SALARY DETERMINANTS OF NHL DEFENSEMEN: A QUANTILE REGRESSION APPROACH

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Gabriel Guentzel

May, 2012

SALARY DETERMINANTS OF NHL DEFENSEMEN: A QUANTILE REGRESSION APPROACH

Gabriel Guentzel

May 2012

Economics

Abstract

Traditionally, defensemen in the National Hockey League (NHL) have been paid unevenly. Statistics measuring production for an NHL defensemen were applied to help determine a salary. Since the lockout of the 2004-05 season in the NHL, the importance of determining salaries for defensemen became important because of the introduction of the salary cap.

The purpose of this study was to analyze this salary disparity by cross-referencing career numbers of 235 NHL defensemen with their salaries, using both an Ordinary Least Squares regression and a Quantile regression to estimate earnings. Data was collected from the 2009-10 season, with salaries taken from 2010-11 season. The regression results showed that 14 independent variables were found to be significant in different quantiles and in the OLS regression. The estimation results suggest that the conditional expectation model used in previous studies misses some of the subtleties of the earnings determination process in the NHL

.

KEYWORDS: (Salary, Defensemen, National Hockey League)

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Basketball Coach Dave Thorson stated it best when he said, "Offense sells tickets; Defense wins championships." He wasn't the only coach or player to use this saying; many often associate it with the great Bear Bryant, legendary coach at Alabama. This phrase can be applied to any sport, especially hockey because of the importance of keeping the puck out of your net to win. A team can't lose if they don't give up any goals. The importance of defense in sport is far greater than what it is recognized for. Often defensive players don't get the accolades that offensive players get because they are not the ones putting points on the board for their teams, or have high-light reel goals that you would see on ESPN. Chris Chelios (Former NHL defensemen and Norris Trophy Winner[1]) was quoted saying, "It takes brains. It's not like a forward, where you can get away with scoring and not play defense. On defense you have to be thinking." But the importance of defensive players in any sport goes way farther than the recognition given to offensive players[2], because, "Defense Wins Championships." About.com gave a little preview looking at the 2008 Stanley Cup Finals, and they noted that the Detroit Red Wings had an upper hand on the series because of having the best

---

[1] The James Norris Memorial Trophy is awarded annually to the National Hockey League's top defense player who demonstrates throughout the season the greatest all-round ability in the defense position.

[2] Alexander, Bibin. The Best Defense is a Good Offense. The Sports Mirror. http://www.thesportsmirror.com/2011/03/the-best-defense-is-a-good-offense/ (accessed March 6, 2012).

defensive pairing in the NHL in Nicklas Lidstrom and Brian Rafalski, also noting the importance of defensive side of the game.[3]

The purpose of this chapter is to introduce the National Hockey league, the lockout of the 2004-05 season, rule changes, introducing topics about my thesis and what will be used in my thesis, and background information about the game of hockey. The rule changes will help understand why my thesis differs from previous studies.

The NHL is the premier league for all hockey players around the world and the information and studies that are done on the NHL have been steadily growing compared to that of the other 3 major sports in the United States. In my thesis, I will be looking at the defensive role in the NHL and the way a defensemen plays with regards to offensive vs. defensive, physical vs. finesse and how experience affects their salaries. I will be doing that by doing a quantile regression approach that will look at defensemen in the NHL that played at least 10 games in the NHL season 2009-10 while using the salaries from the 2010-11. I will be using the Quantile regression because it will help me look at players differently because of the way they are paid, and since everyone in the NHL isn't paid the same amount of money, Quantile regression will help asses each player. In the study done by Vincent and Eastman (which I will be working my thesis off of) they state that, "The difficulty in estimating an earnings function for hockey players is further complicated because most studies on salary determination in the NHL use the standard conditional expectation model to estimate earnings equations. The focus on the conditional mean may misrepresent the relationship between earnings and performance if

[3] Moody, Allen. Stanley Cup Finals Preview. About.com. http://sportsgambling.about.com/od/hockeybetting/a/08stanleycup.htm (accessed February, 2012).

there are differences in the returns to performance along the conditional distribution."[4] With my thesis, I would like to add additional information into looking at the relationship between salary determination and performance to help create an opportunity for General Managers of NHL organizations to better allocate money under the salary cap to put together the best possible team to win a Stanley Cup.[5] If I can find a model that can help General Managers to analyze that is similar to the impact "Money ball" in baseball which was first introduced by Billy Beane and the Oakland Athletics, it will help teams better allocate money based on their budgets and to stay under the salary cap that is in the NHL.

The question I will be looking at in my thesis is that I want to see if the career numbers through points, penalty minutes, plus/minus, among other things helps in determining the salary of an NHL defensemen. I will be using a quantile regression approach in trying to explain this in my thesis.

My thesis differs from the study by Vincent and Eastman, in the way that I used salaries after the NHL lockout of 2004-05, when the National Hockey League and the National Hockey Leagues Players Association (Players Union) agreed on a new Collective Bargaining Agreement following the cancellation of the 2004-05 season that implemented new rules and also affected salaries. The salaries used by Vincent and Eastman is different because following the Lockout there was a 24% rollback on all salaries of players.[6] I will also be adding several variables to my model to see if I can

---

[4] Vincent, Claude and Byron Eastman. 2009. Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. P. 2

[5] The Stanley Cup is awarded to the team that wins the postseason in the NHL, it is often considered the hardest trophy in sports to win because it takes 16 wins in the postseason to win this trophy.

[6] Staudohar, Paul D. 2005. The Hockey Lockout of 2004-05. 128, no. 12: p. 27

further the research and see if I can get a higher r^2 value then the one found by Vincent and Eastman.

The National Hockey League started in 1917 in Canada with a four-team league centered around Montreal. Now the NHL has grown to a league made up of 30 teams consisting of 6 teams in Canada and 24 in the United States. The NHL is considered the most premier league in the world for hockey players and has players ranging from over 20 different countries playing in the NHL. The main source of income for the NHL is a TV contract with NBC and Versus and radio coverage, as well as, promoting its high-end players and merchandise.

In 2004-05, the NHL had a lockout, the owners locked out the players that shut down the season for 310 days. This lockout is the longest lockout in sports history to date. The whole season was cancelled because of the lockout. When Owners and the Players finally agreed on a Collective Bargaining Agreement (CBA), the NHL would change significantly. Before the lockout, there was no salary cap for teams or individuals, or any revenue sharing among teams and players. This created a revenue sharing program for players as well as helped the league secure a television contract and provide a more stable League and a way for players to get a chunk of the money the NHL would be making.[7]

New Rule Changes Following 2004-05 Lockout

When the lockout was over there was a change in the rules for the way the NHL would be played. The new rules that went into place changed the way players played, and the NHL began to focus more on offense and scoring. The idea was to make it more

---

[7] Rosner, Scott and Kenneth Shropshire. 2011. The Business of Sports. Ch. 5. 2, p.140.

of a fan friendly game, and to try and get more people to hockey games, which would lead to more attendance in games with people wanting to see an exciting game and increased revenue for teams. Thus putting less emphasis on the defensive side of the game, and in turn actually putting more pressure on defensemen. One thing the new rules changed was all the clutching and grabbing defensemen could do, which would slow down the higher skilled forwards. The idea the NHL had with the new rules was to increase the skill in the game and for it to be more a faster paced game with speed excelling in the "New" NHL. The big-lanky-slow defensemen of the past that would punish forwards in front of the net and around the rink would be no more because of the change in the interference rules and the speed that was going to be emphasized in the "New" NHL.[8] With the NHL becoming a faster league, the size and speed of defensemen changed, defensemen were now coming into the league smaller in stature and faster on the ice, replacing many of the big slow defensemen of the past.

Another major rule change that the new CBA had was that the league took out the two-line pass[9] (a player cannot make a pass to his teammate who is more than 2 lines on the ice surface away, i.e. a player from defensive zone cannot make a pass to his teammate standing on the offensive side of the center ice red line). Before the lockout and teams could not make a two-line pass, teams would play a style called the "neutral zone trap" which really slowed down the game, and took a lot of the quick transition play out of play and made the game more defensive, and tougher for the high-end skilled forwards to create opportunities for their team. When the two-line pass was taking out

[8] Fitzpatrick, Jamie. The New NHL: Essential Info for 2005-06 NHL Season. About.com. http://proicehockey.about.com/od/thenewnhl/a/05_nhl_calendar.htm (accessed March, 6, 2012).
[9] Fitzpatrick, Jamie. NHL Rules Changes: Probing The Brave New Hockey World. About.com. http://proicehockey.about.com/cs/rules/a/04_rule_changes.htm (accessed February 6, 2012).

following the lockout, the NHL also made the neutral zone (zone between the two blue lines) in turn making the offensive zones larger to create for more space for offensive players to create scoring opportunities.

The new Collective Bargaining Agreement also implemented a "Hard Salary Cap.[10]" The term hard means that teams cannot ever go over the salary cap during the season, under any circumstances. This differs from other major sports leagues are set up. For example, basketball has a soft cap and can offer their players money that can exceed the salary cap, in theory, to foster more fan support in a city. The salary cap really put the pressure on teams to make sure that they found the right pieces to the puzzle to put together a championship team. The salary cap made it hard for one team to create, in a sense, a "Dream Team" that could win a lot of championships and dominate the sport. This created a lot of parity in the league, in thus creating a more exciting game because of a level playing field in that teams cannot exceed a certain payroll to its players. Although there are still large market teams and small market teams, league also had a minimum cap number that teams had to be over, in thus, forcing teams to spend a fair amount of money to put a reasonable hockey team on the ice.

