GETTING THE MOST 'BANG' FOR THEIR BUCK: AN ASSESSMENT OF CONCUSSIONS ON NHL PLAYER CONTRACTS

by Martin J. Habicht

3807795

Major Paper Presented to the
Department of Economics of the University of Ottawa
in partial fulfillment of the requirements of the M.A. Degree

Supervisor: Pierre R. Brochu

ECO 7997

Ottawa Ontario
March 2012

To Martin and Lorraine for their unwavering support;
To Natasha for her patience and encouragement;
To my friends and family.

Acknowledgement

I would like to express sincere appreciation to Professor Pierre Brochu Ph.D. for his assistance throughout this process. His guidance, motivation and passion has been truly commendable.

Abstract

This paper searches for evidence that general managers are discounting players with concussions as a result of their perceived increased riskiness. By analysing new contract signings over the 2007 – 2011 period, I assess whether a players concussive history affect the negotiated contract, in terms of both earnings and length. Using regression analysis, I find no evidence that suggests general managers' discount, or adjust contract lengths of players who have a concussive history – even after controlling for performance and personal characteristics. This result is robust after controlling for differences in the concussion measure and also after considering differences among the upper and lower earnings quartiles.

1. Introduction

Professional ice hockey is a fast-paced, high-intensity sport. It is both mentally and physically demanding as on-ice decisions must be made and executed within fractions of a second. Classified as a collision sport, player to player contact is not only allowed, it is encouraged and incorporated into a coaches' strategies. With players reaching such high speeds, the on-ice collisions have been likened to car accidents (Haché, 2002). It is not surprising then that the National Hockey League (NHL) has seen, on average, 79.8 concussions per season between 1997-98 and 2003-04 (Benson et al., 2011).

As the players compete on the ice, the general managers are busy competing in the front office. They are tirelessly scouting talented players that are capable of performing at an elite level. In tendering a contract, the general manager must forecast the productive capacity of a player and place a monetary value on their predicted productivity. As productivity is directly related with the amount of playing time received, a general manager must take into consideration a player's health status – particularly concussive history.

Benson et al. (2011) shows that NHL players that have been diagnosed with a concussion are remaining out of active duty longer, and are more likely to be subjected to recurrent traumatic injury. As neuroscience research is extending the knowledge about the debilitating effects from concussions – both in the short term and in the long term – an air of uncertainty arises. It seems only logical to wonder if general managers are taking into account the uncertainty of this injury in their contract negotiations. If general managers are truly acting as rational economic agents, then evidence should suggest that this uncertainty is taken into account and that it is reflected either in the wage, the contract length, or both.

In this paper I examine individual player contracts; observing previous performance, personal characteristics, and most importantly concussive history. The motivating question is whether or not general managers take into account the nature of uncertainty that has most recently been associated with concussions when negotiating player contracts.

I find no evidence which suggests that general managers will take a player's concussive history into account during the contract negotiating process. The effects of a concussive history on the average salary of a contract are economically small and statistically insignificant, even after controlling for a player's past performance and personal characteristics. I find a similar result when I focus on contract length. These results are robust to the approach used to measure a concussive history. Finally, the results went unchanged even after differences among the earnings spectrum were taken into account.

I do find, however, similar to much of the literature on wage determination in the NHL that points per game were a significant contributor to both salary and contract length. Games played were also statistically significant in both cases, but were economically very small, and forwards were found to earn significantly less and obtained shorter contracts than defence men.

In contrast to the literature, penalty minutes per game were economically small contributors to salary and contract length – where in most cases they were not statistically significant.[1] Age was not statistically significant to average salary but was later found highly significant in determining the contract length.

The results suggest there may be other factors which may explain why general managers are not taking concussive history into account. It is possible that general managers do not feel pressured to account for concussions since the Collective Bargaining Agreement (CBA) allows

[1] Increasing penalty minutes by 82 minutes per season (or 1 minute per game) led to – at most – a 6.3% increase in salary. To put this into context, the average player in my sample earned 39.41 penalty minutes a season. The average player would then have to increase their penalty minutes by 200% to get this 6.3% increase in salary.

players to be replaced – and salary cap exceeded – as long as the replacement players average yearly salary is less than or equal to that of the player being replaced. It may also be that their club is not operating near the salary cap.

From a player's perspective this result is welcome, as players can identify their true injury symptoms without fear of being financially penalized. Lastly, from the leagues perspective, a zero discount factor likely leads to a higher quality product – players can play a 'riskier' game – in turn attracting more fans as consumers.

2. Background

Before I begin an analysis, it is imperative that I present a thorough examination of the landscape upon which my analysis is based – namely the NHL. In this section I will develop an understanding of the contract negotiating process involved as well as the restrictions imposed by the NHL and National Hockey League Players Association (NHLPA). I then identify a major implication of the scarcity problem resulting from the league imposed restrictions.

2.1 League Restrictions on Contracts and Wages

In 2005, following the NHL lockout, the NHL and NHLPA came to an agreement on terms which are outlined in the CBA. Under the terms of the 2005 CBA, general managers are, for the first time in league history, constrained by the league in their decision making. Among other things, the CBA dictates the levels – both maximums and minimums – for the average of the total teams' payroll, and for individual player's salaries.

2.1.1 The Salary cap

The upper limit on a teams' payroll is commonly known as the "salary cap". For the NHL, it defines the maximum amount of *average annual salary* a general manager is allowed by the league to spend on his players. The salary cap is adjusted after the completion of each season. The magnitude of the adjustment is determined by the league revenues of the preceding season. The salary cap adjustments give the general manager an opportunity to offer raises to free agents enabling teams near the upper limit to retain their current players.

There are two exceptions for exceeding the salary cap level, one of which involves Long-Term Injury/Illness (such as concussion). The cap may be exceeded in the event a player is deemed unfit to play for 24 consecutive calendar days and/or misses 10 consecutive NHL games, in which case a replacement player is needed to fill the gap in the teams' line-up. The replacement player's salary and bonuses must be less than or equal to the player's salary with whom he is replacing. The replacement player's salary will count towards the salary-cap. If the upper limit is exceeded, it is permissible only until the injured player returns to active NHL duty. Upon return of the injured player, the team must return to compliance with the league set upper limit.

2.1.2 Limits on Individual Player Salary

When evaluating player salaries it is important to know the structured guidelines to which the Standard Player Contract (SPC) must adhere as it is outlined in the CBA. As an upper limit, an individual player may not earn more than twenty percent (20%) of the salary cap (Average Club Payroll Upper Limit). Since the individual salary upper limit is based on a percentage of the team salary cap, it should be noted that as the team salary cap is adjusted, the maximum player

salary will also be adjusted. As a lower limit, a player is not to earn less than the league minimum salary which is outlined by the CBA. Like the upper limit, the lower limit is also subject to increase or decrease following each season, the magnitude of which is dependent on the preceding seasons' league revenues. It is not, however, a fixed percentage of the salary cap like the individual upper limit.

Following the 2004/05 NHL lockout season, an amendment to the CBA was made known as the "*100% Rule*". This rule sets limits on the yearly wage progression (and in some cases regression). It also prevents teams from circumventing the salary cap by signing players to long-term front-loaded contracts in which it is likely that the player will end his career before the termination of his contract. Since average yearly wages are used in evaluating cap adherence, the additional non-playing years as per the contract reduce the players' impact against the salary upper limit. Such contracts would result in what the league deemed to be salary cap circumvention.

2.1.3 Restricted Free Agency and Entry Level Contracts

The NHL imposes an extra set of restrictions on young players (below age 25) who enter the league. These restrictions outline contract length, compensation quantities, and free agency. The restrictions are necessary to maintain the competitiveness across the league; wealthier, better-performing teams cannot poach the young talented players from the poorer, inferior-performing teams. Because new entrants to the league (rookies) are not established, there is risk involved in negotiating a contract. The restrictions of the entry level contracts prevent teams from over-investing in such a risky asset. The entry level contract restrictions also free up room

under the salary cap for the general manager to offer higher wages to the more seasoned veteran players.

As for the restrictions on free agency, players are considered "restricted free agents" following the termination of their entry level contract, or any other contract until the player reaches age 27 or has acquired 7 seasons of NHL experience. A restricted free agent may negotiate with any team and sign a contract with any team. However, any offer-sheet presented and accepted by the player can be matched by the players current club, if they so desire to which the player must oblige. Should the current club elect to release the player to the new club, the new club is then penalized, and must donate future draft picks to the players' original club as compensation. The number of draft picks and location within the draft is pre-arranged within the CBA and is determined by the value of the restricted free agents new contract.

