Hold-Up in the NFL: Team Specific investment in the National Football League

By

Darren King
B.A., Wilfrid Laurier University

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Name: **Darren King**

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Examining Committee:

Chair: Ken Kasa

Christoph Luelfesmann
Senior Supervisor

Simon Woodcock
Supervisor

Phil Curry
Internal Examiner

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Abstract

In a Nash bargaining scenario players will not be fully compensated for investments in their own productivity which are not transferable between teams. This paper constructs a model of NFL players' compensation to examine the optimal investment level when there are both general and team specific investments. It is found that specific investment will lead to less than optimal investment levels. Furthermore, teams and players will be able to increase the optimal investment level by agreeing to an initial contract. The model predicts that players in positions that require a large specific investment will find it optimal to agree to a long term contract in which a greater proportion of the salary is paid in the first period. The model also predicts that players in positions that require a large specific investment will switch teams less often. Using NFL data I find evidence to support these predictions.

Keywords:

Specific Investment, Contracts, NFL

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Introduction

In 2003 the Denver Broncos acquired Jake Plummer as a free agent from the Arizona Cardinals. The Broncos had spent the previous four years struggling to overcome the retirement of their Hall of fame quarterback John Elway, who led the team to back-to-back Super Bowl wins before retiring. Without Elway the team was unable to win a single play-off game. Their supposed future star, who had been learning the offense during Elway's last season, suffered one frustration after another. With the acquisition of the new quarterback there were big expectations in Denver. In his first two seasons with the Broncos, Plummer was mediocre and the Broncos had limited success, once again failing to win a play-off game. The 2005 season, however, was a different story for the Broncos. Plummer had perhaps the best season of his career, was voted to the Pro-Bowl, and led the Broncos deep into the post-season. When asked about the recent success of his quarterback, coach Mike Shanahan replied that he had expected it would take three seasons for Jake Plummer to learn the Broncos offensive system[1].

In 2004 the Denver broncos traded away one of the league's top running backs to Washington for cornerback Champ Bailey. Champ had a reputation as a "shut-down-corner", referring to his ability to stop opposing receivers. Bailey's impact on the Broncos defense was immediate. In his first season with the team he established himself as one of the team's best defensive players. In his second season he set a new personal best for interceptions, despite missing several games with injuries.

In 2005 Sports columnist Pete Prisco[2] observed that the quality of play from offensive linemen around the league has not been as good as what we have come to expect. Prisco attributed this decline in play to the free agency era and the increased mobility of players. The problem is that it takes an offensive line a long time to learn a team's system and play competently as a unit. With players switching teams more frequently there is less opportunity for a team to build an effective offensive line than there was prior to free agency.

The same has not been true for defensive line play, and it is not the result of less mobility among defensive linemen compared to their offensive counterparts. In 2005 the

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[1] Krieger, Dave. *Rocky Mountain News*
[2] Pete Prisco writes for www.cbssportsline.com

Denver Broncos shocked NFL observers by acquiring through trades and free agency, almost the entire defensive line of the Cleveland Browns; a cast of underachievers if there ever was one. Using some of these players to patch holes in the Broncos starting defense resulted in the best line play the Broncos have had since the Super Bowl years.

All of these examples demonstrate the importance of team specific capital for certain positions in the NFL. In the first instance, Bailey was able to switch defensive systems with no loss in productivity, while Jake Plummer took three years to adjust to a new system and a new set of receivers. In the second example, offensive line play has arguably deteriorated because players do not have continued access to a team's system or consistent teammates. The same problem has not occurred for defensive linemen.

But if players in some positions do make large team specific investments, economic theory suggests that players at these positions will not be fully compensated for the efforts. This paper models an NFL labour contract, dependent on investments in specific and general skills, and then tests the model's implications using NFL salary data.

Incomplete Contracts and Contract Renegotiation

This model of NFL contracts will follow the usual Principal-Agent framework. The team, acting as the principal, seeks to obtain a given level of performance from the player, who is the agent. If compensation is not dependent upon the player's performance, the player will shirk and not give the appropriate level of effort. Problems arise, however, in trying to arrange the appropriate level of performance and compensation in the contract for a number of reasons. First of all, a player cannot perfectly determine their level of performance. Although they would like to be able to control the level of catches or tackles they will have in a given season, there are too many variables outside of their control that have an impact on how well they will actually perform. What players do have is the ability to invest in their own skills, allowing them a measure of influence over their own performance. Teams then have the option of writing a contract which can specify a given level of pay for a given level of performance, or they can write a contract that specifies a given level of pay for a given level of player investment. As we will see, neither approach will work in the context of the NFL.

If a player's compensation is tied to performance, it must be tied to measurable statistics which are then verifiable by a third party, or the contract will not be enforceable. In American Football, more than in any other professional sport, performance statistics are not always an accurate indication of a player's performance. Football statistics can be hard to interpret for some positions while other's have no measurable statistics to begin with. For example, tackles for a cornerback could be interpreted positively or negatively, since the offensive player they are covering must beat him for a reception in order for the corner to record a tackle. And while there are other statistics that could be used for corners, offensive linemen have no measurable statistics on which to base their compensation. Fumbles recovered is the only statistic that an offensive linemen might record, and they are only a weak measure of the player's overall performance. Furthermore, a risk averse player will not invest in his training at the efficient level if there is a chance that his efforts will not be reflected in his performance and compensation.

Nonetheless, a portion of the player's salary is usually tied to performance statistics. Heubeck and Scheuer (2002) report that these incentives account for only 5% of total pay. I find them to be slightly higher at 7.38% of Cap Value in 2004 (See Table Four). Even though they are common, they do not make up a large portion of the salary. Heubeck and Scheuer attribute this to the ability of tournament-style incentives to achieve the first best level of investments for the player, but I would attribute it to the imperfect performance measures and difficulty in implementing these in statistics in NFL contracts. Perhaps my intuition is incorrect, however, since the offensive line and the cornerback positions both have an above average proportion of incentives, despite having difficult measures for which to base these on. The wide receiver and running back are among the positions with the highest proportion of salary in bonuses, which we would expect given the ability of performance statistics measured for those positions to reflect the player's responsibilities.

If the team cannot tie compensation to performance statistics they may instead link compensation to a player's training, hoping to guarantee that the player will invest in his abilities. This contract would ensure that even a risk averse player would invest in skills at an efficient level, since while performance is uncertain, investments are completely within their control. There are, however, two problems that prevent such a contract from being written. First, a player's necessary investments will not be perfectly foreseeable at the time of the initial contract. Extra time may be required studying game tape, or extra work practicing a particular formation depending on the circumstances that develop as the season progresses. Secondly, the player's investments lack perfect verifiability. It is possible to fine players who miss practice, but more difficult to measure the level of effort given or the degree to which the player is paying attention during practices. As a result, compensation cannot be directly linked to a player's investment level, even though it would be desirable to do so.

Contract negotiations in the NFL are, however, a repeated game, which allows teams to tie compensation to a player's investments more generally. Coaches will be able to asses a player's performance throughout the season and form a valuation of the player's worth to the team, based on his investments and the team's circumstances. This valuation will not affect the current period's wage, but it will determine if the team continues contracting with the player in future periods. Therefore, if a player hopes to receive a wage in future periods they must invest in their performance ability at the desired level.

Contracts, Renegotiation and Free Agency

Contracts are made for a set period of time, at the end of which they are renegotiated. Furthermore, only a portion of a player's contracted salary is guaranteed, so that even for a season where the player is under contract there can be some level of contract renegotiation if performance is greater or less than expected. As Leeds and Kowalewski (2001) note, examples of renegotiation are common enough for both players and teams. In the following explanation I consider why a player may be willing to agree to a lower salary during renegotiation than what was previously contracted upon.

