficiency, but also accounts for random factors such as luck (Greene, 2008). These efficiency scores are then used in the second part of this study.

In order to answer hypotheses 1.1. and 1.2. the newly acquired variables expected wins and efficiency are split into the American Football Conference (AFC) and the National Football Conference (NFC) for comparison. Normally, when comparing means of groups, one checks whether the variables are normally distributed. For example, this can be done via the Shapiro-Wilk test or the Jarque-Bera test. If the variables are normally distributed, an independent t-test can be used to measure any significant difference between the means of the two groups. Here however, the variables expected wins and efficiency are constructed already assuming a truncated normal distribution and therefore will violate the normality assumption. For this reason, the distributions are checked to see whether they follow the same shape. If this is the case, the Mann-Whitney U test is used to compare the medians of the variables in question. If the distributions differ, the Mann-Whitney U test is used to compare the mean ranks of the expected wins and efficiency.

Following hypotheses 1.1. and 1.2., the same methods are used to check hypotheses 1.3. and 1.4. with the exception that now total attendance and attendance percentage are checked. These two variables are the independent variables used in the second part of this study. After they are split into the AFC and NFC, they will be inspected for a normal distribution via the Jarque-Bera test. If they follow a normal distribution, the independent t-test will compare the means of the two groups for any significant deviation. If they are not normally distributed, the shapes of the distributions are examined. Following the same shape will lead to the Mann-Whitney U test comparing medians, different shapes will result in the Mann-Whitney U test comparing mean ranks.

3.2 Attendance

For the second part of the research question, the effect of efficiency on attendance is studied. There is one major issue when it comes to studying revenue of the NFL or its franchises. This is the lack of available data for researchers. As all franchises are privately owned, there is no need for them to show their financial records to the general public. What is publicly available though, are numbers for attendance. These attendance numbers are used as a proxy for revenue generation.

Since the vast majority of revenue is evenly shared, the franchises can make a difference with the non-pooled revenue generated by stadium events. For example, club and luxury-seat revenues as well as parking and concession stand revenues are unshared revenues. Local advertisement agreements are also unshared revenue and will most likely generate more revenue when targeted to a larger audience. This also explains the luxury-seat stadium building surge that followed the 1993 Collective Bargaining Agreement. Since then, team-specific revenue has doubled from 10% to 20% of total revenue (Vrooman, 2012). The Fan Cost Index[6] (FCI) calculated by *Team Marketing Report* estimates for the NFL average, that a small group of four adult fans spend roughly $500,- in total per game in 2016 (Team Marketing Report, 2016). This indicates that high attendance records can be quite interesting from a financial perspective.

There have been many studies on spectator attendance at sporting events. The list includes studies on determining various influential factors of attendance (Welki & Zlatoper, 1999) to addictive behaviour of attendants (Spenner, Fenn, & Crooker, 2010) and everything in between.

For instance, Spenner, Fenn, & Crooker (2010) used a Two-Stage Least Squares model in order to answer their hypothesis whether attendees of sports events exhibit characteristics of rational addiction in their consumption behaviour. Consumption goods such as cigarettes and alcohol have

[6] The Fan Cost Index comprises of four adult average-price tickets, two small beers, four small soft drinks, four regular-size hot dogs, the parking of one car and two least expensive adult-size adjustable caps.

been widely documented as habit forming goods. However, Spenner et al. show that these characteristics in consumption behaviour are also exhibited in attending NFL events.

Spenner et al. (2010) argue that franchise owners seek profit maximization and form a profit equation with ticket prices as a function of expected attendance. Furthermore, the authors forecast future attendance in order to use previous and future attendance to explain current attendance. However, this violates the OLS condition for exogeneity as they are each dependant on current attendance. In order to circumvent this problem, the authors used a Two-Stage Least Squares model with instrumental variables approach, using the forecasted future attendance numbers as the instrumental variable.

In this study however, the focus lies more on production efficiency by the estimation of a production function and its subsequent effect on attendance than on the estimation of a demand curve for attendance itself. The topic at hand, measuring the effect efficient production has on attendance, lies more along the lines of the paper by Welki & Zlatoper (1999). Building upon the work of Schofield (1983), Welki & Zlatoper (1999) estimate attendance as a function of variables falling in four major categories. Firstly, there are economic variables such as income and ticket price. Secondly, demographic variables such as population or the influence of other sports teams. Thirdly, game quality variables such as winning percentage and playoff appearance of the previous year. Lastly, the variables reflecting preferences not yet captured by the former.

Much alike Welki & Zlatoper (1999), this paper estimates attendance as a function of variables falling in the same type of categories as described by the survey of Schofield (1983). For this study, this leads to the following generalized equation:

$$Y_{jt} = \beta_0 + \sum_{i=1}^{n} \beta_i X_{jt} + \varepsilon_{jt} \tag{7}$$

The dependant variable Y_{jt} is the total attendance per year for team j at time t. β_0 is the intercept and β_i (i = 1, …, n) is the corresponding coefficient for the control variable of vector X for team j at time t. Apart from total attendance, attendance has also been converted into a percentage of total stadium capacity in order to even out possible differences that might occur when comparing bigger and smaller stadiums (Welki & Zlatoper, 1999). Total attendance is restricted on the right-hand side by the maximum stadium capacity. For attendance percentage however, the dependant variable lies between 0 and 1 and is also limited on the right-hand side. Since the dependant variables are limited, a Tobit estimator is used. This model has proven useful when the independent variable is censored on one, or both sides. Since maximum capacity constrains the number of attendants, both in absolute and relative values, this indeed is the case. Other studies relating to attendance in sports have not yet examined the effect of efficiency of franchises. The results from Equation (6) are therefore implemented in Equation (7) in order to see what, if any, the effect of efficiency on attendance is. In order to test for robustness of the effect of efficiency, the dependant variable total attendance is exchanged for attendance percentage.

The analysis shows if there is an effect of producing efficiently on attendance. Attendance in this sense is used as a proxy for revenue generation. People coming to the stadium spend money. Cars are parked, beers and sodas are consumed, hotdogs are eaten and programs are bought. All of which are examples of unshared revenue. If efficiency, or the lagged variable of efficiency, has a significant positive effect on attendance, franchises can attract more spectators by improving their efficiency. This would mean that not just a high winning percentage is of importance to attract fans, but efficiency is as well. This would bode especially well for the lesser teams, since they do not have high winning percentages, but they can try to make sure to improve their efficiency.

4. Data

Now that the models for testing the hypotheses are known, the data used in these models is discussed more in detail. As impossible as it is to find any official financial records for the NFL or any of the franchises, the easier it is to find data regarding the players' and teams' statistics. Firstly, the data used for the production function is discussed. Following, the data regarding the model for attendance is explained.

4.1 Production function

The data comprise the years 2001 – 2014 and are predominantly gathered from the official NFL website[7] and to a lesser extent from a football statistics website called *Pro Football Reference*[8]. Only regular season data for all 32 franchises are used, excluding the playoffs, as not all teams make it to these playoffs. Furthermore, the playoffs are different in structure and nature. The playoffs consist of a tournament structure, unlike the regular season. This means one lost game is enough to send a team home, unlike the regular season, where different strategies might be at play in order to make it to the playoffs. Data for the Houston Texans only covers the years 2002-2014, since the franchise did not yet exist in 2001. This makes a total of 447 observations. The vector X containing all 29 variables and their hypothesized sign is listed in Table 1.

