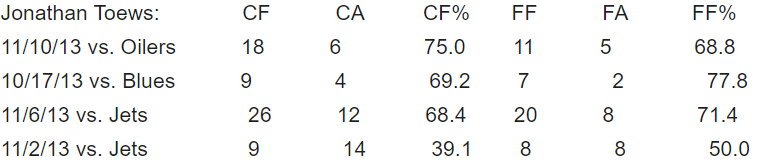
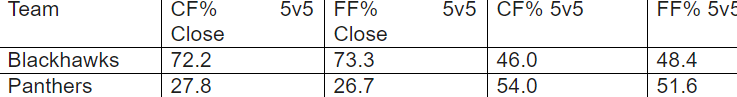
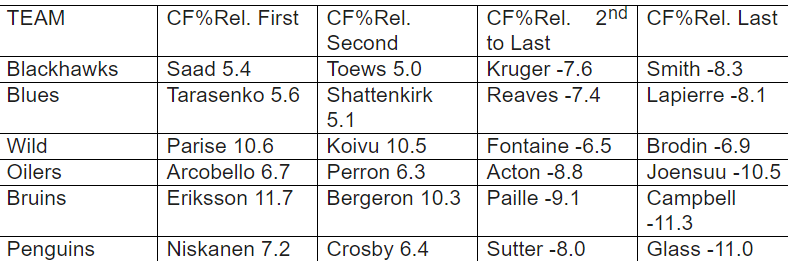
## Stats Made Simple Part 1: Corsi & Fenwick

* Advanced stats/metrics/analytics = initial stages of a movement to bring hockey analysis into modern era.
* Antiquated measures hockey has relied upon since Dark Ages (Plus/Minus (+/-)) = outdated + coming under heavy fire via a realization that there’s a lot more to hockey than simply being on the ice when a goal is scored.
* Better name = “**expanded metrics**” b/c most data being used has been available for a long time.
* \*\**The way* data (like shots + time on ice (TOI) are employed = where growth/expansion comes in\*\*\*
* So, while @ face value, expanded metrics may seem intimidating/too complicated, ***they really are not***
* Don’t have to be an expert in “fancy stats” to grasp their meaning, as many are as simple as BA or OBP in baseball, but b/c they’re relatively new, fans just need a little education.
* Many sports fans = familiar w/ football + at least some elementary stats used to keep track of a team’s performance.
* Time of possession (TOP) = 1 more commonly used simple metric = how long team’s offense controlled ball during a game.
* Obviously, team has a better chance of scoring if controlling the ball.
* In football, rigid structure of the game w/ offense on the field vs. opponent’s defense makes this stat easy to track.
* **In hockey, this is not so easy to do ==** more fluid w/ offensive + defensive players on the ice @ the same time, **but like football, a team = more likely to score when they have the puck (possession) than when stuck in the defensive zone.**
* Apart from teams of people watching skaters w/ timers to determine how long each has the puck, a way to track TOP in hockey = **Corsi** and **Fenwick**.
* **\*\*\*Corsi = shots on goal + missed shots + blocked shots\*\*\***
* basically uses every shot toward the goal throughout the game
* **\*\*\*Fenwick = shots on goal + missed shots\*\*\***
* measures the same thing as Corsi *but excludes blocked shots*.
* Essentially, in order **to shoot the puck**, you **must possess the puck**.
* Since we do not have the tech or another practical way to measure TOP in hockey, must employ a proxy.
* Expanding stats we use to understand a player’s/team’s performance in the past, present, + future opens doors to analyzing the game in all new ways.
* If we can ID trends in #’s, we can predict w/ *some degree of confidence* what’ll happen in the future
* We can determine progress made by teams/players in different areas of the game, figure out if a team’s early season success is built to last for duration of a season or just riding coattails of some hot goal tending.
* **Possibilities = as many + varied as the user wants them to be**.
* Metrics != first + last line of analyzing hockey 🡺 cannot stop watching games + rely solely upon stats
* *but they do enhance our hockey experience.*
* Both Corsi + Fenwick = counted as *“For” or “Against”.*
* “For” = a shot or event that happens while player is on the ice that is *on behalf of his team*
* “Against” = same but for opposing team.
* Both can be applied *team-wide* or *by player*.
* In general, **Fenwick = usually regarded as better indicator over a longer period of time vs. Corsi = better indicator over a shorter period of time.**
* Example: Patrick Kane is on ice for 10 shots on behalf of his team + opposing team takes 3 shots while Kane is on the ice during the game.
* **Corsi For (CF) = 10 Corsi Against (CA) = 3 Kane = a +7 Corsi (10 – 3 = 7) on the night.**
* Let’s say of the 10 shots Kane was on the ice for, *2 were blocked* by players on opposing team.
* Opposing team had 3 shots while Kane was on the ice but *1 was blocked.*
* B/c *Fenwick excludes blocked shots*, Kane’s numbers would look like this:
* **Fenwick For (FF) = 8 Fenwick Against (FA) = 2 Kane = +6 Fenwick (8 – 2 = 6) on the night**
* To make this data easier to use, statisticians express a player or team’s #’s as a %.
* **CF% (Corsi For Percentage) + FF% (Fenwick For Percentage)** can be easily compared among players, teams, + games.
* Example:([www.extraskater.com](http://www.extraskater.com))
* Remembering **Corsi event = any shot toward the goal** (SOG – Shots on Goal, Missed Shots, Blocked Shots), we see Toews’ Corsi For (CF) varies greatly over these games, as does his Corsi Against (CA)
* **Focusing on these #’s *alone* could be misleading for sake of comparing his performance w/ other players throughout the league, teammates, or even own play from game to game.**
* **\*\*\*Using Corsi For Percentage (CF%) allows us to see how the #’s work together + remove game-to-game variables that would otherwise be misleading or confusing.\*\*\***
* Performance against the Blues (10/17/13) + Jets (11/2/13) = both a CF = 9, but when CA is factored in + translated into a %, see just how different those performances really were.
* **Posted very good #’s (i.e. had a good possession game) @ 69.2% against Blues but had a disappointing 39.1% against Jets.**
* When we remove blocked shots, Fenwick #’s take over.
* Toews’ best Corsi game = 3rd in Fenwick.
* Even the “bad game” in Corsi terms (Jets 11/2/13) was a decent showing @ 50.0% when viewed from perspective of FF%.
* CA = 14 becomes FA = 8 due to Blackhawks blocking 6 shots while Toews was on the ice.
* Using Corsi and Fenwick, particularly CF% and FF%, is just the beginning of the expanded metrics possibilities available to us
* Many fans like to see #’s just to confirm what was observed of a certain player/line during a game, others dive deep for more detailed analysis.
* However you choose to use them, if expanded stats enhance experience as a fan of the game, it sounds like a positive outcome/
* Hockey fans = going through a learning process b/c expanded metrics = relatively new to the game.

## Stats Made Simple Part 2: Score Close & Score Effects

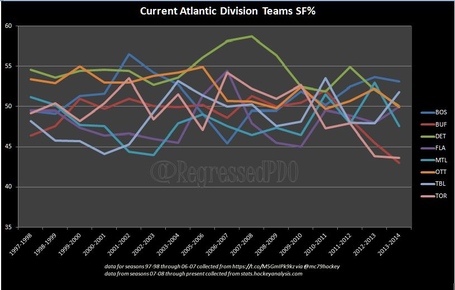
* Game = normally played w/ 5 skaters + 1 goalie == **5v5** or some other similar variation.
* When team takes a penalty + goes on Penalty Kill (PK) may see **4v5**/**Shorthanded** + occasionally **3v5**
* When opponent takes a penalty, team who drew the penalty = awarded a **Power Play (PP)** = **5v4, Man Advantage,** etc.
* **Even strength = any situation when both teams have the same number of players on the ice.**
* **\*\*\*For purposes of advanced stats, best of the above situations to use is 5v5\*\*\***
* **\*\*\*PK, PP, 4v4 = *NOT* considered to be truly representative of a team’s strengths/weaknesses over time\*\*\***
* Point of these metrics = judge a team’s/player’s performance over time + get an idea of what to expect in the future.
* Cannot happen w/out being able to filter out noise + focus on game situations that give clearest results
* To filter out **Score Effects**, statisticians focus on 5v5 performance when score is close.
* **Score Close** = defined as a score that’s tied (*including 0-0*) or w/in 1 goal in the 1st or 2nd period.
* \*\*\*In the 3rd period, score is only considered close when tied\*\*\*
* For those familiar w/ science/research, consider **5v5 Close** (**5 on 5 Score Close**) to be the "control" in this study
* All other situations that arise during the game (PK, PP, etc.) should be considered **experimental variants**.
* In any statistical discussion, \*\*\*sample size is always a concern\*\*\*, so why make the already limited (5v5) pool of data even smaller? 🡺 b/c "**Score Effects**".
* **Score Effects** take over when a team has a lead > 1 goal, *particularly late in the game*.
* Often, team w/ the sizeable lead goes into defensive mode instead of continuing to press offensive attack (think "prevent" defense)
* *Defensively-minded style of play often allows trailing team to make a push offensively = leads to more shots + thus higher possession + offensive zone time for attacking (trailing) team.*
* Further, teams trailing as game gets closer to end tend to throw caution to the wind in efforts to score, **contributing further to disparity in shot attempts** (like to onside kicks, trick plays, Hail Mary)
* *When Score Effects are @ work, tend to see leading team taking defensive zone penalties*.
* Ex: 3rd period of Blackhawks game vs. Stars on December 10, 2013
* Blackhawks had a 5 – 0 lead in the 2nd period, Stars scored + suddenly shot attempts quickly escalated until end of period, bringing 5v5 possession #’s up dramatically.
* In the 3rd, Stars spent a substantial amount of time in the offensive zone = led to 3 penalties taken by Blackhawks forwards, including 1 delay of game penalty (puck over glass) + 2 hooking penalties.
* Stars then enjoyed 3 PP in the 3rd alone, *furthering driving up shot attempts.*
* Practical example of Score Effects: Blackhawks vs. Panthers on December 8, 2013.
* Blackhawks dominated play early in 1st, leading to 2 goals.
* Early goal for Blackhawks in 2nd led to Panthers playing more aggressive offensively
* Panthers scored 2 in the 2nd, **bringing** **the score back to being “close”**.
* Blackhawks scored again [4-2] for remainder of the 2nd
* In the 3rd, Blackhawks scored a PP goal early, making the score 5-2.
* Following that goal, Panthers had 31 shot attempts to Blackhawks 8, + 11 Panthers shots came on 2 PP’s from penalties against the Blackhawks (interference + holding).
* Still leaves 20 shot attempts @ 5v5 = far more than the leading team attempted, a standard example of Score Effects.



