Hockey's Most Controversial Statistic: An Analysis of the Effectiveness of the Plus-Minus Statistic

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Abstract

Here is the abstract.

1 Introduction

Within the realm of sports, many different statistics are used to determine how good a player is. This can include points, assists, time played, etc. But is there just one valaue that can be used to determine the effectiveness of a player? This is an important topic, as fans, coaches, players, and general managers often want to get a better understanding of how an individual is impacting their team. It is one thing to watch the players to determine how good a player is, often refered to as the "eye test" but with so many players, it is hard to quantify this. Enter the plus-minus statistic. Plus-minus is generally calculated by adding all the points scored by their team while they were playing and subtracting by points scored by the opposition while they were playing. The idea is that if a player has a generally positive impact on their team, they will have a highly positive plus-minus. The two main sports where this statistic is used is basketball and ice hockey.

While the plus-minus statistic is a great idea in theory, it does not come without it's weaknesses. The biggest drawback to this statistic is its issues with independece. Take ice hockey for example. Many ice hockey players tend to play on "lines", meaning the same three forwards tend to play together and the same two defensemen usually play together. As a result, the performance of one player is highly dependent on the performance of their linemates. In "A Regression-based Adjusted Plus-Minus Statistic for NHL Players" Macdonald (2011), Brian MacDonald provides a perfect example of this with the Henrik and Daniel Sedin, Swedish twins who played together for the Vancouver Canucks. (Macdonald, 2012, Daniel spent 92% of his playing time with Henrik, the highest percentage of any other player combination where both players have played over 700 minutes. Because of this high colinearity between the twins, it is difficult to separate the individual effect that each player has on the net goals scored on the ice.) Many critics of the plus-minus argue that plus-minus is more of a team statistic, since it is heavily influenced by team dynamics rather than individual contributions. Furthermore, numerous confounding variables, such as the quality of the opponent and situational factors, make the calculation less reliable. As a result of these criticisms, alternatives to the plus-minus statistic have been developed, such as Corsi or Fenwick, which is calculated using shot attempts rather than goals.

The goal of this project will be to shed light on this controversial statistic and determine if plus-minus is truely an effective predictor to individual contribution, specifically in the National Hockey League (hereforth refered to as the NHL). Is the plus-minus a good evaluator of offensive and defensive output? Is the plus-minus more reflective of how well a player is doing than how well a player is preforming? Are there better alternatives to evaluating individual player contribution? These are the questions that will be answered from this analysis.

The rest of the paper is organized as follows. The data will be presented in Section 2. The methods are described in Section 3. The results are reported in Section 4. A discussion concludes in Section 5.

2 Data

The data used to perform this analysis was collected from Natural Stat Trick and the NHL website. The observations in the data is from all players that played in the National Hockey League from the 2021-2022, 2022-2023, and 2023-2024 seasons. Only players that have played in over 25 games were used in the analysis. This is ensure that the players being evaluated were all of similar calliber and were regular NHL players. The columns of the dataset will be combined from the two data sources. The following is a description of each of the columns in the dataset obtained from the website Natural Stat Trick (2023):

Player - Player name.

Team - Team or teams that the player has played for. Not displayed when filtering for specific teams.

Position - Position or positions that the player has been listed as playing by the NHL.

GP - Games played.

TOI - Total amount of time played.

Corsi - Any shot attempt (goals, shots on net, misses and blocks) outside of the shootout. Referred to as SAT by the NHL.

CF - Count of Corsi for that player's team while that player is on the ice.

CA - Count of Corsi against that player's team while that player is on the ice.

CF% - Percentage of total Corsi while that player is on the ice that are for that player's team. CF*100/(CF+CA)

Fenwick - any unblocked shot attempt (goals, shots on net and misses) outside of the shootout. Referred to as USAT by the NHL.

FF - Count of Fenwick for that player's team while that player is on the ice.

FA - Count of Fenwick against that player's team while that player is on the ice.

FF% - Percentage of total Fenwick while that player is on the ice that are for that player's team. FF*100/(FF+FA)

Shots - any shot attempt on net (goals and shots on net) outside of the shootout.

