

# Calculating Point Shares

## I. Introduction

In 2002, Bill James introduced the Win Shares system to the world of baseball. The goal of the system was to estimate the number of wins (actually, win shares) "created" by each player.

Three years later, I used James' work as the foundation for a similar system for basketball.

Since the system seems to work well in both baseball and basketball, I decided to apply the idea to hockey. Some of the ideas I came up with were motivated by research done by hockey analysts Tom Awad, Iain Fyffe, and Alan Ryder, among others.

\* If you believe that any attempt to attribute team success to individual players is an abomination, then read no further, as this article will be of no interest to you.

## II. What is a Point Share?

Bill James developed his system such that one win is equivalent to three Win Shares. My system deviates from James' in three key ways:

In James' system, one win is equivalent to three Win Shares. In my system for hockey, one point is equivalent to one Point Share. James made team Win Shares directly proportional to team wins. In his system, a baseball team that wins 80 games will have exactly 240 Win Shares, a baseball team that wins 90 games will have exactly 270 Win Shares, etc. In my system for hockey, a team with 100 points will have about 100 Point Shares, give or take.

James did not allow for the possibility of negative Win Shares. In his system, the fewest number of Win Shares a player can have is zero. In my system, a player can have negative Point Shares. I justify this by thinking about it in the following way: a player with negative Point Shares was so poor that he essentially took away points that his teammates had generated.

## III. Marginal Goals For and Marginal Goals Against

The Point Shares system is based on the fact that marginal goals for and marginal goals against are linked to team points. At the team level, marginal goals for and marginal goals against are equal to:

$$\text{MGF} = (\text{team goals}) - (7 / 12) \times (\text{team games}) \times (\text{league goals per game})$$

$$\text{MGA} = (1 + (7 / 12)) \times (\text{team games}) \times (\text{league goals per game}) - (\text{team goals against})$$

\* Why 7/12? At even strength a team has six players on the ice, five skaters and one goalie. Imagine each of these players having two chips to contribute to one of two buckets: offense and defense. Collectively the skaters will contribute five chips to the offensive bucket and five chips to the defensive bucket. However, the goalie will contribute both of his chips to the defensive bucket, giving the defensive bucket seven of the twelve chips.

Marginal goals for and marginal goals against can be converted into expected points using the following formula:

$$\text{Expected Points} = (\text{league points per goal}) \times (\text{MGF} + \text{MGA})$$

For example, here is the calculation for the 2009-10 Pittsburgh Penguins:

$$\text{MGF} = 257 - (7 / 12) \times 82 \times 2.765 = 124.74$$

$$\text{MGA} = (1 + (7 / 12)) \times 82 \times 2.765 - 237 = 121.99$$

$$\text{Expected Points} = 0.4059 \times (124.74 + 121.99) = 100.15$$

$$\text{Actual Points} = 101$$

Doing the same calculation for all team seasons from 1917-18 to 2009-10 produces an average absolute error of 4.43 points per 82 games and a root mean squared error of 5.95 points per 82 games.

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## IV. Crediting Offensive Point Shares to Skaters

Offensive Point Shares are credited to skaters based on goals created and either time on ice (1998-99 to present) or games played (1917-18 to 1997-98).

### A. 1998-99 to present

We'll use Sidney Crosby of the 2009-10 Pittsburgh Penguins as an example:

**Calculate goals created for each skater.** In 2009-10, Crosby had an estimated 42.8 goals created.

**Calculate marginal goals for each skater.** Marginal goals is equal to  $(\text{goals created}) - (7 / 12) \times (\text{time on ice}) \times ((\text{goals created by forwards or defensemen}) / (\text{time on ice for forwards or defensemen}))$ . For Crosby this is  $42.8 - (7 / 12) \times (106699) \times (5280.1 / 25945836) = 30.1$ . Note that this formula may produce a negative result for some skaters.

**Calculate marginal goals per point.** Marginal goals per point reduces to  $(\text{league goals}) / (\text{league points})$ . For the 2009-10 NHL this is  $6803 / 2761 = 2.46$ .

**Credit Offensive Point Shares to the skaters.** Offensive Point Shares are credited using the following formula:  $(\text{marginal goals}) / (\text{marginal goals per point})$ . Crosby gets credit for  $30.1 / 2.46 = 12.2$  Offensive Point Shares.

