SIGNIFICANT FACTORS THAT INFLUENCE THE STATISTICAL DETERMINANTS OF WINNING IN HOCKEY

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SIGNIFICANT FACTORS THAT INFLUENCE THE STATISTICAL DETERMINANTS OF WINNING IN HOCKEY

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Abstract

The current study uses data from the 2001-2002 to 2005-2006 season to determine if player characteristics, including positional player size, age, and place of birth, influence the significant statistical determinants of winning in the National Hockey League. The results suggest that a player's size, age, and province/country he originated from are not significant contributors to a team's success in the National Hockey League.

KEYWORDS: (National Hockey League, Determinants of Winning, Player Characteristics)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Michael Beck

Signature

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CHAPTER I

INTRODUCTION

The lockout season in 2004-2005 introduced many changes to the National Hockey League (NHL). One of the changes prior to the 2005-2006 season was the implementation of a salary cap. The presence of a salary cap places additional pressure on the general managers of NHL teams to assemble a successful team on the ice. Unlike the National Football League, where player salaries are not fixed, NHL players have fixed salaries; Teams cannot release a player and drop their contract without consequences.

The NHL after the 2004-2005 lockout also brings a different game to the ice. With stricter enforcement of clutching and grabbing, more freedom is given to the skilled puck carrier. As a result, size is becoming less of an issue, while skating is becoming more of an emphasis. This questions the impact of certain player characteristics with success in the NHL. Does size really matter per position? Does age play a role in team's ability to win games? Does the country/province a player originates from matter?

With these issues, it seems logical to research what exactly produces the most effective team on the ice. A successful team will typically attract more fans for games, and in return, the team will see their revenue increase. The purpose of this study is to determine how specific individual player characteristics affect the determinants of winning in the NHL.

Importance of the Study

Heyne et al. examine the significant determinants of winning in the NHL.[1] All of the major statistics had a significant impact on the success of teams in the league such as: assists, goals against, penalties, and penalty kill success. For the average fan and hockey player, these results are of no surprise. The question lies, however, in what exactly drives these statistics. How do player characteristics such as player height and weight, origin of birth, and age affect these statistical determinants of winning in the NHL? The current study aims to answer that question.

Winning is a key component for financial success. In the 2002-2003 season, the NHL lost a total of 273 million dollars.[2] Player costs accounted for 75 percent of team revenue. Table 1.1 presents the revenue and costs for the 2002-2003 season.

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[1] John J. Heyne, Aju J. Fenn, and Stacey Brook, "NHL Team Production," Working Paper, Colorado College (October 2006):1-25.

[2] Arthur Levitt Jr., "Independent Review of the Combined Financial Results of the National Hockey League 2002-2003 Season," available at http://nhl.speedera.net/images/levittreport.pdf, accessed on March 6th, 2007.

TABLE 1.1

NHL Summary Statement of Operations Combined
League-Wide 2002-2003 Season (Millions of US Dollars)

Revenues	**Regular Season**	**Playoffs**	**Total**
Gate Receipts	886	111	997
Pre-Season & Special Games	50	-	50
Broadcasting and New Media Revenues	432	17	449
In Arena Revenue	401	14	415
Other Hockey Revenue	82	3	85
Total Revenues	**1851**	**145**	**1996**
Player Costs	**Regular Season**	**Playoffs**	**Total**
Salaries and Bonuses	1,415	14	1429
Benefits	64	1	65
Total Player Costs	1479	15	1494
Total Costs	**2215**	**54**	**2269**

Source: *Levitt(2004)*

Table 1.1 shows that the majority of revenue is fan-related. Fans determine the success of gate receipts, arena revenue, and media. This stresses the importance of winning in the NHL. When a team wins, more fans will attend games and support them financially. The player costs section of the table displays how much player salaries make-up the costs of operating an NHL team. This shows how important the composition of a successful hockey team is.

Changes in the NHL

With the implemented salary cap in the new NHL, potential buyers of NHL franchises are willing to pay more cash for the teams. Buyers are attracted to the fixed costs of player salaries with the new salary cap. The increase in interest for owning a NHL team can be seen with the numbers alone. During the 2003-2004 season, the average NHL team was worth 163 million dollars. In the 2006-2007 season, the average team is worth 180 million dollars.[3]

For a general manager, it is important to know how to compose the most efficient team on the ice. General Managers need to maximize on-ice success with a 23 man roster. The pressure on a general manager has increased with the new NHL rules. Under the restrictions of the new salary cap, a team is not only limited by the number of players they can have on the roster, but also the amount of money they allocate towards each player in salary.

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[3] Forbes,"The Business of Hockey," available at http://www.forbes.com/lists/2006/31/biz_06nhl_NHL-Team-Valuations_land.html, accessed on March 6th, 2007.

With the new NHL and the subsequent changes in enforcement of rules, smaller players are having more of an impact in the game. Smaller players such as Martin St. Louis, Brian Gionta, Steve Sullivan, and Michael Cammalleri are some of the top scorers in the NHL. On the defensive side, players with heights under 5'10", such as John-Michael Liles and Trevor Daley, are playing significant minutes for their teams nightly.

With the recent success of smaller players, NHL teams are starting to take notice of the new trends in the NHL. At the 2007 trade deadline, Bill Guerin, a prized NHL goal scorer, was traded for a collegiate player named Jay Barriball. Barriball is freshman for the University of Minnesota, and he is only 5'9" 155 lbs. If teams want to succeed in the NHL, general managers need to become more aware of talent in and outside of the NHL. With size becoming less of an issue, smaller talented players are going to be pursued. This study will look at the importance of size and other player characteristics before and after the changes in the rules of the NHL.

Age is also an interesting player characteristic associated with team success. The Detroit Red Wings are one of the most successful NHL franchises in the last 10 years. The 2006-2007 Detroit Red Wings' nucleus consists of a few players over 35 years old. This includes NHL All Stars Dominik Hasek, Chris Chelios, and Nicklas Lidstrom. Pittsburgh Penguins, on the other hand, are one of the youngest teams in the NHL. Having several poor regular seasons has allowed the team to develop a dozen high draft picks. Sidney Crosby, the leading scorer both in the NHL and for the Pittsburgh Penguins, is only 19 years old. With these age disparities between two successful teams in the league, it brings up the question whether age plays a large impact in winning in the NHL.

Overview of the Paper

This paper aims to investigate the effects of player characteristics on the major statistical determinants of winning in the NHL. Chapter Two will start with a literature review as it relates to the determinants of winning in all major sports as well as hockey.

Chapter Three describes the theoretical models in the current study. The theory chapter will answer the following questions: How does positional height and weight, average age of a team, and the country/province a player originates from have any effect on the statistical determinants of winning?

Chapter Four will discuss the data used in the models. Chapter Five explains the results of the current study. This includes analysis of the regression models as well as conclusions for the current study. Chapter Five also will discuss the difficulties found in the study and ideas for future research.

Chapter Six and Seven are appendixes explaining the specific derivations for profit maximization, marginal effect, and elasticity means for each variable.

CHAPTER II

LITERATURE REVIEW

The objective of this chapter is to discuss literature relating to the production of success in professional sports. The chapter begins by reviewing winning in NCAA sports. Professional sports including the National Basketball Association, Major League Baseball, and English Premier Soccer League will also be discussed. The chapter finishes with a discussion of literature relating to the National Hockey League. In order to become a successful sports franchise, it is necessary to understand how to accumulate the optimal balance of player attributes to the roster. By examining literature that covers optimal performance in sports, one can come closer to building a successful sports franchise.

Winning in Professional Sports

Winning does not occur spontaneously in sporting events. Gerald W. Scully discusses the winning cycle in professional sports. The pattern in winning percentage is not a random fluctuation around a mean percentage. Instead, the wins occur in a cycle.[1] The winning cycle is fueled by momentum. Momentum is the pattern of increasing player quality and winning percentage that is followed by a decline. The author uses a Box

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[1] Scully, Gerald W. The Market Structure of Sports. (Chicago: The University of Chicago Press, 1995), 83-95.

Jenkins estimation to observe the length of cycles for sports franchises in each of the major sports. The average cycle was found to be 11 years. He concludes from his research that it takes time for players to develop into their optimal playing ability. Also, if players were valued completely by their playing ability, the winning percentage of the team would remain very close to an optimal winning percentage. Scully's conclusions prove how important it is to establish the key components that cause wins. If the coach or general manager knows the right ingredients to build a team, they will maintain a very high winning percentage.

NCAA

Winning in collegiate athletics is beneficial not only for the team, but for the college as well. Winning in collegiate sports is strongly correlated with large donations from alumni, as well as increased advertisement for the school across the country. Collegiate football and basketball have been researched heavily in recent years regarding their influences on their respective colleges. The research on these sports will provide insight regarding hockey.

In previous studies, a negative relationship has been found between college team success and graduation rates. Author Irvin B. Tucker applies more research to this relationship. Tucker believes that success on the playing field leads to an increase in publicity for the school. A higher win percentage results in a higher profile for a college as well as an increase in alumni donations.[2] Using a regression model, Tucker tests the significance of academic and nonacademic human capital investment (success of sports

[2] Irvin B. Tucker, "A Reexamination of the Rffect of Big-Time Football and Basketball Success on Graduation Rates and Alumni Giving Rates", *Economics of Education Review* 23 (2004): 655-661.

teams) on graduation rate and alumni giving rates. Data from 87 universities from 1986 to 1996 display that more wins and NCAA basketball tournament appearances result in a greater alumni donation response, as well as an increase in graduation rates.[3] Also, Tucker finds that a winning team increases the applicant pool of the school. With an increased demand, the acceptance rate decreases and the SAT scores increase.

One of the key components of success in any collegiate sport is recruitment. An article by Daniel Sutter and Stephen Winkler discusses the effects of scholarship limits on college football recruitment. They seek to find if reducing the amount of scholarships affects competitive balance. Winkler and Sutter observe the margins between average scores of winning and losing teams, as well as the standard deviation of winning percentages. With a lower amount of scholarships available for recruits, competitive balance decreases.[4] With a high win percentage and well known tradition, powerhouse teams can still attract recruits regardless of the scholarship opportunity. Winkler and Sutter find that weaker teams are forced to recruit more players in hope for finding one quality starter out of the recruitment class.

