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**The Specialization of Informal Social Control: Fighting in the National Hockey League
from 1947-2019**

Abstract:

Fighting in ice hockey has long been of interest to sociologists of sport and serves as a highly visible and well-documented example of informal social control and peer punishment. Drawing on over 70 years of play-by-play records from the National Hockey League, this paper examines how the ritual of fighting has changed over time in terms of context (when fights happen), distribution (who fights), and patterns of interaction (who fights whom). These changes highlight the subtle transformation of fighting from a duel-like retaliatory act, towards the status-seeking practice of specialized but less-skilled players commonly referred to as “enforcers”. This analysis not only broadens our understanding of ice hockey fighting and violence, but also informs our understanding of the theoretical relationships between specialization, status, and signaling processes, and provides a highly-detailed look at the evolution of a system of informal control and governance.

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Introduction:

The sport of ice hockey, particularly at the professional ranks within North America, has long hosted a somewhat peculiar ritual: routine fist fights between members of opposing teams. These fights are in part an element of a larger honor culture that has risen in response to a game that has not been adequately policed by league-appointed referees. Fighting is understood as a form of retaliation and informal punishment after an offending player endangers an opponent through an act of aggression or carelessness. Referees can impose formal penalties in games, but their ability to monitor can be limited (Colburn 1986). Like other contexts that give rise to informal and decentralized control processes (Erikson and Parent 2007), penalties can also be difficult to calibrate with infraction severity.

Fighting in hockey has been commonplace for generations, and is part of an alleged “code” that is adhered to by all players (Roubidox 2001; Bernstein 2006; Atkinson and Young 2008), but it is also the semi-specific domain of archetypical players, referred to as “enforcers” or “goons”, who participate in a disproportionate number of fights. This article examines how fighting manifests its honor code-based origins and justifications by examining over 70 years of National Hockey League (NHL) player statistics and play-by-play data, including over 25,000 fighting interactions. The payoff of this analysis is three-fold: (1) it builds on extant literature on ice hockey violence, an often-studied topic in the sociology of sport, with a definitive and comprehensive quantitative analysis of the history of fighting in the game, (2) introduces a detailed dataset illustrating the historical evolution of informal social control within a controlled context, and (3) examines the relationship between specialized roles and signaling behavior.

The results shed new light on a well-known and well-researched empirical phenomenon with public health and social welfare implications. Fighting in ice hockey is a highly visible and often celebrated form of violence that can lead to negative health outcomes for players and can spill-over into broader attitudes about violence and masculinity in general (Bloom and Smith 1996; Pappas et. al 2004). To this extent, quantitatively tracing the evolution of fighting at hockey’s highest and most popularized level is important, as changes in the fighting norms exhibited by high-profile players may influence how younger or amateur players embrace fighting and violent behavior more generally, both on and off the ice.

This case also adds an empirical and quantitatively robust example to our understanding of informal social control. There has been a great deal of simulation-based and analytical work exploring peer-sanctioning (Heckathorn 1988; 1989; 1990; Macy 1993), laboratory studies of peer-punishments in groups (Yamagishi 1986; Fehr and Gächter 2000; 2002; Sigmund 2007; Baldassarri and Grossman 2011), and detailed but predominantly qualitative descriptions of cultures and systems of informal control that exist in weak states or under-policed contexts (Ellickson 1991; Varese 1994; Gambetta 1996). The data compiled provides an unprecedented set of self-organized violent interactions within a structured and well-documented setting. The high volume of data makes both longitudinal and situational effects on interactions clearly visible. The analysis ultimately shows the gradual specialization of informal control and sanctioning behavior within a larger institution that provides some order but effectively permits vigilantism.

Finally, while retaliation and honor characterize most defenses of fighting in hockey, the primary social processes that shape this dataset include not only sanctioning, but also specialization, status-preservation, and signaling. The data reveals gradual but profound changes in how fighting is distributed across players, the in-game events that precede fights, and the network structure of combatant pairs. These findings suggest that the “enforcer” role gradually emerged in the later part of the 20th century. This process of player specialization has changed the motives of fighting itself, with certain players fighting not only to punish deviant opponents, but also to establish and maintain the reputation of an enforcer who is worthy of a coveted roster spot on an NHL franchise.

After briefly reviewing the origins of retaliatory behavior and honor cultures, I discuss the problems of social control within the world of ice hockey and the role of fighting, and introduce a highly detailed and multi-faceted data set featuring both player statistics and play-by-play game records. A progression of situational, individual, and network analyses reveals an emergent pattern of specialization, underlying a shift in the practice of fighting and the rise of the enforcer role. This specialization, I argue, gives rise to fighting behavior that is driven by signaling motives rather than sanctioning motives. I conclude by discussing implications of these findings for the game itself, and how they can inform sociological perspectives and future research on status, governance, and collective action.

