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Assessing the Impact of Shootouts on NHL Game Importance: A Simulation Approach

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This study examines how structural and rules-based decisions in the National Hockey League (NHL) influence the competitive dynamics of its regular seasons, focusing on two critical measures: mathematical certainty and game importance. Using simulations of 15 NHL seasons (2000–01 to 2016–17, excluding seasons impacted by labor disputes) under varying conditions—including ties, shootouts, and a three-point standings system—this research quantifies how changes to reward structures affect the proportion of games played under mathematical certainty and the average game's playoff significance. The results reveal that the NHL's decision to shift from ties to shootouts has increased mathematical certainty, particularly under homogeneous competitive environments, and has slightly reduced average game importance. Conversely, adopting the three-point system used by the International Ice Hockey Federation (IIHF), which awards three standings points for regulation wins, enhances game importance and reduces mathematical certainty relative to the NHL's current shootout system. These findings underscore the importance of carefully considering the unintended consequences of league design decisions, particularly as they pertain to fan engagement and competitive fairness.

Keywords: competitive balance, hockey, National Hockey League, game importance, Monte Carlo simulation

Introduction

Sports leagues continually adapt rules and structures to enhance their appeal, maintain competitive balance, and maximize fan engagement. Rule changes, whether transformative (such as the National Basketball Association's adoption of the three-point line in 1979) or incremental (consider the English Premier League has featured a consistent relegation structure since 1995) are strategic responses to shifts in audience preferences. Importantly, these modifications are not merely superficial; they often create new—and sometimes unintended—incentives that

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influence strategies, behaviors, and competitive balance. Understanding the interaction between structural changes and incentives provides valuable insights into how leagues can navigate tradeoffs between entertainment and competition.

Figure 1 illustrates the various modifications of the National Hockey League (NHL) regular season during a 15-season span (interrupted by two labor disputes) where the league is consistently comprised of 30 teams. The figure identifies six distinct periods distinguished by game structure (i.e., whether games are permitted to end in ties, and the number of skaters permitted during overtime) and league structure (i.e., salary cap, division composition, and schedule).

Figure 1 also shows the percent of team-games played under mathematical certainty—when a team has mathematically clinched or has been mathematically eliminated from a postseason playoff berth irrespective of all current and future game outcomes. At first glance, only one combination of rules (2008–09 to 2011–12) consistently yields fewer than 6% of team-games played under mathematical certainty. However, this also exists after the implementation of the salary cap (a strict upper and lower limits to each team's total athlete salary). Combined with ever-changing team heterogeneity, the many iterations of game and league structures may lead one to naïvely conclude that the ideal paradigm must have occurred at one point or another.

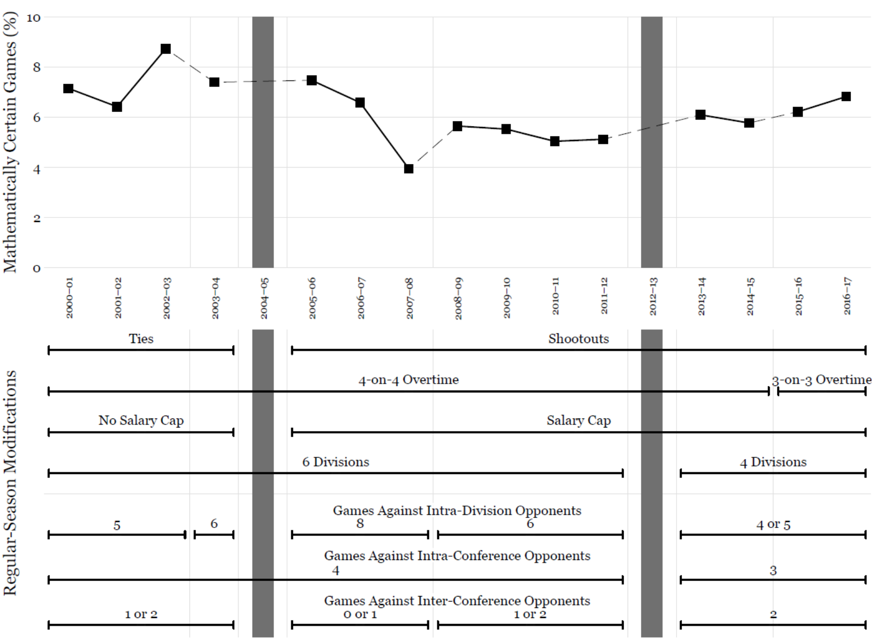

Figure 1: Percent of regular-season NHL games played under mathematical certainty and rule modifications by season, 2000–01 to 2016–17.

This study examines structural modifications to the NHL's game and league formats, focusing on the introduction of the shootout in the 2005–06 season. Previously, games tied at the end of regulation and an overtime period end in a tie; following this rule change, tied games are decided via a shootout. The elimination of ties in favor of shootouts has increased the average number of standings points awarded per game. Contrary to the trends illustrated in Figure 1, this change has led to a 4.5% increase in the proportion of mathematically certain team-games and a corresponding 3.6% decrease in the importance of the average regular-season game (with game importance quantified using "swing"—the difference in a team's playoff probability conditional on winning versus losing).

Further, this study simulates NHL seasons under an alternative point system used by the International Ice Hockey Federation (IIHF), which allocates standings points differently for game outcomes. The simulation reveals that adopting the IIHF system would reduce the prevalence of mathematically certain games by 2.8% and increase the average swing by 4.4% compared to the NHL's shootout-based structure. Finally, the analysis shows that these effects are amplified in a league with homogenous team strength, highlighting the systemic impact of the NHL's point allocation system. Policy implications and potential adjustments to improve competitive balance and game importance are discussed in the concluding section.