Renegotiation

An NFL player's salary has three components: base pay, signing bonuses, and other bonuses, which usually consist of compensation dependent on achieving some threshold of performance measures. The signing bonuses are the only guaranteed component of the player's salary, while the other two components depend on the player making the team for that season.[3] If the player is not kept on the team's roster they do not receive either the base pay or the other bonuses. Therefore, teams have the option to end the relationship with the player if they value him below his contracted salary, though they are still forced to pay any signing bonuses that had been agreed upon. A player may be willing to renegotiate his wage part way through a contract and accept a lower salary, if his alternative is failing to make the team. By agreeing to a lower wage the player increases the probability that he will be able to stay with the team, thus increasing his expected pay. Alternatively, a player may gain a higher wage from the team if the team wants to lock the player into a long term contract.

Since there can always be renegotiation for the next period's wage, players will have an incentive to see that they make the necessary investments in order to earn one of the limited places on the team roster. Therefore, even though investment cannot be contracted, it can be enforced by the management's threat of not contracting with the player in the next season. This situation allows the coaches to assess what investments the

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[3] See Richard Borghesi, Allocation of Scarce Financial Resources: Insight from the NFL Salary Cap. January 14, 2006. http://www.business.txstate.edu/users/rb38/NFL_Salary_Cap.pdf

player has made in a subjective way ex-post, and does not force the investment to be specified in the initial contract. It also allows for more general terms to be used in the contract, (Heubeck and Scheuer, 2002).

In addition to the possibility of team induced renegotiation, regular contract negotiation will take place at the expiration of current agreements. This contract negotiation takes place under the rules of free agency.

Free Agency

Free agency was granted to the NFL players association in 1994. Prior to this there was a limited system of free agency, but the restrictions on player movement was such that players were effectively limited to negotiate a contract with their current team. The players wanted to switch to a system of free agency because it would allow them to market their abilities to other teams and break the virtual monopoly that the owners had over the players. The owners were fearful of free agency because they believed that it could cause salaries of top players to be bid up to levels where only the richest teams could afford them. The result would be devastating for small market teams and would guarantee, they believed, the domination of football by a small number of rich cities[4]. To prevent this imbalance from occurring the league and the players agreed that in addition to free agency there would be a hard salary cap, which would be set according to expected league revenues[5]. The cap, along with a high degree of revenue sharing, has meant that small market NFL teams can afford to have the same pay-roll as that of a large market team, unlike many other professional sports leagues.

A player becomes an unrestricted free agent (UFA) if they have played 4 or more seasons and are no longer under a contract with their current team. A UFA is not limited in the team or salary that can be negotiated, and the player's current team is not eligible to receive any compensation from the next team the player contracts with.

A player is a restricted free agent (RFA) if they have played a minimum of 3 years but less than 4 years and are no longer under contract. The RFA is free to seek a contract with a different team, but the original team has the right to refuse the offer by matching

[4] The owners and the players both agreed that if sports fans wished to see this scenario they would just watch baseball anyway.
[5] Salary Cap Values can be found in table 5.

the contract. If the player does switch teams the original team is compensated in the form of a draft pick, depending on how large the player's new salary is. If the new salary is greater than a determined amount the team may be required to part with more than one draft pick. The round of the draft pick is also determined by the worth of the player.

A player of two years or less whose contract expires can only sign with the original team, provided that they offer a minimum salary.

In addition to these restrictions on free agents a team has the ability to limit the mobility of two of its players each year. The team can designate one player each season as a franchise player, which has two varieties. An exclusive franchise player does not have the ability to negotiate with other teams, but does guarantee them a one year contract equal to either the average of the top five players at his position, or 120% of his previous salary, whichever is larger. If a player is designated as a non-exclusive franchise player it guarantees the original team two first round draft choices from the new team, should the player decided to switch teams.

A team can also designate one player as a transition player, which gives the team the right to keep the player by matching any offer from another team. In order to designate a player as a transition player, the team must guarantee a contract that is equal to 120% of his previous salary or the average of the top ten players at his position, depending on which is larger.

A further addition to the new collective bargaining agreement, which instituted free agency and a salary cap, was the addition of a minimum wage.

Player Investment and the Determination of Salary

In order to contract with a player, teams are forced to offer a salary that is at least as good as the player's best alternative option. The team will not have a problem paying a premium, since when a player's skills are properly matched to a team's needs, the relationship creates a surplus beyond the players outside option salary (McLaughlin, 1994). The surplus can be considered as the difference between the current team's valuation of the player and the next largest valuation from a different team. How the team and player bargain over this surplus has important implications for our expectations of player's salary.

A team's valuation of a player is given by:

$$V^i (g_i, s_i, \theta_i)$$

The subscript 'i' denotes the player. The team's valuation of player i depends on two types of investments that the player can choose to make, g and s, as well as on a random variable, θ.

A player's investments in his own performance consists of two components, one of which is in general skills (g) that are fully transferable, the other in team specific skills (s) that are not transferable. It may be useful to think of these investments as investments in physical conditioning and investments in learning. Physical investments are likely going to be extremely non-specific. Sometimes a team may want a person to be a different weight than they were before, but this is probably the extent to which a physical investment is team specific. It is always better to be faster and stronger, or to have better catching, running and tackling ability.

Investments in learning are a different story. Football teams are very specific in the type of defense and offense that they run, so that learning in one system does not necessarily prepare you to play in another system. This is complicated further, however, since different positions are going to require different degrees of team specific investment. Put another way, investments in learning for some positions are more transferable than for other positions. The quarterback position requires a high degree of familiarity with his team's offensive system and a large degree of coordination with his teammates. Likewise the coverage that a linebacker plays depends on the team's specific defensive system. Learning to play linebacker for one team will be different than learning to play linebacker for another. On the other hand, learning to play the tight end position does not differ very greatly from team to team.

Considering investments from this perspective we can say that the benefit from an investment in learning will be greater if the player has continued access to his current team, but the extent to which the learning is team specific will depend on the player's position.

The random variable in the team's valuation of the player captures the effect of a "good match" between a player and a team. A team's needs may change from year to year depending on changes to the coaching staff or personnel requirements, which will be reflected in θ. There could also be a negative shock to the player's value owing to the availability of other players at that position. A year where there are several talented draft picks available at a particular position may lower the value that gets placed on some of their current players. Thus, despite there being an advantage to staying with the same team (due to sunk specific investments), it may still be optimal for a player to switch teams on occasion, depending on the magnitude of the random shock.

Contract Bargaining

There have been numerous attempts to model the bargaining behaviour of non-cooperative parties. The important question for this problem is the treatment of the outside option. Sutton (1986) has shown that in a simple bargaining game where players have recourse to an outside option, which they are free to choose or to forgo, the bargaining outcome will be one of two options. In this particular case where there is bargaining between NFL players and teams (and assuming that the player stays with the team), the bargaining outcome for the player will be the greater of:

1. A division of the total pay-off determined by pay-off size and bargaining strength alone, independent of the outside option. This is given by $W_i = \gamma V^i(g_i, s_i, \theta_i)$, where γ indicates bargaining strength.
2. The player's outside option, given by $\overline{V}^i(g_i)$, which leaves the remainder of the pay-off for the team, given by $W_i = V^i(g_i, s_i, \theta_i) - \overline{V}_i(g^i)$.

This bargaining outcome is known as the outside-option-principle. Essentially it means that the outside option acts as a lower bound to the players bargaining outcome, but otherwise has no affect on the division of the pay-off. We will consider the total pay-off to be the contracting team's valuation of the player.

Sutton also shows that given slightly altered rules the same game will lead to a very different bargaining outcome. In particular if the two parties are forced, with a given probability, to take their outside options and forgo a division of the surplus, then the outside option will have an affect on the bargaining outcome. In other words, when bargaining may be terminated by an intervention outside the players' or teams' control, small threats become credible, and will influence the outcome of the bargaining. This leads to the split-the-difference bargaining outcome, or the Nash bargaining solution. Given this scenario the player's salary will be given by:

$$W_i = \overline{V}^i(g_i) + \gamma[V_i(g^i, s^i, \theta^i) - \overline{V}^i(g^i)]$$

where V^i is the player's outside option. The term in parentheses represents the bargaining surplus and bargaining strength is given once again by γ.