In another NCAA football paper, George Langelett researches the relationship between recruiting and team performance. Langelett uses a regression model to explore the relationship. The model looks at each class's recruit rankings and their winning percentage. Langelett concludes that the recruiting class has their greatest effect on the

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[3] Tucker, 655-661.

[4] Daniel Sutter and Stephen Winkler, "NCAA Scholarship Limits and Competitive Balance in College Football," *Journal of Sports Economics* 4, no.1 (2003): 3-18.

team during the player's freshman year.[5] After their freshman year, the players' impact decreases. The author also finds that the team performance is very important to recruiting. The winning percentage of a program during the recruit's junior year of high school is the most important in the recruit's decision.

Another NCAA study observes the importance of team strategy and player recruitment in NCAA basketball.[6] By surveying coaches across the country, along with statistical analysis of winning percentages, authors Wright, Smart, and McMahan convey interesting results. Teams that perform outside of their team strategy are less effective. In order to reach optimal performance, a team must match their strategy with their player's skills.[7] This suggests that size of players being recruited should match the system that the team applies. For instance, an NHL team that emphasizes a tough defensive system will recruit larger and more rugged players to fill their roster.

National Basketball Association

In an article by Anthony J. Onwuegbuzie, determinants of winning percentage of the NBA are observed from the 1997-1998 season. Onwuegbuzie uses a multiple regression analysis, and he finds that field goal conversion percentage determines 61 percent of variance in winning percentage.[8] In addition, about 20 percent of the variance

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[5] George Langelett, "The Relationship Between Recruiting and Team Performance in Division 1A College Football", *Journal of Sports Economics* 4, no. 3 (2003): 240-245.

[6] Patrick M. Wright, Dennis L. Smart, and Gary C. McMahan, "Matches between Human Resources and Strategy among NCAA Basketball Teams", The Academy of Management Journal 38, no. 4 (1995): 1052-1074.

[7] Ibid.

[8] Anthony Onwuegbuzie, "Factors Associated with Success Among NBA Teams," *The Sport Journal* 3, no. 2 (2000): 1-5.

of winning percentage relies on three point conversion of the opposition. With more than the majority of variance in winning percentage, offensive production is considered the most important factor in determining NBA success.[9]

Performance in the NBA is also the main focus in a paper by Chatterjee, Campbell, and Wiseman. The authors seek to determine the team performance statistics that significantly affect a team's win percentage. Utilizing a regression model with 1991-1992 season data, field goal percentage, free throws, turnovers, and rebounds are considered the significant determinants of winning in the NBA.[10]

Berri also analyzes production of wins in the NBA. Using an econometric approach with 1994-1998 data, Berri finds possession of the ball and consistency of field goal conversions to be the most valuable factors in producing wins in the NBA.[11] Ball possession and field goal conversion emphasize the importance of rebounds, lack of turnovers, and shooting efficiency. A strong emphasis on rebounds and overall ball possession makes rebound specialists more valuable to a team than scorers.[12] As a result, Berri determines Dennis Rodman, a rebound specialist, the MVP of the 1997-1998 season.

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[9] Onwuegbuzie, 1-5.

[10] Sangit Chatterjee, Martin R. Campbell, and Frederick Wiseman, "Take That Jam! An Analysis of Winning Percentage for NBA Teams", *Managerial and Decision Economics* 15, no. 5 (1994): 521-35.

[11] David Berri, "Who is "Most Valuable"? Measuring the Player's Production of Wins in the National Basketball Association," *Managerial and Decision Economics* 20, no. 8 (1999): 411-427.

[12] Ibid.

Soccer

The English Premier League in soccer is also a focus for win production research. Authors Fiona Carmichael, Dennis Thomas, and Robert Ward investigate the determinants of wins in the elite soccer league. Their research aims to identify the vital playing skills and athletes that positively influence a team's winning percentage. The authors utilize a production function model from the 1997-1998 English Premier League to make conclusions. The results stress importance in defensive play as well as shots on goal, scoring, and passing.[13]

Major League Baseball

In an article by Ray Fair, the effect of age in Major League Baseball is under observation. Looking at data from 1921 to 2004, Fair observes on-base percentage and slugging percentage.[14] In addition, Fair evaluates players' rate of improvement, peak performance age, and the rate of decline after peak performance. Fair determines peak age to be 27 for fielders and 29 for pitchers. From this research, managers can determine what to expect with signing players to long term deals.[15]

Gary Koop also researches the performance of baseball players regarding their offensive abilities. Offensive talent is diverse in baseball. Hitters specialize in getting on base or slugging home runs. Koop uses a statistical method that measures the aggregate

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[13] Fiona Carmichael, Dennis Thomas, and Robert Ward, "Production and Efficiency in Association Football," *The Journal of Sports Economics* 2, no. 3 (2001): 228-243.

[14] Ray C. Fair, "Estimated Age Effects in Baseball", Cowles Foundation Discussion Paper no. 1536.

[15] Ibid.

output for baseball players of all hitting types.[16] Koop measures a player's production by comparing their numbers to the optimal efficient player. Efficiency of a player is plotted against a production possibilities curve. Using data from 1995 to 1999, Koop concludes that his statistical method is the most accurate measure of hitting performance because it measures a player's efficiency in regards to their hitting style.[17]

National Hockey League

Another primary focus of this paper is on the National Hockey League. Much of the research on the NHL discusses attendance, salary determination, and discrimination towards French Canadian players. Very little research has been completed regarding the direct effects of player size, age, and league the players originate from. The research presented, however, gives insight regarding winning, as well as the effect of size on draft position and salaries.

In one article, Leo H. Kahane researches the production efficiency and discrimination in the NHL using a basic economic principle, efficiency. If two teams in the league share identical inputs but differ in winning percentages, one is more efficient than the other.[18] The main objective of the paper is to find what owners can get out of their payrolls in regards to the team's winning percentage. The paper utilizes stochastic frontier estimation and Cobb Douglas functions in search for product inefficiencies. The Cobb Douglas functions test the impact of payroll of the individual players and front

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[16] Gary Koop, "Comparing the Performance of Baseball Players: A Multiple Output Approach", Depart of Economics, University of Glasgow (2001).

[17] Ibid.

[18] Leo Kahane, "Production Efficiency and Discriminatory Hiring Practices in the National Hockey League: A Stochastic Frontier Approach," *Review of Industrial Organization* 27, no. 1 (2005): 47-71.

office and their effects on winning percentage. [19] Payroll is a good measure for player input because it can measure the value of the intangibles a player brings to the team. Inefficiencies were found with coaching, French Canadian players, team ownership, and management experience. A team that incorporates too few or too many French Canadians is inefficient. [20] Management is also a key component of team efficiency. Skilled general managers are talented in finding more productive players as well as accumulating the optimal group of players. When a manager does not make roster decisions based only on productivity, inefficient production occurs.

Another article looks at the NHL entry draft and determines if European and French Canadian players are being discriminated against in the draft. Author Marc Lavoie applies a regression model to find out what determines draft position. Looking at the statistics of the 93-94 entry draft, height, weight, and penalty minutes all play a factor with significant t stats.[21] This suggests the player body composition does influence general managers in recruitment for their teams. Scouts observe these size characteristics and associate them with a high potential in defensive and physical capabilities. Overall, the regression shows that French Canadians and Europeans are underestimated. American teams rarely choose French Canadians, while English Canadian teams discriminate against European players.[22]

An article by William Walsh complements the NHL entry draft article. According to Walsh, player size is a key component of the defensive criteria to get into

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[19] Kahane, 47-71.

[20] Ibid.

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

[22] Ibid.

the league. Overall, size, height, weight, reach, and strength are highly prized attributes from the perspective of a team's front office and scouting.[23] Team success, according to Walsh, is greatly dependent on the correct mix of speed, quickness, puck handling, playmaking, shooting skills, defensive skills, size, and strength. Walsh uses Canadian Hockey League's Memorial Cup, the national championship of major junior "a" hockey, to defend his assertions. The larger teams, statistically coming from the Ontario Hockey League (OHL) and Western Hockey League (WHL), had more success than the Quebec Major Junior Hockey League (QMJHL) teams in the tournament. Walsh relates the lack of size in the QMJHL to the possible discrimination in the NHL. In addition, with emphasis on size and strength, teams will choose bigger players. Larger players are considered to be more durable. [24] They can battle through the long league schedule, travel, and physical play. Big players also contribute on both ends of the ice. Through body checking, larger players can take opponents off the puck. With the opponents being knocked off the puck, bigger players allow their team to face more puck possession, as well as preventing the other team from obtaining scoring chances. Size also brings intimidation to the game, as well as grinding ability. According to Walsh, NHL Stanley Cup champions from the 1980-1991 seasons were statistically larger than the other playoff teams. [25] This suggests size contributes to competitive success.

A paper by Walsh and partner J.C.H. Jones focuses on the determination of National Hockey League salaries. The authors state that skill is the most important factor

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[23] William D. Walsh, "The Entry Problem of Francophones in the National hockey League: A Systemic Interpretation", *Canadian Public Policy* 18, no. 4 (1992): 443-460.

[24] Ibid.

[25] Ibid.

in determining salaries of the players.[26] In order to achieve success, the optimal amount of skill needs to be obtained under financial restrictions. Walsh and Jones use a regression model to find the significant determinants of NHL salaries. Weight proves to be a significant indicator of defense salaries. [27] This correlates with Walsh's other paper. General Managers value size in their defensemen. Weight was not a significant factor for offense salaries. Forwards, on the other hand, were paid more by their height among other offensive skills. [28] One can conclude that height and reach are more valued in offensive capabilities, while defense values weight and physical presence.

