THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF ECONOMICS

UTILIZING QUARTERBACK PRODUCTIVITY TO ANALYZE RACIAL DISCRIMINATION AND DRAFT POTENTIAL IN THE NFL

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SPRING 2019

A thesis
submitted in partial fulfillment
of the requirements
for baccalaureate degrees
in Economics and Finance
with honors in Economics

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ABSTRACT

Professional sports leagues are interesting labor markets to study because performance and worker characteristics can be easily observed. Productivity is an important variable that distinguishes workers from one another, and allows for heterogeneity in output. This paper focuses on measuring the productivity of quarterbacks in the National Football league, framing quarterbacks as workers, whose outputs are the wins and points they produce. A productivity metric is calculated for every quarterback from 2006 to 2017 to test two different hypotheses. The first looks at measuring potential salary discrimination, and the second tests to see if future quarterback productivity can be predicted by looking at where a quarterback was taken in the draft and which college they attended. The Wins Produced metric developed by Berri & Schmidt (2010) limits the effect that the rest of the team's performance has on the quarterback's productivity. This paper expands the literature on player productivity by using the most recent NFL data available.

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ACKNOWLEDGEMENTS

I would like to thank my Thesis Supervisor, Dr. Jadrian Wooten, for his continued help and support throughout the entirety of this undergraduate thesis paper.

I would also like to thank my family who supported me throughout my time at Penn State University, and encouraged me to strive to be my best.

Chapter 1

Introduction

Ever since Billy Beane started using analytics, developed by Bill James, to measure players' true value on the Oakland A's roster, there have been significant changes in the world of sports (Lewis, 2003). Prior to this, managers relied on heuristics to build teams, but focus has shifted to incorporating statistical models in front office decisions. Teams across sports leagues are turning to statisticians more than ever, but prior to this paradigm shift their results were viewed as purely academic rather than being applicable to the sport itself (Harcourt, 2017).

From an economic standpoint, the world of sports is an incredible labor market to study. There is no other public industry in which every individual worker's name, face, history, productivity, and compensation are widely available. This industry allows economists to view a labor pool that has quantifiable statistics on individual performance better than most other visible labor pools (Kahn, 2000).

Sports statistics are simple to observe and calculate, but particular sports and particular statistics are better comparison tools than others. Two of the most well-known sports measurements are the home run in baseball and the touchdown in football. These measurements are often used to compare the quality of basketball and football players, respectively. A home run is based solely off that individual player's skill. A baseball player's teammates cannot help the player hit a home run in a single at bat, it is purely the batter against the pitcher. However, other players are necessary to complete a touchdown. While, the quarterback's passing ability is important, each teammate on the field has an impact on that one throw. Offensive linemen have to block defenders. Wide receivers need to run routes and break away from the defense to give the quarterback a target to throw at, and after the pass is thrown, the receiver needs to have the dexterity and ability to catch the pass and constitute the play as a touchdown. Both the home run and touchdown are popular statistics, but the touchdown has significantly more moving parts that make it difficult to accurately depict how much of the measure is actually due to quarterback productivity.

It is not easy to find a single descriptive measure to account for overall productivity due to the vast number of variables that could attribute to a quarterback's success. Berri & Burke (2012) challenge this notion stating:

> "A multitude of statistics is tracked to separate the performance of the individual from the outcomes we observe for the team. We know who won or lost the game. With performance statistics, teams hope to determine which players were responsible for the team's success (or failure). For player statistics to have value, though, these numbers must be connected to outcomes" (p.33).

Because of the difficulty in measuring an individual player's contribution, most economic analysis has been done in the National Basketball Association or Major League Baseball rather than the National Football League. In the NFL, every player on the field has different roles and statistics to measure their ability in those roles, but there is no measure that can assess a player's ability across different positions in the same way that can be done in basketball or baseball. Due to that difficulty, this paper focuses on just one position, the quarterback, and uses a model that tries to accurately depict a quarterback's production.

The relevant literature in this area focuses on three main topics, the first of which is deriving a measure of quarterback productivity. The other two areas use previously established measures to analyze racial discrimination and future productivity. This paper explores the relevant literature on each of these topics and addresses their strengths and weaknesses. With the changing football landscape over the past decade, this paper conducts analyses similar to the previous work using a sample of the most recent NFL statistics to evaluate a quarterback's production. This paper will determine if the conclusions found in prior work still hold, by addressing if black quarterbacks are being paid fairly based on their overall production, and if the productivity of early draft picks are worth the investment.

Chapter 2

Literature Review

Quarterback Productivity Measures

Published sports statistics date back to baseball statistics in the late 1800s, but it was not until the recent “Moneyball Phenomenon” that people started comparing these statistics to productivity and players’ values (Berri & Burke, 2012). Once the idea of attempting to distinguish a player’s true value was adopted into the NFL, more discussion began to distinguish the best overall measure of a quarterback’s productivity.

Prior to 2007, regression analysis to determine quarterback productivity was not often used, and the NFL had their own measure called the Quarterback Rating (QBR). Berri & Burke (2012) describe the frustration of the measure as such:

> First one takes a quarterback’s completion percentage, then subtracts 0.3 from this number and divide by 0.2. You then take yards per attempts, subtract 3 and divide by 4. After that, you divide touchdowns per attempt by 0.05. For interceptions per attempt, you start with 0.095, subtract from this number interceptions per attempt, and then divided this result by 0.04. To get the quarterback rating, you add the values created from your first four steps, multiply this sum by 100, and divide the result by 6. Oh, and by the way, the sum from each of your first four steps cannot exceed 2.375 or be less than zero. (p.161)

In mathematical terms the measure is:

$$\left(\frac{\frac{COMP}{PASSATT}-0.3}{0.2}+\frac{\frac{PASSYDS}{PASSATT}-3}{4}+\frac{\frac{PASSTD}{PASSATT}}{0.05}+\frac{0.095-\frac{INT}{PASSATT}}{0.04}\right)*\frac{100}{6}$$

Where, COMP represents completions, PASSYDS represents yards passing, INT represents interceptions thrown, and PASSATT represents passing attempts.