It has also been found that imperfect and asymmetric information can have an impact on the bargaining outcome. A player may be in a better position to know the value of his threat point, and similarly a team has better information about the value of the next best player available. The literature suggests that in the case of imperfect information bargaining parties may choose a strategy that attempts to signal the strength of their bargaining position. Colin and Emerson (2003) find evidence that this signalling process takes the form of an extended period of contract bargaining for higher drafted players before they willing to sign with the team. The ability of the player to hold out passed the start of training camp provides a credible signal of the player's quality, since a lesser player will not hold out fearing that missing part of the training camp could lead to being cut from the team.

The important question for us to answer is which bargaining outcome, either the outside-option-principle or the Nash bargaining solution, is most like the real world of NFL contract negotiations. It is difficult to impose one simple model to faithfully represent the complexity of real world NFL bargaining. What we can say is that a player's threat point will at least act as a lower bound for the contract and may also have an affect on the division of the pay-off. Sutton concludes: "That bargaining agents will in practice fail to be influenced by their opponents' access to some relatively unattractive alternative is of course an empirical issue."[6] To this end I appeal to Leeds and Kowalewski, who study the effects of the 1994 change in the NFL to a limited system of free agency, which has increased player's mobility between teams. Leeds and Kowalewski (1999, 2001) note that this adjustment has led to changes in a player's threat point from what they would earn in a profession outside of football, to what they could earn with another NFL team. The increase in the player's outside option has had the result of increasing the salaries of high performance players, suggesting that either players' outside options are binding, or that the threat point does influence the division of the pay-offs. For the purposes of this paper the Nash bargaining solution will be assumed.

[6] Sutton, 1986

The Bargaining Model

A team is in a position at the beginning of period one to offer the player a contract for either one or two periods. The salary for period one is given by B, and the salary for period two is given by $\overline{w}$. In period one the player plays for the team, receives payment B and makes investments in general and specific skills. At the end of this period the team is able to accurately asses the player's investment level as well as their own needs. At this time they will either agree to pay the player the second period wage, $\overline{w}$, or force renegotiation. Additionally, the player may choose to force renegotiation or end the relationship and move to a new team. The team will always force renegotiation if their valuation of the player is less than the initially agreed upon wage $\overline{w}$. The player will force renegotiation if $\overline{w}$ is less than their outside option. Finally, if there is renegotiation and the bargaining outcome is less than the player's outside option, the player will not agree to a contract and will leave the team.

The specific timing of the model is as follows.

Period One		Period Two	
t=0	t=1	t=2	t=3
Initial Contracts: B for period one, and $\overline{w}$ for period two.	Player Investments are made in general and specific skills. Period one play and payment.	Players investment becomes observable as does θ. Possible renegotiation for next season.	Performance and payment for period two.

Assumptions

For the purpose of the model the following assumptions will be made.

1. Investments in (s) and (g) are separable, so that the team's valuation of a player is given by $V(g, s, \theta) = V_g(g) + V_s(s) + \theta$, if the player stays with his current team. If the player switches teams his valuation is given by $\overline{V}(g) = V_g(g)$. Furthermore, there are diminishing returns to investments in team specific skills so that $V_s(s)$ is continuous and concave in s.

2. θ will be modeled as a variable that only affects a player's current team's valuation in the second period. θ is pulled randomly from a distribution between $\underline{\theta}$, which is sufficiently negative to make switching teams the preferred choice given any level of specific investment, and 0. Therefore, θ is always non-positive.
3. The cost of investing in specific capital will be given by $C(s)$, a convex function.
4. Investments in general skills will be assumed to be verifiable, and thus contractible. Players and teams will be able to agree on the first best level of general investment, g^*, and this investment level will always be chosen by the player.
5. The Team's profit condition is $\pi = V(s, g, \theta) - \overline{w} \geq 0$. Therefore the team will not pay a wage that is greater than their valuation of the player.
6. For simplicity, the bargaining strength of the player and the team will be assumed to be equal, therefore γ will equal one half.

Possible Contingencies

If we consider only those position which require a high degree of team specific investment, there are three possible contingencies that will result from the teams evaluation of the player at t=2, depending on the draw of θ, the investment level and the choice of $\overline{w}$. Recall that θ is a random variable distributed between $\underline{\theta}$ and zero. The critical threshold levels of θ for each contingency is as follows.

Distribution of θ			
C Outside Option	B Renegotiation	A Contracted Wage	
$\underline{\theta}$	$\overline{\theta}$	$\hat{\theta}$	0 θ

Scenario 'A'

Scenario 'A' occurs when the random variable θ is at least as large as $\hat{\theta}$. In this contingency the player and the team will both accept the initially agreed upon period two wage, $\overline{w}$, and neither side will choose to force renegotiation. Given this outcome, the player's utility will be $U = \overline{w} + B - C(s) - g^*$. This outcome will occur with a probability dependent on the distribution of θ , the player's level of specific investment, and the agreed upon wage $\overline{w}$.

For this contingency to happen two things must be true. First of all, the wage must be greater than the player's outside option, or the player will not accept it and will force renegotiation. Secondly, for the team to break even they must value the player at the same amount or at an amount greater than the wage. If the team does not they will force renegotiation with the player. The second condition can be written as:

$$V_g(g^*) + V_s(s) + \theta \geq \overline{w}$$

From the above condition we are able to solve for the threshold value $\hat{\theta}$ as a function of the initially agreed upon period two wage and the level of specific investment.

$$\hat{\theta}(s, \overline{w}) = \overline{w} - V_g(g^*) - V_s(s) \tag{1}$$

A draw of θ that is smaller than $\hat{\theta}$ will cause the team's valuation of the player to fall below the agreed upon wage $\overline{w}$, and cause them to seek renegotiation. The team will have a credible threat to do so, since paying the wage will result in negative profits.

Scenario 'B'

Scenario 'B' occurs when there is a draw of θ such that $\overline{\theta} < \theta < \hat{\theta}$. In this contingency the player faces a significant negative shock to their value to the team, and it will no longer be profitable for the team to pay the agreed upon wage $\overline{w}$. The team will, however, hope to keep the player, but at a lower wage and so the player and the team will enter into renegotiation. The player will agree to renegotiate since his alternative is being cut by the team. The wage the player receives in this contingency is given by Nash bargaining, and his utility will be $U = V_g(g^*) + \frac{1}{2}[V_s(s) + \theta] + B - C(s) - g^*$. This scenario occurrs with a probability depending again on the distribution of θ , the player's level of specific investment, and the agreed upon wage $\overline{w}$.

The player will only accept the bargained wage if it is greater than his outside option. Therefore, it will be efficient to stay together if:

$$V_g(g^*) + \frac{1}{2}[V_s(s) + \theta] \geq V_g(g^*)$$

This condition allows us to solve for the threshold value of $\overline{\theta}$ as a function of the players specific investment. Simplifying the above condition gives us:

$$(2) \qquad \overline{\theta}(s) = -\ V_s(s)$$

As long as the return from a specific investment is greater than the negative shock it will remain efficient for the player to stay with the team.

Scenario 'C'

Scenario 'C' occurs when there is a draw of θ which is less than $\overline{\theta}$, as defined above. In this contingency there does not exist a Nash bargaining outcome for which the player will agree to stay with the team. Instead they will leave the team to take their outside option. The outside option could be a place on a roster with a different NFL team, it could be a position on a CFL team, or might be the player's best option outside of football. In this scenario the players utility will be $U = V_g(g^*) + B - g^* - C(s)$. This scenario occurs with a probability depending on the distribution of θ and the player's specific investment level.

A team and a player may initially agree upon a second period wage that is less than the player's outside option, $V_g(g^*)$. In this case Nash bargaining will occur at t=2 as if there were no contract in the first place. Given a draw of θ that makes it efficient for the parties to stay together (that is a draw where $\theta > \overline{\theta}$) the parties will negotiate a spot contract according to Nash bargaining. Without an initial contract $\overline{w} \geq V_g(g^*)$ there will be no $\hat{\theta}$ threshold, and thus no scenario A.

