Overtime! Rules and Incentives in the National Hockey League

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Overtime!

Rules and Incentives in the National Hockey League

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We construct a simple 2-period game model to determine the effects of recent National Hockey League rule changes on team incentives to win. The effects differ depending on the relative quality of the contestants and whether the contestants compete in the same conference. The model predicts that the average number of points during a season will rise, yet the average point differential among clubs within the same conference will fall. The model also predicts that the expected value of points per contest will be higher when playing nonconference opponents but lower when playing conference opponents. Because only a small percentage of contests are nonconference, we predict that more effort will be devoted to conference contests, particularly by lesser-talented clubs. The result is more competitive and exciting conference games requiring fewer overtime periods and potential ties. Empirical data support these hypotheses.

Keywords: revenue sharing; sports league; talent conjectures

Professional sports leagues face an ongoing task of designing strategies to maintain the health of their industry. These include improving promotional efforts, expanding to new cities to sate their hunger for entertainment, negotiating lucrative media broadcast contracts, and dealing prudently but fairly with player contracts. The National Hockey League (NHL) has made inroads into new markets in the United States since the mid-1980s by adopting an aggressive expansion and marketing strategy under the auspices of Commissioner Gary Bettman. Television royalties are up (Strauss, 1998) from the 5-year $216.5 million contract that expired at

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the end of the 1998-1999 season (with the FOX and ESPN networks) to a 5-year $600 million contract (with ESPN). In addition, the NHL negotiated a 5-year $250 million rights deal (Campbell, 2001) in Canada (with the CBC). Television ratings were up 29% during the 2001-2002 seasons (Fisher, 2002), the league has launched a 24-hour hockey channel (NHL Network) in Canada, and the league packages a large number of games for viewing over cable and satellite services with its NHL Center Ice package. The league has recently located new franchises in Atlanta, Georgia, Columbus, Ohio, and Minnesota. League attendance records were set in each year during the 1997-2001 period (Fisher, 2002).[1] The NHL has expanded its international appeal by sending its best players to the 1998 and 2002 Olympic Games.

This success is largely attributable to broad policies that directly target their intended goals. Professional sports leagues, however, occasionally adopt rule changes that indirectly affect broad aggregates such as attendance and revenues. There are many examples of this sort of fine-tuning—the decision of the National Basketball Association (NBA) to adopt the 3-point shot and 24-second play clock, Major League Baseball's (MLB) adoption of the designated hitter in the American League and the strict enforcement of a common strike zone, and the National Football League's (NFL) new rules to protect quarterbacks and reduce rough play. All are examples of subtle rule changes designed to make the game more exciting and relevant to fans.

The NHL seems to experiment more with rule changes than the other North American professional sports leagues. Perhaps this is a result of the NHL's position as the poorer cousin of the other leagues. Recently, the league expanded the size of the goalie's crease area, only to reduce it back. The NHL is also enforcing rules against obstruction and rough play more stringently than in the past, with the hopes of speeding up the game and providing more scoring. This sort of fine-tuning does not go unnoticed by loyal fans who are often puzzled at the intention of the new rules.

We have chosen to use some economics to suggest the motives behind one particular rule change that was adopted for the 1999-2000 season. Rule 89 specifies that two teams now receive 1 point each in the event of a tie at the end of the regulation three periods of play (20 minutes per period). A 5-minute overtime period is then played with each club fielding only four skaters and one goalie instead of the normal five skaters and one goalie. The first team to score in the overtime period receives an additional point toward the league standings, whereas the losing club retains its 1 point earned at the end of regulation play (three periods). Prior to this rule change, each club received 0 points at the end of regulation play in the event of a tie. The teams then played a 5-minute overtime period with the regulation five skaters and a goalie. The first team to score earned 2 points toward the league standings, and the losing team received no points. In the event of a tie at the end of the overtime period, each team received a single point.

The overtime rule was first introduced for the 1983-1984 season for the purpose of decreasing the number of ties for regular-season games. The number of tied games decreased by 4.9% from the previous season. The number of overtime games since that season has steadily increased; the number of games reaching a decision in the overtime period has, however, been consistently decreasing. The percentage of overtime decisions peaked at 41.5% in the 1985-1986 season and reached its lowest point at 24.7% in the 1997-1998 season.[2]

The NHL believes that Rule 89 will make games more exciting, particularly during overtime periods but also during regulation time. They hope this will result in higher attendance and greater league revenues (both from attendance and television royalties). The statistical evidence on how competitive balance affects attendance is mixed. Humphreys (2002) measured the competitive balance ratio for major league baseball during the last 100 years and found a positive association between competitive balance and attendance. Schmidt and Berri (2001) also found a positive association for major league baseball, despite using a different measure of competitive balance.[3] The results for European football are contradictory. Szymanski (2001) found no association between a measure of competitive balance and attendance for a sample of football clubs in the English FA. The same result was found by Czarnitzki and Stadtmann (2002) for a sample of German football clubs. Both articles suggest that reputation is an important factor in determining attendance.

Our model does not directly address the issue of competitive balance, but it does suggest that competitive balance should improve with the new overtime rules via a movement toward a more equitable distribution of talent. We look deeper into the effects of the rule change using a simple game theory model. The overtime rule changes in the NHL change the payoffs to clubs from achieving various levels of performance.[4] Although NHL players do not directly benefit or lose monetarily from changes in payoffs for contests, they could be affected indirectly if contract negotiations are dependent on relative club performance over the season.[5]

Our model suggests that the rule change will affect team strategy in regulation time via two mechanisms. First, Rule 89 should provide an incentive for clubs to divert scarce talent toward games in which they play a team from the same conference,[6] holding constant the probability of a win, loss, or tie during the overtime period if one occurs. This should result in more exciting play and fewer ties in within-conference contests. The effect is reversed for interconference opponents.

The second effect of Rule 89 on regulation play is due to the intention of the rule to increase the number of overtime decisions. If the rule change results in an improvement in a club's overtime play, we show that the club will have a greater incentive to tie in regular time (whereas the effect is the reverse for a club whose overtime play worsens) relative to the club's strategy before Rule 89 was adopted.

The rule changes move the payoff system in the NHL closer to the characteristics of a rank-order tournament such as golf or tennis. The relative payoff against a within-conference opponent that requires an overtime period is reduced, effectively increasing the incentive to win the contest in regular time. For the NBA, Taylor and Trogdon (2002) found evidence that rule changes that give teams a greater incentive to win or lose will give rise to team behavior that is consistent with these incentives.[7] Our empirical evidence confirms our assertion for the NHL.

We also find that the rule change in the NHL will increase the mean of the league point distribution but will also reduce its variance. Hence, the average point differential between any two teams in the same conference will be reduced. This makes for more exciting playoff races. To prevent the compression in the point distribution from creating mediocrity and criticism, the league adopted the 4-skater rule in overtime periods.

The rule change could also affect trading behavior between within-conference and interconference clubs. Marburger (2002) pointed out that when a talented player moves from one team to another within the same conference, one team improves its quality at the expense of the other and hence improves its relative position within the conference. If property rights to the player's talent are owned by the club, the club will be appropriately compensated for the loss in relative position either by trading players or by cash sales. If, however, the property rights are owned by the player and free agency is allowed, clubs will bid up the asking price for talented players. The NHL has a very restrictive system of free agency, implying that trades or cash sales of talented players among conferences is more likely. We do not test this hypothesis, although Marburger (2002) found evidence that relaxation of free-agency rules has resulted in more movement of players within divisions. By adopting the new overtime rules, the NHL owners may be indirectly attempting to limit bidding for free-agent players within conferences.

