LEARNING TO PLAY NICE: STRATEGY EVOLUTION IN THE NATIONAL HOCKEY LEAGUE[1]

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Abstract

The effect of increased monitoring and rule-enforcement in National Hockey League (NHL) games is analyzed at two levels (player and team). The economic theory of crime predicts a reduction of rule breaking due to increased deterrence. No change is observed in behavior at the player level. At the team level, however, we find a change in composition in type of players. Private rule enforcers, the goons, become more costly and less necessary when official monitoring is increased. We observe a decrease in the salaries of the goons as our game theoretic model predicted. These findings suggest that the economic theory of crime needs to be tested at multiple temporal and organizational levels.

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1. INTRODUCTION

One of the difficulties that social scientists face when studying the law is trying to measure the effect of a change. In most settings there are so many other factors that can change at around the same time as a rule changes that it is sometimes very tricky to attribute a change in outcome to a change in a rule. Donald Campbell long ago showed that without really careful research designs attributing major changes in behavior to a simple change in rule could be a mistake[2].

One of the advantages of experimental work in a laboratory is exactly that of control. If a researcher runs a series of experiments using the same set of rules except one that is changed by design, the researcher can more confidently attribute changes in behavior to the change in the rule. This has been a powerful way to examine some of the impacts of changes in rules on behavior in the provision of public goods or the protection of common-pool resources[3].

Experiments are not sufficient, however, to test out the implications of changing rules. Some scholars are skeptical of using undergraduate students as subjects even though findings from experimental laboratories in American universities have been replicated by findings of experiments conducted with mature users of common-pool resources[4]. Further, no matter how substantial the payoffs involved in an experimental laboratory, the individuals are engaged in an activity for only an hour or two and the activity is not key to their own perceptions of self and the payoffs are insubstantial compared to payoffs from the participants' major activities.

The systematic examination of the impact of diverse rules or changes in rules in a sports arena provides a nice complement to the laboratory experiment. When people are engaged in a professional sport they normally take the activity very seriously; few would challenge the validity of the observed behavior in a series of professional sports events. Further, changes in the rules of a sport are not normally accompanied by a simultaneous change in political, demographic, or economic factors. Careful research in sports environments provides some of the assets of an experimental design while existing in a real ongoing setting. A number of important articles have been published focusing on the impact of rules on the strategies and outcomes observed in professional sports[5].

Sport statistics have been used to test the economic theory of crime that predicts

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[2] Campbell, D.T. and Ross, H.L. "The Connecticut Crackdown on speeding: Time series data in Quasi-experimental analysis." *Law & Society Review* 3 (1968): 33-53.

[3] Ledyard, J.O. "Public Goods: A Survey of Experimental Research." in *A Handbook of Experimental Economics*, edited by A. Roth and J. Kagel, Princeton: Princeton University Press, 111-194, 1995; Ostrom, E., Gardner, R. and Walker, J. *Rules, Games. & Common-Pool Resources*, The University of Michigan Press, 1994.

[4] Cardenas, J-C. "How Do Groups Solve Local Commons Dilemma? Lessons from Experimental Economics in the Field." *Environment, Development and Sustainability* 2(3-4) (2000) :305-322.

[5] McCormick, R.E. and Tollison, D.D. "Crime on the Court." *Journal of Political Economy* 92(2) (1984): 223-235; and La Croix, S.J., and Kawaura, A. "Rule Changes, Resource Allocation, and Competitive Balance in Japanese Professional Baseball." *Economic Inquiry* 37 (2) (1999): 353-368.

that an increase in policing resources will lead to a decrease in the crime rate[6]. In their influential paper, McCormick and Tollison[7] applied economic theory of crime to rules infractions in basketball tournaments. They analyzed the effect of the 1979 change from two to three referees in the Atlantic Coast Conference (ACC) basketball tournaments using statistics during the period from 1954 to 1983. They analyzed the effect of more referees on the number of fouls called, finding a reduction in the number of fouls called.

In this paper we test the economic theory of crime using data of the National Hockey League (NHL). During the 1998-99 and 1999-2000 NHL seasons, the League conducted an experiment in which some games had two referees instead of one. The economic theory of crime would predict a reduction of the amount of rule breaking, since two referees make it more likely a transgressor will be caught. Several studies[8] analyzed the impact of an extra referee and found that an extra referee leads to better monitoring and therefore more penalty minutes for players who break the rules of the game. These findings are consistent with the hypothesis that increased monitoring leads to an increase in detection of illegal behavior. But the deterrence hypothesis, which is more consistent with the economic theory based on rational human behavior, has not been empirically supported to date. That is, the aforementioned studies do not find changes in behavior at the individual level.

In this article we present a different scenario by analyzing the NHL experiment on a longer time scale and at both the levels of individual players and the teams. We argue that the extra referee did bring in changes in the patterns of observed behavior in hockey games, but did not require adaptation to the new rules on the part of each player. In fact, individual players, especially the goons, had hard time adapting to the new environment, which explains why the dominant short term effect of the added referee was on the side of detection, not deterrence. Our empirical analyses of the NHL data, not only for the two seasons when one-referee and two-referee systems were both employed but also in subsequent seasons in which the two-referee system has been used exclusively, indicates learning, adaptation at the team level, artificial selection of players types by the teams, changed composition of player types in teams, and as a consequence of all these, changes in observed behavioral patterns which are consistent with the deterrence effect.

Goons are private enforcers, vigilantes. Goons punish the opponent team for breaking the rules when such transgressions are not detected and, thus, not punished by the referees. This private enforcement of rules by goons frequently takes the form of rough behavior that is itself a violation of the rules. Thus, if the goon retaliation is caught by the referees, it is costly to the team because the team suffers a penalty. Goons are also costly when, as often, they do not have as many scoring and defensive skills as the other players.

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[6] Becker, G.S. "Crime and punishment: An economic approach." *Journal of Political Economy*, 76 (1968): 169-217.

[7] McCormick & Tollison *supra* note 5.