Background

From October 2000 to June 2017, the NHL has had fifteen 82-game seasons.[1] Beginning with the 2005–06 season, regular-season games can no longer end in ties. Prior, games concluded in one of three outcomes: regulation win (one team leads after 60 minutes of regulation gameplay); overtime win (teams are tied after regulation gameplay but one team scores during a five-minute, "sudden-death" overtime period); or tie (score remains tied after regulation and overtime gameplay). Between the 2000–01 and 2003–04 seasons, standings points were awarded as follows: two points for a regulation or overtime win, one point for a tie or overtime loss, and zero points for a regulation loss. The left panel of Figure 2 illustrates the game outcomes during this period and the corresponding standings points for the home and away teams, in ordered pairs.

Beginning with the 2005–06 season, the NHL introduced a shootout to resolve regular-season games that remained tied after overtime. Standings points were awarded as follows: two points for a win (regulation, overtime, or shootout); one

[1] The 2004–05 season was cancelled outright and 2012–13 was limited to just 48 games due to labor disputes; these seasons are marked by gray bars in Figure 1 and excluded from the remainder of this study.

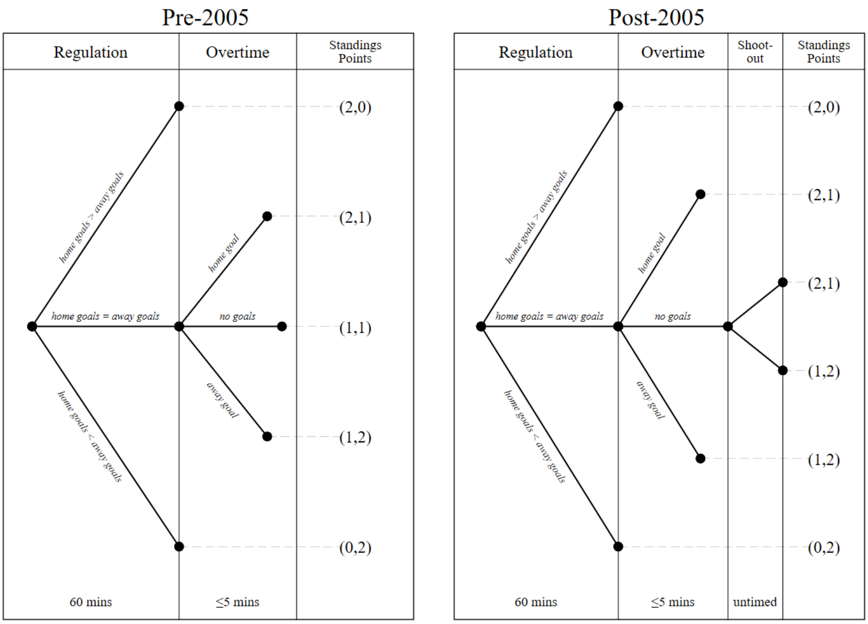

Figure 2: Game trees of NHL regular season standings point systems, 2000–01 to present.

point for a loss in overtime or shootout; and zero points for a regulation loss (see Figure 2, right panel). All games conclude in a decisive winner, thereby awarding a third standings point in games that would have otherwise ended in a tie.

A second major structural change occured beginning with the 2013–14 season: teams were realigned according to geographic proximity. Prior, the league was divided into two conferences—Eastern and Western—consisting of three different five-team divisions (see Table 1). Eight playoff berths are awarded per conference: the top-ranked team from each division is awarded a playoff berth, with the remaining five allocated to the highest-ranking non-division leaders.

The NHL is re-aligned in 2013–14, addressing logistical challenges due to the Atlanta Thrashers re-locating to Winnipeg, Canada and anticipated future league expansion. The Eastern Conference expands to two 8-team divisions, while the Western Conference consists of two 7-team divisions (Table 2). Eight playoff berths are still awarded per conference, with the top three teams from each division receiving berths. The remaining two berths, referred to as "wild-card" berths, are assigned to the two next highest-ranked teams in the conference regardless of division.

Finally, a critical development follows the 2004–05 lockout: the implementation of a salary cap. Previously, teams are unrestricted on player expenditures:

Table 1. Illustration of 2000–01 to 2012–13 League Structure, 2011–12 NHL Standings

Western Conference				Eastern Conference			
Central Division	**Standings Points**	**Playoff Berth**	**Seed**	**Atlantic Division**	**Standings Points**	**Playoff Berth**	**Seed**
St. Louis Blues	109	✔	2	New York Rangers	109	✔	1
Nashville Predators	104	✔	4	Pittsburgh Penguins	108	✔	4
Detroit Red Wings	102	✔	5	Philadelphia Flyers	103	✔	5
Chicago Blackhawks	101	✔	6	New Jersey Devils	102	✔	6
Columbus Blue Jackets	65			New York Islanders	79		
Northwest Division	**Standings Points**	**Playoff Berth**	**Seed**	**Northeast Division**	**Standings Points**	**Playoff Berth**	**Seed**
Vancouver Canucks	111	✔	1	Boston Bruins	102	✔	2
Calgary Flames	90			Ottawa Senators	92	✔	8
Colorado Avalanche	88			Buffalo Sabres	89		
Minnesota Wild	81			Toronto Maple Leafs	80		
Edmonton Oilers	74			Montreal Canadiens	78		
Pacific Division	**Standings Points**	**Playoff Berth**	**Seed**	**Southeast Division**	**Standings Points**	**Playoff Berth**	**Seed**
Phoenix Coyotes	97	✔	3	Florida Panthers	94	✔	3
San Jose Sharks	96	✔	7	Washington Capitals	92	✔	7
Los Angeles Kings	95	✔	8	Tampa Bay Lightning	84		
Dallas Stars	89			Winnipeg Jets	84		
Anaheim Ducks	80			Carolina Hurricanes	82		

since this period, the cap imposes upper and lower limits on team salaries, and individual player maximums. This reform significantly reduced the coefficient of variation (the ratio of the standard deviation to the mean) of team payrolls (Figure 3). The intended purpose of the cap is to enhance competitive balance by narrowing disparities in team spending. Empirical evidence supports this outcome, with a strong correlation (0.74) between equality of salary and equality in measurements of team strength, such as Elo ratings (Elo, 1967; see Appendix for more details on Elo ratings).

