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Econometrics for Business

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Does Defense Still Win Championships?

Abstract:

Football has become a cornerstone of American culture. Over the last decade it has become the most popular spectator sport to watch. The sports attract men and women of all ages with its combination of high-speed contact, intensity, and variety of strategy. Salary cap limitations and players' short time in the league creates a constantly changing environment. Rules and regulations like the salary cap, draft seating, and player negotiations are created to keep teams from becoming monopolies and competition even. However teams like the Patriots and Seahawks have seemed to find ways to maintain successful organizations against these forces. While other teams like the Browns and Lions have been symbols for disappointing their fan bases over and over again.

So, is there an equation to success in the NFL, and is defense the key to championships? Well, I have always had some ideas as to what defines a losing and winning franchise in the NFL. This semester I had the opportunity to test my theory and see if there is an equation for success in the NFL.

Introduction:

"Defense wins Championships",- Paul 'bear' Bryant, has been a cliché saying in football sense the 60's. In my study I look to see how defense along with many other variables impacted winning %'s in last year's (2019) season. To do this I carefully selected variables based off research into what drives consistent success in an NFL franchise. I then created a data set with these variables and teams winning %'s in 2019 and 2018 as well.

2019 is an amazing season to analyze as football constantly changes and I feel past data doesn't help represent the constantly changing league. 2019 had an amazing group of teams built very different from each other. The season ended with a Superbowl show down between the league's best defensive team, The San Fransico 49er's, and the league's best offensive team, The Kansas City chiefs. In the end the Chiefs offensive proves too much for the 49er's and took the win. This sparked much controversy and conversation around the league. "Is defensive based team building dead?" many asked. Well I personally think not.

My study goes on to show that defense is a massive part in NFL performance still and that Defensive yards allowed alone explains 33% of the variability in NFL win/loss %.

Literature Review

The foundation of this study relied on a vast amount of research. I needed to find variables to compare with defense so I could better understand my findings. I have been a lifelong football fan but needed to separate my opinion from how I was going to select my data. Source 1 from bleacher report gave a good basis on the structure of data I had to incorporate. Studying general success must be focused on the organization as a total or the franchise rather than the team. This led to focusing on data from three levels of franchise operation: owners, coaches, and players. This study had to find metrics to include those at the top not just team or player stats. This would better help to see the effect of defense.

Source 2 or HBR ran a very good statistical model with a vast amount of panel data. This study was to see which parts of the organization had the most variance with team winning. They found that 11% came from the owners, 29.08% came from coaches, and 37.7% came from QB's. This gave me groundwork for how to organize data among the categories I previously talked about. Most was going to have to be focused on coach impact and the players category needed to be focused on the QB, with minor contribution of ownership data.

Source 3 gave me context on what decisions owners make that can impact the team. Owning a stadium has been a recent trend which allows teams to see higher cash flow into the organizations this money works its way down to the field, by hiring a more expensive middle office, intern impacting better performance on the field. Source 4 gave me a better understanding of which performance or player stats should be focused on.

Empirical Model & Data Description:

It is important to note that certain data on this topic was extremely difficult to find, due to teams trying to keep a competitive edge. With that said I structured the model to be focused on the thesis of "is defense still the key to championships?" so I decided to just use data from this past season as the game play and league have changed so drastically. So the data is structed as cross section data. This means we are looking at the difference in the variables selected for just the single time series (the 2019 season). I gathered data on 32 teams in the 9 variables I used, along with defense stats, to compare the differences.

The empirical model takes the form of:

Win %= f(dypg, oypg, offsal, dessal, qbsal, hcrank, stage, stown, pwin)

Where (win%) is the win % of each team from the 2019 season, (dypg) is the average defensive yards allowed per game of each team from 2019, (oypg) is the average offensive yards per game, (offsal) is the total amount of salary spent on offense, (dessal) is the total amount of salary spent on defense, (qbsal) is the salary spent on the qb, (hcrank) is the rank of each team's head coach ,with 1 being the best and 32 being the worst, (stage) is the stadium age of each team in the NFL, (stown) is whether the stadium is owned by the team or rented 1=owned 0=not owned, (pwin) is the past win % of each team in the 2018 season.