Our model does not consider how teams will respond strategically to the overtime rule change by what degree; rather, it uses a game-theoretic framework to determine how the opportunity sets available to each club will change with the rule change assuming they do not respond to it. We then use empirical results from the 1998-1999, 1999-2000, and 2000-2001 seasons to estimate the strategies developed by clubs in response to the rule change. Developing a model of optimal club strategy in response to the rule change is an interesting but difficult maximization problem that we leave to future research.

THE MODEL

To keep the model simple, we consider a 2-stage game played between two teams, A and B. Figure 1 aids in the exposition of the model. The league is composed of *n* number of clubs divided evenly into two conferences (dividing the two conferences into divisions is of no importance here). In the first stage, a 3-period contest is played (each period is 20 minutes). If a winner emerges, the game is over. We draw the game tree for a single club. The club has a probability p_1 of winning the game in the first stage, a probability p_2 of losing the game in the first stage, and a probability p_3 of a tie. Obviously we have $p_1 + p_2 + p_3 = 1$. We assume these probabilities are independent of opponent and are only a function of the quality of the

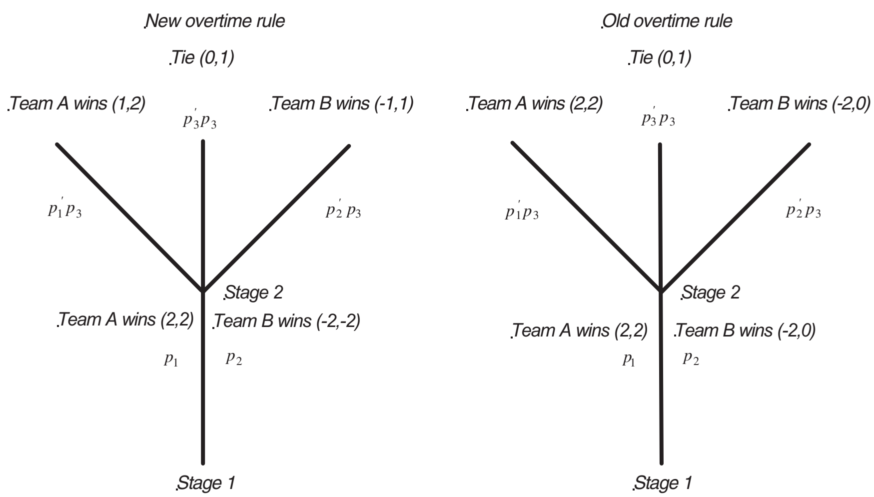

Figure 1: Two-Stage Game

club. One can think of these probabilities as win, loss, and tie percentages at the end of the season for all games. It is important to point out that underlying the determination of p_1 is a team production function that assumes full use of all team resources. Hence, p_1 is the maximal probability of winning in stage 1. The independence assumption is not realistic but does simplify the exposition of the model. In reality, these probabilities are conditional on the values taken by a vector of variables that might include the relative qualities of the contesting clubs, injuries, long road trips, and conference position. The thrust of the model is to determine how changing the payoffs to each outcome changes the opportunity sets available to each club and affects team incentives.

The club is awarded 2 points for a win and 0 points for a loss at the end of stage 1. If the game is tied at the end of the first stage, the club is guaranteed a single point under the new overtime rule only. In this event, a second-stage game is played composed of a single overtime period (5 minutes). Only four attacking skaters are used per side in the overtime period under the new rules; five attacking skaters are used per side under the old rules. If the club wins the second stage, it is awarded an additional point under Rule 89. Under the old overtime rule, the overtime winner is awarded 2 points and the overtime loser is not awarded any.

To emphasize the importance of games played against within-conference and interconference opponents, we index the payoffs to each stage of the game as relative to the club's own conference standings. Thus, a win in Stage 1 awards the club a payoff of 2 points relative to the other clubs in its own conference, whether it plays an opponent from its own conference or outside its own conference (ceteris paribus). These are the lower-left branches of each tree in Figure 1. A loss in Stage 1 against a conference opponent decreases the club's relative position in the conference by 2 points but does not change its relative position if the loss is against a club from the other conference. These are the lower-right branches of each tree in Figure 1. A win or a loss in stage 1 awards the same relative payoff regardless of the overtime rule.

A win in the second stage of the game is conditional on reaching the second stage; hence, its probability is $p_1'p_3$, where p_1' is the probability of winning the contest in the second stage of the game. The unconditional probabilities for overtime losses and ties are $p_2'p_3$ and $p_3'p_3$ respectively. The relative payoff under the old overtime rule is 2 points for a win against a conference opponent, 0 points for a tie (because the relative standing does not change within the conference), and –2 points for a loss. The payoff differs for an interconference opponent in overtime. A win is a win, and 2 points are awarded; 1 point is, however, awarded for a tie (because the club moves up a point in its own conference) and 0 points for a loss (no change in relative standing within its own conference). Under Rule 89, the payoff to beating a conference opponent is 2 points, tying a conference opponent is 0 points, and losing to a conference opponent is –1 point (because a point for the tie at the end of Stage 1 has already been awarded). Against an interconference opponent under Rule 89, the payoffs to winning, tying, and losing are 2 points, 1 point, and 1 point respectively. This completes the upper branches of both trees in Figure 1.

ANALYSES

Point Compression

The new overtime rule will compress the distribution of points within each conference so that clubs will have less separation around each other pointwise. This can be shown by computing the expected payoff from each game under the old and new overtime rules. Under the old (O) and new (N) rule systems, the expected payoffs (V) against a conference opponent (C) are

$$V_C^O = 2(p_1 - p_2) + 2p_3(p_1' - p_2') \quad (1)$$

$$V_C^N = 2(p_1 - p_2) + p_3(p_1' - p_2'). \quad (2)$$

Assuming the probabilities are unchanged, the expected payoff (points) is lower with the new overtime rule.[8] The expected payoffs in (1) and (2) are related by

$$V_C^O = V_C^N + p_3(p_1' - p_2'). \quad (3)$$

The last term in (3) is the difference in expected points between the new and old overtime rule systems for a single game. Over an *n*-game season, the difference in expected points is given by

$$\left(V_C^O - V_C^N\right) = n\left(\overline{p_3 p'_1} - \overline{p_3 p'_2}\right) \tag{4}$$

where a bar denotes an average probability over a season for a single team. The point differential increases as the probability of a tie in Stage 1, p_3, increases, holding overtime success constant because a single point is then awarded to each club. The maximum point differential to the winner then falls from 2 points to only 1 point. Clubs that experience success in overtime play will suffer a reduction in expected points

$$\overline{p_3 p'_1} - \overline{p_3 p'_2} > 0 \tag{5}$$

whereas relatively unsuccessful overtime clubs will experience a gain in expected points (because they receive 1 point for the tie at the end of Stage 1 instead of no points). These two effects should work to compress the point distribution within the same conference.