Table 2: Illustration of 2013–14 to 2016–17 League Structure, 2013–14 NHL Standings

Western Conference				Eastern Conference			
Central Division	**Standings Points**	**Playoff Berth**	**Seed**	**Atlantic Division**	**Standings Points**	**Playoff Berth**	**Seed**
Colorado Avalanche	112	✔	1b	Boston Bruins	117	✔	1a
St. Louis Blues	111	✔	2	Tampa Bay Lightning	101	✔	2
Chicago Blackhawks	107	✔	3	Montreal Canadiens	100	✔	3
Minnesota Wild	98	✔	W1	Detroit Red Wings*	93	✔	W2
Dallas Stars	91	✔	W2	Ottawa Senators	88		
Nashville Predators	88			Toronto Maple Leafs	84		
Winnipeg Jets	84			Florida Panthers	66		
				Buffalo Sabres	52		
Pacific Division	**Standings Points**	**Playoff Berth**	**Seed**	**Metropolitan Division**	**Standings Points**	**Playoff Berth**	**Seed**
Anaheim Ducks	116	✔	1a	Pittsburgh Penguins	109	✔	1b
San Jose Sharks	111	✔	2	New York Rangers	96	✔	2
Los Angeles Kings	100	✔	3	Philadelphia Flyers	94	✔	3
Phoenix Coyotes	89			Columbus Blue Jackets*	93	✔	W1
Vancouver Canucks	83			Washington Capitals	90		
Calgary Flames	77			New Jersey Devils	88		
Edmonton Oilers	67			Carolina Hurricanes	83		
				New York Islanders	79		

Note: Columbus Blue Jackets had more regulation and overtime wins than Detroit Red Wings and is awarded the first wildcard playoff seed.

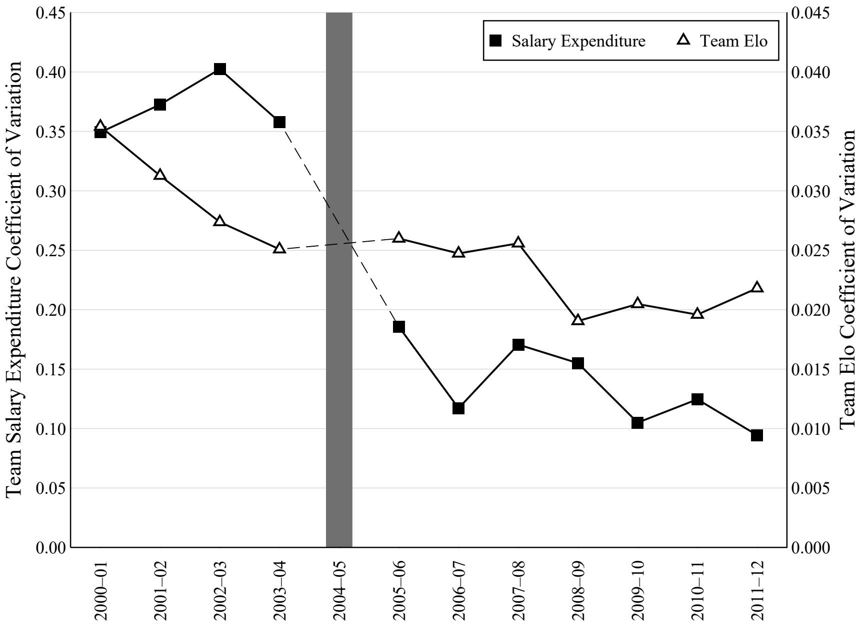

Figure 3: Coefficients of variation of NHL salary expenditure and team strength, 2000–01 to 2011–12.

Antecedents

Few studies focus on the modifications of the NHL's league and game structures in the period considered herein (Lopez 2013). Instead, many studies address a related change in the NHL 2000–01 season, which introduces the single standings points for an overtime loss.[2] Longley and Sankaran (2004) discusses how this "loser point" theoretically leads to more ties as teams in tightly contested games may tacitly agree to play for overtime, allowing each team to secure at least one standings point. Abrevaya (2004), Easton and Rockerbie (2005), and Shmanske and Lowenthal (2007) illustrate this reality and further demonstrate this tacit collusion is most prominent in inter-conference games as these opponents do not directly compete for the same playoff berths. Conversely, Longley and Sankaran (2007) illustrate how avoiding overtime can be a dominant strategy, regardless of opponent. Lopez (2013) shows the probability of an inter-conference game reaching overtime is even more prevalent post 2005–06 (after the introduction of the loser point and after the elimination of ties) and non-constant across the duration of the regular season.

[2] In the context of Figure 2, prior to 2000–01, the game-structure game tree mimics the left panel with payoffs of (2,0), (2,0), (1,1), (0,2), and (0,2) from top to bottom, respectively.

More closely related to this study, Pettigrew (2014) simulates the expected impact from the realignment of the league structure. Dividing teams into two unbalanced conferences leads to a “conference gap,” wherein, *ex ante*, members of the 16-team Eastern Conference are expected to need to win more games than teams in the 14-team Western Conference to qualify for the playoffs.

Franck and Theiler (2012) compares the NHL to Switzerland’s National League (NL), which also introduced the loser point prior to its 2006–07 season but, also, simultaneously increased the payoff for a regulation win to three standings points: the study finds that the inclusion of the third standings point for a regulation win in the NL leads to fewer games being tied after regulation than with the NHL’s loser point system alone.

