



Goal-based Performance Metrics for Ice Hockey Accounting for Goal Importance

Patrick Lambrix, Niklas Carlsson, Rasmus Säfvenberg

Linköping University, Sweden

Motivation for Niklas

Niklas
(and many others)
dream of:



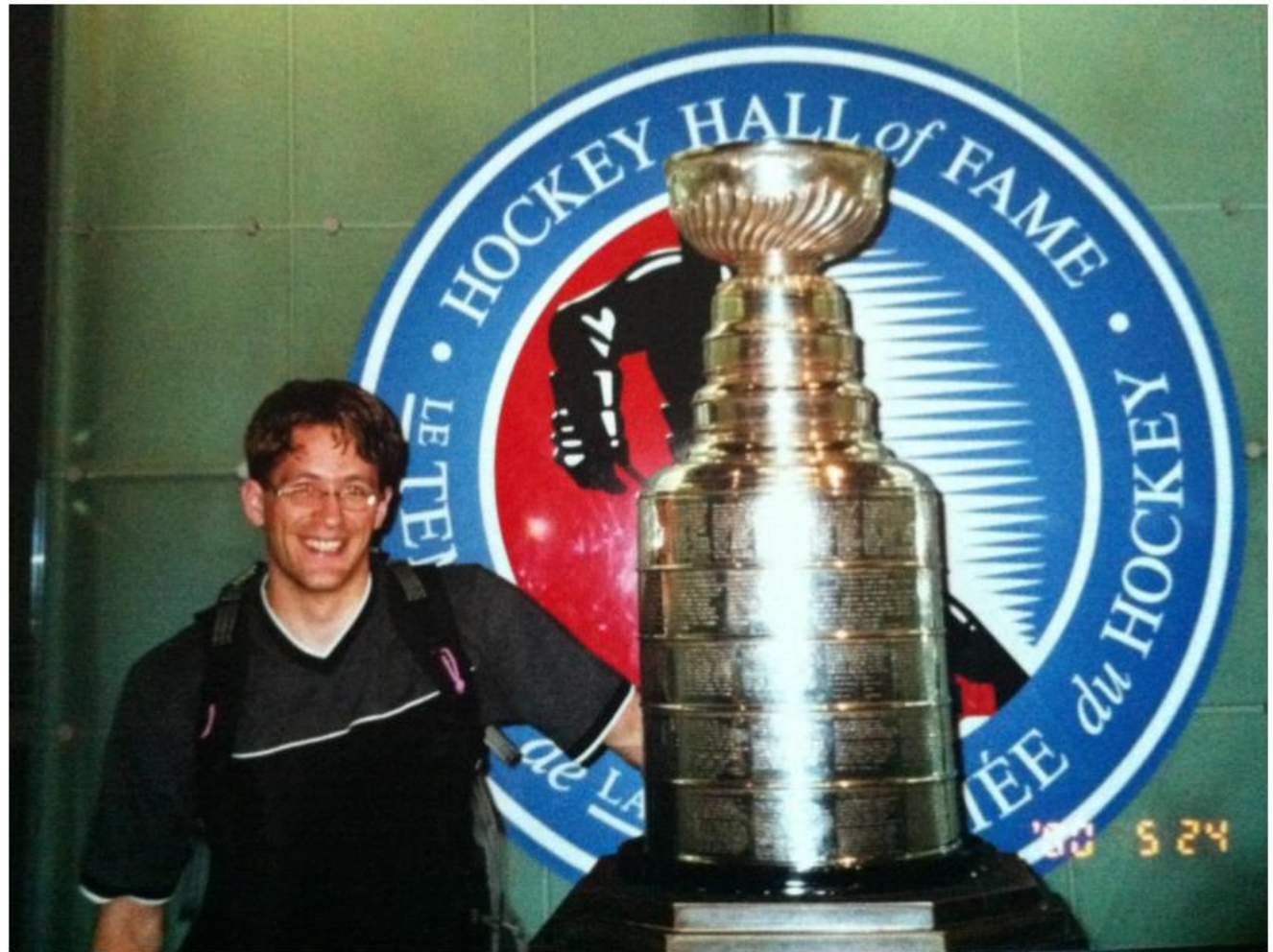
Motivation for Niklas

First try



Motivation for Niklas

A bit easier ...



Motivation for Niklas

Not completely
given up
first method

...



Motivation for Patrick



et
ke
Op
lang
wens
te dag
s bij-
mei
ische
natie is
om een
alleen
et alles
s, maar
termini-
n web-
forma-
enteren
werken
b. Een
en deel
e inter-
zelf al
en in de
et wor-
or wel
g. Zo-

gen.
pees
met
en de
bedc
den
naar
meer
gen.

**Da
ver
eer**
“Ik h
maa
zich
wete
finar
toek
der g
gena
zoek
land




**Wa
eig**
“Lin
200
Het
maa
dan
al be
Link
SAA
(onc
een
F-j
ech



Outline

- Motivation
- Methods and Results
- Conclusion

Performance metrics - traditional

| RANK | SPELARE | NR | LAG | POS | GP | G | A | TP | PIM | GWG | PPG | SOG | HITS | BKS | + | - | +/- | TOI/GP |
|------|------------------|----|--|-----|----|----|----|----|-----|-----|-----|-----|------|-----|----|----|-----|--------|
| 1 | Ryan Lasch | 81 |  Frölunda | F | 37 | 10 | 25 | 35 | 16 | 3 | 2 | 66 | 9 | 2 | 23 | 31 | -8 | 19:02 |
| 2 | Joakim Lindström | 10 |  Skellefteå | F | 38 | 13 | 21 | 34 | 14 | 3 | 4 | 132 | 4 | 8 | 29 | 25 | 4 | 17:15 |
| 3 | Derek Roy | 9 |  Linköping | F | 39 | 5 | 29 | 34 | 22 | 0 | 2 | 74 | 4 | 20 | 29 | 20 | 9 | 17:15 |

■ *Offensive*: G: goals, A: assists, TP: points, GWG: game winning goals, PPG: powerplay goals, SOG: Shots on goal

■ *Defensive*: HITS: hits, BKS: blocked shots

■ +/-: plus-minus

■ PIM: penalty minutes

■ *Time*: GP: games played, TOI: time on ice

Performance metrics - advanced

- **Corsi: shots**
- **xG (Expected Goals):** assigns a value to each shot, based on the likelihood of the shot resulting in a goal.
- **Different game scores**
- These metrics have made it into the ice hockey discourse



Performance metrics - advanced

Critique on advanced metrics: context

Some new approaches:

- Using Markov games
- THOR (Total Hockey Rating)



Motivation

Our goal: **Goal-based** metrics that take into account context

Variant 1

- Are variants on traditional metrics
- Are easy to understand for practitioners
- Take into account goal *importance*

Variant 2

- New metrics based on reinforcement learning
- Take into account actions leading to goals



Outline

- Motivation
- **Methods and Results**
- Conclusion



Data

- Play-by-play data from Sportlogiq
- Seasons 2007-2008 to 2013-2014
- Only regular season



Outline

- Motivation
- Methods and Results
 - Variant 1
 - Variant 2
- Conclusion



Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

Observation:

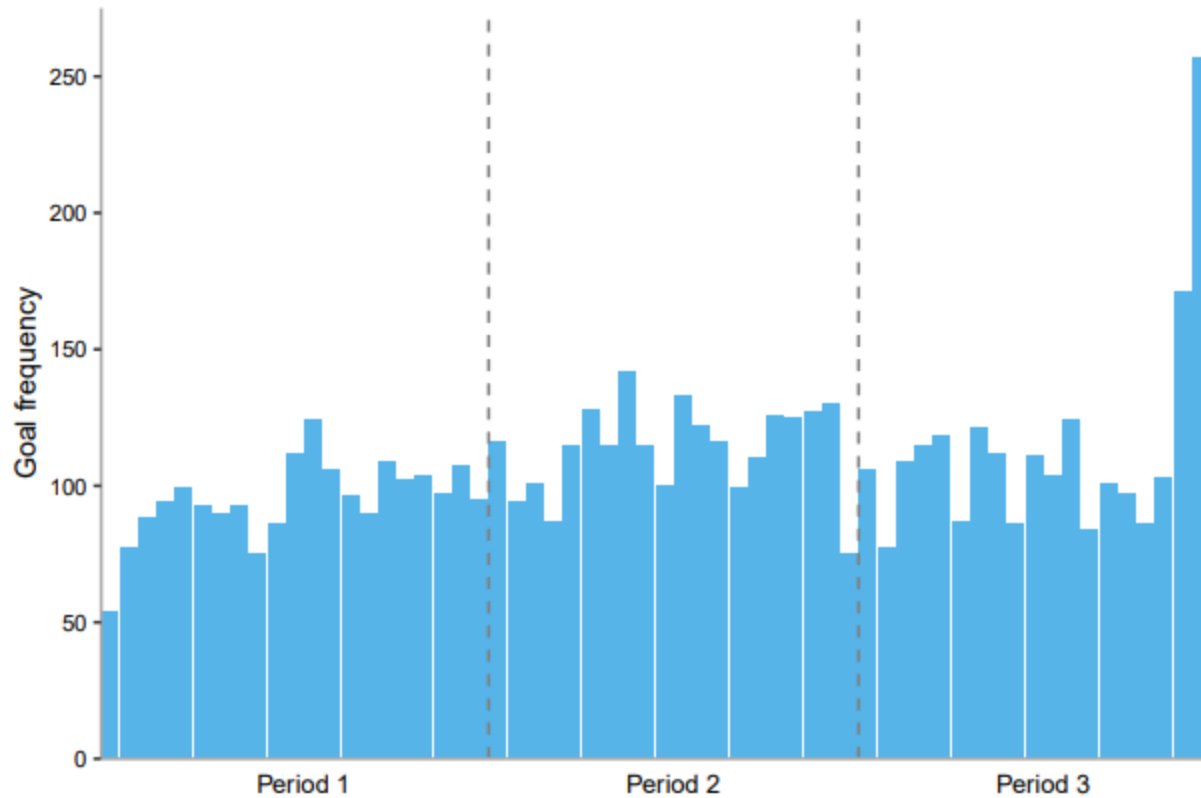


Fig. 1: Goal frequency for each minute of regulation time in the NHL during the 2013-2014 regular season.