SF - Count of Shots for that player's team while that player is on the ice.

SA - Count of Shots against that player's team while that player is on the ice.

SF% - Percentage of total Shots while that player is on the ice that are for that player's team. SF*100/(SF+SA)

Goals - any goal, outside of the shootout.

GF - Count of Goals for that player's team while that player is on the ice.

GA - Count of Goals against that player's team while that player is on the ice.

GF% - Percentage of total Goals while that player is on the ice that are for that player's team. GF*100/(GF+GA)

Scoring Chances - a scoring chance, as originally defined by War-on-Ice

SCF - Count of Scoring Chances for that player's team while that player is on the ice.

SCA - Count of Scoring Chances against that player's team while that player is on the ice.

SCF% - Percentage of total Scoring Chances while that player is on the ice that are for that player's team. SCF*100/(SCF+SCA)

High Danger Scoring Chances - a scoring chance with a score of 3 or higher.

HDCF - Count of High Danger Scoring Chances for that player's team while that player is on the ice.

HDCA - Count of High Danger Scoring Chances against that player's team while that player is on the ice.

HDCF% - Percentage of total High Danger Scoring Chances while that player is on the ice that are for that player's team. HDCF*100/(HDCF+HDCA)

High Danger Goals - goals generated from High Danger Scoring Chances

HDGF - Count of Goals off of High Danger Scoring Chances for that player's team while that player is on the ice.

HDGA - Count of Goals off of High Danger Scoring Chances against that player's team while that player is on the ice.

HDGF% - Percentage of High Danger Goals while that player is on the ice that are for that player's team. HDGF*100/(HDGF+HDGA)

Medium Danger Scoring Chances - a scoring chance with a score of exactly 2.

MDCF - Count of Medium Danger Scoring Chances for that player's team while that player is on the ice.

MDCA - Count of Medium Danger Scoring Chances against that player's team while that player is on the ice.

MDCF% - Percentage of total Medium Danger Scoring Chances while that player is on the ice that are for that player's team. MDCF*100/(MDCF+MDCA)

Medium Danger Goals - goals generated from Medium Danger Scoring Chances

MDGF - Count of Goals off of Medium Danger Scoring Chances for that player's team while that player is on the ice.

MDGA - Count of Goals off of Medium Danger Scoring Chances against that player's team while that player is on the ice.

MDGF% - Percentage of Medium Danger Goals while that player is on the ice that are for that player's team. MDGF*100/(MDGF+MDGA)

Low Danger Scoring Chances - a scoring chance with a score of 1 or less. Does not include any attempts from the attacking team's neutral or defensive zone.

LDCF - Count of Low Danger Scoring Chances for that player's team while that player is on the ice.

LDCA - Count of Low Danger Scoring Chances against that player's team while that player is on the ice.

LDCF% - Percentage of total Low Danger Scoring Chances while that player is on the ice that are for that player's team. LDCF*100/(LDCF+LDCA)

Low Danger Goals - goals generated from Low Danger Scoring Chances

LDGF - Count of Goals off of Low Danger Scoring Chances for that player's team while that player is on the ice.

LDGA - Count of Goals off of Low Danger Scoring Chances against that player's team while that player is on the ice.

LDGF% - Percentage of Low Danger Goals while that player is on the ice that are for that player's team. LDGF*100/(LDGF+LDGA)

PDO

SH% - Percentage of Shots for that player's team while that player is on the ice that were Goals. GF*100/SF

SV% - Percentage of Shots against that player's team while that player is on the ice that were not Goals. GA*100/SA

PDO - Shooting percentage plus save percentage. (GF/SF)+(GA/SA)

SH% - Percentage of Shots for that player's team while that player is on the ice that were Goals. GF*100/SF

SV% - Percentage of Shots against that player's team while that player is on the ice that were not Goals. GA*100/SA

The goal of this dataset was to provide a broader scope of variables that evaluate a players performance. By introducing more advanced and uncovential statistics, there are more factors to consider in evaluating a player's effectiveness on the ice.