An article by Rodney J. Paul discusses the determinants of NHL attendance after recent rule changes. By applying a regression model with attendance as the dependent variable, violence and interdivision rivalry positively affect attendance.[29] Violence can be associated with body checking and fighting. Aggressive play can directly relate to size and strength. Thus, size can play a significant role in attendance numbers for a team. Not surprisingly, the study also indicates that the previous and current seasons' point totals also have a significant positive influence on attendance. [30]

Authors Todd Idson and Leo Kahane also research salary determination in the National Hockey League. Their research investigates the effect of team and coach attributes on an individual player's salary. Kahane and Idson compare salaries with

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[26] J.C. Jones and William Walsh, "Salary Determination in the National Hockey League: The Effects of Skills, Franchise Characteristics, and Discrimination," *Industrial and Labor Relations Review* 41, no. 4 (1988): 592-604.

[27] Ibid.

[28] Ibid.

[29] Rodney, J. Paul, "Variations in NHL Attendence: The impact of Violence, Scoring, and Regional Rivalries", *American Journal of Economics and Sociology* 62, no.2 (2003): 345–364.

[30] Ibid.

individual attributes, then with the addition of team averages, coaching, and other teammates. Player weight was the only variable that had a negative coefficient towards salary.[31] The result indicates that a highly skilled scoring team emphasizes fast players with a long reach. The study determines weight to be a negative influence on speed and scoring. Overall, player attributes and salaries are heavily influenced by their teammates and coaching.

In another study, Heyne et al. look at the determinants of wins through team point production and goals allowed in the NHL. Using data from 1999-2004, Heyne et al. conduct Ordinary Least Squares Regressions to observe the influences of different variables on team points and goals allowed. Heyne et al. find all offensive and defensive variables to have significant influences on team success, but two variables have interesting significant effects on team success: fighting majors and momentum.[32] Fighting majors are a positive effect on points and a negative effect on goals against. This stresses the importance of weight and strength to the success of teams. Also, goals for variable have a negative effect on goals allowed. This means that it is tough to recover after a goal is scored against. [33]

Conclusion

Overall, the literature examining winning and player performance does not include the direct effects of body composition and age on team winning percentages.

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[31] Todd Idson and Leo Kahane, "Team Effects on Compensation: An Application to Salary Determination in the National Hockey League," *Economic Inquiry* 38, no. 2 (2000): 345-357.

[32] John J. Heyne, Aju J. Fenn, and Stacey Brook, "NHL Team Production," Working Paper, Colorado College (October 2006):1-25.

[33] Ibid.

Some articles discuss body composition regarding its effect on certain individual player statistics. Unfortunately, the big picture, or relationship between size and winning, is conspicuously absent from current literature.

Regarding hockey, most papers discuss the effects of body composition and age on salaries or draft status. Team payroll and draft performance are key components of team success, but a direct link between size of a team and winning is lacking. If a model were composed of the direct effects of body composition and age on the key contributions to winning, salaries could match players' outputs more accurately. With salary caps, the proper information is necessary for recruiting the right ingredients for a winning team.

CHAPTER III

THEORY

The purpose of this chapter is to explain the theoretical determinants of winning in professional hockey. The first section will discuss the parallel between microeconomic theory of profit maximization and roster management in hockey. The second section will discuss the concept of winning. The final section will focus on the theoretical determinants of the significant factors of winning.

Microeconomic Theory and Roster Management

Profit maximization in microeconomic theory parallels roster management in all sports, including hockey. Profit maximization occurs when a firm chooses a specific production plan to maximize profits. [1] In a competitive market, the producers have no control over price. In terms of hockey, a team's front office chooses a team to achieve maximum winning percentage as well as profits.

Similar to the profit formula of revenue minus cost, a profit maximization equation for hockey can be portrayed as:

$$Profit(Winning\ \%) = pf(ply1,\ ply2) - s1ply1 - s2ply2$$ [2]

[1] Hal R. Varian, "Profit Maximization," Chapter 19 in Intermediate Microeconomics: A Modern Approach, 6th Ed. (New York: W.W. Norton & Company, 2003), 331-348.

[2] Ibid, 336.

Profit, a function of the team's winning percentage, is dependent on the output of players minus the salaries of each individual player. Output of players is the focus of the current study. Player output is a player's ability to contribute in producing wins. Utilizing the Cobb-Douglas Function and first order conditions, equations for optimal output and costs can be formed.[3] After all the derivations, a final equation displays winning or output as a function of the fixed variable costs and the benefits of winning (see Appendix A).

Economic costs are opportunity costs. By choosing to use one input, a firm must forgo the opportunity of using another input.[4] The input not utilized will be used elsewhere. In hockey, by choosing one player, a team is limiting the opportunity of signing another player of the same caliber. In today's NHL, a salary cap is present. With a salary cap, teams are limited with their inputs. If a player does not like the offer he receives from a team, the player will seek another team that is willing to pay the value he feels that he deserves.

Profit and stock market value also parallel hockey management. The production process in many firms continues for many periods. Inputs used at an early stage might pay off at a later stage in production.[5] This is similar with developing rookies in professional hockey. Their value pays off through years played. Ultimately, owners of firms will want the firm to choose a production plan that maximizes stock market value.[6] In hockey, a team's front office will seek to build a team that will reap the most output or wins. They will want to recruit a team that can reach their highest potential. The success

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[3] Varian, 347-348.

[4] Ibid, 332.

[5] Ibid, 333.

[6] Ibid, 334.

of a team is a long term process. According to Gerald Scully, winning occurs in cycles.[7] As a player develops, the quality of their play increases as well as the team's winning percentage. Ray Fair, in a baseball study, finds that a player's optimal performance occurs in their late 20's.[8] A hockey team's front office needs to acknowledge these facts. If they want to possess the best players they need to be patient in developing their talent or look for players already in their peak performance age.

Profit is the difference between revenue and costs. Costs can be fixed or variable.[9] With hockey, profit is accumulated from the difference between production of wins and its resulting revenue and the salaries that pay the players. Fixed costs of production cannot change. Variable factors can be used in different amounts or change. In professional hockey, players are variable factors. They can be released, waived, or sent to the minors if they are not performing.

In reality, pro teams consist of a mixture of fixed and variable factors. Some players have no-trade clauses in their contracts, while others are under short term contracts and can be traded. Rick DiPietro, a goaltender for the New York Islanders, is an example of a fixed factor for the New York Islanders team. He recently signed a 15 year deal with the team. Fixed factors are paid even if the players produce zero output. If a player is a fixed cost in professional hockey, they are still paid salary regardless of production. This emphasizes the importance of recruiting the right player for professional teams. In the long term, however, all fixed costs are variable. In the NHL, a player's

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[7] Scully, Gerald W. The Market Structure of Sports. (Chicago: The University of Chicago Press, 1995), 83-95. Hal R. Varian, "Profit Maximization," Chapter 19 in Intermediate Microeconomics: A Modern Approach, 6th Ed. (New York: W.W. Norton & Company, 2003), 331-348.

[8] Ray C. Fair, "Estimated Age Effects in Baseball", Cowles Foundation Discussion Paper no. 1536

[9] Varian, 335.

contract is guaranteed, but the team can also trade away the player and his contract in exchange for another player. Thus, a player's salary is fixed, but at the same time the player can be dealt to another team to remove the fixed cost.

Another type of cost is a quasi fixed factor. This is a fixed factor as long as the output is positive. [10] For example, a quasi fixed factor is lighting in a building. If light is not used, no electricity bill will need to be paid. Once light is used, electricity needs to be paid off. [11] In hockey, quasi fixed factors could be players that are paid based on production. Eric Lindros, a player who has faced a dangerous amount of concussions in his career, signed a contract with the Dallas Stars based on how many games he plays and his production.

Determinants of Winning

Managing a hockey team is tough. With many variables affecting the performance of a team, it is difficult for general managers to pick the right group of players. With research on the determinants of winning, choosing the right athletes for a team would be easier to achieve. This current study's goal is to find exactly what causes the specific determinants of winning to occur. The influence of positional player height, weight, the league players originated from, well as age will be observed.

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[10] Varian, 335.

[11] Ibid, 336.

In Heyne et al.'s study, the basic statistical determinants of winning are observed.[12] Heyne et al.'s research uses regressions to determine the significant influences of winning in professional hockey. Heyne et al.'s model is:

$$PTS = \alpha_0 + \alpha_1 GA + \alpha_2 A + \alpha_3 TFW + \alpha_4 TFL + \alpha_5 PIM + \alpha_6 MAJORS + \alpha_7 ESG + \alpha_8 PPG + \alpha_9 SHG + \alpha_{10} G/SHOTS + \alpha_{11} PLSMIN + \alpha_{12} Sav + \alpha_{13} YEAR + e$$ [13]

The model observes how team points are influenced by goals against, assists, face-offs won and lost, penalty minutes, even strength goals, shorthanded goals, power play goals, shots on goal, plus minus, saves, and the year.[14] The current study will observe how NHL positional player size, age, league they originate from, and age will affect Heyne et al.'s significant determinants of team performance. Figure 3.1 is a model of the variables that should influence the determinants found in Heyne et al.'s study.