One can see that investment in team specific skills will have two different effects on the player's utility. The first, and obvious affect is that greater investment will increase a team's valuation of a player, leading to a higher Nash bargaining outcome in scenario B. The second effect, which can be seen from equations (1) and (2), is that a greater investment in specific skills will lower the threshold values of θ, making it more likely that the player will receive the contracted wage, $\overline{w}$, and also more likely that he will stay with the his current team.

Solving the Model for First Best Investment Levels

Efficiency requires two things. Ex-post efficiency is satisfied if a trading relationship occurs whenever it is in the interests of both parties to do so. For this model ex-post efficiency requires that if θ is greater than $\overline{\theta}$, the player and the team will agree to stay together at t=2. Ex-post efficiency will always be achieved.

Secondly, ex-ante efficiency is achieved if total welfare is maximized by the player's choice of investments. Since investment in general skills is assumed to be verifiable and hence contractible, they will always be at the first best level. Thus the first best, efficient level of specific investment will maximize welfare over a distribution of θ.

Total welfare is given by the total valuation of the player in the situation where he switches teams and the situation where he stays with the team. Thus social welfare is:

$$SW = \int_{\underline{\theta}}^{\overline{\theta}(s)} V_g(g^*)dF(\theta) + \int_{\overline{\theta}(s)}^{0} [V_g(g^*) + V_s(s) + (\theta)]dF(\theta) - C(s) - g^*$$

Taking the derivative with respect to specific investment, s, yields:[7]

$$\frac{dSW}{ds} = V_g(g^*)f(\overline{\theta})\frac{d(\overline{\theta})}{ds} + \int_{\overline{\theta}(s)}^{0} \frac{dV_s(s)}{ds}dF(\theta) - [V_g(g^*) + V_s(s) + \overline{\theta}]f(\overline{\theta})\frac{d\overline{\theta}}{ds} - C\,'(s)$$

$$= \int_{\overline{\theta}(s)}^{0} \frac{dV_s(s)}{ds}dF(\theta) - [V_s(s) + \overline{\theta}]f(\overline{\theta})\frac{d\overline{\theta}}{ds} - C\,'(s)$$

Substituting for $\overline{\theta}$ from equation (2) allows the terms in brackets to cancel out. The intuition behind this result is that as you increase your level of specific investment you have a greater probability of staying with your current team. In other words, you will decide to stay with your current team (and thus share the benefits from your specific investment) for lower values of θ as specific investment increases. However, the benefit from gaining a lower leave-stay threshold is completely offset by the lower value of θ, which you only bare if you stay with the original team. The two effects offset and the resulting first order condition for the first best specific investment level is:

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[7] It is assumed that the function C(s) is sufficiently convex in order to make the program SW concave.

$$\frac{dW}{ds} = \int_{\overline{\theta}(s)}^{0} \frac{dV_s(s)}{ds} dF(\theta) - C\,'(s) = 0$$

Or,

$$\text{(3)} \qquad \int_{\overline{\theta}(s)}^{0} \frac{dV_s(s)}{ds} dF(\theta) = C\,'(s)$$

Welfare is maximized when the player has invested to the point where the total marginal benefit from investment (left side) equals the marginal cost of investing (right side). The benefit from a specific investment is only realized if a player stays with his current team, otherwise the first order condition would be $\frac{dV_s(s)}{ds} = 1$.

Equilibrium Investment

In equilibrium the player will not choose his investment level to maximize total welfare, but to maximize his own utility. If we assume that there is no initial contract made between the player and the team[8] (thus scenario A is not an option) the player can expect to form a spot contract with his current team at t=2, provided it is efficient to do so. His expected utility will be given by the two remaining scenarios, depending on θ, one in which he switches teams, the other where he stays with his current team. If the player stays then Nash bargaining determines his wage. Expected utility is given by:

$$U = \int_{\underline{\theta}}^{\overline{\theta}(s)} V_g(g^*) dF(\theta) + \int_{\overline{\theta}(s)}^{0} [V_g(g^*) + \tfrac{1}{2}(V_s(s) + \theta)] dF(\theta) - C(s) - g^*$$

Taking the derivative with respect to specific investment produces the first order condition, which simplifies in the same way as the above equation to:

$$\frac{dU}{ds} = \int_{\overline{\theta}(s)}^{0} \frac{1}{2} \frac{dV_s(s)}{ds} dF(\theta) - C'(s) = 0$$

Or,

[8] Or alternatively, $\overline{W} < V_g(g^*)$

$$(4) \qquad \int_{\overline{\theta}(s)}^{0} \frac{1}{2} \frac{dV_s(s)}{ds} dF(\theta) = C'(s)$$

When one compares equation (4) to equation (3), the impact of specific investment becomes evident. With no initial contract, the team and the players will form a spot contract so long as $v_s(s) > -\theta$, and thus achieve ex-post efficiency. The player will, however, only receive half of the benefit from specific investments, and so he will under invest in team specific skills. Because $V_s(s)$ is concave in s, a higher value for $\frac{dV_s(s)}{ds}$ translates into a lower value of specific investment. Thus, without an initial contract the player will expect to earn only a portion of his return from specific investments. The intuition is that since the player knows he will be held up at t=2, he will under invest in team specific skills.

Equilibrium Investment with an Initial Contract

If we allow for an initial contract of $\overline{w}$ players will, with their choice of specific investment, maximize their expected utility, as before. Now, however, expected utility is given by:

$$U = \int_{\underline{\theta}}^{\overline{\theta}(s)} V_g(g^*) dF(\theta) + \int_{\overline{\theta}(s)}^{\hat{\theta}(s,\overline{w})} [V_g(g^*) + \tfrac{1}{2}(V_s(s) + \theta)] dF(\theta)$$
$$+ \int_{\hat{\theta}(s,\overline{w})}^{0} \overline{w} dF(\theta) + B - C(s) - g^*$$

The player's expected utility is comprised of outcomes A, B, and C as discussed earlier. Which outcome the player actually finds himself in depends on his specific investment level, the size of the contracted wage $\overline{w}$, and of course, the draw of θ.

Taking the derivative with respect to specific investment produces:

$$\frac{dU}{ds} = V_g(g^*) f(\overline{\theta}) \frac{d(\overline{\theta})}{ds} + \int_{\overline{\theta}(s)}^{\hat{\theta}(s,\overline{w})} \frac{1}{2} \frac{dV_s(s)}{ds} dF(\theta) - [V_g(g^*) + \tfrac{1}{2}(V_s(s) + \overline{\theta})] f(\overline{\theta}) \frac{d\overline{\theta}(s)}{ds}$$
$$+ [V_g(g^*) + \tfrac{1}{2}(V_s(s) + \hat{\theta})] f(\hat{\theta}) \frac{d\hat{\theta}(s)}{ds} - \overline{w} f(\hat{\theta}) \frac{d\hat{\theta}(s,\overline{w})}{ds} - C'(s)$$

This simplifies to:

$$\frac{dU}{ds} = \int_{\overline{\theta}(s)}^{\hat{\theta}(s,\overline{w})} \tfrac{1}{2}\, \frac{dV_s(s)}{ds} dF(\theta) + [V_g(g^*) + \tfrac{1}{2}(V_s(s) + \hat{\theta})] f(\hat{\theta}) \frac{d\hat{\theta}(s,w)}{ds}$$
$$- \overline{w} f(\hat{\theta}) \frac{d\hat{\theta}(s,\overline{w})}{ds} - C\,'(s)$$

Substituting from equation (1)

$$\hat{\theta}(s,\overline{w}) = \overline{w} - v_g(g^*) - v_s(s)$$

and

$$\frac{d\hat{\theta}(s,\overline{w})}{ds} = -\frac{dv_s(s)}{ds}$$

into the above equation gives us the first order condition:

$$(5) \qquad \int_{\overline{\theta}(s)}^{\hat{\theta}(s,\overline{w})} \tfrac{1}{2}\, \frac{dV_s(s)}{ds} dF(\theta) + \tfrac{1}{2}\, [\overline{w} - V_g(g^*)] f(\hat{\theta}) \frac{dV_s(s)}{ds} = C\,'(s)$$

From this first order condition a number of observations become clear. The first observation is that there are two benefits from an increase in specific investment. The first term in equation (5) is the same as in equation (4), except for the boundaries of integration. This term is the marginal benefit in the Nash bargaining outcome (scenario B) for an increase in specific investment. As before, given that the parties renegotiate at t=2, the player receives only half of the surplus generated from specific investment. This outcome occurs when $\overline{\theta} < \theta < \hat{\theta}$.