Another major rule change following the lockout was the size of goalies equipment.[11] The size of the leg pads as well as the size of both the blocker and catching glove was reduced in size. Also, goalies protective gear around their torso was reduced in size to create more of a snug fit around goalies and make sure the size of their chest protector fit their body personally and wasn't oversized to take up more room covering

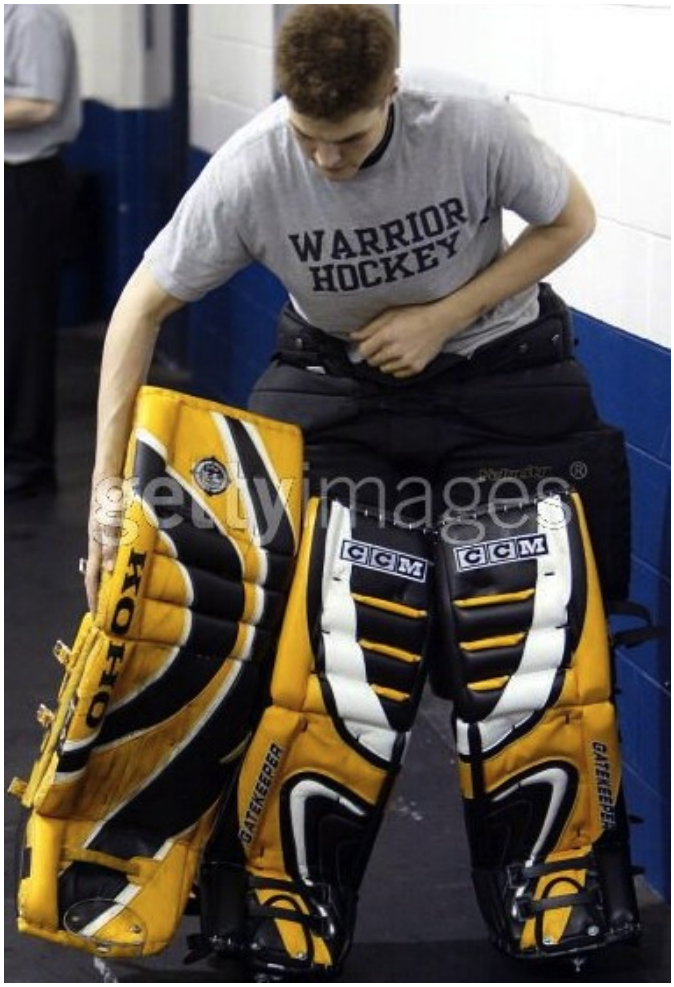
---

[10] Fitzpatrick, Jamie. The New NHL: Essential Info for 2005-06 NHL Season. About.com. http://proicehockey.about.com/od/thenewnhl/a/05_nhl_calendar.htm (accessed March, 6, 2012).
[11] Fitzpatrick, Jamie. NHL Rules Changes: Probing The Brave New Hockey World. About.com. http://proicehockey.about.com/cs/rules/a/04_rule_changes.htm (accessed February 6, 2012).

the net. The leg pads width was reduced from 12 inches to 11 inches, and the length of the leg pads was restricted to 38 inches. The catching glove was also affected as a limit was put on how open it can be, 8 inches. The blocker also saw some changes as it was shrunk to 15 inches by 8 inches. The rule changes to goalies was put into place to increase the scoring and games and make it more of an offensive game and create more excitement for fans. The picture below shoes a difference in leg pads before the lockout, to leg pads following the lockout:

FIGURE 1.1

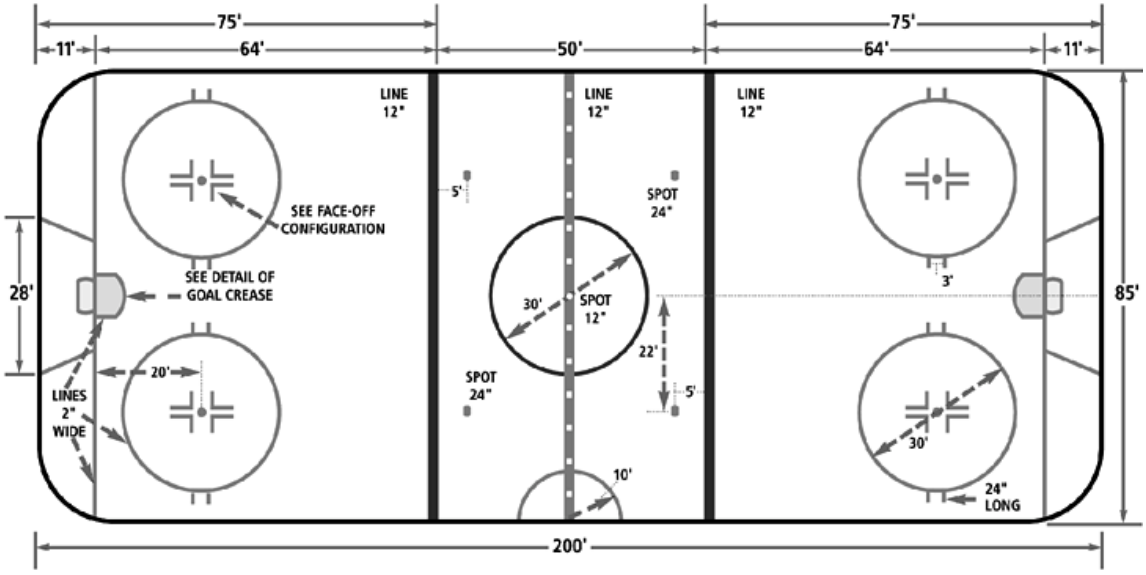
GOALIE EQUIPMENT RULE CHANGES



Adding on, the NHL also limited the area where goalies could play the puck. There is a trapezoid placed behind the goal line (the line drawn fro where a puck must cross for a goal to count in hockey) that restricts the goalies from playing the puck in the corners, and thus, helping defensemen break the puck out easier. The picture below shows the dimensions of the NHL ice surface following the lockout:

FIGURE 1.2

NHL RINK DIMENSIONS FOLLOWING LOCKOUT



The trapezoid behind both goals (28’ area) shows the area that goalies can play the puck behind the goal line. Goalies can play the puck anywhere above the goal line but are restricted in where they can play the puck behind the net, if a goalie is to play the

puck outside of the restricted zone behind the goal line, he is assessed a two minute minor for delay of game.

The defensive role is often under-appreciated by fans of the NHL, as defensemen don't often get the recognition they deserve for what they are asked to do.[12] There isn't a specific definition that can be given to explain a defensemen in the NHL. All players play differently in their own ways, and there are also offensive defensemen and defensive defensemen. Offensive defensemen are considered to help with the offensive and join the rush (when forwards are attacking the other teams defensemen, this is considered a rush) and help score goals, and help set up teammates score goals. Defensive defensemen often block shots (form of blocking a puck from reaching their teams net for a shot on goal), killing penalties (when a team is shorthanded because of an infraction committed by a teammate), and shutting down opposing teams top players. There is also a puck moving defensemen, the puck moving defensemen is clean on breaking the puck out and getting the puck into the forwards hands (breaking the puck out is when the opposing team chips the puck into a team's corner and it is often the role of the defensemen to retrieve the puck and pass to their teammates to help get their team out of their defensive zone). Puck moving defensemen are also quick on transition (transition is when the opposing team turns the puck in the neutral zone or center area of the hockey rink and the team quickly turns the turnover into possession for their team often leads to a rush). Without one specific definition or defining way to coach a defensemen in how to play, it is very difficult to measure a defensemen's contributions.

---

[12] Alexander, Bibin. The Best Defense is a Good Offense. The Sports Mirror. http://www.thesportsmirror.com/2011/03/the-best-defense-is-a-good-offense/ (accessed March 6, 2012).

In short, the lockout hurt hockey in that it lost some of the fan base it already had, and the fan base was already bare. Taking away any professional sports season is going to be detrimental to any sport. But in the long run, hockey has flourished since the lockout and has succeeded in creating a more exciting product to its fans. The NHL got it right when they did agree on a CBA and it took some time for the NHL to get back a good fan base and now hockey is one of the fastest growing games among Americans because of the entertainment it provides for its fans.[13]

The problem this study will have is since the lockout and the introduction of speed, less clutching and grabbing, and the salary cap, is it is tough to measure a defensemen's contributions through one specific measure because defensemen are not the ones scoring all the goals and the recognition they get for defending and keeping opposing teams from scoring goals on an individual basis is tough to measure. Therefore it is tough to determine the perfect or accurate salary for an NHL defensemen. This could potentially be very crucial evidence for NHL franchises in determining how to allocate funds to their defensemen to allow a club to spend money on the other notable areas, goaltending and forwards. If a general manager of a sports franchise, or a CEO of a fortune 500 company, or even a small business owner, could determine what exactly was a significant factor in determining how to pay an employee, the sports/business world could change greatly and these franchises or companies could better allocate funds to make sure they are getting the most bang for their buck, and are getting the most out of the employees. The NHL is a business, the idea is to maximize profit, but in sports, teams want to win championships, because championships lead to more fans, which is

[13] Pierce, Andrew and Conti, John. NHL: Brand Resurrected. Prophet. http://www.prophet.com/thinking/view/297-nhl (accessed March 6, 2012)

what pays the bills for players in sports and leads to a higher revenue, and more successful team or business.

This study will try and help determine how to pay players in the NHL that can be related to employees in a business in the most efficient way possible to ensure for a very productive team and business. The main question this study will examine is: How to accurate estimate the earnings function for an NHL defensemen? I believe that points and penalty minutes will affect player's salaries; with more points and penalty minutes (points for offensive defensemen and penalty minutes for defensive defensemen) they are the ones that will be paid higher salaries in the end. I will run an OLS regression and quantile regression and cross-reference the two to see how salaries and all my variables correlate and to see if each variable is significant in determining salaries for defensemen in the NHL.