It is difficult to tell how QBR determines the productivity of an NFL quarterback, and even professional quarterbacks do not understand how or why their performance was depicted by this statistic. Hall of Fame quarterback Steve Young once stated, “I know interceptions kill your rating, but if you asked me to compute it, I’d have no idea” (Berri & Burke, 2012). Phil Simms once said of the QB rating, “It’s hard to imagine anything more misleading” (Mushnick, 2007). If even NFL Hall of Famers say the measurement is not an accurate representation of performance, then it may not be the best tool for comparison. Economists argue that this statistic is not intuitive and too complex. While not accounting for a magnitude of other variables and mis-weighting the ones included, and when trying to determine optimal players’ salaries, this statistic does not lead to an accurate measure of the value-added by the player (Stimel, 2009).

It is difficult to use economic intuition to estimate a player’s true value without a clear productivity measurement. Researchers started using NFL statistics in linear regression models to determine links between different outcomes that the QBR could not effectively depict. Hunsberger & Gitter (2015) estimate that the value of a win in the NFL is worth $740,000 and that teams are win maximizers. Berri & Burke (2012) used regression analysis to develop their own quarterback measurement depicting a quarterback’s “Wins Produced”. They first established that wins are the product of the individual player's contribution, then described the relationship showing wins as a function of points scored and points allowed. Their model results in a R^2 of 84%, meaning the variables of offensive and defensive abilities included in their model are 84% effective is determining wins. They then determined which variables impacted a team's offensive ability resulting in points scored. This second regression resulted in an R^2 of 91%. The researchers ran a similar regression for the opponent's points scored portion of the overall wins function. From there, they derived the portion of these variables that were direct impacts of the quarterback's play. This established the exact proportion of overall team wins that an individual quarterback is responsible for, using their individual in-game statistics, and limiting all other variables.

Berri and Burke (2012) find that for each yard a quarterback is responsible for (whether they throw the ball, run the ball, or are tackled for a loss) results in 0.0739 points gained or lost, leading to 0.0020 wins produced. Looking at an individual quarterback's season long statistics will result in their net points and wins produced for the season. Dividing the wins produced output by the total number of plays (passing attempts + rushing attempts + sacks) creates a measurement known as Wins Produced per 100 Plays (WP100). These can then be used as more intuitive productivity measure, which only consider variables that are relevant to a quarterback's productivity.

Other quarterback productivity measures have also been developed in an attempt to measure performance, such as the Quarterback Expected Points model, the Success Rate Model, and the Win Probability Model. Each a measure of quarterback productivity, but Berri & Burke (2012) believe are not as useful as the Wins Produced Model because of a lack of transitivity and linear proportionality. This paper will focus on their Wins Produced model for the analysis.

Quarterback Productivity, Race, and Compensation

Research looking at racial discrimination in compensation throughout the major sports leagues is vast, but focus on the National Football League is only a small fraction of the literature. The majority of the literature focuses on the National Basketball Association and finds no salary discrimination among veteran players, but believes there is salary discrimination at the rookie level (Jenkins, 1996). Papers on the NFL have not formed a cohesive picture as some have concluded that salary discrimination is present at varying levels, while others have concluded there are elements of reverse discrimination.

Roger Mogull (1973) published the first literature on discrimination in the NFL, but he used such a small data set that it is difficult to know if his conclusion were relevant to the entire population. Mogull's sample looked at 160 players between two different seasons, which was only 5-8% of the entire league. He estimated a 4% salary gap between black and white veteran players and a 0.1% salary gap between black and white rookies.

Kahn (1992) expanded Mogull's work and found a 4.1% salary gap between black and white players, but only focused on the 1989 season. Kahn also used all player positions in his analysis, which can prove to be difficult since football is such a complex sport. Kahn created regressions around variables that were "related" to player performance, but not actual performance statistics.

Gius and Johnson (1998) found reverse discrimination in the NFL: black players were paid 10% more than white players based on performance. Their work included all positions and used player characteristics rather than performance statistics. Overall productivity is difficult to calculate, and some positions do not even have available statistics. If players should only be compensated for their performance, these studies might not accurately reflect important variables. Rather than performance statistics, past research focused on characteristics like the number of games started, whether their team was in the playoffs, and the team's win-loss ratio. All of these factors are correlated with the player's ability, but there are other factors responsible for these measures outside of any individual player's productivity.

This paper focuses solely on the quarterback position. In total, 67% of NFL players are black, but only between 16-28% of quarterbacks were black between 2001 and 2014. Other positions like running back and wide receiver are comprised of 83% and 84% black players respectively (Volz, 2017). There is a disconnect as to why there are not more black quarterbacks in the league, but this analysis focuses on quarterbacks to see if they are paid based on productivity.

Berri & Simmons (2009) looked at only quarterbacks between 1971 and 2006. The authors believe that the Total Quarterback Rating is biased against black quarterbacks, resulting in an oversight in previous studies. QBR does not consider the quarterback's rushing statistics, and the researchers note that black quarterbacks rush on 11.7% of their plays while white quarterbacks rush only 6.7% of the time. The amount of yardage gained by black quarterbacks exceeded white quarterbacks on 80.7% of those rushed. By not including rushing statistics in prior studies, they underestimate the productivity of black quarterbacks. At the time, Berri & Simmons designed a measure they called the QB Score to evaluate quarterbacks over their sample period, and found that using QBR rather than their QB Score (which does account for a quarterback's running ability) does indeed undervalue black quarterbacks. Contrary to prior studies they find that black quarterbacks faced salary discrimination compared to their productivity level, but over time this difference narrowed.

