Insper Instituto de Ensino e Pesquisa

Economics

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The Purple Loss Effect:
Contracts inside the world's most dangerous game

São Paulo, Brazil

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The undergraduate thesis presented as a course conclusion and requirement to obtain the Bachelor of Science, Major in Economics at Insper.

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Abstract

The objective of this article is to test and estimate the effect of injuries on NFL players' contracts, named the Purple Loss Effect. Following studies like Secrist, Bhat & Dodson (2016), who show shreds of evidence about decreasing compensations for players after suffering injuries, this one brings three econometric models, using panel data on all players from the 2011-2019 seasons, that highlight the existence of positional value, the negative relationship between injuries and cap hit, and analyze injury-risk effect by position.

Keywords: NFL, Salary Cap, Injury, Contracts, Players, Economics, Sports, Purple Loss Effect.

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Summary

1. CONTEXT

It isn't difficult to imagine that 300 lbs lineman rushing and hitting each other would lead to some casualties. Or that a 6-foot-1 wide receiver in motion to receive a pass won't always be able to evade the tackle from the 200 lbs cornerback. And how not to be nervous when a quarterback is sacked from his blindside?

The fact is: football and injuries are things that come with one another. Some even say injuries in football are a necessity because if the players' risk isn't real, there is no heroism (Brand NFL, Michael Oriard). But the risk can be as real as it can get – and it is not from recent days.

Injuries in professional football go as back as the game does and Michael Oriard's book – the one that said football needs injuries – brings plenty of good examples. An informal study conducted by Len Teeuws, a former NFL player, gathered data from players who played between 1921 and 1959 and found an average life expectancy of 61 years. In 1986, *Sports Illustrated* called out the NFL for an "injury plague" because of the high number of starters missing games before the half of the season. In 1988 *Los Angeles Times* found that 78% of 440 retired players (in a survey) suffered from football disabilities. Also in 1988, football was ranked 247th of 250 occupations by *Jobs Rated Almanac*, based on working conditions, income and security. Later in 2001, *Sports Illustrated* examined seven retired players, including big stars such as John Unitas, and found even more shocking results: Unitas ("the greatest passer of his time") had no control over his hand. Other players could barely walk or bend over.

The NFL and injuries' long-lasting relationship has even reached the screens in 2015 with the Golden Globe awarded movie *Concussion*, in which Will Smith plays Dr. Bennet Omalu, forensic pathologist and the first one to discover and publish findings on CTE (Chronic Traumatic Encephalopathy). The movie is a dramatized version of the true story of a concussion lawsuit against the NFL.

Given the level of risk involved, one could expect that injured players would review their career choices and regret playing football. So, we go back to *Brand NFL* for examples. *Sports*

Illustrated in 2001: only one of the seven players admitted changing their minds on playing in the NFL if he had known how he would end up. More than that, another survey from *Newsday* showed that up to 90% of players – in which 66% reported permanent injuries – would stick with the decision of playing football. With all of this said, how can monetary incentives keep players in the NFL rather than looking for other – safer – jobs? Maybe the players, by putting themselves at risk, are getting a higher reward (higher salaries).

Players' salaries in the NFL, in contrast to injuries, have "not been around" since the beginning as they are today. The Heisman Trophy winner (best college football player) and first-ever player taken in the NFL Draft in 1936, Jay Berwanger, never played in the NFL. Neither did Larry Kelly and Clint Frank, the next two Heisman Trophy winners. As rare as it can be today, turning down a pro contract at that time wasn't uncommon. Wilner and Rappoport's book (*On the Clock: The Story of the NFL Draft*) brings Berwanger's own words on why he didn't sign with the NFL: *"I really wasn't interested in pro ball. They weren't paying any money, something like $100 a game."*. The first Heisman to sign a pro contract was Davey O'Brien in 1939, but he played for only two years before leaving for a career in the FBI.

But the NFL has gone a long way since the 1930s – and so have the contracts. The change didn't occur randomly, in fact, it was driven by different factors such as rival leagues like the AFL in the 1960s and player strikes in the 80s. According to the *Los Angeles Times*, the average NFL player earned about $2.7 million in 2017. Furthermore, 31 NFL players are on Forbes' top 100 highest-paid athletes list for 2020 (with two on the top 10). Football is also the second sport with the most names on the list (only behind basketball).

Nevertheless, if we take into account a player's position on the field, it's a whole different story. On the top 25 of Forbes' list, every player from the NFL is a quarterback. According to *Spotrac*, average salaries per position can go from as high as $4.9 and $3.6 million, for quarterbacks and left tackles, to as low as $1.1 and $1.6 for fullbacks and running backs (excluding special teams positions, that average together $1.4 million).

It's even more interesting if we cross the position's average salary with the player's average length of NFL career or injury risks. The running back position is second last in salaries but last in career length, averaging next to 2.5 years according to Career Trend (2018). Following the RB position in shortest career lengths are wide receivers and cornerbacks, whom both average around $1.9 million in salary. Besides, Zach Binney's article about NFL injuries (Football Outsiders, 2015) shows that there are three tiers of positions when it comes to injury risk. Right at the first tier are running backs, wide receivers, and defensive backs (also linebackers and tight ends). With that said, it probably isn't a surprise that these positions stand last at career length. But how about their average salaries? Is injury directly related to a player's compensation?