I believe this is an important problem to look at because it can prove to be very cost-effective for a franchise in determining what players to sign in the off-season through free agency, and how to pay players that come up through the minors and junior ranks into the NHL. The problem of determining salaries for any professional athlete is very tough to decipher and with added research in looking how to determine salary for professional athletes, a lot of information can be found to directly reflect how to accurate pay athletes, while under a strict budget like a salary cap.

CHAPTER II

LITERATURE REVIEW

The purpose of this chapter is to take a look at previous and relevant research on studying the salaries and production of defensemen in the National Hockey League, trying to answer questions about productivity and contracts, location of players, and rule changes have affected player compensation.

The research into salary determination in professional sports has been examined quite extensively, but the studies have been mainly on basketball, baseball, and football and economist have just scratched the surface on the determination of salary in the National Hockey League. Ever since the lockout that occurred in 2004-05 that took away the whole NHL season, the debate of salaries in the NHL has picked up because of the addition of the salary cap into the league. When the Players Association (association all NHL players are a part of) and the brass of the NHL and owners (NHL executives at league office and Owners) agreed to a new Collective Bargaining Agreement, the question of salaries and how much players would get paid was affected by many factors. This includes the salary cap, production, rules changes, and location of where a player played. Before the lockout, high revenue generating teams could pay high salaries to players and buy players through free agency to make their team better, but also sometimes, players would give teams "hometown" or "location" discounts because they

liked the area or they wanted to remain with the same team throughout their career, therefore, players would take less money to stay with a certain team. After the lockout, players would have to take hometown discounts to stick with a team because of the salary cap limiting how much a team can spend on its players. Players after the lockout also tested free agency more in the summer following the lockout then in any other year in NHL history.[1] To become a free agent, a player must have his contract expire and have no future contractual obligations for following years. Being a Free agent has two distinct names for it, Unrestricted and Restricted. Being an unrestricted Free agent in the NHL has changed over the years as the age of players who can become an unrestricted free agent has gone down since the lockout.[2] Immediately following the lockout the age for becoming and unrestricted free agent was 31 years of age.[3] For a player to be a restricted free agent, they must not qualify for the age requirements to be an unrestricted free agent and also not be on an entry level contract. A restricted free agent differs from an unrestricted free agent in that if a player is restricted, he can be offered a contract by any NHL team, but if that so player signs a contract with a different team then he was originally playing on, the original team has 7 days to determine whether they want to match the offer and keep the player or let him go and receive compensation depending on the amount of salary he will receive with his new deal.[4] Teams must extend qualifying offers first for they're to be any possibility of receiving compensation if they were to lose a player to another team. Players are often measured on production, through statistics, as

[1] Fitzpatrick, Jamie. Key points in the NHL collective agreement. About.com. http://proicehockey.about.com/od/thenewnhl/a/salary_cap_expl.htm (accessed March 6, 2012).
[2] Ibid p.2
[3] Ibid p.2
[4] Fitzpatrick, Jamie. NHL free agents explained. About.com. http://proicehockey.about.com/od/nhlfreeagents/a/nhl_free_agents_2.htm (accessed March 6, 2012).

to how they would be paid for their work, because that is the main value that many players are measured on as to how they will be paid by an NHL team.

Because the lockout changed the landscape of the NHL and provided more of a fan friendly environment and created a game more for the skilled players of the NHL and more room to operate. Most of the research and studies on the NHL have been strictly on Forwards because it is easy to measure their value through statistics, it is tough to measure defensemen through production because they do not always account for many goals or assists, also with their being offensive and defensive defensemen in the NHL its tough to measure the defensive side and importance provided by a defensemen. Its tough to measure defensive statistics but some used are plus/minus per game (plus/minus statistic is given to a player when goals are scored: a plus is given to a player when he is on the ice for his teams goal on even strength 5 on 5 play, a minus is given to a player when he is on the ice for an opposing team's goal in even strength play), penalty minutes per game, height and weight. Just recently in the last decade the NHL created more statistical measures for defensemen to be gauged for their value, because goals and assists are not always a great measure for determining the value for defensemen.

Location

Many researchers have studied the impact that geography of where players hail from and where teams are located to see what player's salaries are for these two location values. For unrestricted free agents it's easier to decide where you would like to play geographically, but for drafted players, you have less say in that process of choosing

where to play because you have to play for the team that drafted you. For undrafted players it is also easier to choose where you would like to play and most players choose big market teams because teams that make more money often pay their players more money. Also, French Canadian players often choose to play for a French Canadian team, because they feel they will be paid better then going to an English speaking team.[5] Choosing a team for a player can have a very significant ramifications for the players career because by choosing the right organization or the wrong one can determine whether a player will get an opportunity to showcase his skills at the NHL level or could possibly stuck in the minors behind better players that play above them in the NHL.

Most recent studies of salary determination in the NHL have been concerned with discrimination of Canadian Francophone players or players born in Francophone speaking regions of Canada. Curme and Daugherty argued that English Canadian teams discriminate against French Canadian players.[6] They stated that there was a small type of discrimination against French Canadian players before pending unrestricted free agency, when then French Canadian players could just go to teams that would not discriminate against them because of where they were from. Curme and Daugherty say with the data they used that discrimination is there but it can change from year to year as some data found discrimination and other data didn't find any discrimination.[7] Discrimination is measured by amount of players drafted in the entry draft and also through production. Lavoie also did research on the discrimination of French Canadian players especially defensemen. Lavoie found statistical evidence that showed a substantial amount of salary

[5] Curme, Michael A. and Greg M. Daugherty. May 2004. Competition and Pay for National Hockey League Players Born in Quebec. *Journal of Sports Economics* 5, no. 2: 186-205
[6] Ibid, p. 202
[7] Ibid, p. 202

discrimination against French Canadian forwards on English Canadian NHL teams, but also found discrimination against European and American forwards on teams in English speaking Canadian areas.[8] Therefore, there's belief that there could be some salary discrimination among teams in the NHL but mostly for teams in English speaking Canada. Lavoie stated that Americans are the ones who suffer more from discrimination because American players have a better opportunity of obtaining off-ice endorsement deals when playing for US teams. Lavoie also found that a team's revenue had nothing to do with player's salaries, but the location of teams did. He also found that teams in English speaking Canada underpay forwards who are not English speaking Canadians.[9] In broader terms Lavoie says player's playing in foreign regions are underpaid. When negotiating contracts for American players with US based teams, general managers will often take this into account and will offer lower salaries because of the knowledge they will be getting paid for endorsement deals, therefore discriminating against American players.

After Lavoie conducted his study in 2000, few years later he conducted another study using the same variables in his previous study but also looking at discrimination involved with the NHL's entry draft. Lavoie found in his new study that American teams undervalue and under-appreciate the talent of French Canadian players, also, Europeans suffer from the same fate as French Canadian players.[10] Lavoie takes into account the Collective Bargaining Agreement at the time (2003, pre-lockout), and says that the CBA does not allow any discrimination against any player. He believes that if any player is

[8] Lavoie, Marc. The Location of Pay Discrimination in the National Hockey League. *Journal of Sports Economics* 1, no. 4: 401-411, 2000
[9] Ibid, p.417
[10] Lavoie, Marc. 2003. The Entry Draft in the National Hockey League: Discrimination, Style of Play, and Team Location. *American Journal of Economics and Sociology* 62, no. 2. p. 399

discriminated against, especially French Canadians, it's because of their lack of defensive abilities when being compared to American or even European players. Lavoie notes that the amount of French Canadian players have stayed constant over the period from 1993 to 2002 at 10% American, while players has dropped from 18% to 13%, and the amount of Europeans have increased from 16% to 32%.[11]

Jones and Walsh came to different conclusions about discrimination in the NHL and how players are paid compared to the study done by Lavoie. They looked at franchise characteristics, skills of players, ethnicity, market value, and how teams could exercise their power of monopsonistic pressure on players when it came time to negotiate contracts.[12] However, Jones and Walsh came to the conclusion that there was no glaring evidence of any discrimination among players and they put it simply that "if you can play, you get the pay."[13] There is also a study that examines birthplace of players in the NHL by focusing on the difference between English-speaking Canadians, French-speaking Canadians, Americans, and Europeans. McLean and Veall tested to see if there were discriminations against French-speaking Canadians and if there were any possible trends in salaries among all the groups. The study found that in a similar study done in 1983-84, there was discrimination of the French-speaking Canadian players in regards to their draft status and salary.[14] With Mclean and Veall seeing this they decided to do their own study in 1992 and the value at which there was a clear distinction of salary and draft status began to shrink and it was found that the distinction found in the 1983-84 of hiring

---

[11] Ibid, p. 401
[12] Jones, J. C. H. and Walsh, William D. Ethnicity, Productivity and Salary: Player Compensation and Discrimination in the National Hockey League. 41, no. 4: 592-604 1998
[13] Ibid, p. 608
[14] Mclean, Robert C. and Michael R. Veall. 1992. Performance and Salary Differentials in the National Hockey League. *Canadian Public Policy* 18, no. 4. p. 470-475

discrimination had disappeared due to the fact of "market pressure for winning, and/or increased amount of French-speaking coaches and general managers."[15] It should be noted that teams do not care where players come from in today's NHL, most teams are just looking to win, and will go to wherever they need to go to get the best players.

Another study looking into French Canadians in the NHL is done by Neil Longley, and he examines this topic in regards to team location. McLean and Veall is cited by Longley, with teams just wanting to win, but also says that players in markets where there is a language or cultural barrier are most likely to be valued less by the team, and in turn paid less.[16] This affects any non French-speaking player in Quebec and also with French-speaking Canadians in Western Canada and the United States. Longley focused on forwards in his study and measured them by their offensive production. He looked at the 1989-90 season and divided the 21 NHL teams into three groups: US based teams, Quebec based teams, and English-speaking Canada based teams. Longley found that, "with English-speaking Canadians playing for English-speaking Canada based teams compared to French Canadians playing for English-speaking Canadian teams earned 37% less, while English-speaking Canadians playing for Quebec based teams earned 14% less."[17] Longley found that there is discrimination against French Canadians on teams in English speaking Canadian areas.