Observation

- Goals are not equally important for winning/tying a game

scoring a goal leading 6-0

VS

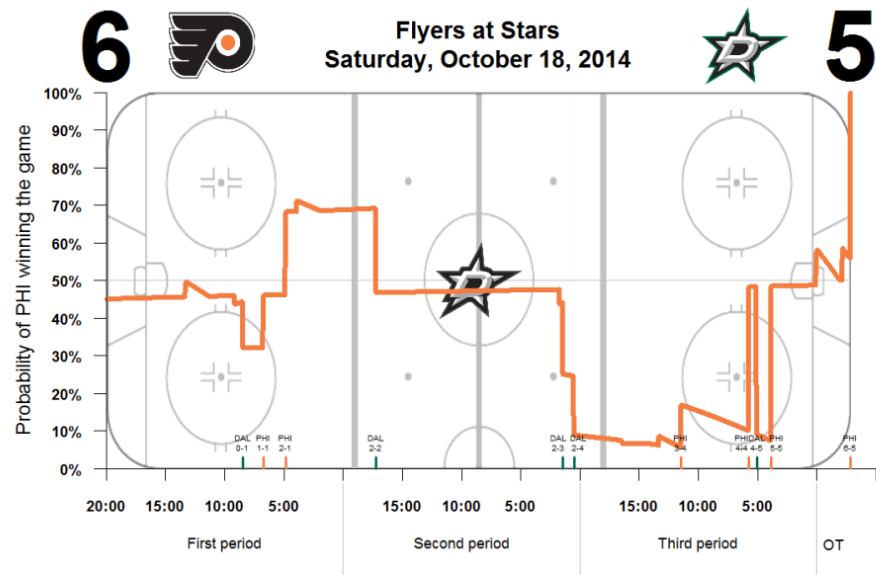
scoring a goal in last minute breaking a tie

Success probabilities

From Oliver Schulte's LINHAC 2022 talk:

- Success: An outcome (binary event) that a team wants to bring about
- Success probability ticker

- Pettigrew
(MIT SSAC 2015):





Success probabilities

- Success: Game points

NHL: 2 GP for a win, 1 GP for an overtime loss

- Success probability ticker based on goal events

Difference in success probability immediately before a goal and after a goal

Game Points Importance Value for a goal in a context

- Outcome in regulation time: win, tie, loss
- Context:
<time, goal differential, manpower differential>

$$P(\textit{outcome} \mid \textit{context}) = \frac{\textit{Occ}(\textit{context} \mid \textit{outcome})}{\textit{Occ}(\textit{context})}$$

Game Points Importance Value for a context

Change of probability of winning the game by scoring the goal

$GPIV_{NHL}^{RT}(\text{context BG})$

$$= 2 \cdot [P(\text{win} \mid \text{context AG}) - P(\text{win} \mid \text{context BG})] \\ + 1 \cdot [P(\text{tie} \mid \text{context AG}) - P(\text{tie} \mid \text{context BG})].$$

Change of probability of the game ending in a tie by scoring the goal

Game Points Importance Value for a context

$$GPIV_{NHL}^{OT}(\text{context BG}) = 0.5.$$

GPIV vs Goal Differential

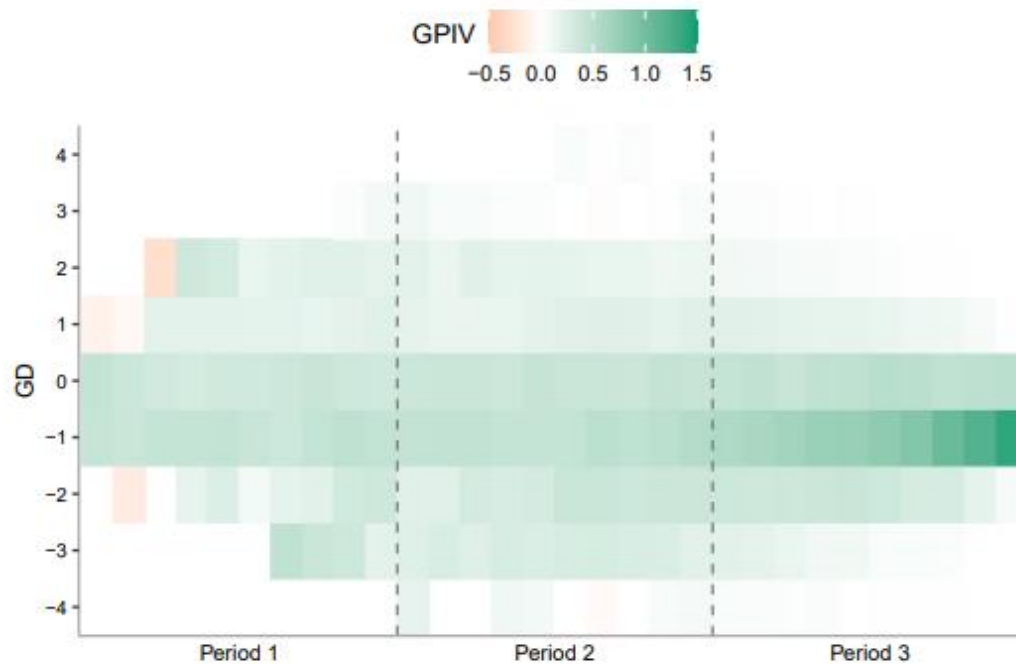


Fig. 2: GPIV versus GD for the 2013-2014 season. Each bin is two minutes. Less than two observations for each bin are left out.

GPIV vs Manpower Differential

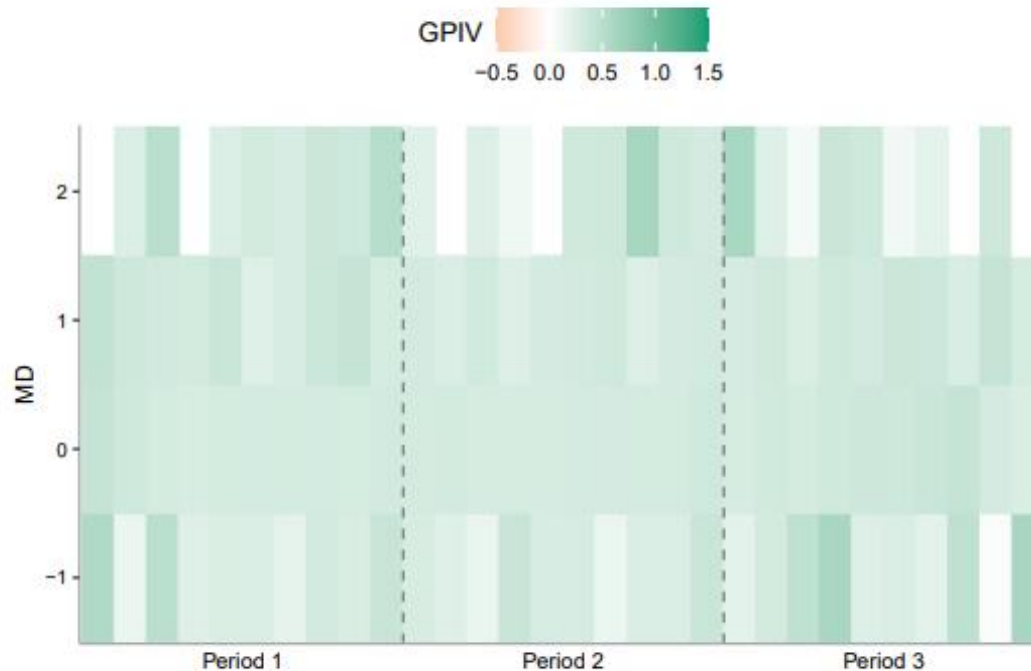


Fig. 3: GPIV versus MD for the 2013-2014 season. Each bin is two minutes. Less than two observations for each bin are left out.

Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

New metrics

- Traditional metrics:

Goal contributes 1 directly (Goals, +/-) or indirectly (Assists)

- Variants of Goals, Assists, Points, +/-:

Goal contributes with its context-based GPIV

New metrics

- Variants of Goals, Assists, Points, +/-:

Goal contributes with its context-based GPIV

→ GPIV-G, GPIV-A, GPIV-P, GPIV-+/-

1. **Number** of goals in which the player is involved
2. **Importance** of the goals in which the player is involved



Defining a metric

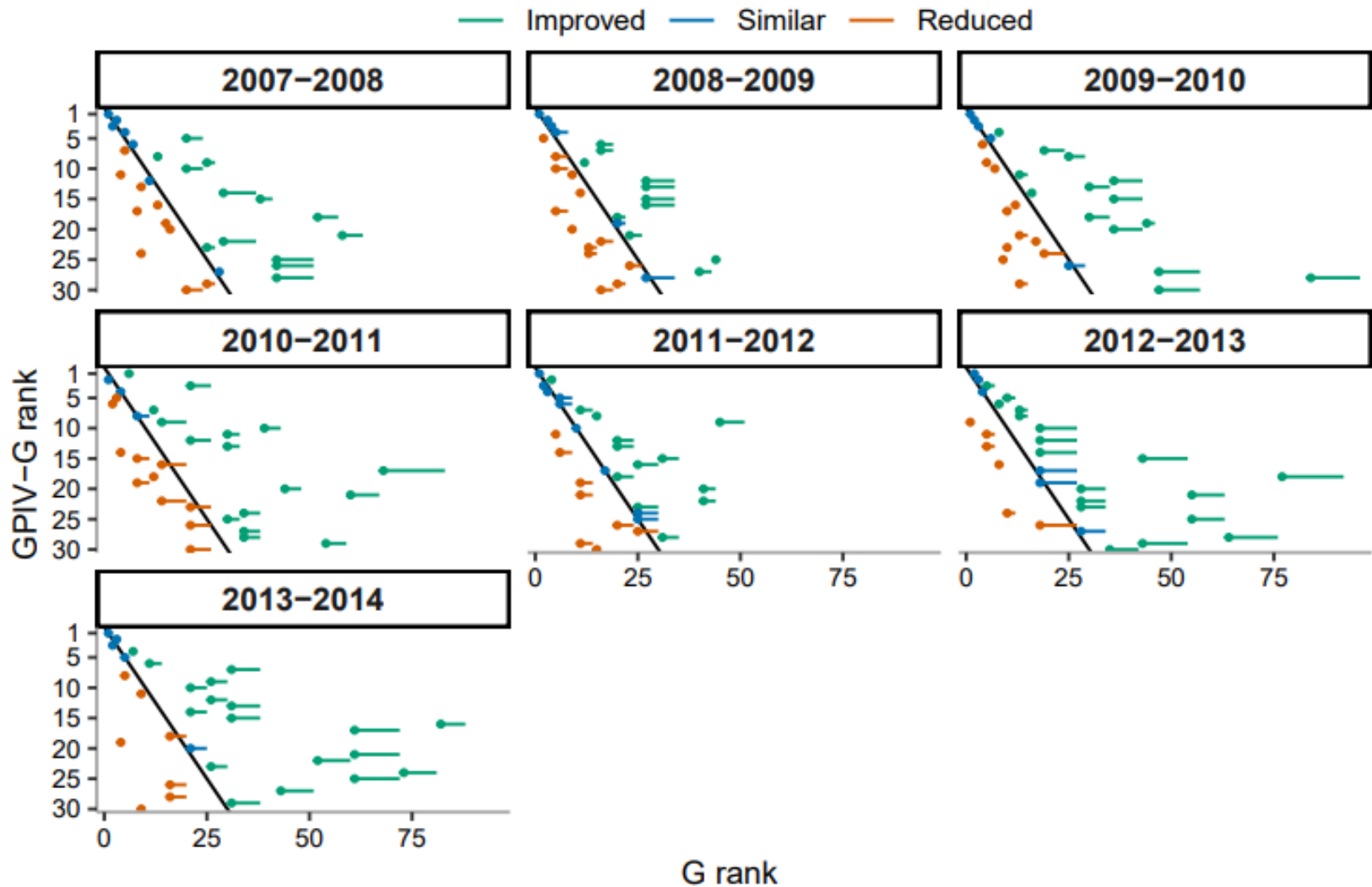
- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

Top 10 players for GPIV-P

Tab. 3: Top 10 players for GPIV-P for the 2013-2014 season.