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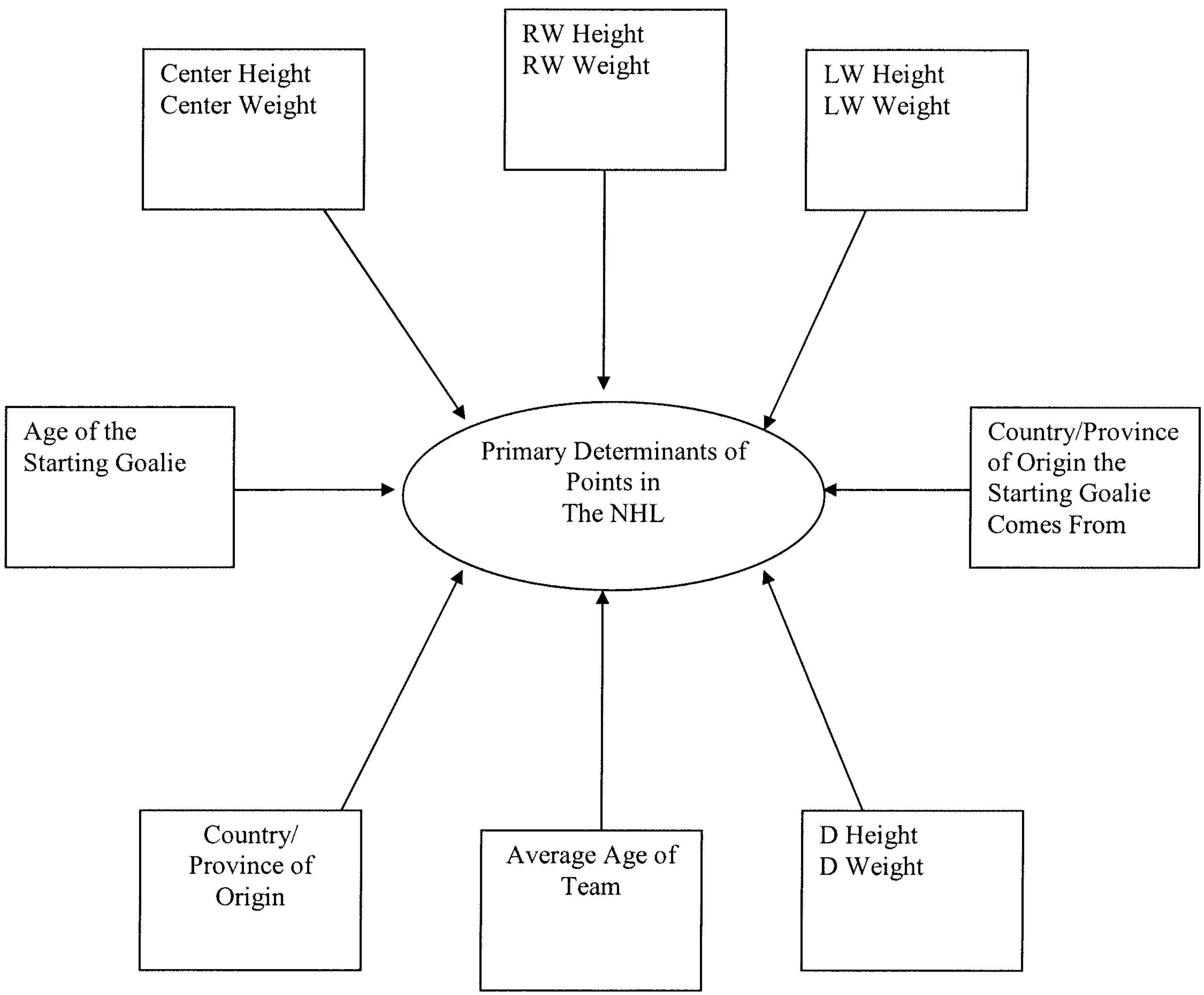
[12] John J. Heyne, Aju J. Fenn, and Stacey Brook, "NHL Team Production," Working Paper, Colorado College (October 2006):1-25.

[13] Ibid.

[14] Ibid.

FIGURE 3.1

Factors that Influence the Determinants of Points in the NHL



Dependent Variables

Due to issues with R-squared values, only Goals Against Per Game, Goals For Per Game, and Minor Penalties are used as dependent variables for this study. Face-offs, penalty kill success rate, and other variables could not achieve high enough R-squared values when they were used as the dependent variable in these production models.

Goals Against

The number of goals against is clearly a symbol of team defense. Defense is based on the ability of team to take possession of the puck from the other team. In order to steal the puck, a player needs to knock their opponent off of the puck, poke check the puck away from them, or intercept a pass.

Player height and weight are vital components to team defense. According to Marc Lavoie, scouts observe size characteristics and associate them with a high potential in defensive and physical capabilities. [15] More height allows players to have a longer reach with their stick. This can be associated with the elimination of passing lanes, an increased ability to poke check the puck away from an opponent, as well as tying up opposing players that do or do not have the puck on their stick.

The weight of a player can be associated with strength: The heavier a player, the greater the ability to knock the opposing team off the puck. With more weight, a body check can be more effective, especially if the other team is larger. The ability to knock opponents off the puck allows bigger players to give their team more puck possession, as

[15] Lavoie, 383-405.

well as preventing the other team from scoring chances or goals against. [16] Also, more weight can intimidate the other team. If a team acknowledges that they're going to be punished if they take the puck in their opposition's zone, a team will play with fear. Overall, larger offensive and defensive players will have a positive influence on defense, and as a result, a lower goals against statistic. If a player is too large, however, their ability to pursue the puck carrier decreases. Thus, a non-linear relationship exists between player weight and ability to defend.

Age is another determinant of goals against. Defense improves with the knowledge of the game. The more experienced defensemen are, or even a forward playing in the defensive end, the better the defense. They know where to tie up their opposition and the tendencies of players in certain situations. Overall age brings preparation. The older a player is, the more prepared they are for all different situations. Age, however, possesses a quadratic relationship with performance; eventually age becomes a burden for the player. Players usually retire around age 40, or even earlier.

In addition, save percentage and goaltender performance are key components of goals against. Solid defense from all positions, including the goaltender, affect this statistic. Good defensive strategy limits the opponent's ability to take shots in effective scoring areas, thus limiting goals against. In addition, where the goaltender comes from could affect this statistic. In the NHL, French Canadian goaltenders have had recent success in the league. On the other hand, not a single starting goalie in the last four seasons came from Saskatchewan.

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[16] Walsh, 443-460.

Goals For Per Game

In order to score goals, the puck needs to move to players in scoring positions. Goals for per game measures the average number of goals a team scores a game. This statistic incorporates assists and other offensive statistics in its production. Weight helps players maintain possession of the puck when they drive towards the net. Possession of the puck is a key component of offense, and weight and strength are necessary to maintain puck possession. Age can also contribute to goals. As a player matures and gathers a better understanding of the game, their playmaking ability should increase up until their age threshold, where conditioning and talents drop off.

Minor Penalties

The more minor penalties a team draws, the more power play opportunities a team will receive. With an effective power play, teams can take advantage of minor penalties and will improve their chances of winning the hockey game. Having fast and skilled players can help draw minor penalties. Slower and weaker players will be forced to break the rules in order to stop the faster and more skilled players. Size and minor penalties could possibly share an indirect relationship. The more size a team has, the chances are they are slower and will struggle when facing off against a fast talented team. At the same time, however, a strong and large team can make it tougher for their opponents to knock them off the puck. As a result, a smaller and weaker team might be forced to use stick work such as slashing, hooking, and tripping to prevent the other team from scoring goals. An increase in stick work on opponents leads to more power play opportunities. With more power plays, a team will have more opportunities to score goals and win games.

Geographic Layout: Where Players Come From

The geographic location that a player originates from will be incorporated into the current research as well. This variable will help determine if French Canadian players should be overlooked in making up team rosters in the NHL. Western Canadians are also known for being tougher players that are valuable to winning teams. The World Junior Canadian team that is very successful tends to pick players from the Western Hockey League (WHL). In the last four World Junior under-20 tournaments, 60 percent of Team Canada's defense is Western Canadian (From the WHL).[17] This paper will show whether a player's home region has an influence on team success.

Conclusions

This chapter has established a theory of explaining why the basic determinants of winning occur in hockey. With statistical analysis in the following chapter, the variables discussed will be tested.

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[17] Hockey Canada,"National Junior Team," available at http://www.hockeycanada.ca/1/8/6/6/index1.shtml, accessed on March 10th, 2007.

CHAPTER IV

DATA / METHODOLOGY

The purpose of this chapter is to explain the data sets utilized in testing the theoretical production models discussed in Chapter III. The data sources will be explained in this chapter as well as description for all of the variables included in the models.

NHL Data and Sources

The current study examines data from four NHL Seasons: 2001-2002 to 2005-2006. The 2004-2005 season was not included because of the NHL lockout. The data set includes statistics for all 30 NHL teams for each individual season. The NHL study consists of 120 observations.

The NHL study data is taken from NHL.com. [1] NHL.com provides statistical biographies for each individual player on a team. From this, player age, height, weight, position, and birth place are identified. Team statistics, such as goals for per game, face-off percentage, and other statistical categories are also included on NHL.com.

NHL.com only provides statistics dating back to the 2001-2002 season. For this study, however, it is important to incorporate data that could be applied to present day

[1] The National Hockey League,"Stats," available at http://www.nhl.com/nhlstats/stats?service=page&context=home, accessed on March 6th, 2007.

hockey. In today's professional ranks, more emphasis is placed on strength and conditioning for the players than ever. Off-seasons no longer exist in the National Hockey League. Players train on and off the ice 12 months a year. Players are bigger and faster than they have ever been in the past.

All variables in the data set are explained in Table 4.1.

