Evaluating Players' Abilities in NHL

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Abstract

I propose a model to evaluate the ability of each player to create goals and defend goals in NHL. In the model, I allocate the team's performance to each player by taking the home-ice advantage, and the manpower (power-play, short-handed) situation and zone start into account. Data on all the games from the 2014-2015 season was downloaded from (http://war-on-ice.com/) and processed into a form suitable for the analysis. When I wrote this paper, I refer to Player Contribution by Alan Ryder. The difference between his model and my model is how to deal with different manpower situations on home and away ice and zone starts and total time on ice. I consider these all of these factors to evaluate each player and try to evaluate each player objectively.

1. INTRODUCTION

Inspired by Alan Ryder's Player Contribution in Ryder (2004), I propose a system that attempts to estimate a player's abilities to defend goals and create goals in 5-on-5 situations, 4-on-4 situations, power-play situations and short-handed situations. If I can evaluate the ability of each player in how many goals he contributes to in one season, you can use these abilities to predict the next season result. I evaluate each player in NHL for several seasons. I estimate my model by calculating abilities of players from the past two seasons and comparing them to the next season.

If this model is accurate enough, this new model enables us to evaluate each player's ability to score goals and prevent goals in each manpower situation on home and away ice. For example, this model can help you answer the following questions.

1. Who are some of the best offensive defensemen?
2. Which player contributes to goals most in this season?
3. Who performs best in the shorthanded situation?
4. Who are underestimated and affordable defensemen?

In this model, I use shots as well as goals mainly because shots are the only actions to generate goals and there are many more samples of shots than goals so that I can evaluate each player more accurately.

2. DATA

I download the data from a war-on-ice website, (http://war-on-ice.com/) from 2009-2010 to 2014-2015 seasons. I have chosen to estimate regular season performance and estimate only regular season data in our models. A regular season has 82 games and you do not play against the same team more than 3 times. In playoff games, you compete against strong teams consecutively. You can get much more unbiased data from regular season games than playoff games. Thus I excluded playoff games and only evaluate regular season games.

3. METHOLODGY (More detailed description starts on page 7.)

Offence

I mainly used Goals, Shots, 1st Assists and 2nd Assists to calculate the abilities to create goals in each manpower situation on home and away ice. Since we have more samples of shots than of goals, shots are less likely to be dependent on luck than goals and we can evaluate abilities of each player more accurately by considering shots. I used the following steps.

1. Calculate each player's Goal Creation from goals, 1st Assists and 2nd Assists.
2. Regress each player's Goal Creation on offensive zone starts, total time on ice. Compare this predicted Goal Creation to the actual Goal Creation. If a player scores more (less) goals than predicted, give him award (punishment).
3. Calculate each player's likely Goal Creation based on shots.
4. Regress each player's shots on offensive zone starts, total time on ice. Compare the predicted number of shots to the actual number of shots. If a player takes more (less) shots than predicted, give him award (punishment).
5. Consider shooting accuracy. Divide players into forwards and defensemen because usually attackers can shoot close to the net, so they should have a higher chance to score goals when they shoot. If the player's shooting accuracy is higher than the average accuracy, I give those players the extra points. If not, I subtract points from them.
6. Based on the results of step 2 and 5, I calculate the abilities of each player to create goals.

Defense

I mainly used Goals Against, Shots Against, Total Time on Ice and Defensive Zone Starts to calculate the abilities of all skaters to defend goals in each manpower situation on home and away ice. I mainly used the adjusted saving percentage and shots faced by goalies to evaluate each goalie. I have decided to use shots against and goals against simultaneously to determine the player's contribution to the team. Since I do not have data about the shot quality when a player is on the ice, I believe that by using shots and goals simultaneously, I can take the quality of shots against into consideration. I used the following steps.

1. Calculate the Goals defended by all the players on a team.
2. Divide the Goals defended all the players into Goals Defended by skaters and Goals Defended by goalies.
3. Allocate the Goals Defended by goalies to each goalie.
4. Allocate goals prevented by skaters to forwards and defensemen. Regress the goals against responsibility based on defensive zone starts and total time on ice. Give credits (punishments) if a player prevents more (few) goals against.
5. Allocate shots against to each player based on positions and time and defensive zone starts. Regress the shots against based on defensive zone starts and total time on ice for forwards and defenders. Give credits (punishments) if a player prevents more (few) shots against.
6. After allocating shots against to each position, regress the goals against based on defensive zone starts and total time on ice. Give credits (punishments) if a player prevents more (few) shots against.
7. Based on the results of step 5 and 7, I calculate the abilities of each skater to defend goals.

Power Play Penalty and Award

I believe that power plays drawn and committed are based on players' abilities. I consider the number of power play penalties drawn and committed to think about goals prevented and created.

1. Regress the penalties drawn based on offensive zone starts, defensive zone starts and total time on ice. Give credits (punishments) if a player draws more (fewer) penalties than predict penalties.

2. Regress the penalties committed based on offensive zone starts, defensive zone starts and total time on ice. Give credits (punishments) if a player commits fewer (more) penalties than predict penalties.