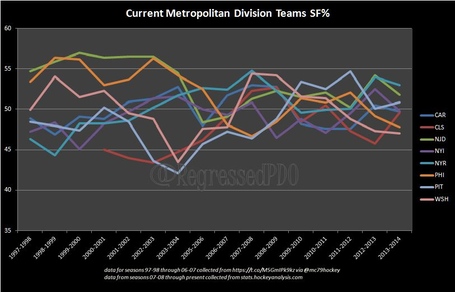
* As you can see from the table above, when score was close (*sans Score Effects*) Blackhawks dominated possession.
* W/ the score filter removed, the Panthers had better possession #’s than the Blackhawks, thus demonstrating the effect of Score Effects on shot attempts + style of play.
* **Once variants are removed, Corsi + Fenwick = much more reliable over time as analytical tools.**
* **CF% + FF% = useful in comparing teams + players across the league, + even game by game.**
* Many fans get an idea from watching the game as to which forward line or defensive pairing had the best performance of the night.
* Comparing players + line combos on a team = aided by adjusting CF% + FF% values to make them **Relative**
* \*\*\***CF% Relative and FF% Relative**\*\*\* allow us to see how a player stacks up against teammates.
* **Relative values** tell us how a team performs when a player is on the ice.
* If positive, team performed better (more shot attempts/higher possession #’s) w/ player on the ice than off.
* If negative, team performed better when player was off ice
* **Relative *Percentages*** do NOT mean certain players are good + others are not good.
* many factors affect these #’s, such as **Quality of Competition** + **Zone Starts**
* What we’re really looking = **strength of performance** 🡪 use this info to determine where strengths + weaknesses of a team are located.
* If team’s checking line consistently has better Relative #’s than the offensively gifted 2nd line, perhaps the usage + deployment of the line needs to be revisited.
* *Further, large disparities between a team’s lines may indicate a team w/ less forward depth or heavily front loaded lines.*
* Some teams in terms of CF% Rel (5v5):
* Distribution such as that seen from the Blackhawks + Blues = representative of many teams, in that Relative #’s = fairly evenly spread out
* Bruins = much wider distribution, as do the Penguins, + Wild = similar to these 2 as well.
* Distribution of a team's Relative possession #’s = heavily dependent upon *not only depth of talent* but *also* ***Usage*** *+* ***Deployment*** *of players*.
* \*All statistical data gathered via [www.extraskater.com](http://www.extraskater.com)

## Using Shots For Percentage

* **Possession statistics** + the data that allows us to use them only reach back to the 2007-2008 season.
* Prior, total shot attempts were not tracked + cataloged into a usable format, thus making the task of taking a statistical look @ team's past performances very difficult.
* 1 method used to get a *general* idea of team's overall possession game = **Shots For Percentage (SF%)**
* **Shots for + Shots against** in a game = 100%, + a team's Shots For are then turned into a % of shots taken in a game.
* A team has to have the puck to shoot it, so w/out more expansive data prior to 2007-2008, *must make what we can of the data we have.*
* **SF% can be used to *gauge* puck possession**.
* More a team possesses puck = more chances to score + thus win.
* **SF% does NOT tell the whole story b/c obviously, a hot goaltender can steal a playoff series, but it is a useful tool**
* Recently, Tyler Dellow (@mc79hockey) publicly shared a [spreadsheet](https://docs.google.com/spreadsheet/ccc?key=0AuFrjZE8ZySpdDZpclc4TG5qX3RjczhpbUtDNHFpX1E#gid=0) w/ SF% for all NHL teams back to 1997-1998 season (further than any other info we have previously had convenient access to + thus can give some insight into history of a team's puck possession game)
* Using that data:

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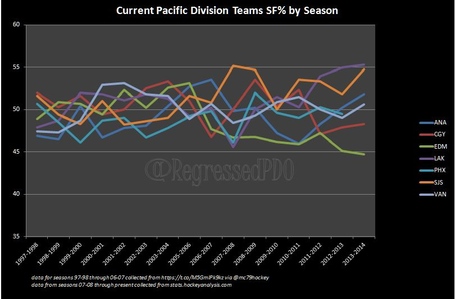
* Dominance of [Detroit Red Wings](http://www.sbnation.com/nhl/teams/detroit-red-wings) = obvious for over a decade, + *no surprise that other teams, such as* [*Blackhawks*](http://www.sbnation.com/nhl/teams/chicago-blackhawks)*, have patterned their game after this team.*
* Rather precipitous drop of possession game for the [Maple Leafs](http://www.sbnation.com/nhl/teams/toronto-maple-leafs) is astounding.
* For years, they hovered ~50%, but since 2009-2010 season, possession game indicators have dropped like a stone.
* Dramatic spike for [Tampa Bay Lightning](http://www.sbnation.com/nhl/teams/tampa-bay-lightning) coincides w/ their [Stanley Cup](http://www.sbnation.com/nhl-playoffs) winning season in 2003-2004

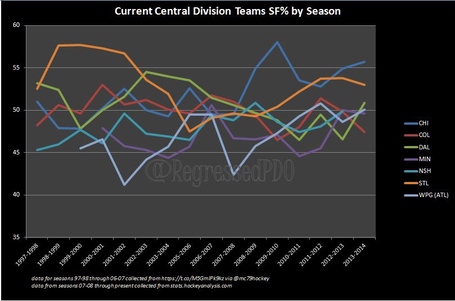
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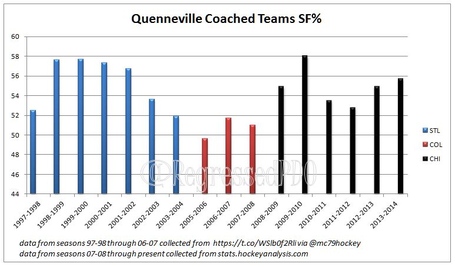
* Both [Capitals](http://www.sbnation.com/nhl/teams/washington-capitals) + [Penguins](http://www.sbnation.com/nhl/teams/pittsburgh-penguins) bottomed out in 2003-2004 + spiked up quickly thereafter = [Ovechkin](http://www.sbnation.com/nhl/players/54337/alex-ovechkin)

drafted in 2004 + [Crosby](http://www.sbnation.com/nhl/players/55428/sidney-crosby) the following season.

* [Devils](http://www.sbnation.com/nhl/teams/new-jersey-devils) early dominance, drop, + slow resurgence in SF% is also notable here.
* This division now seems to be getting more tightly grouped on the possession spectrum (2013)

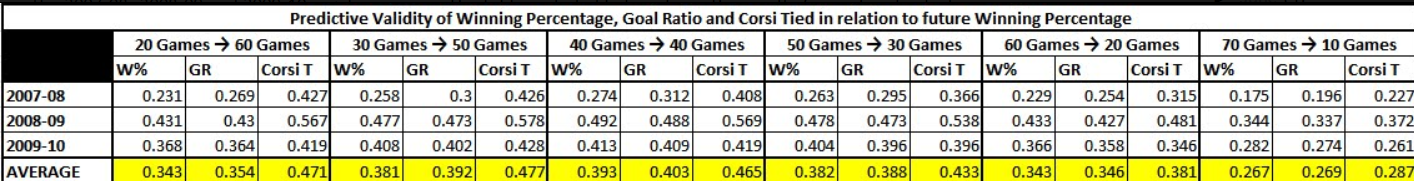
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* [Oilers](http://www.sbnation.com/nhl/teams/edmonton-oilers) continue on long road toward a rebuild of former powerhouse position.
* [Kings](http://www.sbnation.com/nhl/teams/los-angeles-kings) have really shot skyward in terms of SF% + currently lead the NHL in this metric, as well as FF%
* [Sharks](http://www.sbnation.com/nhl/teams/san-jose-sharks) are also sustaining their offensive dominance.
* Pacific teams seem to be spreading out to reveal a serious lack of parity in the division (should come as no shock to anyone)
* [](http://cdn3.vox-cdn.com/assets/4227607/central_season_sf_.JPG)
* Central = bit more spread out over time than other divisions.
* Obviously, these teams have not been playing each other as divisional foes for all of this time, but dominance of the [Blues](http://www.sbnation.com/nhl/teams/st-louis-blues) + Blackhawks for past several seasons is striking.
* This also leads to another point of interest 🡺 early years on this chart (in which Blues were dominant, middle years wherein [Avalanche](http://www.sbnation.com/nhl/teams/colorado-avalanche) were near the top, + last several years where Blackhawks dominate possession), all have 1 thing in common: ***the coach of each of those teams***

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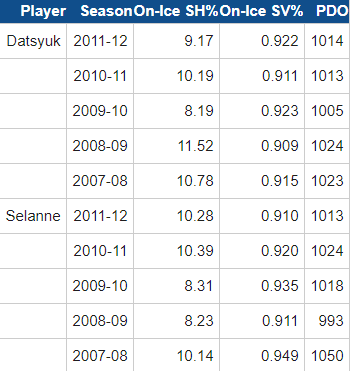
* Joel Quenneville has coached the Blues, Avalanche, + Blackhawks
* SF% for each season of his coaching career are above.
* Only 1 team (2005-2006 Avalanche) finished season w/ < 50% SF%.
* This track record = very impressive + it’s obvious Quenneville has good grasp on coaching puck possession + using both star + depth players in such a way as to maximize effectiveness in this regard
* Links to helpful articles regarding SF% and it's uses:
* Dellow's original article on this topic: <http://www.mc79hockey.com/?p=6451>
* <http://www.extraskater.com/>
* <http://stats.hockeyanalysis.com/>
* <http://www.arcticicehockey.com/2013/10/23/4862840/the-importance-and-misconceptions-of-advance-hockey-analytics>

## Loose Ends - Part I: Predicting Future Success

* Various shot metrics (all calculated @ even strength w/ tied score) can predict future success @ the team level
* How well do these shot metrics predict future success when compared to more conventional measures of team strength (winning % + goal ratio?
* **Split-half reliability of goal ratio** (0.417) was lower than predictive validity coefficients for both Corsi Tied (0.444) + Fenwick Tied (0.429).
* Implication = 2 latter variables are better able to predict goal ratio from ½ of the schedule to the other than goal ratio is itself.
* ***If shot metrics like Fenwick + Corsi fail to predict future success better than conventional measures, that would render them considerably less useful.***
* Method employed = developed and first used by Vic Ferrari
* B/c of relative complexity of the process, including a step-by-step description may be helpful.
* 1) Randomly selected a certain # of games from each team's schedule, w/ each team having an equal # of home + road games selected.
* 2) Calculate how each team performed over those games w/ respect to certain variables = **even strength Corsi w/ the score tied**, **overall goal ratio** (empty net + shootout goals excluded), + **winning %** (defined as WINS/(WINS+LOSSES))
* Games that ended in a shootout = considered ties + therefore not included in calculation.
* 3) Random selected a 2nd, *independent* group of games
* if a game was included in 1st grouping, it was NOT eligible for selection in the 2nd
* Again, equal # of home + road games were selected for each team.
* 4) Determine how each team did in terms of winning % over 2nd group of games + looked @ how each of the 3 variables calculated in relation to 1st group correlated w/ winning % in the 2nd
* Relationship between the size of the 2 groups can be expressed as **y=(80-x),** where x = # of games in 1st group + y = # of games in 2nd group.
* Ex: 20 games selected for 1st group, 2nd group would consist of 60 games.
* Ultimately, x values used = {20, 30, 40, 50, 60. 70}
* Raw data used = from 2007-08, 2008-09, + 2009-10 regular seasons.
* Table below shows results for each individual season, as well as average results, + values represent the average correlation over 1000 calculations
* **Corsi Tied = best predictor of** how a team will perform over remainder of its schedule, regardless of the point in the schedule @ which calculation occurs.
* **Corsi Tied** = only ***marginally* more predictive of future success than goal ratio or winning %** *when looking at samples of 60+ games or more*.
* In other words, as sample size increases 🡺 diminishing returns w/ respect to predictive advantage of Corsi
* **By end of season, all 3 variables seem to predict future success equally well**
* Above fact has implications in terms of determining playoff probabilities @ team level, w/ results suggesting **a composite metric would work best**
* Aggregate values for Goal Ratio + Winning % are remarkably similar w/ implication = once shootout results are controlled for, winning % = as good of a measure of a team as goal ratio