Quarterback Productivity and the NFL Draft

The NFL draft system is based on reverse tournament theory where teams do not compete on price for the best college athletes. The worst team from the previous season can select their top choice for the next season, and theoretically allow for a competitive balance which can be helpful for teams that do not perform well. Research on testing the impact of the draft on competitive balance, however, is not very encouraging (Berri & Simmons, 2011). Quirk (2006) and Quinn, Geier, and Berkovitz (2010) believe that a team with the first overall pick should not use it, but instead should trade the pick for multiple picks later in the draft. This theory is based on the frequency of top draft picks who do not turn out as expected. Quarterbacks selected early receive much more money than those taken later, but do not seem to be significantly more productive. Therefore, teams would be better off trading down and taking a quarterback later in the draft and being able to pay him less (Quinn, et al., 2007). When comparing the value of a quarterback's first 5 years of production to the compensation the player received, players selected lower in the draft have the higher surplus value (Quirk, 2006).

Berri & Simmons (2011) conducted an ex-post analysis to see if NFL scouts and analysts accurately predicted future productivity of college quarterbacks, and the results do not favor the scouts. Between 1970 and 2007, where a quarterback was drafted does not correlate with future productivity. Quinn, et al. (2007) looked at 1999 to 2004 and came to the same conclusion, despite using different performance measures, and also found that teams are more likely to draft players from Power 5 conference teams in early rounds of the draft rather than players from lesser known programs, showing a bias towards players from big schools regardless of if they are a better player.

This paper uses more recent data and a more advanced productivity measure to see if these conclusions still hold. Over the past few years, teams have increased their focus on drafting players that will add the most value to the team. Some factors of this are the “Moneyball Phenomenon”, the most recent Collective Bargaining Agreement reducing the rookie wage scale, and advancements in evaluating college QBs (like the adjustments to the NFL Combine and Wonderlic test) as well as scouts beginning to use newer confidential metrics like ESPN’s Total Quarterback Rating on college athletes (Hunsberger & Gitter, 2015). Constant uncertainty in the future prospects of an individual player and the fear of overvaluing early picks based on their college performance will always be a concern, but based on the time and resources teams put into this, one would hope to see more accuracy in their selection.

Chapter 3

Discussion of the Dataset

Data for this paper was collected from the Pro-Football Reference Database and spans 12 NFL seasons from 2006 to 2017. The sample was restricted to quarterbacks with at least 100 attempts (pass attempts + rush attempts + sacks) in an individual season to avoid the WP100 measure being biased by low denominates. QB characteristics for race, college attended, draft year, draft pick, and total games played was collected from their individual profiles on ESPN.com and NFL.com. Salary information was collected from USA Today, overthecap.com, and spotrac.com, which tracks each player's salary. Due to the length of this dataset, each player's yearly salary had to be adjusted for inflation. By dividing each salary by the respective year's consumer price index (Bureau of Labor Statistics) and multiplying by 100, the salary data is set to inflation-adjusted common dollars. The Consumer Price Index used for adjusting players' salaries in this dataset was an index where 1982-1984 was the base year.

A quarterback's experience is usually measured as the number of years spent in the NFL, including years the quarterback may have been injured, a free agent, or benched for the majority of the season. In each scenario the quarterback would not be developing his skills in the manner consistent with the thought that a more experienced player would be more productive.

The experience variable in this paper is composed of the total number of times the player made an appearance in a game prior to that season. This was calculated by taking total number of games played in each player's career as of 2018 and incrementally subtracting out the number of games played per year from 2018 to 2006, in order to have the player's cumulative games played as of each year. This slight change results in a more accurate depiction of a quarterback's experience. By using games played it shows the assumption that as a player gets more on-field experience they should become more productive. A squared term is included to capture possible diminishing returns that come with experience as the player ages.

Three different productivity measures are calculated: Wins Produced, Wins Produced per 100 attempts (WP100), and Net Points. These calculations were based on models created by Berri & Schmidt (2010). The Wins Produced metric is a calculation of the total number of the team's wins in a season can be contributed to that particular quarterback. As shown in Appendix A, Peyton Manning had 4.264 wins produced in 2006. In that season, the Indianapolis Colts won 12 games in the regular season and won the Super Bowl. This productivity measure estimates that Peyton Manning was responsible for 4.264 of those 12 wins, the rest attributed to other players on the team.

Wins Produced per 100 attempts is the quarterback's wins produced divided by their total attempts times 100 to create a variable that is relative across quarterbacks. Net Points is the number of the team's points that were the result of the quarterback in that season. These productivity measures are used as both dependent and independent variables in two models covered in the upcoming sections. The first model measures potential racial bias in the NFL, and the productivity measure will be used as the main independent variable. In the second model, the productivity measure will be used as the dependent variable in order to observe if a player's draft selection and other college characteristics assess future productivity.

Chapter 4

Empirical Work and Results

Salary, Productivity, and Race

Until roughly the 1950s, African American athletes were denied the right to play in most professional sports leagues. Until the 1990s, black quarterbacks constituted less than 5% of players at the quarterback position, year over year (Berri & Simmons 2009). Since 2006, black quarterbacks comprise an average of 19% of quarterbacks in the NFL despite black players representing nearly two-thirds of all players in the league. As sports and the NFL have evolved, there still remains the question of if black players are discriminated against in terms of compensation. In a perfect “colorblind” system, players would be compensated purely for their contribution to wins, not on any physical characteristics, assuming customers have no taste preferences and solely want to see their team win. This section aims to see if today’s NFL has any racial discrimination in pay.

Table 1: NFL Quarterbacks by Race

Year	Black QBs	White QBs	Percentage Black
2006	10	37	21.28%
2007	8	42	16.00%
2008	6	35	14.63%
2009	9	37	19.57%
2010	7	39	15.22%
2011	8	35	18.60%
2012	6	32	15.79%
2013	11	35	23.91%
2014	8	35	18.60%
2015	8	39	17.02%
2016	8	32	20.00%
2017	10	35	22.22%

Black and white quarterbacks tend to have different playing styles. Black quarterbacks tend to be faster and more agile than white quarterbacks, resulting in more rushing attempts, while white quarterbacks tend to focus on passing attempts. This can be seen in Table 2. Because quarterbacks have different styles, they should be compensated differently for their relative play, and using measures that do not account for rushing would lead to biased conclusions. Prior research often overlooked rushing, which makes Berri & Schmidt's (2010) Wins Produced metric a more effective measure at describing the quarterback's productivity, and creates a more accurate representation of possible discrimination.