Collective Action, Retaliation, and Honor Cultures

The game of ice hockey presents a collective action problem: competing teams have an incentive to play in a manner that could physically harm their opponents but maximizes their own probability of winning. Dangerous play may give one team an edge, but if all players and teams play aggressively and with reckless abandon, the overall well-being of the players and quality of the game will suffer, especially over the course of a 9-month season. The ideal solution to this problem is a strong governing body that punishes infractions. All-powerful institutions can align individual and collective interests by punishing selfish behavior (or rewarding altruistic behavior) (Oliver 1980). Experimental work on public goods games has shown that individuals prefer environments where institutions are in place to enforce pro-social behavior to those where such institutions are absent (Güerke, Irlenbusch and Rockenbach 2006).

However, centralized solutions are not always possible or desirable, and cognitive impulses to punish and retaliate evolved long before the development of social institutions. The origins of retaliatory punishment, or negative reciprocity, are often assessed from an evolutionary perspective. Negative reciprocity is a common feature in many animal societies and deters parasitic or predatory behavior (Clutton-Brock and Parker 1995). Retaliation may be irrational in the short-term, but signaling a willingness to impose costly sanctions on others can be rational in the long-term (Schelling 1960; Elster 1990; Gambetta 2009). While the impulse to punish may have been naturally selected for because of the benefits of forward-looking deterrence, the proximate mechanisms may be driven by backwards-looking vengeance. Punishment in laboratory trust games persists even when recipients will not necessarily realize they are being punished, suggesting that punishment is driven by a sense of vengeance as opposed to explicitly forward-looking motives (Crockett, Ozmedir, and Fehr 2004). A universal “taste for vengeance” also turns the prisoner’s dilemma into a coordination game that rewards cooperative behavior (Friedman and Sing 1999), and negative reciprocity is at the heart of the well-known solution to the repeated prisoner’s dilemma, “Tit-for-Tat” (Axelrod 1981).

Beyond biologically evolved impulses to retaliate, certain contexts may promote cultures or norms that encourage retaliation. Legal scholars have emphasized the importance and prevalence of negative reciprocity, or “self-help”, as an alternative to centralized sanctioning (Black 1983;

Ellickson 1987; Ellickson 1991). Criminologists, sociologists, and anthropologists have found various forms of self-help in areas that have an ineffective, weak, or absent central authority, from the Pacific to the Mediterranean (Colson 1953; Boehm 1987; Gould 2000). Honor cultures, which are characterized by retaliatory norms, hyper-sensitivity to insult, and high rates of risk-taking (as a means of signaling) are found in both rural parts of the U.S. South (Nisbett 1993; Cohen et. al 1996; Cohen and Nisbett 1997; Barnes, Brown and Tamborski, 2012) and portions of certain U.S. cities (Anderson 2000; Stewart and Simons 2010). In the U.S. South this culture was brought over from Scots-Irish herders, whose wealth came from a source that was especially vulnerable to predation (Cohen and Nisbett 1994) and reinforced by weaker state institutions. In inner-city areas in the United States, such cultures are motivated by the belief that the state is unresponsive to acts of crime (Kirk and Papachristos 2011). Simulation-based work has also supported the idea that honor cultures are evolved cultural responses to stateless contexts. (Nowak et. al 2016).

Fighting and The Problem of Social Order in North American Ice Hockey

Ice hockey's collective action problems predate the formation of the National Hockey League in 1917. In late 19th and early 20th century Canada, the elite level amateur hockey played between clubs around Montreal and across Canada transitioned from a 'gentleman's game', to a game where the rational pursuit of winning became the norm and expectation (Barlow 2009). Violent and 'strenuous' play became common. Lawrence Scanlan writes in his study of hockey violence:

“My overwhelming impression from reading the literature, from hearing the testimony of players from the early to mid-1900's and from poring over the news clippings, is that early hockey was very much like war, the blood flowed freely.”
(2002: 30)

Some early incidents of players swinging sticks at their then helmetless opponents ended in death, while other incidents ended in criminal charges of assault (Lorenz and Osborne 2009). In 1904 alone, four players died while playing in Ontario (Metcalf 1997). Fighting is perceived as a ritual outlet to curb the more extreme incidents of violence that occurred more frequently during the early days of the sport. In this view, fighting is a relatively safe way of retaliating against play that is dangerous or aggressive and may deter many of these incidents from occurring in the first

place. In another study of hockey violence, Kenneth Colburn nicely summarizes the causes of fighting:

“Here we come to the problem of why fist-fights occur in ice hockey...it is due partly to the contingent features of the sport such as speed which make detection difficult, and it is due partly to the cultural value placed on honor, the right of the individual to take matters of violation of the law into his own hands.” (1986: 169)

In this view, fighting is part of a larger unspoken ‘code’ among players that keeps the game honorable and safe (Roubidox 2001; Bernstein 2006; Atkinson and Young, 2008). Fighting is also largely approved by younger players, their coaches, and their parents as both an appropriate reaction to violence and as a means of improving their teams’ success (Smith 1979a; Smith 1979b; Loughead and Leith 2001). Ironically, two of the more dangerous incidents in recent NHL history occurred when players who *refused* to fight were assaulted.¹

Alternative Interpretations of Fighting

Fighting is also understood by some as a cultural anachronism that perpetuates outdated norms of masculinity, a marketing ploy, or a way to shift momentum in a game.