Production

[15] Ibid, p. 474-475
[16] Longley, Neil. December 1995. Salary discrimination in the national hockey league: The effects of team location. *Canadian Public Policy* 21, no. 4: 413-422
[17] Ibid p. 417

One of the main aspects of my thesis is looking at production for defensemen, both offensive production and defensive production (offensive production is when defensemen score goals and help teammates score goals, as opposed to, defensive production is having a good plus/minus stat, and keeping the opposing teams top players from scoring goals). Production is measured through statistics, but production doesn't always translate to a player playing well. Some nights a player could be playing poorly but somehow ends up with a goal and assist and a couple hits, and other nights he could play well and be held completely off the score sheet. With my thesis looking solely at defensemen, it is hard to measure production values for defensemen because they are not always factoring in on the scoring and putting up very many points as opposed to forwards who do most of the scoring.

Most of the research available for production on NHL players is done before the lockout in 2004-05. This was a time when mostly offensive production or production by statistics was used to measure a players production for his salary. Hence, the research that is available measures the skills a player has.

A study done by J.C.H. Jones and William Walsh determines that skills of a player are the main factor of salaries for all positions in the NHL. They separated all the players into different regression models: forwards, defensemen, and goalies. They also separated the players into ethnic groups into different models: French Canadians and non French Canadians. Jones and Walsh came to the conclusion that the skills of both the defensemen and forwards are mostly notable for their points per game. They also had the coefficient for forwards higher than defensemen in their equation. They came to the conclusion that points per game, experience, the number of all stars on a team, and

whether a player was drafted in the first round or not was used as a dummy variable, were all found to be significant for both forwards and defensemen.[18] Jones and Walsh used different measures for both forwards and defensemen as they used weight for defensemen and points per game for the forwards. They came to the conclusion that, "To summarize very simply, irrespective of what differences exist among positions, skills are very significant in determining player salaries."[19] Reiterating, "If you can play, you get the pay," found earlier by Jones and Walsh they were looking at location of players. Skills are often measured through a players statistics, and how many goals he scores or how many assists he has.

Another way that production was looked at was the method used by Aju Fenn and John Heyne, when they examined how a team attains success and establishes good attendance by fans at games. Fenn and Heyne were looking at team statistics in their model and "used team points as their great overall measure of an entire team's performance."[20] They also used goals allowed to help them get a deeper insight into a team's defensive contribution to team production.[21] The independent variables used by Fenn and Heyne were goals, goaltending, penalties, faces offs, shooting, assists, and plus/minus rating. Their dependent variables were team points and goals allowed. Fenn and Heyne analyzed their data by using an OLS regression to get their results. What Fenn and Heyne found was that goals were a significant positive factor to their teams point model for estimating team's overall performance, as well that, goals allowed were a

[18] Jones, J. C. H. and William D. Walsh. 1988. Ethnicity, Productivity and Salary: Player Compensation and Discrimination in the National Hockey League. 41, no. 4: p.600
[19] Ibid, p. 600
[20] Fenn, Aju and John Jerald Heyne. 2006. NHL team production. *Department of Economics and Business, Colorado College*. p.8
[21] Ibid, p.8

negative impact on the teams overall performance. They also found that scoring goals played more of an impact on a team then just providing them a point on the scoreboard, they found that goals impact the teams' morale and said that teams are more upbeat after a goal is scored, vice versa, reacting negatively to a goal.[22] Fenn and Heyne also looked at how penalties affect a team's performance. Minor penalties had a negative affect on a team because it is tough to score goals and win games when the opposing team has a man advantage and the opportunity to score more goals. Major penalties had negative impact on the goals allowed model, meaning that when a team fights it helps them win because fighting can often cause a momentum shift for a team and help them win games.[23] Aside from scoring goals, the plus/minus statistic and assists played a key role in a team's success, because if a team works together and plays a team instead of individuals, the team has a better chance of winning and being a successful team with a lot of team points and wins. Fenn and Heyne's study showed the aspects that factor into a team garnering a win and producing more wins, which in turn would create more financial security because fans will pay to watch a winning franchise.

Another study done looking at production was the study done by Prosser and looking at the salaries of NHL defensemen measuring production while looking at offensive defensemen vs. defensive defensemen. Prosser looked at the 2007-08 NHL season and salaries from the 2008-09 years, and used defensemen that played at least 7 games. He split the defensemen through his subjective knowledge about hockey and the NHL into offensive and defensive. He used similar variables done by previous researchers that looked at the NHL in that he used goals, assists, games played, shots,

[22] Ibid, p.17
[23] Ibid, p.23

hits, penalty minutes, etc. Prosser put together three models, one for offensive defensemen, one for defensive defensemen, and one to put all the defensemen together in a model. He ended up concluding that offensive defensemen were paid almost twice the salary that defensive defensemen were.[24] He found that only 6 of the 14 variables he used were significant to salaries, and that age was the most significant factor in salaries.[25] The work by Prosser helped scratch the surface as to determining the difference between offensive and defensive defensemen, because of the very limited research done distinguishing the two.

The main area I looked at is the work done by Vincent and Eastman. Vincent and Eastman used a quantile regression model to measure production for defensemen and forwards to help gain additional insight into offensive-defensive dichotomy.[26] They concluded it would be better to analyze earnings production through this model because they could estimate the returns to performance variable for both high-paid starts and be able to compare them with the low-paid grinders in the NHL.[27] Vincent and Eastman used the earnings data from the 2003-04 season (pre-lockout) and then career numbers for both forwards and defensemen. For each position they used the estimated returns of performance across the quantiles with those from the conditional mean estimated using OLS regression. The variables used by Vincent and Eastman was: The natural log of a player's salary, career points per game, career games played, square of games, whether a player was named to first or second All-Star teams or not, whether a player was drafted in

[24] Prosser, Nathanael. 2010. The Salaries of NHL Defensemen Measured using Production : An Offensive Bias. P. 54
[25] Ibid, p.55
[26] Vincent, Claude and Byron Eastman. 2009. Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3: p.257
[27] Ibid, p.257

the first or second round of the entry draft or not, team revenue, career penalty minutes per game, career plus/minus per game, height, weight, and the location of where the player played before the NHL. They would use these variables for both forwards and defensemen (my thesis just looks at defensemen). Vincent and Eastman used career points per game as the measure for offensive statistics, and plus/minus, penalty minutes per game, height and weight as a measure for defensive statistics. Vincent and Eastman found that by using measures of a players performance over a player's career would help better interpret a player's performance. They also used whether the player was selected on first or second All-Star team, and whether a player was selected in the first or second round of the entry draft had significant positive effects on earnings for both forwards and defensemen.[28] They also found that for defensemen the plus/minus variable was a significant determinant of pay. Also for defensemen, they found that the All-Star nomination only increases earnings for players at the lower quantiles, while being drafted in the first or second round had an effect on the upper quantiles.[29]

CONCLUSION

My study will build off all the previous studies recently talked about, especially the one done by Vincent and Eastman, because I will be using their model, and updating the variables following the lockout and salaries following the lockout. I will also be adding several variables to help me better determine earnings for defensemen in the NHL, and to also add to the research done to enhance it.

---

[28] Ibid, p.275
[29] Ibid, p.275

CHAPTER III

DATA METHODOLOGY

The purpose of this chapter is to discuss the variables used in the empirical model that will help represent earnings for defensemen in the NHL. The data sources, samples, and the time frame will also be explained. A Quantile Regression Approach is the main measure in trying to determine the earnings of NHL defensemen help of an Ordinary Least Squares Regression looking at quantitative numbers found measuring defensemen in the NHL.

Sample and Time Frame

This thesis will examine career statistics from 235 defensemen taken from the 2009-10 season that played at least 10 games during that year, and the salaries of these players from the 2010-11 season. The statistics that were used all came from NHL.com. I chose to pick defensemen as my variable of focus because much of the research done on the NHL is done on forwards, and I would like to add research to defensive players.

Variables

Dependent Variable

In this thesis, all the defensemen account for one observation in the equation and regression through OLS and a quantile approach. The dependent variable in the equations is the natural log of their salaries. I used the Natural log of salaries because I was trying to estimate earnings for defensemen in the NHL. Salaries from the 2010-11 season were used because players are often valued following a year by looking at their production in the previous year. In the NHL, unlike some other sports, regardless of how many games a NHL player plays in, his contract is guaranteed in the NHL and he will receive the amount agreed on prior to the season. The salaries of all the defensemen used in this thesis were gathered from Capgeek.com.

Independent Variables

For the model being used in this thesis, there are 17 independent variables that were used from the 2009-10 season. The first variable is career points per game (PTSGAME), the total number of points a player has gotten over his career in the NHL. A player gets a point when he registers a goal or an assist in a game during the regular season. Points are a good statistic for measuring production or offensive production for a defensemen and also can be looked at as a measure for good teamwork to help a team

win hockey games. Points are a good measure because they are easily accessible and very easy to keep track of throughout an NHL season.

The second independent variable is career games (GAMES) the defensemen has appeared in. This is the number of games a player has played in over his career during the regular season in the NHL.

The third independent variable is the square of games (SQGAMES), this variable is taking the amount of games played by the defensemen and squaring it to ensure any nonlinearity effect of experience on earnings is captured.[1]

The fourth independent variable is a dichotomous variable to show a players reputation, whether a defensemen was selected for the first or second All-Star team during his career (STAR). If a player was selected for the first or second All-Star team during his career, they were given a 1 in the data set and a 0 if they were not selected.