2. INTRODUCTION

Football is a risky sport. Therefore, NFL players are known to be injury prone. So, one can imagine that the drive to play the world's most dangerous game comes from high incentives, more specifically: high monetary incentives. The League's athletes signing huge contracts is now considered routine, but the first NFL million-dollar contract came only in 1980 – with Lam Jones, who signed with the Jets for $2.1M. Although contracts have come a long way – reaching up to $500 million over ten years, like the one Patrick Mahomes signed in 2020 – some positions still get paid a lot less than others. With that said, do salaries and injuries relate to each other and affect NFL players' contracts? Does it have a positional effect?

An NFL franchise is worth more than $3 billion and has $477 million of revenue, on average, according to *Forbes*. And among the top-15 most valuable teams, only one (Houston Texans at No. 9) has never won the Super Bowl. On the top-5, all have won more than once. These values come with winning. The NFL as a league is profitable as well. Football games represent 41 out of the 50 most-watched programs on TV in 2019, making national media rights deals average somewhere around $15 billion a year. Thus, teams want to win, and the NFL wants to be entertaining. However, there is the salary cap, a limit on the total amount that a team can spend on players' salaries, and also a way of maintaining competitive balance on the league – entertainment. To win, teams need good players, and good players ask for high wages. So, when signing a player, a general manager needs to consider (among other variables) if the player will stay healthy. Because if he gets injured, there is a cost in terms of cap space and production for the team.

Past studies have approached both NFL salaries and injuries. Leeds and Kowalewski (2001) studied how players' compensations are affected by the salary cap and free agency, focusing on skill positions. There are also studies, like Richard Borghesi (2008), that found out teams with a more equal payroll distribution perform better, on average. And on the injuries side, there are numerous articles, but most of them from a medical perspective. Some analyze the impact on the field, as does Jones in *Injuries and home advantage in the NFL* (2016), where he looks at a decrease in home advantage after "the new consciousness regarding the long-term consequences of concussions in football". There are close to no studies connecting salaries to injuries, but those that

do will be very important for this study. In particular, an article from the Orthopaedic Journal of Sports Medicine called *The Financial and Professional Impact of Anterior Cruciate Ligament Injuries in National Football League Athletes* (2016), that tried to quantify the impact of ACL injuries on salary and career length.

This paper will focus on understanding how injuries can help explain or affect players' salaries. Moreover, it will also separate players by position, to see if the average positional salary is affected and how can it differ from one position to another. An analysis like this one can help understand the salary gap between certain positions, or even question if they are overvalued or undervalued in terms of compensation.

3. LITERATURE REVIEW

This section will cover three important topics for this study, looking at past academic contributions on each of them. It will start with player positions, followed by salaries. Then, it will show where the consensus stands about injuries and their effects.

There are more than ten positions on the field, divided into three groups: offense, defense, and special teams. As it is said in Leeds and Kowaleski (2001), football players from different positions cannot be compared, unlike other sports. So, in their paper, the authors employ separate regressions for each skill position – they only analyze skill positions –, obtaining far more reliable results than when looking at all players as a single group. They found that players are rewarded more for the position they play rather than how well they play it, reinforcing the idea of dividing them per position. Zach Binney (2015) for *Football Outsiders* is yet another study that shows the difference between positions, as he lists with three tiers of position groups when it comes to injury risk.

NFL salaries are probably the academy's favorite topic to tackle. To understand what variables comprise a player's salary, it is important to look at these studies and build information based on what was already observed. The model for Leeds and Kowaleski (2001), for instance, focuses on salary. And as mentioned previously, the position is a really important component. However, that is different for lower-paid players, who can increase their salary by focusing on some performance categories (pass yardage for quarterbacks, rushing yardage for runningbacks, receiving yardage for tight ends, and the number of receptions for wide receivers). Borghesi (2008) also finds a significant relation between compensations and productivity (performance on the field). Draft pick and experience are two more variables that he finds to be important. Additionally, he points out that teams that compensate their players most inequitably, regardless of fairness, perform the worst. Another thing to take into consideration.

Finally, the media and fans' "favorite": injuries. Secrist, Bhat & Dodson (2016), by comparing salaries of players who suffered ACL injuries – one of the most common in football – to healthy players, found a considerable difference, highlighting the existence of a relation. But

other papers, like Borghesi (2008), for example, already had their model injury-adjusted. Jones (2016) brings up a different point-of-view on how injuries can impact performance (indirectly affecting salary): teammates' defensiveness increases with more names on the team's injury list. In general, it is a consensus among past studies that injuries have different effects on player's compensations, but few are the studies that focus on the specific relationship between the two topics and dive deep to get to the results. Even the former mentioned that brings interesting results, keeps it simple by being mainly descriptive.

The objective of this study is to dive deep. It is to understand how injuries are (or not) an important contributor to the composition of a player's salary. And discuss why it should or should not be. To get there the best way possible, a new model will take into account what past studies have found. That will be done in the following sections, where the theory and methodology behind it are presented and explained.

4. THEORY

After introducing the topic and reviewing past studies around it, this study will come up with a brand-new model, which will try to explain injury's effect on NFL players' salaries. But before getting there, it is crucial to clarify and explain why and how it was built, step by step. That is what this section is about.

As mentioned previously, a General Manager's goal is to win. And one of the – if not the – main components of a winning team is its roster[1]. However, differently from most sports, the NFL has limits when it comes to players, the main one being the Salary Cap.

> The Salary Cap, instituted as part of the 1993 CBA[2], was essentially designed as an accounting system that would be applied to NFL Players. Each team was allotted an equal budget of salary cap dollars (unadjusted team cap) that could be spent, in a given year, on players. (FITZGERALD; NATARAJAN, 2016)

Roster building, as a result of the adoption of the cap, happens to be a very important part of a succesful franchise. So, when signing players, GMs must consider more than just their performance on the field, which is probably the first thing that comes into our minds, and the first variable to enter the equation.