# Intro To Advanced Statistics – PDO

* **PDO (SPSV%) = On-Ice Shooting % + On-Ice Save % +** can be measured for individuals or teams
* = very telling way of exploring a team's "**puck luck**" = which way bounces have been going, *though skill does heavily influence the result.*
* Named after regular Oiler Fans commenter PDO, originally devised by statistical guru **Vic Ferrari.**
* PDO = On-Ice SV% + On-Ice SH%. typically quoted as **10X the actual %**
* **PDO = 10\*(On-Ice SV% + On-Ice SH%)**
* Usually look @ **Even Strength PDO** b/c vast majority of ice time is spent in this game state
* Usually it regresses towards NHL average = 1000 over course of a season, though for some teams their sustainable PDO = higher due to excellent goaltending or consistently good shooters.
* Ex: 2011 Leafs shot 8.6% @ 5v5, ranking 10th, + 5v5 SV% = .906, which ranked 27th.
* Combined PDO score = 10\*(90.6 + 8.6) = **992** = 26th in NHL in ‘11
* Thus, can be argued “bounces went against them”, though Leaf’s atrocious goaltending obviously contributed to such a result.
* Boston + Vancouver consistently (as of 20120) outperform PDO as a result of excellent team goaltending + shooting
* Canucks = top team from a PDO perspective over the past 5 years (2007-2012), w/ Boston = 2nd
* Median SH% over past 5 years in NHL = 8.3% at 5v5, while SV% = .917, which makes median PDO exactly = 1000
* **Teams consistently above/below this level = proving that their results = likely *more than just luck,* particularly if they outperform by a wide margin.**
* Meanwhile, Toronto + Islanders = worst *under*-performers over 2007-2012, w/ Toronto's problems almost solely result from horrid goaltending 🡪 .906 5v5 SV% over 2007-2012 ranks only slightly ahead of Tampa Bay's .905 SV%.
* NYI on the other hand = below average goaltending *AND* shooting for 2007-2012
* **At team level, PDO allows us to quickly spot teams unlikely to sustain performance mid-season.**
* Minnesota = near dead-on-average team over 2007-2012, producing average PDO = 1001.4, largely due to excellent team defense + goaltending combined w/ mediocre offensive results.
* Early 2011, this stretched to extremes 🡺 led NHL through 1st 40 games despite having absurdly low **Team Fenwick = of 44.2**.
* Wild had a team PDO = 1007*, thanks to a very favorable .938 SV%,* due to **regress**.
* By end of season, it went pretty far the other way (as expected given atrocious team Fenwick %), + Wild finished season w/ a team PDO = 989.
* Compared to Kings 🡺 1st 37 games = out of playoffs despite favorable Fenwick % = 51.5.
* After 37 games, Kings had team PDO = 981 🡺 unsustainably low for a team dominating possession as they were.
* Despite having a solid team SV% = .923, *virtually no luck* went their way @ offensive end, as the team was firing home only 5.8% of Even Strength shots.
* As year progressed, goaltending improved even further to .927 SV% + shooting bounced back to a poor, but more respectable 6.0%.
* Thus, Kings closed out season w/ a PDO = 987
* Still less lucky than Minnesota, but trending in right direction + more reflective of quality of play.
* In playoffs, Kings had a dominating PDO = 1038
* Lowest playoff PDO in 20120 = Red Wings = paltry 904, who despite playing reasonably well, got no bounces @ either end of the ice
* Actually, *outshot* playoff opposition by an average of 10 shots/game @ Even Strength, but were *outscored* by almost 2 goals/game at Even Strength.
* In a similar fashion, can explore PDO scores of *individual players* during course of season + reads for who is benefiting from fortuitous bounces while on the ice.
* Perhaps guy padding the score sheet regularly has been seeing benefits of sieve-like goaltending from opposition, or maybe he who looks like worst player ever seen = actually being victimized by atrocious PDO as a result of *teammates* not scoring + *goalie* not doing their job
* Again, can make excellent use of the data provided by TimeOnIce.com to examine "luck" seen by players over a stretch of games.
* Conversely, can also pull data from BehindTheNet.ca
* Leaf-related examples: Darryl Boyce + Philippe Dupuis.
* Following the end of 2011, Boyce looked like lock to be checking forward for Leaf’s entering 2011-12 season.
* Then Leaf’s signed Dupuis to a 1-year contract + a battle ensued in training camp that saw Dupuis get nod for opening night roster.
* What people remember about Boyce = production in limited opportunity (5 goals + 13 points in only 524 minutes of ice time + ended the season a +8 player despite facing tough competition, usually starting shifts in own zone + not being a flashy offensive player)
* *So why should we have been cautious about his results?*
* 2010-11 season 🡺Boyce posted a Fenwick % of .438, Corsi % of .430, + yet somehow... against all odds, Boyce enjoyed .923 goaltending, + the team shot 14.2% w/ him on the ice.
* Goaltending isn't alarmingly good: @ Even Strength, .923 goaltending = pretty close to NHL average, + in fact 19 Leafs had better **ES SV%** while on the ice
* So, his impact on the defense wasn't the reason for his stellar +/- #’s.
* But 14.2% On-Ice shooting? Was Boyce really responsible for that type of offensive production from his line mates? ***NO***
* In fact, his **On-Ice SH%** = highest in NHL amongst forwards to play 30 games in 2010-11, by a margin > 2%
* **PDO** = 1069 resulted from combo of average SV% + ridiculously high SH% + ranked 2nd in NHL
* Just say, either he's 1 of the most skilled forwards in the NHL, or his **PDO from 2010-11 was unsustainably high + he wasn't going to repeat.**
* After losing job to Dupuis, Boyce was placed on waivers + picked up by Columbus where his On-Ice SV% was .923, *again*, so that wasn't something he was ruining.
* But his On-Ice SH% dropped to 5.08%, and his PDO fell to 974, indicating he's pretty far from stellar @ offensive end + ***Luck can make a big difference.***
* Dupuis in Colorado in 2010-11 season worked a lot on the PK + in 674 minutes of ice time produced 6 goals + 17 points
* Looked like a *comparable* defensive player, but *an offensive upgrade on Boyce*, particularly when factoring in likely drop off in Boyce's luck entering 2011-12.
* For sake of discussion, Dupuis = below average PDO = 984 in ’10-11 season w/ Avalanche, mainly stemming from seeing .900 goaltending behind him @ Even Strength.
* On-Ice SH% = 8.4 = just under NHL average 🡺 implied he should be fine @ helping put puck in the net
* Logically expect at least a *slight* improvement in On-Ice SV% Dupuis would play in front of, + if he could replicate his On-Ice SH% = might get at least a comparable 4th line Center
* Unfortunately, that isn't quite how things worked out 🡺 On-Ice SV% = stellar (Even-Strength Leafs goaltenders = .966 SV% w/ Dupuis on ice)
* He probably wasn't driving force behind stellar netminding, but wasn't ruining Leafs w/ defensive miscues apparently either.
* So, what was the problem? 🡺 *Offense* - or a lack thereof.
* Dupuis' On-Ice SH% in 30 GP = 0.00% 🡺 *NO goals were scored with him on the ice.*
* Only 2 players in 2011-12 season played 30+ games w/ On-Ice SH% = 0.00% (Dupuis + Eric Boulton of the Devils = only forwards w/ 30+ GP in a season in past 5 years not on ice for a goal)
* Bad luck 🡺 Dupuis has a legitimate claim
* Typically, guys w/ #’s *that low* = cement fisted enforcers/checkers who see virtually no offensive zone time.
* This would be a case where Dupuis' bad luck prevented him from playing in the NHL.
* So unsustainably bad or unsustainably good
* There’re often guys on every roster = unlikely to repeat stellar or horrid #’s from prior year
* Then there’re players = consistently outperform or underperform expectations.
* **Enforcers** = often horribly low PDO, largely due to a complete lack of offensive contribution.
* Comparably, extremely skilled players = often above average PDO thanks to positive influence on shooting, while top-end goalies can sustain high PDO for the entire team, thanks to high Even Strength SV% values.
* The following chart effectively illustrates **the skill factor of PDO for skaters:**



* Obviously, goaltending = varies wildly for both players, + it should be noted = extremely difficult for a forward to influence On-Ice SV% (completely logical).
* So, when we examine player PDO, it is NOT assumed PDO should regress towards 1000 (as is often suggested)
* *Should* expect depends on **context in which player is used** (**usage metrics**), who they’re playing with, + their own natural talent.
* As Tom Awad of Hockey Prospectus said 🡺 ***PDO is not JUST a measurement of luck.***
* "Even after > 200 games, almost ½ of shooting % + save % = luck
* At the team level, slightly over ½ of team talent exhibits itself as puck possession, + slightly under ½ exhibits itself as finishing (+ preventing finishing).
* **Just so happens the possession talent is much, much easier to measure**"
* Similarly, David Johnson of HockeyAnalysis.com 🡺 **luck is not the *sole* component of PDO**
* To put it simply, need to look @ players *long term* patterns before assessing what's likely to happen in the future.
* @ individual level, player's quality of teammates + offensive opportunities will likely influence PDO 1 way or another*, so when looking for future trends be sure to take this into consideration.*