TABLE 4.1

List of All Variables Utilized in Study along with Their Descriptions

Variable Name	Description
Offense Variables	
FOPCT	Face-off Win Percentage
PPG	Total Number of Power Play Goals Scored by Team
EVEN	Total Number of Even Strength Goals Scored by Team
ASST	Total Number of Assists Scored by Team
SH	Total Number of Shorthanded Goals Scored by Team
SFPG	Shots For Per Game
GFPG	Goals For Per Game
Defense Variables	
GAPG	Goals Against Per Game
SAPG	Shots Against Per Game
SAVPCT	Save Percentage: Total Saves Divided by Shots on Goal
PK	Penalty Kill Success Rate
PP	Power Play Success Rate
Penalty Variables	
MINORS	Total Number of Minor Penalties Served by Team
MAJORS	Total Number of Major Penalties Served by Team
Roster Variables	
AGE	Average Age of Player Roster
ALB	Number of Players Born in Alberta
BC	Number of Players Born in British Columbia
MAN	Number of Players Born in Manitoba
ONT	Number of Players Born in Ontario
QUE	Number of Players Born in Quebec
SK	Number of Players Born in Saskatchewan

TABLE 4.1, Continued

Variable Name	Description
Roster Variables (continued)	
CZE	Number of Players Born in Czech Republic
FIN	Number of Players Born in Finland
RUS	Number of Players Born in Russia
SVK	Number of Players Born in Slovakia
SWE	Number of Players Born in Sweden
USA	Number of Players Born in USA
GONT	Starting Goaltender was born in Ontario
GQUE	Starting Goaltender was born in Quebec
GRUS	Starting Goaltender was born in Russia
GUSA	Starting Goaltender was born in USA
GFIN	Starting Goaltender was born in Finland
GCZE	Starting Goaltender was born in Czech Republic
GAGE	Starting Goaltender Age
Dummy Variables	
Division	Division Team Plays In
WINDIVISION	Team Won the Division During a Season
YEAR	Season of Play

Methodology

Heyne et al.'s study observes the basic statistical determinants of winning in the NHL.[2] The current study takes Heyne et al.'s work one step further and examines the determinants of winning. Production models of Heyne et al.'s statistical determinants of winning are constructed with different player characteristics: positional player size, age, and place of birth. From these production models, conclusions can be made on the influence of specific player characteristics on winning. The dependent variables of the

[2] Heyne et al., 1-25.

models in this study include: goals against per game, goals for per game, and minor penalties. These three variables were chosen as dependent variables because their models have the best fit. Other determinants such as face-off percentage, shorthanded goals, and power play goals were unable to achieve a high r squared value, and were thus left out in this study.

Ordinary Least Squares regressions applied to production functions are used to determine which variables influence the significant variables determined in Heyne et al.'s research. The significant variables determined in Heyne et al.'s research are not purely dependent on player size, age, and country/ province players originate from.[3] As a result, other variables that should determine the dependent variable will be incorporated. For example, assists are also influenced by statistics such as shots for per game, even strength goals, and other variables that are related to offensive production. At the same time, offensive dependent variables rely on a good defense. Good defense leads to more puck possession, and as a result, offensive production increases. Thus, an offensive dependent variable regression model will also have defensive variables incorporated into the equation.

Dummy variables are in this study as well. The YEAR dummy variables serve as time-dependent variables. They will account for the differences between the seasons in regards to the statistics. For instance, in the new NHL, more penalties are assessed. As a result, both goals and goals against should increase with more power play opportunities. In addition, dummy variables for divisions are in the models. These variables will take account for the differences among divisions in statistics.

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[3] Heyne et al., 1-25.

The Ordinary Least Squares measuring the production of goals for per game as the dependent variable is as follows:

GFPG = *f*(LOG (AGE), DIVISION, BC, (4.1)
(LOG (CHT) + LOG (CWT)), (LOG (LWT) + LOG (LHT)),
(LOG (RHT) + LOG (RWT)), (LOG (DHT)+LOG(DWT)) , CZE,
YEAR, FIN, FOPCT, MAN, ONT, MINORS, MAJORS, QUE, RUS,
(PP+SFPG), SK, SVK, SWE, USA, WINDIVISION, (GAPG+SAPG-PK),
SAVPCT)

In this model, assists are a function of player characteristics, face-off percentage, minor and major penalties, offensive and defensive production. In addition, dummy variables are inserted into the equation to account for time as well as cross sectional differences among divisions. To avoid multi-collinearity, offensive statistics are combined as well as the defensive statistics. Details regarding the model will be discussed in the next chapter.

The Ordinary Least Squares equation measuring the production of goals against per game as the dependent variables is as follows:

GAPG = *f* (LOG (AGE), ALB, DIVISION, BC, (4.2)
(LOG (CHT) + LOG (CWT)), (LOG (LWT) + LOG (LHT)),
(LOG (RHT) + LOG (RWT)), (LOG (DHT) + LOG (DWT)), CZE YEAR FIN,
FOPCT, MAN, ONT, MINORS, MAJORS, QUE, RUS,
((PPG+EVEN+ASST+SH)/SFPG), SK, SVK, SWE, USA, WINDIVISION,
(SAPG+PK), GONT, GRUS, GQUE, GUSA, GFIN, GCZE, LOG(GAGE),
SAVPCT)

The model for goals against per game, a primary defensive determinant of winning in the NHL, consists of the following variables: player characteristics, penalties, offensive production, defensive production, face-off percentage, time dependent dummy variables, division dummy variables, and the country/ province the starting goaltender was born in. Again, offensive as well as defensive production is combined to prevent multi-collinearity issues from occurring.

The Ordinary Least Squares measuring the production of minor penalties as the dependent variable is as follows:

MINORS = f(AGE, DIVISION, BC, (CWT + CHT), (LWT+LHT), (RHT + RWT), (DHT+DWT), CZE, YEAR, FIN, FOPCT, MAN, ONT, MAJORS, QUE, RUS, ((PPG+EVEN+SH+ASST)/SFPG), SK, SVK, SWE, USA, WINDIVISION, (GAPG+SAPG+PK), SAVPCT) (4.3)

In this model, logarithms are not used for age and size. This is because of issues with fit and the size of the coefficients. In addition, goaltender information is left out. Where goaltenders come from should have no effect on the number of minor penalties a team receives in a season. Similar to the goals for per game and goals against per game regression models, the minor penalties regression model includes: offensive and defensive production, player characteristics, major penalties, face-off percentage, and dummy variables.

A total of 120 observations are made for each regression equation. This includes all 30 NHL teams and the last four seasons of play.

Several quadratic relationships are present in this study. Age, as well as size, shares a quadratic relationship with the ability to play the game. A player too large or too old will not be able to compete at the NHL level. As a result, logs are utilized to adjust for this non-linear relationship.

Econometric problems are an issue in the initial regression models of the current study. Issues include multi-collinearity and heteroskedasticity. Combinations of variables have been made to assuage multi-collinearity. Utilizing the White Correction, heteroskedasticity issues are fixed as well. [4] Normality is also checked for.

This concludes the Data Methods chapter of the study. The next chapter will discuss the results and conclusions of the study.

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[4] H. White, "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity," Econometrica 48 (1980):817-838.

CHAPTER V

RESULTS AND CONCLUSIONS

This chapter will analyze the results of the three models described in the previous chapter. The first section will discuss the econometric problems confronted in the study. The next section will describe the results for each of the three models: Goals For Per Game, Minor Penalties, and Goals Against Per Game. The conclusion will discuss the current study and will suggest future research.

Econometric Issues

Econometric problems did exist in all of the models but were successfully fixed. Heteroskedasticity was present in all of the models. The problem was identified using the White Test and was fixed using the White Correction. [1] Multi-collinearity exists between positional player height and weight. To fix the issue, the height and weight variables for each position were combined. Combining offensive variables as well as defensive variables is also necessary to prevent multi-collinearity.

Both age and size share non-linear relationships with player ability. These player characteristics can only help a player until a certain threshold. Thus, a change is necessary from functional form to log form for these player variables. As a result, semi-log regression models are implemented in two out of the three models to provide a better

[1] White, 817-838.

fit and ensure that the residuals are normally distributed. The square root of size and age were also employed, but the logarithms' transformations performed better.

In addition to the regression models presented in Table 5.1, 5.2, and 5.3, values for marginal effect and elasticity means are calculated for each coefficient. Marginal effect is the first derivative, or change of y with respect to a change in the x variable. The derivations of marginal effect are provided in Appendix B.

In addition to calculations of marginal effect, elasticity at means is provided for each variable. This displays the percent change in y with respect to a percent change in x. Similar to marginal effect calculations, derivations and values of elasticity at means for each of the models is presented in Appendix B.

These calculations of marginal effect and elasticity provide specific contributions for each variable in the models. Individual variables included in grouped variables such as offense and defense can now be isolated. For example, the penalty kill success rate's individual effect on the dependent variable in the model can be observed through its marginal effect and elasticity.

RESULTS

The following section will discuss the models presented in the previous chapter. Tables 5.1, 5.2, and 5.3 display the results for each model. Description of the results follows each table.

Table 5.1 displays the results for the Goals For Per Game Model.

TABLE 5.1

Ordinary Least Squares Regression Results for GFPG: Coefficients and t-statistics

VARIABLE	COEFFICIENT	T-STATISTIC
C *Constant Term*	21.333	2.492**
ALB *Alberta-Born*	-0.011	-0.696
ATL *Atlantic Division*	0.100	1.528
BC *British Columbia-Born*	-0.006	-0.325
LOG(CHT)+LOG(CWT) *Center Size*	-0.913	-1.809
LOG(LWT)+LOG(LHT) *Left Wing Size*	-0.171	-0.489
LOG(RHT)+LOG(RWT) *Right Wing Size*	-0.327	-0.579
LOG(DHT)+LOG(DWT) *Defense Size*	-0.021	-0.356
CZE *Czech Republic-Born*	-0.019	-1.23
D01 *2001 Season*	0.0873	0.962
D02 *2002 Season*	0.027	0.350
D03 *2003 Season*	-0.003	-0.028
FIN *Finland-Born*	-0.006	-0.325
FOPCT *Face-Off Win %*	-0.034	-3.173**
MAN *Manitoba-Born*	-0.031	-0.915
NE *New England Division*	0.192	2.858**
NW *Northwest Division*	0.089	1.238
ONT *Ontario-Born*	0.000	0.006
PAC *Pacific Division*	0.086	1.338
MAJORS *Major Penalties*	-0.002	-1.177

TABLE 5.1, Continued

VARIABLE	COEFFICIENT	T-STATISTIC
QUE *Quebec-Born*	-0.009	-0.744
RUS *Russian-Born*	-0.018	-1.093
PP+SFPG *Offense*	0.057	8.796**
MINORS *Minor Penalties*	0.001	2.811**
SK *Saskatchewan-Born*	-0.027	-1.591
SVK *Slovakia-Born*	-0.036	-1.339
SWE *Sweden-Born*	0.002	0.157
USA *USA-Born*	-0.019	-1.704
WINDIVISION *Team Wins Division*	0.106	1.806
GAPG+SAPG-PK *Defense*	-0.003	-0.542
LOG(AGE) *Average Age of Team*	0.104	0.206
SAVPCT *Save Percentage*	-7.287	-3.04**
N = 120		
R-squared		**0.802**
Adjusted R-squared		**0.733**

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

In the table 5.1, the R-squared value is 80%, proving that the model has a good fit. Eighty percent of the variation in goals for per game is explained by the model. Few variables are significant; however, there are several interesting significant relationships present.