All variables are paired in two groups, offense and opponent. The offensive variables obviously capture the effect the offensive unit of the team has, whereas the opponent variables capture the defensive impact regarding the offensive variables for the opponent. The lower the scores for the opponent, the better of a job the defence is doing. Furthermore, there are variables capturing the effect the so-called special teams have, as well as variables pertaining exclusively to the defensive unit.

The hypothesized sign for all offensive variables are positive, with the exception for interceptions thrown on offense. These are hypothesized as having a negative impact on wins. The exact opposite holds for the opponent variables, which are all hypothesized to have a negative impact on the number of games won with the exception of interceptions thrown by the opponent. The conversion variables are percentages, the yard variables are in average yards whereas the remaining variables are integers.

[7] www.nfl.com
[8] www.pro-football-reference.com

Table 1: Variable explanation and expected sign

Variable	Explanation and expected sign
W	Number of expected wins.
Offensive 1st downs by penalty	Number of offensive 1st downs by penalties. (+)
Opponent 1st downs by penalty	Number of opponent 1st downs by penalties. (-)
Offensive 3rd down conversion	Percentage of offensive 3rd down conversions. (+)
Opponent 3rd down conversion	Percentage of opponent 3rd down conversions. (-)
Offensive 4th down conversion	Percentage of offensive 4th down conversions. (+)
Opponent 4th down conversion	Percentage of opponent 4th down conversions. (-)
Offensive avg. yards per rush	Average offensive yards per rush. (+)
Opponent avg. yards per rush	Average opponent yards per rush. (-)
Offensive interception conversion	Percentage of offensive interceptions thrown. (-)
Opponent interception conversion	Percentage of opponent interceptions thrown. (+)
Offensive avg. yards per pass	Average offensive yards per pass. (+)
Opponent avg. yards per pass	Average opponent yards per pass. (-)
Special teams field goal conversion	Percentage of special teams field goals made. (+)
Opponent field goal conversion	Percentage of opponent field goals made. (-)
Special teams avg. yards per punt[9]	Average special teams yards per punt. (+)
Opponent avg. yards per punt	Average opponent yards per punt. (-)
Special teams avg. punt return yards	Average special teams return yards per punt. (+)
Opponent avg. punt return yards	Average opponent return yards per punt. (-)
Special teams avg. kick return yards	Average special teams kick return yards per kick. (+)
Opponent avg. kick return yards	Average opponent kick return yards per kick. (-)
Defensive sacks	Number of defensive sacks. (+)
Opponent sacks	Number of opponent sacks. (-)
Defensive forced fumbles[10]	Number of defensive forced fumbles. (+)
Opponent forced fumbles	Number of opponent forced fumbles. (-)
Defensive avg. yards per interception	Average defensive yards per interception. (+)
Opponent avg. yards per interception	Average opponent yards per interception. (-)
Total fumbles recovered	Number of total fumbles recovered. (+)
Opponent total fumbles recovered	Number of total opponent fumbles recovered. (-)

When looking at the descriptive statistics for the production function variables, there are some notable observations. The mean of the observed wins for the entire NFL is 7.98 wins. This is to be expected since for the competition as a whole one franchise's win implies another franchise's loss. The same goes for all variables, all are very closely grouped as one's offence, is another's defence. This is why it is more interesting to take a look at the descriptive statistics at a conference level.

[9] Kicking the football from the hands to the other team.
[10] When a player who has control and possession of the football, loses the ball before being downed.

While some games are played intra-conference, others are played inter-conference, creating opportunities for testing the hypotheses.

For a first glance look, it might be better to split the data into the two conferences of the American Football Conference (AFC) and the National Football Conference (NFC). Indeed, changes do occur though in an absolute sense the differences between the two conferences are relatively small. For instance, the mean of the observed wins for the AFC is now 8.11 versus 7.85 for the NFC. Some other notable differences between the AFC and NFC are the mean of sacks made by the opponent (35.12 and 37.48) and forced fumbles by the defence (18.45 and 19.86). On average, the AFC teams concede 2.36 sacks less than their NFC colleagues, implying a better protection for the quarterback. The AFC force 1.41 less fumbles, implying a slightly lower quality in hitting the opponent. The amount of sacks made by the opponent is just one of the measures for quality of the offense as it measures the protection of the quarterback. The forced fumbles by the defence is one of the many quality measures for the defence of a franchise as it measures how often a defence is able to stop the opponent and get the offense back on the field. The full list of descriptive statistics, sorted by conference, is found in Table 2.

Table 2: Descriptive statistics for the AFC (N=223) and NFC (N=224)

	AFC				NFC			
Variable	**Min.**	**Max.**	**Mean**	**Std. dev.**	**Min.**	**Max.**	**Mean**	**Std. dev.**
W	1	16	8.11	3.16	0	15	7.85	3.02
Offensive 1st downs by penalty	9	47	25.23	7.25	12	44	25.85	6.58
Opponent 1st downs by penalty	11	58	25.46	7.56	7	47	25.66	6.96
Offensive 3rd down conversion	0.26	0.56	0.39	0.05	0.24	0.57	0.38	0.05
Opponent 3rd down conversion	0.28	0.49	0.39	0.04	0.29	0.47	0.38	0.04
Offensive 4th down conversion	0.00	0.89	0.49	0.15	0.00	0.88	0.47	0.14
Opponent 4th down conversion	0.00	0.85	0.48	0.15	0.00	0.86	0.49	0.14
Offensive avg. yards per rush	3.10	5.20	4.11	0.42	3.10	5.50	4.19	0.46
Opponent avg. yards per rush	2.80	5.30	4.13	0.43	2.80	5.30	4.17	0.42
Offensive interception conversion	0.01	0.05	0.03	0.01	0.01	0.06	0.03	0.01
Opponent interception conversion	0.01	0.06	0.03	0.01	0.01	0.06	0.03	0.01
Offensive avg. yards per pass	5.10	9.00	6.94	0.71	5.10	9.30	6.95	0.78
Opponent avg. yards per pass	5.40	8.50	6.90	0.57	5.50	8.80	7.00	0.60
Special teams field goal conversion	0.61	1	0.82	0.07	0.60	0.96	0.81	0.08
Opponent field goal conversion	0.45	1	0.82	0.08	0.61	1	0.82	0.08
Special teams avg. yards per punt	32.9	50.80	43.25	2.73	37.50	50.30	43.14	2.46
Opponent avg. yards per punt	38.2	50.30	43.30	2.14	35.60	48.60	43.25	2.02
Special teams avg. punt return yards	3.40	19.50	9.33	2.51	4.20	17.10	9.13	2.35
Opponent avg. punt return yards	4.20	18.90	9.23	2.45	2.50	16.80	9.14	2.51
Special teams avg. kick return yards	17.00	29.90	22.79	2.12	17.70	27.30	22.40	1.90
Opponent avg. kick return yards	17.80	32.50	22.77	2.23	17.50	32.40	22.54	2.20
Defensive sacks	10	61	35.98	8.29	18	60	36.65	7.69
Opponent sacks	12	76	35.12	11.31	11	66	37.48	10.58
Defensive forced fumbles	5	39	18.45	6.78	8	45	19.86	6.91
Opponent forced fumbles	5	42	18.65	6.69	5	41	19.63	7.15
Defensive avg. yards per interception	3.50	33.30	13.84	4.50	3.00	32.10	14.94	5.37
Opponent avg. yards per interception	2.40	30.20	14.57	4.89	2.30	34.30	14.50	4.93
Total fumbles recovered	10	33	21.12	5.28	8	37	22.45	5.59
Opponent total fumbles recovered	1	26	11.50	4.24	4	30	12.37	4.19