# Colorado Avalanche are not a test case

* 2014: “Avs aren't good enough to outplay their possession problems” 🡺 spurred by spurious claims made in Denver Post + Yahoo as to team's ability to continue racking up seasons of 100+ pts. in perpetuity, despite the fact they “absolutely + positively cannot”
* LV 🡺 many go thinking they have the formula to crack whatever code casinos have created to build up massive monuments to excess, opulence, + human misery.
* While a few *do* leave a couple $K richer, most head short on money + long on regret.
* Inevitably so will the Avalanche
* Math all checks out: *Teams simply cannot sustain score-close possession % south of 50% + PDOs north of 102.*
* To claim otherwise is to say math compiled over nearly a decade is wrong, + *you* are right.
* Crux of argument for Avalanche success = Patrick Roy has figured out something which literally hundreds of NHL coaches have not in past several years: *How to sustain play which has otherwise been found to be wholly unsustainable.*
* In 1st year under new coach 🡺 were able to generate quality chances in relatively few shots (keeps own shooting % high) + to suppress opponent chances effectively so that, even though they're get more, a smaller % are *actually* troubling netminder (keeps team save % high as well).
* But how many times have hockey fans since, let's say, 2010 or so, heard a team assert that “yes, we know we give up a ton of shots etc., but *we* have the ability to do those 2 things reliably enough that we’re going to be able to do it forever”
* 2009-10 Avalanche started out very well 🡺 40-23-6 in 1st 69 games, 5th in West.
* Getting 86 points from 1st 69 games = pace for a little more than 102 points for the season
* But b/c luck runs out + their Fenwick through 69 = 45.5% (26th in NHL): lost 10/final 13 games + went from a playoff lock to barely making it + then getting demolished by San Jose in the 1st round.
* Prior to year-end correction, Colorado's **score-close PDO** for the year = 102.4, 2nd-highest in league
* Time passed + it became increasingly unlikely they'd be able to keep juddering ship from breaking apart
* 1 year later, Dallas Stars were in much the same boat: began season 29-13-5 (63 points in 47 games, pace for ~110 points) w/ PDO at the time = 102.9, top in NHL, while Fenwick = 25th at 46.5%
* Were also 5th in the league standings, 3rd in the West, then lost 2 straight, then 4, then 5, then 6 straight + finished year w/ just 95 points, winning just 13/final 35 (PDO during collapse = 99.4)
* Peaked very early, indeed, + season ended up out of playoffs + in ruins + everyone wondered what happened to them *except nerds who said Stars were cruising for this all season.*
* Very next season, 2011-12 Wild started 20-7-3 atop Western Conference w/ PDO = 3rd in league = 102.1 w/ Fenwick = 42.%.
* Immediately lost 8 in a row + never recovered 🡺 finished @ just 81 points w/ more regulation losses than total wins.
* Blamed injuries, but might’ve also considered **team's worst-in-the-league 97.2 PDO** from the start of 8-game losing streak to end of season 🡺 **That, too, was long predicted.**
* Leafs in lockout-shortened 2013 season got into playoffs despite season-long PDO = 103 (No. 1 in NHL) + possession #’s = 44% (30th in NHL) + also claimed this was all part of their “system.”
* Had season been a full 82 instead of 48, they, too, probably would’ve suffered inevitable collapse *that came next season instead.*
* Now Avalanche = trying to distract selves from the fact they got bounced + significantly out-possessed by deeply mediocre Minnesota team in last year's playoffs + clearly learned nothing from the latest “test case” in Toronto that sent assistant coaches + GMs alike scurrying to unemployment office + brought in all the thinkpieces about nerds having definitively won once and for all.
* Might just believe they're a team like the Bruins
* PDOs posted by Claude Julien's clubs last few years (1st, 3rd, 14th, 1st again from 2010-11 to ’14, , + never < 100)
* Whatever Julien seized upon, it's leading to high save %’s + shooting %’s overall.
* Can attribute this to world-class goaltending from Tim Thomas + Tuukka Rask, minutes-eating of Chara, + the fact that Patrice Bergeron = world-class center.
* But with *that high PDO* (can't call unsustainable, based on what evidence here suggests) comes w/ **the fact the Bruins' possession #’s have been sky-high as well** (16th, 5th, 4th, 6th)
* Are also literally the only team that does this consistently over last few years.
* Even teams like Chicago + LA, other definitive elites over that time, can't really keep up shot-quality efforts as routinely as Boston, even as possession #’s are almost invariably better.
* Can almost see where Patrick Roy + Co. are coming from 🡺 have a very high-quality top-6
* can say has moved laterally at very best in replacing Paul Stastny at center w/ improving Nathan MacKinnon, then slotting Jarome Iginla into wing slot MacKinnon previously occupied
* Stastny drove play consistently in a way haven't seen MacKinnon accomplish yet, especially on road, or against tougher competition.
* If being asked to play the middle, instead of Ryan O'Reilly for instance, that could lead to more questions than answers at the other end of the ice.
* *But bottom 6 is awful, + was made it actively worse in summer by acquiring Danny Briere for no reason at all*
* Avs are, therefore, counting on a lot of development from MacKinnon + continued dominance from Duchene, despite the fact = guy who ate all of Colorado's toughest minutes last year = now playing for a different team in same division.
* And Chicago, Dallas, Nashville, Minnesota, + so on got better
* Conference will be a knife fight from beginning to end + Avs saw fit to actually make sure their switchblade was a little bit smaller than last year, when it absolutely didn't have to.
* To that end, when considering Avs' blue line, must really wonder who's going to do what to improve
* # of even-strength shot attempts conceded by Avalanche last year = 26th in league, ahead of only really awful teams
* Didn't add anyone to help, + in fact brought in someone who's going to hurt (Brad Stuart = awful)
* D corps = going to get run over once again, + it's tough to be sure they can keep suppressing shot quality, 🡺 last year = got lucky
* **Shot-quality reduction** isn't really a big factor for any team (save, again, for Boston, but Bruins have top-shelf goaltending) + that's if teams have a strong collection of defensemen from Nos. 1-6
* If Keith, Seabrook, Oduya, + Hjalmarsson can't keep opponents from getting quality chances (unlucky in this regard last year, for sure), how can you say Erik Johnson, Brad Stuart, Hejda, + Barrie can?
* Examine **goaltending** = **ultimate determiner of save % at any rate**.
* Colorado's even-strength save % last season = ~.931, 5th in league = about 3/4 pts. higher than what Semyon Varlamov (.935 all by himself) has done past few years = potentially huge difference given the gargantuan # of shots he faces per 60 minutes of even-strength ice time (32.5)
* If he plays 3,200+ ES minutes again this season + faces even a *similar* # of shots to the 1,772 from last season, a 6-point drop in save % does major damage = extra 13 goals against, or > 4 pts. in the standings just from him alone.
* If Varlamov plays fewer minutes (ex: gets hurt) + backup Reto Berra has to take a heavier workload, that = even greater # of minutes in which Avs' goaltending will be worse.
* JS Giguere's ES save percentage last season = .924 in nearly 975 minutes.
* Give that much time to Berra (abysmal .905 ES) == another 9 G conceded/3 pts. in standings conceded
* So, from a goaltending standpoint *alone*, regression to historical norms cuts Avs' point total by 7.
* Even before you factor in D's so-called “ability to inhibit shot-quality”
* Also consider Colorado's health last year 🡺 only lost 204 man-games to various ailments, 19th in league
* Can probably expect that # to go up as well, + that's where team's depth kicks in 🡺 they have none
* In reality, the #’s guys say this team could lose as many as 20+ points from last season's total by the time it has played 82
* Even being more conservative, @ a drop of 12 or 15, that presents big problems.
* Given league's new divisional playoff format, dropping into high 90s = move from “comfortable in division” to “oh my god we have to play the Blackhawks/Blues/Stars in the 1st round.”
* This is NOT a team equipped to stand up to what Chicago or St. Louis or (potentially) Dallas will be able to do for 7 straight games 🡺 couldn't take Minnesota last year.
* *They'd probably call that bad luck, which is funny.*
* **Analytics have proven time + again, year after year, this can't happen over, say, 50 (or in outside cases 100) games. Over 164, forget about it.**
* People will say all year Colorado is a “test case” for analytics.
* Hockey world outside greater Denver area largely accepts as gospel that this kind of play simply cannot be kept up.

# Analytics, not statistics, driving NHL evolution (2014)

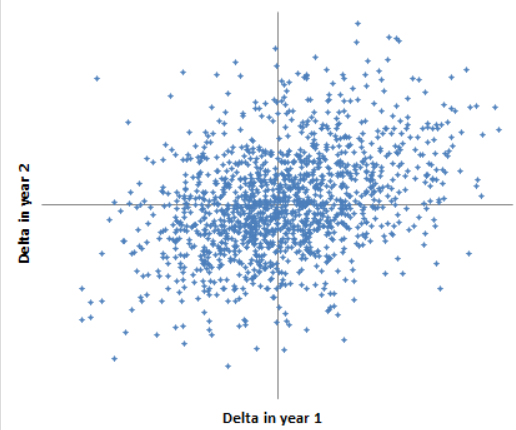
* Every June, executives + columnists wax poetic about traditions that make hockey; handshake line, passion + pain threshold of players, Stanley Cup.
* What has truly made hockey into the exhilarating sport + thriving industry it is today = its ability to adapt, fusing playmaking concepts from European soccer w/ rugged athleticism of rugby + structure + tactical teachings of lacrosse.
* Evolution continues w/ addition of analytical specialists in hockey operations departments of several teams (highlighted by Kyle Dubas named assistant GM of Maple Leafs)
* Such developments suggest hockey may be in process of learning its most important lesson, 1 baseball has only recently come to terms with itself: *"If we weren't already doing it this way, is this the way we would start?"*
* That = the question Paul DePodesta asked Billy Beane when they met: *Was Beane's process guided by principles of accuracy + efficiency or by convention and tradition*?
* For Beane, who soon faced the loss of 3 big-time free agents, the question made an impression.
* < 3 years after he + DePodesta joined forces, 2002 A's won 20 games in a row, an AL record.
* Despite having lowest payroll in baseball, Oakland tied for best record in MLB
* Beane + DePodesta revolutionized baseball w/ those accomplishments. Now, more than a decade later, hockey is facing a similar tipping point.
* There has been an attempt to distance the sport from the "Moneyball philosophy," laid out in "Moneyball: The Art of Winning an Unfair Game," by Michael Lewis.
* *Hockey insiders suggest statistics only lend themselves to slower games which stop + start following every play*
* **But "Moneyball" wasn't about advanced statistics or $**; **it was about thinking differently, asking questions, + never being satisfied w/ doing things the way they’ve always been done**
* "In such a tight market for talent, needed to look beyond conventional means of thinking," hockey executive Mike Gillis told Bruce Dowbiggin in "Ice Storm: The Rise and fall of the Greatest Vancouver Canucks Team Ever."
* Gillis = GM of the Cancuks in run to 2011 Stanley Cup Final.
* "In hockey, people have not wanted to go beyond their experience to find new solutions," he said. "Some hockey people dismissed 'Moneyball' b/c Oakland never won using it. But A's = small-market, + when they taught big guys how it works, advantage was gone. Red Sox *did* adopt those principles + won 2 World Series"
* **Principles of "Moneyball" apply to hockey as much as any other sport, + in order to claim an understanding of the game, executives must be willing to look at it from every angle**
* *This is where analytics come into play 🡺* **willingness to discard preconceived notions that don't stand up to strict scrutiny = already playing a role in separating successful teams from the rest**
* 1st step in embracing analytics = **to understand them**.
* Only w/ that base can misconceptions + biases that skew hockey decision-making @ the highest level be appreciated.
* Last season during a "Hockey Night in Canada" broadcast, when the Oilers lost to Vancouver 6-2, analyst Glenn Healy commented on Oilers' performance in a manner which echoes how many sports fans feel about the analytics movement.
* "When you look @ the stats, every stat was in Edmonton's favor. They were better in faceoffs. They were better in hits. They had more blocked shots. But they weren't even in the game."
* Seems to be an idea among those who oppose analytics that Healy's words present a flaw in the practice, that those who believe in analytics think adding up #’s in a box score should produce game's winner