Finally, this study adds to the literature on match importance (e.g., Corona et al., 2017; Geenens, 2014; Lahvička, 2013b; Scarf & Shi, 2008; Schilling, 1994) by illustrating how subtle changes in the decisions to operate games and leagues can have wide-spread impacts on the importance of the average game. Others have illustrated that match importance can impact fan engagement (Lei & Humphreys, 2013; Losak & Halpin, 2024), the probability of injury (Cisyk & Courty, 2024b), aggressive behavior (Cisyk, Courty, Kouhbor, 2025b), or an increased potential for match-fixing (Goller & Heiniger, 2023).

Methods

Given the numerous changes to game and league structure detailed in Figure 1, one sensible way to disentangle the effects of a small change, such as the elimination of ties, is to simulate each season under various standings point systems (Lahvička, 2013b; Pettigrew, 2014; Scarf & Shi, 2008). Making unilateral comparisons of simulated results under one set of game/league structures (e.g., ties versus shootouts) allows one to observe the impact without imposing structural models as has been suggested by others (e.g., Abrevaya, 2004; Easton & Rockerbie, 2005; Franc & Theiler, 2012; Lopez, 2013; Marek et al., 2014; Shmanske & Lowenthal, 2007).

Game outcome probabilities are collected from 15 NHL regular seasons (2000–01 to 2016–17).[3] Each regular season is simulated *N* times, with game outcomes assigned pseudo-randomly based on each outcome’s likelihood, weighted by Elo ratings (see Appendix for full details on the simulation methodology). Previous studies have used *N* values of 100 (Scarf & Shi, 2008), 5,000 (Goller & Heiniger, 2023), 10,000 (Losak & Halpin, 2024; Pettigrew, 2014), 1 million

[3] Recall, this excludes the 2004–05 and 2012–13 seasons.

(Lahvička, 2013a), and 10 million (Lahvička, 2013b). Here, $N = 999$ is chosen, yet results are robust to this choice.[4]

For each iteration, standings points are assigned simulated game outcomes, and final tallies are calculated to determine iteration-specific playoff berths. From this simulation, two key metrics are derived: first is the number of team-games played under mathematical certainty during each simulated season. A team-game is classified as mathematically certain if the team's playoff status—whether mathematically clinched or mathematically eliminated—remains unchanged regardless of the outcomes of current or future games within the (simulated or actual) season. Formally, a game played by team i at time t is mathematically certain if either of the following mutually exclusive conditions hold:

$$certain_{it} = \begin{cases} P_{it} + \alpha(82 - GP_{it}) < P_{jt} & \text{where } j \text{ is the lowest-seeded team } \textit{with} \text{ a playoff spot} \\ P_{it} > P_{kt} + \alpha(82 - GP_{kt}) & \text{where k is the highest-seeded team } \textit{without} \text{ a playoff spot.} \end{cases}$$

Above, P_{it} is the number of standings points team i has accumulated from its games prior to time t, and GP_{it} denotes the total number of games team i has played prior to time t such that $(82 - GP_{it})$ represents the number of games remaining. Setting $\alpha = 2$ implies that the left-hand side of the top inequality equals the maximum number of standings points team i can possibly attain for the remainder of its 82-game schedule, assuming—no matter how unlikely—it wins all remaining games (recall, the NHL currently awards two standings points for a win; alternative values of α are discussed later). When this total is strictly less than the points of the lowest-ranked team with a playoff spot (P_{jt}) team i is said to be mathematically eliminated from any playoff berth and all its remaining games from period t onwards are mathematically certain. Conversely, when team i's standings points (P_{it}) are greater than the maximum possible standings points of the highest-ranked team without a playoff spot (P_{kt}), the team is said to have mathematically clinched a playoff bid and the remainder of its games are also mathematically certain. Note that mathematical certainty does not incorporate probabilities: a team's playoff berth may be mathematically uncertain even if it is all-but practically certain.

A second measure of game importance is a game's "swing"—a measure of the significance of a game's outcome on a team's probability of securing a playoff berth. Swing quantifies the percentage-point change in the likelihood of a team obtaining a playoff berth when comparing a regulation win versus a regulation loss. This measure is calculated iteratively for team i's game t across

[4] Note that the intentional use of an odd number ensures that the median value will be a single observed outcome instead of a midpoint between two.

the N simulations. Before game t, standings points are aggregated for all teams based on results up to, but not including, game t. Simulations are then filtered to retain only those in which team i either wins or loses game t in regulation. These subsets, N_{RW} (those with team i assigned a regulation win at period t) and N_{RL} (conversely, assigned a regulation loss), determine playoff probabilities f_{it}^{RW} and f_{it}^{RL} as the percentage of the N_{RW} and N_{RL} iterations that team i is assigned a playoff berth, respectively. Team i's swing for game t is defined as the difference of these probabilities, $f_{it}^{RW} - f_{it}^{RL}$.

A game's swing is bound by 0 and 1 with larger values of swing indicating the games' outcome will have more influential results on the team's playoff qualification opportunities and have more excitement for consumers of the sport.[5] A value of 1 indicates a "win-and-in" scenario where the game's outcome entirely determines playoff qualification, while a value of 0 indicates the game's outcome has no bearing. Unlike mathematical certainty, swing is probability weighted, reflecting not only mathematical possibility, but also the likelihood of specific outcomes. This ensures teams with highly improbable playoff scenarios are appropriately assigned low (or even zero) values of swing.

Leagues may aim to enhance swing to increase the excitement and stakes of regular-season games, but approaches to this goal may differ: for example, one could increase the swing of the mean or median game, or focus on creating few games of utmost importance. These objectives may conflict: for example, raising the median swing might inadvertently increase the number of games with zero swing (Cisyk, Courty, & Kouhbor, 2025a).

The historical percentage of actual team-games played under mathematical certainty is presented in Figure 1, which reveals several key trends. For example, the elimination of ties appears to reduce the percentage of mathematically certain team-games. However, Figure 1 does not account for the other changes described in the lower panel or the variability in team strength across seasons. To address this, the simulations described above are run to model each season under both tie and, separately, shootout game structures, enabling direct comparisons of the most likely outcomes given the other choices of game- and league-structure and team heterogeneity.