Point expansion will occur for interconference contests, although separate point standings for interconference contests are not usually maintained. The expected payoffs for interconference contests under the old and new overtime rule systems are given by

$$V_{NC}^O = 2p_1 + p_3\left(2p'_1 + p'_3\right) \tag{6}$$

$$V_{NC}^N = 2p_1 + p_3\left(2p'_1 + p'_2 + p'_3\right). \tag{7}$$

The expected payoffs in (6) and (7) can be expressed as

$$V_{NC}^N = V_{ND}^O + p'_3 p_2. \tag{8}$$

Over an *n*-game season, the expected point differential is given by

$$V_{NC}^N - V_{ND}^O = n\overline{p'_3 p_2}. \tag{9}$$

Because a club moves up in its own conference standings by a single point with a tie in Stage 1 and Stage 2 of the game, increases in the mean probabilities of each outcome result in point expansion for interconference contests. The point-compression and point-expansion results for within-conference and interconference games derived here assume that clubs do not change their efforts to win under either rule system, even though the incentives to win are different under the two rule systems. We explore changes in team behavior in a later section.

A Framework for Analyzing Incentives in Regulation Time

Rule 89 changes the payoffs in Stage 2 of the 2-team game, thus altering the incentives teams face as per their effort to win. Risk-averse clubs (perhaps clubs with little talent) might decide to play defensively in the first stage of the game to earn a single point, then take their chances in the second stage of the game, knowing that the point earned in Stage 1 cannot be taken away. We will discuss the conditions when such a strategy might be adopted under the new rule system shortly, but first we determine the incentives each club faces without changing their strategies of play under either rule system. That is, we first characterize the state of the world (or game) under both rule systems. Later, we discuss how clubs might respond to these states of the world with the use of empirical results.

The old overtime and new overtime rule systems can be analyzed by mapping the expected values of a contest under each rule system. Figure 2 gives an example of the mapping system in three dimensions: p_1, p_2, and p_3. The constraint $p_1 + p_2 + p_3 = 1$ defines the surface of potential outcomes at the end of Stage 1. The contour lines give combinations of p_1, p_2, and p_3 that leave the expected value of a contest unchanged. Naturally, the contour lines increase in expected value as they approach $p_1 = 1$. As will be shown, the expected value of each contour line differs with each of the two overtime rule systems and with conference versus nonconference play.

Rule 89 and Within-Conference Play

We consider first the mapping for the old overtime rule system and within-conference play. Using the adding-up constraint and solving equation (1) for p_2 gives

$$p_2 = \frac{2(p_1' - p_2') + 2p_1(1-(p_1' - p_2')) - V}{2(1+(p_1' - p_2'))}. \tag{10}$$

Figure 3 plots equation (10) for given values of $p_1' = 0.3$, $p_2' = 0.2$, and V in (p_1, p_2) space.[9] Figure 3 collapses Figure 2 into a 2-dimensional picture by using the constraint $p_1 + p_2 + p_3 = 1$. Hence, as p_2 is increasing, for a given value of p_1, p_3 is decreasing. The contour lines for the old overtime rule system are denoted by numerical values, and the contour lines for the new overtime rule system are not, although they have the same expected value. The two contour lines intersect at $p_3 = 0$ because the new overtime rules have no effect on the expected value of the contest if a tie in the first stage is never an outcome.

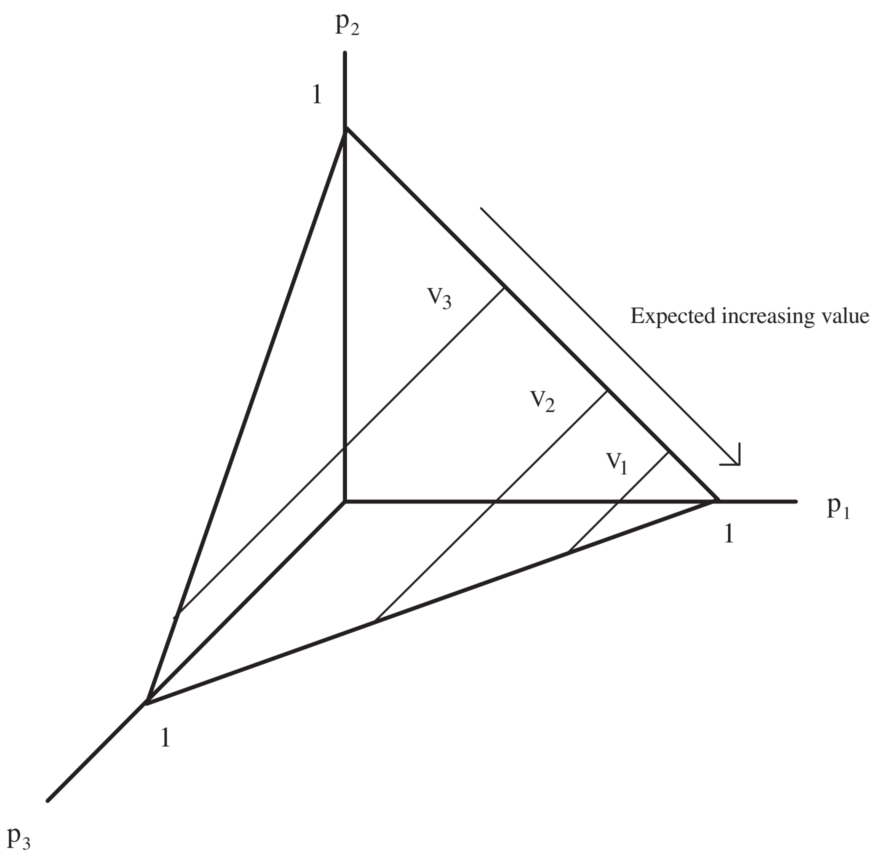

Figure 2: A Mapping of the Expected Value of Points

The effects of the overtime rule change on within-conference play can be explained with the aid of Figure 4. Consider a club described by probabilities p_1 and p_2 operating at Point A. At this position, the expected payoff is given by the value of the contour line passing through Point A. By reducing p_2 by an appropriate amount, the club can increase the expected payoff to point B. The overtime rule change pivots both contour lines so that the expected payoffs at points A and B are reduced. Improving the expected payoff from point A to the desired payoff now requires a greater reduction in p_2 to point C. The club could do this by increasing p_1 from point A, holding p_2 constant, and reducing p_3. This moves the club to the right to a contour line with a higher expected payoff. The overtime rule change requires a greater increase in p_1 to achieve the same increase in expected payoff. The effect is greater the lower the initial value of p_1 for a fixed value of p_2.