The face-off variable has a negative influence on goals for per game. It is significant at the 1% significance level. The partial coefficient of face-offs is negative; which a one percent increase in face-off win percentage causes a .034 decrease in goals for per game. One would assume that winning face-offs would lead to more puck possession and goals scored, but in the current study, the opposite occurs. With this interesting finding, investigation is necessary. In the 2005-2006 season, face-off win percentage varied between 45 and 53%.[2] This means that the goals for per game statistic is not strongly influenced by a wide spectrum of face-off win percentages. The Colorado Avalanche and the San Jose Sharks finished 3rd and 6th in the league with the worst face-off win percentages, but these two teams ranked 4th and 7th in the goals per game category.[3] The Boston Bruins, having the 4th best face-off percentage, finished 24th, or 6th to last, in goals for per game.[4] Thus, losing face-offs motivates the team to play more aggressive to regain control of the puck. With this aggressive play, goals come as a result.

Minor penalties have a significant positive influence on goals for per game. The minor penalties variable is significant at the 1 % significance level. The partial coefficient of minor penalties is positive; one additional minor penalty causes goals for per game to increase by 0.001 goals. This is a very interesting relationship because many would assume the opposite. Minor penalties are generally considered to be a measure of

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[2] The National Hockey League,"Stats."

[3] Ibid.

[4] Ibid.

aggression and intensity. Typically, a successful offensive team possesses a strong work ethic. A hard working team will play aggressive, which is usually associated with more penalties and goals scored.

The minor penalties variable is also worth investigation. In the most recent completed season, 2005-2006, the New Jersey Devils, Tampa Bay Lighting, and Minnesota Wild were three of the top four least penalized teams. [5] They ended up having the 22nd, 16th, and 25th rankings, respectively, for goals per game in the league of 30 teams. At the same time, however, teams that stayed out of the box saw success in offensive categories. These statistics show that penalties can significantly affect offense, but, it is not the single most significant determinant of goals for per game. Team strategy also plays an influence on offense. The Minnesota Wild and the New Jersey Devils are both known as low scoring teams that are more defensive-minded.

The offense variable of power play percentage and shots for per game was also a significant positive influence on goals for per game. The variable was significant at the 1% significance level. This was expected as seen with its high t-statistic level of 8.8; the more shots on goal a team makes, the chance of scoring improves. A higher power play percentage means that a team is more successful in taking advantage of power play opportunities. As a result, a team will net more power play goals as well as goals for per game.

An indirect relationship exists between save percentage and goals for per game with a level of significance at the 1% significance level. This means that teams that play more offensively tend to focus less on their defensive play. According to the model, a

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[5] The National Hockey League,"Stats."

one percent increase in save percentage is associated with a -7.287 decrease in goals for per game. In other words, a good offense typically correlates with a weaker defense. Teams that choose to play a "run and gun" offensive system therefore lack defensive emphasis in their play, and as a result, their save percentage could drop. Again, team strategy can be incorporated into this statistic. Teams that are more defensive-minded are going to have a smaller goals for per game average than an offensive minded team and a higher save percentage. The save percentage statistic also depends on how talented a team's goaltender is. A team can focus more on their offensive play but can depend on good goaltending to take care of their weaker defense.

Table 5.2 displays the results for the Minor Penalties Model.

TABLE 5.2

OLS Regression Results for Minor Penalties: Coefficients and t-statistics

VARIABLE	COEFFICIENT	T-STATISTIC
C *Constant Term*	-1782.049	-2.929**
ALB *Alberta-Born*	5.915	2.089*
ATL *Atlantic Division*	-27.652	-2.045*
BC *British Columbia-Born*	-0.395	-0.102
(CHT)+ (CWT) *Center Size*	-0.394	-0.577
(LWT)+ (LHT) *Left Wing Size*	-0.035	-0.074
(RHT)+ (RWT) *Right Wing Size*	0.963	1.900
(DHT)+ (DWT) *Defense Size*	0.406	2.716**
CZE *Czech Republic- Born*	4.242	1.461
D01 *2001 Season*	-106.412	-5.660**
D02 *2002 Season*	-97.183	-6.662**
D03 *2003 Season*	-109.852	-6.346**
FIN *Finland-Born*	12.470	2.893**
MAN *Manitoba-Born*	8.368	1.336
NE *Northeast Division*	-25.226	-1.714
NW *Northwest Division*	7.037	0.457
ONT *Ontario-Born*	3.736	1.625
PAC *Pacific Division*	-20.922	-1.619
MAJORS *Major Penalties*	1.346	5.058**
QUE *Quebec-Born*	-3.644	-1.379

TABLE 5.2, Continued

VARIABLE	COEFFICIENT	T-STATISTIC
RUS *Russian-Born*	1.389	0.403
SFPG+PPG+EVEN+ASST+SH *Offense*	0.338	5.124**
SK *Saskatchewan-Born*	10.068	3.094**
SVK *Slovakia-Born*	14.358	2.756**
SWE *Sweden-Born*	1.588	0.579
USA *USA- Born*	3.554	1.603
WINDIVISION *Team Wins Division*	-12.251	-1.016
SAPG+GAPG-PK *Defense*	3.955	3.127**
AGE *Average Age of Team*	9.419	2.578**
FOPCT *Face-Off Win %*	8.653	3.956**
SAVPCT*100 *Save %*	13.221	2.425**
N = 120		
R-squared		**0.796**
Adjusted R-squared		**0.727**

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

The Minor Penalties Model presented in table 5.2 has more significant independent variables than the Goals For Per Game Model. This model did not include logarithms for age or positional size; A better fit occurred without logs. With the logs, the partial regression coefficients were unrealistically large. In addition, save percentage was multiplied by 100 to make the partial regression coefficient more realistic.

This model possesses a lower R-squared value than Goals For and Goals Against Per Game Models. Seventy-nine percent of the variation of minor penalties is explained by the model. Penalties could possibly involve more intangible variables than the other two statistical models observed. Aggression, observed through penalties, cannot be measured completely by statistics. Discipline, or the ability to stay away from the penalty box, is an example of an intangible characteristic not included in this model.

Tangible variables, such as the country or province a player was born in, did play a role in this model. Players born in Alberta, Finland, Slovakia, and Saskatchewan all have a positive significant (5% significance level) influence on minor penalties assessed to a team in a given season. Western Canadian players are considered to be more rugged players compared to the rest of Canada. Team Canada likes to recruit players from the Western Hockey League for their World Junior Team because of their toughness. This is proven in this model. [6]

Positional player height and weight also has an influence on minor penalties assessed by a team. Defensemen size positively affects the amount of minor penalties a team receives with significant t-statistics at the 1% significance level. Defensemen are supposed to be the most aggressive players on a team roster, and the results of the Minor Penalties Model are as expected. Larger players are often associated with a more aggressive style of play compared to smaller players. Thus it is expected that an increase

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[6] Hockey Canada,"National Junior Team."

in size positively affects how often teams are penalized with minor calls. It is notable that the other positions fail to have significant impacts on minor penalties.

The Year dummy variables had a significant (1% significance level) negative relationship with minor penalties. This is because of the changes made in the new NHL. After the lockout in 2004-2005, the NHL decided to enforce the rules at a higher level than previously. As a result, more penalties are called in the most recent season in the current study. This explains why the past three season dummy variables have negative significant impacts on the Minor Penalties Model.

Major penalties also share a positive significant (1% significance level) relationship with minor penalties, as expected. The more aggressive a team plays, the more minor penalties a team will receive. In addition, the aggressive play increases the likelihood of fighting. Teams that play aggressive will typically anger their opponents, and the resulting anger will lead to more major penalties with fighting.

The offensive variables share a positive significant (1% significance level) relationship with minor penalties as well. Stated earlier, minor penalties are associated with aggressive play. With an aggressive approach to the game, the chance for scoring more goals increases. This explains why offensive variables are positively related to minor penalties.

Defensive variables also share a significantly (1% significance level) positive relationship with minor penalties. The more shots a team faces and goals they allow, the higher chance of that team getting frustrated. When a team gets frustrated, the intensity level increases and more infractions are noticed by the referees. In addition, if a team allows a high amount of shots on their goal and gets scored on frequently, their defense is often forced into committing penalties to save their team from more goals scored against them.

Save percentage shares a positive significant (1% significance level) relationship with minor penalties. The higher a team's save percentage, the better defense a team possesses. Better defense must be associated with more aggression, and thus more minor penalties.

Age is significantly (1% significance level) positively correlated with minor penalties. This is an interesting result. One would predict that the older a player is, the more calm they become; The opposite is present in this model. The older a player is, the more aggressive he typically becomes. As a result, more minor penalties will be called on him.

Face-off success is also found to positively affect (1% significance level) minor penalties called. This is another interesting relationship. Puck possessions earned by face-off wins create more minor penalty opportunities for a team. The key to a high face-off percentage is a good team effort made by all positions on the ice. The more aggressive a team is off the face-off, the chances of winning a face-off improve. The aggression involved in winning face-offs is most likely the reason behind the relationship between face-off percentage and minor penalties.

The Atlantic division also has a significant (5% significance level) positive relationship with minor penalties. This division must consist of more rivalries, or just chooses to play with more intensity than other divisions.

Table 5.3 presents the results for the Goals Against Per Game Model.