From the second term in equation (5) it can be seen that the player can gain an additional amount of income given a draw where $\theta > \hat{\theta}$, for which the team agrees to pay the player the originally contracted wage, $\overline{w}$. This is scenario 'A' from above. By investing in team specific skills the player will lower the threshold level of $\hat{\theta}$, thereby increasing his probability of earning the second period wage. This is the second effect of a team specific investment. As before there is no benefit from an investment in team specific skills if the player takes the outside option (scenario C).

The second observation is that even though the player may earn a greater return from his specific investment if the team and the player are able to agree on an initial contract, he will receive the full return from his specific investment in period two with a probability of zero. This can be seen from the team's profit condition. If the player and the team initially agree to a period two contract $\overline{w}$, the player knows he will only receive the wage if $V_g(g^*) + V_s(s) + \theta \geq \overline{w}$. Since investments in general skills will always be the first best level, $\overline{w}$ implies a level of specific investments which the player must perform in order to meet the team's profit condition. Because θ equals zero with zero probability and is by definition always non-positive, the player must invest beyond the level implied by $\overline{w}$ if he wants to have some probability of earning the contracted wage.

A final observation is that a team can influence a player's optimal choice of specific investments by their choice of $\overline{w}$. If the wage is set low the player will have a greater chance of achieving the required valuation to earn it, however, the additional income from a low wage will not be as great an incentive as from a larger wage. Alternatively, if $\overline{w}$ is set too high the probability of achieving the required valuation will become too low to make the effort worthwhile for the player. This result can be seen in the comparative statics of equation (5). Differentiating the left hand side of the equation with respect to $\overline{w}$ give us:

$$\frac{dMB}{d\overline{w}} = \frac{1}{2}\,\frac{dV_s(s)}{ds}f(\hat{\theta})\frac{d(\hat{\theta})}{d\overline{w})} + \frac{1}{2}\,\frac{dV_s(s)}{ds}f(\hat{\theta}) + \frac{1}{2}\,\frac{d^2\hat{\theta}}{dsd\overline{w}}[\overline{w} - V_g(g^*)]f(\hat{\theta})$$
$$+\frac{1}{2}\,\frac{dV_s(s)}{ds}[\overline{w} - v_g(g^*)]\frac{df(\hat{\theta})}{d\hat{\theta}}\,\frac{d\hat{\theta}}{d\overline{w}}$$

Since $\frac{d^2\hat{\theta}}{dsd\overline{w}} = 0$ and $\frac{d(\hat{\theta})}{d\overline{w})} = 1$ by the definition of $\hat{\theta}$ in equation (1), we can simplify the above to:

$$\text{(6)} \qquad \frac{dMB}{d\overline{w}} = \frac{dV_s(s)}{ds}f(\hat{\theta}) + \frac{1}{2}\,\frac{dV_s(s)}{ds}[\overline{w} - v_g(g^*)]\frac{df(\hat{\theta})}{d\hat{\theta}}$$

Equation (6) shows the change in the player's marginal benefit, for a level of specific investment, given a change in the initially contracted wage $\overline{w}$. In other words, if equation (6) is positive an increase in the wage will provide the player with a positive incentive to increase his investment in specific skills. If equation (6) is negative an increase in the wage will lead the player to want to reduce his investment in specific skills. Determining the sign of equation (6) is easily done.

One can see that sign of the first term in the equation will always be positive, by the assumptions about the return to a specific investment. The sign of the second term depends on $\frac{df(\hat{\theta})}{d\hat{\theta}}$, which may be positive or negative depending on the distribution of θ and the value of $\hat{\theta}$. If we assume that the distribution of θ is given by the normal distribution, the sign of $\frac{df(\hat{\theta})}{d\hat{\theta}}$ will depend on the particular value of $\hat{\theta}$. Therefore, equation (6) will be positive over a range where $\hat{\theta}$ is relatively low, and turn negative over the range where $\hat{\theta}$ is relatively large. In this case we would expect to see a wage that leads to a $\hat{\theta}$ in the interior of the distribution of θ, and therefore $\overline{w}$ would be paid with some positive probability.

Predictions

The first implication of the model is that an NFL player will always receive their full return from investments in general skills. The player will not, however, be paid the full value from their investment in specific skills. If there is no initial contract, the player and the team will agree to a spot contract at t=2, so long as Nash Bargaining leads to a wage that is greater than the player's outside option. The bargained wage will, however, only pay the player a fraction of the value of his specific investment. Since the player will expect to be held up he will under invest in specific capital.

Secondly, the model predicts that players and teams can do better with an initial contract for the period two wage. By choosing the wage to maximize the player's incentives, the team can induce a level of specific investment that is greater than had there been no initial contract. Because the player still expects to be held up in period two he will only agree to this second period wage if the surplus from the agreement is transferred to him. This transfer is accomplished though the first period wage, B. Even though the player is now obtaining a lump sum transfer, as well as a fixed wage with positive probability, the player will still find it optimal to invest into the team's valuation. Thus, the model predicts that a player in a position with a high degree of specific investment will have a contract that covers both periods one and two, and which pays a greater first period wage and a smaller second period wage than a similar player with low level of team specific investments.

Finally, the model predicts that players in positions requiring a high degree of specific investments will switch teams less often than those who play in positions that mostly require investments in more general skills. This is because players with more specific skills can only capture some of the returns from their specific investments if they stay with the same team, while players with more general skills will be rewarded for their investments by any team.

Testing the Predictions of the Model

Given the preceding predictions we would expect to see wages diminishing with time for those positions that require team specific investments. The player with specific skills would make a larger first period wage on account of the transfer, and subsequently earn less as a result of hold-up. There are, however, several other factors that will combine to increase salaries as players get older. One is that the players' investments in themselves will continue each year. The return from physical conditioning may reach a plateau or a peak, but investments in learning are likely to continue to add value to the player throughout their career, even though at a diminishing rate. They will also become better players with more game experience. These two effects will have an impact on a player's performance statistics, but it will also increase the player's intangible qualities, such as leadership ability, which will have an impact on the team's valuation of the player, but will not be evident from individual statistics. An additional effect is the NFL's bargaining agreement which has set a minimum wage for players that increases with the player's experience level. It is therefore not surprising that Leeds & Kowalewski find experience to have a significant positive (though diminishing) affect on a player's salary, even when controlling for performance statistics.

Nonetheless, when performance variables and personal characteristics are accounted for, the model predicts that players whose positions have a high degree of team specificity will have larger initial wages than those who play positions with more transferable skills, however, they will also find their salaries increasing at a lower rate. This is the main testable implication from the model.

An additional prediction is that players' are less likely to switch teams if their position has a high degree of team specificity. This implication is owing to the fact that players are still likely to receive a portion of the surplus, despite being held up, which may give them a greater salary if they stay with the same team.

Description of the Data

The Dependent Variable

The dependent variable in the regression analysis is the amount of a player's salary for a given year that is counted against the salary cap. The Cap value includes the current year's base salary and bonus pay, plus the signing bonus prorated over the full period of the contract. Signing bonuses are the primary way for a team to create flexibility under the salary cap. By paying a player a signing bonus they can postpone much of the cap value of the contract until future seasons, which allows teams to have a higher payroll in a year they believe they are contenders. The salary cap value has been discounted to 2000 dollars using the average of monthly CPI values for the months of the NFL season, which span more than one calendar year. The regression uses the natural logarithm of the cap value to compress large values and to aid in the interpretation of the coefficients.