5 Logically, a regulation win cannot decrease a team's chance at a playoff berth compared to a regulation loss ($f_{it}^{RW} \geq f_{it}^{RL}$). Note that, in practice, rare instances exist where simulated outcomes produce counter-intuitive results due to the random sequences of the simulated future wins and losses of each team. For example, consider two different sequences from game t to T for a single hypothetical team: first, win-loss-loss and, second, loss-win-win; the former will produce fewer standings points despite beginning with a win and, in such an instance, the swing may be negative. When such idiosyncrasies occur in the simulations, the swing is manually set to identically zero.

Results

Beginning with the results of mathematical certainty, Figure 4 presents box plots for the percentage of mathematically certain team-games under different scenarios. In the left box plot, the actual league structure, schedule, and playoff qualification rules for all 15 seasons are simulated *N* times, allowing games to end in ties. The distribution of mathematical certain games is summarized using the 10th, 25th, 50th, 75th, and 90th percentiles, alongside the mean.

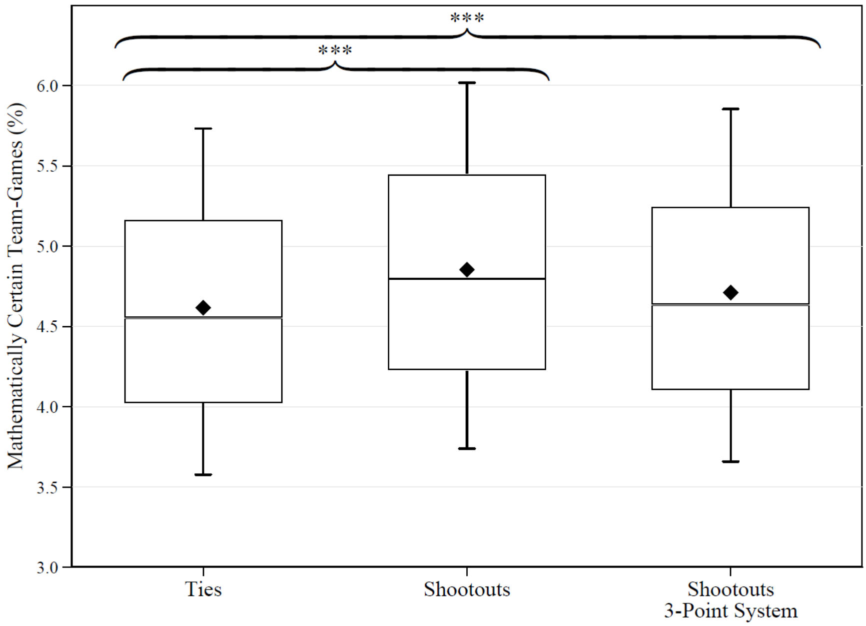

Figure 4. Box plots of percent of mathematically certain team-games.

Note: Asterisks represent t-tests for percent of games played under mathematical certainty for ties versus shootouts and, separately, ties versus shootouts under the three-point system. *$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

In the middle box plot, new simulations explicitly remove ties and, instead, ensure all games are assigned a winner via regulation, overtime, or a shootout. Standings points are assigned accordingly, and a *t*-test confirms the number of games played under mathematical certainty is significantly increased (difference of 0.2 percentage points, $p < 0.01$).[6]

[6] Moreover, a Kolmogorov–Smirnov test reinforces this finding that more games are expected to be played under mathematical certainty with shootouts than ties ($p < 0.01$).

Finally, the right box plot simulates games under a three-point standings system, as suggested by Franck and Theiler (2012) and Lopez (2013), wherein regulation wins earn three standings points, and overtime or shootout wins earn two standings points (also referred to as the IIHF system; mathematical certainty is calculated with $\alpha = 3$). Simulations show that this system increases games played under mathematical certainty by 0.09 percentage points ($p = 0.01$).[7] The impact is less pronounced than that of removing ties alone, providing empirical support for the role of structural adjustments in influencing competitive dynamics.

Figure 5 presents the distribution of simulated swing values across the 15 NHL regular-seasons, again comparing under three different scenarios. Under the first scenario in the left box plot, the mean swing is 7.1 percentage points when permitting ties. This implies that, on average, a regulation win improves a team's playoff probability by 7.1 percentage points compared to a regulation loss. Under the second scenario, which eliminates ties in favor of shootouts (middle box plot), the mean swing drops to 6.8 percentage points—a statistically significant decrease of 0.3 percentage points ($p < 0.01$). This change corresponds to a 3.6% reduction in the average swing ($1 - 0.068/0.071 = 3.6\%$; accounting for rounding).

[7] Again, a Kolmogorov–Smirnov test finds a similar result ($p = 0.01$).

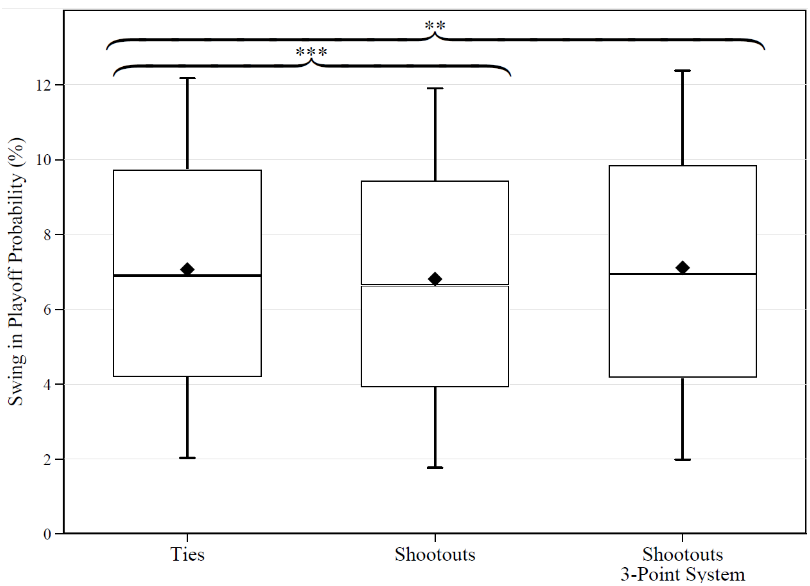

Figure 5: Box plots of average swing.