2.1.4 Arbitration

In the event that a player and his team cannot reach an agreement in contract negotiations, both the team and the player have the right to request for arbitration. If the application for arbitration is accepted by the league, both the player and the team must submit their bid to the arbitrator. The arbitrator is responsible for determining a *fair* contract based on the available information. They are also responsible for forming a decision on the terms of the contract, which is non-negotiable by either party.

2.2 Implications of the Restrictions on Team Management

It is easy to see the direct implications that these league-imposed restrictions have on team management. There is only a small amount of money allotted for the general manager to

sign players.[2] Determining *how* to distribute this money can be a very arduous task. At the moment of the contract negotiation, the general manager must evaluate the role that this player will have on his team, and how much he will contribute to the overall teams' success. They must then place a monetary value onto that contribution. In making the evaluation the general managers must also consider the risks that are involved with signing a player. The perceived risk of a specific player must somehow be reflected in the contract offer.

2.2.1 Perceived Risk of Concussions

It is typical that players will experience their concussions in the midst of their contract. Since this is the case, the discount placed on a player will not be realized until the signing of their *new* contract. It is reasonable to presume that the length of time between the last concussive incident and the signing of the new contract will affect the discount. A shorter period assumes a higher risk as the long-term effects of a concussion remain unknown. A longer delay between the two events lowers the risk as the long-term effects are, to some extent, better known.

3. Literature Review

In this section, I will present a collection of economic findings outlining wage-determining factors for NHL players. I will then present a review of medical literature focusing on the physical consequences of concussions in sports, eventually narrowing the focus to the most recent findings of concussions in the NHL.

[2] However, it was noted that there are teams in the NHL which operate below the salary cap level to which their available salary cap space can vary widely. For teams operating well below the salary cap level, efficiency pressures are more relaxed.

3.1 Wage Determination in the NHL

I have developed an understanding of the limitations on player salaries, contracts, and the available options for both clubs and players during the negotiating process. It is now necessary to find the contributing or determining factors when evaluating the "worth" of a hockey player in the NHL. There is a broad range of literature that focuses on wage determination in the NHL. Some of the key areas focus on player discrimination, monopoly-monopsony powers, and the evaluation of skills and performance measures. My paper follows closely with the literature assessing the evaluation of skills and performance measures. It differentiates from the literature however, that although I am evaluating the skills and performance measures of players and their contribution to salary, I analyse further by assessing the salary effects associated with the risk of signing a player with a concussive history.

3.1.1 Determining Wages Using Skills and Performance Measures

Berri & Brooke (2010) note that player salaries are a forecast of the expected production level or contribution to team success. A widely held view asserts that when making predictions about the future, it is necessary to evaluate a player's past performance (Jones & Walsh, 1988; Jones, Nadeau & Walsh, 1997; Curme & Daughtery, 2004; Lambrinos & Ashman, 2007; Deutscher, 2009; Vincent & Eastman, 2009; Berri & Brook, 2010).

By using a player's career performance statistics, Jones and Walsh (1988) found that a player's "skills" are a significant determinant of salary in the NHL. They described a player's skills in their study by their personal attributes, career performance statistics and personal characteristics. Furthermore, they differentiated players by their position – forward, defence men, or goalie – and distinguished between the required skills for each of these positions. Using

data from the 1977/78 season, they found that career-points-per-game is a statistically significant contributor to a player's salary, particularly forwards. Personal characteristics such as height and weight were not found to be as significant of a contributor to player salary as originally hypothesized, particularly in the case for defence men. Height was statistically significant for forwards only, whereas weight was significant for defence men only at a 10% confidence level.

Expanding on this approach, Vincent and Eastman (2009) evaluate determinants of pay in the NHL using a quantile regression analysis. Using salary data from the 2003/04 season and career performance statistics up to this year, Vincent and Eastman found that not only are the required (and therefore compensated) characteristics different for player positions, they are also different depending on their location amongst the earnings spectrum. A highly paid "star player" is compensated differently for his skills than a lower paid "grinder". This is evident when they consider a player's penalty minutes. Vincent and Eastman achieve an interesting result. Penalty minutes, statistically, do not contribute to a player's salary that is located on the lower end of the earnings spectrum. However, players from the middle to higher end of the earnings spectrum indicate that penalty minutes are statistically significant at the 5% confidence level. Vincent and Eastman attribute this difference to the types of penalties granted to a player. Lower-paid players, they argue, tend to take retaliatory-type penalties; higher-paid players are typically taking aggressive forechecking-type penalties.

Vincent and Eastman (2009) raise awareness to a thought provoking contention of which Lavoie, Grenier & Coulombe (1992) had revealed a clever solution almost two decades prior. Although it is easy to evaluate the offensive performance of a player, it is much more difficult to evaluate their defensive accomplishments. It is thus difficult to conclude the value that a general manager places on a defensive style of play. Any proxies used to capture defensive abilities may

also contribute to their offensive nature and, thus, will bias the results. Gathering unpublished statistics on the number of power play goals scored against a player's team while the player was on the penalty kill indicated to Lavoie, Grenier & Coulombe that the coach viewed the player as having exceptional defensive abilities; the higher the statistic, the more the player was relied on for defensive purposes. When evaluating this statistic into an earnings equation, Lavoie & Grenier (1991) found that it was statistically significant in three out four instances.

3.1.2 Personal Characteristics

Indeed, it is absolutely necessary to evaluate a player's productivity and skills through their playing statistics. These statistics are commonly used as the absolute measure of how well (or poor) a player is performing. As others before me have shown, it would be naive to think that it is only these hard statistics that matter in determining a player's salary (Curme & Daugherty, 2004; Deutscher, 2009; Jones & Walsh, 1988; Lambrinos & Ashman, 2007; Lavoie, Grenier & Coulombe, 1992; Vincent & Eastman, 2009).

Deutscher (2009) investigates the compensation for leadership qualities. Using data from the 2003/04 season to the 2007/08 season, Deutscher measures the wage premium given to players for possessing desired leadership qualities. To control for leadership skills, he assesses the player's role on the team – either captain, or non-captain. Deutscher finds that general managers will compensate their team captains with a significant 21-35% wage premium. What Deutscher showed was that general managers do take into account more than just the hockey-related talents that an individual brings to the organization.

3.1.3 Wage Discrimination

Determining rates of pay for players based on their off-ice demeanour is a logical extension to examine the qualities or characteristics sought by general managers. Studies on the determinants of pay in the NHL reduced a standard earnings equation to show evidence that even nationality (or provinciality) will affect player remuneration (Curme & Daugherty, 2004; Jones & Walsh, 1988; Lavoie, Grenier, & Coulombe, 1992; Lavoie, 2000). It seems that the evidence "speaks for itself". Lavoie, Grenier & Coulombe (1987) use an earnings equation while controlling for player performance to show that, during the 1982/83 and 1983/84 seasons, francophone players were paid significantly less than their equivalently talented English-speaking counterparts.

The idea that discrimination was evident in the NHL drew much attention and debate to the issue of differentials in the rates of pay. Longley (1995) added to the debate by indicating that the aggregation of the French Canadians in the NHL might cause a misrepresentation on the true level of discrimination, as French-Canadian teams (Montreal Canadiens and the now-defunct Québec Nordiques) tend to employ a large share of the francophone players. He added that by controlling for team location, we would see the true extent of discrimination. Longley's results indicated that discrimination against French Canadians existed only on English-Canadian teams and that French Canadians earned 37% less than English Canadians. Longley further explains that it is likely linked to the pre-existing tension between English and French Canada.

In a more recent study, Lavoie (2000) improves upon Longley's by using a more recent study period (1993/94 season) and a modified earnings equation. Lavoie's findings are very similar to those of Longley's five years prior. He finds a wage differential of 36% between

French and English Canadian forwards on English-Canadian teams. He is able to draw further from *his* study that English-Canadian teams under-pay forwards who are not English Canadian.

If these theories of wage discrimination do reign true, then labour market inefficiencies must be present. It creates opportunity for an impartial general manager to capitalize on the "under-valued" French-Canadian players and shy away from the "over-valued" English Canadian players. It would be interesting to assess theories of wage discrimination under the new constrained terms of the 2005 CBA. In a league where dollars matter, the salary cap leaves little room for prejudice and will inherently punish teams for making such trivial valuation assessments.