The sample includes all players at the positions of interest who have significant enough performance statistics to indicate regular play, and who had a minimum of three years of statistics available. Data for Salaries spans the years 2000 to 2004, while personal statistics span the years 1999 to 2004. Any year in which a player switched teams is excluded from the sample. Data for players' salaries comes from the USA TODAY NFL Salaries Databases[9]. A summary of Salary statistics by position is found in Table One.

The Independent Variables

There are a number of independent variables employed to control for variations in a player's salary due to other factors than specificity. These include experience, a player's height and weight, the year's salary cap figure and a range of performance statistics. It was found that using multiple offensive statistics led to multicollinearity, and caused none of the offensive statistics to be significant. When only yards were used the significance level increased considerably. I believe yards provide as reasonable a measure of an offensive player's productivity as can be gained from any statistic.

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[9] http://asp.usatoday.com/sports/football/nfl/salaries/default.aspx

On the defensive side, however, there are a number of significant performance measures. I believe this reflects the greater diversity of objectives among the defensive positions chosen. All performance statistics and personal characteristics come from NFL.com[10]. Players' statistics were used as averages per game and were lagged by one period. Height and Weight are measured as the difference a player is from his positional mean value. A summary of player statistics can be found in table two.

Specificity

The variable to capture specificity is a binary variable which indicates if the player's position has a high degree of team specificity or a low degree of team specificity. This variable is, admittedly, a potentially weak link in the data analysis. That some positions demand high degrees of team specific investments while others do not seems unquestionable. The quarterback is the prime example of a position that requires a large degree of learning in a team specific system. It is by far and away the most mentally demanding position on the football field[11]. On the other hand, a place kicker's skills are probably perfectly transferable from team to team—they just have to kick a ball through some posts, and neither the ball nor the measurements of the posts change from team to team. But while these positions typify the differences in specificity, they are not comparable in a regression: the quarterback because it is a unique position in the NFL and because they are paid for a number of intangible qualities; the kicker because their personal statistics are not comparable to any other position on the field. What we are left with is a number of similar positions to compare. This similarity makes comparison possible, but it also leads to more difficulty in classifying each position as specific or non-specific. With this in mind, the specific and non-specific positions are as follows.

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[10] http://www.nfl.com/stats

[11] For this reason it was long believed that a black QB could not have success in the NFL. Though this prejudice has been proven false by many successful black QB's the informal segregation still exists at the coaching position, and strangely enough at Center, where there are currently no starting black athletes. The Center is the most mentally demanding position on the Offensive line.

Specific	Non-Specific
Running Back	Safety
Wide Receiver	Tight End
Defensive Tackle	Cornerback
Linebacker	Defensive End

This classification was made based on my own intuition as well as the input from an NFL sports columnist[12]. The distinction is motivated by the amount of specific learning required for a given position, as well as by the amount of transferable skills in that position.

For instance, a cornerback plays within a complex defensive system which is designed to be hard to understand from the perspective of the opposing offense. This complexity would give the corner high specificity; however, if we consider the profile of a good corner we get a somewhat different picture. The best cornerbacks are valued for their ability to play man-to-man coverage on a top receiver without any help or double coverage. Furthermore, the cornerbacks are frequently the fastest and quickest players on the field, qualities that are both highly coveted by teams, and perfectly transferable. For these reasons I believe the cornerback position should be considered to have low team specificity. In the preceding model the relative size of the specific investment is irrelevant—only the absolute size should matter. It is, however, not difficult to construct a situation where the negative shock influences the valuation such that the relative size is important.

There is a similar story with the defensive line positions. The defensive ends are not all that different from the tackle position, and both require a large amount of learning to play in a team's defense. The key difference between the positions is that ends are valued for their ability to rush the quarterback much more than tackles are. It is the ability of the defensive end to physically beat the player lined up opposite him which makes the player an effective one, and this skill seems to rely more on individual ability than on a team system. For this reason I consider the defensive ends to be non-specific positions and yackles to be specific. In both these cases one can see how a corner and an end

[12] Jeff Legwold writes for the Rocky Mountain News, out of Denver.

should be able to switch teams and have an instant impact in the team's defensive system, while it will be more difficult for specific positions to have a similar effect.

I have classified the safeties as non-specific, consistent with Jeff Legwold. Their responsibilities are mostly in deep coverage with occasional blitzing. On the other hand the linebackers play a much more diverse role in the defense. This is particularly true when you consider the different formations that teams use for their linebackers. The New England Patriots won three Super Bowls using four (and occasionally five) linebackers, rather than a traditional formation with three. Since then many other teams have been adopting this system, which demands more versatile play from the linebackers.

For the offensive positions I have mostly relied on Jeff Legwold's insight. Most tight ends are not used as extensively in the passing game, and their routes do not depend as much on timing or precision. Tight ends are valued for their ability to block larger opposing players, which depends on size and strength, abilities that are perfectly transferable. In contrast, wide receivers must be more precise in their routes, which depends heavily on learning the particular offensive system and also on gaining a familiarity between the receiver and the quarterback. Access to a teammate can cause as much of the specificity problem as access to a team's systems.

A further complication is that the value of a player will depreciate differently depending on the position he plays. Running backs, for example, are subjected to an incredible amount of pounding, and so their value to the team depreciates much faster than players at other positions. While it is not possible to control for different rates of depreciation between positions, there is enough variation in depreciation rates among the pools of specific and non-specific positions that it should not influence the results.

Old Dummy

The Dummy Variable "OLD" is defined as a player who is in their third year or greater. The third year is the earliest year that a player may be considered a free agent once their contract expires. It is used as an interaction term with the specific dummy to capture the effect of a player's specificity on salary over time. Specificity is also interacted with experience to test the robustness of the results.

Estimation and Results

The following equation was estimated to test for the affect of specificity on salaries. Two other regressions were used to test the robustness of the findings and a fourth uses the signing bonus as the dependent variable. All of the models allow for random player effects. Regressions 2-4 are shown in the tables at the back.

Regression #1

Random-effects GLS regression		Number of Observations	1729
R-sq: within =	0.245	Number of Groups	488
between =	0.5273		
overall =	0.4244		
ln(Capval) on independent variables			

	Coefficient		Z	P-Value
Constant	11.833		77.230	0.000
Offense Dummy	-0.009		-0.130	0.900
Salcap	0.002		1.010	0.314
Exper	0.424		18.090	0.000
Exper_squared	-0.021		-12.260	0.000
Turning Point at	9.9	years		
Height	0.049		3.070	0.002
Weight	0.002		1.510	0.132
Defense				
tackles	0.056		5.810	0.000
sacks	0.664		8.140	0.000
interceptions	0.469		3.000	0.003
pass def	0.296		4.270	0.000
Offense				
Height - diff than defense	-0.029		-1.040	0.297
Weight - diff than defense	0.002		1.510	0.132
yards	0.012		12.130	0.000
Specific Dummy	**0.305**		**5.220**	**0.000**
Specific*Old	**-0.322**		**-6.520**	**0.000**
If Experience is used rather than old				
Specific Dummy	0.049		0.690	0.488
Specific*Experience	-0.002		-0.170	0.861
Intersection at	23.2	years		

The coefficients on the specific dummy and the specific interaction term are both statistically significant and have the predicted signs. The analysis suggests that players in specific skill positions make 0.30 log points, or approximately 30% more than others in their first years of playing, after which they can expect to be paid 0.32 log points less—approximately 32% less each year. For the average salary in our sample this difference amounts to about $450,000. It should also be remembered that this sample excludes the quarterback position, the highest paid and most team specific of all the positions.

This result is also robust to changes in the specification. Regression Two allows for variations in the intercepts based on positions, rather than using the specific dummy variable. The result shows a similar value for the specific interaction term—negative 0.3 log points and statistically significant. It also shows larger intercepts for each of the positions that have been classified as team specific. Comparing the results in Regression Two to the table of average salaries reveals that it is not simply the higher mean salaries that drive the difference in the intercepts. The defensive tackle and the linebackers both have higher intercepts than the cornerbacks despite having lower average salaries.