[8] Allen, W.D. "Crime, Punishment, and Recidivism: Lessons From the National Hockey League." *Journal of Sport Economics* 3(1) (2002): 39-60; Levitt, S.D. "Testing the Economic Model of Crime: The National Hockey League's Two-Referee Experiment." *Contributions to Economic Policy and Analysis* (1/1), article 2. (2002); and Heckelman J.C. and Yates, A.J. "And a Hockey Game Broke Out: Crime and Punishment in the NHL." *Economic Inquiry* forthcoming

With more referees, there is less need for goons and, at the same time, goons become more costly since their illegal rule enforcement will be caught more frequently. We would therefore expect that the role of goons will change when there are more referees. We formulate a game theoretic model that shows the strategic interaction between teams as functions of the level of rule enforcement via referees. We have compiled a data set that contains player level data of the NHL from 1994 to 2002, which includes variables such as goals, assists, penalty minutes, salary, etc. At the aggregate level, the data shows an overall decline of penalty in minutes per team per game since the introduction of the additional referee per game. The data also indicate that a large part of the decline is due to the selection of players by teams, which is shown by the differential patterns of salary change between goons and non-goons before and after the introduction of the additional referee.

The remainder of the paper proceeds as follows. First we discuss the NHL experiment, and the findings of other articles on this experiment. Then we formulate a sequential-move goon game, and test the findings on data of the NHL. We end with a discussion of the broader implications of our findings.

2. THE NATIONAL HOCKEY LEAGUE EXPERIMENT

The National Hockey League (NHL) experimented over a course of two seasons with adding a second referee to some, but not all games. This led to an interesting natural experiment that has been analyzed by various scholars as will be discussed below. Prior to 1998, the NHL employed one referee for each contest. The referees were, and still are, accompanied by two linesmen, but they do not call penalties. During the 1998-99 season, the NHL introduced a second referee to some games. During the regular season between October 15, 1998 and February 28, 1999, all 27 NHL teams competed in 10 home games and 10 away games officiated by two referees. That means that about 20% of the games in the season were officiated by two referees instead of one. The assignment of one or two referees to the games was essentially random. In the 1999-2000 season, the number of games each team played with two officials increased to a minimum of 50. Since 2000, two referees have been used for each game.

Levitt[9] tests the impact of an additional referee on the minor and major penalties on data of the 1998-99 season, and finds that an additional referee led to more minor penalties being called. This result contrasts the findings of McCormick and Tollison[10] in basketball who found that more referees led to a reduction to the numbered fouls called. Furthermore, Levitt finds a small decrease in the number of major penalties called with an additional referee. This might be explained by the fact that an additional referee leads to fewer undetected infractions, and indirectly to less retaliation and fights. Levitt does not find an effect on scoring potential of the change in referees. He concludes that the natural experiments turned out be of limited use for testing deterrence.

Heckelman and Yates[11] argue that there are two effects. More referees leads to fewer actual violations due to rational cost-benefit calculations of the potential infractors. The other effect is that more referees leads to more effective monitoring, with the result

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[9] Levitt *supra* note 8.
[10] McCormick & Tollison *supra* note 5.
[11] Heckelman & Yates *supra* note 8.

that a greater percentage of the transgressions are penalized. In their analysis of the 1999-2000 season, Heckelman and Yates find that two referees call more penalties, suggesting that the monitoring effect dominates the deterrent effect. They use the following determinants of infractions committed: penalties in minutes, total number of penalties, minor and major penalties separately. They used an instrumental variables technique to determine the effect of the number of referees on the number of infractions actually committed by players in the game. They find no significant effect of the number of referees on the number of infractions committed. Since the average number of penalties per game is with two referees compared with one referee, but statistical analysis including control variables about team and player characteristics does not lead to a significant referee effect, they suggests that the players do not rationally make benefit costs-analysis of committing infractions, but commit a sport infraction as a "crime of passion".

Allen[12] studies rule infractions at the player level during the 1998-99 season. He finds that players with larger penalties-in-minutes per game during their career receive more minor and major penalties. Furthermore, experience and average ice time have a positive effect on penalties, while rookies receive significantly fewer penalties. An additional referee has a significantly positive effect on the number of major penalties. Allen suggests that this might be explained by a dominant "apprehension" effect rather than a deterrence effect.

Depken and Wilson[13] study the NHL experiment from a cartel perspective. They argue that a cartel, like a sport league, can benefit by introducing a public good, a second referee. A previous study of hockey using data of the 1983-84 season led to the conclusion that attendance is higher at hockey games if the teams have been playing tough (measured by total penalty minutes) in previous games in both American and Canadian cities[14]. In this study they also found that there is a significant positive relationship between the more extreme forms of violence (proxied by majors and misconducts) and attendance only in American cities. Depken and Wilson use data for both 1998-99 and 1999-2000 seasons. First they analyze the effect of the second referee, and they find that a second referee increased the number of scores, and decreased the number of fights. They argue that introducing more referees leads to fewer rule infractions, since it is unlikely that more referees affect the detection of fights in a hockey game. Note that this conclusion contradicts the findings of Heckelman and Yates[15]. Depken and Wilson estimate the relation between attendance and television viewership with scores and fights and conclude that when the spectators expect more scores they will watch more games. In contrast to Jones et al.[16] they do not find a positive relationship between expected fights and attendance. Depken and Wilson conclude that an extra referee improves the quality of the game, and that this leads to a higher television

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[12] Allen *supra* note 8.

[13] Depken II, C.A. and Wilson, D.P. "Wherein Lies the benefits of the second referee in the NHL." University of Texas-Arlington, 2003

[14] Jones, J.C.H., Ferguson, D.G. and Stewart K.G. "Blood Sports and Cherry Pie: Some Economics of Violence in the National Hockey League." *American Journal of Economics and Sociology*, 52(1) (1993): 63-78

[15] Heckelman & Yates *supra* note 8.

[16] Jones *supra* note 14

viewership. This makes it possible for the hockey league to derive better long-term television contracts, without reducing the attendance of the games. Hence the extra referee is beneficial for the whole league.

In sum, the various studies so far reviewed suggest that an additional referee leads to a more effective monitoring, hence more penalties, but not less rule breaking at the player level. So, the prediction of economic theory on the deterrence effect is not supported by the studies.