| P-rank | GPIV-P rank | Rank change | Player | Position | P | GPIV-P | GPIV-P/P |
|--------|-------------|-------------|--------------------|----------|-----|--------|----------|
| 1 | 1 | 0 | Sidney Crosby | C | 104 | 36.360 | 0.351 |
| 8-11 | 2 | 6 | Alexander Ovechkin | R | 79 | 30.415 | 0.385 |
| 8-11 | 3 | 5 | Nicklas Bäckström | C | 79 | 29.199 | 0.370 |
| 19-22 | 4 | 15 | Blake Wheeler | R | 69 | 29.114 | 0.422 |
| 8-11 | 5 | 3 | Joe Pavelski | C | 79 | 27.995 | 0.354 |
| 4 | 6 | -2 | Tyler Seguin | C | 84 | 27.614 | 0.329 |
| 3 | 7 | -4 | Claude Giroux | C | 86 | 27.440 | 0.319 |
| 19-22 | 8 | 11 | Kyle Okposo | R | 69 | 26.951 | 0.391 |
| 16-18 | 9 | 7 | Anze Kopitar | C | 70 | 26.327 | 0.376 |
| 6-7 | 10 | -4 | Phil Kessel | R | 80 | 26.225 | 0.328 |

Rank changes P vs GPIV-P



Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

P vs GPIV-P

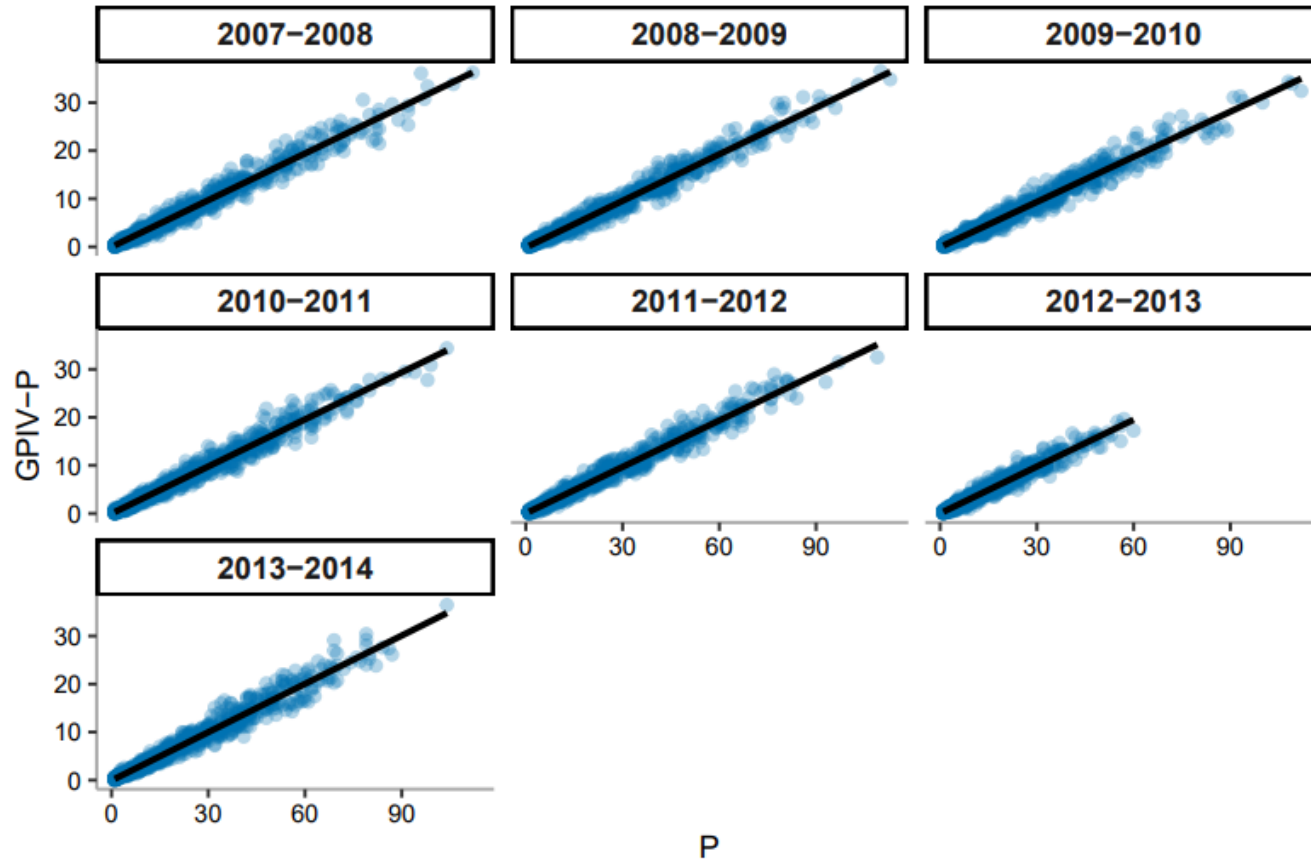


Fig. 10: Correlation traditional points and GPIV-points.

Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

Multiple seasons

Tab. 7: Maximum values for the metrics. Notes below table.

| Season | G | GPIV-G | A | GPIV-A | P | GPIV-P |
|-----------|----|------------|----|------------|-----|------------|
| 2007-2008 | 65 | 20.333 | 67 | 24.762 | 112 | 36.243 |
| 2008-2009 | 56 | 17.126 | 78 | 24.234 | 113 | (4) 36.549 |
| 2009-2010 | 51 | 15.554 | 83 | 23.515 | 112 | (5) 34.359 |
| 2010-2011 | 50 | (1) 13.529 | 75 | 24.401 | 104 | 34.382 |
| 2011-2012 | 60 | 18.889 | 67 | (2) 23.175 | 109 | 32.507 |
| 2012-2013 | 29 | 10.656 | 43 | (3) 13.808 | 60 | (6) 19.668 |
| 2013-2014 | 51 | 19.731 | 68 | 22.481 | 104 | 36.460 |

Table notes:

- (1) Corey Perry 50/13.257 vs Patrick Marleau 36/13.529
- (2) Henrik Sedin 67/22.903 vs Joe Thornton 59/23.175
- (3) Martin St. Louis 43/13.289 vs Nicklas Bäckström 40/13.808
- (4) Evgeni Malkin 113/34.846 vs Alexander Ovechkin 110/36.549
- (5) Henrik Sedin 112/32.425 vs Alexander Ovechkin 108/34.359
- (6) Martin St. Louis 60/17.234 vs Steven Stamkos 57/19.668