Performance can easily be seen as an important part of a player's contract by any casual sports fan, as good player performances increase a team's chance to win. Additionally, NFL contracts are normally structured with performance-based incentives that count towards the cap at the beginning of the current season (if initially considered LTBE[3]) or at the beginning of the following one (in cases of a player achieving an NLTBE[4] or not achieving LTBE incentives). As if the number of pieces of evidence was not enough, Section 3 brought up how past studies have

[1] The official manifest of players on the team
[2] Collective Bargaining Agreement – Labor agreement between the NFL and NFLPA (NFL Players Association)
[3] Likely To Be Earned
[4] Not Likely To Be Earned

found significant results reinforcing the positive relationship between *performance* and compensation (LEEDS; KOWALEWSKI, 2001); (BORGHESI, 2008).

One of the key events for any NFL season is the Draft. That is when franchises take turns selecting the best prospects from College Football. And from it, comes a group of variables that will be part of this study. The first thing to look at is if the player was drafted or not. There are big differences in how the contracts are structured between those two situations. A drafted player's contract is 4-year long – first rounders have 5th-year options – and its value varies according to how high or how low he was selected in the draft. On the other hand, all UDFAs[5] sign the same 3-year contract, with the only difference between them being a signing bonus and guaranteed money. Also, the bonus is limited to a certain amount of available money for all UDFAs signings collectively. The second thing to look at, since rookie contracts are anchored by the player's "draft status", is if players are still under their rookie contract or not. These regulations, combined with past findings, show how *rookie contract*, and *drafted/undrafted* can be important variables to explain salary.

One of the signatures of Football as a sport is the specialization of players, who have their roles on the field specifically defined, leading to differences in skills and physical attributes between positions, making it very difficult to compare players from different groups. For example, how can a quarterback, who drives the offense and throws passes, be directly compared to a defensive lineman, who holds the line to help the defense chase the ball carrier? These differences reflect on different values off-field, with teams paying players based mainly on the position (role) they play, over how well they perform (LEEDS; KOWALEWSKI, 2001). Therefore, *position* is another factor to be considered.

After listing several important parts for any NFL salary-based model, it is time to explain how injuries, which is the focus of this study, are a part of this mix. Injuries can prevent a player from performing well, or even from playing, impacting a team's chance to win. That can happen directly, by simply not having a key player available (or having that player at under 100%), or indirectly, by an increase in teammates' defensiveness with more names on the team's injury list

[5] Undrafted Free Agents

(JONES, 2016). Also, teams prefer to allocate their resources to players who are less likely to miss time, rather than the ones more likely to. That can be emphasized by simply comparing salaries from players who suffered ACL injuries to those who did not (SECRIST; BHAT; DODSON, 2016). Injuries even vary by position, with some being more likely to get injured than others (BINNEY, 2015).

Altogether, these factors can explain a player's cap number, and also help understand how injuries affect it. Most likely, when controlled by this list of variables, an increase in injuries will lead to a decrease in a player's salary cap hit.

5. DATA & METHODOLOGY

This section will be divided into four subsections. It will begin with a summary of how the database was created and where did each piece of information come from. That will be followed by the presentation of a descriptive analysis of the data, to create familiarity and an understanding of what was used to drive this study. Then, describe the econometric models and their results. The following section will develop a more in-depth analysis and discussion of the findings.

5.1 Database

The database for this study contains information on all NFL players from 2011 through 2019, including draft info, performance statistics, injury listings, and financials. Draft information and performance statistics were found on Stathead, a sports statistics research tool from Sports Reference, appointed by Charean Williams (sportswriter for NBC Sports) as "one of the greatest inventions ever". Data regarding injuries were directly provided by Aaron Schatz, attributed as "founding father of football analytics" by *The Ringer*, creator of statistical methods DVOA and DYAR, writer for ESPN.com and *ESPN+*, and founder of Football Outsiders, a well-known site for in-depth football statistical analysis. Lastly, financial data came from Spotrac, one of the largest resources for sports contracts on the internet.

5.2 Descriptive

This database is consisted of 16,642 observations on 7,409 different players, throughout nine years. There are also nine possible position groups players can be attributed to: defensive back (DB), defensive lineman (DL), fullback (FB), linebacker (LB), offensive lineman (OL), quarterback (QB), running back (RB), special teams (ST), tight end (TE), and wide receiver (WR). To simplify, some positions were grouped into one of these categories, no positions were disregarded – cornerbacks and safeties were listed as DBs, for example. *Table 1* on the next page illustrates how this data is distributed, by listing observations per year, for each position. It is noticeable that there is very little variation within the same positions through time, indicating no great changes to the composition of the NFL in terms of players for the given period.

Table 1 - Total observations per Year and Position

	Position									
Year	DB	DL	FB	LB	OL	QB	RB	ST	TE	WR
2011	306	248	26	242	268	76	120	93	102	188
2012	355	289	38	282	326	78	143	101	120	219
2013	341	261	37	268	310	80	134	95	114	194
2014	357	289	32	280	328	84	133	102	114	203
2015	349	273	27	279	307	81	130	100	121	207
2016	355	272	22	282	309	81	134	97	115	208
2017	344	276	21	278	318	83	131	102	127	205
2018	355	274	18	248	318	75	129	102	126	205
2019	343	281	21	236	292	74	120	96	118	201
Total	3,105	2,463	242	2,395	2,776	712	1,174	888	1,057	1,830

Source: Own elaboration based on data from Stathead Football (2020)

An interesting number, when looking at players, is the drafted or undrafted ratio. Out of the 7,409 players observed, only 2,125 were selected by a team in the NFL Draft. That means that 71.3% of all athletes who played between 2011-2019 started as UDFAs. This surprisingly high number can't and won't be left aside, as it was mentioned in the previous section, *drafted/undrafted* will be taken into consideration to get more reliable and interpretable results.