I would expect that dypg, offsal, hcrank, stage and pwin to have negative coefficients, while I would expect oypg, dessal and qbsal to have positive coefficients.

While the data was hard to find "Over The Cap" a fan page has kept record of many different team and player stats over the years. I used this source for all the data in my model due to the depth of their data. Links to the original data are posted below. As I mentioned the data is formatted into 32 teams with 9 variables each. The summary stats for this or data set are posted below

Table 1

Summary Statistics

Variable Name	Observations	Mean	Std. Dev.	Max	Min
win_	32	0.500281	0.198107	0.875000	0.125000
defsal	32	60384202	15084761	88857373	19196303
dypg	32	348.3938	34.26406	402.0000	275.6000
hcrank	32	16.50000	9.380832	1	32
offsal	32	67101768	17800004	1.03E+08	33988864
oypg	32	347.3531	37.67195	431.5000	273.0000
pwin	32	0.500219	0.180660	0.813000	0.188000
qbsal	32	15203160	9140028.	30000000	2120848.
stage	32	23.46875	20.46080	96.00000	0.000000
stown	32	0.218750	0.420013	1	0

The dependent variable in this study is each team's win %. The data for this variable also came from "Over The Cap". The math behind this value is rather simple it's the teams wins/total games played over the season.

The Key independent variable is Dypg. This stat as mentioned earlier is the average yards allowed by each team's defense over the course of all 2019 games. I felt this stat best represented defense performance because of the variability in schedules. If I relied on a point allowed per game metric for defense, teams with per say an easier schedule could scatter the

impact. This is because teams with weaker offenses generally have a tougher time scoring but not necessarily moving the ball. So, if a team had an easy schedule their defense could look better than it is by just analyzing points. With the variety of team building in the league I felt this was the best way to see a team's defensive performance.

Control variables were selected to represent the other 3 categories that are known to drive a team's success: Ownership, Coaching, Player skill. To measure the owners impact I used the most recent trend which would be owning the team's stadium and facilities. Many teams in the past have relied on taxpayer dollars to fund these, but these organizations lose a good chunk of the operating profits as a result. Owning the stadium results in more cash flow which trickles down into better ProFormance. I felt this was the best way to determine if owners are committed to improving their teams. For coaching I used the head coaching ranks to measure how each coach compares to other for impact to teams' players. I also used offense and defense salary totals to see how coaches built their teams. For player stats I used QB salary to determine how much of an asset teams had in there locker-room. If a team commits money to there QB it impacts available money for other positions.

RESULTS

Variables	Pannel A: Original Model									
Win%	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	
dypg	-0.0034 (-3.99)	-0.0031 (-3.96)	-0.0030 (-3.75)	-0.0026 (-2.57)	-0.0026 (-2.46)	-0.0021 (-2.08)	-0.0019 (-2.06)	-0.0019 (-1.75)	-0.0019 (-1.72)	
oypg		0.0019 (2.70)	0.0017 (2.08)	0.0017 (2.00)	0.0016 (1.88)	0.0013 (1.61)	0.0018 (2.25)	0.0019 (2.16)	0.0019 (2.12)	
offsal			8.36E-10 (0.47)	6.70E-10 (0.37)	7.71E-10 (0.40)	6.53E-10 (0.37)	1.55E-10 (0.09)	1.74E-10 (0.10)	1.67E-10 (0.09)	
defsal				1.81E-09 (0.79)	1.88E-09 (0.79)	8.73E-10 (0.40)	1.13E-09 (0.53)	1.29E-09 (0.47)	1.35E-09 (0.48)	
qbsal					-6.54E-10 (-0.21)	-6.01E-10 (-0.20)	1.47E-10 (0.05)	1.12E-10 (0.04)	5.72E-11 (0.02)	
Hc rank						-0.007378 (-2.35)	-0.005923 (-1.94)	-0.005892 (-1.88)	-0.006188 (-1.80)	
STage							0.002575 (2.02)	0.002598 (1.95)	0.002672 (1.92)	
STown								0.007637 (0.09)	0.006572 (0.08)	
Pwin%									-0.040121 (-0.23)	
obs	32	32	32	32	32	32	32	32	32	
Adj. R^2	0.33	0.44	0.43	0.42	0.40	0.49	0.54	0.52	0.50	
F-Stat (P-Value)	15.96 (0.00)	13.29 (0.00)	8.69 0.00	6.58 0.00	5.09 0.00	5.90 0.00	6.26 0.00	5.25 0.00	4.48 0.00	
Heteroskedascticity Test (White or BP)	0.17 (0.69)	2.35 (0.11)	3.66 (0.02)	2.63 (0.06)	2.72 (0.04)	2.46 (0.05)	2.20 (0.07)	2.01 (0.09)	1.64 (0.17)	
Serial Correlat-ion Test (DW Stat)	2.20	2.33	2.40	2.43	2.46	2.35	2.46	2.47	2.48	

