

| Hockey |



Produced by Dr. Mario | UNC STOR 390



(Hockey Explained)





Player Performance

- Unique to Hockey = Rapid Substitutions
 - Median Time for Unique Configuration is 8 Seconds
 - Most Shifts Are Between 30 and 50 Seconds
 - Constant Substitutions Make it Difficult to Value Players for Events Such as Goals
- Plus-Minus (+/-)
 - Difference Between Goals Scored and Goals Allowed Player is on Ice
 - Example of a Marginal Effect
- Marginal Effect = Difference in Variable Between 2 Groups





Player Performance

- Problems With +/-
- Variables Effecting +/- Other Than Player Skill
 - Ability of Player's Teammates
 - Opponent Quality
 - Amount of Playing Time
- Partial Effects = Difference in Variable Between 2 Groups After Controlling for Other Variables





Player Performance

- Experiments = Optimal for Estimating Marginal Effects
 - Pick a Player
 - Randomly Sample from Pool of Other Players
 - Do This When Player is Playing and on Bench
 - Impractical and Need to Rely on Observational Data
- Estimated Using Regression
 - Predict Number of Goals
 - Include All Covariates
 - Massive Set of Covariates
 - Requires a Ton of Data
 - Standard Linear Regression Fails
 - Over-Fit or Fail to Converge





Player Performance

- Proportional Hazards Model
 - Studied by Thomas, Ventura, Jensen, Ma (2013)
 - Goals are Rare and Time is Almost Continuous
- Introduction of Binary Goals
 - Purpose = Simplicity
 - +1 = Goal Scored by Home Team
 - -1 = Goal Scored by Away Team

$$p_i = P(Y_i = 1) = P(\text{Home Team Scored Goal } i)$$





Player Performance

- Logistic Regression Model

$$\log \left[\frac{q_i}{1 - q_i} \right] = \alpha + \mathbf{u}_i' \boldsymbol{\gamma} + \mathbf{v}_i' \boldsymbol{\varphi} + \mathbf{x}_i' \boldsymbol{\beta}_0 + (\mathbf{x}_i \circ \mathbf{s}_i)' (\boldsymbol{\beta}_s + p_i \boldsymbol{\beta}_p).$$

Team/Season

Special Teams:
Penalty Scenarios
Pulled Goalies

Player-Presence
Indicator Variables

Player/Season

Post-Season
Indicator





Player Performance

- Partial Effect of Specific Player

$\beta_{0j} + \beta_{sj}$ \longrightarrow Regular Season Effect of Player j

$\beta_{0j} + \beta_{sj} + \beta_{pj}$ \longrightarrow Post-Season Effect of Player j

- Player-Only Version of Model

$$\log \left[\frac{q_i}{1 - q_i} \right] = \alpha + \underbrace{\beta_{h_{i_1}} + \dots + \beta_{h_{i_6}}}_{\text{Home Players}} - \underbrace{\beta_{a_{i_1}} - \dots - \beta_{a_{i_6}}}_{\text{Away Players}}$$





Player Performance

- Player-Only Version of Model

Y : scoring team

$y_i \in \{-1, 1\}$

X : players

$x_{ij} \in \{-1, 0, 1\}$

	1																	n	
1	0	1	-1	1	0	-1	0	-1	1	-1	-1	0	0	...	0	1	0	1	1
\vdots	\vdots																		
-1	1	-1	1	-1	0	1	0	1	-1	1	1	0	...	0	-1	0	-1	-1	-1

Massive Model Matrix
(All Hockey Players)





Player Performance

- Regularized Approach

- Representation of Log Odds

$$\eta_i = \log[q_i/(1-q_i)]$$

- Negative Log Likelihood Objective Function

$$l(\eta; \mathbf{y}) = \sum_{i=1}^n \log(1 + \exp[-y_i \eta_i])$$

Bernoulli Distribution in Exponential Family

- Penalization of Generalized Linear Model

$$l(\eta; \mathbf{y}) + n\lambda \sum_{j=1}^{\tilde{p}} [c(|\beta_{0j}|) + c(|\beta_{sj}|)]$$

Cost Function of Coefficients





Player Performance

- Lasso Penalization

$$l(\eta; \mathbf{y}) + n\lambda \sum_{j=1}^p (|\beta_{0j}| + |\beta_{sj}| + |\beta_{pj}|)$$

Three red arrows point from the text below to the terms $|\beta_{0j}|$, $|\beta_{sj}|$, and $|\beta_{pj}|$ in the equation.

Penalizing Only Player Effects

- Regularization Path

- Each Lambda Leads to Different Estimates
- Larger Lambda = Effects Pushed Towards 0
- Cross-Validation Used to Choose Lambda
- Alternative: Corrected Akaike Information Criterion


$$AICc = 2l(\hat{\eta}_{\lambda}; \mathbf{y}) + \frac{2kn}{n - k - 1}$$





Player Performance

- Goal-based Effects
 - Utilized Play-by-Play Data from 2002-2014
 - Based on 2,439 Unique Players
 - Involved 69,449 Goals
 - Link Function Makes Coefficients Difficult to Interpret
 - Partial Probabilities for Individual Players

$$\text{PFP}_{sj} = (1 + \exp[-\beta_{0j} - \beta_{sj}])^{-1}$$


Given Goal Scored by Team,
What is the Probability Player j Scored?