### B. 1917-18 to 1997-98

Time on ice is no longer available, so it will be replaced with games played. We'll use Bobby Orr of the 1970-71 Boston Bruins as an example:

**Calculate goals created for each skater.** In 1970-71, Orr had an estimated 47.0 goals created.

**Calculate marginal goals for each skater.** Marginal goals is equal to  $(\text{goals created}) - (7 / 12) \times (\text{games played}) \times ((\text{goals created by forwards or defensemen}) / (\text{games played by forwards or defensemen}))$ . For Orr this is  $47.0 - (7 / 12) \times (78) \times (623.7 / 5867) = 42.2$ . Note that this formula may produce a negative result for some skaters.

**Calculate marginal goals per point.** Marginal goals per point reduces to  $(\text{league goals}) / (\text{league points})$ . For the 1970-71 NHL this is  $3409 / 1092 = 3.12$ .

**Credit Offensive Point Shares to the skaters.** Offensive Point Shares are credited using the following formula:  $(\text{marginal goals}) / (\text{marginal goals per point})$ . Orr gets credit for  $42.2 / 3.12 = 13.5$  Offensive Point Shares.

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## V. Crediting Goalie Point Shares to Goalies

Goalies will receive 2/7 of the team's defensive point shares, on average, although that fraction is adjusted upward or downward in seasons where shots against are available.

\* Why 2/7? Go back to the chips analogy above: of the seven chips contributed to the defensive bucket, two came from the goalie.

Shots against were not officially recorded until the 1983-84 season, so there is one method for 1983-84 to the present and another method for 1917-18 to 1982-83.

### A. 1983-84 to present

We'll use Dominik Hasek of the 1997-98 Buffalo Sabres as an example:

**Calculate the shots against adjustment for each goalie.** The shots against adjustment is equal to  $(\text{shots against per minute}) / (\text{league shots against per minute})$ . For Hasek this is  $0.5092 / 0.4494 = 1.133$

**Calculate marginal goals against for each goalie.** Marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{shots against adjustment}) \times (\text{minutes played}) \times (\text{league goals against per minute}) - (\text{goals against})$ . For Hasek this is  $(1 + (7 / 12)) \times 1.133 \times 4220 \times 0.0421 - 147 = 171.71$

**Calculate marginal goals per point.** Marginal goals per point reduces to  $(\text{league goals}) / (\text{league points})$ . For the 1997-98 NHL this is  $5624 / 2132 = 2.64$ .

**Credit Goalie Point Shares to the goalies.** Goalie Point Shares are credited using the following formula:  $(2 / 7) \times ((\text{marginal goals against}) / (\text{marginal goals per point}))$ . Hasek gets credit for  $(2 / 7) \times (171.71 / 2.64) = 18.6$  Goalie Point Shares.

### B. 1917-18 to 1982-83

Shots against are no longer available, so the adjustment for shots against will be removed from the equation. We'll use Ken Dryden of the 1975-76 Montreal Canadiens as an example:

**Calculate marginal goals against for each goalie.** Marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{minutes played}) \times (\text{league goals against per minute}) - (\text{goals against})$ . For Dryden this is  $(1 + (7 / 12)) \times 3580 \times 0.0561 - 121 = 196.99$ .

**Calculate marginal goals per point.** Marginal goals per point reduces to  $(\text{league goals}) / (\text{league points})$ . For the 1975-76 NHL this is  $4913 / 1440 = 3.41$ .

**Credit Goalie Point Shares to the goalies.** Goalie Point Shares are credited using the following formula:  $(2 / 7) \times ((\text{marginal goals against}) / (\text{marginal goals per point}))$ . Dryden gets credit for  $(2 / 7) \times (196.99 / 3.41) = 16.5$  Goalie Point Shares.

## VI. Crediting Defensive Point Shares to Skaters

Time on ice was not officially recorded until 1998-99, shots against were not officially recorded until the 1983-84 season, and plus/minus was not officially recorded until the 1967-68 season, so there are four methods: one for 1998-99 to present, one for 1983-84 to 1997-98, one for 1967-68 to 1982-83, and one for 1917-18 to 1966-67.

### A. 1998-99 to present

We'll use Chris Pronger of the 1999-00 St. Louis Blues as an example:

**Calculate the proportion of team time on ice for each skater.** This is equal to (time on ice) / (team time on ice for skaters). For Pronger this is  $143343 / 1441216 = 0.0995$ .

**Calculate the proportion of team marginal goals against that will be assigned to skaters.** This is equal to  $(7 - 2 \times ((\text{team shots against per minute}) / (\text{league shots against per minute}))) / 7$ . For the Blues this is  $(7 - 2 \times (0.3645 / 0.4604)) / 7 = 0.7738$ .