3.1.4 Seven Useful Principles for Determining an NHL Players Wage

There are a lot of factors to take into consideration to determine a player's fair wage. Lambrinos & Ashman (2007) outline seven principles that either the team or a player should submit to an arbitrator in the event that salary negotiations go through the arbitration process. In theory, it is the same seven principles that a general manager should take into consideration when negotiating a contract outside of arbitration. With the constraints of an upper limit, it is necessary for general managers to accurately predict a player's future production level. It is in the best interest for general managers to gather all of the available information in order to make an informed decision.

The seven key principles proposed by Lambrinos & Ashman (2007) are (1) Overall Performance/Previous Performance; (2) Games played; (3) League and Team tenure; (4) Contribution to team success; (5) Special qualities not reviewable via statistics; (6) Overall

performance of players considered comparable; and lastly (7) Salary of players considered comparable.

This paper will focus on the second principle (Games Played). Following Lambrinos & Ashman (and many others) we expand on the concept that games played are undoubtedly a factor in determining a fair wage. By indicating that a player is likely to play fewer games, we should see that general managers will discount that player's worth. In this paper, I seek to quantify that discount. To the best of my knowledge, this is the only paper which attempts to quantify any wage discount resulting from an increased likelihood of injury from concussion not only in the NHL, but in any professional sport.

3.1.5 Wage Determination – Summary

I was able to identify some common themes found in the literature on wage determination in the NHL. What I discovered was that skills and performance measures are useful tools for determining wages. One such indicator, games played, is of particular interest because much of the literature found that an increase (decrease) in the number of games played would typically result in an increase (decrease) in wages. The literature also indicates that general managers account for more than just a player's hockey-related abilities. From Deutscher, we know that players are compensated based on their leadership qualities; whereas, Lavoie, Grenier & Coulombe have shown that players may be discounted based on their nationality, or cultural status.

3.2 Concussions

It then follows, if concussions increase the likelihood of recurrent injury – resulting in a reduction in the number of games played – it is expected that this would result in a wage decrease, a shorter contract length, or some combination of the two. I now examine the literature on concussions to determine if a player's concussive history results in an increased likelihood of a recurrent traumatic injury.

3.2.1 Acknowledging the Issue

In 2001, the International Ice Hockey Federation (IIHF), the Federation Internationale de Football Association Medical Assessment and Research Centre (FIFA F-MARC), and the International Olympic Committee Medical Commission (IOC) organized the first International Symposium on Concussion in Sports (Aubry, et al., 2002). Leading experts were brought together to discuss a variety of issues concerning the prevalence of concussions in sports. Since the 2001 symposium, there have been two more Conferences: the 2nd Symposium on Concussions in Sports in 2004, and the 3rd International Conference on Concussion in Sports in 2008 (McCrory, et al., 2009). During these conferences, leading experts summarize and present new findings in concussion research, management, prevention, assessment protocols, and more.

During the 3rd International Conference on Concussion in Sports, McCrory et al. (2009) indicates that a unanimous agreement was reached to abandon the classifications of "simple" and "complex" concussions that were originally proposed during the first conference in 2001. However, the Concussion in Sport (CIS) group (a small group of leading experts formed following the first symposium in 2001) still acknowledges that the majority of concussions

resolved in a seven to ten day period were characteristic of "simple" concussions (McCrory, et al., 2009).

3.2.2 Concussions in Sport

In a study of National Collegiate Athletic Association (NCAA) football players, researchers have found that players who have a concussive history (that is, players who have received an initial or primary concussion) were more likely to sustain a subsequent or recurrent concussion compared to players without such concussive history (Guskiewicz, et al., 2003; Zemper, 2003). Guskiewicz et al. (2003) discovered that even with only one concussive event, it may have cumulative effects in the likelihood of recurrent concussive injury. Guskiewicz et al. (2003) also estimates that a player with a concussive history is three times more likely to experience a recurrent concussion compared to those without a concussive history. In a similar study, Zemper (2003) estimates this rate to be closer to 5.8 times more likely. Guskiewicz et al. (2003) finds that recovery periods are prolonged with each successive concussion.

3.2.3 Concussions in the National Hockey League

In 1997, NHL Commissioner Gary Bettman took a pro-active approach to address the issue of concussions by forming a concussion working group (Benson et al., 2011; Wennberg & Tator, 2008). According to Benson et al. (2011), leading experts in the field analyzed the concussion data and have since provided feedback for improving diagnosis, treatments options, concussion management, and prevention techniques to improve player safety. The formation of this working group signifies the beginning of a complete overhaul in the NHL's injury protocols

and fuels much debate over prevention methods and mitigating disciplinary action for illegal and/or dangerous play.

Benson et al. (2011) (under contract with the NHL) released a comprehensive study of concussions using the statistics collected by the NHL's concussion working group. The study analyzed the NHL's concussion data from the 1997/98 season to the 2003/04 season. They found that, although the incidence rate of concussions per 100 players per season has decreased over the period, there was an increase in the amount of time lost per concussion. The authors go on to explain that this could be attributed to several factors including: an increase in the severity of concussions, the failure of players to report their true symptoms out of fear of being withheld from the line-up, or by more conservative assessments of concussions by physicians. In support of the Guskiewicz et al. (2003) paper, Benson et al. (2011) finds that on-average, a player's time lost from concussion increases two and a quarter times for each subsequent or recurring concussion sustained during the study period. They also found that the incidence rate for centremen were twice as high as those for wingers or defence men.

4. Empirical Specification

In this section, I present the empirical models I will use to evaluate the impact of concussions on player contracts. A general manager has many options that he can choose individually – (or combine) – to alleviate some of the risk associated with the signing of a player who has a concussive history. In this paper I look at two such potential methods. The first, being the more obvious, is salary; and the second, is the contract length.

4.1 The Model

The models used are presented as follows:

$$(1) \quad \ln(AVGSAL)_{i,t} = \beta_0 + \beta_1 CONC_{i,t} + \mathbf{PERF}_{i,t-1}\,\beta_2 + \mathbf{CHAR}_{i,t}\,\beta_3 + \psi_t\,\beta_4 + \varepsilon_{i,t}$$

$$(2) \quad CLENGTH_{i,t} = \beta_0 + \beta_1 CONC_{i,t} + \mathbf{PERF}_{i,t-1}\,\beta_2 + \mathbf{CHAR}_{i,t}\,\beta_3 + \psi_t\,\beta_4 + \varepsilon_{i,t}$$

Where, the observations are of a particular contract *i* signed at a particular point in time *t*[3]. For example, one observation would be Todd Bertuzzi's two-year contract signed in 2010[4]. It is important to note the distinction of the *i* term; as it does not represent an individual player but an individual contract. That is, each contract is its own observation.

For the log salary equation (equation 1) the dependent variable, $AVGSAL_{i,t}$; is the average yearly salary as outlined by the contract. Using the same example as above, Todd Bertuzzi signed a 2-year contract worth $3.875 million. Thus I enter $1.9375 million for the $AVGSAL_{i,t}$ term indicating contract *i*'s yearly worth at time *t*.[5] As previously mentioned, players typically experience concussions in the midst of their contract. In order to capture the reduction in wages attributable to a concussion, I must observe the salary level upon the signing of the *new* contract. That is, the negotiation must occur post-concussion.

To capture the effects that concussions have on the value of the new contract, I use a dummy variable, $CONC_{i,t}$, to indicate whether for contract *i*, at time *t*, the player has experienced a concussion prior to the signing of the contract. $CONC_{i,t}$ is equal to 1 if the player has experienced a concussion before the signing of the new contract; and 0 otherwise. As part of my

[3] This method is similar to the one used in Jenkins (1996).

[4] Todd Bertuzzi would appear again as he signed a 1-year contract in 2009.

[5] $\$1.9375 \text{ million} = \frac{\$3.875 \text{ million}}{2}$

Robustness Check 1, I will evaluate differences in the time delay between the most recent concussive incident to the time of the contract signing.

The $\mathbf{PERF}_{i,t-1}$ term is a vector of performance measures captured in the season prior to the signing of the new contract. I use three measures of performance; (1) Points per Game, (2) Penalty Minutes per Game and (3) Games Played. It should be recognized that in doing this, I am making the assumption that general managers are "short-sighted" in the player evaluations.[6]

The $\mathbf{CHAR}_{i,t}$ term is a vector of personal characteristics of the player signing the contract. There are three measures captured in the CHAR term: (1) Age, (2) Age Squared to capture player experience and (3) Position (a dummy variable equal to 1 for a forward and 0 for a defence men) to differentiate between forward and defence men.