In this instance, Healy was arguing against a caricature 🡺 ***\*\*\*There is a crucial difference between statistics and analytics\*\*\****

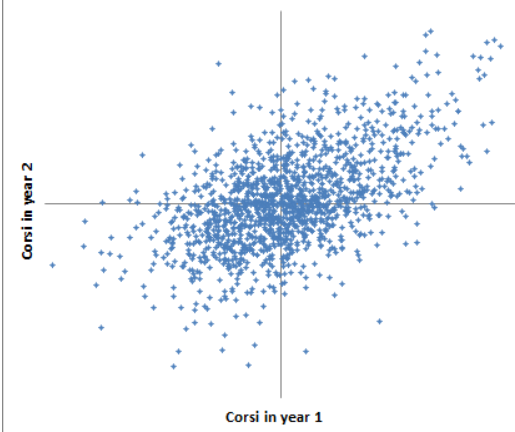
* A **statistic** = simply a piece of data (Sharks defeating Kings 2-1 = a statistic, Tyler Seguin scoring 20th G to put the Stars up 4-3 = a statistic)
* **Anything can be a statistic, + that is why they say statistics can be manipulated to fit any narrative**
* **\*\*\*Analytics** = **distinct study of statistics to find meaning**\*\*\* 🡺 analysts look for **reproducible patterns** in **large samples** which **illuminate** important **lessons** about the game.
* "If a metric is consistent over time, it's a reliable gauge of skill”: A.C. Thomas, co-founder of popular advanced-stats website War-On-Ice.
* Any analyst would say player's performance on Thursdays in March or team's home/road power-play splits = largely meaningless.
* Misuse of statistics = poor analytics (just as taking player's quote out of context = poor journalism)
* "For an analyst to suggest a metric has value, **need to be able to explain how or why it relates to outcomes we desire**, **most generally goals for or goals against**": Stephen Burtch
* "Once we can ID how it relates to winning, **need to be able to show it describes something meaningful + that it relates relatively strongly to goals/wins**."
* Hits = prominent example of a dividing-line statistic.
* Purists cite it as a difference-maker + analysts dispute its importance.
* To evaluate their claims, **analysts test every # under a high degree of scrutiny**.
* *What is a “hit”? How is it tracked? Have more hits historically = more wins?* ***Are there problems w/ the statistic?***
* *Turns out hits = unreliable metric 🡺 Team w/ puck the most = fewest opportunities to record hits*
* Ultimately, there’s very little correlation between hitting + winning.
* Hit = example of a play that *can* make an impact but *also of a statistic analysts have shown to be misleading*
* Analysts + non-analysts = on same side in struggle to counteract abuse of statistics.
* There’re a lot of #’s out there, but **if a statistic isn't a true indicator of performance or in large samples tends to predict future success, it can lead to misinformation**.
* **W/out thinking analytically: nearly impossible to determine which #’s = important + which = noise**
* **Trusting analytics is difficult w/out a fundamental understanding of metaphysics involved in sport.**
* Most conventional analysis treats hockey as a solely **deterministic entity 🡺** conditions which lead to every occurrence in a game, **deterministic theory** dictates*, couldn't have resulted in any other outcome.*
* i.e. Game's result = product of physical manifestations independent of past or future games.
* *Under a strictly deterministic lens*, winning = only metric that matters b/c every game is a clean slate +, *under fresh conditions*, anybody can defeat anybody + anything is possible.
* As commentators often state @ beginning of an important PP, "Throw the %’s out the window here"
* **Deterministic logic** *does* hold up in a hockey game 🡺 **Hockey = deterministic; every game is a fresh opportunity for success in an ever-changing environment.**
* **But the sport is NOT *exclusively* deterministic** 🡺 that = the key behind much of the disagreement between analysts + purists, between those who played @ a high level + those whose expertise rests in quantitative fields.
* Consider Texas Hold 'em, a form of poker where players combine privately held + publicly shared cards to form best possible hand, placing bets along the way.
* On the surface, seems like a very different game from hockey b/c it's all about **odds**.
* Player estimates chance of winning a particular hand based on available info + bets accordingly
* Game = **probabilistic in nature** = in long term, probabilities bear out.
* *Even if a player sees his full house defeated by a straight flush in 1 instance, he should bet on a full house winning the next time around.*
* It would seem as though hockey + poker are metaphysically opposed: 1 = deterministic, the other = probabilistic -- *but there is a problem with that view.*
* *Poker = an example of a game that is deterministic AND probabilistic.*
* Result of each hand comes from the physical process of shuffling, but b/c no players know the result of that process *beforehand*, the game = one of probabilities.
* *Hockey is very much the same way.*
* When Ovechkin decides to wind up for his patented one-timer from the left circle on the PP or to pass to the slot, he must take into account a # of factors: timing of windup, direction of swing, weight of the pass, + texture of the ice all decide, *in absolute terms*, where a shot would end up.
* If the puck doesn't go in, critics argue it was b/c *he* did something wrong.
* If he opts to pass + the play doesn't connect, they’d ask why didn't he take the shot?
* But whether the effort went bar-down + in or struck the wrong side of the post would **largely be a result of variance**, or as it's called in metaphysics, **chaos**.
* Because Ovechkin doesn't know how variance will impact his shot (how a deck will be shuffled), he must trust in probabilities + must to go w/ the play he thinks gives the Caps the best chance to score
* **During the course of thousands of repetitions, those probabilities will remain constant**.
* It is why best scorers during long periods tend to stay constant, but why in *individual* games/seasons there may be inexplicable hot + cold streaks.
* Players will make the right decision a certain % of the time based on their hockey IQ, + their physical makeup will allow them to deke, pass, check, clear, deflect, + score a certain % of the time.
* But the determination of when they’re able to do those things successfully = largely out of their control
* So, yes, each PP = a fresh chance to do the little things right + score a critical goal, but **through *enough* of those chances, the *true* talent of the group will be revealed, whatever it may be.**
* So, no, someone CAN'T throw the %’s entirely out the window.
* Fans generally think of luck in most blatant form: strange bounce, bad call, broken stick.
* **Variance**, though, affects results of games in *more critical ways*, and *THAT is why winning is NOT the only metric that matters*.
* **A good process, across a large #’s of games, will lead to the most wins.**
* Though winning a game in the present is nice, having *sustainable* success (making the playoffs, winning 4 playoff series in a row, or ascending to dynasty status) is what every team + player seeks.
* **Those successes = dictated by an accumulation of probabilities**; teams most likely to win the most games will *eventually* win the most games.
* **The aspect of variance that’s most difficult to understand = outcomes are NOT evenly distributed**
* Ex: Senators forward Bobby Ryan was left off U.S. Olympic team, + a story from ESPN's Scott Burnside revealed Ryan was disparaged in the process, w/ Calgary Flames executive Brian Burke metaphorically painting him as someone who "can't spell intense."
* In the 5 weeks following the decision, leading up to the 2014 Sochi Olympics, Ryan had 7 points in 17 games, causing commenters to opine Burke was right + Ryan missed an opportunity to prove the executive wrong
* It certainly wasn't the 1st time a player was criticized for a scoring drought, but it echoed a failure by many, from fans to executives, to understand variance + how it manifests itself in hockey + more broadly.
* When Apple's iPod came out w/ shuffle option, customers complained software must be broken b/c they kept getting 2 songs by the same artist back to back, or several in a row of the same genre.
* *Didn't think built-in randomness was "random" enough.*
* In reality, **randomness** "creates ***counterintuitively dense clusters***," + the **mind is programmed to read patterns even when none exist**
* According to Nobel Prize-winning psychologist Daniel Kahneman, we "understand sentences by *trying to make them true*."
* **If there’s the potential for a causal connection, we naturally cling to that explanation.**
* In an experiment done at a university in Barcelona, students were asked to predict a sequence of 5 coin tosses.
* In the aftermath, 1 student was IDed as having predicted the most tosses correctly, + 1 the least.
* Audience members were told they’d either be betting on the student who had been *least* successful for a 2nd round of flipping, or could pay to switch to the student who had done the best.
* Anonymously, 82% of audience paid to switch.
* *In a simple game that was so clearly decided by chance, the audience was fooled by randomness.*
* In the end, Barcelona students lost money betting on randomness disguised as reproducible success.
* Steve Jobs had to change the iPod shuffle feature to manufacture false randomness in a way that would appease customers.
* Bobby Ryan had to address the media to make excuses for a sudden inability to score that was more likely the result of variance than of criticism or skill level.
* **Hockey = fast, fluid game of small margins**.
* Even across samples as large as a season or 2, bounces can go 1 team's way more than another's.
* 1 player may see his shots tip in off of a stick or post, or may benefit from fortunate screens, + another may not.
* Variance = difficult to catch w/ naked eye, b/c a shot off the crossbar + in looks like something a player could repeat every time if focused.
* **Analytics have a ways to go in differentiating variance from talent, but an inability to recognize clustered randomness in extreme cases has led to some of the biggest management mistakes in hockey history.**
* Being wary of chaotic concepts can give a team numerous wins a season but falling prey to them can waste millions.
* From the time Bill James published his 1st "Baseball Abstract" in 1977, purists have accused analysts of not watching games, suggesting they treat a spreadsheet as manuscript + pleasure derived from sports is drawn only from calculations. *This, by and large, couldn't be further from the truth.*
* Massive amounts of most cutting-edge analysis in hockey have been recorded by watching game film repeatedly + tracking metrics in an attempt to make sense of what goes on at ice level.
* But there are also reasons *only* watching games isn't sufficient, + why conventional scouting alone is flawed
* 1st problem = *nobody can watch every game*.
* Even w/ an implausibly packed schedule, a scout could see ~300 games a year, split between teams and leagues.
* A GM or coach will watch mostly his team's games, seeing snippets of other players as a result.
* **Analytics allow the ability to attain a level of insight into a team or player that can't be gleaned from sporadic viewings.**
* #’s *can* see *every* game + provide a better idea of how a certain team/player is doing than by going off past viewings, hearsay, the odd shift, or, worst of all, reputation.
* **More statistics available, + the better those statistics are at measuring value = better the insight**
* That's why some advanced stats are better than goals, assists, +/-, etc. 🡺 They get you closer to an all-encompassing understanding of a game in a sport that tends to be dictated by selective viewing.
* **Advanced statistics provide a more precise understanding of the broader game.**
* Beane was asked a question about trusting the eye test + responded, "The idea that I trust my eyes more than the stats, I don't buy that b/c I've seen magicians pull rabbits out of hats + I just know that rabbit's not in there."
* Sports = obviously different from magic tricks, b/c players aren't intending to fool the viewer at every turn, but there is so much happening during any play that a similar effect is present.
* "The eye test isn't sufficient for analyzing a fast-moving game like hockey," Burtch said. "There's just far too much going on at far too fast a pace for any 1 individual to easily track + store the info they're seeing via memory."
* Hockey's pace makes numerical analysis + eyeball scouting more difficult when compared to baseball, but doesn't make either method less valid.
* Just means each needs to be handled with more scrutiny.
* Watching games can give us info but *can't get us all the way there*.
* Preconceived notions, biases, + inability to capture everything that happens make the eye test imperfect as a means of evaluating performance.
* There needs to be an objective layer 🡺 That is what analytics provide.
* Around the time Beane's Oakland team was becoming a contender, hockey's wave of analytics was beginning to take shape in the comments section of blogs like Irreverent Oiler Fans.
* Impassioned fans who understood analytic principles searched for areas of the game that most strongly correlated to winning, attempting to syphon the variance/chaos that clouded decision-making + analysis at the highest levels.
* They found that **shot-attempt differentials, w/ a sample size that accumulated far quicker than a +/- of goals or regular shots, were able to do that** 🡺 led to the creation of **Corsi** = a metric that has infiltrated the mainstream media + front offices, + on NHL.com = called Shot Attempts
* They discovered that **uncharacteristically high or low shooting + save %’s**, even during a full season, **aren't sustainable** for players or teams.
* Therefore, **adding them together + comparing to past team performance or league averages can work as a decent proxy for variance** 🡺 became known as **PDO** (called **SPSV%** on NHL.com)
* Several pioneers (Tim Barnes (Caps), Tyler Dellow (Oilers), + Sunny Mehta (Devils)) now work for teams + find ways to account for parts of the game that puck-possession metrics like Shot Attempts miss, + to reconcile newfound importance of controlled-zone entries + deployment optimization w/ challenges including imperfect data recording, changing environments, and noise.
* For some teams, that’s meant sweeping systematic changes.
* Wild have gone from a neutral-zone-trapping, dump-and-chase behemoth to promoting controlled entries + faster play, leading to vastly improved even-strength #’s recently undone by disappointing goaltending + special teams.
* For others it has meant an evolving lineup structure 🡺 Leafs waived physical players Colton Orr + Frazier McLaren + signed undervalued targets Daniel Winnik + Mike Santorelli
* Ultimately, **judging analytics on short-term results of recent converts = an affront to the analytic process itself**.
* \*\*\***Analytics aren't any more of a magic bullet than a new GM or a first-round pick \*\*\***
* "B/c #’s are involved, there’s the perception that statistical predictions have to achieve perfect accuracy": Rob Vollman. "But results only need to be compared w/ *traditional* analysis."
* In other words, **analysts aren't trying to take unpredictability out of sport but are attempting to improve on evaluative practices.**
* Adopting an analytical mindset in a salary-cap world can't overcome challenges created by fielding a bad team, but **by extracting a fraction more out of every player + situation through optimal deployment + then working to improve by acquiring undervalued assets + avoiding costly mistakes, are the ways a team can pave the way for a successful future.**
* "Analytics = about effective decision-making w/ a high reward," said Thomas, War-On-Ice founder.
* "If hiring someone for $100k right now can get you a free-agent-value savings of $1M + more flexibility under the cap, they've paid for themselves right there."
* Stars GM Jim Nill told Travis Yost: "We’re all trying to get 3-5% better. It's a cap world + we’re limited. We are always looking for the next thing."
* A team can win w/out analytics, + many will lose employing them, but the additional info + a scrutinized process provide a greater chance at success.
* As metrics improve + attitudes shift, this will become more apparent.
* Analytics have led hockey execs, journalists, + fans to pose the same question DePodesta asked Beane prior to joining him in Oakland, + have precipitated a massive shift in ways teams do business.
* Rather than exclusively trusting the eye test, condemning players for misfortune in small samples, or labeling players as lazy/enigmatic based on reputation or hearsay, **analytics has provided the opportunity to scrutinize decision-making and avoid those characterizations.**
* **Dismissing analytics = settling for an obsolete method of evaluation + using an inefficient business practice.**
* "Hockey analytics = simply the objective analysis of hockey," Vollman said. "Teams are bringing in outsiders to challenge conventional wisdom, + there's an opportunity to gain an edge."
* NHL has experimented w/ SportVision to work on advanced player tracking w/ microchips placed in pucks + jerseys, + that could lead to an entire new world of data to be analyzed.
* The so-called "Summer of Analytics" doesn't represent the beginning of analytical adoption in hockey; analytics have been in use for some time.
* It proves, in no uncertain terms, that Beane's progressive thinking is flowing into hockey.
* Inclusion of enhanced stats on NHL.com + a partnership w/ SAP that’ll continue to expand + is expected to produce further innovations could help.
* If a 28-year old former sports-management major, a university statistics professor, + a practicing lawyer (none having played professional hockey) can successfully replace longtime execs, the door is open for other innovative thinkers to follow them into positions of influence.
* Execs, journalists + fans will continue to revere the tradition behind the Cup, but the future will bring new challenges to teams hoping to win it, + *that's good.*
* The spirit of evolution that has crafted the hockey we enjoy remains alive, well and back on track
* **PUCK POSSESSION**
* **\*\*\*Shot attempts = best proxy for puck possession\*\*\***
* Not all shots = created equal, but **good teams create more shots + chances than opponents**, a process = far less subject to variance than *actually* scoring
* *Teams w/ best even-strength shot-attempt differentials tend to perform best in regular season + Playoffs*
* **ZONE ENTRIES**
* Manual tracking games = uncovered evidence opposing use of **dump-and-chase** as a primary strategy
* **Controlled entries** of offensive zone lead to, ***on average***, 2X as many shot attempts as dump-ins
* Contrary to popular belief, *forcing other team to move the puck 200 feet doesn't appear to significantly decrease opposition chances.*
* **SCORE EFFECTS**
* *Trailing Teams = tend to shoot more, + for a lower %, than leading teams or when score is* tied
* **Any useful statistic needs to be adjusted for the score @ time in it is recorded; otherwise oft-trailing teams will appear better than they are by shot metrics.**
* **BACK-TO-BACKS**
* Goaltenders who start on back-to-back nights have save % on average 11% points *lower* (.901 vs. .912) on *the 2nd night*
* So, teams w/ a good backup should split back-to-back starts as much as possible to avoid such drop-offs
* **PLAYER DEPLOYMENT**
* Analyzing where players begin shifts after stoppages of play (**zone starts**) can help determine how much they’re driving puck possession + offer some insight into coaching strategy.