TABLE 5.3

Ordinary Least Squares Regression Results for GAPG: Coefficients and t-statistics

VARIABLE	COEFFICIENT	T-STATISTIC
C *Constant Term*	36.322	6.431**
ALB *Alberta-Born*	-0.001	-0.103
ATL *Atlantic Division*	-0.038	-0.854
BC *British Columbia-Born*	-0.007	-0.700
LOG(CHT)+LOG(CWT) *Center Size*	-0.502	-1.176
LOG(LWT)+LOG(LHT) *Left Wing Size*	0.244	1.199
LOG(RHT)+LOG(RWT) *Right Wing Size*	-0.796	-3.098**
LOG(DHT)+LOG(DWT) *Defense Size*	-0.006	-0.118
CZE *Czech Republic- Born*	0.010	1.048
D01 *2001 Season*	-0.080	-1.137
D02 *2002 Season*	-0.085	-1.432
D03 *2003 Season*	-0.121	-1.758
FIN *Finland-Born*	0.001	0.058
FOPCT *Face-Off Win %*	-0.007	-0.899
MAN *Manitoba-Born*	0.015	0.909
NE *Northeast Division*	-0.020	-0.558
NW *Northwest Division*	-0.073	-1.796
ONT *Ontario-Born*	0.016	2.059*
PAC *Pacific Division*	-0.019	-0.462
MINORS *Minor Penalties*	0.000	0.185

TABLE 5.3, Continued

VARIABLE	COEFFICIENT	T-STATISTIC
MAJORS *Major Penalties*	0.001	0.763
QUE *Quebec-Born*	0.010	1.154
RUS *Russia-Born*	-0.010	-0.855
(PPG+EVEN+ASST+SH)/SFPG *Offense*	-0.006	-1.141
SK *Saskatchewan-Born*	0.010	0.864
SVK *Slovakia-Born*	-0.017	-1.116
SWE *Sweden-Born*	0.013	1.876
USA *USA-Born*	0.005	0.816
WINDIVISION *Team Wins Division*	-0.008	-0.220
SAPG-PK *Defense*	0.057	14.365**
LOG(AGE) *Average Age of Team*	-0.517	-1.516
SAVPCT *Save %*	-20.053	-13.808**
GONT *Starting Goaltender is Ontario-Born*	0.018	0.462
GQUE *Starting Goaltender is Quebec-Born*	0.008	0.205
GRUS *Starting Goaltender is Russia-Born*	-0.028	-0.504
GUSA *Starting Goaltender is USA-Born*	0.069	1.332

TABLE 5.3, Continued

GFIN *Starting Goaltender is Finland-Born*	-0.035	-0.542
GCZE *Starting Goaltender is Czech Republic-Born*	-0.032	-0.734
GAGE *Starting Goaltender Age*	-0.002	-0.646
N=120		
R-squared		**0.947**
Adjusted R-squared		**0.923**

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

The production model in Table 5.3 has a very high R-squared value of 94.7 %. This means that almost 95% of the variation in goals against per game is explained by the variables in this model. The presence of the defensive variables helps obtain this high percentage fit. Other variables, however, did find significant relationships with the dependent variable.

In the Goals Against Per Game Model, player characteristics did not have a significant impact on the dependent variable. Right wing size, however, does significantly (1% significance level) decreases the amount of goals scored against a team per game. Size on the wing helps teams possess the puck along the boards in their zone. This makes it easier for teams to break the puck out of their zone. It is interesting that only the right wing position has an effect on goals against.

Ontario-born players had a significant (5% significance level) positive effect on goals against per game. This proves that the Ontario province is less defensive minded compared to other provinces of Canada and countries. This could be why Team Canada's world junior team tends to have more western Canadians on their defensive squad. [7]

As expected, defensive variables significantly affect goals against per game (1% significance level). A higher amount of shots against per game and a lower penalty kill percentage positively affects the amount of goals against per game. As expected, a higher save percentage decreases the amount of goals against per game.

The constant also has a positive influence on the amount of goals against per game.

Conclusions

The current study examines the variables that affect the determinants of wins in the NHL. The majority of the statistical determinants that affect wins in Heyne et al.'s study could not be successfully measured with models having high R-squared values.[8] These statistical determinants such as face-offs, power play goals, and penalty kill success are influenced by many intangible variables. Intangible variables include skill, talent, leadership, and other player qualities that are not measurable. The presence of these variables would have a large impact on the production models of all the statistical determinants of wins in the NHL.

The current study, however, consists of several models that had high

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[7] Hockey Canada,"National Junior Team."

[8] Heyne et al., 1-25.

R-squared values. The statistical determinants of goals for per game, goals against per game, and minor penalties are the dependent variables in the three models. The purpose of this study is to observe the affect of player characteristics, including size, age, and the province or country they were born on the three models listed above. From these three regression models, conclusions can be made regarding the impact of each player characteristic.

Size only plays an impact in the right wing and defense positions. These impacts are only observed in the Goals Against Per Game and Minor Penalty Models. Not a single player characteristic plays a role in the Goals For Per Game model. Overall, size does not make a big difference in offensive or defensive play. This means that general managers should not discriminate against the thought of acquiring smaller players.

The lack of significance with size variables disagrees with general manager strategy observed in the previous research on French Canadian salary discrimination and NHL draft position. According to one study on the NHL Draft, player size is a significant factor in determining draft position of players. [9] General Managers pursue heavier and taller players in the higher rounds of the draft. Another study researching French Canadian salary discrimination observes player size as a key component to defensive play. [10] The study attributes French Canadian's lack of size as one of the main reasons why salary discrimination exists with their race. In comparison with the WHL and the OHL, the QMJHL players were significantly smaller in size. In another study,

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[9] Marc Lavoie, 383-405.

[10] William D. Walsh, 443-460.

defense salaries are observed having a significant impact on their salaries.[11] General Managers feel that larger defensemen improve their defensive play and lower their goals against per game statistic.

Regarding offense and defense, only Ontario born players made an impact in at least one of the models. French Canadian players did not have a visible negative effect on any of the models. This means that there is no reason for teams to discriminate against French Canadian salaries, which is found in other studies. [12] Overall, it really does not matter where a player originates from. Regarding goaltenders, there was no significance at all with any certain province or country the player was born in. French Canadian goaltenders are typically considered the best by the casual hockey fan, but they made no significant impact in the Goals Against Per Game Model.

Age did play an influence in the minor penalty model. In regards to producing offense, however, age was not seen as a significant variable. Although, one could observe that age positively influences minor penalties, which can increase offensive production. Overall, player characteristics really do not play any effect on the statistical determinants of wins in the NHL.

Future Research

The current study observes the influences of the statistical determinants of wins in the NHL from a team perspective. Player characteristics were accumulated from team rosters. Size and age were averaged from these team rosters. This approach makes sense

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[11] Jones and Walsh, 592-604.

[12] Ibid.

because hockey is a team game, and the proper make-up of a team is necessary to win games.

Another approach, however, could also test the effects of player characteristics on the determinants of wins in the NHL. This would involve looking at the statistical determinants found in Heyne et al.'s study, and observing the top players that produce these statistics. [13] For example, a face-off percentage model would include only the top 60 players from each season in face-offs and include their height, weight, location of birth, and age. Along with their personal characteristics, team data would be included. The positional player size and age would also be included along with the personal data. This approach would look strictly at the player characteristics and take focus off of the obvious statistical determinants of offense and defense.

The current study pursued a team approach to finding the significant variables that affect the determinants of wins in the NHL. Several player characteristics made a significant impact in the three models in the study. Overall, the impact of player characteristics was not convincing enough to make any ultimate conclusions. Future research is necessary to find what exactly determines success in the statistical determinants of winning in hockey.

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[13] Heyne et al., 1-25.

APPENDIX A

Profit Maximization[1]:

Max pf(ply1, ply2)- s1x1-s2x2 (A 1.1)

Ply1= Player 1 *s1= Player 1's salary*

Ply2= Player 2 *s2= Player 2's salary*

First order conditions:

$p\, d(f(ply1, ply2) / d\,(ply1) - s1 = 0$ (A 1.2.1)

$p\, d(f(ply1,ply2) / d\,(ply2) - s2 = 0$ (A 1.2.2)

Utilizing Cobb Douglas $f(ply_1, ply_2) = ply1^a ply2^b$, The two first order conditions become:

$pa\, ply1^{a-1} ply2^b - s_1 = 0$ (A 1.3.1)

$pb\, ply1^a ply2^{b-1} - s_2 = 0$ (A 1.3.2)

Multiply the first equation by *ply1* and the second by *ply2*

$pa\, ply1^a ply2^b - s_1 ply1 = 0$ (A 1.4.1)

$pb\, ply1^a ply2^b - s_2\, ply2 = 0$ (A 1.4.2)

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[1] Varian, 347-348.