Finally, the ψ_t term is a vector of time dummies with 2007 being the base year and the $\varepsilon_{i,t}$ is the normally distributed error term.

Using a similar model specification as the salary equation, the contract length equation (equation 2) will capture the effect that concussions have on the contracts length. The $\text{CLENGTH}_{i,t}$ term is the length of contract i signed at time t. Again using Todd Bertuzzi's contract signed in 2010; the contract length would be 2 (years).

5. Data

After developing the empirical model, it becomes clear which pieces of data are required to perform such an evaluation. In this section, I present the data used, how it was obtained, and will provide a description of the data set in the form of descriptive statistics.

[6] A referee noted that lifetime statistics would have been ideal, but was reasonably satisfied since several seasons were evaluated.

5.1 Contract and Salary Data

Since I am looking solely at new contracts (not extensions), the signing dates occur in the off-season. The data begins in the summer of 2007 (for the 2007/08 season) and ends in the summer of 2011 (for the 2011/12 season). Player salary was obtained from the NHLNumbers.com database. The database provides yearly salary (in USD) including any signing bonuses and performance based incentives. In the NHL, performance based incentives are not permissible with the single exception of entry level contracts. Since entry level contracts are subject to different restrictions, they were excluded from my data set.

The NHLNumbers.com database displays its data on a seasonal basis and it is sorted based on team. Each season indicates the full contract to which the player is currently signed. Since the database displays previous and future seasons' earnings, I was able to deduce a signing date.[7] The NHLNumbers.com database begins with the 2006/07 season. Since information regarding salary prior to this season went unrecorded, I was unable to clearly identify which contracts were signed in the summer of 2006 and which contracts were signed earlier. I thus begin my data set with contracts signed in the summer of 2007 for the 2007/08 season.

Contracts extensions are contracts that are signed in the midst of a season and prior to the expiration of the players' current contract. For this reason I must eliminate extensions from the dataset; as it is nearly impossible to generalize a signing date for a contract extension.

Lastly, since the NHLNumbers.com database forecasts contracts into the future, I am only able to infer a contracts length which does not extend beyond the 2019-2020 season.

[7] Signing date was generalized to July as this is the beginning of the free agency period and is the time a standard players' contract expires.

5.2 *Concussion Data*

To evaluate the impacts that concussions have on salary negotiations, I have collected concussion data at the individual player level. The concussion data available is rather detailed, as it indicates the name of the players who have reportedly received a concussion, the date the concussion had reportedly occurred, and the number of games the player has missed due to the reported concussion. Concussive history was recorded as far back as 2000/01, as this is the furthest season to which the data set extends.

To collect the data, I accessed every player profile located on the The Sports Network (TSN) online database. The TSN database collects injury information under the "Injury, Trade, and Suspension" log. This log contains all of the useful information necessary to address the hypothesis. For the purpose of this paper, I narrowed the focus to only those injuries exclusively reported as "concussion", "slight concussion", or "mild concussion".

I want to stress the fact that the concussion data is "reported". "Reported", in this sense means that the injury sustained by the player was explicitly indicated as a "concussion", "slight concussion", or "mild concussion" in the player profile. Any injuries associated with concussions or any *suspected* concussions (such as head injuries, headache, etc.) were not included in the concussion group as it is not conclusive that the injury sustained was, in fact, a concussion.

5.3 *Performance Statistics and Personal Characteristics*

Following Lavoie & Grenier (1992); Jones & Walsh (1988); McLean & Veall (1992); and others, I use performance indicators to evaluate contribution to team success. Much of the literature suggests that performance indicators can be a useful measure in determining a player's wage. I was able to collect the performance indicators directly from the NHL.com database. I

have chosen to use the leagues statistical database as it is recognized as the *official* league statistics. The performance indicators collected include games played, points, and penalty minutes.

Aside from performance indicators, non-performance based wage determining factors must also be accounted. I will differentiate here the non-performance based factors as "personal characteristics". Personal characteristics contain data which are attributable only to the individual player. These characteristics include, position, age, and age squared. The personal characteristics were also obtained through the NHL.com Bio Profile database.

5.4 Summary Statistics: Concussions

The TSN database yielded 467 concussions, where 350 are first occurrence concussions.[8] When performing this analysis, it is important that a comparison to the full spectrum of concussion reporting be examined.

Figure 1 illustrates the comparison of the TSN reported concussions used in this paper with those retrieved by Benson et al. from the National Hockey League Injury Surveillance System (NHLISS). For seasons in which comparisons can be drawn, the difference in reporting rates can be seen. Comparing the number of concussions reported by TSN to the NHLISS, Figure 1 shows that that the TSN database does not record all concussions made known to the league; however, their recording rates are increasing.

It is also interesting to note, following the NHL Lockout season (2004/05) the number of concussions per season dropped by almost one-third, according to TSN estimates. However, by the 2010/11 season the number is again equivalent to the 2003/04 season estimates.

[8] "First occurrence" means first recorded occurrence on the TSN database. It is possible that a player has experienced concussions prior to their first recorded concussion.

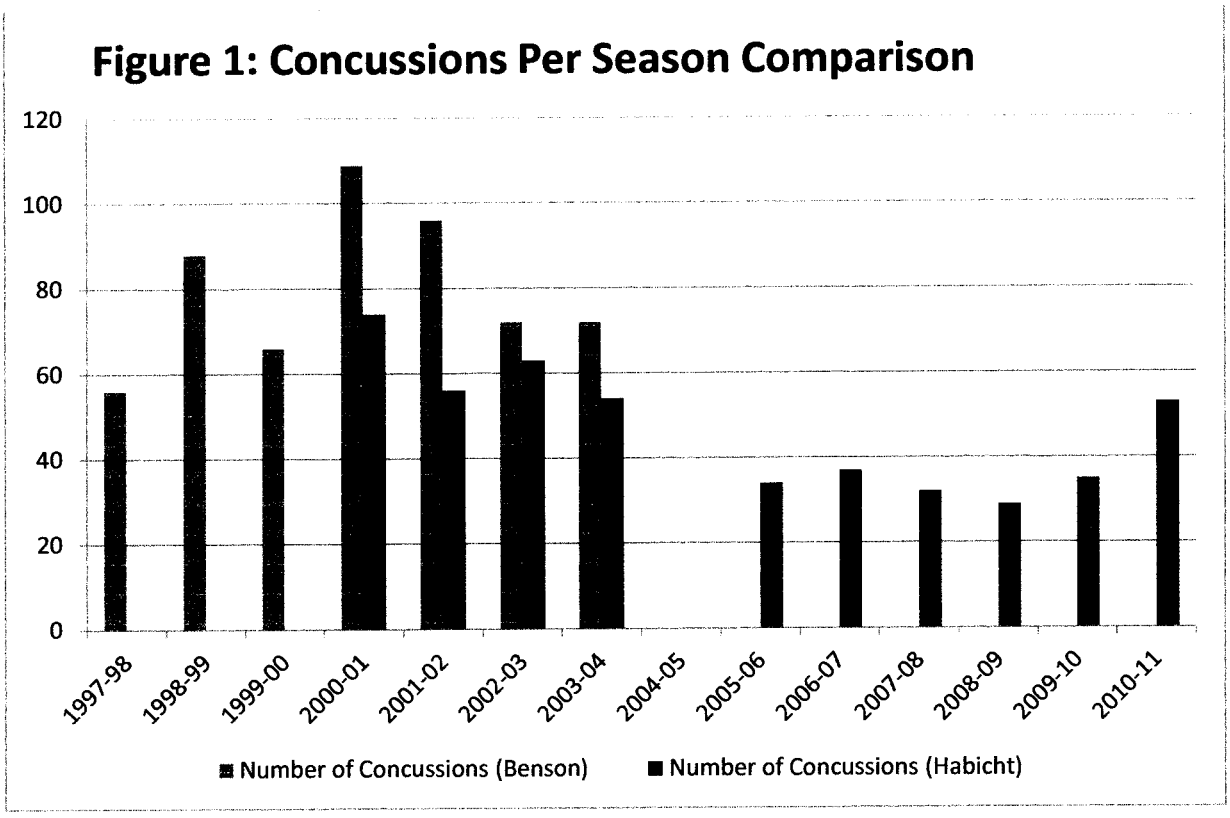
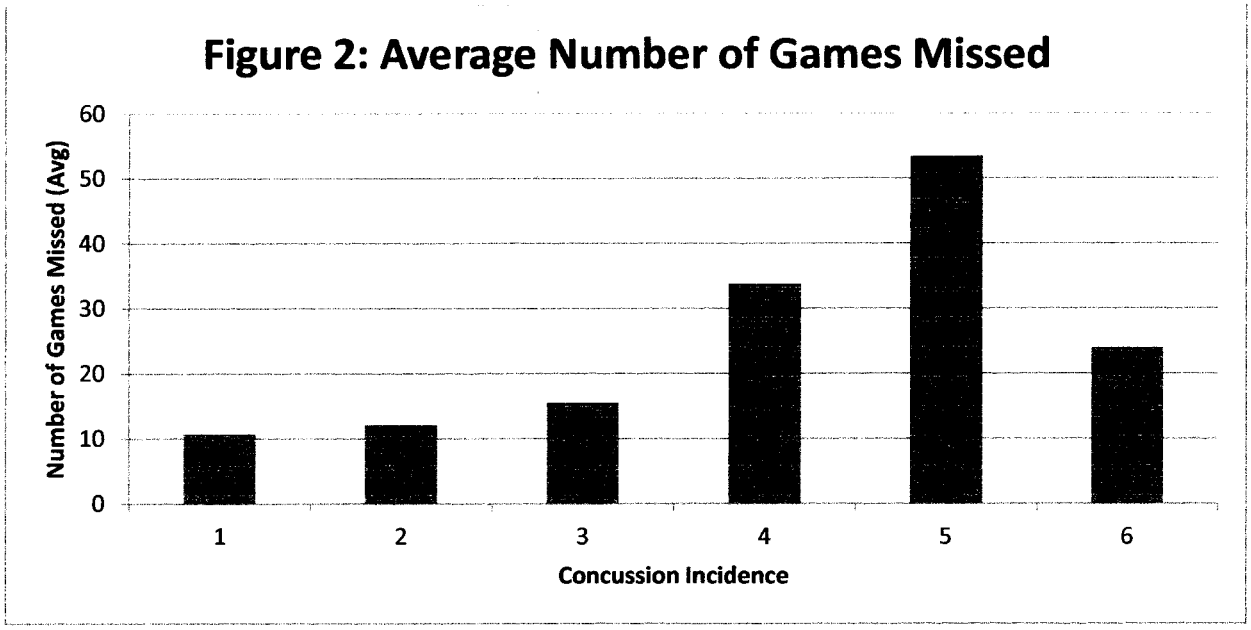