Defining a metric

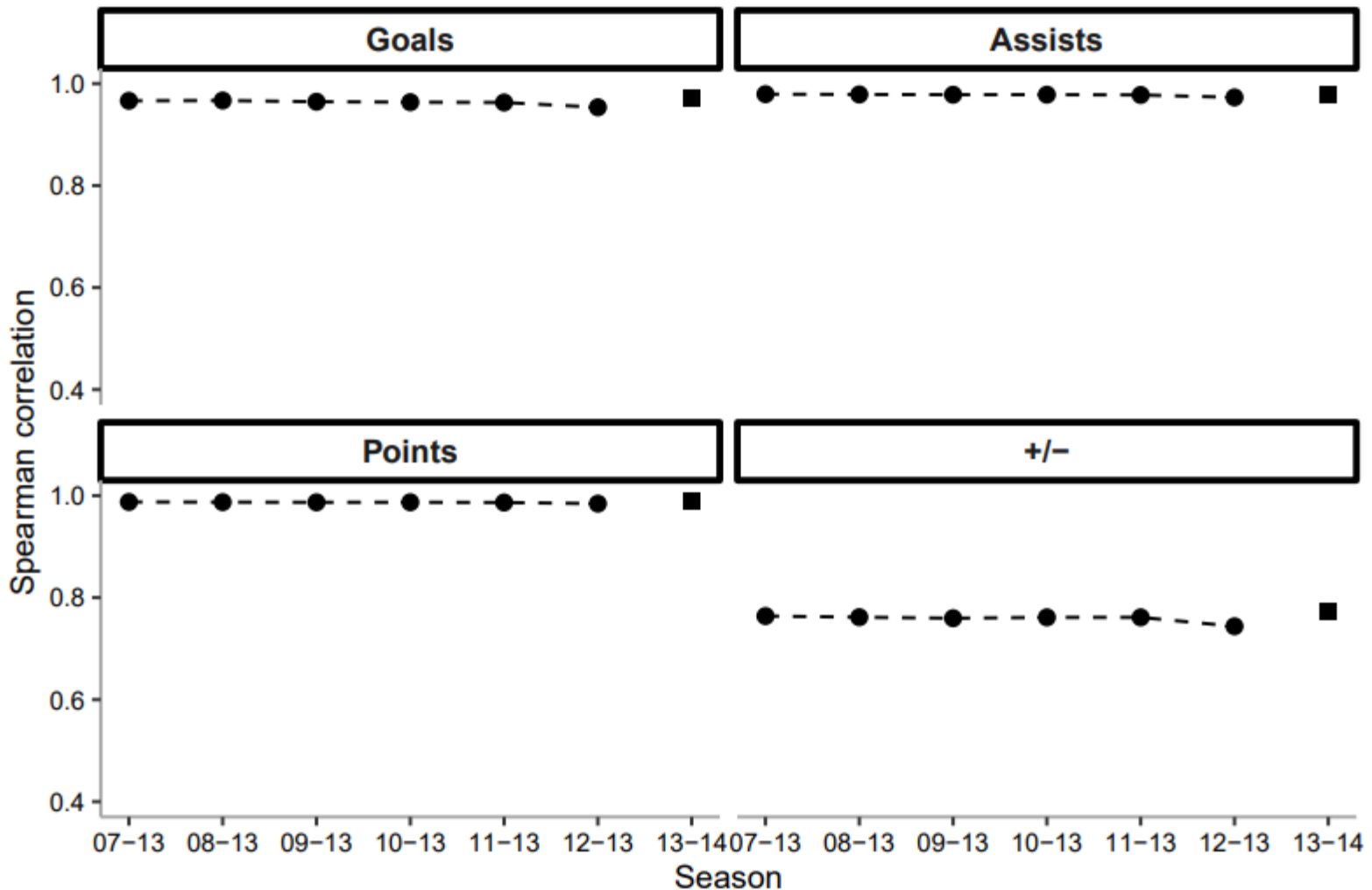


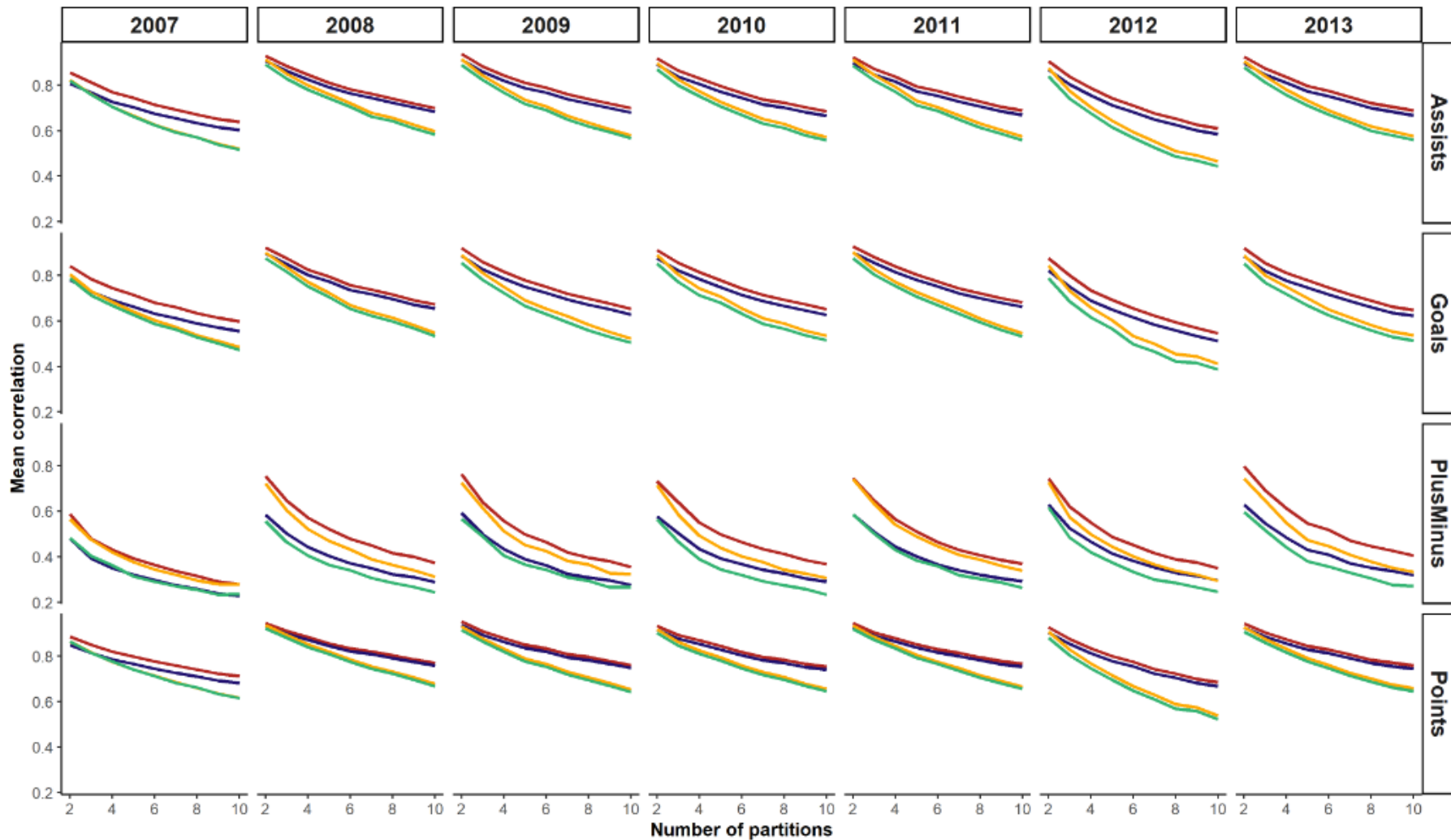
Fig. 12: Correlation between traditional and GPIV metrics during the 2013-2014 season based on occurrences from multiple seasons

Defining a metric

- What are the intuitions behind the metric?
- How is the metric defined?
- Does it pass the eye test?
- Are there correlations with existing metrics?
- Is the metric stable?
- Can one predict the value of the metric at the end of a season based on data for part of the season?

Correlation for different partitions and seasons for Pearson

- Generalized traditional vs. traditional
- Generalized GPIV vs. GPIV
- Generalized traditional vs. GPIV
- Generalized GPIV vs. traditional





Playoffs

Playoffs

$$\text{GPIV}_{\text{NHL}}^{\text{RT (playoffs)}}(\text{context BG}) = P(\text{win} \mid \text{context AG}) - P(\text{win} \mid \text{context BG})$$

$$\text{GPIV}_{\text{NHL}}^{\text{OT (playoffs)}}(\text{context BG}) = 0.5$$

Playoffs

Tab. 10: Top 10 players for GPIV-P for the 2013-2014 playoffs. GP = Games played.

| P-rank | GPIV-P rank | Rank change | Player | Position | GP | P | GPIV-P | GPIV-P/P |
|--------|-------------|-------------|-----------------|----------|----|----|--------|----------|
| 2 | 1 | 1 | Justin Williams | R | 26 | 25 | 4.705 | 0.188 |
| 1 | 2 | -1 | Anze Kopitar | C | 26 | 26 | 4.301 | 0.165 |
| 7-8 | 3 | 4 | Jonathan Toews | C | 19 | 17 | 3.988 | 0.235 |
| 6 | 4 | 2 | Drew Doughty | D | 26 | 18 | 3.944 | 0.219 |
| 5 | 5 | 0 | Patrick Kane | R | 19 | 20 | 3.923 | 0.196 |
| 4 | 6 | -2 | Marian Gaborik | R | 26 | 22 | 3.805 | 0.173 |
| 14-19 | 7 | 7 | P.K. Subban | D | 17 | 14 | 3.539 | 0.253 |
| 2 | 8 | -6 | Jeff Carter | C | 26 | 25 | 3.297 | 0.132 |
| 28-33 | 9 | 19 | Duncan Keith | D | 19 | 11 | 3.111 | 0.283 |
| 10-13 | 10 | 0 | Brent Seabrook | D | 16 | 15 | 3.096 | 0.206 |

Playoffs

Tab. 11: Top 10 players for GPIV-P/P with minimum 5 P for the 2013-2014 playoffs. GP = Games played.

| P-rank | GPIV-P rank | Rank change | Player | Position | GP | P | GPIV-P | GPIV-P/P |
|--------|-------------|-------------|------------------|----------|----|----|--------|----------|
| 59-77 | 20 | 39 | Daniel Briere | C | 16 | 7 | 2.282 | 0.326 |
| 78-94 | 33 | 45 | Dany Heatley | L | 11 | 6 | 1.918 | 0.320 |
| 59-77 | 26 | 33 | Mikko Koivu | C | 13 | 7 | 2.048 | 0.293 |
| 34-45 | 13 | 21 | Nathan MacKinnon | C | 7 | 10 | 2.844 | 0.284 |
| 95-114 | 55 | 40 | Marc Staal | D | 25 | 5 | 1.421 | 0.284 |
| 28-33 | 9 | 19 | Duncan Keith | D | 19 | 11 | 3.111 | 0.283 |
| 59-77 | 30 | 29 | Ryan Suter | D | 13 | 7 | 1.971 | 0.282 |
| 52-58 | 21 | 31 | Nick Bonino | C | 13 | 8 | 2.247 | 0.281 |
| 78-94 | 44 | 34 | Jared Spurgeon | D | 13 | 6 | 1.637 | 0.273 |
| 95-114 | 60 | 35 | Matt Nieto | L | 7 | 5 | 1.366 | 0.273 |



Pairs of players

Pairs of players – direct impact

Tab. 12: Top 10 direct pairs for the 2013-2014 season. Player position in parentheses (L for left wing, R for right wing, C for center).

| Rank | Player pair | Team | GPIV-G-DP (G-DP) | GPIV-G-DP-1 (G-DP-1) | GPIV-G-DP-2 (G-DP-2) |
|------|--|------|---------------------|-------------------------|-------------------------|
| 1 | Jamie Benn (L), Tyler Seguin (C) | DAL | 13.96 (45) | 7.42 (23) | 6.54 (22) |
| 2 | Chris Kunitz (L), Sidney Crosby (C) | PIT | 12.92 (39) | 6.63 (26) | 6.29 (13) |
| 3 | Corey Perry (R), Ryan Getzlaf (C) | ANA | 12.30 (39) | 8.66 (25) | 3.64 (14) |
| 4 | Alex Ovechkin (R), Nicklas Backstrom (C) | WSH | 12.27 (35) | 10.61 (29) | 1.66 (6) |
| 5 | Phil Kessel (R), James van Riemsdyk (L) | TOR | 11.56 (34) | 5.88 (17) | 5.68 (17) |
| 6 | Andrew Ladd (L), Bryan Little (C) | WPG | 11.05 (29) | 5.98 (15) | 5.07 (14) |
| 7 | Paul Stastny (C), Gabriel Landeskog (L) | COL | 9.65 (24) | 5.15 (14) | 4.50 (10) |
| 8 | Claude Giroux (C), Jakub Voracek (R) | PHI | 9.50 (29) | 5.74 (14) | 3.75 (15) |
| 9 | Kyle Okposo (R), John Tavares (C) | NYI | 8.98 (24) | 5.95 (14) | 3.03 (10) |
| 10 | David Krejci (C), Milan Lucic (L) | BOS | 8.78 (27) | 4.47 (10) | 4.31 (17) |

Pairs of players – on ice

Tab. 13: Top 10 indirect pairs for the 2013-2014 season. Player position in parentheses (L for left wing, R for right wing, C for center).

| Rank | Player pair | Team | GPIV-GD-IP (GD-IP) | GPIV-GF-IP (GF-IP) | GPIV-GA-IP (GA-IP) |
|------|--|------|-----------------------|-----------------------|-----------------------|
| 1 | Sidney Crosby (C), Chris Kunitz (L) | PIT | 27.39 (79) | 40.60 (117) | 13.21 (38) |
| 2 | Claude Giroux (C), Jakub Voracek (R) | PHI | 22.68 (52) | 35.74 (98) | 13.05 (46) |
| 3 | Joe Pavelski (C), Joe Thornton (C) | SJS | 20.64 (57) | 27.95 (77) | 7.31 (20) |
| 4 | Wayne Simmonds (R), Scott Hartnell (L) | PHI | 20.16 (42) | 23.54 (60) | 3.39 (18) |
| 5 | Tyler Seguin (C), Jamie Benn (L) | DAL | 19.87 (56) | 32.23 (101) | 12.36 (45) |
| 6 | Wayne Simmonds (R), Claude Giroux (C) | PHI | 19.03 (33) | 21.22 (53) | 2.19 (20) |
| 7 | Wayne Simmonds (R), Jakub Voracek (R) | PHI | 18.51 (33) | 19.45 (46) | 0.94 (13) |
| 8 | Sidney Crosby (C), Matt Niskanen (D) | PIT | 18.39 (49) | 22.09 (63) | 3.70 (14) |
| 9 | Ryan Getzlaf (C), Corey Perry (R) | ANA | 18.21 (58) | 31.66 (102) | 13.46 (44) |
| 10 | Jakub Voracek (R), Kimmo Timonen (D) | PHI | 18.11 (41) | 23.07 (56) | 4.96 (15) |

Conclusions – variant 1

- Introduced new goal-based performance metrics for ice hockey players
- Strong correlation for G, A, P between new and traditional metrics
- Pass the eye test
- Data from previous season can be used to approximate new metrics for regular season
- Predict using data from part of a season



Outline

- Motivation
- Methods and Results
 - Variant 1
 - Variant 2
- Conclusion

Action Impact Model

- Based on the work by Routley and Schulte 2015*
- Idea:
 - Define state $s = \langle c, ps \rangle$
where c is a context and ps is a play sequence
 - Actions are performed in states
 - Define impact of action in a state
 - Define player impact based on action impacts

*Schulte's group presented a more extended model at IJCAI 2018.