However, these studies do not utilize the available data fully and, thus, tend to miss long-term patterns, patterns starting before and ending after the addition of another referee. Figure 1 depicts the average penalty in minutes per team per game for 9 seasons from 1994-1995 to 2002-2003. Contrary to the previous studies, the data shows that the average penalty minutes - an indication of the extent to which rules are broken and such infractions are caught - has decreased significantly, from about 20 in 1994-1995 to about 15 in 2002-2003. In addition, the two experimental seasons of 1998-1999 and 1999-2000 appear to mark the critical point. Thus, the assertions of previous studies — that monitoring became more efficient with the additional referee per game but players did not break the rules less ~ conflict with the long term trend in the data.

Why did the previous studies fail to notice the decrease in penalty minutes with two referees? We think that this failure stems from the fact that most of the studies utilize only limited data, especially the data from the seasons when both one-referee and two-referee games co-existed. Focusing only on the official experimental years, when both one and two referees were used in the same season, has its drawbacks as well as its benefits. Changes in team behavior from one year to the next might be missed in a comparison of behavior across games within the season. Yet teams might be expected to respond over the seasons to the new rule change. They might, for example, change the type of players composing their teams, or the relative ice-time of the different types of players. As noted above, since monitoring became more effective with an additional referee, players who commit a lot of rule infractions have become both less useful and more costly.

This has obvious consequences for the goons. As rule-enforcement by the officials became more effective, teams needed their own enforcers less. At the same time, we the goons became more costly, since their retaliatory enforcement activities were more likely to be detected and punished by the officials. In the following section we will formulate the strategy of a team in a game theoretic framework, and provide a possible explanation for the trends shown in Figure 1.

[Figure 1 About Here]

3. THE GOON GAME

To analyze how the added referee might affect the teams' strategies in a game, we constructed a simple goon game in which the number of referees is modeled as the probability of detecting a transgression. The two teams in the game model are nicknamed "Maple Leafs" and "Red Wings" without any intention of portraying the real teams as having the tendencies depicted in the game model. The payoffs are relative values representing the changes in winning probabilities corresponding to certain strategy

combinations[17].

As can be seen from Figure 2, the first mover is Maple Leafs. The Flyers must decide whether to commit an infraction of the rules (signified by the word "violate" or "infract" or "transgress") or to refrain from breaking the rules. In some situations, it makes sense to break the rules. For an easy example, if the opposing team, Red Wings, has a player on a breakaway, he has a pretty good chance (perhaps 25%, as judged by the frequency of scoring on a penalty shot)[18] of scoring a goal, and that goal may well be the deciding factor in the game. In some such situations, a Maple Leafs player can use his stick to hook the Red Wings player, restraining him and thereby preventing the goal. In this example, preventing the goal in a close game improves Maple Leafs's chances of winning by 20%, and reduces Red Wings's chances of winning by the same amount, if it were to go undetected by the referee and unretaliated by Red Wings. The amount of difference the violation will make can of course be higher or much lower. In a game that is already 7 to 1, there is little chance that any move will affect the outcome.

But, of course, that is not the end of the calculations. This hooking violation will often result in a penalty, the probability of which is called *p* in the game. In such situations, the cheating player will have to spend some time in the penalty box and his team will have to play with fewer players during that time. The next node in the game models that event, the referee calling a penalty (called "detection") for the violation of the rules. This is called a "power play" for Red Wings, and the chances of scoring are fairly high, although the success of teams on power plays varies widely across the league, as does the ability of teams to "kill" (fend off) power plays. Usually, if the referee has penalized the cheating Maple Leafs player, Red Wings does not need to retaliate. Indeed, retaliation may result in a "stupid penalty" to Red Wings, canceling the powerplay and nullifying the benefits they would have obtained by the penalty against Maple Leafs, and thus our model does not give Red Wings the option of retaliating when Maple Leafs has been called for a penalty, even though in theory of course that is also an option.

However, if the referee does not penalize the Maple Leafs player, for whatever reason, the next move is Red Wings's. Red Wings must decide whether to privately enforce the rules. If Red Wings chooses to retaliate, it will usually do so by sending a goon out onto the ice to inflict some pain on the offending Maple Leafs player. Of course, even though this is hockey, this is a violation of the rules and may result in a penalty. The effects of the goon's retaliation are numerous. First, the goon may injure the Maple Leafs offender enough that he is unable to play, or play well, in the game. This effect may carry over to future games, and is signified by the -5% effect on Maple Leafs winning games in the future. In addition, the Maple Leafs players may be somewhat intimidated during the present game and thus may be slightly less likely to win. This effect, too, may carry over to other games. Other opponents of Red Wings in the future, having seen the brutal retaliation against Maple Leafs, may be somewhat intimidated and therefore may be slightly less likely to commit infractions against Red Wings, giving Red Wings a small advantage *a* in those later games. On the flip side, if Red Wings does not employ a goon to retaliate, it loses a little credibility, making it more likely to be the victim of cheating

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[17] These estimates are expert judgments of the authors. Two of the authors have been actively been involved in hockey as players, as well as observers of the NHL over many years.

[18] For example, the 2002-2003 regular season witnessed 39 penalty shots for which 9 went in. http://www.sportschronicles.com/stats/nhl_penalty_shots.asp (accessed:8/25/03)

by other teams in the future, which is signified by the -5% in future games. Thus, the goon's brutality may result in an advantage for Red Wings in this and future games. The effects on the future games, of course, do not affect the wining probability of the current game, but they can be interpreted as the positive or negative effects on the future game translated to the equivalent value of changes in winning probability in the current game. That is, -5% for Maple Leafs as consequence of having its one of its key players attacked by Red Wings's goon implies that Maple Leafs would take any action in the current game that might decrease its probability of winning the current game by 5% to avoid such an attack by Red Wings.

The referee may impose a penalty, and does so with probability *q* in the game. If that happens, we have essentially the reverse of the situation in which the referee caught the Maple Leafs cheater. In this case, however, the cost to Red Wings is slightly less because Red Wings loses the use of a slightly less useful player. Moreover, there may be a long-term future-game advantage to the goon being caught in that the high number of penalty minutes the goon has suffered sends the clear signal that Red Wings is willing to impose justice when the referees fail to do so.