Figure 2 depicts the number of games missed on average per concussive incident. For example, on a players' first concussive incident the average number of games missed were slightly over 10. The jump from the third concussive incident to the fourth is rather staggering. The average number of games missed jumps from roughly 15 games missed for the third concussive incident, to roughly 35 games for the fourth concussive incident. It is at this point where the time off becomes emphatically longer and longer. When analysing missed games per concussion, this paper is consistent with much of the concussion literature.



5.5 Summary Statistics: Contract and Player Stats

Figure 3 illustrates the Earnings Distribution of the Average Yearly Contracted Salary. It is visible from this figure that the data yields a right skewed distribution.

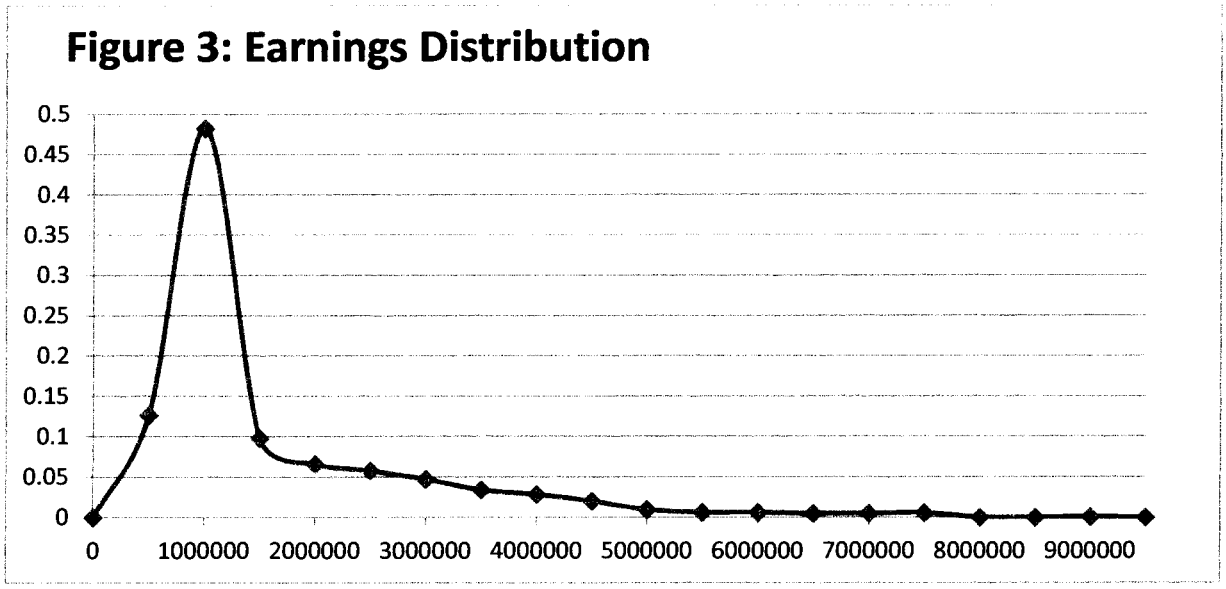


Table 1 provides descriptive statistics of the whole data set. Combining the contract, concussion and player (performance and personal characteristics) the data yields 1,446 observational units. Of the 1,446 observations, 13.5% (195 observations) had experienced a concussion sometime prior to the signing of the contract.

In panel A, the Mean Average Yearly Salary for contracts signed from summer 2007-summer 2011 was $1,439,521 and the average contract length was 1.845 years. Since my observation period spans 5 years, it is likely that I observed several contracts for the same player.

Panel B gives the mean of performance statistics of players for the season prior to their contract signing. The mean number of games played in the season prior was 49.95 games. As there are 82 games in an NHL season; this suggests that on average the players in my data set missed roughly 30 games in the season prior to the signing of their next contract.[9] The mean points per game were 0.3069. The mean penalty minutes per game are 0.7890. The minimum number of penalty minutes a player can earn at one time is 2 minutes. This means players earn on average approximately 1 penalty every 2.5 games, or 1 penalty every 7.5 periods of play. The mean age of the data is given in Panel C. Players were on average 27.85 years of age at the time they signed their new contract.

Table 2 provides a comparison of forwards to defence men. First and foremost, it is interesting to note the proportion of previously concussed players is higher for defence men at 14.9% in comparison to forwards at 12.8%. Panel A provides the contract statistics for both defence men and forwards. The data indicates that defence men earn on average $232,620 (USD) more than forwards for each year of their contract. Both defence men and forwards signed, on average, approximately the same length of contract at just under 2 years long. The performance

[9] Missing 30 games of the season is rather significant. This could be the result of injuries – including those other than concussion, or players being sent to the minors. It would be of interest to look at the impact of all disabling injuries.

statistics in Panel B are as expected with the only significant difference being the points per game statistic, where forwards earned significantly more than defence men.

6. Empirical Results

6.1 Log Salary Equation (Equation 1)

Table 3 provides the regression results of the log salary equation (equation 1), where controls were added sequentially. After controlling for performance, the concussion dummy becomes statistically significant only at the 10% level, and once both personal characteristics and performance are controlled, the concussion variable becomes no longer statistically significant. Not only is the variable not statistically significant, the coefficient was opposite of the a priori expectations – positive coefficient – and was very economically small. Under this model, the result suggests that general managers may not be discounting players based on their previous concussive history.[10]

The other independent variables used in the regression were consistent with the literature on NHL wage determination. All three performance measures were found to be statistically significant, with games played and points per game being highly significant. Most notably, the points per game coefficient is 1.8286 which suggests that for each increase in points per game by 10 percentage points (0.1); players should expect a 18.286% increase in salary. Age and Age Squared were not found to be statistically significant, but the sign of the coefficients were as expected. The forward dummy was -0.3397 which suggests that, ceteris paribus, defence men

[10] It was suggested that a correlation between concussion and penalty minutes may exist. If a correlation exists it may provide an explanation to the given results. A regression was run using the same specification interchanging the dependent variable. It was found that a concussion was a statistically significant determinant of penalty minutes per game. In fact for each concussion there was an increase in penalty minutes per game by 2.76; that's more than 1 penalty per game! The model used, suffers from multicolinearity. This does not affect the unbiasedness or consistency of the estimator in the above results, but this result does raise an interesting issue.

who record similar statistics as their forward counterparts are compensated with a 33.97% higher salary for their achievements. This is explained based on the a priori expectation that forwards achieve higher performance statistics than defence men. More simply, forwards are paid to score.