Action Impact Model

Context

| Notation | Name | Range |
|-----------|-----------------------|--------|
| <i>GD</i> | Goal Differential | [-8,8] |
| <i>MD</i> | Manpower Differential | [-3,3] |
| <i>P</i> | Period | [1,7] |

Action Impact Model

Events

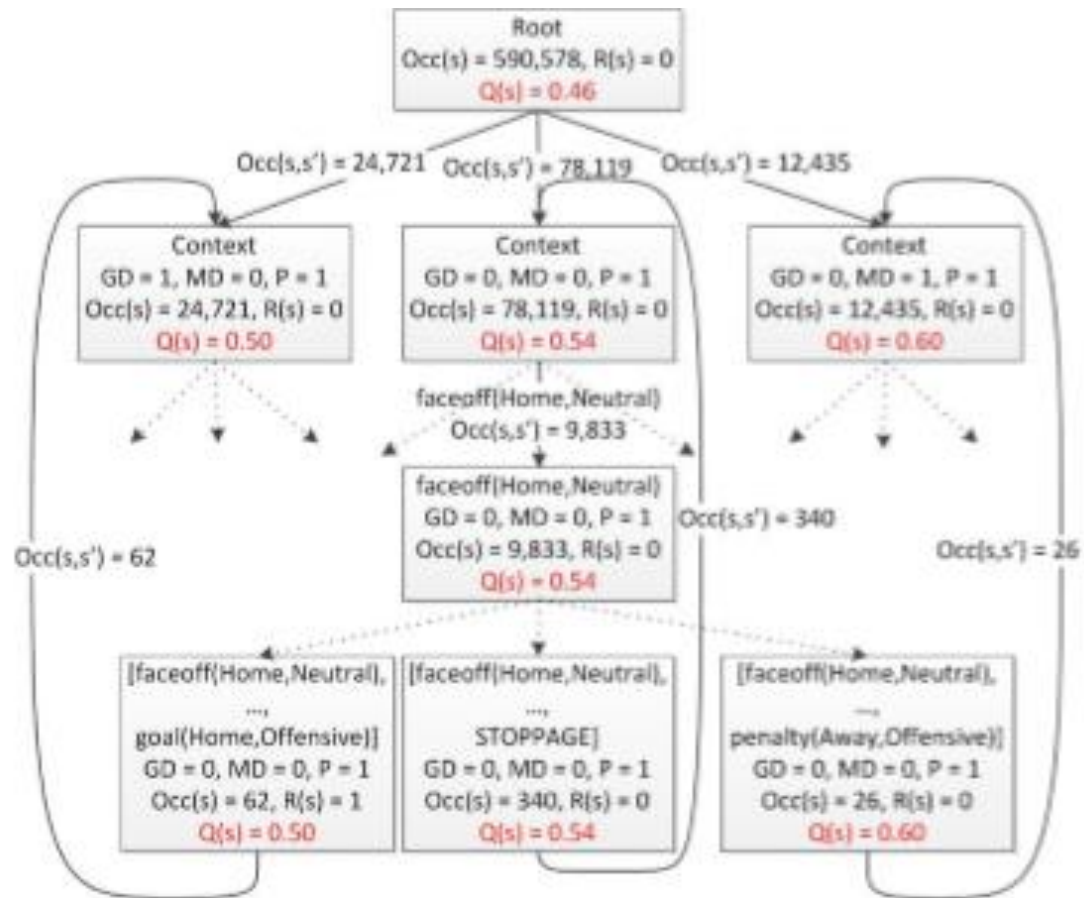
| Action Event | Start/End Event |
|--------------|--------------------------|
| Faceoff | Period Start |
| Shot | Period End |
| Missed Shot | Early Intermission Start |
| Blocked Shot | Penalty |
| Takeaway | Stoppage |
| Giveaway | Shootout Completed |
| Hit | Game End |
| Goal | Game Off |
| | Early Intermission End |

Action Impact Model

A play sequence is defined as

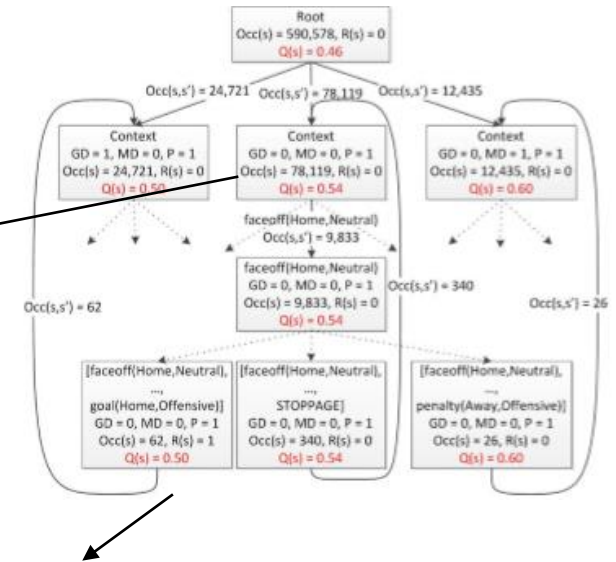
- the empty sequence or
 - a sequence of events
 - first event: start marker
 - (possible) next events: action events
 - (possible) last event: end event
- (→ complete sequence)

Action Impact Model



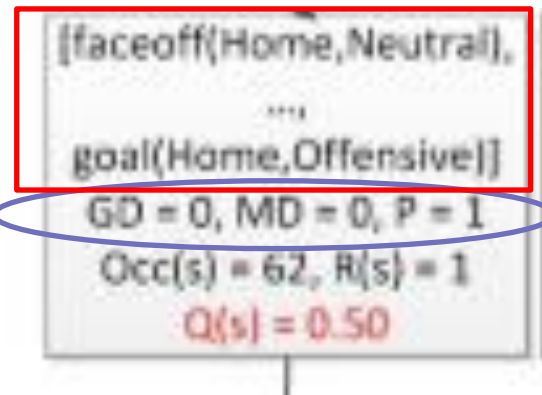
Action Impact Model

State $s = \langle c, ps \rangle$



Context

Play sequence



Action Impact Model

- Actions are performed in states

$\langle c, ps \rangle * a =$

$\langle c, \text{append}(ps, a) \rangle$ if state has no end event
(add action to play sequence, e.g., shot)

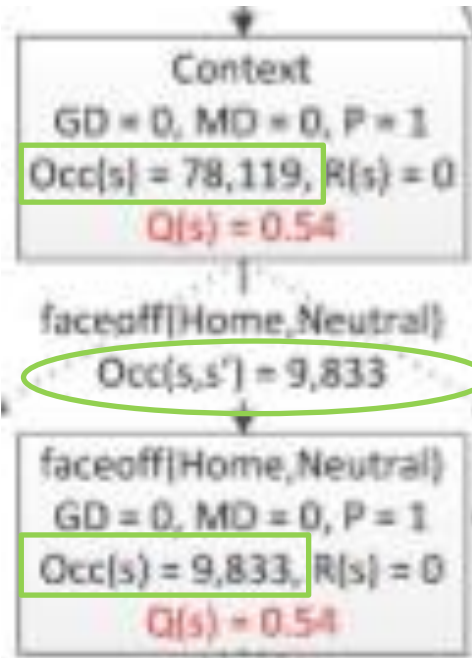
$\langle c', \text{empty-set} \rangle$ if state has end event
(change context, e.g., after a goal)

Action Impact Model

Based on play-by-play data:

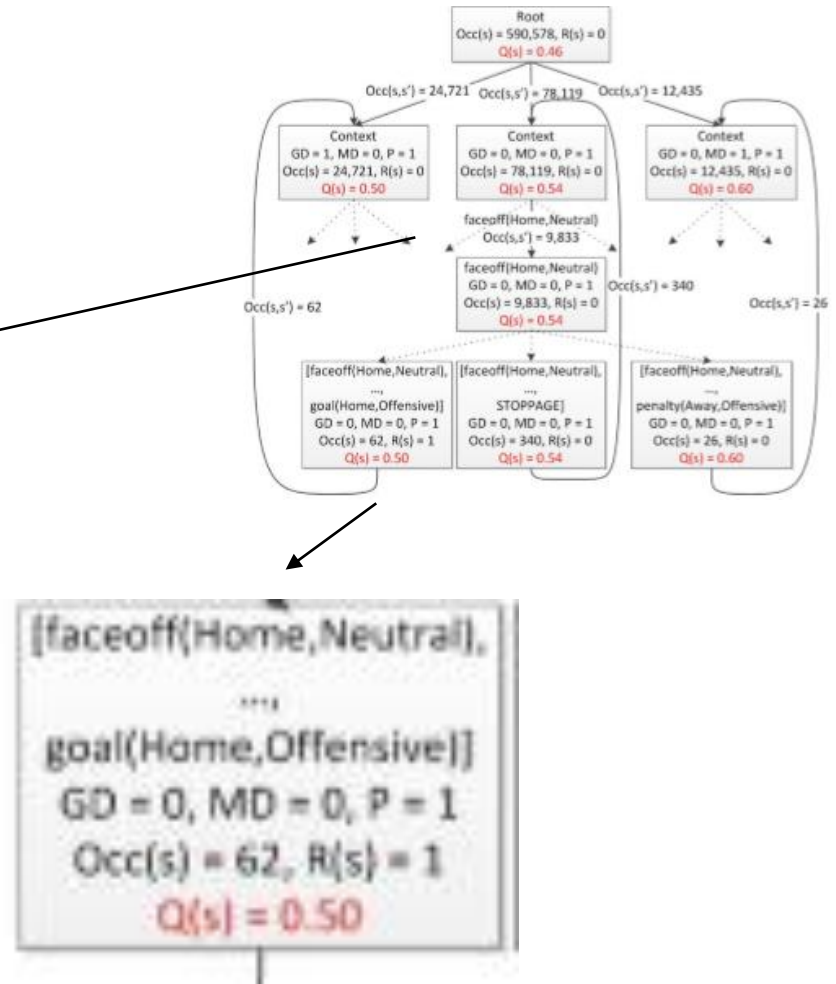
- Occurrences of state s : $Occ(s)$
- Occurrences of state s immediately followed by state s' : $Occ(s,s')$
- Transition probability $T(s,s') = Occ(s,s') / Occ(s)$

Action Impact Model



Occurrences

Occurrences



Action Impact Model

Value iteration algorithm \rightarrow Q-values

Reward function: goal states receive reward 1

(In single player experiments
also goal against reward -1)

■ Impact of action a in state s : $Q_T(s * a) - Q_T(s)$

Action Impact Model

Algorithm 1 Dynamic Programming for Value Iteration

Require: Markov Game model, convergence criterion c ,
maximum number of iterations M