[TABLE 1 ABOUT HERE]

The goon game (Figure 2) is constructed based on the payoffs shown in Table 1. The payoffs are divided into two sources, future games and the immediate game that the two teams are playing. The payoffs in the immediate games are the changes in the probability of winning. The payoffs in the future games are, as just noted, the benefits for a team that accrues in the future translated as equivalents of the changes in the winning probability in the current game. The two sources of payoffs are combined and incorporated into the payoffs of the Goon game shown in Figure 2. For convenience of analysis the payoffs are multiplied by 100 - because the utility payoffs in games are defined up to scale, this linear transformation does not change the nature of the game at all.

[FIGURE 2 ABOUT HERE]

The parameter p in Figure 2 is the probability that Maple Leafs's transgression will be caught by the referees. The parameter *q* is the probability that the referees will catch the Red Wings goon's reaction. The two probabilities are exogenously given for a given game (i.e. they are not strategic choices of the referees). We can think of the two probabilities as the League's policies that are fixed for a given game. Since a goon action is more conspicuous than other illegal actions intending to prevent the opponent from scoring a goal, we assume that *q* is greater than/?. The league may as well change the probabilities by changing the number of referees of other rules of the game. In that case, we assume that both *p* and *q* changes but still *q* remains greater than *p*. The subgame perfect equilibria of the game are functions of the two probabilities, *p* and *q* as shown in Table 2.

[TABLE 2 ABOUT HERE]

To find the subgame-perfect equilibria of the game, we conduct backward induction, i.e., start with Red Wings's rational choice and then find Maple Leafs's rational choice given Red Wings's rational choice. Red Wings faces the decision whether or not to use goons when Maple Leafs cheats and is not caught by the referees. Red Wings, given q, chooses to use goons if the expected utility of using goons is greater than the expected utility of not using them. The expected utility of not using goons is -25. The expected utility of letting the goons loose is q(-25+a) -5. Thus Red Wings uses goon if $q < 20/(25\text{-a})$.

Maple Leafs's optimal strategy needs to be calculated separately for when $q < 20/(25\text{-a})$ and, thus, Red Wings uses goons when Maple Leafs commits a violation against Red Wings's skilled players, and when $q>20/(25\text{-a})$ and, thus, Red Wings does not use goons. For both of the cases, Maple Leafs's payoff of not transgressing is 0. If Red Wings is ready to use goons Maple Leafs still attacks if the expected utility of attacking is greater than 0 – the expected utility of not attacking, or when $p < (6q+1)/(6q+3)$. Therefore, if $q < 20/(25\text{-a})$ and $p < (6q+1)/(6q+3)$, the subgame perfect equilibrium is [Maple Leafs infracts, Red Wings retaliates], which is the kind of game in which a lot violence is observed. If, on the other hand, $q < 20/(25\text{-a})$ but $p > (6q+1)/(6q+3)$, the subgame perfect equilibrium is [Maple Leafs does not infract, Red Wings uses goons] and the outcome we actually observe is [Maple Leafs plays by the rules]. That is, in this equilibrium, Red Wings does not have to make the decision of whether or not to use goons because that decision node is never reached.

What if $q > 20/(25\text{-a})$ and, thus, Red Wings does not use goons even when its information set is reached (i.e., when Maple Leafs infracts and the referees fail to catch it)? Again, Maple Leafs's utility of not transgressing is 0. Maple Leafs transgresses if the expected utility of doing so is greater than 0, given that Red Wings would not use goons. The expected utility for Maple Leafs of transgressing in this case is $p(-10)+(1-p)(20)$. Therefore, Maple Leafs transgresses if $p < 2/3$. Otherwise, Maple Leafs plays by the rules. Therefore, the subgame perfect equilibria when $q>20/(25\text{-a})$ are as follows. When $q > 20/(25\text{-a})$ and $p < 2/3$, the subgame perfect equilibrium is [Maple Leafs infracts, Red Wings does not use goon]. When $q > 20/(25\text{-a})$ and $p > 2/3$, the subgame perfect equilibrium is [Maple Leafs does not infract, Red Wings does not use goon].

Our assumption is that the addition of a referee has changed the detection probabilities p and q to, say, p' and q' such that $p' > p$ and $q' > q$. These changes in detection probabilities can have different observable effects depending on how large were the original p and q, and how large were the changes in those valued due to the added referee. Figure 3 depicts possible equilibrium regimes of the goon game, which helps to understand the effects of rule change on behavior. Given the assumption that $q > p$, the feasible equilibrium space is limited to the triangle demarcated by the bold lines. The four zones in Figure 3 correspond to the four equilibria shown in Table 2. An increase of referees may lead to no observable effect in the use of goons, when increases in p and q are not enough to move the equilibrium zone. Suppose that the League was concerned with too much violence in the game (which corresponds to the equilibrium in zone IV) and added another referee to increase the detection probabilities p and q. This would cause the equilibrium to move somewhat northeast of the original one. However, there is no guarantee that the equilibrium actually moves to another zone, zones I, II, or III. In

this case, while the only change would be an increase in penalties which results from a combination of the same violent equilibrium and the enhanced detection capability. The findings of earlier studies using the outcomes of the experimental seasons correspond to this scenario.

[FIGURE 3 ABOUT HERE]

More referees, of course, may disturb the old equilibrium and create a new one, which probably was the intention of the League. If the equilibrium moves to either zone I or zone III, there would be a substantial reduction of violence in games. Though the two equilibria differ from one another, the outcomes actually observed are the same. That is, in these two equilibria, there is no intentional rule infraction by Maple Leafs to discourage Red Wings's skilled players. But there is subtle difference, which at the same time may have different ramifications for the fate of goons. In zone III, Red Wings's readiness to use goons is in part responsible for Maple Leafs's refraining from transgressions. Thus, though the usefulness of goons for Red Wings is somewhat lower than that in zone IV, Red Wings might still need to have some goons ready for action to prevent Maple Leafs's attack on Red Wings's skilled players. On the other hand, in zone I, Red Wings would not use goons even when Maple Leafs violates the rules and the violation is not detected by referees. Here, what deters Maple Leafs from such actions is the referees and referees alone. Thus, the goons are no longer useful for Red Wings.