For performance, *games played* and *games started* were used to calculate the *starter percentage* for each player, by simply finding the ratio between the two of them (*games played/games started*). To measure player contribution: Approximate Value (AV), created by Pro Football Reference founder Doug Drinen as an attempt to accredit a single number on the seasonal value of a player at any position from any year (Pro Football Reference, 2008).

> AV is not meant to be a be-all-end-all metric. Football stat lines just do not come close to capturing all the contributions of a player the way they do in baseball and basketball. If one player is a 16 and another is a 14, we can't be very confident that the 16AV player actually had a better season than the 14AV player. But I am pretty confident that the collection of all players with 16AV played better, as an entire group, than the collection of all players with 14AV. ("Approximate Value» Pro-football-reference.com blog," 2011)

As discussed before, it is very difficult to compare different positions in Football. And so, positions will still be looked at individually at the beginning, when it comes to analyzing results (this will be developed in the next section). However, when it comes to performance statistics, the Approximate Value method is a great way of simplifying without losing any credibility. Instead of selecting one or a couple of stats for each position by hand, the AV already includes every important aspect of a player's contribution on the field, no matter what position he plays in. Also includes Pro Bowls[6] and First-team All Pro[7] selections, therefore there was no need on having them as separate variables.

Regarding injuries, the data comes from the Adjusted Games Lost (AGL) by the Football Outsiders. This method can help quantify how much teams are affected by injuries, or how a player is affected by them. AGL uses the historic values for players missing time given a particular injury status (such as questionable, doubtful, probable) and start/reserve role on a six-point scale.

$$AGL = 6 * (1 - percentage\ of\ the\ time\ a\ player\ suited\ up)$$

[6] All-star game of the NFL
[7] Honor that designates the best player at each position for the given season

Table 2 – Participation baselines for AGL calculation (2016-2019)

	Starters, situational reserves, new starters		Reserves	
Status	DNP[8] Rate	Used	DNP Rate	Used
"Blank" / Probable	2.1%	0.02	16.8%	0.17
Questionable	27.1%	0.27	47.2%	0.47
Doubtful	99.0%	0.99	98.5%	0.99
Out	99.9%	1.00	99.9%	1.00
IR[9]	100.0%	1.00	100.0%	1.00
NFI[10]	100.0%	1.00	100.0%	1.00
PUP[11]	100.0%	1.00	100.0%	1.00

Source: Football Outsiders Injury Database (2020)

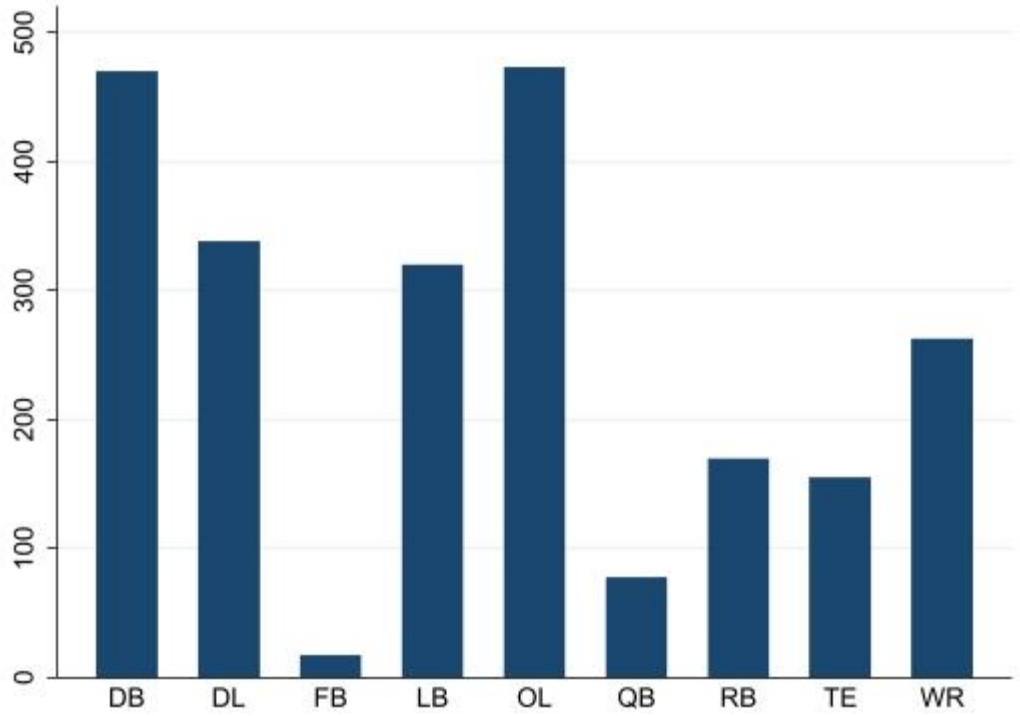
For example, a starter listed as doubtful is expected to miss action 99% of the time, so his AGL would be 5.94. For this study, the sum of AGLs for all players from a position in a season was denominated total AGL. When divided by total games played by players in that position, it is labeled as Injury Risk. The following charts illustrate how positions compare.