4.2 Attendance

The second dataset comprises statistics covering the years 2008 – 2014 all of the 32 franchises. This leads to 224 observations. The attendance data as well as the number of Pro Bowl players, playoffs and Super Bowl victories are obtained from the *Pro Football Reference* website as mentioned before. The average ticket prices and Fan Cost Index (FCI) have been gathered from the websites of *Statista*[11], *Team Marketing Report*[12] and *Sports Business Daily*[13]. Input for other professional sports teams of the "big six"[14] in the area are collected from various city websites. Information with regards to the stadiums, such as expansions, maximum capacity and locations are obtained from the website of *Stadiums of Pro Football*[15]. The economic data relating to real per capita personal income are gathered from the *Bureau of Economic Analysis*[16] with inflation data coming from the *Bureau of Labor Statistics*[17]. These inflation numbers are used to convert all monetary input into 2009 dollars, since the real per capita personal income were already in 2009 dollars. Furthermore, there have been some own calculations, with the help of Equations (1) and (2), for the variables expected wins and efficiency. The vector X containing all variables and their hypothesized sign is listed in Table 3.

Table 3: Variable explanation and expected sign

Variable	Explanation and expected sign
Att. $\%_{tj}$	The total attendance as a percentage of stadium capacity for team j at time t.
Att. $total_{tj}$	Total attendance for team j at time t.
Efficiency	Estimated variable for team *j* at time *t*. (+)
$Efficiency_{t-1}$	Estimated variable for team *j* at time *t-1*. (+)
Playoff	Dummy variable for team *j* at time *t* equals 1 for franchises that reached the playoffs, equals 0 if not. (+)
$Playoff_{t-1}$	Dummy variable for team *j* at time *t-1* equals 1 for franchises that reached the playoffs, equals 0 if not. (+)
Super Bowl	Dummy variable for team *j* at time *t* equals 1 for franchises that have won the Super Bowl, equals 0 if not. (+)
Super $Bowl_{t-1}$	Dummy variable for team *j* at time *t-1* equals 1 for franchises that have won the Super Bowl, equals 0 if not. (+)
Pro Bowl	Number of Pro Bowl players for team *j* at time *t*. (+)
Pro $Bowl_{t-1}$	Number of Pro Bowl players for team *j* at time *t-1*. (+)
Big 6	Other professional sports teams from the "big six" for MSA i at time *t*. (-)
RPCPI	Real per capita personal income for MSA i at time *t* (2009 dollars). (+)
FCI	Real "Fan Cost Index" team *j* at time *t* (2009 dollars). (-)
ε	The error term for team *j* at time *t*.

[11] https://www.statista.com/
[12] https://www.teammarketing.com
[13] http://www.sportsbusinessdaily.com/
[14] The big six consists of the NFL, MLB, NBA, NHL, MLS and CFL
[15] http://www.stadiumsofprofootball.com/
[16] http://www.bea.gov
[17] http://www.bls.gov

Again, the dataset is split into the two conferences in order to be able to make a proper comparison. What strikes most at first glance, is that again the absolute differences between the two conferences are not that big. The mean of total yearly attendance is roughly 11,000 attendees higher in the NFC than in the AFC. The same holds for the percentage of which stadiums are filled. The mean of the attendance percentage is roughly 1 percentage point higher in the NFC than in its AFC counterpart.

The expected wins variable, calculated using the previous dataset, suggests ever so slightly more wins are expected in the NFC, as shown by the means of 9.07 for the NFC over 9.04 for the AFC. It is interesting to see that, though more wins are expected in the NFC, the AFC seems to be more efficient by 2 percentage points, resulting in an 87% efficiency score for the AFC versus the 85% efficiency for the NFC.

Another set of variables, the economic variables, are also of some interest. The *Fan Cost Index* shows that a game day costs more for an NFC attendee than for an AFC attendee. On average, attending a game (incl. tickets) for a family of four costs $406.07 in the AFC opposed to $420.39 in the NFC. Furthermore, it seems that the AFC franchises are located in slightly higher income areas, as the mean for real per capita personal income is $44,935 for the AFC against $43,539 for the NFC. The full list of descriptive statistics for all variables is listed in Table 4.

Table 4: Descriptive statistics AFC (N=112) and NFC (N=112)

	AFC				**NFC**			
Variable	**Min.**	**Max.**	**Mean**	**Std. dev.**	**Min.**	**Max.**	**Mean**	**Std. dev.**
Attendance total	354,276	632,704	533,688	56,994	394,513	720,558	544,227	74,568
Attendance percentage	0.70	1	0.94	0.06	0,75	1	0.95	0.05
Expected wins	3.23	14.87	9.04	2.74	1.37	14.90	9.11	2.74
Efficiency	0.34	1.42	0.87	0.19	0	1.31	0.85	0.19
Efficiency$_{t-1}$	0.23	1.42	0.87	0.20	0	1.31	0.85	0.19
Playoffs	0	1	0.375	0.49	0	1	0.38	0.49
Playoffs$_{t-1}$	0	1	0.375	0.49	0	1	0.38	0.49
Won Super Bowl	0	1	0.03	0.16	0	1	0.04	0.19
Won Super Bowl$_{t-1}$	0	1	0.02	0.13	0	1	0.04	0.21
Number of Pro Bowl players	0	11	3.56	2.34	0	10	3.57	2.56
Number of Pro Bowl players$_{t-1}$	0	10	3.54	2.37	0	13	3.49	2.71
Big 6 sports teams	1	10	3.56	2.25	1	10	4.21	2.14
Real per capita personal income (‘09)	37,232	54,893	44,935	3,708	35,082	54,893	43,539	4,379
Real Fan Cost Index (’09)	297.90	600.13	406.07	74.65	325.58	607.85	420.39	70.71

5. Results

In this chapter, the results of the study are discussed. The chapter starts with testing the assumptions for the production function, as previously discussed in chapter three. Only if the assumptions are not violated, will the results be valid. Once the assumptions are checked, the production function is estimated using maximum likelihood estimates from the stochastic production frontier model. This way, estimates are made for the number of expected wins for each franchise in a given year. The number of observed wins are then converted to a percentage of expected wins, in order to measure efficiency.

Once the expected number of wins and efficiency scores are estimated, their respective hypotheses are tested. First, the hypothesis that there is no difference in the expected number of wins between the AFC and the NFC is tested. Secondly, the hypothesis that there is no difference in efficiency between the AFC and the NFC is tested. These are an indication of whether the NFL is as egalitarian as proclaimed. Another such indication is that of attendance. If there are significantly more attendees in one conference than the other, this might indicate a discrepancy. One league is then able to generate more revenue than the other league, enabling it to attract better players. Therefore, the third and fourth hypotheses are tested. The third hypothesis is that there is no difference in total attendance between the AFC and the NFC. The fourth hypothesis is that there is no difference in attendance percentage between the AFC and the NFC.

Finally, the efficiency scores are regressed using a Tobit regression to see whether they have an effect on attendance. The assumptions are mostly similar to the assumptions for an OLS model and are discussed first, namely that of normality and equal variance of the errors. Following these assumptions, the results of the Tobit regression are discussed. Next to the efficiency variable at time t, a second efficiency variable at time t-1 is implemented to capture a possible lagged effect. In order to test for robustness of the results, both total attendance and attendance percentage are used as dependent variable. If a significant positive relation is found, it means franchises can improve their revenue by producing more efficiently. When a significantly positive effect is found for both total attendance and attendance percentage, this increases the robustness of the efficiency variables.