4. EMPIRICAL GOON ANALYSIS

Goons are popular players among hockey fans and various websites and list the favorite goons in the NHL. Those sites usually define goons by the number of major fights that players were involved in for a given season. We think this is not enough. In fact, the quality of being a goon, which we call "goonness" can be better captured on a continuous dimension. The most notorious goons can still skate and use sticks (legally) far better than the rest of us, and the physical nature of the hockey game sometimes puts the most gentlemanly player into fights. Thus, we have developed a measure of goonness as a composite measure derived from three numbers available for each player: penalty-time-in-minutes (PIM), goals, and assists. Specifically goonness is defined as PIM/(GOALS+ASSISTS+1). The number of goals and assists, of course, are among the most important indicators of how essential a player is to his team's reason for being, which is winning hockey games. The PIM is taken as one indicator of how often a player is involved in retaliatory actions.

This section utilizes the goonness measure and other aspects of the data we gathered for the NHL seasons from 1994-1995 to 2002-2003 to study how a rule change, i.e., the added referee per game, affects the behavior of the players and the outcomes of the game. We will start by re-examining the hitherto prevalent view that the added referee only contributed to better crime detection, but not prevention. The enhanced dataset that we utilize shows a substantial reduction in crime in hockey games, indicating adaptation to the new rules, with learning occurring over time rather than instantaneously. This finding leads us to inquire as to the mechanism by which the change occurred. Have the players learned immediately to refrain from illegal actions after such infractions

became more costly? The data indicate of previous studies as discussed in secion 2 show that this is not the case. This should not be a surprise. Goons were useful for being goons, not for being skilled. They might want to adapt to the new environment, but unfortunately achieving an excellence in professional level hockey games is not something a person can do at will. The mechanism of change appears to reside at a higher level. That is, the teams - the decision makers in teams such as coaches and management ~ seemed to have learned that the costs of utilizing goons have surpassed the benefits. The goons were subjected to a form of artificial selection; their importance is decreased. Because of the change in payoffs accompanying the increase in referees, teams use fewer goons in games (and pay less to goons). It is the choice of the teams not to use the goons, rather than the choice of the players not to be goons, which caused the substantial decrease of goon actions in hockey games.

A Data base

We constructed a data base of player characteristics for nine seasons, namely from 1994-1995 to the 2002-2003 season. For each player, the usual statistics like games played, scores, assists, and penalty minutes are collected from official online resources[19]. In order to standardize the database, only regular season statistics were included because only select teams (and thus players) advance to the playoffs. Goalies were not included because goalies cannot be considered candidates for goon status and therefore offer no comparative utility.

Furthermore, we estimated the salaries of the individual players from various sources. Those salary figures are not officially published but based on estimates from a list of online resources[20]. A total of 73% of the possible salary entries were estimated.

B Estimating the level of goonness

Being a goon is not an official recorded position of a player, so we have to estimate indirectly which player can be characterized as a goon. Nevertheless we can check our estimates with unofficial goon lists on fan pages, and with the top 25 on the goon-o-meter of the CBS[21].

We chose official recorded statistics like penalties in minutes, goals and assists, so that we where able to derive estimates of goonness for all players for all nine seasons. The goon-o-meter of CBS provides different weights to different type of penalties related to the aggressiveness of the convict, but this detailed information is not available to us. For example, penalty minutes derived for Match penalty or gross misconduct derived weight 25, while fighting a major scores 10 points, and elbowing, kneeing, slashing, spearing, unsportsmanlike conduct or obstruction cross-checking is only weighted by one

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[19] http://www.nhl.com/ [accessed:8-9-03] and http://www.hockeydb.com/ [accessed:8-9-03].
[20] http://moo.hawaii.edu:1749/hockey/misc/salary.html (season:1995-1996 [accessed: 8-9-03]), http://users.pullman.com/rodfort/PHSportsEcon/Common/OtherData/NHLSalaries/NHLSalaries.html (seasons:1996-1997, 1997-1998, 1998-1999 [accessed: 8-9-03]), http://www.seattleinsider.com/shared/sports/nhl/stats/salaries.html (season:1999-2000 [accessed: 7-20-02]), http://www.cris.com/~khallowe/powerplay/reports/reports.html (season:2000-2001 [accessed:7-20-02]), http://www.faceoff.com/nhl/salaries/ (season:2001-2002 [accessed:7-20-02]), http://www.hockeyzoneplus.com/$salai_e.htm (season:2002-2003 [accessed:8-9-03]).
[21] http://cbs.sportsline.com/u/hockey/nhl/enforcers/ [accessed: 8-8-03].

point per derived penalty minute.

Figure 4 shows that the majority of the players have a goonness quotient of less than 3. As a reasonable arbitrarily threshold we define a goon to be a player with a goonness quotient of greater than 25. The resulting list of 30 goons in the 2001/2002 season consisted of 13 players of the top 25 from the goon-o-meter. Given the 860 players in the NHL in that season, our goonness measure is to some degree validated by the subjective estimator of the CBS goon-o-meter. There is a difference, however, in that players who are highly penalized but score reasonably well are not classified as a goon in our estimator, but do show up on the goon-o-meter. For example, Andrei Nazarov, second in the CBS list did not reach our goon list although he had 215 penalty-in-minutes, since he scores 6 goals and had 5 assists.

[FIGURE 4 ABOUT HERE]

[TABLE 3 ABOUT HERE]

It appears that the experimental seasons 1998/1999 and 1999/2000 divide two periods of high goonness and low goonness, as we could expect from Figure 1 (Table 3). Also the number of players with a high goonness score are somewhat lower after the experimental seasons, than before. In sum, we are not able to identify precisely the goons for all seasons, but we argue that we have a reasonable estimator that can be used for the analysis of salary developments.

C. Goonness and Salary Change.

Previous studies of the effects of the NHL rule change have found that the effects are more on the side of detection than deterrence. But these studies used a single season in which games are played under both rules - some with one referee and some with two referees. Unless one assumes that the effects of a rule change are instantaneous, using only the official experimental period may not properly capture all of the effects of rule change. The decrease in PIM over the several years since the rule change (Figure 1) indicates that the teams have learned to adapt to the new environment over time. One of the testable implications is that the value of goons is lower than it used be before the introduction of two referees. In this subsection we test how goonness affects salary change.