6.2 Contract Length Equation (Equation 2)

Table 4 displays the regression results where contract length was used as the dependent variable. Similar to the log salary equation, the controls for the contract length equation (equation 2) were applied in stages. Immediately from the basic regression with only year fixed effects, the concussion dummy is found to be not statistically significant. After adding in performance and personal characteristics sequentially, this result remains statistically insignificant and close to 0.

The other independent control variables were all found to be statistically significant determinants of contract length, and the signs of all coefficients were as expected. However, the coefficients were all economically small. The only variable which could significantly lengthen or shorten contracts was the points per game variable. A 1 point increase in points per game, leads to an increase in contract length of 1.83 years. This is still surprisingly small, as a 1 point increase in points per game is extremely difficult to achieve. To only increase contract length by 1.83 years is shocking. Personal characteristics like age, age squared and the forward dummy all had coefficient as expected but were much smaller in magnitude.

The evidence suggests that General Managers will not shorten (or lengthen) contracts of players with concussive history, and concussions do not affect a player's salary. Of course it is important to check if these results are robust. I have chosen three methods of checking robustness. The first robustness check – robustness check 1 – will evaluate differences in time

from the most recent concussive incident to the signing of the new contract. Robustness checks 2 and 3 will evaluate differences among the top 25th percentile in earnings and the bottom 25th percentile in earnings respectively.

6.3 Robustness Check 1: Time Differences from Concussive Incident to Contract

If a player has not received a concussion several years following the initial concussion, perhaps general managers view this as a reduced risk indicator. For the first robustness check I create three new variables, each differentiated based on the length of time between the most recent concussion incident and the signing of the contract. The variables will indicate whether the player has experienced a concussion within 1, 2 and 3 seasons prior respectively. To clarify, all contracts falling under the "concussion within one season prior" variable are also included in the "concussion within two seasons prior" variable.

Table 5 presents the regression results of the log salary equation (equation 1) using each of the new concussion dummy variables and the full set of controls. Table 5 shows that I achieved very similar results to the original regression equation. The concussion coefficients are positive, which is counter to the a priori expectations. The variable most intuitively expected to show results (the "concussion within one season prior" variable) was found to be not statistically significant. Less surprising, was the "concussion within three seasons" variable was found not statistically significant, as the long-term effects are relatively better known. As the time restriction on the concussion group was loosened the coefficient became even smaller.

The performance and personal characteristics variables remained consistent across all models as the coefficients changed very little. The statistical significance of these variables was also consistent with the original model. Points per game, games played and the forward dummy

remained highly significant, whereas age and age squared had the expected signs but, were not statistically significant.

Table 6 shows the regression results for the contract length equation (equation 2). Applying the full specification of the model the results were in line with the initial regression results. Counter to the a priori expectations regarding contract length, the coefficients on the concussion variables were positive. Similar to the results in Table 5; as the time restrictions on the concussions variables were progressively relaxed, the concussion coefficients became smaller.

The other explanatory variables in the model were similar to the initial regression results. All variables were statistically significant; and maintained their expected signs. However; like the initial regression results, the only variable which could drastically account for the lengthening or shortening of a contract was the points per game variable. All other variables were economically very small.

6.4 Robustness Check 2: Evaluating the Top 25 Earnings Percentile

Perhaps there is a problem of selection bias. It is conceivable that players who go on record revealing their concussive history are those at the upper end of the earnings spectrum. There are two potential reasons why this might be the case. (1) It may be that those players who are willing to divulge information about their concussive history are those same players that are skilled and feel secure in their job. (2) It is also possible that only those players at the upper end of the earnings spectrum are followed closely by fans, media, and the like, raising the reporting percentage for players earning upper level salaries. Thus, for robustness, I restrict the sample to only include those contract earnings which are in the top 25 percentile.

Table 7 gives the regression results of equation 1 (Log Salary Equation) after restricting the sample to include only those contracts in the upper 25th percentile. Using the same process as in Robustness Check 1, where time restrictions were differentiated with the full model specification, the regression results suggest a new finding. For the first time, the sign of the concussion variables are all negative which is consistent the original hypothesis, but none are statistically significant. In fact, they are all very close to zero and get increasingly smaller as the time restriction on concussions is eased.

The personal characteristics are all statistically significant determinants of wage, and have the expected sign. As for the Performance statistics, only the points per game variable was found to be a statistically significant determinant of wage.

6.5 Robustness Check 3: Evaluating the Bottom 25 Earnings Percentile

As a final robustness check, I evaluate the bottom 25th percentile in earnings. It is possible that the selection bias may work the other way. Perhaps the concussed group is over represented by high-end players that general managers are not willing to discount due to their skill level. A highly skilled player is a rare asset that many general managers may not be willing to take the risk in losing. Thus, an analysis of the lower end of the spectrum should be considered. Players at the lower end are far more abundant and may be considered "replaceable". If there was any evidence that general managers would discount players with a concussive history, it is likely to occur within this group. By restricting the sample to include only players in the lower end of the earnings spectrum (bottom 25th percentile), a regression on the log salary equation (equation 1) is run with Table 8 presenting the results.

Table 8 shows that the log salary equation (equation 1) has no explanatory power. The results in Table 8 indicate that none of the independent variables were statistically significant. This is a new result which shows that the power of the salary regressions is derived from the presence of the upper 75 percentile of players (in earnings). However, not much more can be drawn from this regression.

7. Discussion

The empirical results are clear; under the specified model used in this paper, I find no evidence of a discount on players who have a concussive history. This result is robust, as adjustments for time lags between the concussive event and the contract signing were evaluated. As well, differences amongst the earning spectrum were considered.

A discussion on some potential problems with the model may be beneficial in understanding the results. Firstly, there may be a problem of omitted variable bias; where it is possible that some important control variables were excluded or missing. In this paper, I made the assumption that general managers were "short-sighted" by only considering a players previous seasons performance. It could be very likely that a player has a good or bad previous season, and while it may impact the negotiations, it is not a true picture of the entire process. However, this may not be a significant problem as the results are robust to the choice of specification.

Another notable problem might be the measure of concussions used. For the purposes of this paper, I made the very clear distinction between concussed and non-concussed players. Only those players who exclusively were reported as suffering a concussion were included in the

concussion group, all others were part of the non-concussed group. Defined in this way, there is a possibility that players who have experienced a concussion (which went unreported) were placed in the "non-concussed" group. An improvement on this measure, such as an exclusion of players who have reported symptoms closely related to concussions may show more accurate and possibly statistically significant results.

Aside, from the potential problems, or root causes; as to why I may have achieved these results, the potential implications of these findings should also be noted. The entire premise of this paper was based on a logical and rational argument in which players who have been assessed as an increased risk are discounted. Players are (or they should be) thought of as an investment. If an investment suddenly became more risky, one of two things must occur in order to keep the investment attractive. (1) The expected profit must go up as a result of the increased risk, or (2) the cost of investing must go down. Since player outputs are to some extent limited and are typically stable and easy to forecast, the only adjustment available to a general manager when facing a riskier investment is to reduce the cost. If in fact general managers are not discounting players with concussions (as this paper suggests) and, if many researchers like Benson et al. are correct; then general managers are not acting as rational economic agents. They could potentially improve their teams' productivity by discounting players who are riskier, opening up more space under the salary cap to acquire other skilled players they would otherwise not be able to afford.