The above results are for the original model and test for my equation. It shows the impact for the key independent variable, and then every other control variable added afterwards. I Highlighted in red a problem I had running the original model which was that all models except for three showed signs of Heteroskedasticity. To adjust for this, I rand these models again but adjusted for Heteroskedasticity. I posted these results below.

Variables	**Pannel B: Adjusted for Heteroskedasticity**									
Win%	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	
dypg			-0.003032 (-3.81)	-0.002575 (-2.59)	-0.002541 (-2.50)	-0.002038 (-1.94)	-0.001910 (-1.80)	-0.001864 (-1.55)		
oypg			0.001730 (1.49)	0.001679 (1.44)	0.001644 (1.44)	0.001319 (1.28)	0.001832 (1.91)	0.001853 (1.81)		
offsal			8.36E-10 (0.30)	6.70E-10 (0.23)	7.71E-10 (0.27)	6.53E-10 (0.22)	1.55E-10 (0.06)	1.74E-10 (0.07)		
defsal				1.68E-09 (1.08)	1.88E-09 (1.11)	8.73E-10 (0.49)	1.13E-09 (0.56)	1.29E-09 (0.46)		
qbsal					-6.54E-10 (-0.27)	-6.01E-10 (-0.25)	1.47E-10 (0.06)	1.12E-10 (0.04)		
Hc rank						-0.007378 (-2.25)	-0.005923 (-2.15)	-0.005892 (-2.10)		
STage							0.002575 (2.36)	0.002598 (2.26)		
STown								0.007637 (0.13)		
Pwin%										
obs										
Adj. R^2										
F-Stat (P-Value)										
Heteroskedascticity Test (White or BP)										

Serial Correlat-ion Test (DW Stat)										

These models support my hypothesis which was that defense still wins championships. The results show that every yard allowed has a (-0.002) impact on a team's win% for that season. Also important to note is the lag offensive yards produced has compared to defensive yards allowed. While the coefficients become more similar as more control variables are added, defense has a more negative impact than offense has a positive one.

The high amount of heteroskedasticity in the data is likely to be caused by the lack of data used and complexity of the comparison. Comparing defense salary to performance is expected to have issues due to some salaries being impacted by growing teams' debts and that just defense alone can't win games. What makes running an NFL team hard is the combination of offense and defense. However we can infer that a lack of defense is more significant than a lack of offense.

As said this model has many issues. The first is the lack of data available when it comes to crucial team decisions. Teams like to keep as much of their business behind closed doors as they can. This leads to data mining problems for complex comparison such as this. The complexity of NFL success is also an issue. Injuries plague teams every year and severely impact certain functions of teams. Hopefully overall spending metrics shows the teams financial intentions rather than just performance.

Regardless the overall complexity of the sport makes comparisons like this so difficult. The law of large numbers is also an important factor NFL prediction face. There are only 16 regular season games followed by 2-3 post season and then 1 Superbowl. Compared to hockey baseball of basketball were teams play upwards of 70 games in some situations. This lack of games leads to data representation issues as well.

Conclusion:

This study confirms my hypothesis that defense still wins championships. While the NFL has become flashier over the past 10-20 years, the consequence of not focusing on defense for offense in 2019 proved to be damaging. For every extra yard a team allowed on defense they averaged an impact of (-0.002) on their win loss %. While every extra yard gained on offense only generate an impact of (+0.0017) on teams win %. The purpose of this study was to see the impact of defensive yards allowed on teams' win %. Limitations faced during this study where the lack of data available, complexity of the comparison, complexity of the sport, and heteroskedasticity. These issues create much room for future research in this and similar topics. While offense may attract the fans' and spectator's attention, if it attracts too much of GMs', coaches' and Owners' attention; a team will lose more games.