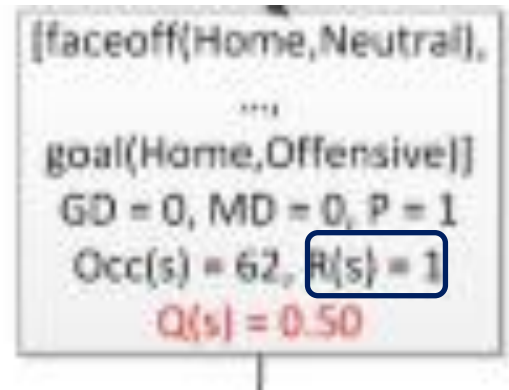
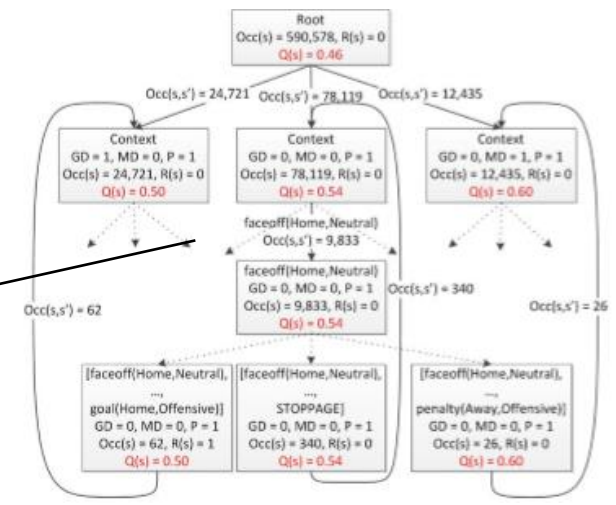
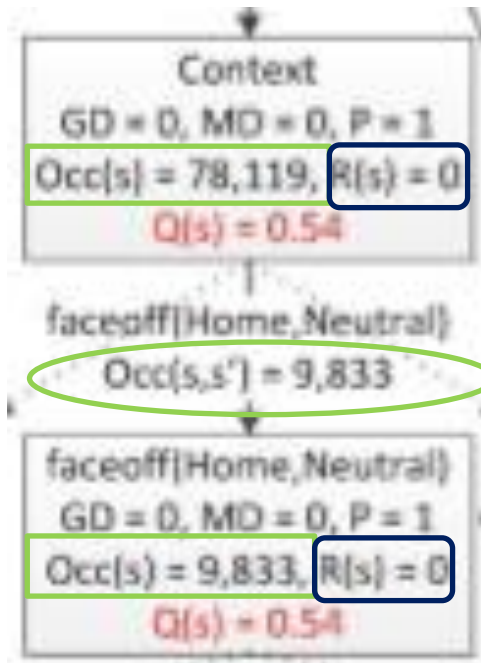
```
1: lastValue = 0
2: currentValue = 0
3: converged = false
4: for  $i = 1; i \leq M; i \leftarrow i + 1$  do
5:   for all states  $s$  in the Markov Game model do
6:     if converged == false then
7:        $Q_{i+1}(s) =$ 
8:          $R(s) + \frac{1}{Occ(s)} \sum_{(s,s') \in E} (Occ(s,s') \times Q_i(s'))$ 
9:       currentValue = currentValue +  $|Q_{i+1}(s)|$ 
10:    end if
11:  end for
12:  if converged == false then
13:    if  $\frac{currentValue - lastValue}{currentValue} < c$  then
14:      converged = true
15:    end if
16:  end if
17:  lastValue = currentValue
18: end for
```

Action Impact Model

$$7: \quad Q_{i+1}(s) = R(s) + \frac{1}{Occ(s)} \sum_{(s,s') \in E} (Occ(s, s') \times Q_i(s'))$$

Compute separate Q-values for Home and Away teams

Action Impact Model



Occurrences

Occurrences

Reward

Q-value



Player Impact

Sum of action impacts

1. Based on all actions performed by the player
(direct goal-based impact)
2. Based on actions when the player is on the ice
(on-ice goal-based impact)

Variants normalized by time



Player Pair Impact

Sum of action impacts when both players are on the ice (on-ice goal-based impact)

Variants normalized by time

Top players 2007-2008 and 2008-2009 for direct impact

| PlayerName | Position | Age | Salary | GP | G | GA | PlusMin | Points | Direct | Directh | On-ice | On-iceh |
|--------------------|----------|-----|--------|----|----|----|---------|--------|--------|---------|--------|---------|
| 2007 | | | | | | | | | | | | |
| Alex Ovechkin | F | 22 | 3.83 | 82 | 65 | 47 | 28 | 112 | 71.96 | 182.65 | 232.56 | 588.85 |
| Dion Phaneuf | D | 22 | 0.94 | 82 | 17 | 43 | 12 | 60 | 59.22 | 134.05 | 246.12 | 559.67 |
| Rick Nash | F | 23 | 5.50 | 80 | 38 | 31 | 3 | 69 | 59.01 | 181.80 | 158.82 | 485.99 |
| Jarome Iginla | F | 30 | 7.00 | 82 | 50 | 48 | 27 | 98 | 58.94 | 161.92 | 204.12 | 560.88 |
| Dustin Brown | F | 23 | 1.18 | 78 | 33 | 27 | -13 | 60 | 53.78 | 156.41 | 171.40 | 501.48 |
| Brenden Morrow | F | 28 | 4.10 | 82 | 32 | 42 | 23 | 74 | 51.15 | 146.62 | 171.59 | 504.57 |
| Zdeno Chara | D | 30 | 7.50 | 77 | 17 | 34 | 14 | 51 | 50.74 | 117.69 | 203.78 | 468.89 |
| Trent Hunter | F | 27 | 1.55 | 82 | 12 | 29 | -17 | 41 | 50.31 | 167.65 | 153.36 | 508.27 |
| Mike Green | D | 22 | 0.85 | 82 | 18 | 38 | 6 | 56 | 48.26 | 122.63 | 219.72 | 545.08 |
| Pavel Datsyuk | F | 29 | 6.70 | 82 | 31 | 66 | 41 | 97 | 48.22 | 134.68 | 198.44 | 559.41 |
| 2008 | | | | | | | | | | | | |
| Alex Ovechkin | F | 23 | 9.00 | 79 | 56 | 54 | 8 | 110 | 75.93 | 194.34 | 239.89 | 612.23 |
| Dustin Brown | F | 24 | 2.60 | 80 | 24 | 29 | -15 | 53 | 59.76 | 177.60 | 178.34 | 540.84 |
| Shea Weber | D | 23 | 4.50 | 81 | 23 | 30 | 1 | 53 | 53.14 | 136.10 | 201.19 | 511.36 |
| Evgeni Malkin | F | 22 | 3.83 | 82 | 35 | 78 | 17 | 113 | 50.76 | 134.92 | 220.41 | 591.75 |
| Dion Phaneuf | D | 23 | 7.00 | 79 | 11 | 36 | -11 | 47 | 50.34 | 122.64 | 240.57 | 532.49 |
| Vincent Lecavalier | F | 28 | 7.17 | 77 | 29 | 38 | -9 | 67 | 49.46 | 143.99 | 188.17 | 549.37 |
| Sheldon Souray | D | 32 | 6.25 | 81 | 23 | 30 | 1 | 53 | 49.38 | 125.86 | 203.08 | 514.73 |
| Jeff Carter | F | 24 | 4.50 | 82 | 46 | 38 | 23 | 84 | 48.88 | 141.78 | 189.35 | 548.30 |
| Rick Nash | F | 24 | 6.50 | 78 | 40 | 39 | 11 | 79 | 48.88 | 145.11 | 171.59 | 498.26 |
| Martin St. Louis | F | 33 | 5.00 | 82 | 30 | 50 | 4 | 80 | 47.82 | 135.55 | 204.19 | 569.06 |

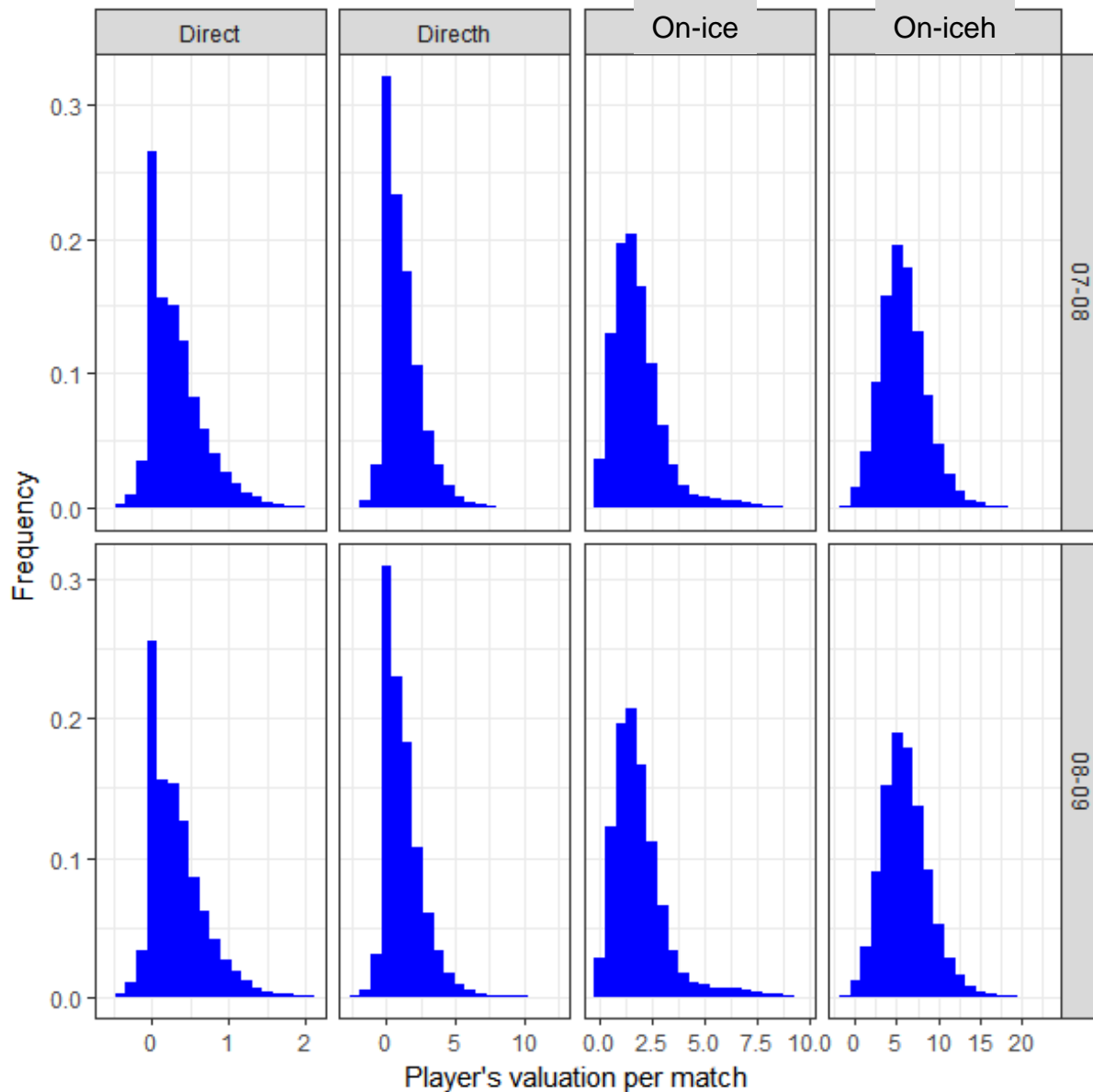
Table 5.1: Top 10 Players performance for 2007-2008 and 2008-2009 for the Direct metric.