The fifth independent variable is a dichotomous variable looking at when a player was drafted (DRAFT). If the player was drafted in the first or second round of the entry draft, they were given a 1 and if not drafted in the first or second round they were given a 0 in the data set that was collected. A player that is drafted in the 1st or 2nd round of the NHL entry draft often has the chance to negotiate a higher rookie contract, and also is given a better opportunity to reach the NHL because they possess good initial skills and are seen to have good future performance in the NHL.

The sixth independent variable team revenue (TEAMREVENUE), team revenue was used to control for differences among teams because of the amount of money they made and the salaries they compensate players with.

---

[1] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3

The seventh independent variable used in this thesis is career penalty minutes per game (PIMGAME). Penalty minutes are often used to measure a player's intensity of play and his aggressiveness. Career penalty minutes per game were used because we are looking at a defensemen aggressiveness and intensity per game to help measure there performance and defensive abilities for their career.

The eighth independent variable is career plus/minus per game (PLUSGAME). The plus-minus statistic is measures of a player's two-way play, in that it is a measure of whether a player is on the ice for the goals scored during the course of a game. If the player is on the ice in an even strength situation (5-5 play, most of the game is played with 5 players for each team playing against each other) and his team scores he is given a plus for being on the ice for a goal, vice versa if a player is scored on by the opposing team and he is on the ice he is given a minus. This statistic often measures how well a player helps influence his team's ability to score goals or keep goals out of his team's net.

The ninth independent variable is weight (WEIGHT). Physically, larger players often use their size to gain an advantage on opposing players by being physical and creating more space for their teammates by using their weight to hit opposing players and intimidate opposing players.

The tenth independent variable is height (HEIGHT). Again, physically larger players can play an intimidating role on opposing players as all can cause for reduced amount of room for opposing players because of the room that larger physical players take up on the ice.

The next 5 independent variables are dichotomous variables controlling for league fixed effects. I do this by dividing up the leagues in which the defensemen played in

Variable	Description	Expected Sign
LNSAL	The natural log of salary	N/A

before playing in the NHL. The leagues that I used for my independent variables are the Quebec Major Junior Hockey League (QMJHL), the Western Hockey League (WHL), the NCAA route in the United States (USCOLLEGE), the European leagues (European), and the Ontario Hockey League (OHL). By controlling where a defensemen played prior to the NHL, we can look to see if any league or route has more of an influence on player's earnings as opposed to another league.

The sixteenth independent variable is shooting percentage (SHOOTING). Shooting percentage is the percentage calculated when a defensemen scores a goal. Every time a defensemen gets a shot on net he registers a shot, but for a defensemen to register a shooting percentage he must score a goal. This variable helps show a defensemen offensive production.

The seventeenth and final independent variable is a dichotomous variable looking a player's handedness (LEFTHANDEDNESS). For every defensemen used in the data that is left-handed, they were given a 1 and for right-handed defensemen they were given a 0 in the data set. This variable is used to see whether a defensemen handedness has any affect on a defensemen's earnings.

TABLE 3.1

DESCRIPTION OF VARIABLES

PTSGAME	Career points per game	+
GAMES	Career games played	+
SQGAMES	The square of GAMES	+
STAR	Dichotomous variable equal to 1 if the player was selected to the first or second All- Star teams, equal to 0 otherwise	+
DRAFT	Dichotomous variable equal to 1 if the player was selected in the first two rounds of the NHL entry draft, equal to 0 if otherwise	+
TEAMREVENUE	Team Revenue	+
PIMGAME	Career penalty minutes per game	+
PLUSGAME	Career plus-minus per game	+
WEIGHT	The weight of the player in pounds	+
HEIGHT	The height of the player in inches	+
QMJHL	Dichotomous variable equal to 1 if the player played his junior career mainly in the QMJHL, equal to 0 otherwise	Unsure
WHL	Dichotomous variable equal to 1 if the player played his junior career mainly in the WHL, equal to 0 otherwise	Unsure
USCOLLEGE	Dichotomous variable equal to 1 if the player played mainly in the NCAA, equal to 0 otherwise	Unsure
EUROPE	Dichotomous variable equal to 1 if the player played mainly in the European leagues, equal to 0 otherwise	Unsure
OHL	Dichotomous variable equal to 1 if the player played his junior career mainly in the OHL, equal to 0 otherwise	Unsure
SHOOTING	Percentage of goals scored from all the shots taken by a player	+
LEFTHANDEDNESS	Dichotomous variable equal to one if player is Left Handed, equal to 0 otherwise	Unsure

Summary Statistics

Listed below are the summary statistics, specifically showing the mean, standard deviation, minimum, and maximum of the data collected on NHL defensemen.

TABLE 3.2

SUMMARY STATISTICS OF VARIABLES

Variable	Mean	Standard Deviation	Minimum	Maximum
PTSGAME	0.286	0.149	0	0.74
GAMES	429.877	293.29	13	1513
SQGAMES	268,034.24	343,422.40	169	2,289,169
STAR	0.055	0.229	0	1
DRAFT	0.417	0.494	0	1
TEAMREVENUE	97.77	28.45	63	187
PIMGAME	0.775	0.457	0.18	3.15
PLUSGAME	-0.002	0.104	-0.52	0.34
WEIGHT	208.638	23.55	172	270
HEIGHT	73.783	2.14	68	81
QMJHL	0.081	0.273	0	1

WHL	0.25	0.435	0	1
USCOLLEGE	0.277	0.448	0	1
EUROPE	0.2	0.401	0	1
OHL	0.196	0.398	0	1
SHOOTING	0.047	0.019	0	0.09
LEFTHANDEDNESS	0.0689	0.464	0	1
NATURALLOG	14.331	0.829	13.122	15.895
SALARY	2,308,310.08	---	500,000	8,000,000

As we can see from the summary statistics, the average salary for an NHL defensemen is US$ 2,308,310.08. In the previous study by Vincent and Eastman, the average salary for defensemen in 2003-04 season was US$ 1,749, 541; that's an increase over half a million dollars in 7 seasons.[2] There is an increase in salaries for defensemen because of since the lockout; the league has generated more revenue through a TV contract with now NBC and Versus. Of the summary statistics taken in the previous study 11 of the variables increased from the study including team revenue, which jumped over US$ 27 million from the previous literature and research done by Vincent and Eastman. The jump in revenues for teams is good news for the NHL because the amount

[2] [2] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. p.263

of money teams are now making as opposed to before lock out when a lot of teams were losing money.

The Model

The standard approach to model earnings indicates to use a log-linear earnings equation that includes, as independent variables, measures of both offensive and defensive performance, franchise characteristics, experience of the player, and reputation through draft status and star power. The model that will be used was replicated from a work done by Vincent and Eastman. Let SAL_i specify a player *i*'s earnings, $LNSAL_i$ the natural logarithm of earnings and x_i a vector of independent variables. We must assume that the conditional mean of the dependent variable LNSAL is a linear function of all the independent variables *x*:[3]

Equation 1

$$LNSAL_i = \alpha + \beta x_i + u_i \text{ and } E(LNSAL_i|x) = \alpha + \beta x_i$$

where α is the constant term, β is a vector of unknown parameters, u_i is an unknown error term that satisfies distributional assumptions and $E(LNSAL|x)$ is the conditional mean of LNSAL. Estimates of the parameters for β are obtained using OLS.[4]

The model equation used for obtaining parameters used from OLS was in the empirical form:

---

[3] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. p.258

[4] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. p.258

OLS MODEL

$$\text{Natural Log of Salaries for Defensemen} = \beta_0 + \beta_1 (\text{PTSGAME}) + \beta_2 (\text{GAMES}) + \beta_3 (\text{SQGAMES}) + \beta_4 (\text{STAR}) + \beta_5 (\text{DRAFT}) + \beta_6 (\text{TEAMREVENUE}) + \beta_7 (\text{PIMGAME}) + \beta_8 (\text{PLUSGAME}) + \beta_9 (\text{WEIGHT}) + \beta_{10} (\text{HEIGHT}) + \beta_{11} (\text{QMJHL}) + \beta_{12} (\text{WHL}) + \beta_{13} (\text{USCOLLEGE}) + \beta_{14} (\text{EUROPE}) + \beta_{15} (\text{OHL}) + \beta_{16} (\text{SHOOTING}) + \beta_{17} (\text{LEFTHANDEDNESS})$$

In the standard approach, the focus is to explain earnings at the conditional mean and we assume that the marginal effect of an explanatory variable does not change along the conditional earnings distribution. In comparison, the quantile regression model is less restrictive in modeling earnings in the sense that the marginal effect of an explanatory variable is allowed to vary at different points of the conditional distribution. In hockey, players of differing skills are paid differently for their roles on their respective teams. The quantile regression will help model specific predictor variables with specific quantiles or in this model, different levels of pay for defensemen. The quantile regression will help me model and get data for players who are paid different salaries, as not all players are paid the same amount, and are often paid by there production and contributions to the team. The quantile regression model specifies that the θth quantile of the conditional distribution of LNSAL is a linear function of the explanatory variables *x*:

Equation 2

$$LNSAL_i = \alpha(\theta) + \beta(\theta)x_i + v_{\theta i} \text{ and } Q^{\theta}(LNSAL_i | x_i) = \alpha(\theta) + \beta(\theta)x_i \text{ , } 0 < \theta < 1 \quad [5]$$

where $\alpha(\theta)$ is the constant term, $\beta(\theta)$ is a vector of unknown parameters, $v_{\theta i}$ is the unknown error term, and $Q^{\theta}(LNSAL_i | x_i)$ is the conditional quantile function.[6] No distributional assumptions are made about the error term $v_{\theta i}$ other than that it satisfies the constraint $Q^{\theta}(v_{\theta i}|x_i) = 0$. Because the vector of parameters $\beta(\theta)$ depends on the quantile θ, the marginal effect of any explanatory variable on LNSAL varies along the conditional distribution.[7] The parameters in $\beta(\theta)$ can be interpreted in a manner similar to those of the conditional expectation model. The quantile regression estimates of $\beta(\theta)$ for a given quantile θ, $0 < \theta < 1$, are obtained by solving the problem:[8]

$$\min \sum \theta | LNSAL - (\alpha(\theta) + \beta(\theta)x_1) | + \sum (1-\theta) | LNSAL - (\alpha(\theta) + \beta(\theta)x_1) |$$

This minimization problem does not have an explicit form solution but the estimates of $\beta(\theta)$ can be obtained by linear programming methods. It can be shown that the estimator is asymptotically normally distributed.[9] By using this I can confirm whether or not the earnings equation described by the quantile regression is better than the one under OLS. If rejection of the null hypothesis that the vector of parameters $\beta(\theta)$

[5] Ibid, p. 259
[6] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. p.259
[7] Vincent, Claude and Byron Eastman. 2009 Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3. p.259
[8] Ibid, p. 259
[9] Ibid, p.259

in Equation 2 does not change with θ, OLS can be rejected in favor of a quantile regression. However, if I cannot reject the null hypothesis of equivalence of the slope parameters across the quantiles, the quantile regression model reduces to the standard conditional expectation model and with identical slope coefficients and different intercept terms across the quantiles.