There have been previous studies on the player and team characteristics that affect the salaries of the players. Not surprisingly, these analyses show that star players in teams with higher revenues get higher salaries than others[22]

We will simply determine whether there is a difference in salary development between players classified as goons by our estimator, and other players. Players that are identified as a goon, receive a lower salary, and the trend of the salary mimics the general

[22] Idson, T.L. and Kahane, L.H. "Team effects on compensation: an application to salary determination in the national hockey league." *Economic Inquiry* 38(2) (2000): 345-357.

trend of salaries before the NHL experiment, but after the NHL experiment, the average salary of players with a high goonness score reduces relative to the general trend. This finding holds when we use different thresholds (a goonness quotient of 10 or 25) for identifying a goon. This trend in salary development is in line with the prediction of the game theoretical model in our previous section.

[FIGURE 5 ABOUT HERE]

5. DISCUSSION

This paper analyzes the effect of increased monitoring on the behavior of players and teams in the NHL. Our results suggest that players do not change their behavior, but teams do. Teams change their composition, the type of players on the team. These results do not support the economic theory of crime at the player level, but do support the economic theory of crime at the team level.

This analysis was performed on data of professional sport, but may provide insights and predictions for other action areas. There are various situations in which rules aim to reduce certain type of behavior, but where we would expect that individuals may not be able to adapt and change their behavior. Groups, from hockey firms to the mafia, however, may be able to adapt and may do so by changing their own composition to include fewer of the persons whose behavior has become uneconomic.

For example, a law change may aim to increase the quality of accounting of firms. Firms, who have a flexible interpretation of accounting rules may replace certain employers to reduce the expected high costs of continuation of practices. As another example, consider employer liability for violence of their employees. Suppose that the law changes to increase the civil liability for violent acts. Some individuals will respond by controlling their tempers. But others have a harder time doing so. For example, it has been found that persons with a certain gene are much more likely to be violent as adults if they were subjected to violence as minors.[23] The environment influenced the expression of the gene, leading to a person much more likely to be violent than someone without the gene or without the child abuse. Increasing the penalties for abuse might have little effect on such persons; they may be unable to control their tempers. Nevertheless, firms potentially employing such persons might investigate to identify them, avoid hiring them, and reduce the amount of violence.

A second insight of our analysis is that the effect of a rule change may not be measured directly or immediately. Previous studies of the NHL experiment all focused on one or two seasons in which the experiment took place, and compared the games with one and two referees. As our analysis shows a behavioral change that is measurable only over a period of various seasons. As the classic study of Campbell and Ross[24] (1968) showed, a broader dynamic perspective of factors at multiple levels of scale influence the observations, and need to be taken care of.

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[23] Ridley, M. Nature Via Nurture: Genes, Experience, and What Makes Us Human, HarperCollins, 2003

[24] Campbell & Ross *supra* note 2.

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FIGURES AND TABLES

Figure 1: Average penalties in minutes (PIM) per team per game for 9 seasons, where the average is depicted as solid dots, and the dotted lines shows the standard deviation of the average PIM per team.

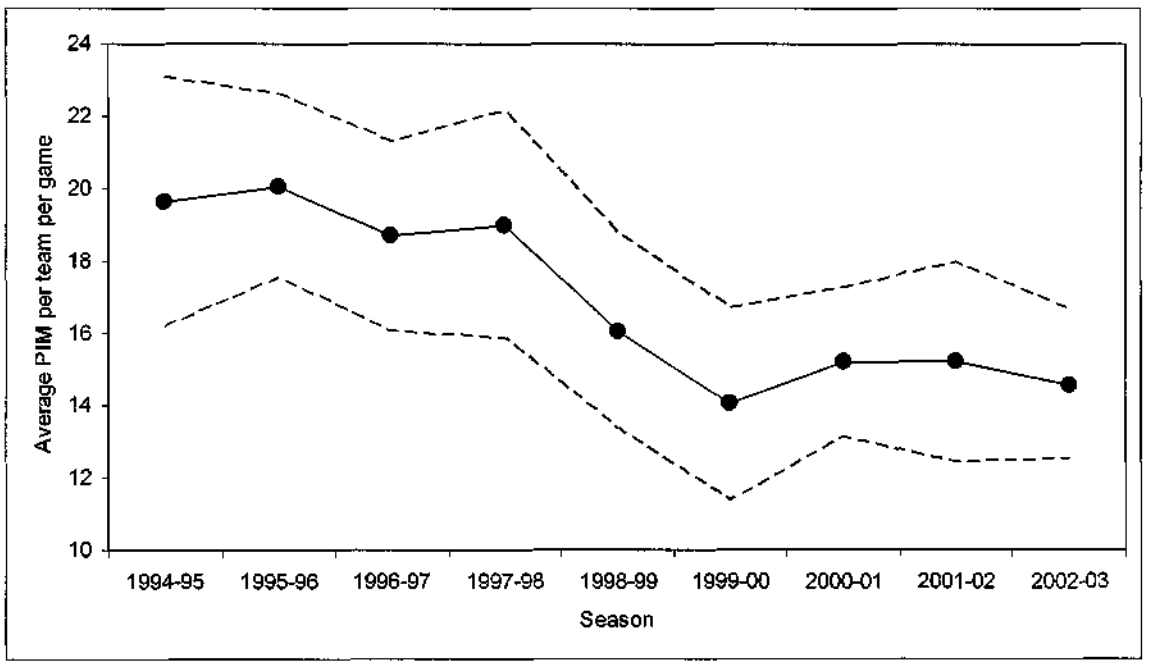


Figure 2. Sequential Goon Game with Imperfect Legal Enforcement. First payoff entry is for Maple Leafs and the second for Red Wings. Also, $q > p$.