Top players 2007-2008 and 2008-2009 for on-ice impact

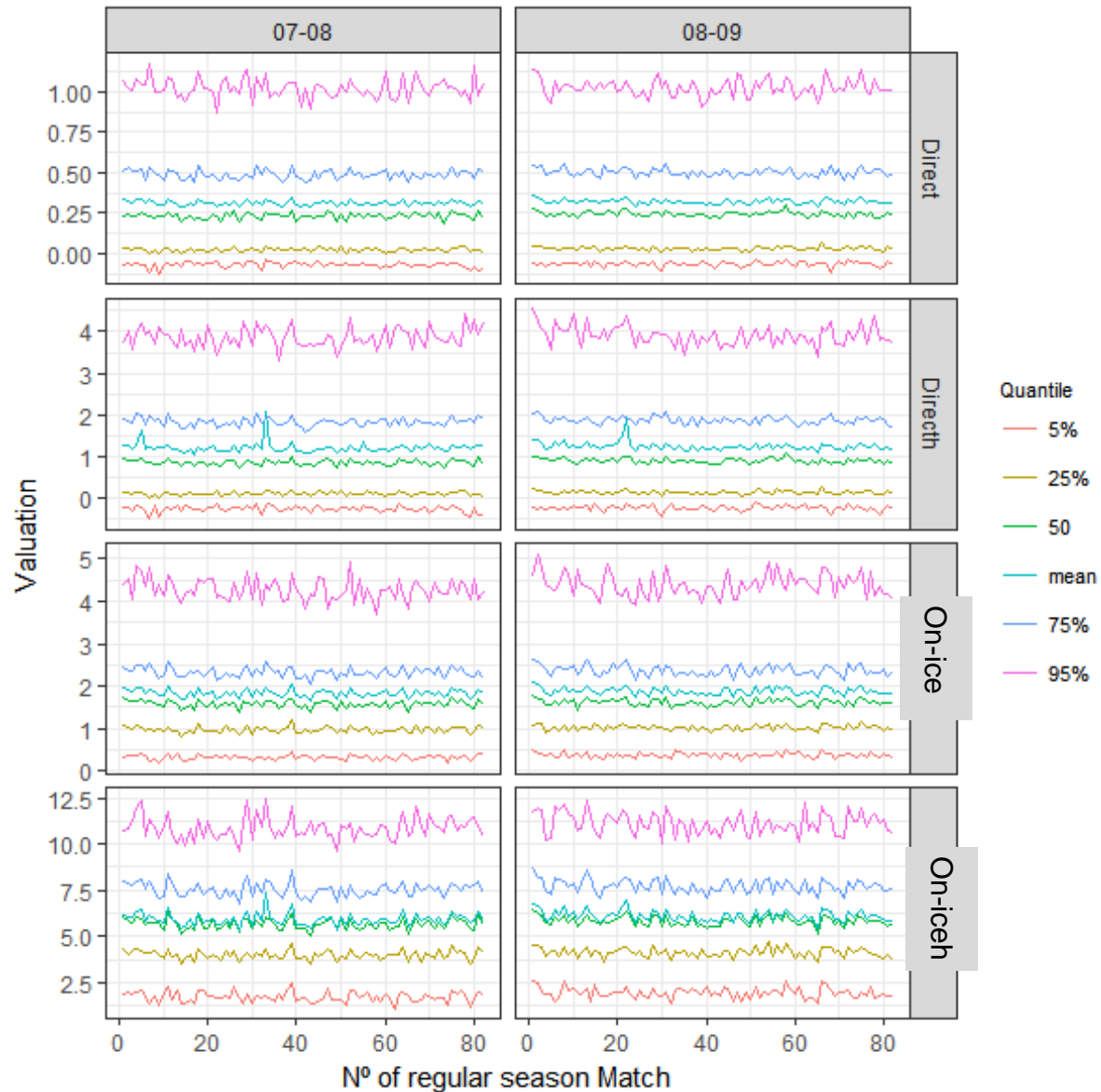
| PlayerName | Position | Age | Salary | GP | G | GA | PlusMin | Points | Direct | Directh | On-ice | On-iceh |
|-------------------|----------|-----|--------|----|----|----|---------|--------|--------|---------|--------|---------|
| 2007 | | | | | | | | | | | | |
| Dion Phaneuf | D | 22 | 0.94 | 82 | 17 | 43 | 12 | 60 | 59.22 | 134.05 | 246.12 | 559.67 |
| Alex Ovechkin | F | 22 | 3.83 | 82 | 65 | 47 | 28 | 112 | 71.96 | 182.65 | 232.56 | 588.85 |
| Tomas Kaberle | D | 29 | 4.25 | 82 | 8 | 45 | -8 | 53 | 38.32 | 93.36 | 221.93 | 551.72 |
| Mike Green | D | 22 | 0.85 | 82 | 18 | 38 | 6 | 56 | 48.26 | 122.63 | 219.72 | 545.08 |
| Andrei Markov | D | 29 | 5.75 | 82 | 16 | 42 | 1 | 58 | 42.37 | 105.18 | 213.81 | 530.37 |
| Nicklas Lidstrom | D | 37 | 7.60 | 76 | 10 | 60 | 40 | 70 | 29.04 | 66.41 | 205.68 | 480.18 |
| Jarome Iginla | F | 30 | 7.00 | 82 | 50 | 48 | 27 | 98 | 58.94 | 161.92 | 204.12 | 560.88 |
| Zdeno Chara | D | 30 | 7.50 | 77 | 17 | 34 | 14 | 51 | 50.74 | 117.69 | 203.78 | 468.89 |
| Lubomir Visnovsky | D | 31 | 2.05 | 82 | 8 | 33 | -18 | 41 | 32.64 | 83.52 | 201.34 | 523.00 |
| Roman Hamrlík | D | 33 | 5.50 | 77 | 5 | 21 | 7 | 26 | 37.79 | 93.89 | 201.29 | 509.39 |
| 2008 | | | | | | | | | | | | |
| Dion Phaneuf | D | 23 | 7.00 | 79 | 11 | 36 | -11 | 47 | 50.34 | 122.64 | 240.57 | 532.49 |
| Alex Ovechkin | F | 23 | 9.00 | 79 | 56 | 54 | 8 | 110 | 75.93 | 194.34 | 239.89 | 612.23 |
| Evgeni Malkin | F | 22 | 3.83 | 82 | 35 | 78 | 17 | 113 | 50.76 | 134.92 | 220.41 | 591.75 |
| Dan Boyle | D | 32 | 6.67 | 77 | 16 | 41 | 6 | 57 | 36.11 | 88.65 | 219.94 | 539.81 |
| Chris Pronger | D | 34 | 6.25 | 82 | 11 | 37 | 0 | 48 | 43.40 | 99.89 | 217.92 | 503.72 |
| Mike Green | D | 23 | 6.00 | 68 | 31 | 42 | 24 | 73 | 46.41 | 106.62 | 214.33 | 493.09 |
| Nicklas Backstrom | F | 21 | 2.40 | 82 | 22 | 66 | 16 | 88 | 37.12 | 111.83 | 214.19 | 630.43 |
| Braydon Coburn | D | 23 | 1.20 | 80 | 7 | 21 | 7 | 28 | 40.78 | 100.10 | 211.64 | 516.12 |
| Andrei Markov | D | 30 | 5.75 | 78 | 12 | 52 | -2 | 64 | 38.03 | 96.17 | 209.18 | 527.62 |
| Mark Streit | D | 31 | 4.10 | 74 | 16 | 40 | 6 | 56 | 39.38 | 97.60 | 206.59 | 504.31 |

Table 5.4: Top 10 players performance for 2007-2008 and 2008-2009 for the (On-ice metric without goalkeeper positions