Ice hockey is argued to perpetuate a violent and aggressive form of masculinity in a society with shifting gender roles (Gruneau & Whitson 1993; Allain 2008). Violent behavior is accepted and celebrated (Smith 1974) and violent play is judged as competent play even amongst younger players (Weinstein, Smith and Wiesenthal 1995). The approval of violence on the ice also may translate into more violent behaviors off the ice (Bloom and Smith 1996; Pappas et. al 2004). In particular, much academic attention has been paid to Don Cherry, a former NHL coach and television personality, who defends fighting and violence within the game as both a means of deterrence and as a moral virtue in its own right during Canadian Broadcasting Corporation hockey

¹ In both incidents, a player attempted to provoke a player into a fight to address a prior infraction, and the targeted player refused. These incidents occurred between Martin McSorely and Donald Brashear in 2000, and Todd Bertuzzi and Steve Moore in 2004.

broadcasts (Knowles 1995; Gillet, White, & Young, 1996; Elcombe 2010; Allain 2015). Fighting's decline in recent years has arguably caused more people to defend the practice in public discussion (Sailofsky and Orr 2020).

Fighting is also thought to generate popularity and revenue. The notion that violence is explicitly used by teams to fill seats is widely held (and is the premise of the popular film, *Slap Shot*), but research on its profitability has been mixed (Stewart, Ferguson, and Jones 1992; Rockerbie 2015). The NHL and its feeder leagues have a standardized penalty for fighting (both players are excluded for five minutes, therefore, unless one player is given an additional penalty for instigating neither team is put at a disadvantage), but strictly forbid a third player from joining: this keeps the fight fair, and may encourage more fights to proceed (Collins 2008). In contrast, other leagues have been able to curb fights through excessive penalization, including most European and North American Collegiate leagues, suggesting that the NHL may have been reluctant to suppress the ritual in the past due to its popularity (although this may be beginning to change).

Considering the potential strategic implications of fighting requires separate consideration of short-term (winning the game at hand) and long-term interests (winning games in the future). An individual fight could change the outcome of a game as a means of generating momentum or restoring "emotional energy" (Collins 2008), but research on the influence of fighting and violence on winning is mixed (Widmeyer and Birch, 1979; 1984; Englhardt 1995). In the short-term, it is theoretically impossible for both teams to improve their odds of winning a game, so a purely short-term strategic explanation seems implausible given that fights are consented to by parties on both teams. However, there may be a long-term deterrence value for either team to signal their willingness to fight to other teams in the league. While the problem of social control within the game is amplified by the difficulty of monitoring by on-ice officials, the fights that do (and do not) occur are televised and highly visible to all other teams and players. A team that does not retaliate against predatory play by other teams may be quickly found out.

While fighting may be a vessel of masculinity, a form of entertainment, or a means of inspiring teammates and intimidating opponents, this does not change the fact that fighting is largely experienced by players and coaches as an element of a larger system of social control. There is little question that the NHL and other leagues could further reduce fighting by punishing it more

severely, and in recent years this has been the case. It is unclear that they could prevent the type of violent incidents that fights allegedly deter, and players and teams have long perceived the need to police the game themselves. Fights have occurred, ultimately, because players find fights appropriate in certain situations, the culture of hockey permits and encourages fighting, and it is tacitly permitted by the bodies governing the game (Colburn 1985).

The Enforcer

“But our game is improved tremendously by players’ ability to police the game. It makes it more exciting and honorable. It allows skill players to focus on the skilled aspects of the game because someone else can watch their back. And it fundamentally makes our game safer.” (Burke 2013)

The “someone else” of the above *USA Today* op-ed quote refers to an informal group of players known as “enforcers”. Enforcers participate in a disproportionate amount of fighting and typically are less skilled in other aspects of the game. These players in some cases have had tragic outcomes. Derek Boogaard, a well-known NHL enforcer, died in 2011 of an overdose of alcohol and painkillers that was likely mediated by brain damage from repeated head-trauma (Branch 2011a; 2011b; 2014).

The unofficial designation of an enforcer offers a solution to a more subtle collective-action problem that occurs within teams as opposed to between teams. When a teammate is attacked, how do players decide who should impose costly sanctions on behalf of the group? While one solution is to simply have the violated player, or the most proximate teammate, deliver sanctions to the offending player, this is sub-optimal if the most convenient sanctioner is ineffective or vulnerable. Having a subset of players who are designated to avenge their teammates solves this problem, but these players then have career and reputation maintenance as an extra motive to fight. An analysis of the 2011-12 season salaries found that enforcers are rewarded differently than their less-violent peers (Burdekin and Morton 2015). Like *mafiosi* who must continuously perform violent actions to maintain their reputation (Smith and Varese 2001), enforcers may be concerned with their continued status as producers of violence. Status is especially important when the underlying

quality is difficult to ascertain (Podolny 2001), and it is difficult to measure the exact influence an enforcer or a fight has on the outcome of a game or season.

Furthermore, status is thought to “leak” across relationships (Benjamin and Podolny 1999; Podolny 2005). To the extent that fighting is a relationship, two players with strong reputations as fighters may have an incentive to fight one another. For similar reasons, players with reputations as enforcers may wish to avoid fighting with players who are not known fighters, as this may harm their reputation. Conflict is also more likely to occur between individuals of similar status (Gould 2003) seeking to resolve status ambiguity, which may also incentivize conflict between enforcers. Furthermore, players who typically do not fight will likely wish to avoid experienced fighters.