Table 2: Average Season Performance of Black and White Quarterbacks Between 2006 and 2017

Variable	All QBs *(n = 532)*	White QBs *(n = 433)*	Black QBs *(n = 99)*
Completion %	60.68	61.02	59.23
Passing attempts	30.63	31.31	27.64
Passing yards	214.25	219.10	192.47
Passing touchdowns	1.26	1.31	1.07
Interceptions	0.86	0.89	0.75
Sacks	2.09	2.05	2.23
Rushing attempts	2.54	2.17	4.16
Rushing yards	16.19	7.53	22.04
Rushing touchdowns	0.09	0.07	0.18
Fumbles lost	0.21	0.21	0.20
Net points	6.37	6.42	6.12
Wins produced	1.69	1.71	1.58
WP100	0.41	0.43	0.35

Notes: Sample only includes QBs with at least 100 attempts.
All stats are "per game", with exception of Wins produced and WP100.

This paper will use a version of the Mincer model using an ordinary least squares regression and the log of the quarterback's salary as the dependent variable to measure if there has been any racial bias in salary over the past decade.

A racial binary variable would only show the difference in the intercept term between black and white quarterbacks, but in reality, coefficients for each of the variables would most likely change because of different playing styles. This paper will compare the results of three different regressions, in which the first regression is based on all quarterbacks in the sample period, the second covering only black quarterbacks, and the third covering only white quarterbacks. This will show how each of the coefficients are impacted by race, and from there judging which variables have a larger impact on salary.

The full regression equation for each of the three regressions is:

$$\ln SAL = ß_0 + ß_1*WP + ß_2*EXP + ß_3*EXPSQ + ß_4*PROBOWL + ß_5*NEWCBA + e_t$$

which estimates the percentage change in a quarterback's salary based on their productivity (Wins Produced), experience, if they made the Pro Bowl in the previous season, and the CBA they were under. The productivity variable in this model is the Wins Produced (WP) measure of each quarterback in the sample. The experience variables account for the number of games played, and the Pro Bowl variable is based off the honor a player receives via fan voting. This is normally correlated with the player having an exceptional season, so one might expect that the player would be compensated for such a feat. The NFL entered a new Collective Bargaining Agreement just before the start of the 2012 regular season. This causes some of the player's contracts within this dataset to reside under the old CBA and some under the new. A variable is included to test the impact the new CBA had on player's salaries.

This model is heavily based on the theory that marginal revenue product is the basis for pay, such that more productive players should be compensated for increased productivity.

Assuming perfect competition with non-discriminatory owners and fans, players who are more productive should receive a higher salary regardless of race. The results of the three regressions are shown in Table 3:

Table 3: Regression Results of Log Salary

Variable	**All QBs** ***(n = 532)***	**White QBs** ***(n = 433)***	**Black QBs** ***(n = 99)***
WP	0.131 (0.016)***	0.129 (0.018)***	0.131 (0.039)***
EXP	0.010 (0.001)***	0.010 (0.001)***	0.013 (0.003)***
EXPSQ	0.000 (0.000)***	0.000 (0.000)***	0.000 (0.000)***
PROBOWL	-0.046 (0.052)	-0.035 (0.059)	-0.076 (0.114)
NEWCBA	-0.033 (0.032)	-0.043 (0.035)	0.018 (0.081)
CONSTANT	5.607 (0.035)***	5.613 (0.038)***	5.539 (0.091)***
R^2	0.5230	0.5361	0.441

**Significant at the 10% level* *Std. Err. in parentheses*
***Significant at the 5% level*
****Significant at the 1% level*

The Wins Produced measure is significant in all three regressions. An increase in Wins Produced by one additional game is correlated with a 13.12% increase in salary. Based on the combination of the three regression results, the coefficient for black quarterbacks is roughly 0.2 percentage points higher than the productivity coefficient for white quarterbacks, but when taking the coefficients' standard errors into account, it shows that the two are not statistically different from one another. This result finds that black and white quarterbacks are paid similarly based on productivity, which contradicts the results found in the relevant literature on this topic.

Experience is also significant in all three models. Comparing the coefficients between black and white quarterbacks, the coefficients are again statistically indifferent from each other, finding that both black and white quarterbacks are compensated similarly based on experience. This challenges the intuition of Berri & Simmons (2009) that because black quarterbacks tend to rush the ball much more often, they have a higher risk of injury resulting in these quarterbacks having shorter careers and therefore general managers may not compensate them as much based on experience due to the fear of a potential looming injury (Berri & Simmons 2009).

Finally, in all three instances both the Pro Bowl and New CBA variables are insignificant, meaning that quarterbacks do not see a change in their salary based on if fans vote them into a Pro Bowl or the impact of the new CBA. The cause of this may be related to NFL contracts being multi-year agreements. In many cases changes like a player making a Pro Bowl or the signing of a new CBA may have happened in the middle of their contract. The player would not see this impact their salary until their next contract, which may be a few years after.