Note: Asterisks represent t-tests for average swing per game under ties versus shootouts and, separately, ties versus shootouts under the three-point system. *$p < .01$; **$p < 0.05$; ***$p < 0.01$.

In contrast, under the IIHF three-point system (right box plot), the mean swing exceeds that of the expected swing under ties by 0.07 percentage points ($p < 0.05$). This suggests that the three-point system may enhance game importance relative to the NHL's current structure, offering a modest increase in average swing.

Figures A1 and A2 of the Appendix extend the analysis of mathematical certainty and swing by examining season-specific trends. The top panel of Figure A1 replicates Figure 4 but now breaks down the results by season, showing the mean percentage of team-games played under mathematical certainty across simulations. For example, in the 2000–01 season, 5.4% of team-games are mathematically certain when ties are allowed, 5.8% when shootouts are used, and 5.6% when shootouts are combined with the IIHF three-point system. The ordinal pattern persists across all seasons, with the highest certainty observed under shootouts, the lowest under ties, and intermediate levels with shootouts and the three-point system.

In the lower panel of Figure A1, team heterogeneity is removed by assigning each team an Elo value of 1,500. This adjustment minimizes seasonal variation within each structure, as differences between seasons now reflect only schedule changes and playoff berth criteria. These simulations introduce a level shift: team homogeneity significantly reduces the proportion of mathematically certain games. Across all scenarios, ties consistently produce the least mathematical certainty, followed by the three-point system with shootouts, and, finally, shootouts alone, which generate the most certainty.

Figure A2 explores seasonal variations in median swing values, using the same data as Figure 5. The top panel shows that under shootouts alone, the median swing is consistently lower than under the other two structures (ties and the three-point system with shootouts), though the superior structure between the latter two varies by season. The lower panel, which applies uniform Elo values, reveals a significant increase in median swing values under all structures, consistent with others (e.g., Cisyk, Courty & Kouhbor, 2025a). Most notably, the analysis highlights that shootouts combined with the three-point system yield consistently higher median swing values across all seasons, emphasizing the potential benefits of this structure in maximizing game significance.

Conclusion

This study investigates the impact of key changes in the NHL's league structure and game rules from 2000–01 to 2016–17, focusing on their implications for game importance. By simulating each regular season under different paradigms—including ties, shootouts, and the three-point system for standings points—this research provides insights into the consequences of these modifications on mathematical certainty and swing, two critical measures of game importance.

The findings suggest that the NHL's 2005 shift to shootouts over ties has nuanced effects. While, *ex post*, there has been a reduction in the percentage of mathematically certain games; much of this shift aligns with structural changes such as the introduction of the salary cap, which has narrowed the competitive disparity among teams. Simulations confirm that, *ex ante*, resolving games under shootouts is expected to increase mathematical certainty relative to ties and reduce average swing.

The average effect of moving from ties to shootouts is an increase of 4.5% in games played under mathematical certainty. In a standard NHL season, this corresponds to approximately five additional team-games per year for which outcomes have no bearing on playoff qualification. While seemingly modest, this effect is non-trivial when considered alongside the limited number of home games (41 per team) available to generate gate and in-game revenue. A similar pattern emerges when examining swing; under the shootout system, approximately 150 team-games per season are expected to have a very low swing (defined as a change in playoff probability of less than one percentage point) compared to 134 under ties.

The results also demonstrate that adopting the IIHF's three-point system for standings points could mitigate some of the weaknesses of the NHL's current shootout system. Simulations indicate that the three-point system leads to higher average swing and a lower proportion of games played under mathematical certainty compared to shootouts alone (three fewer team-games played under mathematical certainty and 13 fewer team-games of very low swing, in expectation). These changes could heighten the importance and unpredictability of standings, which are highly valued by fans (Goller & Heiniger, 2023; Lei & Humphreys, 2013).

In conclusion, while the NHL's transition to shootouts aligns with a broader trend toward creating decisive outcomes in sports, its impact on game importance and league dynamics warrants further consideration (see also Franck & Theiler, 2012; Lopez, 2013). While the magnitudes may be modest, the impact becomes economically meaningful when aggregated across teams and seasons, though it may not, in isolation, imply that a rule change is warranted. Because league standings have been found to be consequential for fan engagement (Losak & Halpin, 2024), leagues may want to consider improvements to minimize the number of low-stakes games by changing self-imposed rules, such as standing points systems. Adopting the three-point system offers a promising alternative to enhance game importance while preserving the decisive nature of modern NHL games. This study contributes to the literature on sports league design and underscores the importance of empirically driven approaches to policymaking in professional sports.