Regression Three allows the performance statistics to be interacted with the positional dummy variables. The results of this regression are as expected, with performance measures becoming more significant the closer they mirror the position's main responsibilities. For instance the cornerback has a much larger and more significant coefficient on passes defensed than the other positions, but actually has a negative coefficient on sacks[13]. The coefficients for the specific dummy and the specific interaction term do not change meaningfully with the additional variables.

Unfortunately, the results are not robust to changes in the definition of the old dummy variable. If old is defined as a player who is in their fourth season or more, than the coefficients lose significance. If specificity is interacted with experience rather than with the dummy variable old the significance of the coefficients are lost, though the signs remain as expected. Each regression reported lists the coefficient for specificity interacted with experience in the alternative specification.

[13] It is not entirely surprising that salary would be inversely related to sacks for CBs. If you were going to blitz with one of your Corners and leave the other in coverage I would be inclined to blitz with the one who is least effective in coverage.

Regression Four replaces the salary cap value with the signing bonus as the dependent variable. The results show that signing bonuses do not appear to be determined by the amount of team specificity. It is likely that there are too many other factors involved in determining the structure of the salary, foremost of which is probably the desire of teams to have flexibility with their cap. A further consideration might be the durability of the player, considering that signing bonuses must be paid if the even if the player fails to make the team the next season. If the player is no longer part of the team the signing bonus must be paid off in an accelerated way, giving teams additional cap problems which they would not have anticipated. The result is that teams will avoid paying signing bonuses unless they are sure of a long term relationship with the player. It is not necessary for our results that highly specific positions receive the signing bonus more than others since the transfer at period one can be in terms of the base salary just as easily.

Several other interesting observations can be seen from the estimation. A player's weight is insignificant or marginally positive, contrary to expectations that it would have a large influence. A possible explanation is that the variable for weight is capturing the affects of the omitted variable speed. If speed could be included in the regression than I would expect both it and weight to be positive and significant. However, since speed cannot be controlled for, and since it is likely very negatively correlated to weight, the results for a player's weight captures much of this additional affect.

Testing for Mobility

If we examine the number of players who have switched teams at least once during our sample it shows that players who are considered to have more specific skills will switch teams less often. These results are not particularly strong, however, since we cannot reject the null hypothesis that specific players switch teams more often.

Team Switchers by Specific and Non-Specific Positions				
	stayed	switched	Total	Percent
Non-Specific	140	98	238	41%
Specific	154	90	244	36%
Total	294	188	482	39%
P-value for Ho: $\text{Mean}_{\text{non-specific}} < \text{Mean}_{\text{specific}} = 0.1677$				

Also worth noting is that the most frequent team switchers are the cornerbacks and the safeties. One would expect the frequency of switching teams to increase with playing experience, and these two positions tend to have long playing careers. Table Six has a complete list of team switchers by position as well as the average experience by position. What we find is that the specific positions tend to have longer careers than the non-specific positions, and so this explanation can be ruled out.

To control more formally for the affect of experience and skill level on a player's decision to switch teams I estimate a Probit regression, where the dependent variable is a binary variable indicating whether the player has switched teams or not in the sample. A team switcher is given by a value of one. The results are as follows.

Probit Regression

Probit Estimate		Observations	467
		LR chi^2 (8)	145.67
Log likelihood =-237.54522		Prob > chi^2	0
		Pseudo R^2	0.2347

Switcher on independent variables

	Coefficient	Marginal Effects (valued at the mean)	Z	P-Value
Constant	-3.359		-7.960	0.000
Exper	0.909	0.333	7.240	0.000
Exper_squared	-0.044	-0.016	-5.340	0.000
defense				
tackles	-0.030	-0.011	-0.750	0.456
sacks	-0.986	-0.360	-2.560	0.010
interceptions	-0.668	-0.244	-0.770	0.441
pass def	-0.649	-0.237	-1.590	0.113
Offense				
yards	-0.013	-0.005	-3.610	0.000
Specific Dummy	**-0.191**	**-0.070**	**-1.180**	**0.237**

As was expected, experience is strongly correlated to the probability of a player switching teams. I also find that performance levels are negatively correlated to the probability of a player switching teams, so that better players do not switch teams as frequently. Finally, players in specific positions are approximately 7% less likely to switch teams in their career. Although the results are not particularly significant, the negative coefficient on specificity is robust to changes in the model's specifications.

Conclusions

This paper has argued that positions in the NFL vary by the degree of team specific investment that they are required to make. From a theoretical perspective we can expect this specificity to lead to longer contracts for these positions and for the salary to be disproportionately loaded onto the first years of the contract. An examination of the data supports the predictions of the model. Players in specific skill positions begin with a higher initial wage, but find that their wages increase at a lower rate over time, when all else is held constant. I also find some evidence to support the prediction that players who make specific investments will switch teams less often.

Tables and Regressions

Table 1: Salary Cap Value by Position
(2000 Dollars)

Position	Observations	Mean	Std. Dev.	Min	Max
CB	313	1,576,743	1700090	251,666	10,200,000
DE	306	1,657,369	1722536	235,000	11,500,000
DT	251	1,570,939	1418673	265,000	8,418,049
LB	385	1,372,438	1387313	262,833	7,621,337
RB	181	1,816,359	1780879	239,583	8,458,485
S	220	1,200,346	1188122	239,333	738,2400
TE	135	955,747	713043.4	239,306	3,931,370
WR	238	1,928,210	1746023	290,600	8,882,727
Total	**2029**	**$1,529,890**	**1547454**	**$235000**	**$11,500,000**

Table 2: Player Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
Height	2286		1.63	-9.6	4.3
Weight	2286		13.11	-49.8	56.8
ht and wt are differences from the position average					
Experience	2286	4.4	2.6	1	15
Defensive Statistics					
Total tackles	1650	3.46	2.01	0	11.4
sacks	1650	.157	.211	0	1.43
Interceptions	1650	.065	.106	0	.625
Passes defensed	1650	.243	.256	0	1.6
Offensive Statistics					
Attempts	609	6.22	6.34	0	25.16
yards	609	45.2	29.9	0	129.12
TD's	609	.305	.272	0	1.68
First Downs	609	2.24	1.49	0	7.14

All defensive and offensive statistics are averages per game and are lagged by one year.

Table 3: Specific & Old Dummies

Variable	Freq.	Percent
Old (3 yrs & plus)		
0	600	26.25
1	1,686	73.75
Specific		
0	1,101	48.16
1	1,185	51.84

Table 4: Average Salaries' Composition by Position 2004

(In Order of Average Salary)

Position	Base Pay as a % of Cap Value	Signing Bonus as a % of Cap Value	Other Bonus as a % of Cap Value
QB	47.76%	83.73%	5.33%
DE	56.80%	74.76%	5.83%
WR	51.03%	45.81%	8.52%
CB	57.77%	64.53%	11.26%
OL	60.55%	48.20%	7.83%
DT	53.69%	70.64%	7.95%
LB	60.38%	44.85%	5.91%
S	62.63%	39.44%	11.26%
K	66.74%	39.40%	2.78%
RB	62.31%	41.39%	10.42%
TE	63.35%	39.36%	8.41%
P	72.13%	27.97%	3.33%
Average	**58.17%**	**55.28%**	**7.38%**

Table 5: Salary Cap by Year[14]

1994	36.4 M
1999	57.3 M
2000	62.2 M
2001	67.4 M
2002	71.1 M
2003	75.0 M
2004	80.5 M

[14] From the NFL Player's Association, http://www.nflpa.org/PDFs/Shared/Media_Misperceptions.pdf, and from AsktheCommish.com, http://www.askthecommish.com/salarycap/