4. IMPLEMENTATION of MY METHOD

Abilities to Create Goals

1. Calculate each player's Goal Creation based on goals, 1st Assists and 2nd Assists.

When I think about the individual performance, I believe that one goal's contribution from a goal, a 1st assist and a 2nd assist is the ration of 1:0.75:0.25 on average because some statisticians do not use 2nd assists to consider a player's ability and NHL treats both assists equally, I have decided to use a midpoint between them.

$$\begin{aligned}&\left(\text{Player's Goal Creation based on Goals (PGCG)}\right)\\&= 0.5\\&*\left(\text{(A Player's Goals For)}\right.\\&\left.+\left(\frac{\left(0.75*\text{(A Player's 1st Assists)}+0.25*\text{(A Player's 2nd Assists)}\right)*Team\ Goals\ For}{\sum_{player}^{Team}\left(0.75*\text{(A Player's 1st Assists)}+0.25*\text{(A Player's 2nd Assists)}\right)}\right)\right)\end{aligned}$$

In each situation, I used the above formula to calculate each player's goal contribution based on goals. Basically I divide a team's goal into each player's contribution to goals.

2. Regress each player's Goal Creation on offensive zone starts, total time on ice. Compare this predicted Goal Creation to the actual Goal Creation. If a player scores more (less) goals than predicted, give him award (punishment).

I made a liner regression model to predict Goal Creation Based on the number of offensive zones starts (OZS) and total tome on ice (TTI). I use the data from 2009-2010 to 2014-2015 season and divide the data into offensive players and defensive players. I compare this predicted Goal Creation to the actual Goal Creation and give each player plus or minus. When I made a linear mode, I used Akaike's method to figure out which variable is the most important in each situation.

$$(Predicted\ PGCG) = OZS * C1 + TTI * C2 + C3$$

$$(PGCG\ Award) = (Actual\ PGCG) - (Predicted\ PGCG)$$

The following is the summary of C1, C2 and C3. NA means that that variable is not significant to predict PGCG according to Akaike's methods.

Offense	C1	C2	C3	Defense	C1	C2	C3
5-on-5 Home	0.0247	0.0057	-0.4746	5-on-5 Home	0.0062	0.0012	-0.1139
5-on-5 Away	0.0224	0.0058	-0.4836	5-on-5 Away	0.0064	0.0008	-0.0709
4-on-4 Away	0.0036	0.0130	-0.0009	4-on-4 Away	0.0032	0.0046	-0.0015
4-on-4 Home	0.0159	0.0113	-0.0051	4-on-4 Home	0.0043	0.0060	-0.0015
SH Away	0.0210	0.0040	0.0064	SH Away	NA	0.0005	0.0010
SH Home	0.0082	0.0058	-0.0034	SH Home	NA	0.0005	-0.0006
PP Away	0.0285	0.0025	0.0025	PP Away	0.0164	NA	-0.0356
PP Home	0.0269	0.0057	-0.0801	PP Home	0.0124	0.0045	-0.0451

3. Calculate each player's likely Goal Creation based on shots.

I consider the ability to take shots as important as score goals because we have more samples of shots. Sometimes, scoring goals depends on luck, but since we have more samples of shots, shots are not likely to be dependent on luck. Based on the number of shots, I calculate the number of predicted goals based on shots.

$$\begin{aligned}&\left(\text{Player's Goal Creation based on Shots (PGCS)}\right)\\&\quad=\text{(The number of shots a player takes)}\\&\quad*\frac{(Goals\ by\ all\ the\ players\ at\ his\ position)}{(Shots\ by\ all\ the\ players\ at\ his\ position)}\end{aligned}$$

4. Regress each player's shots on offensive zone starts, total time on ice. Compare the predicted number of shots to the actual number of shots. If a player takes more (less) shots than predicted, give him award (punishment).

I regress shots based on the number of offensive zones starts and total tome on ice. If a player does not shoot as many shots as he should, I will subtract his goal's contribution.

$$(Predicted\ number\ of\ shots) = OZS * C1 + TTI * C2 + C3$$

$$\begin{aligned}&(Predicted\ PGCS)\\&\quad=(Predicted\ number\ of\ shots)\\&\quad*\frac{(Goals\ by\ all\ the\ players\ at\ his\ position)}{(Shots\ by\ all\ the\ players\ at\ his\ position)}\end{aligned}$$

$$(PGCS\ Award) = PGCS - (Predicted\ PGCS)$$

The following is the summary of C1, C2 and C3. NA means that that variable is not significant to predict PGCS according to Akaike's methods.

	Offense			Defense		
	C1	C2	C3	C1	C2	C3
5-on-5 Home	0.1338	0.0896	-1.9131	0.1683	0.0188	-1.5223
5-on-5 Away	0.1141	0.0920	-1.9941	0.1569	0.0181	-0.7898
4-on-4 Away	0.0430	0.1364	-0.0039	0.1162	0.0640	-0.0505
4-on-4 Home	0.0795	0.1330	-0.0282	0.0446	0.0956	-0.0619
SH Away	0.148	0.0444	0.0258	NA	0.0146	0.0119
SH Home	0.1131	0.0502	0.0306	0.0248	0.0130	0.0280
PP Away	0.1096	0.0889	-0.4517	0.0959	0.0941	-0.1428
PP Home	0.1210	0.0863	-0.4870	0.1054	0.0959	-0.2325

At the same time, we need to think about the shooting accuracy. The average shooting accuracy depends on the positions. I divide all the players into defenders and attackers. Usually attackers can shoot close to the net, so they should have a higher chance to score goals when they shoot. If the player's shooting accuracy is higher than the average accuracy, I give those players the extra points. If not, I subtract points from them.

$$Shot\ Accuracy\ Award\ (SA\ Award) = (A\ Player's\ Actual\ Goals) - (Predicted\ PGCS)$$

5. Divide players into forwards and defensemen because usually attackers can shoot close to the net, so they should have a higher chance to score goals when they shoot. If the player's shooting accuracy is higher than the average accuracy, I give those players the extra points. If not, I subtract points from them.