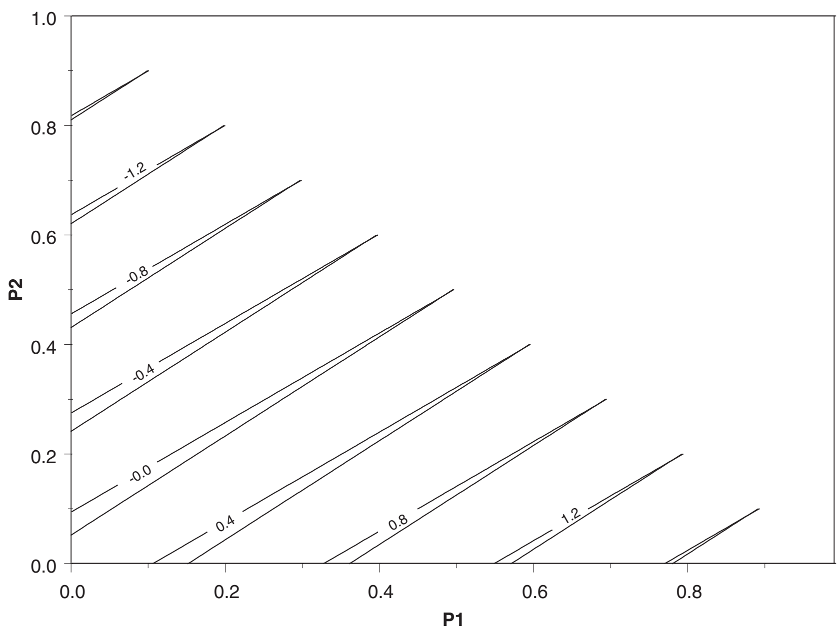

Figure 3: Divisional Play: Old and New Rules

NOTE: Numbered contour lines are old overtime rules. Unnumbered contour lines have the same value as the numbered lines but refer to the values with the new overtime rules.

The upshot of Figures 3 and 4 is that the opportunity sets for higher payoffs are reduced for all clubs that play within the same conference but more so for losing clubs. How this will affect actual play in Stage 1 of the game cannot be determined without a more formal maximization model. It is interesting to note that a club's degree of success in Stage 2 of the game (overtime) will affect the opportunity sets available in stage 1. This can be seen by inspection of (10). The differential $p_1'–p_2'$ is of key importance, as is demonstrated next.

The slope of each contour line in Figure 3 is given by

$$\frac{\partial p_2}{\partial p_1} = \frac{1-x}{1+x} \qquad (11)$$

where $x = p_1'–p_2'$. The change in the slope with respect to a change in x is given by $–2/x^2$. The effect is demonstrated in Figure 5.

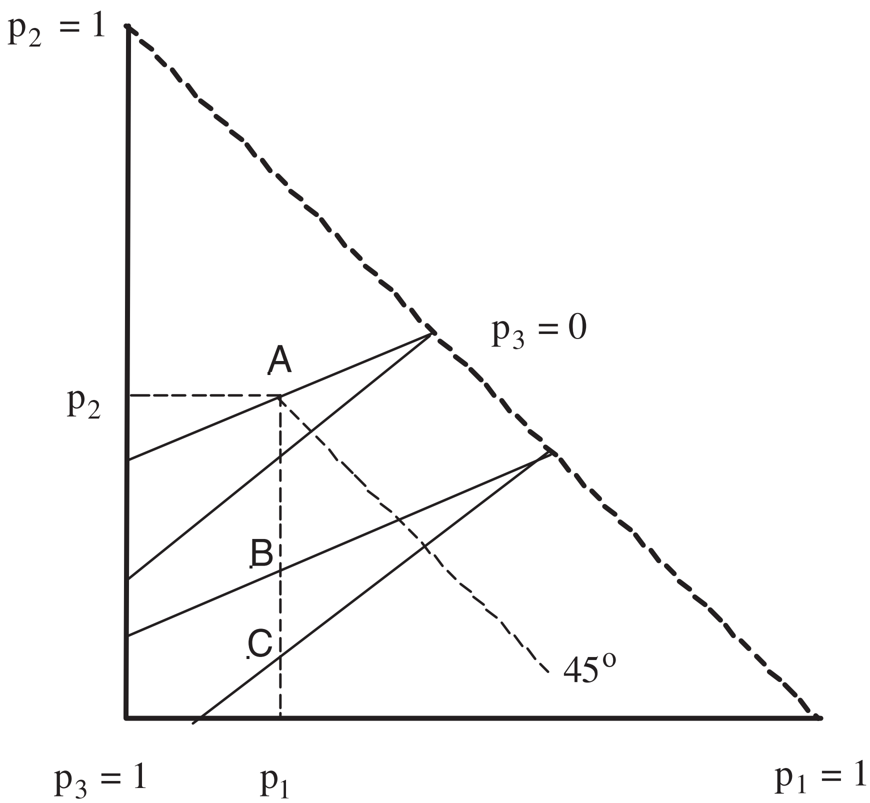

Figure 4: Effect of Overtime Rule Change on Within-Conference Play.

Suppose that two clubs are operating with identical winning and losing probabilities defined at Point A but that one of the clubs has a historically greater degree of success in overtime. An increase in the differential overtime probabilities (x) (increasing p_1' and/or decreasing p_2') decreases the slope of the contour passing through Point A with the same expected value. This opens up a region τ to the southwest of Point A that has a higher expected value than Point A but with a lower value of p_1 and a higher value of p_3. Playing for the tie in Stage 1 of the game becomes a more feasible strategy for the club with greater overtime success. Playing for the win in Stage 1 of the game (increasing p_1 and reducing p_3) becomes a less feasible strategy due to the presence of the new region φ to the northeast of Point A, where the expected value is lower than at Point A. This result holds regardless of which overtime rule system is used.

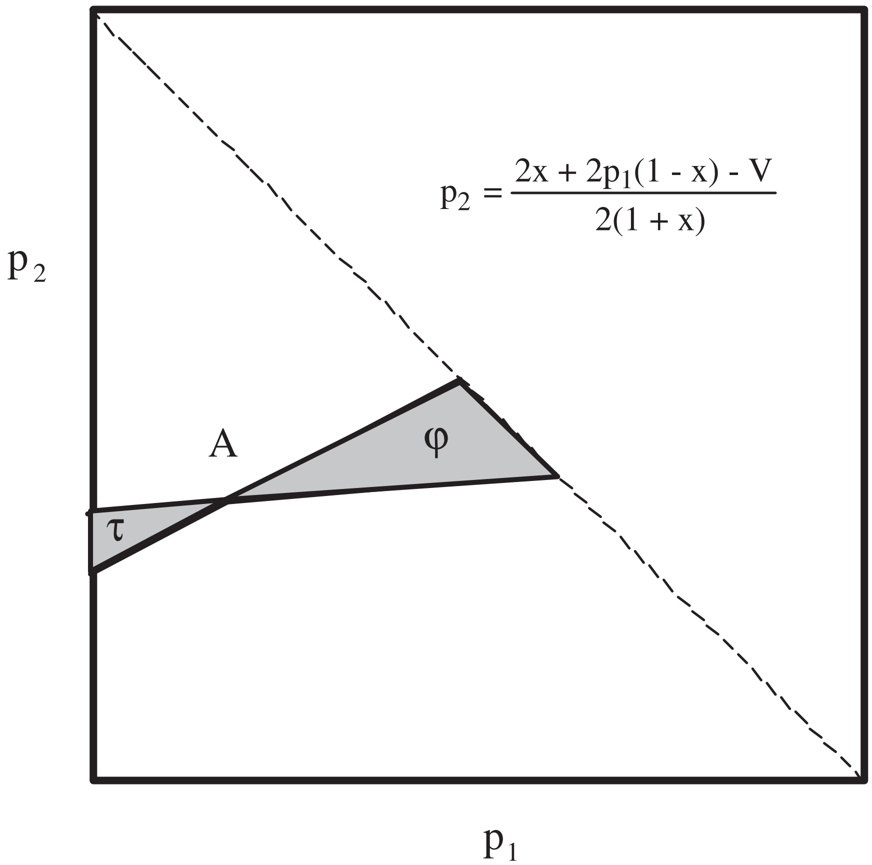

Figure 5: Effect of a Change in x on Strategic Play

Rule 89 and Nonconference Play

Under the old overtime rule system in nonconference play, the contour line is given by

$$p_2 = \frac{p_1\left(2-\left(2p_1'-p_3'\right)\right)+\left(2p_1'-p_3'\right)-V}{\left(2p_1'-p_3'\right)}. \tag{12}$$