3 Methods

3.1 Correlation Analysis

The main issue with the data is multicollinearity, where independent variables are highly correlated. A correlation matrix was created with some of the more basic nhl statistics to highlight this issue, shown in Table 1.

There is a high correlation between different shot related statistics and point related statistics. For example, there is a 0.826371 correlation between Goals and Shots. This makes since because in order to score a goal, the player needs to shoot first. Correlation

Table 1: Correlation Matrix of Variables

	GP	G	A	P	+/-	P/GP	EVG	EVP	PP
GP	1.000000	0.660694	0.742812	0.742844	0.212674	0.542885	0.694755	0.806373	0.4759
G	0.660694	1.000000	0.819358	0.933217	0.234048	0.881798	0.980843	0.926390	0.9017
A	0.742812	0.819358	1.000000	0.970627	0.335785	0.895312	0.800044	0.945635	0.748
P	0.742844	0.933217	0.970627	1.000000	0.308682	0.931216	0.913072	0.981470	0.847
+/-	0.212674	0.234048	0.335785	0.308682	1.000000	0.276643	0.235106	0.326182	0.1866
P/GP	0.542885	0.881798	0.895312	0.931216	0.276643	1.000000	0.851663	0.892999	0.8329
EVG	0.694755	0.980843	0.800044	0.913072	0.235106	0.851663	1.000000	0.932690	0.8049
EVP	0.806373	0.926390	0.945635	0.981470	0.326182	0.892999	0.932690	1.000000	0.783
PPG	0.475903	0.901738	0.748186	0.847371	0.186643	0.832988	0.804992	0.783327	1.0000
PPP	0.526041	0.844470	0.912095	0.926069	0.227844	0.908954	0.778026	0.838735	0.884
SHG	0.410720	0.439135	0.350123	0.403738	0.180917	0.328880	0.416574	0.408319	0.2976
SHP	0.505980	0.417944	0.430347	0.445126	0.282005	0.340711	0.401315	0.454309	0.2850
OTG	0.442653	0.715858	0.708249	0.744332	0.158837	0.725762	0.689839	0.709961	0.6828
GWG	0.599482	0.922624	0.789043	0.881744	0.296291	0.838393	0.901905	0.868988	0.8407
S	0.826371	0.907769	0.892553	0.940538	0.246253	0.835197	0.904258	0.949149	0.782
S%	0.246746	0.594148	0.335478	0.459613	0.054788	0.555692	0.598461	0.464550	0.4954
TOI/GP	0.559038	0.415454	0.680776	0.601041	0.238598	0.572602	0.394952	0.591843	0.4040

analysis can be used to identify the strength and direction of the relationship between various advanced metrics and the plus/minus statistic. Metrics with high positive correlations (e.g., GF% and PDO) suggest a strong alignment with the plus/minus, indicating that they may reflect similar aspects of offensive or defensive performance. This was done by calculating the correlation coefficient between +/- and each metric (like CF%, GF%, SCF%, etc.).The correlation values, ranging from -1 to 1, tell us how closely each metric aligns with the plus/minus. Higher positive correlations (e.g., with GF% and PDO) indicate metrics that vary similarly to plus/minus, suggesting that they may capture overlapping aspects of offensive or defensive performance.

3.2 Ridge Regression

Due to the presence of correlation among variables, ridge regression was performed in order to identify how plus/minus can be employed to assess offensive and defensive contribution. It was also used to determine if other advanced metrics Corsi or Fenwick have the same, better, or worse predictive abilities compared to plus-minus. Ridge regression, a form of regularized linear regression, is beneficial in handling datasets where predictor variables are highly interrelated, as is the case with advanced hockey metrics. Ridge regression estimates the contribution of metrics like Corsi, Fenwick, and scoring chances while controlling for their interdependencies. This applies to hockey metrics like Corsi, Fenwick, scoring chances, etc. since these statistics often interact or overlap in measuring aspects of performance.