I use the data from 2009-2010 to 2014-2015 season and divide the data into offensive players and defensive players. I regress the number of goals (GFPlayer) on the number of shots (SFPlayer).

$$(\text{Predicted GFPlayer}) = \text{SFPlayer} * \text{C1} + \text{C2}$$

Let the R-square of this regression be R1.In each situation (5on5, 4on4, shorthanded, power play), I calculated the total goals defended based on the following formula. I think goals are more important than shots and I put a stronger emphasis on goals than shots.

$$Total\ Goals\ Created\ by\ a\ Player = \frac{(PGCG + PGCG\ Award + SA\ Award) * 1 + (PGCS + PGCS\ Award) * R1}{1 + R1}$$

The R-Square table is on the next page.

R-Square	Defense	Offence
5-on-5 Home	0.839	0.835
5-on-5 Away	0.861	0.84
4-on-4 Away	0.365	0.402
4-on-4 Home	0.288	0.349
SH Away	0.808	0.822
SH Home	0.828	0.823
PP Away	0.459	0.485
PP Home	0.453	0.462

Result

The following is the result of top 15 forward and defenders for Overall GC.

Top 15 Forwards and Defenders for Overall GC

Forward			Defense		
Name	Team	GC	Name	Team	GC
Alex Ovechkin	WSH	40.4	Erik Karlsson	OTT	29.3
Tyler Seguin	DAL	38.9	Oliver Ekman-Larsson	ARI	23.9
John Tavares	NYI	37.0	P.K Subban	MTL	23.7
Steven Stamkos	T.B	36.2	Roman Josi	NSH	21.8
Jamie Benn	DAL	35.8	Dustin Byfuglien	WPG	21.2
Rick Nash	NYR	35.1	John Carlson	WSH	20.7
Nick Foligno	CBJ	34.7	Dennis Wideman	CGY	20.4
Tyler Johnson	T.B	34.3	Trevor Daley	DAL	20.2
Vladimir Tarasenko	STL	33.5	Justin Faulk	CAR	19.7
Joe Pavelski	S.J	31.3	John Klingberg	DAL	19.1
Jarome Iginla	COL	29.9	Tyson Barrie	COL	18.9
Sidney Crosby	PIT	29.3	Mike Green	WSH	18.3
Mark Stone	OTT	29.0	Mark Streit	PHI	18.2
Jiri Hudler	CGY	29.0	Andrei Markov	MTL	18.0
Evgeni Malkin	PIT	29.0	Shea Weber	NSH	16.8

Defense Abilities

1. Calculate the Goals defended by all the players on a team.

I define the total goal defending as the following value.

$$(Goals\ Defended\ by\ all\ the\ players) = (Goals\ Defended\ by\ all\ the\ skaters) + (Goals\ Defended\ by\ all\ the\ goalies)$$

I believe that the total defense contribution and offence contribution of skaters is the same. This means the total goal defending of all teams is bigger than offence of all teams because there is goalie contribution of defense. The following equation explains this more.

$$Goals\ Created\ by\ Skaters = Goals\ Defended\ by\ Skaters$$

$$Goals\ Created\ by\ Skaters < Goals\ Defended\ by\ all\ Players = Goals\ Defended\ by\ Skaters\ and\ Goals\ Defended\ by\ Goalies$$

2. Divide the Goals defended all the players into Goals Defended by skaters and Goals Defended by goalies.

First, I need to think about how to divide goals defended into goalies and skaters. I divide the defense into four situations (5on5, 4on4, shorthanded and power play). Since each situation has different number of players, at each situation I set the goalie's contribution to defend a goal when a goal was defended. From now, I call the contribution to defense of goals by skaters "DS" and contribution to defense of goals by goalies "DG".

In 5on5, there are 5 skaters and 1 goalie. I think there are 0.5 contributions of skaters to both offence and defense by skaters on average and 1.0 whole contribution to defense by a goalie. As a result, I consider a goalie to be responsible for defending

1/(0.5*5+1)=2/7 goals when a team defends a goal on average. I call the mean defense of a goal by a goalie "MeanDG".

As a result, I decided to think that the defense contribution of an entire team is
$\left(Defense\ by\ a\ Team\ (DT)\right) =$
$(Mean\ Goals\ Against\ of\ All\ Teams\ in\ entire\ season\ at\ a\ situation) * (2 + MeanDefensebyGoalie\ at\ a\ situation) - (Actual\ Goals\ Againsnt\ at\ a\ situation)$

In shorthanded situations, $MeanDG = \frac{1}{1+4*0.5} = \frac{1}{3}$ because there are 4 skaters and 1 goalie. MeanDG in 4on4 is the same as shorthanded because there are 4 skaters and 1 goalie.

The following table is a summary of MeanDG in each situation.

Situation	MeanDG
5on5	2/7
4on4	1/3
Shorthanded	1/3
Power Play	2/7

3. Allocate the Goals Defended by goalies to each goalie.

I ponder over DG based on the adjusted saving percentage on the data source (war on the ice). I set the Maximum and Minimum possible contribution of goalies on one team.