Draft Selection and Future Productivity

A large amount of time, effort, and money goes into deciding which player to select in the NFL draft. Selecting a player in the draft is a gamble that the selection will be more productive than someone who could have been taken later in the draft. A quarterback drafted early is assumed to be more productive. Quarterbacks tend to be a very large investment and teams often build around them, causing a poor draft choice to be harmful to a team's future. Table 4 shows the difference in the average statistics between quarterbacks selected during different portions of the draft:

Table 4: Average Season Performance Based on Draft Selection and College Classification Between 2006 and 2017

	Draft Selection				College Classification	
Variable	**Top 5**	**Round 1**	**Round 2-7**	**Undrafted**	**Power 5**	**Non-Power 5**
Number of quarterbacks	26	25	78	17	93	53
Number of seasons	147	108	244	53	349	183
Completion %	61.04	60.29	60.41	61.64	60.52	60.99
Pass attempts	32.76	30.49	29.51	29.70	30.95	30.00
Passing yards	232.81	211.48	203.73	211.82	217.69	207.39
Passing touchdowns	1.43	1.24	1.17	1.22	1.30	1.19
Interceptions	0.86	0.87	0.85	0.87	0.86	0.86
Sacks	2.06	2.29	2.03	2.00	2.07	2.12
Pro Bowls	44	14	44	6	80	28
All Pro Seasons	6	2	4	0	11	1
Net points	7.48	6.46	5.86	6.16	6.64	5.85
Wins produced	2.22	1.56	1.47	1.39	1.79	1.49
WP100	0.40	0.32	0.32	0.36	0.36	0.32

Notes: Round 1 excludes players drafted in the top 5
All stats are "per game", with exception of Wins Produced and WP100

In almost every performance variable there is a downward trend for quarterbacks picked in later rounds of the draft. The one exception is for undrafted quarterbacks, who on average, have outperformed quarterbacks drafted in rounds 2 through 7 on the basis of yards, touchdowns, sacks, net points per game, and WP100.

This section will still use a measure of productivity based off the works of Berri & Schmidt (2010), but rather than using "Wins Produced", this section will use the "Net Points" (NP) productivity measure as the dependent variable in this OLS model. This model will determine how productive a quarterback should be based on the player's draft characteristics, and test the hypothesis of whether quarterbacks drafted earlier, and paid the higher signing bonuses, should be more productive.

This section uses three different regressions to test this hypothesis. The first using all quarterbacks in the sample, the second only using quarterbacks from Power 5 conferences[1] and the third using quarterbacks from non-Power 5 conferences.

The full regression equation for each of the three regressions is:

$$\text{Net Points} = ß_0 + ß_1\text{*TOP5} + ß_2\text{*ROUND1} + ß_3\text{*LATEROUND} + e_t$$

The regression uses of three dummy variables to depict where the quarterbacks were taken in the draft. Incorporating dummy variables for if the quarterback was drafted in the top 5, in the first round (excluding the top 5), or after round one will show the quarterback's expected productivity based on when they were selected. Quarterbacks taken in the top 5 spots in the draft are considered top-tier, highly regarded prospects, and should be reflected in their future

[1] Power 5 colleges include universities in the ACC, BIG 10, PAC 12, SEC, and BIG 12 Conferences.

productivity. Players selected in the first round are expected to have a major impact on the team. Drafting a quarterback in the first round rather addressing a different team need signals that the team expects this quarterback to lead the team within the next few years, if not immediately, depending on the situation. Quarterbacks drafted in later rounds tend to get less on field opportunities compared to those drafted earlier, but some have succeeded once they received sufficient playing time. These players normally lack the physical stature, skill, or did not play at a reputable college which results in them being overlooked in the draft (Quinn, Geier, & Berkovitz, 2010). Because all of the variables are indicator variables, the constant in the regressions depicts the net points of a quarterback who went undrafted. Undrafted players are often signed for low salaries to add depth to a team's roster, but they infrequently amount to much success.

Players at top universities receive national recognition and play against high-caliber defenses that will compare more closely to the defenses that they will see in professional football. Non-Power 5 quarterbacks' abilities may not translate well when facing the better defenses.

The outputs from the model are shown in Table 5:

Table 5: Regression Results of Net Points

Variable	All Quarterbacks (n = 532)	Power 5 in College (n = 349)	Non-Power 5 in College (n = 183)
TOP5	38.75 (9.00)***	59.62 (14.42)***	33.08 (12.83)***
ROUND1	9.12 (9.43)	28.54 (15.17)*	1.61 (11.48)
LATEROUND	4.25 (8.59)	36.56 (14.28)**	-25.18 (10.03)**
CONSTANT	69.02 (7.72)***	46.69 (13.41)***	81.50 (8.44)***
R^2	0.0693	0.0689	0.1453

**Significant at the 10% level* *Std. Err in parenthesis*
***Significant at the 5% level*
****Significant at the 1% level*

Of quarterbacks who go undrafted, the ones from the non-Power 5 conferences are almost twice as productive as QBs from Power 5 conferences. This may relate to the thought that QBs from non-Power 5 conferences do not receive the recognition that Power 5 QBs do and have a higher probability of not getting drafted regardless of their skill level, but some of those quarterbacks from smaller schools end up having decent careers once given the opportunity.

In each model the TOP5 variable is significant at the 1% level and shows that quarterbacks drafted in the top 5 spots of the draft are more productive in the NFL than those drafted later. Comparing these results to prior studies done on the labor market of the draft system, we can see that over the past two decades front offices have actually been effective in their ability to draft quarterbacks at the top portion of the draft. This differs from the argument of prior studies that shows that teams are may benefit more from trading those top picks for picks later in the draft.

As the game of football has evolved, teams need a top tier quarterback, and relying more heavily on a quarterback will also add to his productivity. This may cause teams to look ahead and scour the college landscape to find the best overall quarterback's and draft them early to ensure that they have a centerpiece to build their team around. It is possible the dataset for this study focuses on a time period where some of the best quarterbacks of all time have played.

Chapter 5

Conclusion

The models constructed in this paper use recent NFL data to focus on salary and productivity determination. This study shows that black and white quarterbacks are paid similarly based on their production. In regards to determining a quarterback's future productivity based on draft position, this study finds that quarterbacks drafted in the top 5 picks of their respective drafts are correlated with higher productivity measures than quarterbacks selected later in the draft, but determining the productivity of quarterbacks selected outside the top five may be dependent on where the quarterback went to college or other variables entirely.

One limitation of this study is that these results are only applicable to NFL quarterbacks rather than all NFL players. At this time there is no productivity variable that translates across all positions in football, which caused studies like this to only be applicable to individual positions rather than across the entire league like papers on the NBA or MLB.