Using a vast dataset of play-by-play records and individual player statistics, a 70-year history of hockey fighting is outlined with a multi-faceted set of descriptive analyses and statistical models. The results shed light not only on the role of fighting within the game, but also on status, specialization, and signaling processes. The findings also offer a detailed quantitative and empirical description of an evolving system of social control and introduce promising avenues for future work on governance and collective action.

Data Sources and Analytic Strategy:

The analysis draws on a record of regular season play-by-play data from the 1947-48 season through the 2018-19 season acquired via the NHL API. Data is available from 51,276 of 52,183 (98.2%) regular season games and 7,046 individual players. The historical accuracy of the data is corroborated by two additional websites where fans of the game have compiled their own records of fighting incidents, hockeyfights.com and the now defunct dropyourgloves.com. Data from HockeyFights.com is available from 1960-2016, and data from HockeyFights.com is available from 2000-2019. These data sets are largely in agreement in terms of year-to-year fighting rates (see Figure 1), indicating that notions of fighting are consistent between fans and officials. Individual-level records of player performance are also acquired via the NHL API.

The data is almost completely exhaustive given the time and space being considered, and the empirical strategy has descriptive, analytical, and deductive components: the aim is to illustrate

the broader contours of fighting in the NHL, explore the social mechanisms and changes that underlie these patterns, and test explanations proposed by prior work on ice hockey and inferred from other social science research. Taken together, the analysis synthesizes several descriptive analyses, and the results from hundreds of negative binomial regression models (290 in total) and exponential random graph models (142). Visualizations are used whenever possible for the sake of brevity and narrative clarity, and sample tables of model coefficients and visual summaries of all estimated coefficients are left to appendices B and C.

Figure 1 – Rates of fighting per regular season game observed in the National Hockey League API, and fan-compiled websites ‘DropYourGloves.com’ and ‘HockeyFights.com’. Trends are mostly consistent between these three sources.

While prior work has analyzed overall rates of fighting (Depken et. al 2019), I present a three-part analysis highlighting the shifting situational, individual, and interactional nature of fighting. The first portion consists of a situational analysis of the game-contexts in which fighting is most likely to occur, and longitudinal assessment of fighting as both a retaliatory and signaling mechanism. The second portion traces the distribution of fights across individual players and the emergence of the enforcer role. The final portion of the analysis examines fighting-dyads and the structure of fighting networks for evidence of whether fighting reflects a gradually emergent status-

consciousness among enforcers. Altogether, the data reveals how norms of enforcement have shifted and how this change has shifted the fighting motives of individual players.

The Situational Determinants of Fighting

The in-game situations that lead to fights reflect the broader norms that govern the outbreak of a fight. Prior research has examined whether fighting overall in hockey is either impulsive or calculated (Goldschmeid and Espindola 2013), but the play-by-play data allows for the identification of both motives. There are two main situations of interest, the first is the co-occurrence of fighting and in-game penalties. This reflects the notion that fighting is likely an impulsive retaliatory act and when it is a supplement to formal punishment provided by officials. It is also likely retaliatory in many instances when no other penalties are given, but these cannot be identified through the data available. The second situation is when fights immediately follow “face-offs”, which are used to begin and resume play. Fights are found to be common after face-offs, but in this situation immediate retaliation is not the motive. Rather, the fight reflects a calculated act of signaling or deterrence, or a premeditated act of retaliation addressing an earlier infraction.

Fighting as Immediate Retaliation and Supplemental Social Control

If fighting occurs as a supplement or substitute to official punishment for violent incidents that occur in ice hockey, we should expect that a sizable fraction of fights occur at the same time as penalties for other violent events. Looking at the proportion of fights that occur in conjunction with another penalty, and conversely, the proportion of penalties that occur with a fight, will provide a sense of how changes in fighting norms are related to changes in violent play more generally.

Nearly 600,000 penalties are recorded in the play-by-play dataset. These are divided into classes based on their nature and rates of co-occurrence with fighting events overall (see Table 1). Some penalized acts are violent and are accompanied by a penalty in cases where they are particularly extreme (cross-checking, spearing, and roughing) whereas other common penalties are not particularly dangerous (interference, hooking, tripping) and are far less likely to be followed by a

fight. Three other classes of penalties are also identified: one for fighting itself, one for supplemental penalties that often accompany fighting penalties but do not cause reflect fight-causing incidents, and one for unsportsmanlike penalties that tend to occur after play has stopped.

Class	Description	Examples	Frequency (%)	Fighting Co-occurrence rate
Violent	Illegal play that may endanger players.	“Roughing”, “Slashing”, “High-Sticking”, “Cross-Checking”	226,500 (37.8%)	6.2%
Non-Violent	Illegal play that typically does not endanger players.	“Holding”, “Hooking”, “Tripping”, “Interference”	280,098 (46.7%)	0.6%
Fighting	Penalties assessed for fighting.	“Fighting”	57,023 (9.5%)	100%
Supplemental	Penalties for fighting under certain circumstances.	“Instigator”; “Misconduct”	25,067 (4.2%)	50.8%
Unsportsmanlike	Penalties for unsportsmanlike activity - generally after play has stopped.	“Unsportsmanlike Conduct”	11,138 (1.9%)	12.5%

Table 1 – A classification of 599,826 penalties observed in NHL regular season play-by-play data from the 1947-48 season through the 2018-19 season. Penalties are manually collapsed into 5 categories based on their perceived danger to other players and their relationship with fighting.