First, in order to calculate the total contribution of goalies on one team, I used the following formula in each situation.

$$Team\ Adjusted\ Saving\ Percentage = \frac{\sum Each\ Goalie\ Saving\ Percentage\ on\ the\ Team * Shots\ Faced\ of\ each\ Goalie\ on\ the\ Team}{\sum Shots\ Faced\ of\ each\ Goalie\ on\ the\ Team}$$

Since the number of skaters in each situation is different, we need to think about DG in each situation.

In 5on5, there are 5 skaters and 1 goalie. I think there are 0.25 contributions of skaters to both offence and defense and 1.0 whole contribution to defense by a goalie if the adjusted saving percentage of a team is the maximum of all the teams. As a result, I consider the maximum prevention by a goalie to be

$$MaxDG = \frac{1}{1+5*0.25} = \frac{4}{9}.$$

4/9 goals when a team prevents one goal. The mean should be around 2/7 goals as I calculated as MeanDG. $\text{MeanDG} = \frac{\text{MaxDG+MinDG}}{2}$

So MinDG should be $MinDG = 2 * \frac{2}{7} - \frac{4}{9} = \frac{8}{63}$.

Power Play situation is the same as the 5on5 because there are 5 skaters and 1 goalie.

In 4on4 situation, there are 4 skaters and 1 goalie. I think there are 0.25 contributions of skaters to both offence and defense and 1.0 whole contribution to defense by a goalie if the contribution of a goalie on a team is the maximum of all the teams combined. As a result, I consider the maximum prevention by a goalie to be

$$MaxDG = \frac{1}{1+4*0.25} = \frac{1}{2}.$$

1/(0.25*4+1)=1/2 goals when a team prevents one goal. The mean should be around 1/3 goals as I calculated as MeanDG. $\text{MeanDG} = \frac{\text{MaxDG+MinDG}}{2}$

So MinDG should be $MinDG = 2 * \frac{1}{3} - \frac{1}{2} = \frac{1}{6}$

The maximum adjusted saving percentage of a team out of all teams should have MaxDG and the minimum adjusted saving percentage of a team out of all teams should have MinDG.

$$\begin{aligned}&The\ number\ of defended\ Goals\ by\ goalies\ on\ a\ team\\&\quad = (MeanGoalsAgainst * (2 + MeanPreventionbyGoalie)\\&\quad - ActualGoalsAgaisnt) * PG\end{aligned}$$

After you decide the DG of a team, you allocate the DG of a team to each goalie on the team based on the following formula.

$$PG\ of\ a\ goalie = \frac{(Goalie\ Saving\ Percentage * Shots\ Faced) * PG\ of\ a\ Team}{\sum_{Team}(Each\ Goalie\ Saving\ Percentage\ on\ the\ Team * Shots\ Faced\ of\ each\ Goalie)}$$

The following is the top 10 goalies in 2014-2015 season.

Name	Team	DG
Carey Price	MTL	65.3
Roberto Luongo	FLA	52.2
Mike Smith	ARI	46.1
Antti Niemi	S.J	41.1
Semyon Varlamov	COL	38.5
Sergei Bobrovsky	CBJ	36.0
Cory Schneider	N.J	33.2
Jonas Hiller	CGY	30.6
Jonathan Quick	L.A	30.6
Marc-Andre Fleury	PIT	30.2
Brian Elliott	STL	26.4

4. After allocating goals prevented by skaters to forwards and defensemen, regress the goals against responsibility based on defensive zone starts and total time on ice. Give credits (punishments) if a player prevents more (few) goals against.

As I mentioned in Step 2, $MeanGoalsAgainst * (2 + MeanPreventionbyGoalie) - ActualGoalsAgaisnt$ is all the defended goals of one team. I need to divide these goals into goals defended by skaters and goalies. In Step 3, I have already calculated the goals defended by goalies. So the following is the goals defended by skaters.

$$\sum_{Team} (DS\ of\ each\ skater)$$
$$= (The\ number\ of\ goals\ defended\ by\ skaters\ on\ one\ team)$$
$$= (MeanGoalsAgainst * (2 + MeanPreventionbyGoalie)$$
$$- ActualGoalsAgaisnt) * (1 - PG)$$

First, I think about allocating goals defended to each player based on positions and time and defensive zone starts. I believe that the ratio of the sum of goals created by three offensive players and the sum of goals created by two defensemen should be the same as the ratio of the sum of goals defended by two defensemen and the sum of goals defended by three offence players.

$$The\ number\ of\ goals\ created\ by\ three\ offensemen$$
$$: The\ number\ of\ goals\ created\ by\ two\ defensemen$$
$$= The\ number\ of\ goals\ defended\ by\ two\ defensemen$$
$$: The\ number\ of\ goals\ defended\ by\ three\ offense$$

$$FGA = \frac{DGC(Goals\ Created\ by\ defense\ on\ the\ team)}{2}$$

$$DGA = \frac{FGC(Goals\ Created\ by\ offence\ on\ the\ team)}{3}$$

However, sometimes FGC or DGC can be negative in 4on4 or shorthanded situations because there are not many scoring chances in both situations. If this is the case, I

decide to make FGC as 0.03 or DGC as 0.01 in each case so that DGA/(FGA+DGA) or FGA/(FGA+DGA) cannot be negative.