However, there may be other factors at play. General managers may not be taking concussions into consideration due to the fact that they may not be heavily constrained by the cap – some clubs operate well below it – alleviating the pressure for efficiency spending. General managers whose club is operating near the cap, may find their efficiency pressures relieved as there is a stipulation in the CBA which relates to long-term injury/illness in which the salary cap

may be exceeded in the event a player is injured for 24 consecutive calendar days or miss 10 consecutive games. A replacement player may be used – and the salary cap exceeded – as the long as the average yearly salary of the replacement player is equal to or less than the average yearly salary of the injured player. It is not until the return of the injured player that the team must return to cap adherence.

In terms of implications for the players, this is an ideal result. Discounting players based on their concussive history may compel players to avert from truly identifying their symptoms out of fear of salary reduction or decreasing job security. The fact that no evidence was found that general managers are discounting players with concussions should ease their minds when disclosing concussion symptoms.

From the perspective of the NHL, this is likely also the preferred result. Since general manager's are (suggestively) not discounting players based on their concussive history, the quality of play is likely higher as players are no more or less likely to make plays which risk injury. A higher quality of play will draw the attention of more consumers resulting in potentially higher profits. If general managers did begin discounting, the effect could be so profound that the NHL could see a reduction in total revenues.

7.1 Areas for Further Research

There are many areas for further research on *this* particular topic. They include, setting a better measure of concussed or non-concussed players by differentiating based on concussion *related* injuries, evaluating the effects for entry level contracts, or the inclusion of contract extensions into the model. Extending this study further, could be an evaluation of the impact of *all* disabling injuries on player salaries and contract lengths.

Other related topics which would be of interest include, an assessment of the effects that concussions have on player performance; answering questions such as "Do players perform poorer following a concussion?" or "Will Sidney Crosby be the same player when he returns?"

8. Conclusion

With an increasing awareness on the long-term and short-term effects of concussions, the NHL has taken a pro-active approach to understanding this elusive injury. In negotiating a contract, the general manager of a team must forecast player productivity and assign players a monetary value on an individual basis. It was hypothesized that a general manager must take into consideration a player's health history – particularly in the case of concussions.

In this paper, I examined individual player contracts, observing concussive history, prior performance, and personal characteristics. More precisely, I explore whether or not general managers will negotiate different contracts for players with concussive histories, both in terms of contract length and average salary over the life of the contract.

Using regression analysis, I do not find any evidence to suggest that general managers take a player's concussive history into account when negotiating a contract. The presence of a concussive history has little impact, both economically and statistically, on the average salary of a contract—even after controlling for a player's past performance and personal characteristics. I get similar findings when the focus is on contract length. These results are not sensitive to the approach used to measure a concussive history. Finally, the results are robust even when differences in the earnings spectrum were taken into account.

Similar to the rest of the literature on wage determination in the NHL, points per game were found to be an important contributor to the player's salary. It also mattered for contract length. Games played were also found to be statistically significant, but were economically very small. Also notable was that forwards, ceteris paribus, earned significantly less and obtained shorter contracts than their defensive counterparts. In contrast to the literature, penalty minutes per game were not economically significant contributors and were often found only statistically significant at the 10% level. Age was not a statistically significant contributor to average salary but was found highly significant in determining the contract length.

Explanations for these results include omitted variable bias, an improper definition of the concussion variable; or perhaps concussions are just not considered by general managers to be important indicators of future player performance. It is also likely that the options under the 2005 CBA make concussive history inconsequential. General managers are authorized to exceed the salary cap in cases of long-term injury/illness where replacement players are essential in order to fill a team's line-up.

Players would be likely to embrace these results as they suggest that players can truly identify concussions without the fear of being financially penalized in their next contract. From a league perspective, reducing a players' fear of injury may result in higher quality (and perhaps riskier) play attracting more fans as consumers. Although no evidence was found in this paper, it would be worthwhile to perform further research on this, and other similar areas.

References

Aubry, M., Cantu, R., Dvorak, J., Graf-Baumann, T., Johnston, K. M., Kelly, J., et al. (2002). Summary and Agreement Statement of the 1st International Symposium on Concussion in Sport, Vienna 2001. *Clinical Journal of Sports Medicine , 12* (1), 6-11.

Benson, B. W., Meeuwisse, W. H., Rizos, J., Kang, J., & Burke, C. J. (2011). A prospective study of concussions among National Hockey League players during regular season games: the NHL-NHLPA Concussion Program. *Canadian Medical Association Journal , 183* (8), 905-911.

Berri, D. J., & Brook, S. L. (2010). On the Evaluation of the "Most Important" Position in Professional Sports. *Journal of Sports Economics , 11* (2), 157-171.

Curme, M. A., & Daugherty, G. M. (2004). Competition and Pay for National Hockey League Players Born in Quebec. *Journal of Sports Economics , 5* (2), 186-205.
Deutscher, C. (2009). The Payoff to Leadership in Teams. *Journal of Sports Economics , 10* (4), 429-438.

Guskiewicz, K. M., McCrea, M., Marshall, S. W., Cantu, R. C., Randolph, C., Barr, W., et al. (2003). Cumulative Effects Associated With Recurrent Concussion in Collegiate Football Players: The NCAA Concussion Study. *Journal of the American Medical Association , 290* (19), 2549-2555.

Haché, A. (2002). *The Physics of Hockey.* JHU Press.

Jenkins, J. A. (1996). A Re-examination of Salary Discrimination in Professional Basketball. *Social Science Quarterly , 77* (3), 594-608.

Jones, J. C., & Walsh, W. D. (1988). Salary Determination in the National Hockey League: The Effects of Skills, Franchise Characteristics, and Discrimination. *Industrial and Labor Relations Review , 41* (4), 592-604.

Jones, J. C., Nadeau, S., & Walsh, W. D. (1997). The Wages of Sin: Employment and Salary Effects of Violence in the National Hockey League. *American Economic Journal , 25* (2), 191-206.

Lambrinos, J., & Ashman, T. D. (2007). Salary Determination in the National Hockey League: Is Arbitration Efficient? *Journal of Sports Economics , 8* (2), 192-201.

Lavoie, M. (2000). The Location of Pay Discrimination in the National Hockey League. *Journal of Sports Economics , 1* (4), 401-411.

Lavoie, M., & Grenier, G. (1991). Discrimination and Salary Determination in the National Hockey League: 1977 and 1989 compared. Working Papers 9110e, University of Ottawa, Department of Economics.

Lavoie, M., Grenier, G., & Coulombe, S. (1987). Discrimination and Peformance Differentials in the National Hockey League. *Canadian Public Policy , 13* (4), 407-422.

Lavoie, M., Grenier, G., & Coulombe, S. (1992). Performance Differentials in the National Hockey League: Discrimination Versus Style-of-Play Thesis. *Canadian Public Policy , 18* (4), pp. 461-469.

Longley, N. (1995). Salary Discrimination in the National Hockey League: The Effects of Team Location. *Canadian Public Policy , 21* (4), 413-422.

McCrory, P., Meeuwisse, W., Johnston, K., Dvorak, J., Aubry, M., Molloy, M., et al. (2009). Concensus Statement on Concussion in Sport - The 3rd International Conference on Concussion in Sport Held in Zurich, November 2008. *American Academy of Physical Medicine and Rehabilitation , 1* (5), 406-420.

McLean, R. C., & Veall, M. R. (1992). Performance and Salary Differentials in the National Hockey League. *Canadian Public Policy , 18* (4), 470-475.

National Hockey League. (2005, July 22). Collective Bargaining Agreement Between National Hockey League and National Hockey League Players' Association. Retrieved Mar 09, 2012, from: http://www.nhl.com/cba/2005-CBA.pdf

Szymanski, S., & Longley, N. (2001, March). *A Market Test for Discrimination in the National Hockey League.* Retrieved Dec 14, 2011, from: http://law.psu.edu/_file/Sports%20Law%20Policy%20and%20Research%20Institute/Market%20Test%20for%20NHL%20Discrimination.pdf

Vincent, C., & Eastman, B. (2009). Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics , 10* (3), 256-277.

Wennberg, R. A., & Tator, C. H. (2008). Concussion and Incidence of Time Lost from Play in the NHL During the Past Ten Years. *The Canadian Journal of Neurological Sciences , 35* (5), 647-651.

Zemper, E. D. (2003). Two-Year Prospective Study of Relative Risk of a Second Cerebral Concussion. *American Journal of Physical Medicine and Rehabilitation , 82* (9), 653-659.