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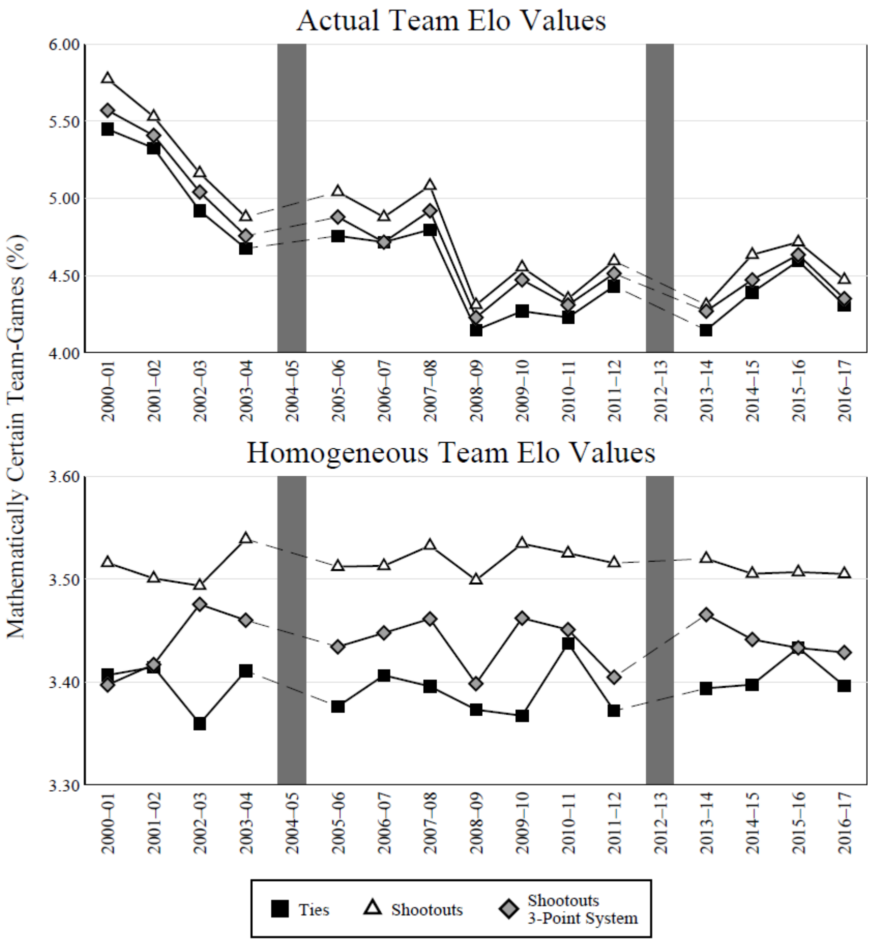
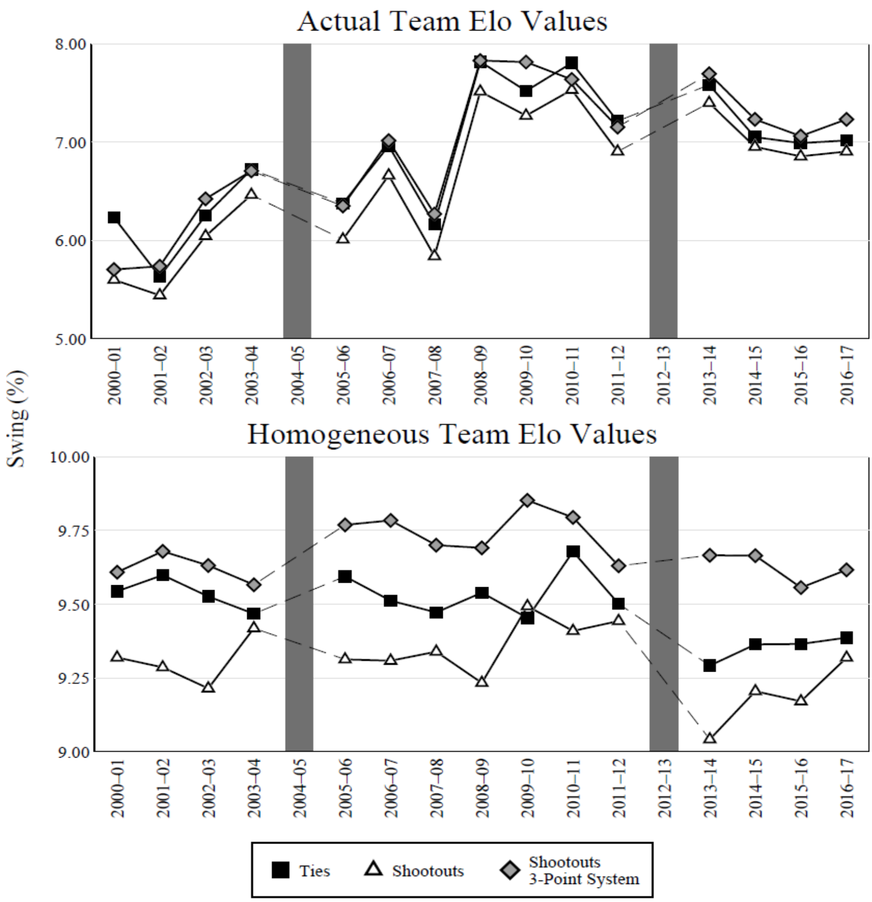
Appendix



Appendix Figure A1: Percent of mathematically certain team-games



Appendix Figure A2: Average swing

Elo ratings and game outcome probabilities

Elo ratings from FiveThirtyEight are used as a measure of team strength and to generate the probabilities of game outcomes.[8] In a traditional Elo model, each competitor is assigned an initial rating that serves as an ordinal measure of quality and can be used to infer the probability of a specific outcome (e.g., a win, loss, or draw). After a match, the Elo ratings of each competitor are updated according to the discrepancy in the Elo ratings of both competitors and the realized outcome.

The probability that the home team, H, wins a game against away team, A, in any fashion (i.e., regulation, overtime, or shootout) is calculated as follows:

$$pr(H) = \frac{1}{1 + 10^{-(Elo_H + 50\delta - Elo_A)/400}}$$

where Elo_H and Elo_A represent the Elo ratings of the home and away teams, respectively, and δ is a binary variable for when the designated home team is playing in its home arena (i.e., the game is not played in a neutral location) representing the small additional benefit of the well-established phenomenon known as 'home-field advantage' (or, for our context, 'home-ice advantage'). The probability the visiting team wins the game, $pr(A)$, is the complement of $pr(H)$.