The tendency for fighting to be used as a retaliatory norm can be operationalized by looking at what percentage of fights occur at the same time as violent penalties. This peaks at around 45-50% in the mid-1970s. Conversely, the number of violent penalties that co-occur with a fight reaches its maximum at around 12% in the mid-1980s (see Figure 2a). By these measures, the use of fighting as a retaliatory norm peaks just before overall rates of fighting reach their peak in the late 1980s. A portion of this shift coincides with a sudden increase in ‘supplemental’ penalties on fighting itself that occurred from 1986-1993. Yet the decline of fighting as a direct response to other violent events continues through about 2010.

Figure 2a (Top) shows how the co-occurrence of fighting penalties and violent penalties has shifted over time, this serves as a proxy for how often fighting is used as an immediate retaliatory sanction. Figure 2b(Bottom) shows the number of seconds that transpired between a faceoff and the next fighting penalty (green) or violent penalty (purple) from 2003-2019. Fighting often occurs in the first 10 seconds after a faceoff, suggesting that it is also frequently premeditated or calculated.

Fighting as Signal or Delayed Retaliation

While fights are often immediate transgressions to other in-game infractions, they can also take a more calculated or premeditated character. In play-by-play data from 2003-2019, fighting penalties are far more likely to be given almost immediately after a face-off, which is the event that begins play and resumes play after a stoppage, compared to penalties given for other violent infractions (Figure 2B). (Unfortunately, data on face-offs is not available prior to the 2003-04 season.) If fighting penalties and violent penalties were to occur randomly and independently, we would expect the ratio of fighting penalties to violent penalties to have a constant value of roughly 0.027 given our dataset. In actuality, the ratio vastly exceeds this until roughly 10-15 seconds after the most recent faceoff.

This finding reflects accounts that two players on opposing teams will often line up for a face-off with the intention of fighting one another. These two types of fights show opposing sides of the same ritual: one impulsive and retaliatory, the other planned and calculated. Later analysis will show how these fights differ not only in terms of motive, but also in terms of participants. The emerging norm of specialized enforcement is largely reflected in calculated or premeditated fight. Attention is now turned towards changes in the distribution of fights across players and the emergence of the specialized enforcer.

Distributional Analysis and The Emergence of the Enforcer

Just as the frequency of fighting and its relationship to other in-game events has changed over time, the distribution of fighting across players has also shifted drastically. However, while fighting frequency and retaliatory character has waxed and waned, changes to how fighting is distributed among players have persisted. This change has two main elements. First, the distributional inequality of fighting has increased drastically – a larger portion of fighting penalties are concentrated in the hands of a smaller number of players. Second, fighting behavior has become negatively correlated with scoring behavior. These trends are illustrated in Figure 3 which shows the Gini Coefficient for fights (adjusted for differences in games played by each player), and the Kendall Correlation of rates of fighting per game and scoring per game for each season from 1947-2019. In the mid-1980's there is a clear acceleration towards both (1) specialized

enforcement, fighting becomes inversely correlated with scoring, and (2) concentration, fighting becomes concentrated in the hands of only a few players. Somewhat surprisingly, this change occurs most rapidly during the 1980's, when fighting is most deeply embedded in the fabric of the National Hockey League.

Figure 3 – Changes in the concentration of fighting among players (Gini Coefficient) and the specialization of fighting with scoring abilities (Kendall Correlation) from 1947-2019.

Negative binomial regression models are estimated for each year to examine how fighting is a function of traditional measures of player success (goals, assists, plus/minus rating) and the rate at which players commit violent penalties, while holding player position (Left Wing, Right Wing, Center, or Defense – goalies are omitted) constant. The number of games played in a year is included in the models as an exposure variable. Furthermore, fights are estimated for each of the two different subtypes estimated in the prior portion of the analysis: “retaliatory” fights, where fights occur at the same time as another violent penalty, and “calculated” fights, where fights occur within 10 seconds of a playoff. (“Calculated” is only estimated for seasons from 2004-2019, when face-off data is available.) Players who have played in less than 20 games, players who did not

record at least one goal or assist, and goalies (who rarely fight and have different sets of performance metrics), are all omitted from the analysis.

For each year, separate models are estimated for all fighting penalties, “retaliatory” fighting penalties, and “calculated” fighting penalties. Two models are estimated for each fight, one featuring plus-minus ratings (a metric used to measure defensive success) and one excluding this term. The full form of the negative binomial regression models (including the plus-minus (+/-) term) estimated for each season is as follows:

$$\frac{FightPen}{GP} = e^{(a + \beta_1 \log(\frac{Goals+1}{GP}) + \beta_2 \log(\frac{Assists+1}{GP}) + \beta_3 (\frac{V.Pen.}{GP}) + \beta_4 (\frac{+/-}{GP}) + \beta_5 (Pos.=L) + \beta_6 (Pos.=R) + \beta_7 (Pos.=C))}$$

In addition, an overdispersion term is estimated to account for whether variance for the fighting rate is higher or lower than what would be predicted by a standard Poisson model (the mean) in each season.