5.1 Assumptions

First, the assumption of no multicollinearity is tested. One way to check for this is via variance inflation factors (VIF). According to O'Brien (2007), a VIF of 10 is generally a sign of severe multicollinearity. Some maintain a lower threshold of 4. All VIF for all variables are displayed in Table

5. As can be seen, all VIF are well below 10 and even below the more stringent threshold of 4. The only variable that comes close to the threshold of 4 is that of the defensive forced fumbles, with a VIF of 3.313. This leads to believe that the data contain no indications of multicollinearity.

Table 5: Variance inflation factors

Variable	VIF	Variable	VIF
Offensive 1st downs by penalty	1.165	Special teams average yards per punt	1.681
Opponent 1st downs by penalty	1.171	Opponent average yards per punt	1.717
Offensive 3rd down conversion	2.072	Special teams average punt return yards	1.093
Opponent 3rd down conversion	1.587	Opponent average punt return yards	1.100
Offensive 4th down conversion	1.086	Special teams average kick return yards	1.225
Opponent 4th down conversion	1.136	Opponent average kick return yards	1.279
Offensive average yards per rush	1.130	Defensive sacks	1.667
Opponent average yards per rush	1.297	Opponent sacks	1.520
Offensive interception conversion	1.370	Defensive forced fumbles	3.313
Opponent interception conversion	1.195	Opponent forced fumbles	2.251
Offensive average yards per pass	1.856	Defensive average yards per interception	1.084
Opponent average yards per pass	1.582	Opponent average yards per interception	1.087
Special teams field goal conversion	1.220	Total fumbles recovered	1.691
Opponent field goal conversion	1.144	Opponent total fumbles recovered	2.145

The second assumption is that of independence of elements for the error term v_{jt}. This can be checked via the Durbin-Watson statistic. The Durbin-Watson statistic *d*, has a value between 0 and 4. If *d* has a value greater than 2, it might mean the errors are negatively correlated, whereas a value below 2 might indicate a positive correlation between the errors. As a rule of thumb, if $1.5 < d < 2.5$, it means that independence of elements can be assumed (Field, 2009). As can be seen in the model summary, represented in Table 6, the Durbin-Watson statistic is 1.897. Since this lies within the interval, $1.5 < 1.897 < 2.5$, independence of elements is assumed.

Table 6: Model summary

R	R Squared	Adjusted R Squared	Std. Error	Durbin-Watson
0.902	0.814	0.801	1.378	1.897

Thirdly, equal variance for the residuals, or homoscedasticity, is another important assumption. A common way to check for homoscedasticity is by plotting the regression standardized predicted values (x-axis) against the regression standardized residuals (y-axis) for the dependent variable W. This should provide a visual basis for either hetero- or homoscedasticity. When the scatterplot is roughly symmetrically distributed around the x-axis, homoscedasticity can be assumed. Figure 1 shows the scatterplot with the standardized residuals and standardized predicted values for dependent variable W. Since the scatterplot looks roughly to be evenly distributed around the x- axis, equal variance for the residuals is assumed.

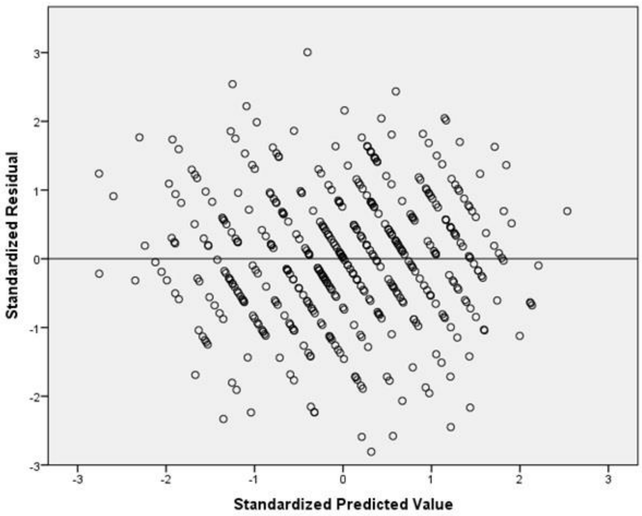
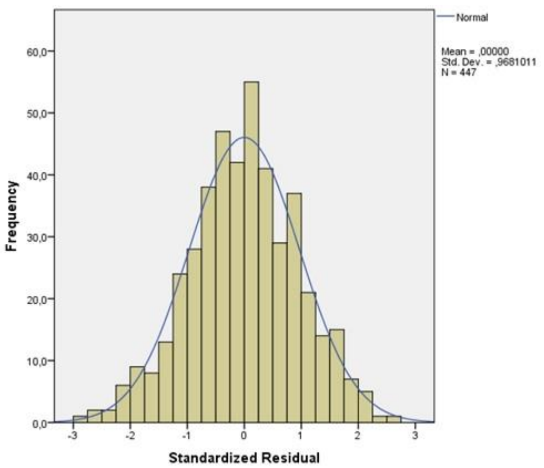


Figure 1: Scatterplot of the residuals for number of wins (W)

The fourth assumption is that of the normal distribution of the error term v_{jt}, with mean 0. Again, this can be checked visually, though this time via a histogram. Figure 2 shows a histogram of the standardized residuals for the production function. For extra visibility, a normal distribution curve has been added. One can see that the standardized residuals approximate a normal distribution, with a mean of 0 and a standard deviation of 0.968. Another way to visually check for normally distributed errors, is by looking at a normal P-P plot of the regression standardized residual. Figure 3 depicts such a P-P plot. The observed cumulative probability is plotted against the expected cumulative probability. The closer all points are to the 45 degree line, the more of a normal distribution it represents.



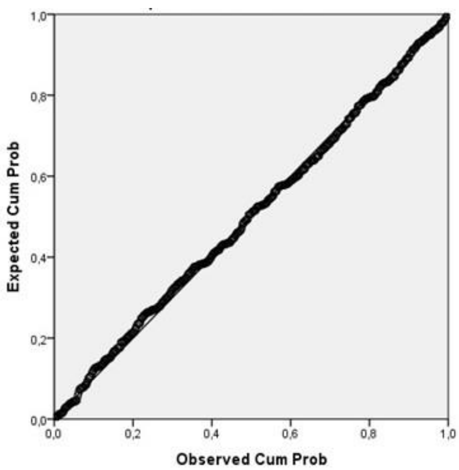


Figure 2: Distribution of the residuals for number of wins (W) **Figure 3: P-P plot of the residuals for number of wins (W)**

5.2 Production function

The tested assumptions provide the basis for the validity of the stochastic production frontier approach. In order to estimate a proper production function, 28 variables have been selected capturing offensive, defensive as well as special teams characteristics. The results are shown in Table 7. Nearly all variables are significant at the 1% or 5% level, with the exception of *opponent average yards per punt*, *special teams average kick return per kick*, *defensive average yards per interception* and *opponent total fumbles recovered*. These four variables appear statistically insignificant. Furthermore, all signs are as expected. All of the franchise variables have a positive impact on the number of games won, whereas all of the opponent variables have a negative impact. The reverse is true for the variables *offensive interception conversion* and *opponent interception conversion*. This is as anticipated. All variables account for 81.4% of the total variation of the dependent variable *W*, number of wins.