Like FiveThirtyEight, the probability of overtime (i.e., that a game remains tied after 60 minutes of regulation time) is estimated using a logistic regression with historical data of whether a game required overtime on the absolute difference in team Elo ratings (including the home-ice advantage). FiveThirtyEight uses a single logistic regression to assign the probability of overtime to a given game. However, given the changes in game and league structure throughout the history of the NHL (for example, see Figure 1) this is likely too general. Breaking from FiveThirtyEight, two logistic regressions are estimated: (a) from 2000–01 to 2003–04; and (b) from 2005–06 to 2016–17 (excluding 2012–13) as these periods represent the periods with ties and with shootouts, respectively.

$$pr(OT) = \frac{1}{1 + exp\left(-\beta_0 - \beta_1(Elo_H + 50\delta - Elo_A)\right)}$$

where $\beta_0 = \begin{matrix} -1.035124 & \textit{if ties permitted} \\ -1.114369 & \textit{if ties not permitted} \end{matrix}$ and

$$\beta_1 = \begin{matrix} -0.001830 & \textit{if ties permitted} \\ -0.000985 & \textit{if ties not permitted} \end{matrix}$$

which come from the logistic regression described above.

[8] FiveThirtyEight, "Our Data," available at https://data.fivethirtyeight.com/.

Last, the probability that a game that remains tied after regulation (and thereby requires an overtime period) and remains tied after overtime (and thereby ends in a tie or requires a shootout) is calculated using the observed probabilities. This method is suggested by FiveThirtyEight and is also preferred to a logistic regression given the selection issue that teams must be tied at the end of regulation to be observed. Again, since changes have been made to the game structure regarding overtime, three probabilities are calculated depending on the season of the observed game.

$$pr(T \oplus SO|OT) = \begin{matrix} 0.536 \text{ } if \text{ } 2000{-}01 \text{ } to \text{ } 2003{-}04 \\ 0.566 \text{ } if \text{ } 2005{-}06 \text{ } to \text{ } 2014{-}15 \\ 0.365 \text{ } if \text{ } 2015{-}16 \text{ } to \text{ } 2016{-}17 \end{matrix}$$

Combining the above, the probabilities of each game outcome when ties are permitted are calculated as follows:

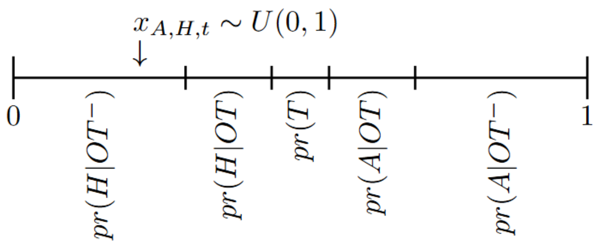
$$pr(T) = pr(OT) \text{ x } pr(T|OT)$$
$$pr(H|OT) = pr(H) \text{ x } (pr(OT) - pr(T))$$
$$pr(A|OT) = pr(A) \text{ x } (pr(OT) - pr(T))$$
$$pr(H|OT^{-}) = pr(H) \text{ x } (1 - pr(H|OT) - pr(A|OT) - pr(T))$$
$$pr(A|OT^{-}) = pr(A) \text{ x } (1 - pr(H|OT) - pr(A|OT) - pr(T))$$

Similarly, the probabilities of each game outcome when shootouts are required for games that remain tied after the overtime period are calculated as follows:

$$pr(H|SO) = pr(H) \text{ x } pr(OT) \text{ x } pr(SO|OT)$$
$$pr(A|SO) = pr(A) \text{ x } pr(OT) \text{ x } pr(SO|OT)$$
$$pr(H|OT) = pr(H) \text{ x } (pr(OT) - pr(SO))$$
$$pr(A|OT) = pr(A) \text{ x } (pr(OT) - pr(SO))$$
$$pr(H|OT^{-}) = pr(H) \text{ x } (1 - pr(H|OT) - pr(A|OT) - pr(SO))$$
$$pr(A|OT^{-}) = pr(A) \text{ x } (1 - pr(H|OT) - pr(A|OT) - pr(SO))$$

Simulations

To simulate the outcome of a game between home team H and away team A at time t, a pseudo-random number, $x_{H,A,t} \sim U(0,1)$, is drawn (pseudo-random reflects the use of a deterministic random number generator with a fixed seed to ensure reproducibility; all results are robust to the choice of seed). Game outcomes are assigned by partitioning the unit interval according to the model-implied probabilities of each mutually exclusive outcome. For example, when ties are permitted, the home team is assigned a regulation win if $x_{H,A,t} < pr(H|OT^{-})$; an overtime win if $pr(H|OT^{-}) < x_{H,A,t} < pr(H|OT^{-}) + pr(H|OT)$; a tie if $pr(H|OT^{-}) + pr(H|OT) < x_{H,A,t} < pr(H|OT^{-}) + pr(H|OT) + pr(T)$; and so on and so forth. Because the probabilities are mutually exclusive and collectively exhaustive, this ensures each game is assigned exactly one outcome. Appendix Figure A3 illustrates this approach: in the example, the randomly drawn number $x_{H,A,t} < pr(H|OT^{-})$ results in a regulation win assigned to the home team (and, therefore, a regulation loss assigned to the away team).



Appendix Figure A3: Visual depiction of simulation strategy

A single iteration of a simulated season includes all 1,230 games in the NHL season resolved in this manner. For each iteration, standings points are allocated according to the relevant point system and are then accumulated sequentially from $t = 1$ to T, producing iteration-specific standings and playoff assignments. In each iteration, the number of games played under mathematical certainty and the average swing is calculated.

A Note on Elo Ratings Used in the Simulations

Unlike a traditional Elo ratings system, the Elo ratings used herein are not updated as to avoid feedback loops that can occur with the simulation of pseudo-random events. Instead, Elo ratings are held constant at the team's preseason value. This assumption comports well with the result of Steeger, Dulin, and Gonzalez (2021) that NHL games do not follow patterns of momentum and that future games' outcomes are not dependent on past results. Moreover, to the extent possible, the Elo-based probabilities described are skill-based. This avoids a secondary feedback loop wherein game importance causes a team to alter its in-game tactics (Bradley & Noakes, 2013).