3.3 Cross-Validation

Coupled with ridge regression, cross validation was utilized to assess the predictive power of different groups of variables (offensive, defensive, possession-based) on the plus/minus statistic. Cross-validation splits the data into training and testing sets multiple times, computing a model's predictive accuracy each time. In this case, the data was split into five subsets. In each iteration, one subset was kept as the test set and the other four were used to train the ridge regression model. The R-sqared value was reported for each iteration to measure how well offensive, defensive, and possession-based metrics (like Corsi and Fenwick) predict plus/minus. This process ensures that the model's performance is consistent across different data partitions.

3.4 Mixed Model Effects

In order to separate individual contributions to plus/minus from team-level effects, a mixed-effects model was used. The mixed-effects model combines:

- **Fixed Effects**, which capture the influence of player-specific variables that directly relate to individual performance, such as Corsi For Percentage (CF%), Goals For Percentage (GF%), and other advanced metrics.

- **Random Effects**, which account for variability at the team level, recognizing that a player's plus/minus statistic can be influenced by the overall performance and style of their team. Including team-level random effects helps control for unobserved team factors that may affect each player similarly.

To apply this model, individual metrics that describe on-ice performance (e.g., CF%, GF%) were used as fixed effects to estimate each player's contribution to plus/minus. At the same time, team-level averages (e.g., TeamMeanCF%, TeamMeanGF%) were included as random effects. This approach distinguishes how much of a player's plus/minus statistic is attributable to their own performance versus the performance of their team. By using this mixed-effects approach, we can assess to what extent the plus/minus statistic reflects individual skill as opposed to team strength, thus helping clarify if plus/minus can serve as a reliable individual performance measure.

4 Results

The results of the correlation analysis and statistical modeling of plus-minus reveal several insights into how this statistic reflects both individual and team-level contributions.

4.1 Correlation Analysis

The initial analysis involved calculating the correlation coefficients between plus-minus and various performance metrics. The correlation coefficients are displayed in Table 5.

Metrics such as GF%, FF%, SF%, PDO, xGF%, and HDGF% show moderate to strong positive correlations with plus-minus (0.705, 0.554, 0.569, 0.546, 0.586, and 0.614, respectively). This result aligns with expectations, as many of these metrics are related to goal-scoring chances and shot control, which contribute directly to team scoring and subsequently affect plus-minus. Higher correlations among these metrics indicate a similar variation pattern to plus-minus, suggesting that they capture overlapping aspects of a player's offensive and defensive performance.

Table 2: Correlation Coefficients with Plus-Minus

Variable	Correlation Coefficient
GP	0.232
G	0.237
A	0.343
P	0.315
+/-	1.000
P/GP	0.278
EVG	0.239
EVP	0.336
PPG	0.187
PPP	0.227
SHG	0.177
SHP	0.283
OTG	0.162
GWG	0.306
S	0.256
S%	0.048
TOI/GP	0.253
TOI	0.292
CF	0.369
CA	0.211
CF%	0.534
FF	0.374
FA	0.213
FF%	0.554
SF	0.376
SA	0.212
SF%	0.569
GF	0.424
GA	0.083
GF%	0.705
xGF	0.387
xGA	0.196
xGF%	0.586
SCF	0.387
SCA	0.192
SCF%	0.585
HDCF	0.399
HDCA	0.196
HDCF%	0.551
HDGF	0.442
HDGA	0.093
HDGF%	0.614
On-Ice SH%	0.324
On-Ice SV%	0.419
PDO	0.546
Off. Zone Starts	0.310
Neu. Zone Starts	0.295

Table 3: Cross Validation Scores

Both	Offensive	Defensive
0.5696297	0.64692431	0.73265605
0.50125171	0.62667921	0.70862251
0.47617049	0.62263538	0.69467537
0.48944826	0.58484799	0.65315835
0.57586267	0.69145036	0.76239753

4.2 Ridge Regression Analysis of Offensive and Defensive Contributions

Ridge regression was performed on three different sets of variables: combined metrics, offensive only, and defensive only. The combined metrics included GF%, SF%, HDSC%, PDO, On-Ice SH%, and HDGF%, metrics that combine both offensive and defensive factors, similar to plus-minus.The offensive only metrics were CF, FF, SF, GF, SCF, HDCF, HDGF, GF%, G, A, P/GP, CF%, SCF%, and On-Ice SH%. The defensive only metrics were CA, FA, SA, GA, SCF, HDCA, HDGA, On-Ice SV%. The results can be seen in the table below.