Literature review Sources:

1.) https://bleacherreport.com/articles/276939-the-best-vs-rest-what-separates-the-consistently-good-from-their-peers

2.) https://hbr.org/2019/04/whos-the-most-important-member-of-an-nfl-franchise

3.) https://www.loeb.com/en/insights/publications/unused/the-changing-economics-of-sports-stadiums-and-ar__

4.) https://www.espn.com/nfl/story/_/id/20114211/the-nfl-stats-matter-most-2017-offseason-bill-barnwell

EVIEWS DATA:

Equation: (win_ c oypg dypg qbsal dessal offsal hcrank stage stown pwin)

Results :

WIN_ = 0.460331592089 + 0.00188277882167*OYPG - 0.00186419782623*DYPG + 5.72089496602e-11*QBSAL + 1.34803815828e-09*DESSAL + 1.66955235712e-10*OFFSAL -

0.00618814929782*HCRANK + 0.00267157451268*STAGE + 0.0065723969909*STOWN - 0.0401210434062*PWIN

Estimated Output:

Dependent Variable: WIN_
Method: Least Squares
Date: 12/12/20 Time: 19:02
Sample: 1 33
Included observations: 32

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.460332	0.636871	0.722802	0.4774
OYPG	0.001883	0.000886	2.124615	0.0451
DYPG	-0.001864	0.001087	-1.715353	0.1003
QBSAL	5.72E-11	2.95E-09	0.019416	0.9847
DESSAL	1.35E-09	2.83E-09	0.475977	0.6388
OFFSAL	1.67E-10	1.77E-09	0.094116	0.9259
HCRANK	-0.006188	0.003443	-1.797396	0.0860
STAGE	0.002672	0.001391	1.920330	0.0679
STOWN	0.006572	0.083076	0.079113	0.9377
PWIN	-0.040121	0.173219	-0.231620	0.8190

R-squared	0.647188	Mean dependent var	0.500281
Adjusted R-squared	0.502856	S.D. dependent var	0.198107
S.E. of regression	0.139682	Akaike info criterion	-0.848584
Sum squared resid	0.429246	Schwarz criterion	-0.390541
Log likelihood	23.57734	Hannan-Quinn criter.	-0.696756
F-statistic	4.484017	Durbin-Watson stat	2.475812
Prob(F-statistic)	0.001951		

Links for excel data

HC rank link : https://www.fantasypros.com/2020/05/nfl-head-coach-rankings-2020/

Qb sal link: https://overthecap.com/position/quarterback/2019/

Def Sal: https://overthecap.com/position/quarterback/2019/

Off sal: https://www.spotrac.com/nfl/positional/2019/offense/

GRAPHS:

Table 1

Summary Statistics

Variable Name	Observations	Mean	Std. Dev.	Max	Min
win_	32	0.500281	0.198107	0.875000	0.125000
defsal	32	60384202	15084761	88857373	19196303
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offsal	32	67101768	17800004	1.03E+08	33988864
oypg	32	347.3531	37.67195	431.5000	273.0000
pwin	32	0.500219	0.180660	0.813000	0.188000
qbsal	32	15203160	9140028.	30000000	2120848.
stage	32	23.46875	20.46080	96.00000	0.000000
stown	32	0.218750	0.420013	1	0

Table 2 Durbin Watson: dL=(0.674) dU=(1.995)

Variables	**Pannel A: Original Model**									
Win%	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	
dypg	-0.0034 (-3.99)	-0.0031 (-3.96)	-0.0030 (-3.75)	-0.0026 (-2.57)	-0.0026 (-2.46)	-0.0021 (-2.08)	-0.0019 (-2.06)	-0.0019 (-1.75)	-0.0019 (-1.72)	
oypg		0.0019 (2.70)	0.0017 (2.08)	0.0017 (2.00)	0.0016 (1.88)	0.0013 (1.61)	0.0018 (2.25)	0.0019 (2.16)	0.0019 (2.12)	
offsal			8.36E-10 (0.47)	6.70E-10 (0.37)	7.71E-10 (0.40)	6.53E-10 (0.37)	1.55E-10 (0.09)	1.74E-10 (0.10)	1.67E-10 (0.09)	
defsal				1.81E-09 (0.79)	1.88E-09 (0.79)	8.73E-10 (0.40)	1.13E-09 (0.53)	1.29E-09 (0.47)	1.35E-09 (0.48)	
qbsal					-6.54E-10 (-0.21)	-6.01E-10 (-0.20)	1.47E-10 (0.05)	1.12E-10 (0.04)	5.72E-11 (0.02)	