For future literature on this subject, ESPN has created a new measure called the Total Quarterback Rating. Hunsberger & Gitter (2015) found that a quarterback with a higher Total QBR would win 83% of the time, which may show its effectiveness as a productivity variable. The issue with this measurement is that it is proprietary to ESPN resulting in people in the field of sports economics not being able to use it in their own studies or adjust the formula to allow for different assumptions. A measure like this may be able to verify the results of this study using an alternative productivity measurement, but until a measurement that is applicable to all positions is created results of a study on this topic across the entire NFL landscape will be inconclusive.

Appendix A

Top 50 Most Productive Quarterbacks by Season

Wins Produced Metric

Rank	Player	Team	Year	Wins Produced
1	Drew Brees	Saints	2011	5.504
2	Matt Ryan	Falcons	2016	5.306
3	Aaron Rodgers	Packers	2011	5.306
4	Tom Brady	Patriots	2011	5.126
5	Peyton Manning	Broncos	2013	5.126
6	Aaron Rodgers	Packers	2014	4.852
7	Tom Brady	Patriots	2007	4.702
8	Tom Brady	Patriots	2012	4.608
9	Drew Brees	Saints	2008	4.606
10	Carson Palmer	Cardinals	2015	4.544
11	Drew Brees	Saints	2013	4.508
12	Kirk Cousins	Redskins	2016	4.486
13	Ben Roethlisberger	Steelers	2014	4.458
14	Alex Smith	Chiefs	2017	4.390
15	Tom Brady	Patriots	2015	4.310
16	Peyton Manning	Broncos	2012	4.272
17	Peyton Manning	Colts	2006	4.264
18	Philip Rivers	Chargers	2017	4.258
19	Drew Brees	Saints	2016	4.252
20	Drew Brees	Saints	2017	4.244
21	Drew Brees	Saints	2015	4.184
22	Philip Rivers	Chargers	2013	4.166
23	Drew Brees	Saints	2012	4.154
24	Philip Rivers	Chargers	2009	4.104
25	Tom Brady	Patriots	2017	4.092
26	Matt Schaub	Texans	2009	4.086
27	Philip Rivers	Chargers	2010	4.080
28	Matthew Stafford	Lions	2011	4.062
29	Tom Brady	Patriots	2016	4.056
30	Aaron Rodgers	Packers	2009	4.038
31	Eli Manning	Giants	2011	4.010

32	Peyton Manning	Broncos	2014	4.008
33	Matt Ryan	Falcons	2012	3.982
34	Peyton Manning	Colts	2009	3.978
35	Russell Wilson	Seahawks	2015	3.968
36	Aaron Rodgers	Packers	2016	3.956
37	Robert Griffin	Redskins	2012	3.948
38	Russell Wilson	Seahawks	2014	3.946
39	Tom Brady	Patriots	2010	3.910
40	Drew Brees	Saints	2009	3.886
41	Matt Ryan	Falcons	2014	3.884
42	Tony Romo	Cowboys	2009	3.876
43	Drew Brees	Saints	2014	3.806
44	Tom Brady	Patriots	2009	3.792
45	Andrew Luck	Colts	2014	3.764
46	Drew Brees	Saints	2006	3.738
47	Aaron Rodgers	Packers	2010	3.728
48	Dak Prescott	Cowboys	2016	3.726
49	Brett Favre	Vikings	2009	3.688
50	Matthew Stafford	Lions	2016	3.684

Wins Produced per 100 Attempts Metric

Rank	Player	Team	Year	WP100
1	Aaron Rodgers	Packers	2011	0.8873
2	Matt Ryan	Falcons	2016	0.8756
3	Tom Brady	Patriots	2016	0.8539
4	Josh McCown	Bears	2013	0.8363
5	Aaron Rodgers	Packers	2014	0.8210
6	Drew Brees	Saints	2011	0.7840
7	Nick Foles	Eagles	2013	0.7826
8	Carson Palmer	Cardinals	2015	0.7741
9	Philip Rivers	Chargers	2009	0.7642
10	Aaron Rodgers	Packers	2013	0.7519
11	Tom Brady	Patriots	2011	0.7472
12	Donovan McNabb	Eagles	2006	0.7469
13	Tom Brady	Patriots	2007	0.7393
14	Alex Smith	Chiefs	2017	0.7317
15	Robert Griffin	Redskins	2012	0.7271
16	Peyton Manning	Broncos	2013	0.7230

17	Drew Brees	Saints	2017	0.7205
18	Peyton Manning	Colts	2006	0.7178
19	Tom Brady	Patriots	2010	0.7135
20	Jimmy Garoppolo	49ers	2017	0.7124
21	Brian Hoyer	Bears	2016	0.7118
22	Matt Schaub	Texans	2011	0.7096
23	Derek Anderson	Panthers	2014	0.6991
24	Drew Brees	Saints	2009	0.6989
25	Philip Rivers	Chargers	2017	0.6969
26	Philip Rivers	Chargers	2013	0.6920
27	Colin Kaepernick	49ers	2012	0.6916
28	Dak Prescott	Cowboys	2016	0.6887
29	Drew Brees	Saints	2008	0.6875
30	Peyton Manning	Broncos	2012	0.6813
31	Kirk Cousins	Redskins	2016	0.6766
32	Michael Vick	Eagles	2013	0.6740
33	Philip Rivers	Chargers	2010	0.6711
34	Tom Brady	Patriots	2012	0.6707
35	Ben Roethlisberger	Steelers	2015	0.6706
36	Todd Collins	Redskins	2007	0.6667
37	Peyton Manning	Colts	2009	0.6630
38	Ben Roethlisberger	Steelers	2014	0.6614
39	Andy Dalton	Bengals	2015	0.6609
40	Tony Romo	Cowboys	2014	0.6559
41	Philip Rivers	Chargers	2008	0.6543
42	Aaron Rodgers	Packers	2010	0.6540
43	Chad Pennington	Dolphins	2008	0.6532
44	Russell Wilson	Seahawks	2014	0.6448
45	Brett Favre	Vikings	2009	0.6425
46	Jared Goff	Rams	2017	0.6404
47	Tom Brady	Patriots	2017	0.6384
48	Michael Vick	Eagles	2010	0.6360
49	Ben Roethlisberger	Steelers	2010	0.6295
50	Russell Wilson	Seahawks	2015	0.6288