In Figure 4, results of these models are displayed in terms of the predicted number of fighting penalties for “high-skill”, “medium-skill”, and “low-skill” players for any given season and type of fight. (Each of these six models for one year (2012) and graphical summaries of all model coefficients across all years are included in Appendix B.) “High-skill” players are hypothetical players who have log-transformed goal-scoring and assist-scoring rates that are two-standard deviations above average, “medium-skill” players have average scoring rates, and “low-skill” players are two-standard deviations below average. Each hypothetical player has a mean-level of violent penalties, participates in 80 games, and is a ‘Center’. Consistent with expectations and prior findings, the expected number of fights is much higher for low-skill players. Furthermore, this tendency clearly has a longitudinal component, with differences becoming more pronounced from roughly 1970 to 2000. These results are understated if other violent penalties are inversely correlated with player success metrics. Furthermore, we see that these differences are muted for fighting penalties given to “retaliatory fights” and are exaggerated for fighting penalties given for calculated fights. This finding clearly shows that specialized fighters are more likely to participate in pre-meditated fights immediately after play resumes. Enforcers do not only fight more and score less than their teammates, they also tend to participate in a fundamentally different type of fight.

Figure 4a (Top) shows the predicted number of fighting penalties per 80 games and retaliatory fighting penalties, with 95% confidence intervals, for hypothetical high-skill, medium-skill (average), and low-skill players, based on two series' of negative binomial models from 1947-2019. Significant differences emerge between players over time, from roughly 1970 to 200. The gap between players shrinks for retaliatory penalties, which align more closely with honor-based and impulsive conceptions of fighting. Figure 4b (bottom) compares models for retaliatory and calculated fighting penalties from 2003-2019. Participation in calculated fights is far more likely for low-skill players, but differences are less pronounced for retaliatory fights.

The origins and causes of the rise of the enforcer remain less clear. While distributional changes may in part due to the aforementioned increase in the supplemental penalization of fighting from 1986-1993, the shifting size and composition of the league also points towards a more comprehensive explanation: parallel organizational responses to changes in the availability of more skilled players. A descriptive analysis supporting this explanation is left to Appendix A for the interested reader.

Pairwise and Network Analysis of Fighting Interactions

The evidence of enforcer specialization provided and prior research on status and conflict suggest that there should be meaningful patterns in who fights whom. The expectation is that players who fight frequently should be disproportionately likely to fight one another, and that this tendency will increase with enforcer specialization. To assess this, individual fighting penalties in the play-by-play dataset are transformed into a set of fighting pairs. A pair is identified when exactly one player on each team receives a fighting penalty at the exact same time in a game. Across 71 seasons of data there are a total 25,576 such pairs.

Two analyses, one dyadic and one network-based, confirm this tendency. Once again, players who are in less than 20 games, have no goals or assists, and goalies are all excluded from analysis. At the dyadic-level, I calculate Kendall correlations in the fighting rates and scoring rates of opposing pairs of fighters. The results for each season are plotted in Figure 5a. In accordance with prediction, these correlations increase over time, mainly from 1970 to 2000, which is when enforcer specialization was found to increase in the prior distributional analysis.

Each seasonal set of fighting pairs is also transformed into a large social network, as network analysis methods allow us to better account for the non-independence of fighting pairs. Two sets of exponential random graph models (ERGMs), which estimate the predictors of tie (fight) formation given the properties of nodes, the properties of dyads, and structural features of the networks (Robins et. al 2007) are estimated for seasonal fighting network. The chief variable of interest in this case is dyadic, which is whether pairs of players with similar fighting rates are more likely to have fights.

The likelihood of each tie in the fighting network forming is estimated as a function of five elements. The first is a baseline constant for edge formation that will vary from year to year. This accounts for seasonal changes in overall fighting rates. The second is a term accounting for the

number of isolates in any given network. The third is the fighting rate of each player, which absorbs variance in tie formation at the level of the nodes. One set of models is estimated where the fighting rate is simply the rate observed by each player, another is estimated with the fighting rate predicted for each player from the previously estimated negative binomial models. The fourth, and the key variable of interest, is the difference in fighting rates (actual or predicted), between the two players. A large negative estimate for this coefficient indicates that players with vastly different fighting rates are very unlikely to pair up with one another. Differences in fighting frequency are expressed in terms of percentile-rank of fighting rates, making these terms independent from year-to-year changes in fighting distributions across players and comparable across models. Finally, a term for geometrically weighted edgewise shared partners (GWESP), a “curved” term (Hunter and Handcock 2006) which broadly speaking accounts for the level of triangle formation in the network, is included in order to account for the fact that opportunities for interaction may cluster along the lines of division or conference in certain years given the schedule of matches between teams.² This would also account for any tendency for transitivity among players but given that ties have a negative valence in this context this is not expected to be a factor.