Contour lines computed for p_1' = 0.3 and p_2' = 0.2 are shown in Figure 6. The effects of the overtime rule change on nondivisional play can be explained with the

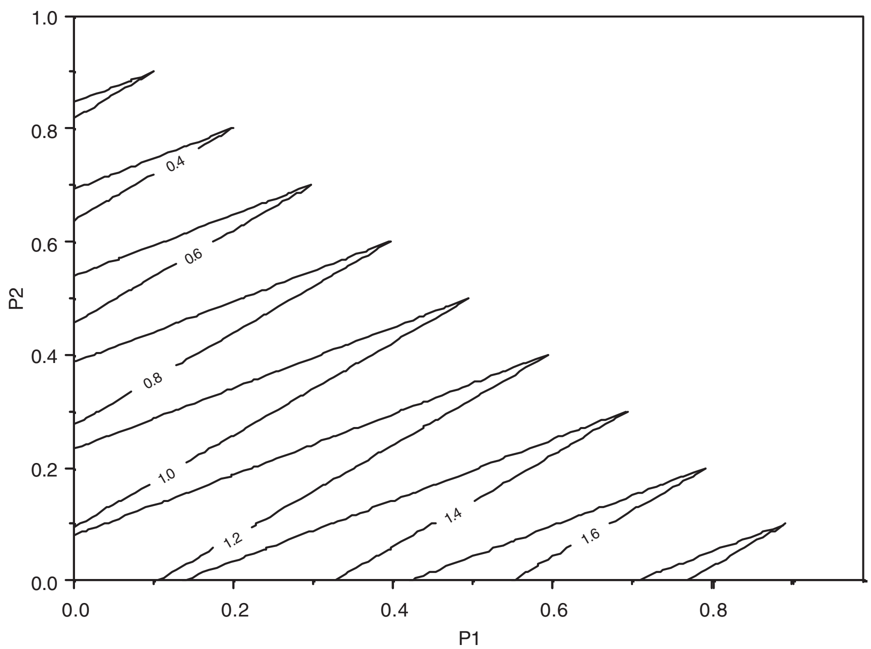

Figure 6: Nondivisional Play: Old and New Rules

NOTE: Numbered contour lines are old overtime rules. Unnumbered contour lines have the same value as the numbered lines but refer to the values with the new overtime rules.

aid of Figure 7. Consider a club initially at Point A with probabilities p_1 and p_2 of winning and losing in Stage 1 of the game. To reach a higher expected payoff contour, the club must reduce p_2 and increase p_3 so that Point B is reached. The rule change pivots the expected payoff contour upward from Point A so that Point A now has a higher expected payoff (due to the awarding of a single relative point for a tie or a loss in Stage 2). To achieve the same increase in expected payoff, the club must now only move to Point C. Clearly, the overtime rule change expands the opportunity sets available to clubs who are nonconference opponents. The effect is larger for clubs who historically have losing records.

The effect of a greater overtime success on the opportunity set available in Stage 1 of the game is straightforward. The slope of (12) is given by $(2 - x)/x$ where $x = 2p_1' + p_3'$. The change in the slope when p_1' increases (and thus p_2' decreases for a given p_3) is given by $(x - 4)/x^2$, which is negative. The slope of the contour line passing through an arbitrary point in Figure 5 becomes flatter, opening up similar opportunity sets (regions) as discussed in the case of within-conference play. An improvement in the probability of winning in the second stage of the game in

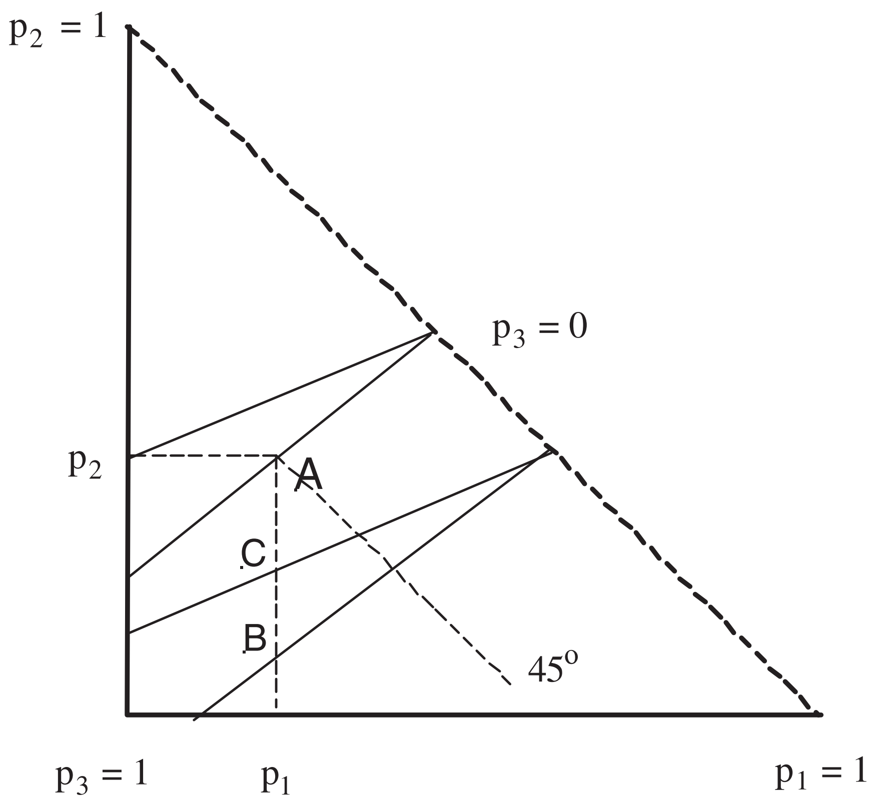

Figure 7: Effect of Overtime Rule Change on Nondivisional Play.

nonconference play has qualitatively the same effect as for conference play in Figure 5, regardless of the overtime rule system.

FROM INCENTIVES TO BEHAVIOR

What will be the club's response to Rule 89 for conference and nonconference games? By assuming unconditional and independent probabilities of winning and losing, based only a club's own stock of talent, our answers are limited, but we shall make an attempt here. A formal model of how teams respond to the new overtime rule would require a club that maximizes its expected points from a contest by adjusting its stock of talent for every contest in response to its opponents' stock of talent and its remaining schedule of games, subject to an overall talent stock constraint. This would allow us to draw indifference curves in Figures 3 and 6 and solve for tangencies. We see this as a dynamic programming problem that we leave to future research.