**Calculate the position adjustment for each skater.** For defensemen the position adjustment is 10/7 and for forwards the position adjustment is 5/7. For Pronger this is 10/7.

**Calculate team marginal goals against.** Team marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{team games}) \times (\text{league goals per game}) - (\text{team goals against})$ . For the Blues this is  $(1 + (7 / 12)) \times 82 \times 2.747 - 165 = 191.65$ .

**Calculate the plus/minus adjustment for each skater.** The plus/minus adjustment is equal to  $(1 / 7) \times (\text{position adjustment}) \times ((\text{plus/minus}) - (\text{time on ice}) \times ((\text{team plus/minus for position}) / (\text{team time on ice for position})))$ . For Pronger this is  $(1 / 7) \times (10 / 7) \times (52 - 143343 \times (132 / 592882)) = 4.099$ .

**Calculate marginal goals against for each skater.** Marginal goals against is equal to (proportion of team time on ice)  $\times$  (proportion of team marginal goals against assigned to skaters)  $\times$  (position adjustment)  $\times$  (team marginal goals against) + (plus/minus adjustment). For Pronger this is  $0.0995 \times 0.7738 \times (10 / 7) \times 191.65 + 4.099 = 25.18$ .

**Calculate marginal goals per point.** Marginal goals per point reduces to (league goals) / (league points). For the 1999-00 NHL this is  $6306 / 2410 = 2.62$ .

**Credit Defensive Point Shares to the skaters.** Defensive Point Shares are credited using the following formula: (marginal goals against) / (marginal goals per point). Pronger gets credit for  $25.18 / 2.62 = 9.6$  Defensive Point Shares.

### B. 1983-84 to 1997-98

Time on ice is no longer available, so it will be replaced with weighted games played. We'll use Paul Coffey of the 1984-85 Edmonton Oilers as an example:

**Calculate the proportion of weighted team games played for each skater.** For forwards this is equal to (games played) / ((team games played by forwards) +  $2 \times$  (team games played by defensemen)) and for defensemen this is  $(2 \times \text{games played}) / ((\text{team games played by forwards}) + 2 \times (\text{team games played by defensemen}))$ . For Coffey this is  $(2 \times 80) / (953 + 2 \times 484) = 0.0833$ .

**Calculate the proportion of team marginal goals against that will be assigned to skaters.** This is equal to  $(7 - 2 \times ((\text{team shots against per minute}) / (\text{league shots against per minute}))) / 7$ . For the Oilers this is  $(7 - 2 \times (0.5395 / 0.5022)) / 7 = 0.6931$ .

**Calculate the position adjustment for each skater.** For defensemen the position adjustment is 10/7 and for forwards the position adjustment is 5/7. For Coffey this is 10/7.

**Calculate team marginal goals against.** Team marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{team games}) \times (\text{league goals per game}) - (\text{team goals against})$ . For the Oilers this is  $(1 + (7 / 12)) \times 80 \times 3.887 - 298 = 194.35$ .

**Calculate the plus/minus adjustment for each skater.** The plus/minus adjustment is equal to  $(1 / 7) \times (\text{position adjustment}) \times ((\text{plus/minus}) - (\text{games played}) \times ((\text{team plus/minus for position}) / (\text{team games played for position})))$ . For Coffey this is  $(1 / 7) \times (10 / 7) \times (55 - 80 \times (194 / 484)) = 4.680$ .

**Calculate marginal goals against for each skater.** Marginal goals against is equal to (proportion of weighted team games played)  $\times$  (proportion of team marginal goals against assigned to skaters)  $\times$  (position adjustment)  $\times$  (team marginal goals against) + (plus/minus adjustment). For Coffey this is  $0.0833 \times 0.6931 \times (10 / 7) \times 194.35 + 4.680 = 20.71$ .

**Calculate marginal goals per point.** Marginal goals per point reduces to (league goals) / (league points). For the 1984-85 NHL this is  $6530 / 1680 = 3.89$ .

**Credit Defensive Point Shares to the skaters.** Defensive Point Shares are credited using the following formula: (marginal goals against) / (marginal goals per point). Coffey gets credit for  $20.71 / 3.89 = 5.3$  Defensive Point Shares.

### C. 1967-68 to 1982-82

Shots against are no longer available, so the proportion of team marginal goals against assigned to skaters will be a constant (5/7). We'll use Larry Robinson of the 1975-76 Montreal Canadiens as an example:

**Calculate the proportion of weighted team games played for each skater.** For forwards this is equal to (games played) / ((team games played by forwards) +  $2 \times$  (team games played by defensemen)) and for defenseman this is  $(2 \times \text{games played}) / ((\text{team games played by forwards}) + 2 \times (\text{team games played by defensemen}))$ . For Robinson this is  $(2 \times 80) / (902 + 2 \times 447) = 0.0891$ .