By using R, I regress the goals against responsibility based on defensive zone starts and give each player credits by using the data from 2009-2010 to 2014-2015 season.

$$(Predicted\ Goals\ Against\ while\ a\ player\ is\ on\ the\ ice) = Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3$$

C1, C2 and C3 are the constants.

$$(Goals\ Defended\ by\ a\ player\ based\ on\ Goals\ (if\ the\ player\ is\ a\ forward)) = \big((Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3) * (2 + MeanPreventionbyGoalie - PG\ of\ the\ Team) - Goals\ Against\ while\ he\ is\ on\ the\ ice\big) * \frac{FGA}{(FGA + DGA) * 3}$$

$$(Goals\ Defended\ by\ a\ player\ based\ on\ Goals\ (if\ the\ player\ is\ defense)) = \big((Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3) * (2 + MeanPreventionbyGoalie - PG\ of\ the\ Team) - Goals\ Against\ while\ he\ is\ on\ the\ ice\big) * \frac{DGA}{(FGA + DGA) * 2}$$

The following is the summary of C1, C2 and C3. NA means that that variable is not significant to predict “Goals Defended by a player based on Goals” according to Akaike’s methods.

	Offense			Defense		
	C1	C2	C3	C1	C2	C3
5-on-5 Home	0.1338	0.0896	-1.9131	0.0321	0.0247	0.3270
5-on-5 Away	0.1141	0.0920	-1.9941	NA	0.0378	0.4688
4-on-4 Away	0.0430	0.1364	-0.0039	0.1162	0.0450	0.0071
4-on-4 Home	0.0795	0.1330	-0.0282	0.0877	NA	0.0757
SH Away	NA	0.0146	0.0119	0.0230	0.0918	0.1102
SH Home	0.1131	0.0502	0.0306	0.0766	0.0248	0.2701
PP Away	0.1096	0.0889	-0.4517	NA	0.0106	-0.0062
PP Home	0.1210	0.0863	-0.4870	NA	0.0138	-0.0359

5. Regress the goals against based on defensive zone starts and total time on ice for forwards and defenders. Give credits (punishments) if a player prevents more (few) shots against.

I firmly believe that the ability to prevent opponents from shooting is very important and valuable. I regress shooting against on defense zone starts and time on the ice as the shots. The number of shots prevented is divided into forwards and defensemen as the same allocation as the goal allocation. We have more samples in shots against and the shots against times the average conversion rate of shots into goals in that manpower situation on home or away ice is a measure of a player's contribution on defense. I have decided to use shots against and goals against simultaneously to determine the player's contribution to the team. Since I do not have data about the shot quality when a player is on the ice, I believe that can take the shot quality into consideration by using shots and goals simultaneously.

By using R, I regress the goals against responsibility based on defensive zone starts and give each player credits by using the data from 2009-2010 to 2014-2015 season.

$$Shots\ Against\ while\ a\ player\ is\ on\ the\ ice = Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3$$

C4, C5 and C6 are the constants.

$$Goals\ Defended\ by\ a\ player\ based\ on\ Shots\ (if\ the\ player\ is\ offence) = \big((Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3) * (2 + MeanPreventionbyGoalie - PG\ of\ the\ Team) - Goals\ Against\ while\ he\ is\ on\ the\ ice\big) * \frac{FGA}{(FGA + DGA) * 3} * \frac{\sum_{Team} Goals\ Against\ while\ a\ player\ is\ on\ the\ ice}{\sum_{Team} Shots\ Against\ while\ a\ player\ is\ on\ the\ ice}$$

$$Goals\ Defended\ by\ a\ player\ based\ on\ Shots\ (if\ the\ player\ is\ defense)$$
$$= \big((Time\ On\ Ice * C1 + Defensive\ Zone\ Start * C2 + C3)$$
$$* (2 + MeanPreventionbyGoalie - PG\ of\ the\ Team)$$
$$- Goals\ Against\ while\ he\ is\ on\ the\ ice\big) * \frac{DGA}{(FGA + DGA) * 2}$$
$$* \frac{\sum_{Team} Goals\ Against\ while\ a\ player\ is\ on\ the\ ice}{\sum_{Team} Shots\ Against\ while\ a\ player\ is\ on\ the\ ice}$$

The following is the summary of C1, C2 and C3. NA means that that variable is not significant to predict “Goals Defended by a player based on Goals” according to Akaike’s methods.

	Offense			Defense		
	C1	C2	C3	C1	C2	C3
5-on-5 Home	0.1114	0.4480	-1.9063	0.2742	0.3953	0.8794
5-on-5 Away	0.1072	0.4705	-1.7671	0.2248	0.4257	2.0331
4-on-4 Away	0.0754	0.5056	0.0162	0.2167	0.4671	0.2167
4-on-4 Home	0.1126	0.4693	0.0196	0.1940	0.4335	0.1452
SH Away	0.0592	0.8289	-0.1019	0.1098	0.7867	0.5338
SH Home	0.0911	0.7651	-0.0577	0.2049	0.6620	0.4402
PP Away	0.2757	0.1334	-0.1139	0.1957	0.1371	-0.0757
PP Home	0.2969	0.1237	-0.1118	0.2832	0.1212	-0.0833

6. Based on the results of Step 5 and 7, I calculate the abilities of each skater to defend goals.

I regress "goals against while a player is on the ice (GAPlayer)" on "shots against while a player is on the ice (SAPlayer)".

$$\text{GAPlayer} = \text{SAPlayer} * \text{C1} + \text{C2}$$

Let the R-square of this regression be R1. In each situation (5on5, 4on4, shorthanded, power play), I calculated the total goals defended based on the following formula. I think goals are more important than shots and I put a stronger emphasis on goals than shots.

$$Total\ Goals\ Defended = \frac{GDSG * 1 + GDSS * R1}{1 + R1}$$

The following is a table for R-Square in each situation.