Table 6: Team Switchers and Experience by Position

POS	Stayed	Switchers	Percent switched	Average Experience
RB	30	13	30%	4.2
DT	31	26	46%	4.9
LB	57	33	37%	4.2
WR	36	18	33%	5.0
Total Specific	154	90	36%	4.6
S	30	29	49%	4.4
TE	23	12	34%	3.9
CB	41	28	41%	4.2
DE	46	29	39%	4.4
Total Non-Specific	140	98	41%	4.3
Total	294	188	0.39	4.4

Regression #2

Random-effects GLS regression		Num. of Observations	1729
R-sq: within =	0.4283	Num. of Groups	488
between =	0.5978		
overall =	0.5536		

ln(Capval) on independent variables

	Coefficient	Z	P-Value
Constant	11.799	75.120	0.000
Salcap	0.003	1.290	0.199
Experience	0.416	17.790	0.000
Experience_squared	-0.021	-12.090	0.000
Turning Point at	9.9	years	
Height	0.047	2.990	0.003
Weight	0.003	1.640	0.102
Defense			
tackles	0.072	6.980	0.000
sacks	0.569	6.230	0.000
interceptions	0.541	3.370	0.001
pass def	0.285	3.900	0.000
Offense			
Height - diff from defense	-0.027	-1.010	0.314
Weight - diff from defense	-0.001	-0.210	0.833
yards	0.013	12.060	0.000
Position Dummies			
CB	dropped		
DE	0.070	0.880	0.378
DT*	0.441	4.880	0.000
LB*	0.203	2.450	0.014
RB*	0.267	2.410	0.016
S	-0.173	-2.490	0.013
TE	0.031	0.310	0.753
WR*	0.310	2.940	0.003
Specific*Old	-0.336	-6.760	0.000
Experience used rather than old (Note: other coefficients change but are not reported)			
Specific*Experience	-0.006	-0.460	0.647

* indicates specific positions.

Regression #3

Random-effects GLS regression — Number of Observations: 1729

R-sq: within = 0.4385 — Number of Groups: 488

between = 0.6018

overall = 0.5585

ln(Capval) on independent variables

	Coefficient		Z	P-Value
Constant				
Salcap	0.002		1.040	0.300
Experience	0.421		17.860	0.000
Experience_squared	-0.021		-12.190	0.000
Turning Point at	9.8	years		
Height	0.042		2.680	0.007
Weight	0.003		1.770	0.076
Offense				
Height - diff from defense	-0.022		-0.790	0.430
Weight - diff from defense	-0.001		-0.320	0.752
Position Dummies				
CB	dropped			
DE	-0.126		-0.990	0.325
DT	dropped			
LB	-0.122		-1.010	0.310
RB	-0.118		-0.850	0.397
S	-0.116		-0.890	0.374
TE	0.033		0.250	0.805
WR	-0.019		-0.140	0.888
Tackles (CB)	0.065		2.340	0.019
DE - diff. from CB	0.051		1.060	0.288
DT - diff. from CB	0.050		1.080	0.279
LB - diff. from CB	0.012		0.380	0.701
S - diff. from CB	0.002		0.070	0.947
Sacks (CB)	-1.203		-2.170	0.030
DE - diff. from CB	1.842		3.220	0.001
DT - diff. from CB	1.702		2.890	0.004
LB - diff. from CB	1.565		2.640	0.008
S - diff. from CB	1.217		1.530	0.127
Interceptions (CB)	0.682		2.900	0.004
DE - diff. from CB	0.501		0.480	0.630
DT - diff. from CB	1.255		0.830	0.408
LB - diff. from CB	-0.501		-1.090	0.277
S - diff. from CB	-0.116		-0.310	0.756

	Coefficient		Z	P-Value
Pass Defensed (CB)	0.331		3.180	0.001
DE - diff. from CB	0.178		0.740	0.462
DT - diff. from CB	-0.166		-0.500	0.614
LB - diff. from CB	-0.162		-0.760	0.446
S - diff. from CB	-0.197		-0.950	0.340
Yards (RB)	0.013		9.220	0.000
TE - diff than RB	-0.002		-0.440	0.659
WR - diff than RB	-0.001		-0.530	0.596
Specific Dummy	0.334		2.430	0.015
Specific*Old	-0.334		-6.580	0.000
If Experience is used rather than old				
Specific Dummy	0.133		0.960	0.339
Specific*Experience	-0.0003		-0.020	0.981
Intersection at	438.7	years		

Regression #4

Random-effects GLS regression		Num of Observations	1750
R-sq: within =	0.0178	Num of Groups	488
between =	0.4249		
overall =	0.1336		

ln(SignBon) on independent variables

	Coefficient		Z	P-Value
Constant	15.896		8.250	0.000
Offense Dummy	0.291		0.450	0.654
Salcap	-0.253		-9.930	0.000
Experience	2.160		8.440	0.000
Experience_squared	-0.120		-6.060	0.000
Turning Point at	9.0	years		
Height	0.209		1.630	0.104
Weight	0.014		0.950	0.344
Defense				
tackles	0.161		1.580	0.114
sacks	0.959		1.070	0.284
interceptions	-0.084		-0.040	0.968
pass def	1.278		1.500	0.134
Offense				
Height - diff from defense	-0.046		-0.210	0.830
Weight - diff from defense	-0.023		-0.770	0.440
yards	0.020		1.940	0.053
Specific	**-0.175**		**-0.470**	**0.635**

References

Ask the Commish, "Capenomics." AsktheCommish.com http://www.askthecommish.com/salarycap/ (Accessed February, 2006).

Borghesi, Richard. "Allocation of Scarce Financial Resources: Insight from the NFL Salary Cap" (Draft: May, 2004). http://www.business.txstate.edu/users/rb38/NFL_Salary_Cap.pdf (Accessed January, 2006).

Conlin, Michael and Emerson, Patrick M. "Multidimensional Separating Equilibria and Moral Hazard: An empirical study of National Football League Contract Negotiations" in *The Review of Economics and Statistics*, August 2003, 85(3): 760–765.

Hart, Oliver (1995): *Firms, Contracts and Financial Structure*, Oxford, UK, Oxford University Press

Heubeck, Tina and Scheuer, Jochen. "Incentive Contracts in Team Sports - Theory and Practice (Draft)." http://eale2002.phs.uoa.gr/papers/Heubeck%20&%20Scheuer.pdf (Accessed November 29, 2005).

Krieger, Dave. "Can Plummer work without a safety net?" in *The Rocky Mountain News.* http://www.rockymountainnews.com/drmn/sports_columnists/article/0,1299,DRMN_83_4408135,00.html. (Accessed January 23, 2006)

Leeds, Michael A. and Kowalewski, Sandra (2001): *Winner Take All in the NFL: The Effect of the Salary Cap and Free Agency on the Compensation of Skill Position Players.* Journal of Sports Economics 2:3.

Legwold, Jeff. "Broncos Inbox". *The Rocky Mountain News.* http://blogs.rockymountainnews.com/denver/broncos/

NFL.com, "NFL Stats Home," http://www.nfl.com/stats (Accessed January-February, 2006)

NFL Player's Association, "Misperceptions". www.nflpa.org http://www.nflpa.org/PDFs/Shared/Media_Misperceptions.pdf (Accessed February, 2006).

Prisco, Pete. CBS Sports, "CBSsportsline.com" www.cbssportsline.com

Schmitz, Patrick W. (2001): *The Hold-Up Problem and Incomplete Contracts: A Survey of Recent Topics in Contract Theory.* Bulletin of Economic Research 53:1.

Sutton, John, "Non-Cooperative Bargaining Theory: An Introduction," in *The Review of Economic Studies*, Vol. 53, No. 5 (Oct. 1986), 709-724.

USA Today, "NFL Salaries Database," http://asp.usatoday.com/sports/football/nfl/salaries/default.aspx (Accessed January - February, 2006).

Weisstein, Eric W. "Leibniz Integral Rule." From *MathWorld*--A Wolfram Web Resource. http://mathworld.wolfram.com/LeibnizIntegralRule.html (Accessed March 5, 2006)

Wooldridge, Jeffrey M. *Introductory Econometrics: A modern Approach.* Thomson, South-Western. 2003.