$$tAGL_{position,season} = \sum AGL_{i,position,season}$$

$$InjuryRisk_{position,season} = \left(\frac{tAGL}{total\ games\ played}\right)_{position,season}$$

[8] Did Not Play
[9] Injury-Reserve is a slot teams have to stash players with major injuries and will be out for a long period
[10] Non-Football Illness
[11] Physically Unable to Play

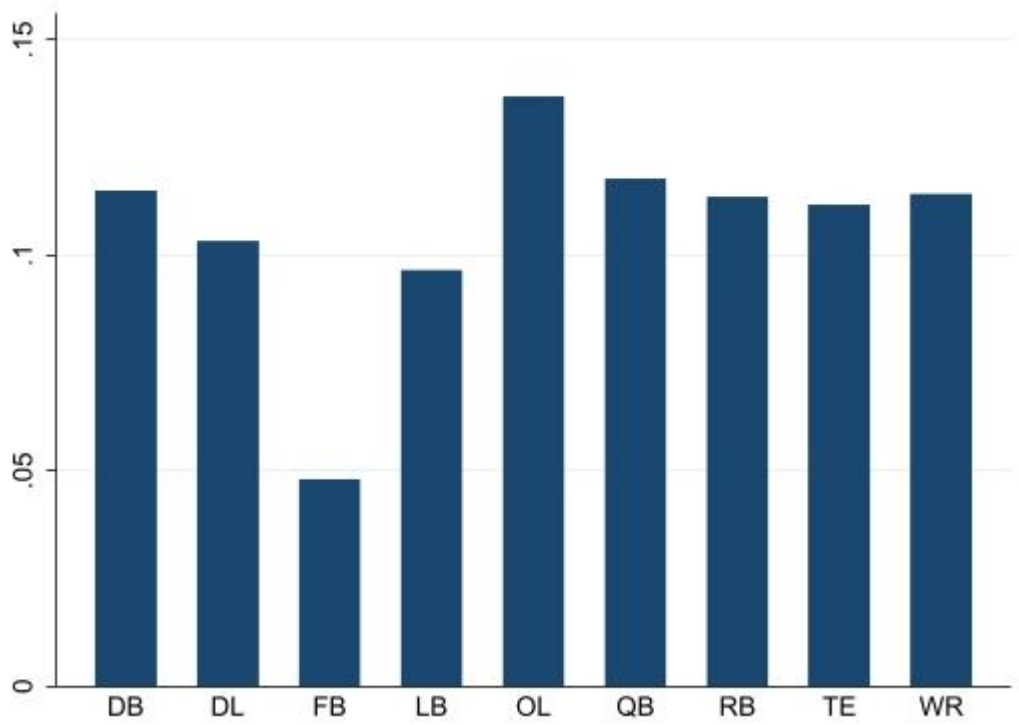
Chart 1 – AGL per Position (Season average)



Source: Own elaboration based on data from Football Outsiders Injury Database

This chart comes with a lot of information. First, it reinforces how positions are uniquely characterized, even in terms of injury-suffering. That means the observed injury risk is strongly dependent on the position the individual plays in – special teams don't have their AGL accounted for, as they play isolated roles in specific parts of the game, lowering their injury-risk significantly. With some help from *Table 1* the positions can be divided into two groups: those with more than 2,000 players, and those with less. The chart shows, for the first group, OLs and DBs as clear leaders. RBs, TEs and WRs are at the top for the other group. Looking back at Zach Binney's article where he tier-listed positions for injury-risk (Football Outsiders, 2015), defensive backs, running backs, wide receivers, and tight ends were, indeed, part of the first tier. The next chart brings the seasonal average for what this study calls Injury Risk. With the same positions at the top, the only difference from what was seen before is the quarterback position at the top. Most likely due to the low number of games played, as players from this position are not as interchangeable as others can be.

Chart 2 - Injury Risk per Position (Season average)