Maximal likelihood estimations yield coefficients for each of these five parameters. These coefficients broadly inform the likelihood of any given edge being present, given the properties of the nodes and the presence of other edges in the network. For example, higher positive values for the *isolates* coefficient suggests that a network has a higher number of isolated than expected by chance given other features, but negative values for the *absolute difference in fighting rate percentile* coefficient indicate that ties are unlikely between nodes with different fighting rates compared to what we would see given the other features. (For more detailed examples of ERGMs in social networks, see Goodreau 2007; Goodreau et. al 2009.)

Full coefficient tables for two sample models, and figures showing coefficients and confidence intervals for all models, are included in Appendix C. Figure 5b features the main coefficient of interest: the absolute difference in fighting rate percentile. When the model is estimated using actual fighting rates, terms become profoundly more negative in the 1980s, suggesting an increasing level of status awareness among players as the enforcer role becomes more pronounced. This pattern is less pronounced when predicted fighting rates from scoring and penalization rates

² In each model the GWESP term τ is fixed at 0.25.

are used to estimate nodal and dyadic variance, but coefficients are still negative and statistically significant from the late 1970s and onwards.

Figure 5a (top) displays the Kendall correlation of fighting pair scoring rates and fighting rates by season. Over time player rates more closely resemble the rates of their fighting opponents. Similarly, Figure 5b shows exponential random graph model coefficients for the absolute difference term of fighting rate percentiles. More negative values indicate that, all else equal, fights are more likely to occur between players the similar tendencies towards fighting.

In summary, dyadic (dis)similarity in fighting rates, a broad proxy for enforcer status, is a large positive (negative) predictor of whether two players will fight. Mathematically it is expected that enforcers will fight one another frequently given their collective proclivity to fighting behavior, but the ERGM coefficients reveal an additional level of attraction between enforcers and/or avoidance between enforcers and non-enforcers.

Calculated Fights Among Enforcers and Network Visualization

Visualizations of the broader fighting network add a final level of intuition to how the situational, distribution, and interactional changes in fighting are all intertwined. Prior models of fighting penalties per player and seasonal fighting networks suggest that the overall network structure of fights will have a dense core of enforcers/low-scoring players connected to one another, and a sparse periphery. Adding in the situational differences between fights, it is also expected that the edges closer to the core of a fighting networks contain a higher rate of “calculated fights”. Enforcers who have the chance to fight one another right after a faceoff should have sufficient career-driven motivation to “drop the gloves.”

Figure 6 is a multi-paneled network visualization of fighting pairs during a 7-season period from 2005-2012, between the NHL labor disputes of the 2004-05 and 2012-13 seasons. During this period the rules and league format are consistent, data on face-off timing is available for the identification of calculated fights, and enforcer specialization is roughly at its peak.

The overall network includes 1306 players (goalies, players with no goals or assists, or less than 20 games during this period are again omitted) and 3891 fighting pairs. The panels illustrating the network layout focus on the largest connected component, which contains 700 players and 3576 edges. Figure 6a shows the network layout with edges repressed to better highlight the nodes. It reveals the predicted core-periphery structure, with the core being mainly comprised of players who have lower scoring rates. Figure 6b shows how the network position of nodes (log eigenvector centrality) is related to scoring rates of players. There is an inverse relationship between scoring and network position, with the caveat that higher-skilled players who are also towards the center of the graph (points towards the top right corner) have played in more games and have had more opportunities for edge formation.

Figure 6a (top) shows the largest connected component of the fighting network from 2005-2012, edges are repressed, and nodes are colored according to their percentile scoring rank (higher-skill players are more yellow, lower skilled players are more purple). Figure 6b (bottom) shows each player's network centrality as a function of their scoring rate, with note colored according to games played. Players who appear more central than what would be expected by their scoring are simply players who played in more games and had more opportunities to form ties (i.e., fight).

Figure 6c (top) shows the largest component of the fighting network with an identical layout to 6a, but with nodes repressed instead of edges. The 25.5% of fights occurring within 10 seconds of a faceoff are colored purple, and more concentrated towards the network core. Figure 6d (bottom) further emphasizes this. Fighters are divided into five adjusted quantiles based on fighting rate per game. Each cell shows the number of fights occurring between or within these quantiles in parentheses, with squares sized proportional to fight counts and colored according to the percentage of post-faceoff fights. Square sizes show that players target players in similar quantiles, and square colors show that fights between higher quantiles are more likely to be calculated.

The network visualization in Figure 6c has the same layout as the network in Figure 8a, but nodes are repressed instead of edges. The 963 edges (25.5% of all edges) that represent a “calculated” fight are highlighted in purple and are located disproportionately in the core of the graph. This is illustrated more clearly in Figure 6d, which shows a tabular classification of fights based on the fighting rates of both fighters. Fighters are assigned to one of 5 adjusted quantiles based on their fighting rates, such that the total number of fights participated in by each quantile is roughly 20%. (The highest fighting rate quantile contains 35 players, while the lowest contains 456 players, but each quantile is responsible for roughly 20% of fighting behavior.) The size of each square is proportional to the total number of fights between members of each quantile. Each square is colored according to the percentage of those fights that are within 10 seconds of a faceoff. If players randomly select their opponents regardless of how frequently they fight, each square would be equal in size. Confirming earlier findings, the squares along the symmetric diagonal of the graph tend to be larger than smaller squares that represent lopsided matchups. Furthermore, the squares towards the top right corner of the heat map are lighter in color, reflecting the fact that fights between enforcers are more likely to occur after a faceoff.