This chapter examined the variables being used for my empirical model in both the quantile regression and ordinary least squares regressions. It also showed the data sources, samples, and time frame used to measure the defensemen in the NHL under my thesis. The expected outcomes of the independent variables were also given and defined. The next chapter will discuss the results found using the regression models.

CHAPTER IV

RESULTS

This chapter will examine my empirical models and regression models featuring 235 defensemen from the NHL that played during the 2009-10 season. The results will help answer the question of estimating earnings for defensemen in the NHL using a Quantile regression approach. I am trying to accurately estimate earnings for defensemen in the NHL through the use of a Quantile regression to better the literature on defensemen and earnings in the NHL.

The OLS estimates for defensemen are found in Table 3.1. The results are somewhat similar to those found in previous literature in that experience or GAMES and SQGAMES were found to be significant at the 5% level. GAMES have a positive affect, but different from research, SQGAMES had a negative affect. With GAMES being significant it tells us that the more games a defensemen plays in, it will translate to a higher salary, because it is often considered around professional sports leagues that a player with more games played or more experience in the league can provide valuable experience and leadership, or intangibles that cannot be measured. PTSGAME, which was also significant in previous literature, was also positively effective and significant at the 5% level. Different from previous literature was that HEIGHT was found to be significant and positive at the 15% level. Also, LEFTHANDEDNESS and SHOOTING were found to be significant at the 15% and 5% respectively, with LEFTHANDEDNESS

having a positive impact and shooting having a negative impact on earnings for defensemen. With SHOOTING found to be significant it shows that, scoring more goals for defensemen leads to a lower salary.

The Quantile regression permits more thorough analysis. The results of the Quantile regressions are presented in Table 3.1 for five quantiles ($\theta = 0.10, 0.25, 0.50, 0.75, 0.90$). The table also presents the goodness of fit measures in the last row. The traditional model explains less variation in earnings for lower paid defensemen than that of higher paid defensemen. The estimates of the pseudo-R^2 for the quantile regressions show that the earnings equation explains 31.2% of the variation at the 10^{th} quantile and 48.4% of variation at the 90^{th} quantile with a high of 53.9% of the variation at the median.

Experience (GAMES, SQGAMES) is similar to the OLS regression in that they are significant at the 5% level, and that GAMES is positive and SQGAMES is negatively impacting earnings for defensemen throughout all of the quantiles. In previous research, it was found also that SQGAMES was significant and negative for estimating earnings for defensemen. PTSGAME was also significant in all of the quantiles at 5% and positively affecting earnings for defensemen throughout all of the quantiles, similar to previous literature. Also similar to the OLS regression was that SHOOTING was found to be significant and negative at every quantile except at the 90^{th}. Throughout the quantiles there were different variables at different quantiles that had significance to estimating earnings for defensemen. In the 10^{th} quantile we found that every amateur or junior league prior to the NHL had significance to estimating earnings for defensemen except the OHL, which becomes significant at the 90^{th} quantile at the 15% level, but has

a negative impact on earnings for defensemen in the NHL. QMJHL, USCOLLEGE, and EUROPE are significant again at the median quantile with EUROPE being significant at the 10% level with USCOLLEGE and QMJHL being significant at the 15% level. The LEFTHANDEDNESS variable was only found to be significant at the 10^{th} and 25^{th}, with a significance of 15% at the 10^{th} quantile and 10% at the 25^{th} quantile, both were positively impacting earnings for defensemen. The quantile regressions also show that SHOOTING was also found to be significant in estimating earnings for defensemen in the NHL. SHOOTING had a negative impact through all the quantiles except for the 90^{th} quantile, which was not expected before hand because in previous research for forwards, scoring goals often leads to higher salaries, but for defensemen that is not the case. No previous research was done on shooting percentage by defensemen as often researchers use goals as an independent variable. STAR and DRAFT were found to be different then previous research as STAR was found to be significant at the 25^{th} and median quantile and DRAFT found only to be significant at the median quantile. In previous literature it was found that star was significant at the 10^{th}, 25^{th}, and median quantiles and DRAFT was found to be significant at the median, 75^{th}, and 90^{th} quantiles. The results suggest that the players in the lowest quantile (10^{th}) often haven't achieved star status yet and the players in the upper quantiles (75^{th} and 90^{th}) have a reputation already established as being a high profile player, and don't need to be voted onto a All-Star team to reaffirm their status. With Draft only affecting the median quantile, it is suggested that with players often being drafted in the first two rounds of the NHL entry draft, they often can negotiate higher starting salaries than players drafted in later rounds, or players not drafted at all. Another variable found to be significant in the Quantile regression was

TEAMREVENUE, it was found only to be significant in the 90th quantile, with being positively impacting earnings at the 5% level. This gives the interpretation that teams with a higher amount of revenue they generate that they can afford to pay the high priced defensemen. Previous research had TEAMREVENUE significant at the 25th quantile, and had it negatively affecting earnings for defensemen at the 5% level.

Below is the OLS regression and Quantile regressions ran on the 235 defensemen during the 2009-10 season:

TABLE 4.1

QUANTILE AND OLS REGRESSIONS FOR DEFENSEMEN (n = 235)

Regression Coefficients						
Variable	**OLS**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
PTSGAME	2.544 (.362)*	2.36 (1.02)*	2.65 (.728)*	2.22 (.489)*	2.40 (.440)*	2.60 (.703)*
GAMES	.004 (.000)*	.003 (.001)*	.004 (.001)*	.005 (.001)*	.004 (.001)*	.004 (.001)*
SQGAMES	-2.20E-06 (2.78E-07)*	-1.8E-06 (5.79E-07)*	-2.63E-06 (5.98E-07)*	-2.69E-06 (6.26-07)*	-2.33E-06 (4.51E-07)*	-2.25E-06 (5.11E-07)*
STAR	.178 (.169)	.314 (.259)	.453 (.205)*	.235 (.120)**	.096 (.127)	.073 (.145)
DRAFT	.083 (.071)	.088 (.142)	.081 (.118)	.146 (.081)**	.107 (.081)	.084 (.090)
TEAMREVENUE	.001 (.001)	.002 (.003)	.000 (.002)	.003 (.002)	.003 (.002)	.005 (.002)*
PIMGAME	.007 (.082)	.103 (.311)	.069 (.097)	.043 (.096)	-.054 (.102)	.096 (.109)
PLUSGAME	.286 (.325)	.851 (.841)	.179 (.434)	-.157 (.441)	.171 (.469)	.352 (.333)
WEIGHT	.000 (.002)	.000 (.004)	.001 (.001)	.000 (.001)	.002 (.001)	.002 (.003)
HEIGHT	.027 (.018)***	.044 (.046)	.027 (.019)	.021 (.018)	.005 (.022)	-.002 (.025)

QMJHL	.217 (.519)	.850 (.551)***	.132 (.381)	.040 (.237)	-.104 (.281)	-.180 (.330)
WHL	.347 (.507)	.824 (.512)***	.428 (.363)	.290 (.191)***	.061 (.128)	-.159 (.173)
USCOLLEGE	.448 (.505)	1.05 ((.515)*	.363 (.373)	.311 (.194)***	.153 (.155)	.055 (.177)
EUROPE	.430 (.517)	1.01 (.573)**	.527 (.368)	.368 (.202)**	.039 (.166)	-.089 (.227)
OHL	.261 (.514)	.727 (.526)	.407 (.371)	.159 (.207)	.012 (.163)	-.265 (.171)***
SHOOTING	-5.97 (2.42)*	-6.46 (4.06)***	-8.91 (3.51)*	-6.68 (3.05)*	-6.96 (2.66)*	-2.34 (4.43)
LEFTHANDEDNESS	.108 (.072)***	.257 (.169)***	.225 (.115)**	.109 (.084)	.058 (.090)	.096 (.085)
R^2 (pseudo)	0.695	0.312	0.461	0.539	0.503	0.484
Note: This is standard Ordinary Least Squares and Quantile regression. Coefficients are given first, with standard error given underneath in parenthesis. *Significant at 5% level for one-sided t test. **Significant at 10% level for one-sided t test. ***Significant at 15% level for one-sided t test.						

The next table will show the deviations from the mean calculated for both the OLS regression and Quantile regressions.