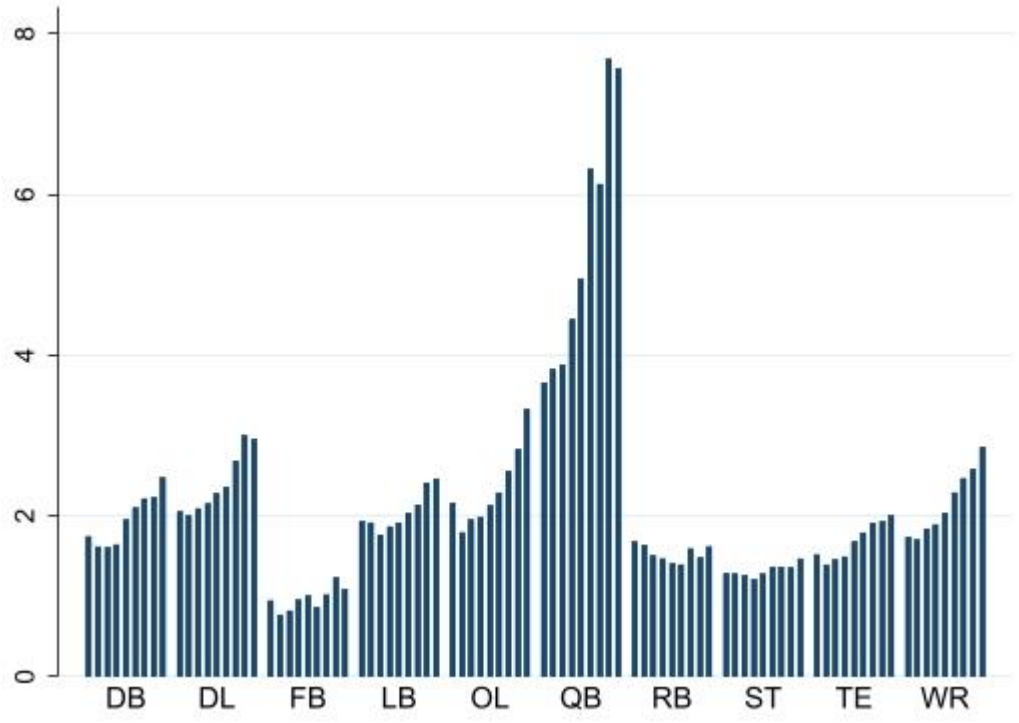


Source: Own elaboration

Now, looking at financials, will these "most likely to get injured" still be at the top of the list? Before answering that question, the main financial variable that this study will be looking at: *salary cap hit*, must be explained. A player's contract in the NFL is composed of a list of different earnings, incentives, and bonuses, such as the LTBE and NLTBE mentioned earlier. But each part of the contract is paid at different moments and count towards the salary cap in a specific way. So, instead of looking at the P5 Base Salary[12] and possibly not taking into consideration the typical maneuvers made in NFL contracts to navigate the salary cap – like huge bonuses and a smaller base salary, for example – this study will look at the *salary cap hit* for each year. By doing so, the study will be looking at the "true value" the team attributes to the player, knowing that in this case, the salary cap is what matters the most – and not the actual paid amount. *Chart 2* illustrates that value, on average, over the years.

[12] The base salary a player receives for a given season paid on a weekly or bi-weekly basis

Chart 3 - Average salary cap hit (MM) per Year and Position (2011-2019)



Source: Own elaboration based on data from Spotrac

The NFL Salary Cap has grown every single year between 2011 and 2019, a 56.8% surge from $120 million to $188.2 million, so an increase in players' average salary cap hit is a fair expectation. And, from 2011 to 2019, salary cap averages have risen for most positions. However, the only two positions to match that number are QBs and WRs, with 106.8% and 64.3% increases. Interestingly, WRs find themselves in a really good position, even though they were at the top of the injury list. Running backs, on the other hand, also first tier for injury risk, have not seen the same trend. Instead, they have seen a 3.1% drop. Not only that, but they also stand as one of the lowest cap averages among all positions, down with fullbacks and special teams. Tight end is another position high ranked for injuries that sit low on the value list, only one spot ahead of RBs for the average cap hit. Defensive backs are right in the middle, sitting at fifth place for both average salary cap hit and percentage increase throughout the years.

In closing, a more isolated look at salary cap numbers can help us get a better hold of how this variable behaves.

Table 3 - Summary: Salary Cap Hit ($)

	Mean	Median	Std. Dev.	Min.	Max.
Salary Cap Hit	2,219,025.00	760,000.00	3,182,436.00	1,500.00	37,000,000.00

Source: Own elaboration

The table indicates how high differences between contracts can be. Probably the most shocking is the fact that most of the players' earnings are below average, more notably the 75% percentile is around $2.5M, showing how the mean is influenced by the "exception" (incredibly high numbers at the top), rather than by the "rule" (with 50% of the players earning between $500 thousand and $2.5 million). Another number that catches our eyes is the minimun, at only $1,500. That number comes from an atypical situation: Andrew McDonald, who went undrafted in the 2012 NFL draft, signed a low-valued contract, and later was diagnosed with cancer. On the other side, the top contract hit belongs to Jimmy Garoppolo in 2019, QB for the San Francisco 49ers, who led the team to Super Bowl 54 that year – which they ended up loosing to the Kansas City Chiefs of Patrick Mahomes.

5.3 Econometrics

Every regression is from panel data and every model is random effects. The choice of using random effects, rather than fixed, was due to the various sub-groups players can be categorized in, from NFL players, to their positions, starter or reserve, drafted or undrafted, good and not so good, and so on. These groups are most likely differently distributed and, therefore, should not be estimated independently.

They will all have the same variable as its outcome: the player's salary cap hit. Also, the same group of control variables is used: Average Value, starter percentage, and dummies for: rookie contract, undrafted players, and years. The first regression model is described below.

$$SalaryCapHit_{it} = \beta_0 + \sum_{k=1}^{8} \beta_k \, dPosition_{k,it} + \beta_9 \, AV_{it} + \beta_{10} \, Starter_{it} + \beta_{11} \, dRookieContract_{it} + \beta_{12} \, dUndrafted_i + \sum_{y=13}^{8} \beta_y \, dYear_{y,it} + u_{it}$$

This is the least injury-specific out of all three, not including any variable directly related to injuries. However, β_k captures the effect player positions have on their salary cap hit. And that is, in a sense, the first step into looking at how injuries affect contracts, as it has been shown previously how injury risk is drastically attached to the position played in. In this manner, for the second regression model, positional dummies are replaced by total AGL – each player receives the total AGL of the respective season for its position.

$$SalaryCapHit_{it} = \beta_0 + \beta_1 \, tAGL_{it} + \beta_2 \, AV_{it} + \beta_3 \, Starter_{it} + \beta_4 \, dRookieContract_{it} + \beta_5 \, dUndafted_i + \sum_{y=6}^{9} \beta_y \, dYear_{y,it} + u_{it}$$

Now, it includes a variable directly related to injuries. So, by capturing total AGL's effect, β_1 will represent injury's effect on salary cap hit. However, there is a caveat which concerns the validity of the results: *tAGL* is not taking the variation of the number of players between positions into consideration. That does not mean this step is dispensable, as it indicates if injuries have indeed any effect. That is why there is one more model, where total AGL is replaced by Injury Risk, which takes into consideration games played – therefore the number of players is also incorporated implicitly.

$$SalaryCapHit_{it} = \beta_0 + \beta_1 \, InjuryRisk_{it} + \beta_2 \, AV_{it} + \beta_3 \, Starter_{it} + \beta_4 \, dRookieContract_{it} + dUndrafted_i + \sum_{y=6}^{9} \beta_y \, dYear_{y,it} + u_{it}$$

Finally, with this last model, injury's effect over a player's salary cap hit can be de facto captured by β_1. Results are displayed in the following subsection.