Net Points Metric

Rank	Player	Team	Year	Net Points
1	Drew Brees	Saints	2011	243.662
2	Matt Ryan	Falcons	2016	231.383
3	Aaron Rodgers	Packers	2011	230.038
4	Peyton Manning	Broncos	2013	229.510
5	Tom Brady	Patriots	2011	228.138
6	Aaron Rodgers	Packers	2014	212.083
7	Tom Brady	Patriots	2007	209.521
8	Drew Brees	Saints	2008	208.035
9	Tom Brady	Patriots	2012	205.182
10	Drew Brees	Saints	2013	204.354
11	Kirk Cousins	Redskins	2016	202.321
12	Carson Palmer	Cardinals	2015	201.909
13	Ben Roethlisberger	Steelers	2014	201.124
14	Drew Brees	Saints	2016	196.027
15	Tom Brady	Patriots	2015	193.883
16	Alex Smith	Chiefs	2017	193.075
17	Drew Brees	Saints	2012	192.152
18	Peyton Manning	Broncos	2012	192.069
19	Philip Rivers	Chargers	2017	190.337
20	Peyton Manning	Colts	2006	190.141
21	Drew Brees	Saints	2015	189.979
22	Drew Brees	Saints	2017	188.074
23	Matthew Stafford	Lions	2011	187.607
24	Philip Rivers	Chargers	2013	187.179
25	Matt Schaub	Texans	2009	186.883
26	Philip Rivers	Chargers	2010	185.407
27	Eli Manning	Giants	2011	184.876
28	Tom Brady	Patriots	2017	184.489
29	Peyton Manning	Broncos	2014	183.295
30	Aaron Rodgers	Packers	2009	182.924
31	Matt Ryan	Falcons	2012	182.894
32	Philip Rivers	Chargers	2009	182.640
33	Aaron Rodgers	Packers	2016	180.901
34	Peyton Manning	Colts	2009	180.720
35	Russell Wilson	Seahawks	2015	179.269
36	Matt Ryan	Falcons	2014	179.260
37	Drew Brees	Saints	2014	178.348
38	Andrew Luck	Colts	2014	177.228
39	Tony Romo	Cowboys	2009	176.795

40	Russell Wilson	Seahawks	2014	176.377
41	Drew Brees	Saints	2009	176.307
42	Tom Brady	Patriots	2016	175.340
43	Robert Griffin	Redskins	2012	173.913
44	Tom Brady	Patriots	2009	173.558
45	Tom Brady	Patriots	2010	172.148
46	Drew Brees	Saints	2006	171.514
47	Jay Cutler	Broncos	2008	170.976
48	Peyton Manning	Colts	2010	170.913
49	Philip Rivers	Chargers	2015	169.345
50	Matthew Stafford	Lions	2016	169.240

Appendix B

Top 100 Highest Paid Quarterbacks by Season

Rank	Player	Team	Year	Cash Spent
1	Matthew Stafford	Lions	2017	$ 51,000,000
2	Joe Flacco	Ravens	2016	$ 44,000,000
3	Andrew Luck	Colts	2016	$ 44,000,000
4	Aaron Rodgers	Packers	2013	$ 40,000,000
5	Drew Brees	Saints	2012	$ 40,000,000
6	Philip Rivers	Chargers	2015	$ 37,500,000
7	Eli Manning	Giants	2015	$ 37,000,000
8	Ben Roethlisberger	Steelers	2015	$ 35,250,000
9	Russell Wilson	Seahawks	2015	$ 31,700,000
10	Matthew Stafford	Lions	2013	$ 31,500,000
11	Drew Brees	Saints	2016	$ 31,250,000
12	Tom Brady	Patriots	2013	$ 31,000,000
13	Cam Newton	Panthers	2015	$ 31,000,000
14	Matt Ryan	Falcons	2013	$ 30,000,000
15	Joe Flacco	Ravens	2013	$ 30,000,000
16	Tom Brady	Patriots	2016	$ 28,764,706
17	Ben Roethlisberger	Steelers	2008	$ 27,701,920
18	Matthew Stafford	Lions	2010	$ 26,900,000
19	Sam Bradford	Rams	2011	$ 26,845,000
20	Tom Brady	Patriots	2010	$ 26,500,000
21	Tony Romo	Cowboys	2013	$ 26,500,000
22	Philip Rivers	Chargers	2009	$ 25,556,630
23	Derek Carr	Raiders	2017	$ 25,175,000
24	Peyton Manning	Broncos	2013	$ 25,000,000
25	Kirk Cousins	Redskins	2017	$ 23,943,600
26	Cam Newton	Panthers	2016	$ 23,000,000
27	Jay Cutler	Bears	2014	$ 22,500,000
28	Matt Schaub	Texans	2012	$ 22,450,000
29	Jay Cutler	Bears	2009	$ 22,044,090
30	Drew Brees	Saints	2006	$ 22,000,000
31	Matt Ryan	Falcons	2014	$ 21,500,000
32	Joe Flacco	Ravens	2014	$ 21,000,000
33	Brock Osweiler	Texans	2016	$ 21,000,000
34	Eli Manning	Giants	2009	$ 20,500,000