TABLE 4.2

DEVIATIONS FROM MEAN, OLS AND QUANTILE REGRESSIONS (n=235)

Regression Coefficients						
Variable	**OLS**	**Q10**	**Q25**	**Q50**	**Q75**	**Q90**
PTSGAME	2.54 (.362)*	2.36 (1.11)*	2.65 (.730)*	2.22 (.674)*	2.40 (.489)*	2.60 (.658)*

GAMES	.004 (.000)*	.003 (.001)*	.004 (.001)*	.005 (.001)*	.004 (.001)*	.004 (.001)*
SQGAMES	-2.20E-06 (2.78E-07)*	-1.80E-06 (6.16E-07)*	-2.63E-06 (6.76E-07)*	-2.69E-06 (6.36E-07)*	-2.33E-06 (5.74E-07)*	-2.25E-06 (5.24E-07)*
STAR	.179 (.169)	.314 (.328)	.453 (.273)**	.235 (.163)***	.096 (.134)	-.073 (.199)
DRAFT	.083 (.071)	.088 0(.203)	.081 (.120)	.146 (.074)*	.107 (.091)	.084 (.109)
TEAMREVENUE	.001 (.001)	-.002 (.003)	.000 (.002)	.003 (.003)	.003 (.002)	.005 (.002)*
PIMGAME	.007 (.082)	-.103 (.263)	.069 (.126)	.043 (.063)	-.054 (.074)	.096 (.099)
PLUSGAME	.286 (.325)	.851 (.723	.179 (.515)	-.157 (.415)	.171 (.276)	.352 (.305)
WEIGHT	.000 (.002)	-.000 (.007)	.001 (.003)	.000 (.001)	.002 (.002)	.002 (.003)
HEIGHT	.027 (.018)***	.044 (.047)	.027 (.025)	.021 (.024)	.005 (.020)	-.002 (.028)
QMJHL	.217 (.519)	.850 (.550)***	.132 (.289)	.040 (.291)	-.104 (.192)	-.180 (.330)
WHL	.347 (.507)	.823 (.496)**	.428 (.319)	.290 (.158)**	.061 (.124)	-.159 (.189)
USCOLLEGE	.448 (.505)	1.05 (.504)*	.363 (.282)	.311 (.172)**	.153 (.145)	.055 (.205)
EUROPE	.430 (.517)	1.01 (.550)**	.527 (.283)**	.368 (.162)*	.039 (.126)	-.089 (.217)
OHL	.261 (.514)	.727 (.566)	.407 (.268)***	.159 (.134)	.012 (.160)	-.265 (.216)
SHOOTING	-5.97 (2.42)*	-6.46 (4.80)	-8.91 (4.01)*	-6.68 (3.84)**	-6.96 (4.03)**	-2.34 (3.45)
LEFHANDEDNESS	.108 (.072)***	.257 (.198)	.225 (.141)***	.109 (.084)	.058 (.084)	.096 (.103)
PSUEDO R^2	0.695	0.312	0.461	0.539	0.503	0.484

Note: Each continuous variable is measured in deviations from its mean. Coefficients are given first with standard errors in parenthesis. OLS=Ordinary Least Squares/
*Significant at 5% level for one-sided t test.
**Significant at 10% level for one-sided t test.

***Significant at 15% level for one-sided t test.

As we can see from both the tables on the OLS and Quantile regression there are a lot of similarities between a simple regression done for both OLS and Quantile's and the regression used to look at the deviations from the mean for both OLS and the Quantile's. But if you look closely there are also some differences in the two. In the two OLS regressions, we find that there are no changes between a simple OLS regression and a regression run on the deviations from the mean. When we look at the Quantile regressions, this leads to more interpretation as to explaining the differences between the deviations from the mean and the simple Quantile regression. In the 10^{th} quantile there are some noticeable changes that need to be discussed. After running the deviations from the mean regression using a Quantile regression we find that PTSGAME, GAMES, and SQGAMES all stayed the same and were significant as they were in the first Quantile regression above in Table 4.1. However, in the deviations from the mean there were some differences from the first regression run. As you can see, the significance levels changed on some variables, as also there were fewer variables that were significant in the deviation from the means regression. Both SHOOTING and LEFTHANDEDNESS were dropped out of the significance levels and no longer were found to be important in estimating earnings for defensemen in the NHL. There were also some variables that were found to be significant in the deviations from the mean that were not significant in the normal regressions run.

The next table adds additional insight into the determinants of the earnings of defensemen by testing whether or not the returns to the performance measures and the other significant variables are statistically different across quantiles.

TABLE 4.3

INTERQUANTILE TESTS

Logarithm of Earnings (LNSAL)				
Variable	Q90-10	Q75-25	Q50-10	Q90-50
PTSGAME	-.143 (1.15)	.031 (.785)	.030 (.899)	-.174 (.535)
GAMES	.000 (.001)	-.001 (.001)	.001 (.001)**	-.001 (.001)
SQGAMES	-3.21E-07 (7.90E-07)	5.78E-07 (6.66E-07)	5.73E-07 (4.91E-07)	5.73E-07 (4.91E-07)
STAR	-.720 (.593)	-.430 (.391)	-.412 (.629)	-.308 (.204)***
DRAFT	.118 (.136)	-.009 (.120)	.129 (.103)	-.011 (.102)
TEAMREVENUE	.009 (.003)*	.001 (.002)	.006 (.002)*	.003 (.003)
PIMGAME	.063 (.316)	.005 (.131)	.028 (.226)	.036 (.063)
PLUSGAME	.074 (.565)	-.053 (.564)	-.377 (.643)	.450 (.415)
SHOOTING	2.79 (4.81)	5.80 (3.56)***	-1.22 (3.65)	4.01 (3.99)
Note: The variables that are used were found to be significant in the OLS and Quantile regressions. Coefficients are given first with Standard Errors given in the parenthesis. *Significant at 5% level for one-sided t test.				

**Significant at 10% level for one-sided t test. ***Significant at 15% level for one-sided t test

As we can see in the interquantile regression results, we see from the variables that were found to be significant in the previous OLS and Quantile regressions, that when conducting interquantile tests we can see there is at least one significant variable in each of the interquantile tests performed. The interquantile tests were performed to see if there was any similarities between quantiles and whether the range between the quantiles can tell anything about the range between quantiles and tell us how the natural log of salaries are related to the variables that were found to be significant in the Quantile regressions. When we look at the table we see that TEAMREVENUE was significant in the 10^{th} to 90^{th} quantile range in that with an increase in team revenue through this range it was positively increasing the natural log of salaries. When looking at the 50^{th} to 90^{th} quantile range we see that STAR is found significant at the 15% level, but with an increase in STAR, there is a decrease in the natural log of salaries. The tests were done using the Natural log of salaries of the defensemen, so the results show the differences in the estimates of the percentage returns from the quantile regressions on LNSAL that were presented from TABLE 4.2. When looking at PTSGAME, we see there is some difference in that the results of the statistical tests show that the increase in the scoring proficiency of defensemen is identical in the comparisons of the 90^{th} and 10^{th} quantiles and 90^{th} and 50^{th} quantiles.

Expected vs. Actual

Of the independent variables that are not dichotomous variables, there were only two variables that were found to be wrong than what was the expected value and impact that was thought. The variable SQGAMES and SHOOTING were thought to positively affect salaries for defensemen, but it was found that they negatively affected salaries for NHL defensemen. Of all the other non-dichotomous variables, they were found to be what was expected of them and have a positive impact on salaries.

Conclusion

This chapter discussed the empirical models and regression models featuring 235 defensemen from the NHL that played during the 2009-10 season. After examining the results given by the OLS regression, Quantile regressions, and looking at interquantile regressions models, there is interpretation to follow. The next chapter will explain the conclusions and impact of the regression results and discussing potential follow-ups.

CHAPTER V

CONCLUSION

In this chapter, there will be a research summary, as well as discussion of the goals and results of this thesis. Limitations and possible areas for future study will also be presented in this chapter.

Summary

The focus of this study and thesis was the salary determinants for defensemen in the NHL using a Quantile regression with data from the 2009-10 NHL season and salaries taken from the 2010-11 season to help look to see what statistical data, whether experience, and where a defensemen came from to help a defensemen earn a higher salary. In total, 235 defensemen were evaluated, with seventeen variables used for all defensemen to help determine salaries for defensemen in the NHL. All of the variables were chosen through previous studies, and also new variables that were expected to affect the dependent variable, salary. This thesis aimed to analyze what statistics, production, and a defensemen's previous experiences to determine salaries. Most studies on the determination of player earnings in the NHL estimate earnings equations in the conditional expectation model or framework. The studies often looked specifically at

forwards. Forwards were used because of the readily available offensive statistics that could be used to interpret earnings through production. Defense statistics did not become popular or readily available until the early 2000's, which restricted economists to study defensemen in previous years. Some researchers would use a defensemen's size, skill, and experience to determine his salary, however some economists determined it was impossible to measure a defensemen through conventional statistics often used for forwards.

Of the seventeen variables that were tested in both the OLS and Quantile regressions, fourteen of the seventeen were found to be significant in either the OLS or one of the five quantiles that were tested.

The OLS estimates of the earnings equation for the 2009-10 season are consistent with the results of previous studies in that GAMES, SQGAMES, and PTSGAME were all found to be significant at the 5% level and also had the same impact as previous studies. Using measures of performance over a player's career, it was found that experience, through games played by defensemen (GAMES) had a positive impact on the natural log of salaries in the OLS regression. What was found to be different then previous studies was that, following the lockout only HEIGHT, SHOOTING, and LEFTHANDEDNESS were also found to be significant in the OLS regression, which was different from studies finding PLUSGAME, DRAFT, and STAR were found to be significant. HEIGHT was also found to be significant in my OLS regression, which was different from previous studies. Height is considered to be significant because from anyone that knows anything about size in professional sports, especially hockey, a lot of the players are above six feet tall, and for scouts looking for players, teams like players

and defensemen specifically who are above average in size, and often stand over six feet 2 inches tall. Another variable found to be significant in the OLS regression was LEFTHANDEDNESS. This variable measured the handedness at which a defensemen holds his stick and shoots the puck. Of the 235 defensemen measured in this study, 69% of the defensemen were left-handed. This is a very high number because NHL teams often will have 3 left handed defensemen and 3 right handed defensemen in their lineup, because of the versatility and availability it provides NHL coaches with. SHOOTING was found to be significant also in the OLS regression, but it negatively impacted salaries for defensemen. This is unique in that it is thought that the more a defensemen scores goals for his team, it would help his team win, help his statistical values, and in turn help the amount he would be paid, but through this thesis we find that the percentage at which a defensemen scores goals, negatively affects a players salaries.