We will assume that players play to win and thus so do clubs. Nevertheless, sports leagues are always characterized by good (high p_1), middling ($p_1 \cong p_2$), and poor teams (low p_1). Their strategic response to the overtime rule change will likely depend on their historical degree of success.

Consider within-conference games in Figure 7, which is a stylized picture of Figure 3. A poor club is currently positioned at Point A under the old overtime rule. Increasing its expected payoff from a game (or a season of games) by a desired amount requires reducing its probability of losing in Stage 1 of the game, p_2, by the distance AB, in this case by increasing the probability of a tie, p_3. Poor clubs could also reduce p_2 by increasing p_1, holding p_3 constant, and move to the same higher expected payoff contour. The net effect will be a mixture of the two. The relative increases in p_1 and p_3 will be determined by where the club finds itself in relation to the 45-degree line emanating from Point A. Successful clubs that possess a higher initial p_1 must also reduce p_2 or increase p_1 by a greater amount due to the rule change. Both poor clubs and good clubs will shift talent to within-conference contests and put in more relative effort if we assume that players always play to win.[10]

Clubs, however, face limited resources (player talent), so they must allocate these resources efficiently between within-conference and interconference contests. It is not hard to understand why teams will regard within-conference games as more important than interconference games by resorting to the familiar sports argument of the "4-point swing." The cost of losing an interconference game is 0 points relative to within-conference opponents; the cost of losing a within-conference game is a 2-point fall in the standings. Winning either contest rewards the club with a 2-point increase in the standings relative to a within-conference opponent. This holds regardless of which overtime rule is applied.

Suppose that each club allocates talent to minimize losing (more technically, to minimize the expected loss in points from losing or the expected utility from losing if one liked).[11] This could be computed as $-2p_{wc} + (0)p_{ic}$ where p_{wc} is the probability of losing a within-conference game[12] and p_{ic} is the probability of losing an interconference game. Because interconference games have a payoff of 0 (relative to all other within-conference clubs) in the event of a loss, the value of p_{ic} is of little interest to the club. Rule 89 reduces the expected value of points from within-conference games for each team but less so for historically successful teams. If we can center the distribution of the expected number of points from a contest on its expected value, then reducing the expected value of points increases the probability of a loss (–2 points) and reduces the probability of a win (2 points). Clubs should then allocate scarce talent away from interconference games to within-conference games until the marginal expected loss in points for a loss is equated between the two.

Because more within-conference contests are played than nonconference contests, and conference contests carry much more importance in determining relative position within the conference, we suggest that clubs will allocate more scarce talent to conference contests than to nonconference ones, particularly for relatively wealthy clubs because they have a larger talent stock with which to work. This does not mean that players do not play to win in nonconference games; rather, the club may alter the lineup so as to divert talent to within-conference games.

We suggest that an increase in relative talent in within-conference games for wealthy clubs will result in fewer ties at the end of Stage 1 of the game. Nonconference contests will be characterized by a greater number of ties at the end of Stage 1 of the game as wealthy clubs reduce their relative talent in these contests (they move to the northwest of Point A in Figure 7) much more so than poor clubs (who cannot reduce their talent much without generating an almost certain loss). The next section attempts to estimate the effects of the overtime rule change on how NHL clubs choose to allocate their scarce talent.

EMPIRICAL EVIDENCE

We first test the point-compression result. Equations (4) and (9) predict that the new overtime rules will compress conference point distributions for within-conference games and expand the point distribution for interconference games. Table 1 provides end-of-season point totals for within-conference and interconference contests for the 1999-2000 and 2000-2001 seasons, using both rule systems. In most cases, the standard deviation of points falls for within-conference games and increases for interconference games. The result are reasonably consistent among the Eastern and Western conferences.[13]

We next wish to estimate how Rule 89 changed the allocation of talent for clubs between within-conference and interconference contests. More talented clubs will tend to win more contests; the number of wins in a season or even the winning percentage is, however, only a rough proxy for talent and cannot take into account variations in talent on a game-by-game basis. Noting whether individual contests end as a win, loss, or tie for a particular club is also a crude measure of talent because it does not take into account the magnitude of the win or loss. We use a simple proxy measure of the talent each club possesses on a game-by-game basis: the goal differential of the outcome. Highly talented clubs should demonstrate positive goal differentials (wins) that are consistently larger than for lesser-talented clubs. The large differential may be due to a highly skilled offensive club, a highly skilled defensive club, or both. Our conjecture is that talent ultimately determines the goal differential, and goal differential is a good measure of talent.[14]

We borrow from the literature that attempts to predict goal differentials, represented by Maher (1982) and Dixon and Coles (1997). They specified a regression equation for the number of goals scored by each of the two contestants in Contest i, X_i and Y_i, where $X_i \sim \text{Poisson}(\lambda_{1i})$ and Y_i $\text{Poisson}(\lambda_{2i})$. Taking the absolute value of the difference $X_i - Y_i$ (the "over-under" in betting terminology) results in a random variable that is Poisson-difference distributed and is difficult to work with.[15] When

TABLE 1: Standard Deviation of Points for New and Old Overtime Rules

	1999-2000 Season				*2000-2001 Season*			
	*WC Points**	*IC Points**	*WC Points*	*IC Points*	*WC Points**	*IC Points**	*WC Points*	*IC Points*
Eastern Conference								
Philadelphia Flyers	80	25	78	24	70	30	67	30
New Jersey Devils	78	25	74	23	71	40	69	39
Washington Capitals	80	22	77	22	72	24	70	22
Toronto Maple Leafs	70	30	67	30	57	33	54	31
Florida Panthers	65	33	61	32	39	27	34	23
Ottawa Senators	76	19	75	18	76	33	73	32
Pittsburgh Penguins	68	20	64	18	67	29	66	27
Buffalo Sabres	58	27	55	26	75	23	75	22
Carolina Hurricanes	63	21	63	21	69	19	67	18
Montreal Canadiens	60	23	58	21	49	21	46	18
Boston Bruins	53	20	49	19	65	23	62	18
New York Rangers	52	21	50	20	54	18	54	17
New York Islanders	43	15	42	15	41	11	38	11
Tampa Bay Lightning	33	21	28	19	43	16	39	15
Atlanta Thrashers	29	10	28	7	42	18	40	18
Standard deviation	16.190	5.617	16.184	5.976	13.563	7.687	14.245	7.611
Western Conference								
St. Louis Blues	77	37	76	37	75	28	72	26
Detroit Red Wings	71	37	70	36	81	30	77	30
Dallas Stars	65	37	60	36	71	35	69	35
Colorado Avalanche	70	26	70	25	86	32	83	31
Los Angeles Kings	62	32	59	32	65	27	63	26
Phoenix Coyotes	60	30	57	29	63	27	61	26
Edmonton Oilers	47	41	41	39	74	19	72	18
San Jose Sharks	54	33	48	31	69	26	67	25
Vancouver Canucks	43	40	37	37	69	21	64	19
Anaheim Mighty Ducks	60	20	59	18	44	22	40	21
Chicago Blackhawks	51	27	50	26	54	17	50	16
Calgary Flames	47	30	43	29	52	21	50	19
Nashville Predators	39	31	33	30	53	27	50	27
Columbus Blue Jackets					48	23	43	22
Minnesota Wild					48	20	43	20
Standard deviation	11.673	6.007	13.425	5.956	13.005	5.113	13.467	5.391