5.4 Results

The tables from this subsection will bring the estimates from applying the data to each of the models presented previously.

Table 4 – Regression results for positional dummies model

	Salary Cap Hit (M)
DL	143.55**
FB	49.70
LB	-142.24**
OL	-375.92***
QB	1,625.87***
RB	-423.22***
TE	72.31
WR	80.37
Average Value	353.32***
Start percentage	788.54***
Rookie Contract	-2,276.72***
Undrafted	-150.17***
Constant (DB)	2,178.26***

Year dummies included in the regression

Source: Own elaboration

Some may notice that DBs are not among the positions listed on *Table 4*. The choice of dropping the DB dummy and using that position as reference (constant) came from their rank among other positions in terms of cap hit, which is the outcome for the models. Defensive backs' average is the median, so it facilitates the interpretation of the estimates.

Table 4 carries the first estimates of the study, focusing on positional analysis. Quarterbacks really distance themselves from other positions when it comes to most criterias, and here is no different. QBs have an average positive difference of $1,625,870.00 on their salary cap hit over DBs (the median). At the other end, are the running backs, who are worth, on average, around $420,000 less than the reference. Offensive linemen also suffer from a $375,000 lower average.

The main takeaway from the first batch of results is that positions are, on average, valued differently. The sole fact of playing for a specific position can increase or reduce the value attributed to the player by NFL teams, and that is mirrored on their contracts. Being an undrafted player only amplify those conditions.

But to understand why positions are valued differently, deeper and more specific theories must be tested. That is why the second model is tested, to see wether injuries are a factor.

Table 5 - Regression results for total AGL model

	Salary Cap Hit (M)
tAGL	-1.30***
AV	350.73***
Start percentage	849.14***
Rookie contract	-2,285.00***
Draft Pick	-154.24***
Constant	2,509.50***

Year dummies included in the regression

Source: Own elaboration

The main explanatory variable now is *tAGL*, referring to injuries. For both drafted and undrafted groups, an increase in total Average Games Lost leads to a decrease in a player's salary cap hit. That probably means that some of the positional effect (see *Table 4*) comes from AGL. And to understand its effect, it is important to remember the variable is directly attached to injury listing status. In other words, it varies depending on the expectations of the player suiting up after

being listed with an injury. So, for every listing the players from a certain position have, there is an average decrease on that position's cap hit.

Normally, the interpretation would be that for every 1-point increase on *tAGL*, on average, there is a $1,300.00 decrease in players' salary cap hit. Still, it makes a lot more sense to look at types of injury listings, to understand the real effect. Accordingly, the estimates should be multiplied by the Δ*tAGL* caused by each status listing. It can be as insignifacnt as a $104.00 reduction per probable listings, but also as impactful as $7,800.00 per Out listing or IR allocation. The calculations and values are described below.

$$\Delta tAGL_{status} = AGL_{status} =$$
$$= 6 * (1 - percentage\ of\ the\ time\ a\ player\ suited\ up_{status})$$

$$Real\ estimated\ effect_{status} = tAGL\ estimate * \Delta tAGL_{status}$$

Table 6 - Total AGL's real estimated effect per injury listing

Status	For starters, situational reserves, new starters ($)
"Blank" / Probable	-104.00
Questionable	-2,106.00
Doubtful	-7,722.00
Out / IR / NFI / PUP	-7,800.00

Source: Own elaboration

Table 6 measures the effect per injury listing, generalizing the effect for every NFL player, but it still is not clear how positional value might be injury related. The next table has the estimates for the third model, which will help understand how injuries are affected diferently.

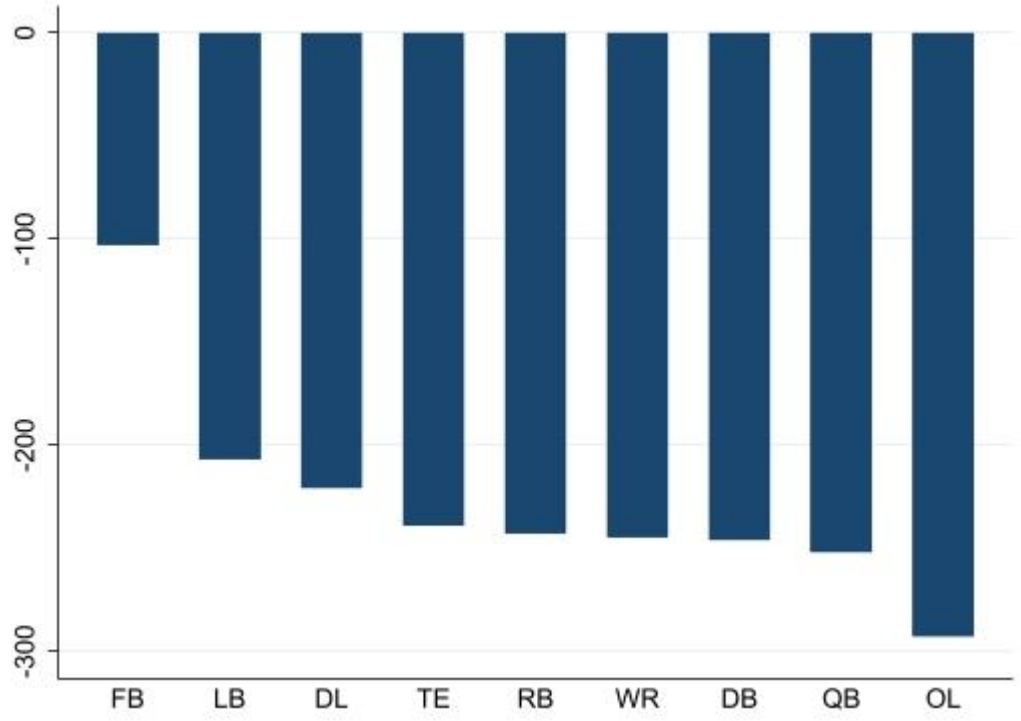
Table 7 – Regression results for injury risk model