Table 1: Descriptive Statistics

	Mean	St. Dev
A. Contracts		
Average Yearly Salary	1,439,521	(1,358,334)
Contract Length	1.845	(1.208)
B. Performance Statistics		
Games Played	49.957	(28.210)
Points Per Game	0.307	(0.237)
Penalty Minutes Per Game	0.789	(0.822)
C. Characteristics		
Age	27.851	(4.424)
Proportion Concussed	0.135	(0.00898)
Proportion Forwards	0.675	(0.0123)
Number of Observations	1,446	--

Table 2: Descriptive Statistics by Position

	Defence Men		*Forwards*	
	Mean	St. Dev	Mean	St. Dev
A. Contracts				
Average Yearly Salary	1,596,531	(1,441,846)	1,363,911	(1,310,294)
Contract Length	1.942	(1.281)	1.799	(1.169)
B. Performance Statistics				
Games Played	49.604	(27.265)	50.127	(28.666)
Points Per Game	0.239	(0.172)	0.340	(0.256)
Penalty Minutes Per Game	0.761	(0.601)	0.803	(0.910)
C. Characteristics				
Age	28.094	(4.487)	27.734	(4.391)
Proportion Concussed	0.149	(0.0164)	0.128	(0.0107)
Number of Observations	470	--	976	--

Table 3: Regression Results of Log Salary Equation

	(1)	(2)	(3)
Concussion	0.287***	0.0643*	0.0448
	(0.0572)	(0.0372)	(0.0359)
Performance Statistics (lagged)			
Points Per Game	--	1.645***	1.829***
		(0.0612)	(0.0599)
Penalty Minutes Per Game	--	0.0146	0.0278*
		(0.0156)	(0.0149)
Games Played	--	0.00997***	0.00934***
		(0.000509)	(0.000494)
Personal Characteristics			
Age	--	--	0.0198
			(0.0291)
Age Squared	--	--	-0.000324
			(0.000484)
Forward	--	--	-0.340***
			(0.0261)
Year Fixed Effects	Yes	Yes	Yes
Number of Observations	1,446	1,446	1,446

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%

Table 4: Regression Results of Contract Length Equation

	(1)	(2)	(3)
Concussion	0.0993 (0.0926)	-0.0985 (0.0852)	0.0148 (0.0837)
Performance Statistics (lagged)			
Points Per Game	--	1.540*** (0.140)	1.831*** (0.140)
Penalty Minutes Per Game	--	0.0438 (0.0358)	0.0579* (0.0346)
Games Played	--	0.00827*** (0.00117)	0.00925*** (0.00115)
Personal Characteristics			
Age	--	--	0.146** (0.0679)
Age Squared	--	--	-0.00342*** (0.00113)
Forward	--	--	-0.356*** (0.0608)
Year Fixed Effects	Yes	Yes	Yes
Number of Observations	1,446	1,446	1,446

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%

Table 5: Regression Results of Robustness Check 1 (Time since most recent Concussion) on Log Salary Equation

	(1)	(2)	(3)	(4)
Concussion *anytime prior*	0.0449 (0.0359)	--	--	--
Concussion *1 season prior*	--	0.0605 (0.0434)	--	--
Concussion *2 seasons prior*	--	--	0.0164 (0.0390)	--
Concussion *3 seasons prior*	--	--	--	0.0193 (0.0371)
Performance Statistics (lagged)				
Points Per Game	1.829*** (0.0599)	1.828*** (0.0599)	1.830*** (0.0599)	1.830*** (0.0599324)
Penalty Minutes Per Game	0.0278* (0.0149)	0.0272* (0.0149)	0.0282* (0.0149)	0.0280* (0.01489)
Games Played	0.00934*** (0.000494)	0.00934*** (0.000493)	0.00937*** (0.000494)	0.00936*** (0.000495)
Personal Characteristics				
Age	0.0198 (0.0291)	0.0225 (0.0291)	0.0221 (0.0291)	0.0221 (0.0291)
Age Squared	-0.000324 (0.000484)	-0.000354 (0.000483)	-0.000350 (0.000483)	-0.000350 (0.000483)
Forward	-0.340*** (0.0261)	-0.339*** (0.0261)	-0.340*** (0.0261)	-0.341*** (0.0261)
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,446	1,446	1,446	1,446

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%

Table 6: Regression Results of Robustness Check 1 (Time since most recent Concussion) on Contract Length Equation

	(1)	(2)	(3)	(4)
Concussion *anytime prior*	0.0149 (0.0837)	--	--	--
Concussion *1 season prior*	--	0.164 (0.101)	--	--
Concussion *2 seasons prior*	--	--	0.129 (0.0907)	--
Concussion *3 seasons prior*	--	--	--	0.0943 (0.0865)
Performance Statistics (lagged)				
Points Per Game	1.831*** (0.140)	1.825*** (0.140)	1.827*** (0.140)	1.829*** (0.140)
Penalty Minutes Per Game	0.0579* (0.0346)	0.0545 (0.0346)	0.0549 (0.0346)	0.0555 (0.0347)
Games Played	0.00925*** (0.00115)	0.00916*** (0.00115)	0.00913*** (0.00115)	0.00915*** (0.00115)
Personal Characteristics				
Age	0.146** (0.0679)	0.148** (0.0677)	0.147** (0.0677)	0.147** (0.0678)
Age Squared	-0.00342*** (0.00113)	-0.00343*** (0.00112)	-0.00341*** (0.00113)	-0.00342*** (0.00113)
Forward	-0.356*** (0.0608)	-0.352*** (0.0608)	-0.355*** (0.0608)	-0.356*** (0.0608)
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	1,446	1,446	1,446	1,446

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%

Table 7: Regression Results of Robustness Check 2 (Top 25 Percentile in Earnings) on Log Salary Equation

	(1)	(2)	(3)	(4)
Concussion *anytime prior*	-0.0469 (0.0361)	--	--	--
Concussion *1 season prior*	--	-0.0458 (0.0431)	--	--
Concussion *2 seasons prior*	--	--	-0.0445 (0.0404)	--
Concussion *3 seasons prior*	--	--	--	-0.0477 (0.0385)
Performance Statistics (lagged)				
Points Per Game	1.331*** (0.0774)	1.333*** (0.0777)	1.334*** (0.0777)	1.333*** (0.0776)
Penalty Minutes Per Game	0.0630* (0.0370)	0.0588 (0.0368)	0.0585 (0.0368)	0.0612* (0.0369)
Games Played	0.00155 (0.000995)	0.00149 (0.000996)	0.00148 (0.000996)	0.00149 (0.000995)
Personal Characteristics				
Age	0.161*** (0.0365)	0.157*** (0.0364)	0.157*** (0.0364)	0.156*** (0.0364)
Age Squared	-0.00263*** (0.000603)	-.00258*** (0.000602)	-0.00258*** (0.000602)	-0.00256*** (0.000602)
Forward	-0.416*** (0.0354)	-0.415*** (0.0354)	-0.414*** (0.0353)	-0.412*** (0.0353)
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	359	359	359	359

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%

Table 8: Regression Results of Robustness Check 3 (Bottom 25 Percentile in Earnings) on Log Salary Equation

	(1)	(2)	(3)	(4)
Concussion *anytime prior*	-0.0155 (0.0318)	--	--	--
Concussion *1 season prior*	--	0.0263 (0.0384)	--	--
Concussion *2 seasons prior*	--	--	0.0195 (0.0328)	--
Concussion *3 seasons prior*	--	--	--	0.0160 (0.0310)
Performance Statistics (lagged)				
Points Per Game	0.0208 (0.0549)	0.0221 (0.0549)	0.0209 (0.0549)	0.0215 (0.0549)
Penalty Minutes Per Game	0.0106 (0.00772)	0.00987 (0.00766)	0.00990 (0.00766)	0.00988 (0.00766)
Games Played	0.000000515 (0.000434)	-0.000000463 (0.000434)	-0.000000400 (0.000434)	-0.0000000865 (0.000434)
Personal Characteristics				
Age	-0.0276 (0.0301)	-0.0279 (0.0300)	-0.0286 (0.0300)	-0.0291 (0.0300)
Age Squared	0.000477 (0.000518)	0.000480 (0.000516)	0.000491 (0.000516)	0.000498 (0.000516)
Forward	0.00924 (0.0193)	0.00867 (0.0193)	0.00882 (0.0193)	0.00883 (0.0193)
Year Fixed Effects	Yes	Yes	Yes	Yes
Number of Observations	304	304	304	304

Notes. Standard errors are in parentheses. Level of statistical significance: * 90% ; ** 95% ; *** 99%