The results in Table 5 reveal: - **Combined Metrics**: A moderate cross-validation score around 0.53 suggests that these metrics explain a moderate amount of variance in plus-minus. - **Offensive Metrics**: With an average score of 0.63, offensive metrics are predictive of plus-minus to a certain extent, indicating the offensive contributions captured by plus-minus. - **Defensive Metrics**: The highest average score (around 0.71) suggests that defensive metrics have a more substantial impact on plus-minus, aligning with the fact that plus-minus also reflects defensive contributions.

Mixed Effects Model:

The results of the mixed effects model can be summarized in the table.

The coefficient for individual Corse For percentage is a small, positive effect on plus/minus, though it is not statistically significant (p = 0.345). This suggests that while Corsi percentage (CF%) has a slight positive association with plus/minus, it may not have a substantial or reliable impact on explaining variance in plus/minus at the individual level. The positive and

Table 4: Mixed Effects Model Results for Plus-Minus Prediction

Predictor	Coefficient	Significance
GF%	1.950	0.000
CF%	0.313	0.345
Team Mean CF%	-3.111	0.000
Team Mean GF%	0.846	0.000

highly significant coefficient for individual GF% (p ¡ 0.001) indicates a strong and reliable positive relationship between goals-for percentage and plus/minus. Players with a higher individual GF% are likely to have a higher plus/minus score, suggesting that goal-scoring and offensive contribution are important for explaining plus/minus. The coefficent for Team Mean CF% negative, statistically significant coefficient (p ¡ 0.001) indicates that the team's mean CF% negatively impacts individual plus/minus. In teams with higher Corsi percentages, individual players might have lower plus/minus scores, possibly due to the distribution of possession-based contributions across the team. The positive coefficient of Team Mean GF%, significant at p ¡ 0.01, confirms that team-level GF% positively influences individual plus/minus. This suggests that players benefit from being on teams that are generally good at scoring, supporting the notion that plus/minus partially reflects team-level offensive strength. These results highlight that plus/minus is significantly influenced by both individual offensive performance (e.g., GF%) and team-level scoring success (e.g., Team Mean GF%), while possession metrics like CF% are less predictive of plus/minus, especially at the individual level.

4.3 Plus-Minus vs Corsi vs Fenwick

Both Corsi and Fenwick were used as predictors in ridge regression with the variables GF%, SCF%, HDCF%, PDO, On-Ice SH%, On-Ice SV%, G, A. The results of the cross validation are shown in the table below

These values are notibly better that the cross validation scores for plus-minus, regardless of which set of predictors. This indicates that both Corsi and Fenwick are significantly better

Table 5: Cross Validation Scores

Corsi	Fenwick
0.93898296	0.95099819
0.90054897	0.93012992
0.93915158	0.9528202
0.92841222	0.95201592
0.9325304	0.95921829

at predicting player effectiveness than plus-minus.

5 Discussion

Like the plus-minus statistic, this project does not come without its limitations. This analysis relies on specific datasets from Natural Stat Trick and includes only a selection of individual and team-based metrics. Other relevant factors like zone entries, exits, or additional situational metrics might provide further insights into player contributions but were not available in this dataset. The model does not capture all nuances of game context, such as player fatigue, line changes, and shifts against specific opponents, which can all influence a player's plus/minus. The mixed-effects model approximates some of these factors with team-level random effects, but a more complex model might be required for a comprehensive understanding.

In this paper, the effectiveness of the plus-minus statistic was evaluated to see if it is an effective predictor of player contribution in the National Hockey League. The plus minus does have some value as a predictor of offensive and defensive metrics. However, other advanced metrics like Corsi and Fenwick perform much better. The plus-minus is also heavily influenced by a player's team, making it less valuable as an indivual evaluator of player effectiveness. Overall, the NHL should maybe consider phasing out the use of the plus-minus statistic and consider more advanced metrics such as Corsi or Fenwick.

References

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