It is clear from these results, that all parts of the game, offense, defence and special teams, matter a great deal in order for a franchise to win. However, the force of the coefficients alters for all three of these game aspects. For example, when it comes to special teams it seems the focus should lie more on the defence as the coefficient for the *opponent field goal conversion* is stronger than the coefficient for *special teams field goal conversion* (-4.02 and 3.42). Apparently, reducing the *opponent field goal conversion* will lead to more games won than increasing your own *special teams field* goal conversion. This can be achieved by either blocking field goal attempts or forcing the opponent to kick from a longer distance. When it comes to punting however (which is again part of special teams), it seems that the focus should lie more on the offense. The coefficient for *special teams average punt return yards* is 0.09 versus -0.05 for *opponent punt return yards*. This means *special teams average punt return yards* have a higher impact on winning games than *opponent average punt return yards*. It is clear that franchises can improve their number of games won through all aspects of the game. However, there always is a trade-off to be made even within just one aspect of the game.

For instance, if a franchise were able to increase their *offensive average yards per pass* by just 1 yard, this would in turn lead to 1.16 more games won. However, this is incredibly hard as the mean of average yards per pass on offense for the NFL is just under 7 yards, as can be seen in Table 2. One can imagine how difficult it is then to increase this with an extra yard. Still, the coefficient for *opponent average yards per pass* shows this is of a greater influence on winning a game than the *offensive average yards per pass*. By reducing the *opponent average yards per pass* with one percentage point an extra 1.34 games can be won. Another interesting example is the interceptions variables. When a franchise lowers its percentage of offensive interceptions thrown by one percentage point, this will increase their number of games won by 0.5612. Furthermore, when increasing its interceptions made by the defence with one percentage point, as measured by *opponent interception conversion*, this will increase its number of games won by 0.5220. Both variables are significant at the 1% level. Instead of throwing the ball, one can also run with the ball. A one percentage point increase in *offensive average yards per rush* will lead to a 0.60 increase in number of games won.

The difficulty with running or throwing the ball again lies in the trade-off made by the coach. Focussing more on increasing the average yards per pass than the average yards per rush also increases the risk of throwing an interception, possibly mitigating any positive returns. Throwing the football clearly indicates a high-risk high-reward strategy, whereas running with the football is a more defensive strategy. If offensive coaches spend more time during training on throwing the ball, this might lower the risk as communication between quarterback, receivers and the offensive line is better aligned, decreasing the number of opponent sacks. Also, the offensive line could just give the quarterback the little extra time he needs to find his target as well as for the receiver to get open for the completion. As can be seen in the descriptive statistics in Table 2, the *offensive average yards per rush* is roughly 4.15 as opposed to an *offensive average yards per pass* of roughly 7 yards. This shows that the average distance covered per pass is over 1.5 times that of a rush. From Table 7 it follows that a one yard increase on *offensive average yards per pass* would lead to 1.16 extra games won, which is almost two times more than a one yard increase in *offensive average yards per rush*. This does not mean teams should never run with a ball. In order to have the element of surprise teams should always mix runs and throws. However, there should be an emphasis on throwing. Overall, this might improve the chances of winning more than running with the football. All in all, offense may very well be the best defence.

There are more variables worth highlighting, such as the 3rd down conversion variables. Increasing the 3rd down conversion percentage on offense by one percentage point, leads to another 0.1203 games won. Conversely, if the defence sees a chance to lower the opponents 3rd down conversion percentage by one percentage point, this accumulates some 0.1078 games won. This seems intuitive, as the 3rd down conversion is key in keeping a drive alive for the offense. Often coaches opt to punt the football or settle for a field goal when the team fails to convert on 3rd down. These are safer options than trying to go for it on 4th down. Field goals obviously put points on the board, though fewer than a touchdown. If a 4th down try fails, the opponent will gain possession of the ball on that exact spot, possibly providing them with great field position and chances to score a touchdown. This probably explains the relatively low coefficients for the 4th down conversion. Here, a one percentage point increase would lead to roughly another 0.0148 games won, much less than the 3rd down conversion but still highly significant at the 1% level.

Table 7: Frontier maximum likelihood parameter estimates

Variable	Coefficient	Standard error	*z*
Intercept**	8.81	3.86	2.28
Offensive 1st downs by penalty***	0.04	0.01	3.97
Opponent 1st downs by penalty***	-0.03	0.01	-3.62
Offensive 3rd down conversion***	12.03	1.76	6.85
Opponent 3rd down conversion***	-10.78	1.97	-5.47
Offensive 4th down conversion***	1.48	0.45	3.32
Opponent 4th down conversion***	-1.95	0.46	-4.21
Offensive average yards per rush***	0.60	0.16	3.86
Opponent average yards per rush***	-0.57	0.17	-3.28
Offensive interception conversion***	-56.12	8.43	-6.65
Opponent interception conversion***	52.20	7.54	6.92
Offensive average yards per pass***	1.16	0.12	10.03
Opponent average yards per pass***	-1.34	0.14	-9.85
Special teams field goal conversion***	3.42	0.91	3.75
Opponent field goal conversion***	-4.02	0.87	-4.64
Special teams average yards per punt***	0.11	0.03	3.48
Opponent average yards per punt	-0.04	0.04	-1.02
Special teams average punt return yards***	0.09	0.03	3.27
Opponent average punt return yards**	-0.05	0.03	-1.99
Special teams average kick return yards	0.03	0.03	0.91
Opponent average kick return yards***	-0.09	0.03	-2.71
Defensive sacks***	0.03	0.01	3.09
Opponent sacks ***	-0.05	0.01	-6.49
Defensive forced fumbles***	0.05	0.02	2.71
Opponent forced fumbles***	-0.05	0.01	-3.36
Defensive average yards per interception	0.01	0.01	0.59
Opponent average yards per interception***	-0.04	0.01	-3.03
Total fumbles recovered***	0.05	0.01	3.10
Opponent total fumbles recovered	-0.04	0.02	-1.63
R^2	0.814		
Adjusted R^2	0.801		

Note: Significance level is denoted by (*)
* denotes significant at the 10% level
** denotes significance level at the 5% level
*** denotes significance level at the 1% level

5.3 Efficiency

With the results from Table 7, the expected number of wins for every franchise from 2001 – 2014 is estimated. This leads to a new variable *expected number of wins*. Now another new variable, *efficiency*, can be calculated by dividing the observed number of wins *W* by the *expected number of wins*. Table 8 shows some descriptive statistics for these new variables *expected number of wins* and *efficiency*. It seems again there is little difference between the two conferences. The mean of *expected number of wins* for the AFC is 9.20 whereas the mean for the NFC lies at 8.91. With regards to the *efficiency* variable, it is even more close. The means of both conferences are roughly equal at 87% efficiency.

Table 8: Descriptive statistics AFC (N=223) and NFC (N=224)

	AFC				NFC			
Variable	**Min.**	**Max.**	**Mean**	**Std. dev.**	**Min.**	**Max.**	**Mean**	**Std. dev.**
Expected number of wins	1.49	15.99	9.20	2.79	1.37	14.90	8.91	2.71
Efficiency	0.23	1.42	0.87	0.18	0.00	1.50	0.87	0.19

Since *efficiency* is defined as the observed number of wins divided by the estimated *expected number of wins* it is possible for some teams to incidentally produce outside of their frontier. As Table 8 shows, the maximums for *efficiency* lie above 100%, indicating some franchises win more games than expected. This is to be expected, for if some franchises produce less than expected, it follows that others must produce more than what is expected of them. One franchise's loss is another franchise's win, but not all franchises play against each other. This could be due to some unmeasurable factor such as change in tactics by sending in more rookies and giving star players some rest. Coaches already placed for the playoffs with nothing to win or lose in the remaining game(s) can choose to give their star players some much needed rest. Overall, these numbers indicate little difference between the number of games franchises are expected to win as well as their ability to produce accordingly.