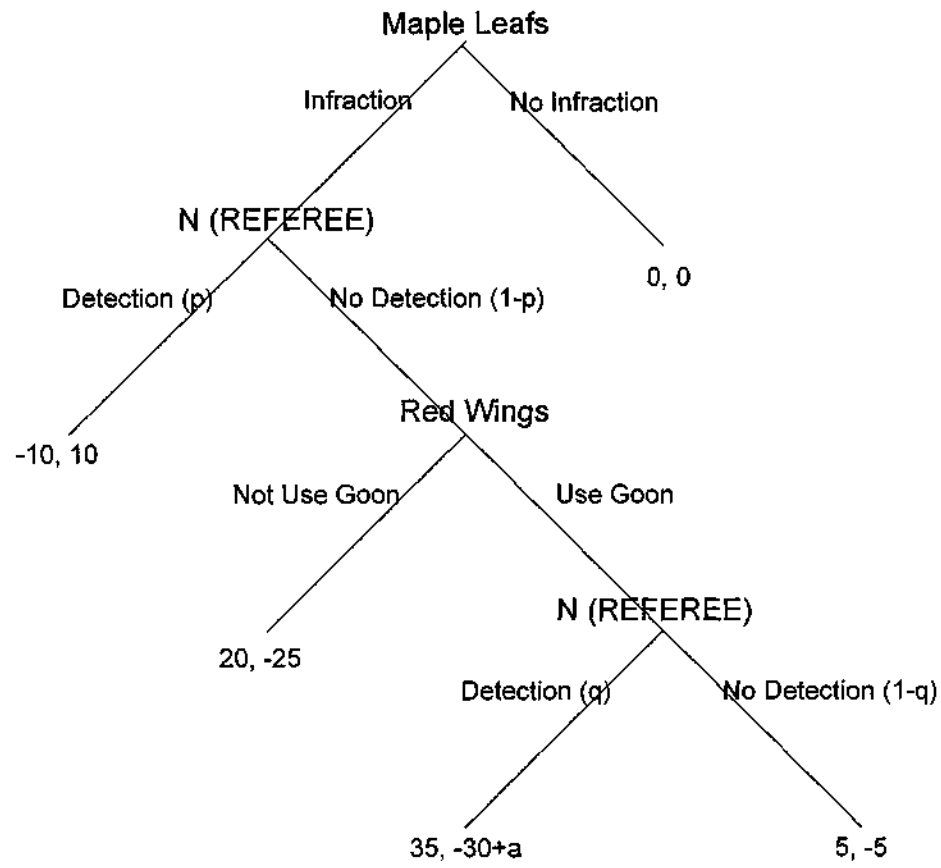
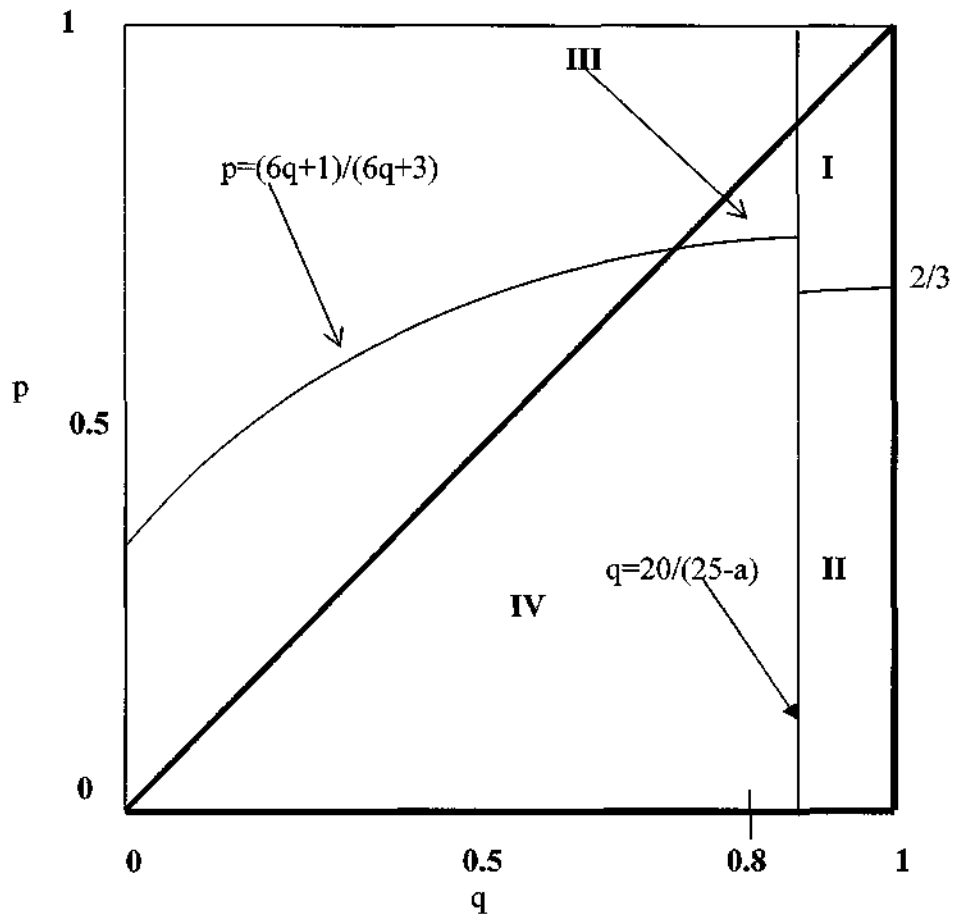


Figure 3. Equilibrium Zones of the Goon Game.