Hc rank						-0.007378 (-2.35)	-0.005923 (-1.94)	-0.005892 (-1.88)	-0.006188 (-1.80)	
STage							0.002575 (2.02)	0.002598 (1.95)	0.002672 (1.92)	
STown								0.007637 (0.09)	0.006572 (0.08)	
Pwin%									-0.040121 (-0.23)	
obs	32	32	32	32	32	32	32	32	32	
Adj. R^2	0.33	0.44	0.43	0.42	0.40	0.49	0.54	0.52	0.50	
F-Stat (P-Value)	15.96 (0.00)	13.29 (0.00)	8.69 0.00	6.58 0.00	5.09 0.00	5.90 0.00	6.26 0.00	5.25 0.00	4.48 0.00	
Heteroskedascticity Test (White or BP)	0.17 (0.69)	2.35 (0.11)	3.66 (0.02)	2.63 (0.06)	2.72 (0.04)	2.46 (0.05)	2.20 (0.07)	2.01 (0.09)	1.64 (0.17)	
Serial Correlat-ion Test (DW Stat)	2.20	2.33	2.40	2.43	2.46	2.35	2.46	2.47	2.48	

win_ c dypg oypg offsal dessal qbsal hcrank stage stown pwin

Table 3 : same thing just adjusted for hetero or serial correlation

Variables	**Pannel B: Adjusted for Heteroskedasticity**									
Win%	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	
dypg			-0.003032 (-3.81)	-0.002575 (-2.59)	-0.002541 (-2.50)	-0.002038 (-1.94)	-0.001910 (-1.80)	-0.001864 (-1.55)		
oypg			0.001730 (1.49)	0.001679 (1.44)	0.001644 (1.44)	0.001319 (1.28)	0.001832 (1.91)	0.001853 (1.81)		
offsal			8.36E-10 (0.30)	6.70E-10 (0.23)	7.71E-10 (0.27)	6.53E-10 (0.22)	1.55E-10 (0.06)	1.74E-10 (0.07)		
defsal				1.68E-09 (1.08)	1.88E-09 (1.11)	8.73E-10 (0.49)	1.13E-09 (0.56)	1.29E-09 (0.46)		

qbsal					-6.54E-10 (-0.27)	-6.01E-10 (-0.25)	1.47E-10 (0.06)	1.12E-10 (0.04)		
Hc rank						-0.007378 (-2.25)	-0.005923 (-2.15)	-0.005892 (-2.10)		
STage							0.002575 (2.36)	0.002598 (2.26)		
STown								0.007637 (0.13)		
Pwin%										
obs										
Adj. R^2										
F-Stat (P-Value)										
Heteroskedascticity Test (White or BP)										
Serial Correlat-ion Test (DW Stat)										

Table 2

Main Results

Variables	**Original Models**				**Adjusted for Heteroskedasticity or Serial Correlation**			
Y	Model I	Model II	Model III	Model IV	Model I			Model VIII
X1	-1.34*** (-67.16)	-1.21*** (-5.38)	-0.04** (-2.03)	0.45 (1.34)	-0.12 (-2.90)			
X2		-0.06***	-0.32***	-0.32***				

		(-6.62)	(-3.10)	(-3.10)				
X3			1.11* (1.89)	1.11* (1.89)				
X4				-5.59** (-2.05)				
Obs	367	359	344	344				
Adj R^2	0.49	0.57	0.63	0.70				
F-stat (p-value)	10.58 (0.00)	58.48 (0.00)	12.24 (0.00)	15.15 (0.00)				
Heteroskedasticity Test (White or BP)	4.13 (0.04)	1.19 (0.31)						
Serial Correlation Test (DW Stat)	1.94	1.83						