## How to bring shot quality into player evaluation: Can we improve on Corsi by factoring in shot location and type?

* **Not all shots are equal**
* Stats community relies heavily on **shot differential measures** (**Corsi**, **Fenwick**) that *don't make any effort to account for quality of shots*.
* Shot quality must matter 🡺 try to factor it in
* Michael Parkatti created **Expected Goals** = instead of treating all shots equal, put a *weight* on each shot *based on how often shots of that type + location go in* = Makes a lot of intuitive sense
* 2006: Ken Krzywicki published detailed regression analysis of the likelihood any given shot would go in = <http://www.hockeyanalytics.com/Research_files/Shot_Quality_2006_Krzywicki.pdf>
* Tom Awad built on that + produced a stat = **Delta** = almost identical to Michael's expected goals but also added **corrections** *for situation, opponents, + teammates in* ***DeltaSOT***.
* Later, Sports Analytics Institute was selling something very similar to Delta to the Penguins.
* Michael Schuckers added in plays *other* than shots + also accounted for quality of teammate + competition in **Total Hockey Rating (THoR)**
* \*\*\*So why haven't any of these stats really caught on?\*\*\*
* Easy to dream up a new stat, **but how do you decide whether it's meaningful?**
* Simple intuition = not enough + many stats are not really important (think about popularity of hits, plus/minus, goalie wins)
* There's a certain standard of proof required for a new stat to catch on widely
* <https://www.sbnation.com/nhl/2013/11/21/5096220/nhl-stats-advanced-idiots-criticism>
* 1 basic expectation = advocates look at whether it is a **repeatable talent** = important b/c it tells us *how to interpret strong results.*
* Think about the 2 possible scenarios:
* If stat is highly repeatable (ex: Corsi), a player posting good #’s for a stretch = good news + it means they're probably genuinely good at it + we should expect them to continue to do well.
* **If stat is poorly repeatable (ex: on-ice save %), a player posting good #’s for a stretch is likely bad news = means we should bet on them fading as performance regresses toward the mean.**
* Pretty important difference 🡺 hard to be enthusiastic about a new stat before we even know whether to be excited or concerned if a player top-ranked
* Another important question for analysts to answer: \*\*\***if the stat is repeatable, does it correlate with future results?\*\*\***
* # of hits = highly repeatable stat, but its’ clear it doesn't bear much relation to success.
* **\*\*\*Be skeptical of any stat that doesn't come w/ an assessment of correlation to future results.**
* Until recently, that's never really been done for any of these stats.
* Evaluating shot quality measures
* Parkatti found that, in 1 season, expected goals @ the team level became more predictive than Corsi after ~35 games
* *Be aware: Corsi significantly outperformed shot quality measures in other years*
* <https://www.sbnation.com/nhl/2013/12/3/5153828/nhl-stats-close-range-shots-predictions>
* Schuckers looked more closely at THoR + showed it had a higher YOY repeatability @ player level than Corsi + subsequently observed that, w/in a game, a team's total THoR = better predictor of the outcome than shots on goal (*though not as good as Corsi)*
* <http://statsportsconsulting.com/2013/11/13/an-evaluation-of-the-total-hockey-rating-thor-part-i/>
* <http://statsportsconsulting.com/2013/11/26/an-evaluation-of-the-total-hockey-rating-thor-part-ii/>
* Analysts testing new statistics = a significant step forward that allows us to assess utility of metricc, but *there's still a hole in the analysis*
* **Key question = "Should we expect a team that does well by a metric over 1 period of time to outscore opponents in the future?"**
* And, relatedly, **"If a team does well by this metric w/ a certain player on the ice over 1 period of time, should we expect them to outscore opponents in his future minutes?”**
* The 1st one but not the 2nd was answered for Expected Goals.
* Schuckers published info from which you can infer implications about the 2nd, but didn't directly answer either
* A closer look at Delta
* Few metrics have been published for public scrutiny, Awad did w/ 4 years worth of tabulated **Delta** (<https://drive.google.com/drive/folders/0B8D4onnbcAAUMjhlNTc0NjYtNjQ1NS00NGZmLTkzNGYtZTYxOTAzNTVkNTU3?hl=en&tid=0B8D4onnbcAAUNDJjNmRkNjMtNzEyYi00YmY2LTg4YjUtZGZiOTNhNmUwMzcz>) which allows us to do the legwork to assess its utility.
* By comparing it to Corsi, we can look at how much value **shot location + type** data has added.
* Correlation between a player's Delta 1 year + Delta in the next year = 0.35, a modest figure + enough that a player's Delta in 1 year tells us something about what to expect next year
* But, players obviously bounce up and down a fair bit from year to year.