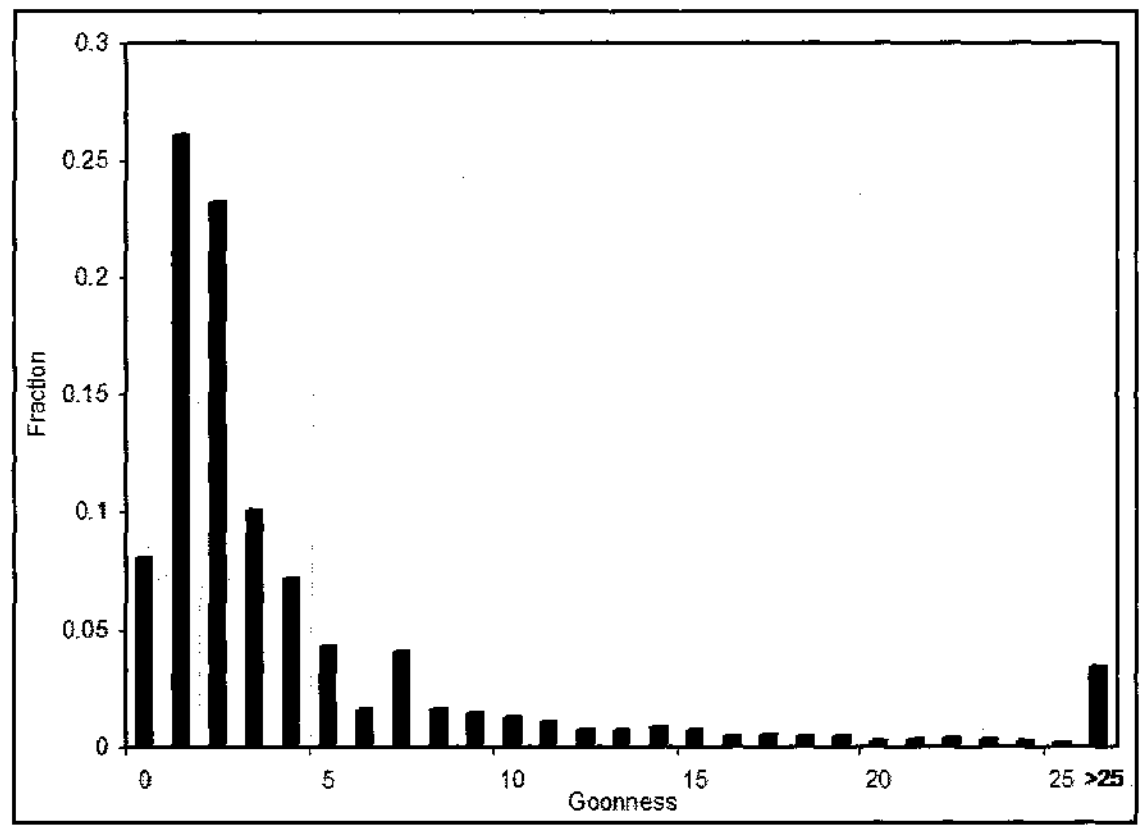


Figure 4. Distribution of Goonness – pooled across seasons

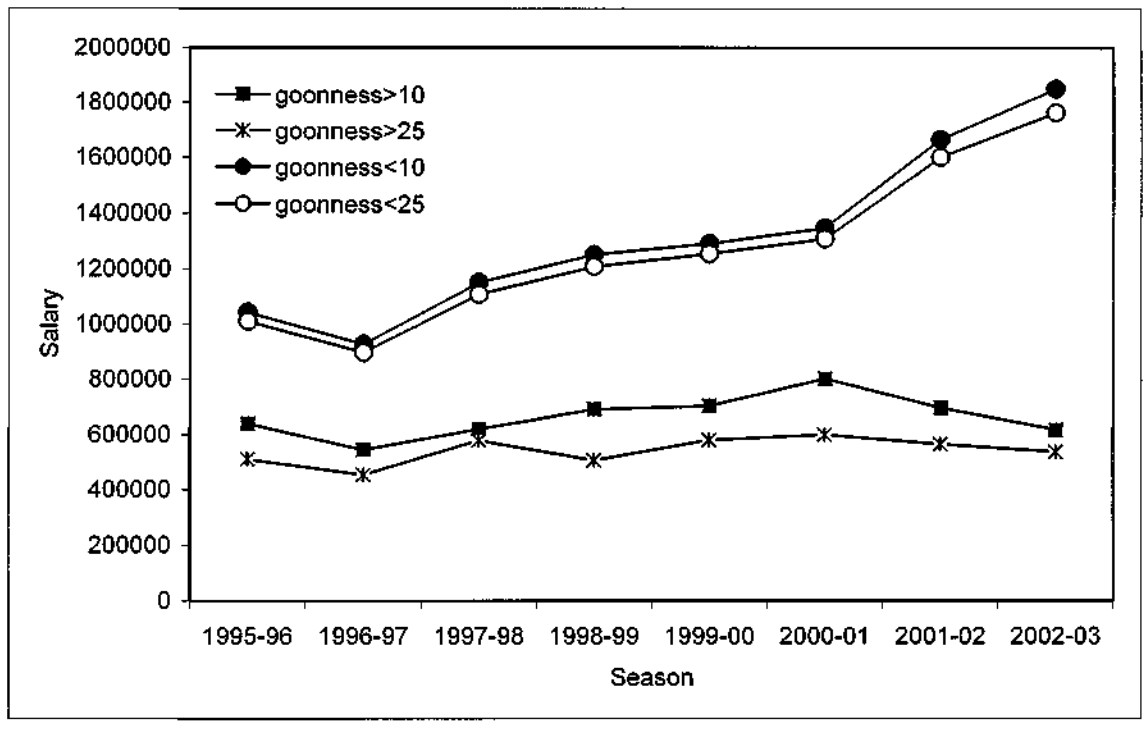


Figure 5: Average salaries of players of agents with a high goonness score, and a low goonness score, using threshold 10 and 25.

Table 1. Payoffs of the goon game

	Immediate Game		Future Games	
	Maple Leafs	Red Wings	Maple Leafs	Red Wings
Maple Leafs Cheats (Attack)	20	-20	0	0
No Attack	0	0	0	0
Maple Leafs Caught	-30	30	0	0
Goon Retaliates	-10	10	-5	5
Goon Caught	25	-25	0	5+a
No Goon	0	0	0	-5

Table 2. Equilibria of the Goon Game

	Q	P	Equilibrium	Outcome
I	q>20/(25-a)	p>2/3	Maple Leafs Not Cheat Red Wings Not Use Goons	Maple Leafs Not Cheat
II	q>20/(25-a)	P<2/3	Maple Leafs Cheats Red Wings Not Use Goons	Maple Leafs Cheats Red Wings Not Use Goons
III	q<20/(25-a)	p>(6q+1)/(6q+3)	Maple Leafs Not Cheat Red Wings Uses Goons	Maple Leafs Not Cheat
IV	q<20/(25-a)	P<(6q+1)/(6q+3)	Maple Leafs Cheat Red Wings Uses Goons	Maple Leafs Cheats Red Wings Uses Goons

Table 3. Goons and Goonness across Seasons

Season	Average Goonness	Number of Goons (%)
1995-6	4.84	24 (3.5%)
1996-7	4.92	35 (4.9%)
1997-8	6.03	38 (5.2%)
1998-9	4.80	26 (3.3%)
1999-0	3.78	19 (2.3%)
2000-1	4.10	20 (2.3%)
2001-2	4.26	30 (3.4%)
2002-3	4.32	28 (3.1%)