	Defense	Offence
5-on-5 Home	0.839	0.835
5-on-5 Away	0.861	0.84
4-on-4 Away	0.365	0.402
4-on-4 Home	0.288	0.349
SH Away	0.808	0.822
SH Home	0.828	0.823
PP Away	0.459	0.485
PP Home	0.453	0.462

Results for Defense Contribution

The following is a list of top 15 skaters at defense in 2014-2015 season.

Forwards			Defensemen		
Name	Team	Points	Name	Team	Points
Luke Glendening	DET	16.33	Andrew Greene	N.J	31.00
Marcus Kruger	CHI	13.96	Dennis Seidenberg	BOS	30.59
Drew Miller	DET	13.75	Alexander Edler	VAN	30.40
Sean Couturier	PHI	13.49	Daniel Girardi	NYR	29.03
Ryan Kesler	ANA	13.48	T.J. Brodie	CGY	28.69
David Backes	STL	13.46	Ryan Suter	MIN	27.88
Jay McClement	CAR	13.24	Christopher Tanev	VAN	27.45
Joe Pavelski	S.J	12.86	Anton Stralman	T.B	26.78
Claude Giroux	PHI	12.51	John Carlson	WSH	26.77
Ben Smith	CHI	12.46	Jonas Brodin	MIN	26.75
Alex Steen	STL	12.33	Matt Niskanen	WSH	26.46
Riley Nash	CAR	11.84	Drew Doughty	L.A	26.06
Andrew Ladd	WPG	11.76	Andrei Markov	MTL	25.25
Dustin Brown	L.A	11.75	Ryan McDonagh	NYR	25.05
Jakob Silfverberg	ANA	11.71	P.K. Subban	MTL	24.98

Special Situations (Power Play Penalty and Award)

I believe that power plays drawn and committed are based on players' abilities.

1. Regress the penalties drawn based on offensive zone starts, defensive zone starts and total time on ice. Give credits (punishments) if a player draws more (fewer) penalties than predict penalties.

I regress power plays drawn (PPD) on Offensive Zone Starts (OZS), Defensive Zone Starts (DZS) and Total Time on Ice (TTI) by using data from 2009-2010 to 2014-2015. I used Akaike's methods to remove variables, which are not statistically significant in each situation (5on5, 4on4, shorthanded and power play).

$$Predicted\ PPD = OZS * C1 + DZS * C2 + TTI * C3 + C4$$

$$Power\ Play\ Award(PPA) = ((Actual\ PPD) - (OZS * C1 + DZS * C2 + TTI * C3 + C4))$$

The summary of C1, C2, C3, C4 is on the next page.

The following is the summary of C1, C2, C3 and C4. NA means that that variable is not significant to predict “Goals Defended by a player based on Goals” according to Akaike’s methods

	Offense				Defense			
	C1	C2	C3	C4	C1	C2	C3	C4
5-on-5 Home	-0.0053	NA	0.0108	0.2826	NA	-0.0049	0.0067	-0.0288
5-on-5 Away	NA	-0.0031	0.0106	0.2935	NA	-0.0025	0.0058	0.0857
4-on-4 Away	NA	NA	0.0090	0.0343	NA	NA	0.0047	0.0229
4-on-4 Home	0.0084	NA	0.0047	0.0376	NA	NA	0.0062	0.0033
SH Away	NA	NA	0.0059	0.0812	0.0168	-0.0026	0.0093	0.0585
SH Home	0.0124	-0.0019	0.0074	0.0610	NA	NA	0.0080	0.0578
PP Away	NA	NA	0.0092	0.1110	NA	NA	0.0029	0.0166
PP Home	0.0032	0.0259	0.0047	0.0985	NA	-0.0099	0.0026	0.0390

In order to think about the contribution of goals by drawing penalties, I need to think about goals for per minute (GFPM) and goals against per minute (GAPM) in each situation.

$$GAPM = \frac{All\ the\ Goals\ Against\ in\ the\ situation}{All\ the\ Time\ of\ the\ situation\ (minutes)}$$

$$GFPM = \frac{All\ the\ Goals\ For\ in\ the\ situation}{All\ the\ Time\ of\ the\ situation\ (minutes)}$$

$$Mean\ Penalty\ Time = \frac{All\ the\ time\ of\ penalties}{The\ number\ of\ all\ the\ penalties}$$

$$\begin{aligned} &Goals\ Created\ from\ Power\ Play\ Award(GCPPA) \\ &\quad = Power\ Play\ Award(PPA) \\ &\quad * \big((GPM\ at\ the\ Consequent\ Situation) \\ &\quad - (GPM\ at\ the\ Previous\ Situation)\big) * (Mean\ Penalty\ Time) \end{aligned}$$

$$\begin{aligned} &Goals\ Prevented\ from\ Power\ Play\ Award(GPPPA) \\ &\quad = Power\ Play\ Award(PPA) \\ &\quad * \big((GPM\ at\ the\ Previous\ Situation) \\ &\quad - (GPM\ at\ the\ Consequent\ Situation)\big) * (Mean\ Penalty\ Time) \end{aligned}$$

2. Regress the penalties committed based on offensive zone starts, defensive zone starts and total time on ice. Give credits (punishments) if a player commits fewer (more) penalties than predict penalties.