In order to compare the means of two groups, normally the assumptions of normal distribution and equality of variances need to be tested. However, the variables *expected wins* and *efficiency* are estimated with the assumption of a truncated normal distribution. Therefore, a histogram will be used to determine if the distributions have the same shape. If this is not the case, a Mann-Whitney U test is used, comparing mean ranks. As can be seen in Figures 4 and 5 both *expected wins* and *efficiency* do not follow a similar shape when both conferences are compared to each other. In this case the Mann-Whitney U test comparing mean ranks is used.

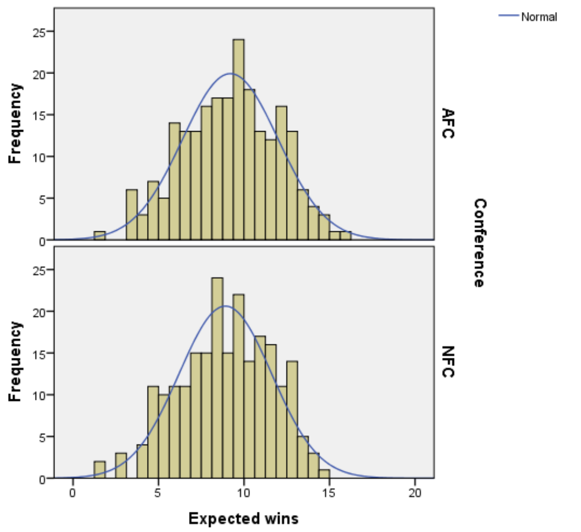


Figure 4: Distributions of expected wins per conference

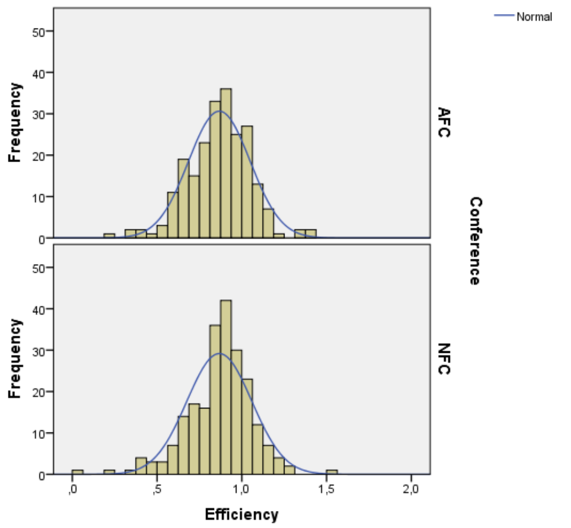


Figure 5: Distributions of efficiency per conference

The results for *expected wins* as well as for *efficiency* are shown in Table 9. The Mann-Whitney U test shows there is no statistically significant difference in mean ranks for *expected wins* between AFC and NFC franchises. The u-statistic for this test is 23,638, which is not significant at the 5% level, as 0.324 > 0.05. This implies that for the first hypothesis, there is no statistically significant difference in expected number of wins for AFC and NFC franchises, H_0 cannot be rejected.

When testing the second hypothesis, there is no statistically significant difference in efficiency between AFC and NFC franchises, the results show that this is indeed the case. The Mann-Whitney U test comparing mean ranks for *efficiency* has a significance of 0.726, which is well over the 5% level. This means H_0 cannot be rejected, as 0.726 > 0.05, leading to the conclusion that there is no statistically significant difference between efficiency for AFC and NFC franchises.

Table 9: Comparison results for the AFC and NFC

	Mann-Whitney Test		
Variable	**U**	**Z**	**Significance**
Expected wins	23,628	-0.987	0.324
Efficiency	24,497	-0.351	0.726

5.4 Attendance

Now we know the number of expected wins and efficiency of each franchise in each year and that there are no statistically significant differences between the two conferences with regards to both variables. Yet, the question remains how efficiency relates to attendance. First, the hypothesis that there is no statistically significant difference in attendance between the AFC and NFC franchises will be tested. That would conclude the hypotheses with regards to the egalitarian claim on which the tax exempt status of the NFL is based. If there are significant differences in either total attendance or attendance percentage between the two conferences it could indicate one conference has an advantage of greater unshared revenue over the other conference. Secondly, the estimated variables expected wins and efficiency are used in the Tobit regression. This provides grounds for either accepting or rejecting the main hypothesis of the effect of efficiency on attendance.

Again, the assumption of an approximately normal distribution has to be tested. This time the Shapiro-Wilk test is used to test for normality. This time, the variables used are *total attendance* and *attendance percentage*. The results, shown in Table 10, indicate both variables do not follow a normal distribution. It shows that for both conferences, *attendance total* and *attendance percentage* are significant at the 5% level, leading to the conclusion that a normal distribution cannot be assumed.

Table 10: Shapiro-Wilk test normality test

	AFC		NFC	
Variable	**Statistic**	**Significance**	**Statistic**	**Significance**
Attendance total	0.945	0.000	0.977	0.047
Attendance percentage	0.811	0.000	0.796	0.000

Since for both variables normality cannot be assumed, the histograms must indicate whether the distributions follow the same shape. Figures 6 and 7 show histograms for both variables. It is clear not one approximates a normal distribution as already indicated by the Shapiro-Wilk test. Furthermore, they show both variables are of different shapes, leading to the conclusion that for both variables the Mann-Whitney U test comparing mean ranks is best suited.

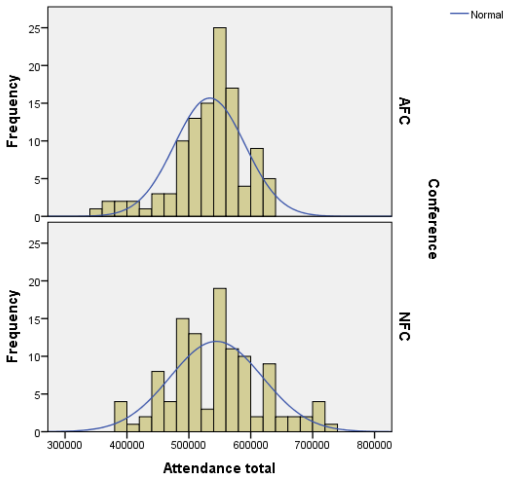


Figure 6: Distributions for attendance total per conference

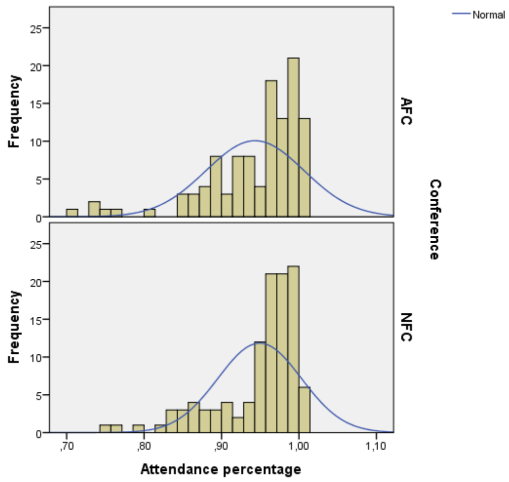


Figure 7: Distributions for attendance percentage per conference

As can be seen in Table 11, when comparing the mean rank of *attendance total* of the AFC and NFC franchises it can be concluded that there is no statistically significant difference between the two conferences. The Mann-Whitney U test comparing mean ranks for *attendance total* has a significance of 0.528 which is well past the 5% level. It is clear H_0 cannot be rejected. Therefore, the conclusion is that there is no statistically significant difference in attendance total between AFC and NFC franchises.