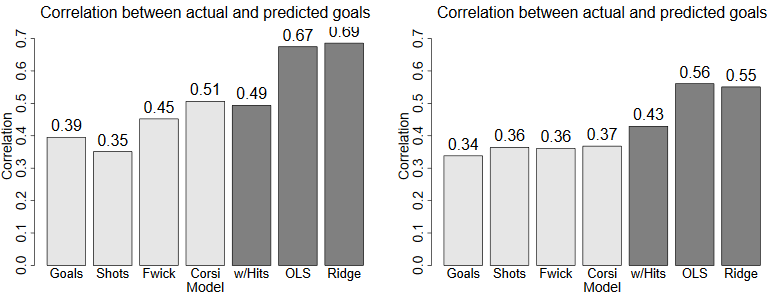
* If repeatability were really high, dots on plot would = straight line (if we know how a player did in year 1, can predict very accurately how they’d do in year 2)
* Here, result isn't completely random 🡺 definitely a bit of a slope from bottom-left to top-right.
* But it's NOT a *strong* relationship 🡺 players near bottom of league in year 1 = all over in year 2, so points scatter into more of a blob than a line.
* *Is Corsi more repeatable?* 🡺 Yes 🡺 repeatability = 0.56 + points are clustered more towards a line:



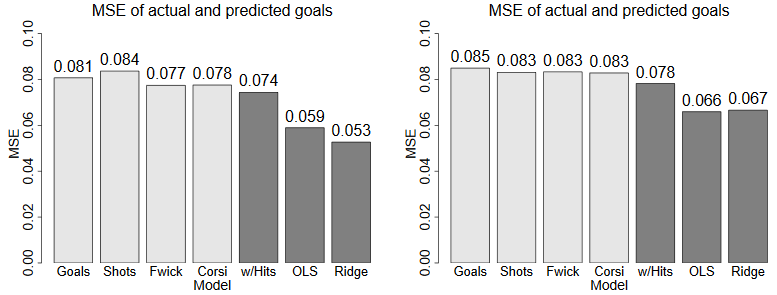
* Still a fair bit of spread in the data, but dots = more tightly grouped + blob is elongated into a shape w/ a distinct slope to it = how a more **repeatable** stat looks
* range of possible year 2 outcomes = smaller, so blob = compressed more closely like a line
* **Repeatability isn't everything** (hit totals) 🡪 can still not predict future outcomes.
* Question is really **whether factoring in shot quality leads to a stronger correlation to future scoring**
* ***Is the added info more important than the added noise?***
* There’re lots of different ways to use data for this assessment.
* Do we express Delta + Corsi as **cumulative** (counting) statistics or as **rate** statistics?
* Do we include all players or just ones w/ significant playing time?
* It turns out that it doesn't matter in this case:
* 
* No matter what form data is in, Corsi = better job of predicting next year's goal differential w/ the player on the ice than Delta does.
* **This is b/c the “shot quality” factor in Delta has a lot of randomness in it**.
* variability = so bad that not only is Delta a *worse* predictor than Corsi of future goal differential but is *even a slightly worse predictor of future Delta.*
* Remember: Only difference between Delta v. Corsi = Delta accounts for location + type of each shot.
* *So, doing significantly worse @ predicting future implies including shot quality factor = not helping*
* THoR = more repeatable than Corsi or Delta, but unless Schuckers has markedly improved on Krzywicki's shot quality assessment, it’s likely that this arises from inclusion of plays like penalties + faceoffs + NOT from inclusion of shot location data.
* **“Shot quality” factor appears to add more noise than value over sample sizes of ~82 games** = why these metrics have never really caught on.
* Extracting value from shot quality
* **\*\*\*Added info should NEVER make analysis worse\*\*\***
* When people try to incorporate shot quality 🡪 often makes things worse b/c they **fail to account for variance.**
* **Shot quality measures have a lot of random fluctuations**, but CAN add value in some instances as Parkatti + others have shown.
* However, ***to get the most out of them*, they must be regressed *properly* 🡺 must pull estimates in towards the average so random fluctuations don't have a large influence on our assessments.**
* **As long as sample sizes = large enough that shot quality factors aren't *completely* dominated by randomness, including them w/ a proper regression will improve quality of the analysis a bit.**
* Ex: for putting together very best evaluations they can:
* **Step 1: Include shooting talent too**
* Shot type + location = easier to pull from scoresheet than shooting skill, so it's what most people focus on.
* But **shooting talent** = nearly as large a factor in shooting % as shot location is
* Might expect shot location to be an even smaller factor for on-ice shooting %.
* Guy who plays in front of net = many shots from in close
* But if every line has 1 of those guys, won't necessarily see a difference *between lines* in average shot distance the way we do for individuals
* So, *do the extra work* to figure out not just *what type* of shots a player takes, but also *whether he scores on more of those shots than the average player.*
* **Step 2: Account for scorer bias**.
* Rinks don't record shot location very accurately + some rinks tend to record shots as being closer than others 🡺 can have a disastrous impact on results
* Over the 4 years Tom tabulated Delta, Colorado = middling 8.18% 5v5 shooting % + 99.8 PDO, yet had 16 players among top 10% in the league in Delta's shot quality factor.
* W/out even looking, can bet they had a huge home/road split indicative of a biased scorer.
* **Step 3: Separate shot quality For + shot quality Against, + separate forwards from defensemen**
* We know forwards drive shooting % a lot more than defensemen + that save % differences = more heavily driven by variance than shooting % differences.
* So, don't want to lump everything together 🡺 some shot quality factors will need to be regressed more heavily than others.
* **Step 4: Regress the data**.
* For each shot quality factor, **calculate variance across the league + variance contributed by simple random chance.**
* Difference between the 2 = amount of variance due to some factor of skill or usage
* the smaller that is = the more you should pull each player's observed results in towards the mean to account for the role of chance.
* **Step 5: Show that your data is better**.
* Now that you've gone through these steps to calculate something that should be better, don't stop here 🡺 ***prove it to the reader***.
* Dot the i's by calculating correlation between your measure + future results + show you've actually produced a better estimate of value.
* Good = simplicity of just using shot differential 🡺 very nearly as precise + much simpler to explain.
* Still, there’re occasions where we want the *very best accuracy* we can get.
* In those cases, including all available info makes sense, **but it needs to be done carefully, + readers should expect to see the result tested**

# [Expected goals & ridge regression](http://www.hockeyanalytics.com/Research_files/NHL-Expected-Goals-Brian-Macdonald.pdf)

* <http://www.hockeyanalytics.com/Research_files/NHL-Expected-Goals-Brian-Macdonald.pdf>
* 1 difficulty w/ analyzing performance in hockey = relatively low scoring rates vs. to other sports
* **Fenwick rating** (shots + missed shots) + **Corsi** rating (shots, missed shots, blocked shots) have been used to analyze players + teams b/c they’ve been shown to be better than goals as a predictor of future goals
* “missed shots” = an attempted shot that went wide of net, over net, or hit post
* Can use variables like faceoffs, hits, + other stats as predictor variables *in addition to* goals, shots, missed shots, + blocked shots, to predict goals.
* These models outperform previous models w/ regard to **mean squared error** of actual and predicted goals.
* Results can be interpreted as **expected goals** + can be used in adjusted +/- models *instead of goals*
* Used **Ridge regression** to estimate player’s contribution to team’s expected goals per 60 minutes, *independent of his teammates, opponents, and the zone in which his shifts begin*.
* Also give **adjusted +/- estimates** based on goals, shots, Fenwick rating, + Corsi rating alongside results for expected goals to provide an *additional* means by which NHL analysts, decision-makers, + fans can measure how valuable a player is to his team.
* 1 Introduction
* Low scoring rates = source of difficulty when analyzing team + player performance in hockey, particularly when using < a season’s worth of data.
* Randomness + scarcity of goals limit the ability to properly judge current performance + predict future performance of teams + players using goals *alone*.
* Shot differential, Fenwick rating differential, + Corsi rating differential = popular in hockey analysis community for analyzing performance of teams + players.
* 1 reason hockey analysts use these statistics = one can obtain better predictions of a team’s future performance by using shots, Fenwick or Corsi rating *instead of goals*.
* Specifically, **team’s current shot, Fenwick, + Corsi differentials = each better than current *goal* differential at predicting goal differential when a ½ season’s worth of data is used [1].**
* These statistics = less scarce + less random than goals, + are good indicators of **territorial advantage + possession advantage** @ the team level.
* 1 benefit of using these statistics to evaluate a player’s performance = for the most part, **goalies will not have a big impact on a player’s defensive ratings**.
* Further details about benefits of using Fenwick + Corsis rating are discussed in [1], [2], [3], [4], [5]
* 1st goal of paper = to answer following question: **Can the above predictive performance be improved further if including additional stast = hits, faceoffs, etc., as predictor variables, along w/ some combo of goals, shots, missed shots, + blocked shots?**
* Form new models using these stats + show they perform better than previous models *in terms of mean squared error* of predicted goals + actual goals.
* **Focus** strictly on **team offense**, + we **restrict** attention to 5v5 situations in which both goalies are on ice.
* *Unless otherwise specified*, all stats throughout paper = given as “per 60 min" **rate stat** during *even strength* situations.
* \*\*\*Ex: “Goals” or “GF” = “Goals For per 60 minutes of playing time at even strength."
* Results of models = interpreted as “**expected goals**” based on various stats mentioned above.
* Many uses for an expected goals statistic
* to evaluate team offensive + defensive performance over a ½ season’s worth of games.
* to evaluate players
* 2nd focus of paper = **use of expected goals in an adjusted +/- model to evaluate players.**
* Adjusted +/- models were introduced in basketball ([6], [7], [8], [9]) to estimate player’s contribution to team, independent of strength of teammates + opponents.
* 1 main downside of adjusted +/- = large error bounds on estimates of player performance obtained from the model.
* 1 reason for large errors = **tendency of some teammates to play together often = causes collinearity to be present in the data.**
* Ex: Daniel Sedin is on ice w/ twin brother Henrik 93% of the time, + their adjusted +/- estimates have very large error bounds as a result.
* Another source of large errors in hockey = low goal scoring rates.
* In light of these issues, used an adjusted +/- model similar to those described in [10], [11], [5], using ***expected* goals per 60 minutes as dependent variable instead of goals per 60 minutes.**
* Results give an estimate of player’s contribution to team’s expected goals, independent of strength of teammates, opponents, + zone in which his shifts begin.
* 1 main benefit of using expected goals = much more data compared to just using goals = helps produce lower error bounds.
* Also use **ridge regression** (1st first used by Joe Sill in basketball [12] to estimate each player’s adjusted +/-)
* **Ridge regression = statistical technique commonly used when collinearity is present in data +** helps reduce error bounds in estimates + typically improves model’s predictive performance
* Also use ridge regression to estimate adjusted +/- stats based on goals, shots, + Fenwick + Corsi ratings.
* Combo of ridge regression + expected goals, along w/ adjusted +/- results based on other stats provides useful means w/ which to analyze performance of players.
* 2. Two new models
* Used both **ordinary least squares regression** + **ridge regression** w/ goals, shots, missed shots, + blocked shots, along w/ several additional stats from ½ a season to predict **goals scoring rate** in the *other ½* of a season
* Team statistics considered:
* Goals Goals scored Shots Shots on goal
* Missed Shots = Attempted shots that missed the net wide/high, or hit goalpost
* Blocked Shots = Attempted shots blocked by opposing team’s forward/defenseman,
* Fenwick rating = Shots + missed shots
* Corsi rating = Shots + missed shots + blocked shots
* Zone starts = # of shifts that begin w/ a faceoff in the offensive, defensive, neutral zone.
* Turnovers = Giveaways and takeaways.
* Faceoffs = Faceoff wins, losses, faceoff winning %, net faceoff wins (faceoff wins - losses), + total faceoffs
* Hits = Player on team hit a player on other team
* Hits against = player on team hit by player on other team
* Shooting % = Team shooting % (= goals/shots)
* Used data from last 4 full NHL seasons + for each team, season was split into 2 halves.
* Midseason trades + injures can have impact on team’s performance, we did not use statistics from 1st ½ of season to predict *goals* in 2nd half
* **Instead, split season into odd + even games**, + used stats from odd games to predict goals in even games
* Data from 2007-08, 2008-09, + 2009-10 = used as **training** data to estimate parameters in the model, + data from entire 2010-11 = set aside for **validating** the model via 10-fold CV
* **Mean squared error (MSE)** of **actual goals** and **predicted goals** = choice for measuring performance of models.
* Chose subset of above predictor variables that yielded best fit, according to **adjusted R2**, in an **ordinary least squares (OLS) model**.
* Then removed 2 more variables which were not statistically significant.
* Predictor variables remained + used in OLS +ridge regression models 🡺 goals, shots, hits, hits against, faceoffs.
* Also tested Corsi rating w/ hits (Corsi rating + Hits Against - Hits)