I regress power plays committed (PPC) on Offensive Zone Starts (OZS), Defensive Zone Starts (DZS) and Total Time on Ice (TTI) by using data from 2009-2010 to 2014-2015. I used Akaike's methods to remove variables, which are not statistically significant in each situation (5on5, 4on4, shorthanded and power play).

$$Predicted\ PPP = OZS * C1 + DZS * C2 + TTI * C3 + C4$$

$$Power\ Play\ Penalty(PPP) = ((Actual\ PPP) - (OZS * C1 + DZS * C2 + TTI * C3 + C4))$$

The following is the summary of C1, C2, C3 and C4. NA means that that variable is not significant to predict "Goals Defended by a player based on Goals" according to Akaike's methods.

	Offense				Defense			
	C1	C2	C3	C4	C1	C2	C3	C4
5-on-5 Home	-0.0053	NA	0.0108	0.2826	-0.0056	NA	0.0102	0.3484
5-on-5 Away	NA	-0.0031	0.0106	0.2935	NA	-0.0145	0.0136	0.4183
4-on-4 Away	NA	NA	0.0090	0.0343	NA	NA	0.0094	0.0314
4-on-4 Home	0.0084	NA	0.0047	0.0376	NA	NA	0.0091	0.0156
SH Away	NA	NA	0.0059	0.0812	NA	NA	0.0068	0.0471
SH Home	0.0124	-0.0019	0.0074	0.0610	0.0124	NA	0.0061	0.0308
PP Away	NA	NA	0.0092	0.1110	0.0059	0.0210	NA	0.0807
PP Home	0.0032	0.0259	0.0047	0.0985	0.0052	0.0258	NA	0.0673

$$Goals\ Created\ from\ Power\ Play\ Penalty(GCPPP)$$
$$= Power\ Play\ Penalty(PPP)$$
$$* \big((GPM\ at\ the\ Consequent\ Situation)$$
$$- (GPM\ at\ the\ Previous\ Situation)\big) * (Mean\ Penalty\ Time)$$

$$Goals\ Prevented\ from\ Power\ Play\ Penalty(GPPPP)$$
$$= Power\ Play\ Penalty(PPP)$$
$$* \big((GPM\ at\ the\ Previous\ Situation)$$
$$- (GPM\ at\ the\ Consequent\ Situation)\big) * (Mean\ Penalty\ Time)$$

Result

The following is a table for best and worst performers to create a power play situation for his team.

Best Performers			Worst Performers		
Name	Team	Points	Name	Team	Points
Jonas Brodin	MIN	2.30	Steve Downie	PIT	-3.83
Matt Moulson	BUF	2.22	Dustin Byfuglien	WPG	-3.19
Justin Schultz	EDM	2.05	Brad Marchand	BOS	-2.90
Sean Monahan	CGY	2.04	P.K. Subban	MTL	-2.57
Cody Ceci	OTT	2.00	Dion Phaneuf	TOR	-2.52
Jason Pominville	MIN	1.99	Ryan Garbutt	DAL	-2.31
Cam Fowler	ANA	1.98	Scott Hartnell	CBJ	-2.23
Anze Kopitar	L.A	1.96	Jarret Stoll	L.A	-2.22
Rob Scuderi	PIT	1.96	Eric Gryba	OTT	-2.17
Ryan O'Reilly	COL	1.95	David Savard	CBJ	-2.10

Results of Goals Contribution

Goals Contribution is the sum of Goals Created Contribution, Goals Defended Contribution and Power Play Contribution. The following is a list of top 15 defenders in 2014-2015 season.

Forwards			Defensemen		
Name	Team	Points	Name	Team	Points
Alex Ovechkin	WSH	48.6	Erik Karlsson	OTT	52.0
Tyler Seguin	DAL	47.0	Roman Josi	NSH	49.1
Jamie Benn	DAL	45.5	John Carlson	WSH	49.0
Joe Pavelski	S.J	44.9	P.K. Subban	MTL	47.9
John Tavares	NYI	44.2	Dennis Wideman	CGY	46.8
Rick Nash	NYR	43.0	Andrei Markov	MTL	45.6
Steven Stamkos	T.B	42.1	T.J. Brodie	CGY	44.4
Nick Foligno	CBJ	41.7	Oliver Ekman-Larsson	ARI	43.9
Tyler Johnson	T.B	41.1	Anton Stralman	T.B	41.4
Ryan Getzlaf	ANA	40.9	Shea Weber	NSH	41.0
Vladimir Tarasenko	STL	40.5	Justin Faulk	CAR	40.9
David Backes	STL	39.0	Trevor Daley	DAL	39.4
Jarome Iginla	COL	39.0	Andrew Greene	N.J	38.3
Max Pacioretty	MTL	38.6	Mark Giordano	CGY	38.3
Mark Stone	OTT	37.7	Drew Doughty	L.A	38.0

From this model, the most valuable player this season is Carey Price. The most valuable defender is Erik Karlsson and the most valuable forward is Alex Ovechkin.