When looking at the relative attendance, or *attendance percentage*, it shows that this variable too is not significant. The significance when comparing the mean rank of *attendance percentage* of the AFC and NFC is 0.988, well over the 5% threshold. Given these two significance levels, H_0 cannot be rejected. This leads to the conclusion that there is no statistically significant difference in attendance percentage between AFC and NFC franchises.

Table 11: Mann-Whitney U test

	U	Z	Significance
Attendance total	5,966	-0.631	0.528
Attendance percentage	6,265	-0.014	0.988

Now it is time to check whether efficiency has an effect on attendance. In order to check for the robustness of the results, both *attendance total* and *attendance percentage* are used as independent variables. If results vary with the dependent variable, they are not robust. As said, this is done by using a Tobit regression, since the dependent variables are censored at the right-hand side. *Attendance total* is limited by the maximum stadium capacity, whereas *attendance percentage* is limited at 100%. The Tobit regression makes the same assumptions as the OLS model on the error term distribution. An approximately normal distribution with mean 0 and equal variance (homoscedasticity) are assumed for the errors in order for the estimations to be more precise. First, the assumption of normality is checked. Secondly, the equal variance assumption is checked.

The assumption of a normal distribution for the residuals can be checked visually as well as with the Shapiro-Wilk test or Jarque-Bera test. For both independent variables, *attendance total* and *attendance percentage*, the Jarque-Bera test will be used to test the normality of the residuals. These results are presented in Table 12. As one can see, the significance level of the residuals for the variable *attendance total* are well above the 5% level, meaning they approximate a normal distribution. However, the residuals for the *attendance percentage* variable are significant at the 5% level, indicating they do not approximate a normal distribution. *Attendance percentage* could therefore be problematic for the Tobit regression.

Table 12: Jarque-Bera test

Variable	Statistic	Significance
Residuals attendance total	2.146	0.342
Residuals attendance percentage	213.0	0.000

The second assumption that needs to be checked is that of equal variance of the error term, or homoscedasticity. Again, by providing a scatterplot one can visually look for evidence whether heteroscedasticity occurs. Figure 8 shows the scatterplot for the residuals of the *attendance total* variable. It seems as though most of the residuals are of equal variance. Figure 9 on the other hand, is a clear example of heteroscedasticity. The funnel shape of the scatterplot is a good indicator of heteroscedasticity, showing lack of equal variance for the residuals of *attendance percentage*.

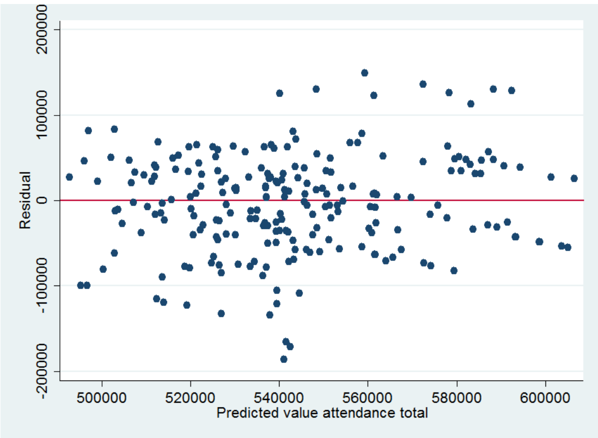


Figure 8: Scatterplot of the residuals for attendance total

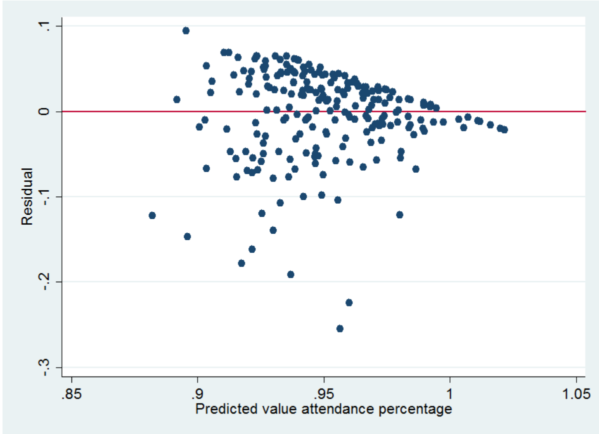


Figure 9: Scatterplot of the residuals for attendance percentage

It seems that the variable *attendance total* might give the best estimations as the residuals approach a normal distribution and appear to have equal variance. The residuals for the *attendance percentage* variable neither follow a normal distribution nor do they show equal variance. The fact that the residuals for *attendance percentage* do not have equal variance and a normal distribution will result in estimated standard errors which could be too small. This in turn leads to significant variables that should not be interpreted in such a way. Using a model with bootstrapped standard errors gives larger, more accurate standard errors when the homoscedasticity and normality assumptions are not met. As the standard errors are more accurate, the significance of the variables is estimated more precise. The results for both *attendance total* and *attendance percentage* are presented in Table 13. The results for the model with *attendance total* as dependent variable are discussed first, followed by the results for the model with *attendance percentage* as dependent variable.

All of the results for the *attendance* total model are presented in Table 13, column 1-4. Some of the results are quite noteworthy. For instance, the *efficiency* score of the previous year has a positive effect on *attendance total*, which is significant at the 5% level. For every one percentage point increase in efficiency, an extra 26,795 attendants per year come to the stadium. Another result that might raise some eyebrows, is the coefficient for the *Fan Cost Index* (*FCI*). Apparently, the *FCI* has a positive effect on *attendance total*, meaning the more expensive a day at a stadium is, the more attendants it attracts. The variable is significant at the 1% level. This feels counterintuitive. Another explanation is that a higher *FCI* is an indicator of higher quality teams. Higher quality teams attract more fans. This is also shown by the *Pro Bowl* variable, which is another proxy for team quality. The amount of *Pro Bowl* players in a team has a positive effect on attendance, which is significant at the 5% level. One extra *Pro Bowl* player in a squad attracts an extra 2,376 fans per year to the stadium.

When *attendance percentage* is the dependent variable, there are some noticeable changes. These are presented in Table 13, column 5-8. Since the homoscedasticity and normality assumptions are violated, bootstrapped standard errors are used to give better estimated standard errors. The *efficiency* score of the previous year still has a positive effect on the dependent variable, significant at the 5% level. In this model a one percentage point increase in previous year's *efficiency* would raise *attendance percentage* with 3.92 percentage point. In this model, the dummy variable for reaching last year's *playoffs* is also significant just over the 5% level. Making it to the playoffs in the previous year increases *attendance percentage* with 1.41 percentage point. A 1% increase in *real per capita personal income* (*RPCPI*) leads to a 0.2123 percentage point increase in *attendance percentage*. The *FCI* variable has changed sign and is no longer statistically significant.

Even though the assumptions are not met with regards to the model with dependent variable *attendance percentage*, the assumptions are met for the first model with dependent variable *attendance total*. In order to increase the validity of the *attendance percentage* model, bootstrapped standard errors are used. In both of the models, the variable of last year's efficiency has a positive influence on the dependent variable, significant at the 5% level. For the main hypothesis, the efficiency of NFL franchises has no significant impact on attendance, H_0 has to be rejected. This leads to the conclusion that the efficiency of NFL franchises has a positive significant impact on attendance.