NOTE: WC = within conference; IC = interconference; * = the new overtime rule system.

the sign of the goal difference is preserved, we could not reject a normal distribution based on a Jarques-Bera test for the 1998-1999 and 1999-2000 seasons ($p = .53$ and $p = .32$ respectively). This allowed us to specify a least-squares regression of the form

$$(X_i - Y_i) = \alpha + \beta_1 G_{X-Y} + \beta_2 GA_{X-Y} + \beta_3 D + \beta_4 DGA_{X-Y} + \beta_5 DGF_{X-Y} + e_i. \quad (13)$$

In (13), $GF_{X\text{-}Y}$ is the difference between the total number of goals scored between Team X and Team Y up to the current Game i, whereas $GA_{X\text{-}Y}$ is the difference between the total number of goals allowed for each club up to the current Game i. Team Y is always assumed to be the home team in the analysis to follow. As in Maher (1982) and Dixon and Coles (1997), these two independent variables are thought to best represent a club's offensive and defensive capabilities over all current-season games prior to the current game. The term α is the intercept that reveals the average goal differential in favor of the visiting club if relative talent is held constant. The Variable D is a dummy variable that gives an estimate of the shift in the average goal differential for within-conference versus interconference contests, holding relative talent constant (1 = within-conference contest, 0 = interconference contest). The independent variables $DGA_{X\text{-}Y}$ and $DGF_{X\text{-}Y}$ are interaction terms that estimate the change in return to offensive and defensive talent due to a within-conference contest. Our data set included goal differentials at the end of regulation play for all games for the 1998-1999 (N = 1,107), 1999-2000 (N = 1,148), and 2000-2001 (N = 1,230) seasons and statistics for $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$ for each season.[16] Descriptive statistics for the end-of-season value of each variable appear in Table 2.[17] The estimates of (13) appear in Table 3.[18] Equation (13) was also estimated using end-of-season totals for $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$. These results appear in Table 4.

The second column of Table 3 gives the results for the 1998-1999 season before Rule 89 was adopted. The third column gives the best-fitting results for the 1998-1999 season, based on adjusted R^2. The estimate for β_1 is positive and statistically significant, as expected: An increase in the season (up to the current game played) goals-scored differential, $GF_{X\text{-}Y}$, is associated with an increase in the goal differential for the current contest. The estimate for β_2 is negative and statistically significant, which also conforms to prior beliefs. The estimate for α suggests that, holding relative talent constant, the goal differential for two clubs playing an interconference contest will slightly favor the home club in regulation play—a home-ice advantage. The estimate for β_3, the coefficient for the conference dummy variable, is not statistically significant, suggesting that the home-ice advantage for regulation play applies equally to within-conference and interconference contests. Neither of the interaction terms for conference versus nonconference is statistically significant.

The fifth column gives the best-fitting results for the 1999-2000 season, the first season in which Rule 89 was in effect. The estimates for β_1 and β_2 suggest that defensive talent is more highly associated with the goal differential as $|\beta_2| > \beta_1$ with a much larger t statistic. The home-ice advantage for interconference games, holding relative talent constant, disappears. The best guess for the outcome of an interconference contest is a tie (0-goal differential). The estimate for β_3 shows no statistically significant home-ice advantage for within-conference games, although

TABLE 2: Descriptive Statistics for End-of-Season Data

Variable	*Season*	*Mean*	*Standard Deviation*	*Range*	*Sample Size*
$X_i–Y_i$	1998-1999	–0.282	2.363	–9 to 8	1,107
	1999-2000	–0.208	2.306	–7 to 9	1,148
	2000-2001	–0.207	2.301	–7 to 9	1,230
$GF_{X\text{-}Y}$	1998-1999	0.000	32.46	–89 to 89	1,107
	1999-2000	0.000	31.33	–108 to 108	1,148
	2000-2001	0.000	44.56	–127 to 127	1,230
$GA_{X\text{-}Y}$	1998-1999	0.000	40.73	–124 to 124	1,107
	1999-2000	0.000	49.07	–148 to 148	1,148
	2000-2001	0.000	41.82	–106 to 106	1,230

the value of the coefficient is of an order of magnitude larger than in the previous season (and is consistent with the size of the coefficient in the following season). The results suggest that some factor(s) during the 1999-2000 season altered team strategies for interconference games such that playing for a tie became an attractive strategy. We propose that Rule 89 was responsible for this effect—that "playing for a tie" became a dominant strategy in interconference games because the reward of 1 point relative to the other clubs within the club's same conference is assured. This is not the case for within-conference games under Rule 89. Neither of the interaction terms is statistically significant.

To check for consistency of the effect of Rule 89, an estimate of equation (13) was computed for the 2000-2001 season. The best-fitting results in the last column of Table 3 confirm that the effect of Rule 89 is virtually the same as the previous season, although the home-ice advantage for within-conference games is slightly larger and statistically significant.

The estimates for α and D, using the cumulative values (up to the present game) of GFX-Y and $GA_{X\text{-}Y}$, suggest some evidence for our hypothesis that the effect of Rule 89 is to encourage clubs to reallocate scarce talent toward conference games. The statistical insignificance of the interaction terms for all three seasons suggests that if clubs did reallocate talent as we suggest, the increases in talent for each club essentially canceled each other out, leaving relative talent unchanged.

The results in Table 4, using the end-of-season totals for $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$, provide stronger support for our hypothesis. The estimates for β_1 and β_2 are very similar to those in Table 2; defensive talent is, however, only marginally more significant to determining the goal differential than offensive talent. The home-ice advantage for conference games for the 1998-1999 season persists, then disappears after the adoption of Rule 89. The interaction term for $GA_{X\text{-}Y}$ is statistically signifi-

TABLE 3: Least-Squares Estimates of Equation 13 Using Cumulative Values for $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$

Coefficient	*1998-1999 Season*	*1998-1999 Season (Best Fit)*	*1999-2000 Season*	*1999-2000 Season (Best Fit)*	*2000-2001 Season*	*2000-2001 Season (Best Fit)*
β_1	0.0159 (1.943)**	0.0138 (1.807)**	0.0041 (0.623)	0.0062 (1.809)**	0.0160 (3.907)*	0.0141 (6.808)*
β_2	–0.0106 (1.928)**	–0.0140 (4.785)*	–0.0267 (4.667)*	–0.0259 (4.882)*	–0.0170 (3.630)*	–0.0135 (5.606)*
β_3	–0.0181 (0.120)		–0.2255 (1.547)	–0.2247 (1.545)	–0.2977 (2.328)*	–0.2591 (3.912)*
β_4	–0.012 (1.311)	–0.0096 (1.115)	0.0029 (0.373)		–0.0025 (0.532)	
β_5	–0.0106 (0.721)		0.0082 (1.262)	0.0072 (1.220)	0.0047 (0.863)	
α	–0.2677 (2.126)*	–0.2825 (4.042)*	–0.0504 (0.410)	–0.0510 (0.412)	0.0509 (0.341)	0.0473 (0.317)
N	1,107	1,107	1,148	1,148	1,230	1,230
SEE	2.327	2.325	2.227	2.225	2.324	2.322
R^2	0.0347	0.0367	0.0719	0.0722	0.0506	0.0516

* Denotes statistical significance at 95% confidence.