Year-to-Year Comparison of Performance

In order to see the validation of this model, I used the data of past four years. I used the following formula to predict player's performance.

$$(Predicted\ Performace\ of\ the\ next\ year)$$

$$= ((Performance\ of\ this\ year) * \frac{(The\ number\ of\ games\ predicted\ to\ play)}{(The\ number\ of\ games\ played)} * 5$$

$$+ (Performance\ of\ the\ last\ year) * \frac{(The\ number\ of\ games\ predicted\ to\ play)}{(The\ number\ of\ games\ played)} * 3)/8$$

The number of games predicted to play is 73 games when you assess players who play more than 65 games (80 percent of all the games).

$$(Difference\ of\ Performance)$$
$$= |(Actual\ Performance) - (Predicted\ Performance)|$$

I will evaluate the total points contribution, total points defended and total points created.

1. Since there was lockout in 2012-2013 season and there were only 48 games compared to usual 82 games, I decided to multiply the player's performance by 82/48.
2. In order to evaluate players who have enough time on ice, I only consider players who play more than 65 games (80 percent of all the seasons).

The following is the example of validation of players' performance in 2015.

$$(Predicted\ Performace\ in\ 2015)$$

$$= ((Performance\ in\ 2014) * \frac{(The\ number\ of\ games\ predicted\ to\ play\ in\ 2015)}{(The\ number\ of\ games\ played\ in\ 2014)}$$

$$* 5 + (Performance\ in\ 2013)$$

$$* \frac{(The\ number\ of\ games\ predicted\ to\ play\ in\ 2015)}{(The\ number\ of\ games\ played\ in\ 2013)} * 3)/8$$

$$(Difference\ of\ Performance\ in\ 2015) = |(Predicted\ Performace\ in\ 2015) - (Actual\ Performance\ in\ 2015)|$$

Results

Players who played more than 65 games for 2012-2013, 2013-2014 and 2014-2015.

DTP means Difference in Total Points.

$$(\text{DTP Contributed } in\ 2015) = |(Predicted\ Total\ Points\ Contributed\ \ in\ 2015) - (Actual\ Total\ Points\ Contributed\ in\ 2015)|$$

$$(\text{DTP Created } in\ 2015) = |(Predicted\ Total\ Points\ Created\ in\ 2015) - (Actual\ Total\ Points\ Created\ in\ 2015)|$$

$$(\text{DTP Contributed Defended } in\ 2015) = |(Predicted\ Total\ Points\ Defended\ in\ 2015) - (Actual\ Total\ Points\ Defended\ in\ 2015)|$$

	DTP Contributed	DTP Created	DTP Defended
Mean	6.59	5.21	2.69
80th percentile	9.59	7.88	4.18
90th percentile	13.3	10.6	5.24

Sum, Difference and Percent of Difference mean the following in the below table.

$$Sum = \sum (Actual\ Performance\ in\ 2015)$$

$$Difference = \sum (Difference\ of\ Performance\ in\ 2015)$$

$$(Percent\ of\ Difference) = \frac{Sum}{Difference * 2}$$

	Sum	Difference	Percent of Difference
Total Points Contributed	4264.6	1080.9	12.4
Total Points Created	2159.4	853.9	19.8
Total Points Defended	2047.1	440.7	10.8

Percent of difference means that you can predict the player's goal's contribution at that percent of accuracy. For example, if the percent of difference is 12 percent and the player's prediction is 30 points, the actual performance will be 30 ± 3.6 points on average.

2013-2014 season

Players who played more than 65 games

	DTP Contributed	DTP Created	DTP Defended
Mean	6.79	5.43	2.89
80th percentile	11.75	9.68	4.21
90th percentile	15.74	12.03	6.06

	Sum	Difference	Percent of Difference
Total Points Contributed	4090.3	1106.2	13.5
Total Points Created	2028.2	885.3	21.8
Total Points Defended	2046.1	471.9	11.5

2012-2013 season

Players who played more than 65 games

	DTP Contributed	DTP Created	DTP Defended
Mean	6.75	5.71	2.96
80th percentile	10.9	9.71	4.86
90th percentile	13.2	12.81	6.27

	Sum	Difference	Percent of Difference
Total Points Contributed	4063.2	1086.7	13.4
Total Points Created	2201.5	919.9	20.9
Total Points Defended	1830.8	447.1	12.2

From the result of the past three seasons, I can summarize the results as the following on average.

$$(Actual\ Overall\ Performance) = (Predicted\ Overall\ Performance)(1 \pm 0.13)$$

$$(Actual\ Offensive\ Performance) = (Predicted\ Offensive\ Performance)(1 \pm 0.21)$$

$$(Actual\ Defensive\ Performance) = (Predicted\ Defensive\ Performance)(1 \pm 0.12)$$

From the comparison of performance of different years, it is harder to evaluate the abilities to create goals than to the ability to defend goals.

Conclusion

I have made a model to evaluate the performance of each player in NHL by using data about NHL from the 2009-2014 season on war-on-ice.com.

I would like to insist three improvements that could be made by my model. The most important addition to this work would probably be to include a player's offensive and defensive in all the manpower situations on home and away ice. The second improvement is to consider zone starts and total time on ice to evaluate all the players. The third improvement is to evaluate not only goals but also shots to calculate each player's ability.

From the analysis of each player over seasons, I can conclude that it is harder to predict the offensive performance than defensive performance. You can predict the defensive performance at +-10 percent on average. Defensemen tend to be underestimated than forwards, so you can use this model to see who is an affordable good defenseman.