The earnings estimation and determination process in the NHL is much more complex than the one described by the conditional expectation model estimated by OLS. Using the Quantile regression, it was shown that the economical empirical specification of the earnings equation using career statistics for an NHL defensemen explains much less of the variation in the earnings of low-paid players than it does for the median to high-paid players.

In the Quantile regressions, the results were different from what was found to be significant in the OLS regression other than PTSGAME, GAMES, and SQGAMES as they were all found to be significant in all of the regressions. In the quantiles (10, 25, 50, 75, and 90) we found that a defensemen being selected for an All-Star team was significant at the 25^{th} and 50^{th} quantiles. This shows that with the lower paid defensemen

in the NHL, the defensemen can often negotiate a better salary if they are selected for an All-Star team because the importance of being named a high end defensemen is better for low-paid players because the high end players are often already recognized for their abilities, they were also significant at the 5% level and 10% levels, respectively.

DRAFT was also found to be significant at the median quantile at the 10% level, which states that a defensemen who is drafted in the first two rounds of the NHL entry draft can negotiate better salaries because of where they were taken in the draft. They are in the median because they often are paid more in their first contract because of their draft status.

Where a defensemen played his amateur hockey before the NHL also played a significant role in determining salaries for defensemen throughout the quantiles. In the 10^{th} quantile four amateur avenues for a player to play were found to be significant. The variables QMJHL, WHL, USCOLLEGE, and EUROPE were all found to be significant in the 10^{th} quantile, with also all of them being significant with the exception of QMJHL at the median quantile as well. This shows that all of these routes of getting to the NHL was significant in determining a salary for low-paid NHL defensemen as well as defensemen that are paid at the median salaries. The only amateur route that was found to be negatively impacting salaries was OHL at the 90^{th} quantile. This showed that defensemen who came from the OHL and were apart of the higher paid defensemen, this negatively affected their salaries.

Also found to be negatively impacting salaries at four of the five quantiles was the SHOOTING variable. From low-end players to players who are paid at the 75^{th} quantile,

SHOOTING was negatively affecting their salaries. This shows that defensemen who score goals often earn less unless they are part of the highest paid players.

LEFTHANDEDNESS or left-handed defensemen were found to be significant at the 10^{th} and 25^{th} quantiles and positively affected a defensemen's salaries. This shows that defensemen who shoot left handed at the lower quantiles will get a increase in pay because of how they shoot the puck.

Another variable that was found to be significant was TEAMREVENUE, team revenue was used to see if the amount of money an NHL team brings in through ticket sales, jersey sales, television contracts, etc. had any affect on defensemen. It was found that TEAMREVENUE was significant at the 90^{th} quantile, which says that teams who have a high revenue can pay the high end defensemen higher salaries therefore it increases salaries for defensemen because NHL teams who bring in more revenue often can pay more then market value for a defensemen.

Practical Applications

My results help to explain the important decisions that have to be made by NHL General Managers and their scouts. They must scout, recruit, and determine which defensemen and players to construct together a winning team that is constrained by a hard salary cap in the NHL. Because of the restriction of a salary cap, General Managers must carefully coordinate a plan and strategy to select defensemen whose skills and capabilities fit into the team concept (often a balance between offense and defense). General Managers must try and predict the future as to how a defensemen will perform

and what kind of defensemen their team needs, but also with the new rules following the lockout of the 2004-05 season, and with the current collective bargaining agreement ending in September 2012. With a salary cap currently sitting at $64.3 million in the NHL, General Managers must carefully put together a roster of a minimum 20 players and still fit under the salary cap.

This thesis uncovers some important practical trends for determining salaries for NHL defensemen. GAMES and PTSGAME were found to be significant determinants of salaries, which is valuable information for a General Manager because he would like defensemen who chip in on the offense, as well, has some experience.

Limitations

There is specifically one significant limitation in this thesis, in that there was only one year analyzed. Although the defensemen that were used, the statistics were career numbers, had a few more years been analyzed, that would have created an opportunity for more observations or more defensemen to be analyzed. With also looking at more defensemen it would provide more analysis on salaries for defensemen.

Future Study

With only one year being analyzed in this thesis, it provides for future study in that, more years could be used to gather more observations to better determine what affects salaries for defensemen in the NHL. Data could possibly taken for the next five

years to gather more observations. Another possible area to look at would be to try different independent variables to help determine salaries for defensemen in the NHL. Possible variables could be shots, time on ice, or looking specifically at goals and assists rather then points per game.

Another possible area of study or for future research would be to apply this study to a different sport, like National Basketball Association and looking at career numbers with PTSGAME, GAMES, SQGAMES, where players came from before the NBA, which way they shoot the basketball, star status, draft status, HEIGHT, and WEIGHT could all be used in the NBA.

WORKS CONSULTED

Alexander, Bibin. The Best Defense is a Good Offense. The Sports Mirror. http://www.thesportsmirror.com/2011/03/the-best-defense-is-a-good-offense/ (accessed March 6, 2012).

Baldrica, Gian Marco. 2003. *National Hockey League Wage Determination : The Effects of Extenended Statistics on Player Salaries*.

Brehm, Mike. 2006. NHL Giving Obstruction The Hook. *USA Today* Sports, (February).

Buchinsky, Moshe. 1998. Recent Advances in Quantile Regression Models: A Practical Guideline for Empirical Research. *The Journal of Human Resources* 33, no. 1: pp. 88-126.

Curme, Michael A. and Greg M. Daugherty. May 2004. Competition and Pay for National Hockey League Players Born in Québec. *Journal of Sports Economics* 5, no. 2: 186-205.

Fenn, Aju and John Jerald Heyne. 2006. NHL Team Production. *Department of Economics and Business, Colorado College*.

Fitzpatrick, Jamie. NHL Rules Changes: Probing the Brave New Hockey World. About.com. http://proicehockey.about.com/cs/rules/a/04_rule_changes.htm (accessed February 6, 2012).

———. Key Points in the NHL Collective Agreement. About.com. http://proicehockey.about.com/od/thenewnhl/a/salary_cap_expl.htm (accessed March 6, 2012).

———. The New NHL: Essential Info for 2005-06 NHL Season. About.com. http://proicehockey.about.com/od/thenewnhl/a/05_nhl_calendar.htm (accessed March, 6, 2012).

———. NHL Free Agents Explained. About.com. http://proicehockey.about.com/od/nhlfreeagents/a/nhl_free_agents_2.htm (accessed March 6, 2012).

Idson, Todd and Leo H. Kahane. 2000. Team Effects on Compensation: An Application to Salary Determination in the National Hockey League. *Economic Inquiry* 38, no.

2: 345-357.

Jones, J. C. H. and William D. Walsh. 1988. Ethnicity, Productivity and Salary: Player Compensation and Discrimination in the National Hockey League . 41, no. 4: 592-604.

Lavoie, Marc. The Location of Pay Discrimination in the National Hockey League. *Journal of Sports Economics* 1, no. 4: 401-411.

Lavoie, Marc. 2003. The Entry Draft in the National Hockey League: Discrimination, Style of Play, and Team Location. *American Journal of Economics and Sociology* 62, no. 2: 383-405.

Longley, Neil. December 1995. Salary Discrimination in the National Hockey League: The Effects of Team Location. *Canadian Public Policy* 21, no. 4: 413.

Marchand, Joseph T., Timothy M. Seeding, and Barbara Boyle Torrey. 2006. Salary Distribution and Performance: Evidence from the National Hockey League. *Department of Economics, Center for Policy Research, Maxwell School of Citizenship and Public Affairs, Syracuse University and Population Reference Bureau*.

Mclean, Robert C. and Michael R. Veall. 1992. Performance and Salary Differentials in the National Hockey League. *Canadian Public Policy* 18, no. 4: 47-475.

Miller, Gregory J. 2008. Does Player Size Affect Productivity in the "New NHL"? *Issues in Political Economy* 17, .

Moody, Allen. Stanley Cup Finals Preview. About.com. http://sportsgambling.about.com/od/hockeybetting/a/08stanleycup.htm (accessed February, 2012).

Pierce, Andrew and Conti, John. NHL: Brand Resurrected. Prophet. http://www.prophet.com/thinking/view/297-nhl (accessed March 6, 2012).

Prosser, Nathanael. 2010. *The Salaries of NHL Defensemen Measured Using Production : An Offensive Bias*.

Richardson, David H. 2000. Pay, Performance, and Competitive Balance in the National Hockey League. *Eastern Economic Journal* 26, no. 4: 393.

Rosner, Scott and Kenneth Shropshire. 2011. The Business of Sports. 2, : 140.

Scully, Gerald W. 2004. Managerial and Decision Economics. Chap. 2, In . Vol. 25, 77-86.

Staudohar, Paul D. 2005. The Hockey Lockout of 2004-05. 128, no. 12: 23.

Vincent, Claude and Byron Eastman. 2009. Determinants of Pay in the NHL: A Quantile Regression Approach. *Journal of Sports Economics* 10, no. 3: 256-277.

Westhead, Rick and Paul Jay. 2004. Cost Certainty: No Salary Cap. *Canadian Business*

Websites:

www.NHL.com

www.Capgeek.com