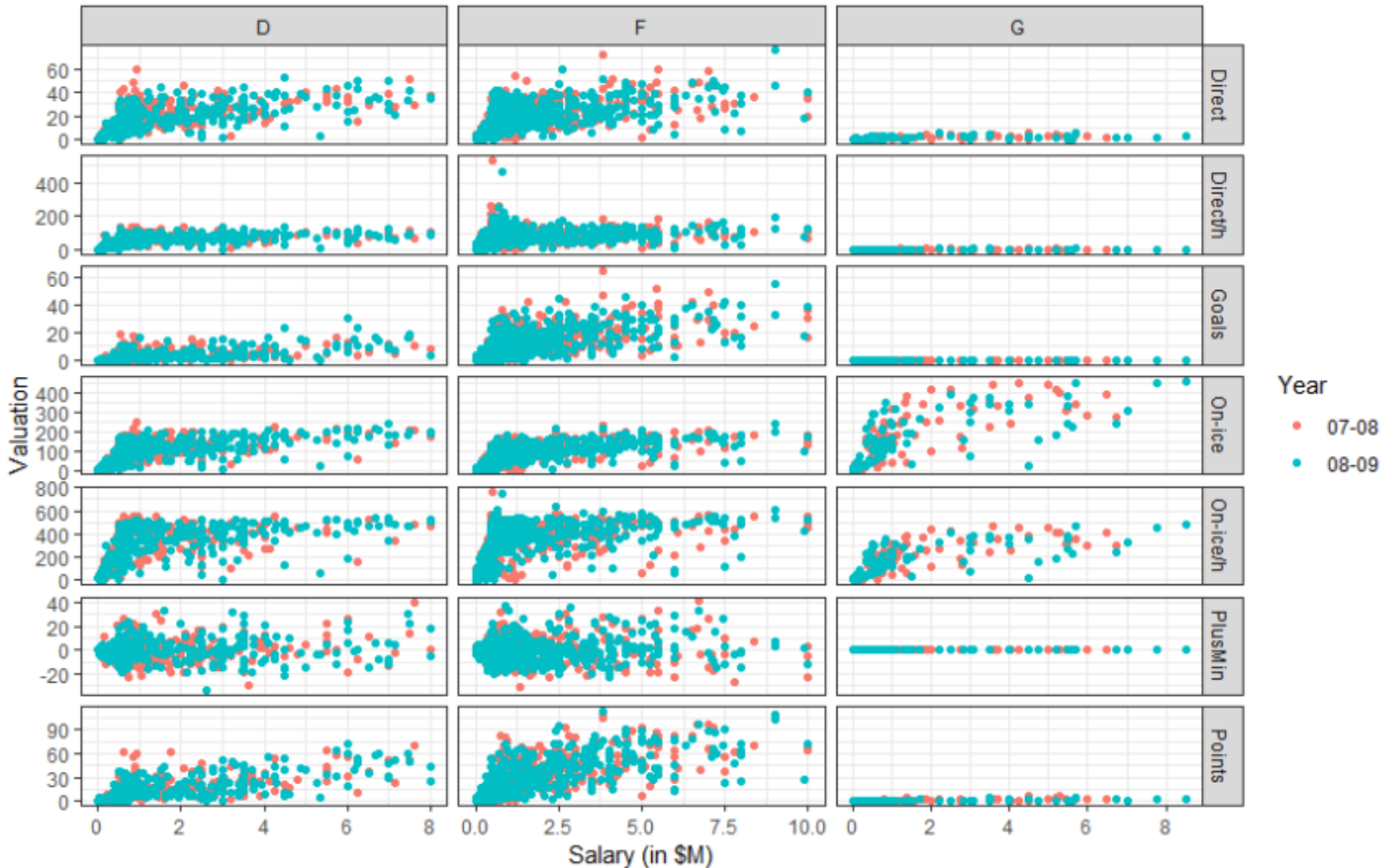
Distribution of impact values



Quantiles per game



Impact vs salary per position

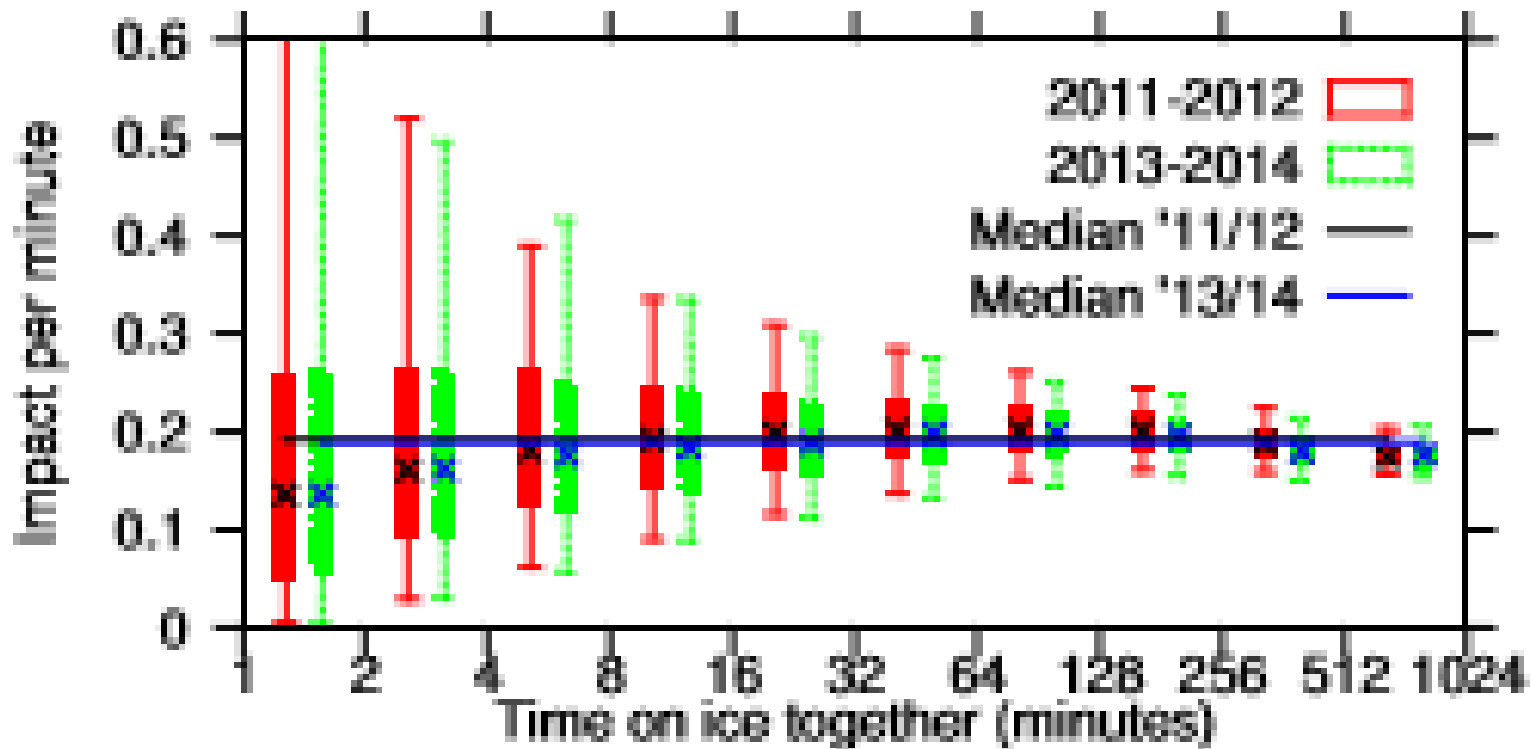


Top pairs 2011-2012

Table 3. Top pairs 2011-2012 according to *total* impact.

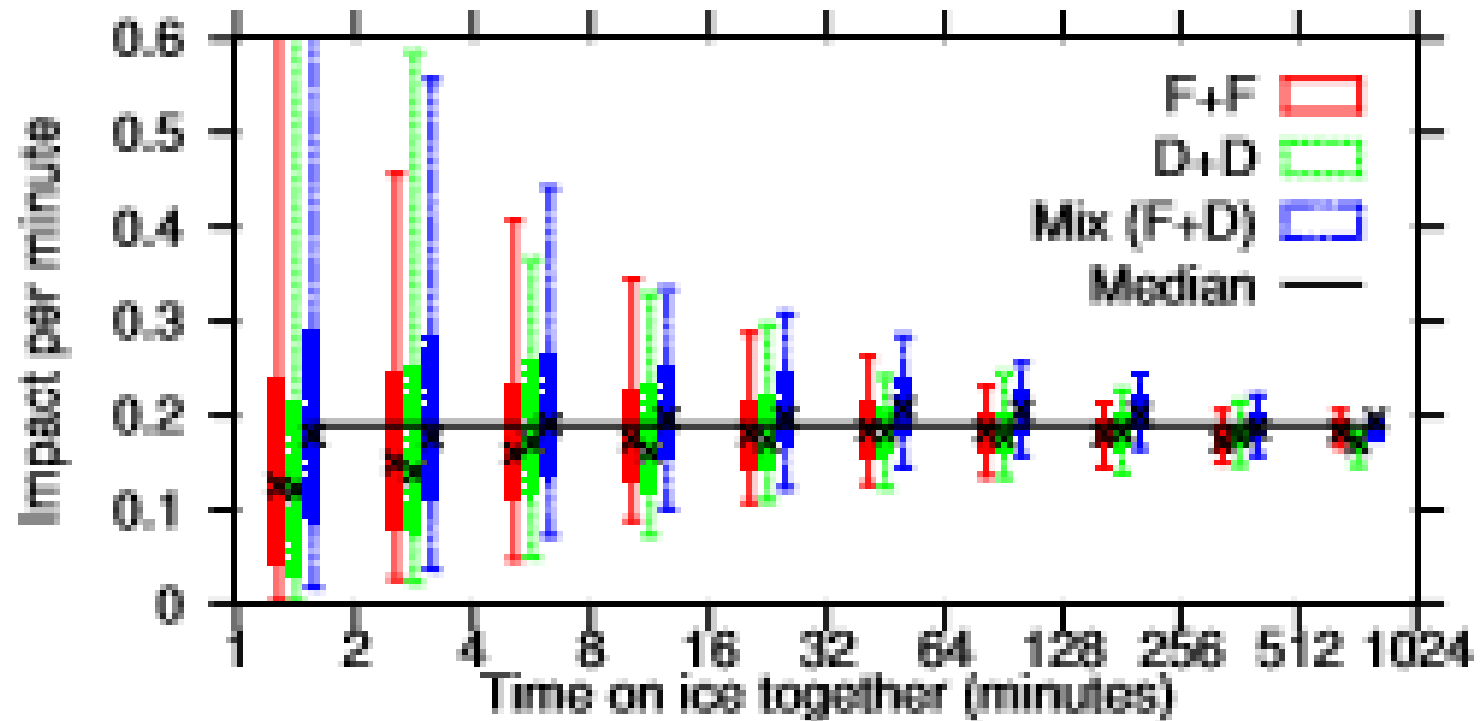
| | | Player 1 | | | | Player 2 | | | | | Pair stats | | | |
|-----------|--|---------------------|-----|----|----|----------|-------------------|-----|----|----|------------|------|--------|--------|
| | | Name | Pos | G | A | +/- | Name | Pos | G | A | +/- | Team | Impact | TOI |
| Forwards | | Ilya Kovalchuk | R | 37 | 46 | -9 | Zach Parise | L | 31 | 38 | -5 | NJD | 121.17 | 40,163 |
| | | Ryan O'Reilly | C | 18 | 37 | -1 | Gabriel Landeskog | L | 22 | 30 | +20 | COL | 115.74 | 39,021 |
| | | Joe Pavelski | C | 31 | 30 | +18 | Joe Thornton | C | 18 | 59 | +17 | SJS | 112.65 | 39,353 |
| | | Steven Stamkos | C | 60 | 37 | +7 | Martin St. Louis | R | 25 | 49 | -3 | TBL | 111.77 | 35,941 |
| | | Milan Michalek | L | 35 | 25 | +4 | Jason Spezza | C | 34 | 50 | +11 | OTT | 111.73 | 36,689 |
| Defenders | | Dan Girardi | D | 5 | 24 | +13 | Ryan McDonagh | D | 7 | 25 | +25 | NYR | 155.28 | 55,911 |
| | | Filip Kuba | D | 6 | 26 | +26 | Erik Karlsson | D | 19 | 59 | +16 | OTT | 134.74 | 47,985 |
| | | Francois Beauchemin | D | 8 | 14 | -14 | Cam Fowler | D | 5 | 24 | -28 | ANA | 125.54 | 45,795 |
| | | Josh Gorges | D | 2 | 14 | +14 | P.K. Subban | D | 7 | 29 | +9 | MTL | 125.16 | 44,390 |
| | | Carl Gunnarsson | D | 4 | 15 | -9 | Dion Phaneuf | D | 12 | 32 | -10 | TOR | 123.06 | 36,181 |
| Mixed | | Jason Spezza | C | 34 | 50 | +11 | Erik Karlsson | D | 19 | 59 | +16 | OTT | 110.58 | 35,990 |
| | | Joe Pavelski | C | 31 | 30 | +18 | Dan Boyle | D | 9 | 39 | +10 | SJS | 106.04 | 35,612 |
| | | Joe Thornton | C | 18 | 59 | +17 | Dan Boyle | D | 9 | 39 | +10 | SJS | 102.96 | 35,160 |
| | | Tomas Fleischmann | L | 27 | 34 | -7 | Brian Campbell | D | 4 | 49 | -9 | FLA | 98.08 | 31,804 |
| | | Stephen Weiss | C | 20 | 27 | +5 | Brian Campbell | D | 4 | 49 | -9 | FLA | 96.79 | 32,995 |

Impact per minute



Variation decreases when more joint TOI
Medians highest in 16-256 minutes joint TOI

Impact per minute



Mixed pairs may have higher impact



Further Reading

Papers available at the
LiU Sports Analytics Group page:

<https://www.ida.liu.se/research/sportsanalytics/>



Currently working on

- Combine variant 1 and 2 by using GPIV as the reward function in variant 2
- Roles of ice hockey players



Other work

- Game prediction and season simulation
- Ranking of players
- Importance of powerplay
- An ontology for ice hockey



Linköping Hockey Analytics Conference - LINHAC

LINHAC aims to bring together professionals and academics with an interest in hockey analytics. LINHAC will feature the latest research in hockey analytics in academia and companies, panel discussions with analysts, coaches, GMs and players, industry sessions with the latest hockey analytics products, and an analytics competition for students.

LINHAC 2022: recordings available

LINHAC 2023: recordings available

LINHAC 2024: June 3-5, 2024



Thanks to our students

- Carles Sans Fuentes
- Dennis Ljung
- Jon Vik
- Min-Chun Shih
- Rabnawaz Jan-Sher
- Sofie Jörgensen
- Haris Kozlica
- Timmy Lehmus Persson