Using $y = ply1^a ply2^b$ as output of the firm the equations can be rewritten as:

$$pay = s_1 \, ply1 \quad \text{(A 1.5.1)}$$

$$pby = s_2 \, ply2 \quad \text{(A 1.5.2)}$$

Solve for ply1 and *ply2*

$$ply_1{}^* = pay \ / s_1 \quad \text{(A 1.6.1)}$$

$$ply_2{}^* = pby \ / s_2 \quad \text{(A 1.6.2)}$$

Substitute the equations for $x_1{}^*$ and $x_2{}^*$ into the Cobb Douglas output equation $y = ply1^a ply2^b$

$$(pay \ / s_1)^a \ (pby \ / s_2)^b = y \quad \text{(A 1.7)}$$

Factor out the y

$$y = (pa / s_1)^a \ (pb / s_2)^b \ y^{a+b} \quad \text{(A 1.8)}$$

Which leads to the final equation:

$$y = (pa / s_1) \ a^{/(1-a-b)} \ (pb / s_2)^{b/(1-a-b)} \quad \text{(A 1.9)}$$

APPENDIX B

Calculation of Marginal Effect[1]

Linear Variable:

$$Yi = B_1 + B_2 X_{2i} + \ldots + B_R X_{Ri} \quad \text{(B 1.1.1)}$$

$$dYi / dX2i = B_2 \quad \text{(B 1.1.2)}$$

Marginal Effect = B_2

Log Variable:

$$Yi = B_1 + B_2 LOG(X_{2i}) + \ldots + B_R X_{Ri} \quad \text{(B 1.2.1)}$$

$$dY_i / dX_{2i} = B_2 / \overline{X}_{2i} \quad \text{(B 1.2.2)}$$

Marginal Effect = $B_2 / \overline{X}_{2i}$

Calculation of Elasticity at Means [2]

Linear Variable:

$$Yi = B_1 + B_2 X_{2i} + \ldots + B_R X_{Ri} \quad \text{(B 1.3.1)}$$

$$dYi / dX2i = B2 \quad \text{(B 1.3.2)}$$

$$e_{yi,\, x2i} = (dYi / dX2i) * (\overline{X}_{2i} / \overline{Y}_i) \quad \text{(B 1.3.3)}$$

$$e_{yi,\, x2i} = B2 * \overline{X}_{2i} / \overline{Y}_i \quad \text{(B 1.3.4)}$$

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[1] Aju J. Fenn, "Day 15: Functional Form." Notes presented for Functional Form in EC 408 at Colorado College, Colorado Springs, CO October 2005

[2] Ibid.

Calculation of Elasticity at Means, Continued [3]

Log Variable:

$$Yi = B_1 + B_2\, LOG\, (X_{2i}) + \ldots + B_R X_{Ri} \qquad \text{(B 1.4.1)}$$

$$dY_i / dX_{2i} = B_2 / \overline{X}_{2i} \qquad \text{(B 1.4.2)}$$

$$e_{yi,\ x2i} = dYi / dX2i * (\overline{X}_{2i} / \overline{Y}_i) \qquad \text{(B 1.4.3)}$$

$$e_{yi,\ x2i} = dYi / \overline{Y}_I \qquad \text{(B 1.4.4)}$$

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[3] Fenn.

TABLE B.1

Goals For Per Game Model's Marginal Effects and Elasticity at Means

VARIABLE	MARGINAL EFFECT	ELASTICITY
ALB *Alberta-Born*	-0.011	-0.009
ATL *Atlantic Division*	0.100	0.006
BC *British Columbia-Born*	-0.006	-0.003
LOG(CHT) *Center Height*	-0.013	-0.005
LOG(CWT) *Center Weight*	-0.005	-0.002
LOG(LHT) *Left Wing Height*	-0.002	-0.001
LOG(LWT) *Left Wing Weight*	-0.001	0.000
LOG(RHT) *Right Wing Height*	-0.004	-0.002
LOG(RWT) *Right Wing Weight*	-0.002	-0.001
LOG(DHT) *Defense Height*	0.000	0.000
LOG(DWT) *Defense Weight*	0.000	0.000
CZE *Czech Republic-Born*	-0.019	-0.014
D01 *2001 Season*	0.087	0.008
D02 *2002 Season*	0.027	0.002
D03 *2003 Season*	-0.003	0.000
FIN *Finland-Born*	-0.006	-0.002
FOPCT ** *Face-Off Win %*	-0.034	-0.626
MAN *Manitoba-Born*	-0.031	-0.006
NE ** *Northeast Division*	0.192	0.012
NW *Northwest Division*	0.089	0.005

TABLE B.1, Continued

ONT *Ontario-Born*	0.000	0.000
PAC *Pacific-Born*	0.086	0.005
MAJORS *Major Penalties*	-0.002	-0.034
QUE *Quebec-Born*	-0.009	-0.006
RUS *Russian-Born*	-0.018	-0.010
PP ** *Power Play %*	0.057	0.347
SFPG ** *Shots For Per Game*	0.057	0.600
MINORS *Minor Penalties*	0.001	0.158
SK *Saskatchewan-Born*	-0.027	-0.010
SVK *Slovakia-Born*	-0.035	-0.012
SWE *Sweden-Born*	0.002	0.001
USA *USA-Born*	-0.019	-0.026
WINDIVISION *Wins Division*	0.106	0.008
SAPG *Shots Against Per Game*	-0.003	-0.030
GAPG *Goals Against Per Game*	-0.003	-0.003
PK *Penalty Kill Success Rate*	0.003	0.092
LOG(AGE) *Average Age of Team*	0.004	0.038
SAVPCT ** *Save %*	-7.287	-2.435

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

TABLE B.2

Minor Penalty Model's Marginal Effects and Elasticity at Means

VARIABLE	MARGINAL EFFECT	ELASTICITY
ALB * *Alberta-Born*	5.915	0.029
ATL * *Atlantic Division*	-27.652	-0.011
BC *British Columbia-Born*	-0.395	-0.001
CHT *Center Height*	-0.394	-0.067
CWT *Center Weight*	-0.394	-0.183
LHT *Left Wing Height*	-0.035	-0.006
LWT *Left Wing Weight*	-0.035	-0.017
RHT *Right Wing Height*	0.963	0.163
RWT *Right Wing Weight*	0.963	0.455
DHT ** *Defense Height*	0.406	0.070
DWT ** *Defense Weight*	0.406	0.198
CZE *Czech Republic-Born*	4.242	0.019
D01 ** *2001 Season*	-106.412	-0.062
D02 ** *2002 Season*	-97.183	-0.056
D03 ** *2003 Season*	-109.852	-0.064

TABLE B.2, Continued

FIN ** *Finland-Born*	12.470	0.026
MAN *Manitoba-Born*	8.368	0.010
NE *Northeast Division*	-25.226	-0.010
NW *Northwest Division*	7.037	0.003
ONT *Ontario-Born*	3.736	0.041
PAC *Pacific Division*	-20.922	-0.008
MAJORS ** *Major Penalties*	1.346	0.145
QUE *Quebec-Born*	-3.644	-0.017
RUS *Russian-Born*	1.389	0.005
SFPG ** *Shots For Per Game*	0.338	0.022
PPG ** *Power Play Goals*	0.338	0.050
EVEN ** *Even Strength Goals*	0.338	0.114
ASST ** *Assists*	0.338	0.297
SH ** *Shorthanded Goals*	0.338	0.007
SK ** *Saskatchewan-Born*	10.068	0.024
SVK ** *Slovakia-Born*	14.358	0.030
SWE *Sweden-Born*	1.588	0.006
USA *USA-Born*	3.554	0.030

TABLE B.2, Continued

WINDIVISION *Wins Division*	-12.251	-0.006
SAPG ** *Shots Against Per Game*	3.955	0.262
GAPG ** *Goals Against Per Game*	3.955	0.025
PK ** *Penalty Kill Success Rate*	-3.955	-0.767
AGE ** *Average Age of Team*	9.419	0.589
FOPCT ** *Face-Off Win Percentage*	8.653	1.006
SAVPCT*100 ** *Save %*	13.221	0.028

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

TABLE B.3

Goals Against Per Game Model's Marginal Effects and Elasticity at Means

VARIABLE	MARGINAL EFFECT	ELASTICITY
ALB *Alberta-Born*	-0.001	-0.001
ATL *Atlantic Division*	-0.038	-0.002
BC *British Columbia-Born*	-0.007	-0.003
LOG(CHT) *Center Height*	-0.007	-0.003
LOG(CWT) *Center Weight*	-0.003	-0.001
LOG(LHT) *Left Wing Height*	0.003	0.001
LOG(LWT) *Left Wing Weight*	0.001	0.000
LOG(RHT) ** *Right Wing Height*	-0.011	-0.004
LOG(RWT) ** *Right Wing Weight*	-0.004	-0.001
LOG(DHT) *Defense Height*	0.000	0.000
LOG(DWT) *Defense Weight*	0.000	0.000
CZE *Czech-Republic-Born*	0.010	0.007
D01 *2001 Season*	-0.080	-0.007
D02 *2002 Season*	-0.085	-0.008
D03 *2003 Season*	-0.121	-0.011
FIN *Finland-Born*	0.001	0.000
FOPCT *Face-Off Win %*	-0.007	-0.129
MAN *Manitoba-Born*	0.015	0.003
NE *Northeast Division*	-0.020	-0.001

TABLE B.3, Continued

NW *Northwest Division*	-0.073	-0.004
ONT * *Ontario-Born*	0.016	0.027
PAC *Pacific Division*	-0.019	-0.001
MINORS *Minor Penalties*	0.000	0.010
MAJORS *Major Penalties*	0.001	0.017
QUE *Quebec-Born*	0.010	0.007
RUS *Russian-Born*	-0.010	-0.006
SFPG *Shots For Per Game*	0.004	0.045
PPG *Power Play Goals*	0.000	-0.005
EVEN *Even Strength Goals*	0.000	-0.011
ASST *Assists*	0.000	-0.028
SH *Shorthanded Goals*	0.000	-0.001
SK *Saskatchewan-Born*	0.010	0.004
SVK *Slovakia-Born*	-0.017	-0.006
SWE *Sweden-Born*	0.013	0.007
USA *USA-Born*	0.005	0.007
WINDIVISION *Team Wins Division*	-0.008	-0.001

TABLE B.3, Continued

SAPG ** *Shots Against Per Game*	0.057	0.598
PK ** *Penalty Kill Success Rate*	-0.057	-1.750
LOG(AGE) *Average Age of Team*	-0.019	-0.190
SAVPCT ** *Save %*	-20.053	-6.700
GONT *Starting Goaltender is Ontario-Born*	0.018	0.001
GQUE *Starting Goaltender is Quebec-Born*	0.008	0.001
GRUS *Starting Goaltender is Russia-Born*	-0.028	-0.001
GUSA *Starting Goaltender is USA-Born*	0.069	0.003
GFIN *Starting Goaltender is Finland-Born*	-0.035	-0.013
GCZE *Starting Goaltender is Czech Republic-Born*	-0.032	-0.001
GAGE *Goaltender Age*	-0.002	-0.022

*indicates significance at the 5% significance level
** indicates significance at the 1% significance level

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