	Salary Cap Hit (M)
Injury Risk	-2,139.88***
AV	353.48***
Start percentage	802.12***
Rookie contract	-2,289.44***
Undrafted	-149.51***
Constant	2,376.45***

*Year variables included in the regression

Source: Own elaboration

Chart 4 - Injury Risk estimated effect by Position



Source: Own elaboration

This estimate indicates a 1-point increase in Injury Risk per position implicates an average decrease of $2,139,880.00 in a player's salary cap. That can be applied to each position's Injury Risk (*Chart 4*), to understand how much lower they are valued than they could be if it were not for

injuries and compare the effects between them. One way of doing that is looking at how the effects compare to the positional average or to a reference – that is done in the following table and paragraph, respectively.

Table 8 – Injury Risk effect: Position comparison

Position	Average Injury Risk (%)	Estimated effect by Position	Estimated effect over positional average
OL	13.68	-$292,735.58	-12.56%
QB	11.77	-$251,863.88	-4.70%
DB	11.49	-$245,872.21	-12.56%
WR	11.43	-$244,588.28	-11.32%
RB	11.34	-$242,662.39	-15.83%
TE	11.17	-$239,024.60	-14.09%
DL (Reference)	10.32	-$220,835.62	-9.19%
LB	9.66	-$206,712.41	-10.12%
FB	4.80	-$102,714.24	-10.90%

Source: Own elaboration

Offensive linemen, as the position with the higher Injury Risk (and stronger estimated effect), see their value more than $70,000 lower than defensive linemen, on average, exclusively because of injuries. Fullbacks and linebackers are the only positions that, in comparison to DLs, are valued higher because they are less injured. Ranks change drastically, however, when we take an approach by the effect over positional average. Running backs and tight ends distance themselves from the other positions jumping from 5th and 6th in injury risk to the top 2, with a reduction of almost 16% and 14% over their average salary cap hit. OLs are still at the top, right behind the two formers, at 3rd place, and with a negative 12% effect. The bottom three does not see that much movement. However, quarterbacks dip from 2nd in absolute numbers to dead last in percentage over average, with only a -4.70% estimate, as the top movers. Second and third-last are defensive linemen and linebackers, whom, at a -9.19% and -10.12%, maintained their positions at bottom three, but with estimates two times bigger than the QBs', in terms of percentage points.

6. CONCLUSION

This study has tested the effect of injuries in NFL players' contracts, for the period of 2011-2019, and estimated it for each position on the field. Findings indicate not only the existence and relevance of a negative effect caused by injuries over salary cap hit, but also a significant difference between positions, specially when comparing the effect over positional averages. The fact that this effect exists, and can be measured, raises interesting points of discussion on how teams and players negotiate contracts in the League. I name it "Purple Loss Effect". For those who have had the opportunity to take a close look at the color of a pro athlete's injury, "purple" speaks for itself. The "loss effect" is what I have presented throughout this article.

As mentioned earlier, teams try to avoid the allocation of resources on players from positions that are most likely to get injured (and not perform), indicating an "injury risk averse" profile, mainly at positional level, for most of the NFL franchises. Players contract value can fall, on average, by the increase of injury listings throughout the league or by simply playing for a certain position. However, estimates indicate some positions are overlooked as "injury-risky" and, on average, have smaller deduction of their contracts than what is shown by the Purple Loss Effect. As it was revealed, quarterbacks average the second highest injury risk among positions, but suffer the smallest value discount, if compared by effect over positional averages. Of course, one can easily argue that QBs are overlooked due to their importance on the game, yet these results can help teams save up cap space when negotiating a player's contract. Wide receivers, in a much smaller proportion, benefit from the same situation, as they have their contracts reduced, on average, in 4 percentage points less than other positions with similar injury-risks.

From a player's perspective, when negotiating a contract, they want to sign the highest contract value possible. Therefore, they could look for bargaining power at the opposite situation from the one described previously. Estimates show running backs and tight ends, 5^{th} and 6^{th} in injury-risk, have the biggest and second-biggest reductions of their contract values, in terms of percentage over positional average. With that said, these players could be pointed out by their agents (in negotiations) as "better options of cap space allocation", as teams should not be inflating the injury effect for their positions.

Overall, it is a matter of perspective, however, it is difficult to ignore the Purple Loss Effect, with injury's effect being overestimated for some positions, and underestimated for others, on current NFL contracts. Most importantly, this study revealed solid estimations, regardless of the side you are in – player or franchise – and can be useful for future studies on the topic or analysis when designing new contracts in the League.

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