* Correlation between actual goals + predicted goals using Goals, Shots, Fenwick rating, Corsi rating, as well as our new models, Corsi w/ Hits, OLS + Ridge.
* Left = correlation of entire 2010-11 season (validation data)
* Right = cross-validated correlation
* In both cases, OLS + Ridge have the highest correlation.
* Results for new models = given in dark grey.
* In order to compare results to those in [1], look @ correlation between actual vs. predicted goals using various models in Figure 1.
* Note correlations for goals, shots, Fenwick + Corsi ratings = fairly similar to those given in [1].
* Differences = likely b/c we’ve restricted to offense, while in [1], author considered both offense + defense.
* **Note**: Shots, Fenwick + Corsi ratings tend to have a slightly higher correlation than goals.
* Correlation between actual goals + predicted goals = highest w/ OLS + Ridge models.



* MSE of actual + predicted goals using Goals, Shots, Fenwick rating, Corsi rating, as well as new models, Corsi w/ Hits, OLS, + Ridge.
* Left = MSE for entire 2010-11 season as validation data set
* Right, CV MSE
* In both cases, OLS + Ridge have the lowest MSE.
* New models = lower MSE, indicating difference between actual vs. predicted goals = lower, on average
* Ridge estimates perform slightly better than OLS regression for 2010-11 season as validation data, while OLS performs slightly better when using CV.
* Since ridge regression typically performs better than OLS regression when predictor variables = correlated, use ridge regression results for computing expected goals in Section 3.
* ***Note***: In forming final model, removed 4 outliers: Ottawa + Carolina in 07-08 + Wild + Islanders in 2010-11, + also fit model w/out removing outliers, + results for correlation + MSE = similar (see Figure 3 the Appendix).
* 3: Using Expected Goals in Adjusted Plus-Minus
* Expected goals can be used to analyze team performance, but here we focus on player performance, and specifically on using adjusted plus-minus with expected goals to evaluate players. Recall that we use an adjusted plus-minus model similar to those described in [10], [11], and [5], using expected goals per 60 minutes as the dependent variable instead of goals per 60 minutes. Also, recall that we use ridge regression as in [12] and [5] instead of OLS regression. In Table 1, we list the top players in E of f EV , the offensive component of adjusted plus-minus during even strength situations based on expected goals. In that table we have also listed each player’s G of f EV , S of f EV , F of f EV , and C of f EV , which are the offensive components of adjusted plus-minus at even strength based on goals, shots, Fenwick rating, and Corsi rating, respectively. We also give some per 60 minute versions of these statistics in the last 3 columns. For comparison, the top 10 players in G of f EV , the Table 1: The top 10 offensive players in the NHL according to G of f EV . offensive component of adjusted plus-minus based on goals, are given in Table 2 in the Appendix. Not surprisingly, Sidney Crosby is the best offensive player at even strength according to both E of f EV and G of f EV , despite the fact that he missed significant amounts of time during the last four full seasons. The two lists contain many of the same players. Two players, Eric Staal and Jeff Carter, are in Table 1 but not Table 2 probably because of the number of shots that they generate (recall that shots was one of the variables that we used in our expected goals models). Nathan Horton may be a surprise as the fifth player in Table 2, as he is typically not regarded as one of the league’s best offensive players. One might prefer to consider a player with significantly better 4 MIT Sloan Sports Analytics Conference 2012 March 2-3, 2012, Boston, MA, USA E of f EV or S of f EV , like Zach Parise, among the top 5 offensive players at even strength instead of Horton. However, we note the strength of Horton’s teammates (2.43 goals per 60 minutes) is fairly low, and when Horton is on the ice, his team scores 3.20 goals per 60 minutes. That is a difference of 0.77 goals per 60 minutes, which is the third best total in the league among players with 600 minutes played2 . In light of this ranking, Horton’s G of f EV seems reasonable and he should be considered one of the best offensive players in the league at even strength. 4 Discussion The results of our model can also be used to analyze the relative value of different box score statistics. For example, in every model that we tried during our model building process, hits were a significant predictor, but not in the way you might think. We now discuss some of the predictor variables that we considered in further detail. Hits One thing that stood out from the model building process was that hits and hits against were significant statistics. That is not terribly unexpected perhaps, but it is the sign of the estimates for hits and hits against that may be a bit surprising. The coefficients of hits and hits against are negative and positive, respectively. This means that low hits, and high hits against, are good predictors of goals. In other words, the teams more hits against than hits are the teams with higher goals. There are two possible explanations. First, typically the team doing the hitting does not have the puck. So hits and hits against contain information about possession. Hits against indicate possession of the puck, and hits indicate that the opposition had the possession of the puck. Good puck possession teams have more hits against than hits simply because they have the puck more often than their opponents. Another potential reason is that a player who applies a hit often takes himself out of the play temporarily, along with the player he hit. A hit typically means the other team has the puck, and after a hit, the play can momentarily be 4-on-4 instead of 5-on-5. This is even more true on the power play. If a penalty killer hits someone on the other team, the play is temporarily 4-on-3 instead of 5-on-4, even if it is only for a half of a second. Even fractions of a second can matter, especially at the NHL level, and especially in the defensive zone. We remark that these results do not necessarily indicate that hits are bad, or that players should stop finishing their checks. But it does provide some evidence that hits, hits against, and puck possession are related, and that poorly timed hits can impact goal scoring. Total faceoffs Interestingly, total faceoffs were a significant variable. Intuitively, offensive zone faceoffs should be a significant predictor of goals, but the importance of total faceoffs is not as obvious. One reason is that total faceoffs contain some information about goals, since every goal results in a neutral zone faceoff. But even when we excluded the neutral zone faceoffs that followed a goal, total faceoffs were still significant. Another possible reason total faceoffs are significant is that the flow of a game is more structured after a faceoff, since a team that wins a faceoff can run an organized play. A third possible reason is that typically after a faceoff there is not a lot of dead time in the play when both teams are changing players “on the fly”. One team may hold the puck behind their net for 5-10 seconds while the substitutions occur, and this break in activity reduces the goals scoring rate (for both teams). On the other hand, after a faceoff, there is typically not a break in activity like this as often. We tried the model without total faceoffs. The performance of both the OLS model and the ridge model was reduced without the total faceoffs, however both models still performed better than shots, Fenwick rating, or Corsi rating alone. See Figure 6 in the Appendix. In the end we included faceoffs because performance increased with this variable, and while they may be not an obvious explanation for why they should matter, it appears that they do indicate an increase in goal scoring rate. 2 Incidentally, Crosby is first in this measure also, with 1.03 goals per 60 minutes. 5 MIT Sloan Sports Analytics Conference 2012 March 2-3, 2012, Boston, MA, USA Faceoffs Wins We note that if a predictor variable, such as faceoff wins or net faceoff wins, for example, was removed from our model, it does not necessarily mean that the statistic is not important. It may just mean that the statistic does not provide any information that is not already provided by other predictor variables. In the case of faceoff wins, one would think that they are important because possession is important. But several other statistics, namely shots, missed shots, and hits against, are all indicators of possession. Faceoffs wins, net faceoff wins, or faceoff percentage may not be adding much additional information about possession. 5 Future work and Conclusions A natural idea for future work would be to develop similar models for goals against or net goals. One added complication that goalies are involved, but one could take steps to account for the strength of a team’s goalies. We could also do similar studies for special teams situations. The significance of some statistics could be different for special teams situations as opposed to even strength situations. One problem with studying special teams would be the lack of data compared to even strength. Another approach we could take is to split the season in half using a random sample of 41 games, instead of using odd and even games, fit the model, and repeat this process many times. This approach may yield more robust results. A statistic like total faceoffs may have come up as significant in our model by chance, but may not be significant if the data were split randomly and the models were fit several times. Drawing any firm conclusions about a statistic like faceoffs could be deferred until after this approach is taken. One could also partition each season into smaller chunks of games. One may be interested in finding the variables that are the best predictors of performance in 10-game chunks, for example. The significant variables would likely change when using smaller chunks of data. For example, shots would likely become a stronger indicator than goals using a smaller chunks of games. Different sized partitions are studied in [13]. We noted that many of the predictor variables were correlated, which is one reason we chose the ridge regression model as our final model. Other methods, such as principal component regression or partial least squares regression, are commonly used when the predictors are correlated, and those models might improve performance. These methods are used in a forthcoming article [14]. In both of those methods, new uncorrelated predictor variables that are combinations of the original predictor variables are formed. It is typically harder to interpret the results for specific predictor variables (like we did for hits) with these models, which is one reason we chose to use OLS and ridge regression first. But if the main goal is to predict goal scoring, these models, and others like them, could prove useful. Bayesian techniques, non-parametric techniques, or time-series techniques, for example, could give better predictions. The results of any of these models could be interpreted as expected goals. We believe that the use of expected goals in a ridge regression to estimate adjusted plus-minus, coupled with the results based on goals, shots, Fenwick rating and Corsi rating, can be useful to NHL teams, analysts, and fans as they evaluate the performance of teams and players.