TABLE 4: Least-Squares Estimates of Equation 13 Using End-of-Season Values for $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$

Coefficient	*1998-1999 Season*	*1998-1999 Season (Best Fit)*	*1999-2000 Season*	*1999-2000 Season (Best Fit)*	*2000-2001 Season*	*2000-2001 Season (Best Fit)*
β_1	0.0091 (2.653)*	0.0117 (6.269)*	0.0118 (2.578)*	0.0117 (4.885)*	0.0124 (4.326)*	0.0111 (7.346)*
β_2	–0.0186 (4.273)*	–0.0171 (4.256)*	–0.0123 (4.106)*	–0.0113 (7.334)*	–0.0146 (5.213)*	–0.0148 (5.362)*
β_3	–0.0491 (0.335)		–0.2177 (1.542)	–0.2177 (1.544)	–0.2823 (2.289)*	–0.2472 (3.856)*
β_4	–0.0037 (0.913)		0.0001 (0.002)		–0.0018 (0.526)	
β_5	0.0115 (0.391)		0.0014 (2.218)*	0.0093 (2.026)*	0.0043 (1.261)	0.0047 (1.422)
α	–0.245 (2.027)*		–0.0530 (0.442)		0.0481 (0.333)	
N	1,107	1,107	1,148	1,148	1,230	1,230
SEE	2.256	2.255	2.160	2.159	2.250	2.249
R^2	0.0925	0.0927	0.1267	0.1270	0.1101	0.1113

* Denotes statistical significance at 95% confidence.

cant for the 1999-2000 season. Its positive value suggests that the return to reallocating defensive talent to conference games did result in a larger goal differential in favor of the home club. The effect is reduced for the 2000-2001 season. Overall, the estimates of (13) using the end-of-season totals outperformed the estimates using the cumulative totals for GF_{X-Y} and GA_{X-Y} based on goodness of fit and significance of the coefficients. It could be that relative differences in talent will take some time to reveal themselves using the cumulative measures. Early in the season, there is little distinction in relative talent because most clubs are close in goals scored and allowed. Toward the middle and end of the season, differences in relative talent based on the cumulative measures should become more evident. This effect might cause the early-season observations for relative talent to be unreliable. Using the end-of-season totals for GF_{X-Y} and GA_{X-Y} assumes that clubs possess the same talent through the entire season, which is also questionable if a club suffers a loss of talent through injuries. Our results suggest that the latter effect is not large enough to prevent the use of end-of-season totals.

Both sets of results suggest that clubs are able to reallocate scarce talent toward improving defensive play in conference games, but this is not so for offensive talent. This might be easier to understand when one realizes that most clubs accumulate a stock of offensive talent in the off-season and that that stock is relatively unchanged during a season. Coaches can reallocate defensive talent by simply playing more defensively in conference games (adopting a tighter checking strategy and/or playing the best goaltender). There is an old adage in hockey that if a team plays poorly defensively, it is the coach's fault, but if a team plays poorly offensively, it is the general manager's fault.

CONCLUSIONS

In major professional sports, simple changes in the rules can lead to profound changes in outcomes. The types of changes engineered recently in the NHL illustrate what appear to be marginal changes for within-conference competition. Our model suggests that the outcomes can be forecast with some degree of success. What is particularly striking is that if the outcome for league competition is consistent with the (true) goals of the league, these outcomes can be forecast systematically using the most basic game-theory analysis. Instead of rule changes and rule reversals as the most crude and expensive tool to study behavior, the quantitative impact on the league standings are amenable to pen-and-paper assessment of the consequences. Many other features of team behavior affect the outcomes for profitability and competitive success, but the league rulebook is a device that affects each and every team. Although possibly a special case in a complex environment, the current set of rule changes leads a comparatively straightforward set of predictions. Point standings within each conference will tighten up resulting in more exciting playoff races. Teams will allocate more of their scarce talent toward within-conference contests. Interconference contests will become the opportunity for the press-box player to impress. Perhaps the next set of changes can be modeled more formally before the teams hit the ice.

NOTES

1. This isn't to say that there are no attendance problems. Attendance in Buffalo, New York, Nashville, Tennesse, Atlanta, Georgia, and Phoenix, Arizona was less than 13,000 per game in the 2002-2003 season. and the low numbers in these markets are a concern to the NHL (Shoalts, 2002).

2. See "Rule 89—Overtime" (2003).

3. They use a variation of the idealized standard deviation of winning percentage developed by Scully (1989).

4. Rule changes that change the payoff to performance are the main focus of this article. Strategic behavior may also be affected by enforcing existing rules more rigorously with greater monitoring. Allen (2002) found that placing an additional referee on the ice does not reduce the incentive to commit penalties but does result in more penalties being assessed due to a greater degree of monitoring.

5. Kahane (2001) found empirical evidence that differences in mean salaries among NHL clubs are partly due to differences in club revenues, which are greatly dependent on relative standing.

6. The NHL is composed of 30 clubs, 15 in the Western Conference and 15 in the Eastern Conference. Within each conference, there exists three divisions of five clubs each. The top club in each of the six divisions earns a playoff spot. Five additional clubs from each conference earn playoff spots based on highest point totals.

7. We see no reason why this would not be true in the NHL, although we are not aware of any study that provides explicit evidence.

8. This is a heroic assumption but useful for the purpose of comparing the point distribution. The probabilities can be conditional for different games in this section.

9. Choosing the p' values has no impact on the qualitative characteristics we describe in the figures, although of course the values differ numerically.

10. Relatively little research has been devoted to player incentives to win. Maxcy, Fort, and Krautmann (2002) found that there is no strategic behavior by baseball players just prior to contract negotiations (playing harder) or after signing long-term contracts (shirking). Variations in playing performance can be due to many factors, most notably injuries and the quality of other players on the club, yet it is likely that most professional athletes perform as well as they can.

11. If clubs are risk averse and many teams make the playoffs (16 of 30 clubs in the NHL), maximizing wins may give way to minimizing losses. The problems are not dual to each other due to the difference in payoffs for losses. In a league that does not allow ties and that allows few teams into the playoff pool, clubs are more likely to maximize wins. Major league baseball is a good example.

12. Again, probabilities are assumed to be nonconditional here.

13. Results for the 2001-2002 season are virtually identical to those of the two previous seasons but were not included in Table 1 for the sake of brevity.

14. An alternative approach would be to estimate how talent is actually redistributed between conference and nonconference games using minutes played by players. The NHL does collect "time on ice" minutes for every player but unfortunately only began collecting this data in the 2001-2002 season, not far enough back in time to consider the effects of Rule 89.

15. See Karlis and Ntzoufras (2003) for examples of how to analyze sports data using this distribution.

16. All data were obtained from Hockeynut.com (2003a, 2003b, 2003c, 2003d, 2003e, 2003f).

17. We do not provide descriptive statistics for the cumulative values of the independent variables because they are not variance stationary during the course of a season. This should be expected because early goals scored and goals allowed can vary considerably among teams early in the season. As the season progresses toward its end, the variability in the independent variables decreases considerably.

18. We initially also included the payroll differential for each game; team payroll was, however, highly correlated with the $GF_{X\text{-}Y}$ and $GA_{X\text{-}Y}$ talent variables, so we dropped the payroll differential.

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