**Calculate the position adjustment for each skater.** For defensemen the position adjustment is 10/7 and for forwards the position adjustment is 5/7. For Robinson this is 10/7.

**Calculate team marginal goals against.** Team marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{team games}) \times (\text{league goals per game}) - (\text{team goals against})$ . For the Canadiens this is  $(1 + (7 / 12)) \times 80 \times 3.412 - 174 = 258.19$ .

**Calculate the plus/minus adjustment for each skater.** The plus/minus adjustment is equal to  $(1 / 7) \times (\text{position adjustment}) \times ((\text{plus/minus}) - (\text{games played}) \times ((\text{team plus/minus for position}) / (\text{team games played for position})))$ . For Robinson this is  $(1 / 7) \times (10 / 7) \times (50 - 80 \times (266 / 447)) = 0.489$ .

**Calculate marginal goals against for each skater.** Marginal goals against is equal to (proportion of weighted team games played)  $\times$  (5 / 7)  $\times$  (position adjustment)  $\times$  (team marginal goals against) + (plus/minus adjustment). For Robinson this is  $0.0891 \times (5 / 7) \times (10 / 7) \times 258.19 + 0.489 = 23.96$ .

**Calculate marginal goals per point.** Marginal goals per point reduces to (league goals) / (league points). For the 1975-76 NHL this is  $4913 / 1440 = 3.41$ .

**Credit Defensive Point Shares to the skaters.** Defensive Point Shares are credited using the following formula: (marginal goals against) / (marginal goals per point). Robinson gets credit for  $23.96 / 3.41 = 7.0$  Defensive Point Shares.

#### D. 1917-18 to 1966-67

Plus/minus is no longer available, so the plus/minus adjustment will be dropped from the equation. We'll use Red Kelly of the 1951-52 Detroit Red Wings as an example:

**Calculate the proportion of weighted team games played for each skater.** For forwards this is equal to (games played) / ((team games played by forwards) + 2 × (team games played by defensemen)) and for defenseman this is (2 × games played) / ((team games played by forwards) + 2 × (team games played by defensemen)). For Kelly this is  $(2 \times 67) / (698 + 2 \times 340) = 0.0972$ .

**Calculate the position adjustment for each skater.** For defensemen the position adjustment is 10/7 and for forwards the position adjustment is 5/7. For Kelly this is 10/7.

**Calculate team marginal goals against.** Team marginal goals against is equal to  $(1 + (7 / 12)) \times (\text{team games}) \times (\text{league goals per game}) - (\text{team goals against})$ . For the Red Wings this is  $(1 + (7 / 12)) \times 70 \times 2.595 - 133 = 154.61$ .

**Calculate marginal goals against for each skater.** Marginal goals against is equal to (proportion of weighted team games played) × (5 / 7) × (position adjustment) × (team marginal goals against). For Kelly this is  $0.0972 \times (5 / 7) \times (10 / 7) \times 154.61 = 15.33$ .

**Calculate marginal goals per point.** Marginal goals per point reduces to (league goals) / (league points). For the 1951-52 NHL this is  $1090 / 420 = 2.60$ .

**Credit Defensive Point Shares to the skaters.** Defensive Point Shares are credited using the following formula: (marginal goals against) / (marginal goals per point). Kelly gets credit for  $15.33 / 2.60 = 5.9$  Defensive Point Shares.

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## VII. Putting It All Together

The final step of the process is to find the sum of Offensive Point Shares (OPS), Defensive Point Shares (DPS), and Goalie Point Shares (GPS) for each player. For example, in 1988-89 Mario Lemieux had 17.68 OPS and 1.88 DPS for a total of 19.56 Point Shares.

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## VIII. Does This Work?

Because this metric is designed to estimate a player's contribution in terms of points, it makes sense to see if the sum of player Point Shares for a particular team closely matches the team's point total. Looking at all NHL teams from 1917-18 to 2009-10, the average absolute error is 5.05 points per 82 games and the root mean squared error is 6.64 points per 82 games. (These errors are larger than the errors reported in Section III because the errors in Section III were computed starting at the team level, while the errors reported here were computed starting at the player level.)

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## IX. Feedback

If you have any comments or questions about the Point Shares methodology, please send me some feedback.

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