35	Michael Vick	Eagles	2011	$ 20,000,000
36	Kirk Cousins	Redskins	2016	$ 19,953,000
37	Mitchell Trubisky	Bears	2017	$ 19,719,500
38	Eli Manning	Giants	2010	$ 19,500,000
39	Kurt Warner	Cardinals	2009	$ 19,004,680
40	Drew Brees	Saints	2015	$ 19,000,000
41	Peyton Manning	Broncos	2015	$ 19,000,000
42	Carson Palmer	Cardinals	2014	$ 19,000,000
43	Alex Smith	Chiefs	2014	$ 19,000,000
44	Jared Goff	Rams	2016	$ 18,968,308
45	Carson Palmer	Cardinals	2016	$ 18,500,000
46	Andy Dalton	Bengals	2014	$ 18,086,027
47	Carson Wentz	Eagles	2016	$ 18,050,972
48	Eli Manning	Giants	2016	$ 18,000,000
49	Peyton Manning	Broncos	2012	$ 18,000,000
50	Ben Roethlisberger	Steelers	2016	$ 17,750,000
51	Marc Bulger	Rams	2007	$ 17,502,040
52	Carson Palmer	Cardinals	2017	$ 17,500,000
53	Jameis Winston	Buccaneers	2015	$ 17,132,292
54	Matthew Stafford	Lions	2016	$ 17,000,000
55	Tony Romo	Cowboys	2015	$ 17,000,000
56	Matt Schaub	Texans	2009	$ 17,000,000
57	JaMarcus Russell	Raiders	2008	$ 16,872,400
58	Philip Rivers	Chargers	2016	$ 16,500,000
59	Mark Sanchez	Jets	2010	$ 16,455,000
60	Donovan McNabb	Redskins	2010	$ 16,387,500
61	Marcus Mariota	Titans	2015	$ 16,305,164
62	Tom Brady	Patriots	2006	$ 16,004,840
63	Jay Cutler	Bears	2016	$ 16,000,000
64	Brett Favre	Vikings	2010	$ 16,000,000
65	Mike Glennon	Bears	2017	$ 16,000,000
66	Michael Vick	Eagles	2012	$ 16,000,000
67	Peyton Manning	Colts	2010	$ 15,800,000
68	Matt Ryan	Falcons	2016	$ 15,750,000
69	Matt Ryan	Falcons	2017	$ 15,750,000
70	Carson Palmer	Bengals	2006	$ 15,750,000
71	Eli Manning	Giants	2014	$ 15,650,000
72	Jay Cutler	Bears	2015	$ 15,500,000
73	Alex Smith	49ers	2010	$ 15,050,000
74	Matt Cassel	Chiefs	2009	$ 15,005,200
75	Peyton Manning	Broncos	2014	$ 15,000,000

76	Andrew Luck	Colts	2012	$ 14,908,544
77	Cam Newton	Panthers	2011	$ 14,893,544
78	Mark Sanchez	Jets	2011	$ 14,725,000
79	Tyrod Taylor	Bills	2017	$ 14,500,000
80	Colin Kaepernick	49ers	2016	$ 14,300,000
81	Alex Smith	Chiefs	2016	$ 14,200,000
82	Robert Griffin	Redskins	2012	$ 14,189,344
83	Peyton Manning	Colts	2009	$ 14,005,720
84	Philip Rivers	Chargers	2017	$ 14,000,000
85	Philip Rivers	Chargers	2014	$ 13,800,000
86	Kevin Kolb	Cardinals	2011	$ 13,783,333
87	Blake Bortles	Jaguars	2014	$ 13,761,672
88	Cam Newton	Panthers	2017	$ 13,660,000
89	Eli Manning	Giants	2013	$ 13,500,000
90	Eli Manning	Giants	2017	$ 13,500,000
91	Tony Romo	Cowboys	2014	$ 13,500,000
92	Alex Smith	49ers	2006	$ 13,350,000
93	Aaron Rodgers	Packers	2017	$ 13,312,500
94	Alex Smith	Chiefs	2017	$ 13,300,000
95	Andy Dalton	Bengals	2017	$ 13,300,000
96	David Carr	Texans	2006	$ 13,255,940
97	Ryan Fitzpatrick	Bills	2011	$ 13,220,000
98	Vince Young	Titans	2007	$ 13,143,000
99	Colin Kaepernick	49ers	2014	$ 13,073,766
100	Drew Brees	Saints	2017	$ 13,000,000

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ACADEMIC VITA

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EDUCATION

The Pennsylvania State University, *University Park, PA*

Smeal College of Business, College of the Liberal Arts
Bachelor of Science in Finance, Bachelor of Science in Economics

- Participated as a teaching assistant for an upper-level economics course for two semesters
- Completed the Economics of Business and Law Course Module in the Department of Economics
- Recipient of The Catherine Schultz Rein Trustee Scholarship in the College of the Liberal Arts, The Mimi Coppersmith Renaissance Scholarship, and The McKeon Family Trustee Scholarship

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EXPERIENCE

The Hershey Company, Hershey, Pennsylvania — May 2018 – August 2018
Finance Intern

Interned in the Financial Data Systems department to aide in making the month-end financial close process more efficient, streamlined, and accountable by implementing BlackLine's account reconciliation and task management software to current SAP ERP and CFIN systems. While also participating in the monthly financial close activities and GAAP compliance for the Fortune 500 international organization

Global Tungsten & Powders Corporation, Towanda, Pennsylvania — May 2017 – August 2017
Finance/Accounting Intern

Major projects: led total plant fixed asset inventory audit of over $400 million in assets, conducted inventory cycle counts, capital purchase organization, updating multiple department's P&Ls, bill of material yield project, analysis and journal entries for employee purchasing cards, a presentation of overall internship experience and projects for various levels of management, and multiple other projects of varying sizes

ACTIVITIES

Trading Society of Penn State, *Member*	2017 - 2018
Penn State Economics Association, *Member*	2016 - 2018
Penn State Investment Association, *Member*	2016 – 2018
Penn State Student Red Cross Club, *Volunteer*	2016 - 2018
NY Penn Leadership Program, *Graduate*	2014 - 2015

SKILLS

Proficient in BlackLine Accounting Software, SAP, STATA, Bloomberg, FactSet, Microsoft Power BI, Word, PowerPoint, Outlook, and Excel

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Beta Gamma Sigma International Business Honor Society, *Lifetime member*
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