Player Performance

- Goal-based Effects
 - Translate Player Effects Into Scale of Goals
 - Partial Plus-Minus

$$PPM_{sj} = g_{sj}PFP_{sj} - g_{sj}(1 - PFP_{sj}) = g_{sj}(2PFP_{sj} - 1)$$



Number of Goals Player j Was on the Ice For





Player Performance

- Goal-based Effects
- Results

Top 25 and Bottom 20 Player-Seasons When Ranked by Their Regular-Season PPM

Goal-Based Performance Analysis							
Rank	Player	Season	Team	PFP	FP	PPM	PM
1	Peter forsberg	2002–2003	COL	0.68	0.77	55.52	85
2	Sidney crosby	2009–2010	PIT	0.60	0.64	43.47	60
3	Dominik hasek	2005–2006	OTT	0.59	0.67	42.45	80
4	Sidney crosby	2008–2009	PIT	0.60	0.61	42.26	48
5	Sidney crosby	2005–2006	PIT	0.60	0.62	41.86	52

↑
Completely Different Ranking
↑



Player Performance

- Problem With Previous Analysis

- Focused on Goals
- Other Important Events
 - Shots on Goals
 - Missed Shots
 - Blocked Shots

- Corsi and Fenwick Statistics

Corsi = shots on goal + missed shots + blocked shots

Fenwick = shots on goal + missed shots





Player Performance

- Results for Corsi-Based Partial +/-

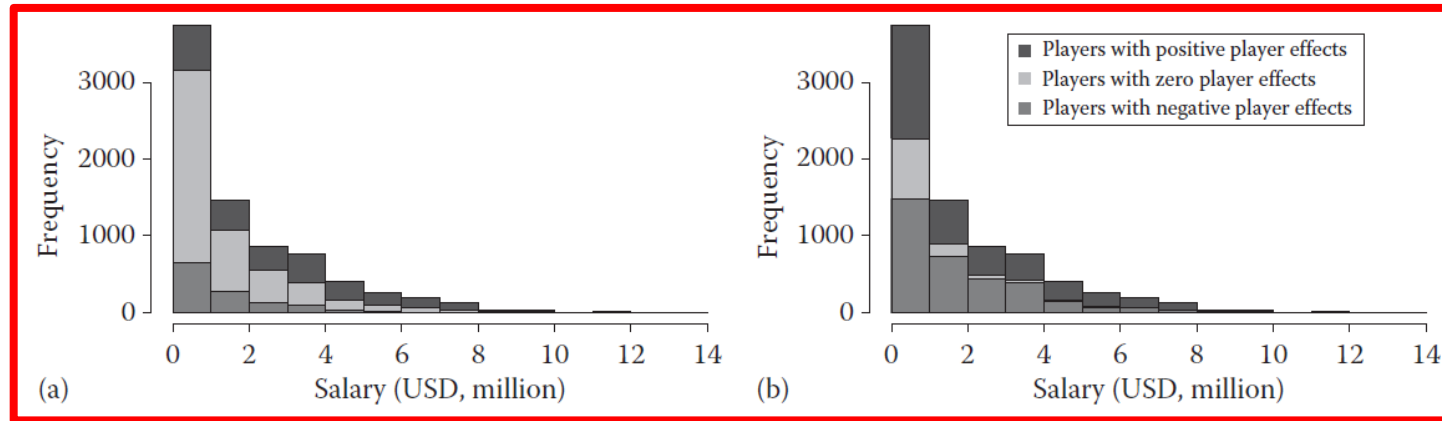
Top 25 and Bottom 20 Players by Corsi-Based PPM

Corsi-Based Performance Analysis							
Rank	Player	Season	Team	PFP	FP	PPM	PM
1	Daniel sedin	2010–2011	VAN	0.60	0.65	615.14	876
2	Eric staal	2008–2009	CAR	0.58	0.59	605.41	619
3	Mikhail grabovski	2010–2011	TOR	0.60	0.57	597.05	465
4	Joe thornton	2011–2012	SJS	0.59	0.61	596.37	742
5	Alex ovechkin	2009–2010	WAS	0.59	0.66	575.72	1047



Player Performance

- Salary and Performance



Goals-Based

Corsi-Based





Player Performance

- Salary and Performance

Top 20 Value Players as Ranked by PPM/Salary

Rank	Player	Team	Goals per million
1	Ondrej palat	TAM	58.27
2	Ryan nugent-hopkins	EDM	19.81
3	Gabriel landeskog	COL	16.74
4	Tyler toffoli	LOS	16.72
5	Gustav nyquist	DET	9.08
6	Jaden schwartz	STL	8.43
7	Eric fehr	WAS	7.51
8	Andrew macdonald	NYI	7.48
9	Benoit pouliot	NYR	6.43
10	Brad boyes	FLA	6.01

2013-2014
Season





Final Inspiration

I will personally challenge anyone who wants to get rid of fighting to a fight.

-Brian Burke