Table 13: Tobit maximum likelihood parameter estimates

Variable	**Coefficient**	**Std. error**	***z***	**Variable**	**Coefficient**	**Bootstrap Std. error**	***z***
Attendance total				Attendance %			
Intercept	-405,522	631,400	-0.64	Intercept	-1.2417	1.0011	-1.24
Efficiency	707	12,890	0.05	Efficiency	0.0142	0.0186	0.76
Efficiency_{t-1}**	26,795	12,434	2.15	Efficiency_{t-1}**	0.0392	0.0192	2.04
Playoffs	7,889	6,100	1.29	Playoffs	0.0126	0.0077	1.63
Playoffs_{t-1}	5,768	6,056	0.95	Playoffs_{t-1}**	0.0141	0.0069	2.08
Super Bowl	-3,706	12,673	-0.29	Super Bowl	0.0016	0.0093	0.17
Super Bowl_{t-1}	-7,407	12,453	-0.59	Super Bowl_{t-1}	-0.0019	0.0085	-0.23
Pro Bowl**	2,376	1,176	2.02	Pro Bowl	0.0003	0.0015	0.20
Pro Bowl_{t-1}	-312	1,071	-0.29	Pro Bowl_{t-1}	0.0017	0.0013	1.28
Big 6	3,507	4,446	-0.79	Big 6	-0.0006	0.0055	-0.10
RPCPI 2009 (LN)	37,438	60,187	0.62	RPCPI 2009 (LN)**	0.2123	0.0962	2.21
Real 2009 FCI (LN)***	83,017	29,669	2.80	Real 2009 FCI (LN)	-0.0230	0.0485	-0.47
R^2	0.2687			R^2	0.2457		
Adjusted R^2	0.2308			Adjusted R^2	0.2065		

Note: Significance level is denoted by (*)
* denotes significant at the 10% level
** denotes significance level at the 5% level
*** denotes significance level at the 1% level

6. Conclusions

There have been many studies in the fields of sports economics studying efficiency or determinants of attendance. None however, have combined these two topics to study the effect of efficiency on attendance. It appears that the efficiency level of the previous season has a significant positive effect on today's attendance numbers. By increasing this efficiency level by one percentage point, a franchise can expect an increase in stadium attendance in the following season of some 27,000 fans, or an increase in attendance percentage of 3.9%. Given the difficulty of obtaining financial data from the NFL and its subsequent franchises, attendance is used as a proxy for revenue. The NFL Fan Cost Index (FCI) for 2016 is estimated by *Team Marketing Report* (2016). This FCI represents the cost of attending a game for a small group of four adults. The NFL average FCI for 2016 is estimated to be $502.84 for four adults. Therefore, by increasing last year's efficiency score with one percentage point, the average NFL franchise would generate roughly $3.37 million in extra revenue. In the next paragraph the conclusions for the sub-hypotheses are discussed and linked to the theoretical framework in which they should be seen. After this, conclusions are drawn for the main hypothesis and the research question is answered. This chapter concludes by a short discussion of the limitations of this study combined with suggestions for further research.

6.1 AFC versus NFC

Sports teams can be seen as though they are just another production firm. Given their own set of input variables such as sacks, passing and rushing yards, each franchise can produce a certain output of games won. As players and coaches are employees, they may have different objectives than the owner as described by Coase (1937). The coaches possibly prefer to spend money on a new quarterback, whereas the owner wants to maximize profits. There is an obvious relation between winning and profit (Scully, 1989). Wins increase exposure, media coverage and air time, as well as win premiums offered by sponsors or leagues. Therefore, the last thing an owner needs is an inefficient team. Instead of win-maximizers, some have suggested owners are *sportsmen* (Sloane, 1971). If owners are *sportsmen*, they are less interested in maximizing profits as they are in maximizing the number of wins in a season. It is argued that if owners are indeed *sportsmen*, revenue sharing increases competitive balance (Vrooman, 2009). This was also an argument used by congress in 1961 when giving the NFL a tax exempt status.

This study uses a set of input variables in order to estimate a production function for all franchises as one would do for any other firm. Due to the stochastic production frontier model, deviations from the maximum attainable output are not only attributed to inefficiency. Random external factors such as luck are also accounted for. All variables account for 81.4% of the total variation of the dependent variable number of wins. With this production function the number of expected wins and efficiency scores are estimated. The results show that the mean efficiency for the NFL lies at roughly 87%. In general, franchises are quite capable of producing as expected and there is only limited room for luck at play in the NFL.

The number of expected wins and the efficiency scores are used to test for equality between the American Football Conference (AFC) and the National Football Conference (NFC). Later on these variables are used as an explanatory variable for attendance. The results from this study confirm the ideas regarding competitive balance. For all four sub-hypotheses comparing the (AFC) with the (NFC) the null hypothesis is not rejected. The conclusion is that there is no significant difference between the AFC and NFC when it comes to the number of expected wins, efficiency, total attendance and attendance percentage. The NFL is truly an egalitarian competition when it comes to these measurements.

6.2 Attendance

The result of a sports game has implications beyond whether a team wins or loses. Fans identify themselves with a certain team and bask in the glory of winning teams (End, Dietz-Uhler, Harrick, & Jacquemotte, 2002). Their link to a certain team even goes so far that sports fans' judgments, regarding their own personal capabilities, are affected by team performance (Hirt, Zillmann, Erickson, & Kennedy, 1992). The NFL capitalizes on this fan commitment. Due to the economic structure of the NFL, the league has been able to become the largest in revenue generation compared to the other big leagues (Gaines, 2014). Strongly related to this economic structure is the league's revenue sharing policy. Most of the revenue is shared, such as television rights fees and merchandising. Revenue generated by stadium events are exempt from this model (Vrooman, 2012). In order to increase this unshared revenue stream, franchises must increase stadium attendance.

The research question for this study, what is the impact of the efficiency of the National Football League franchises on attendance, has a clear answer. This study finds evidence that increased efficiency of franchises has a significant positive effect on stadium attendance, therefore rejecting the null hypothesis that efficiency has no effect on attendance. In this paper, fans are used as a proxy for revenue. A one percentage point increase in efficiency leads to 26,795 extra fans in the stadiums the following year. Given that the average cost of game day attendance is $502.84 for a group of four adults, the results imply an extra $3.37 million in revenue per percentage point increase in efficiency.

6.3 Future research

There are some caveats for this study worth mentioning. The variables used for estimating the production function are in absolute values. One sack is counted as one sack. However, a sack in the first minutes of the game may contribute less to winning a game than a sack in the dying seconds. The same goes for variables capturing yardage, which also are in absolute values. A yard gained from the own 10 yard line has less value than a yard gained at the opponents 1 yard line, which results in a touchdown. Not to mention taking into account on which down and distance a sack or yard gained takes place. Here lies a great opportunity for further research. Using play-by-play data one might be able to further perfection the production function. Every down and distance combined with the position on the field and time remaining can be converted into a unique value contributing to victory. This would give different values for the example of a one yard gain as down, distance and field position are now incorporated.

Another issue encountered is the lack of financial data to study. This is a problem encountered by many other researchers. Using actual financial data obviously greatly improves the reliability and validity. It also opens up more fields of research. In here lies a very difficult task for future researchers. Thirdly, when examining the different drivers of attendance, the results of this study deviate from other studies such as Welki and Zlatoper (1999). Material for the topic of this study has not been exhausted and should therefore be continued by future researchers.

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