In what we might call the late golden age of the specialized enforcer (2005-2012), enforcers tend to score less than their teammates, tend to fight one another, and are more likely to fight when fights seem completely unnecessary. In other words, specialized enforcement led to the emergence of a separate “game within a game” played by hockey’s otherwise least talented players.

Discussion

On January 9th, 2007, Eric Godard of the Calgary Flames and Derek Boogaard of the Minnesota Wild lined up across from one another during a second period face-off at the Calgary Saddledome. Immediately after the puck is dropped and play resumes, both players drop their sticks, fling off their gloves, and exchange punches. On the television broadcast, one announcer declares:

“And now we got a fight at center ice, the guys we’ve waited all night for, Boogaard and Godard, two former Western Hockey Leaguers that can be tough Eric Godard coming up from Omaha, there’s not a lot of reasons he’s here but to kind of watch over what the big guy from Minnesota is (doing) is one of them.”

The other announcer notes that the two players spoke with one another during the pre-game warm-up, and a slow-motion replay of the face-off then reveals more discussion between the two players. After the fight, a dazed Boogaard skates first to the wrong penalty box and then to the locker room.³ Eric Godard played 17 games for the Calgary Flames and 29 games for their minor league affiliate that year. He participated in 8 fights for each team, scored only 2 points for Calgary, and 9 for Omaha. Boogaard played 48 of 82 possible regular season games for Minnesota, earning 1 assist, no goals, and participating in 13 fights.

This is an archetype of the calculated fights that characterize the system of informal but specialized sanctioning that has emerged in the NHL. This type of fighting can be traced to teams within the NHL hiring designated enforcers, and less-skilled players deliberately signaling their ability to fulfill this role, regardless of whether a situation demands peer-punishment.

The shifting situational, distributional, and interactional nature of fighting in the NHL all reflect the ritual's transition from a shared cultural norm to a specialized practice. While fighting originated as an arguably necessary and decentralized form of peer sanctioning, it proliferated as the game became more violent, and then concentrated in the hands of low-skilled players over time. (Appendix A explores how this transition may have resulted from an increase in league size and then an increased influx of talent from outside of North America.) The emergence of the enforcer role led to the occurrence of fights that had less to do with honor cultures or entertainment, and more to do with status and job-maintenance. These findings not only broaden our understanding of fighting in hockey in general, a social problem of frequent study within the sociology of sport literature, but also have theoretical implications for our understanding of status, governance, and collective action.

Implications within Hockey

Much has been made of the 'fall' of the enforcer, and the decline of fighting more generally, in recent years. Whether fighting frequency will continue to decline is unclear. On one hand, it seems like there is more than enough talent to fill each of the 31 (soon to be 32) rosters in the NHL

³ Video available at: <https://www.youtube.com/watch?v=d86wx-cU1n4>

without resorting to excessively violent and physical play, and the league does appear to have a public image motive to limit fighting. On the other hand, a drift towards more skilled or “finesse” players may make a highly physical form of play again more attractive. During the late 1960s and early 1970s the newly minted Philadelphia Flyers used violence as a collective strategy and enjoyed great success. Finesse teams may give way to physical teams, who then give way to specialized teams, who then give way to finesse teams. If fighting continues to decline, we might expect some teams to experiment with a very physical style of play as a counter to an increasingly skilled league overall. A game-theoretic analysis of how these broader team employment strategies interact with one another could be a promising topic of study for scholars of sports management and complex systems.

While extra penalties for fighting by the NHL may have depressed overall fighting, this does not address the type of violent, dangerous, and semi-legal play that leads to fights. Increasing the cost of fighting may in effect decrease the cost of other violent play. This is a potential area for future work on both hockey fighting and the relationship between informal and formal sanctions more generally.

Implications beyond hockey

A theoretical contribution of this article is the illustration of how the process of specialization can transform backwards-looking reactive behavior into forwards-looking signaling behavior. While this finding is situated here in a context of networked violence, we can imagine how this process may manifest in other occupational or organizational settings. The specialization of an activity may introduce rewards at the individual level that are dependent on the identity of the practitioner, as opposed to collective rewards dependent on the situational relevance of the activity. Within the context of sanctioning behavior more specifically, this possibility has interesting consequences for our understanding of both governance and collective action.

Evolving Systems of Governance

This case also illustrates how systems of governance can evolve more generally. Typically studies of governance assume a central collective interest that must be protected: be it a shared common resource (Olson 1965), an investment pool in a laboratory experiment (Yamagishi 1986), or a pre-existing state that has plundered and hoarded resources (Tilly et al. 1985). From these shared

interests and resources strong governing institutions are coordinated and funded. Yet little is known about how sophisticated governance can emerge without strong collective interests. In the case of competitive sports, players and teams are involved in a series of contests with one another and shared interests are weaker. Not surprisingly, hockey's shift towards specialized but informal control – a middle layer between purely decentralized and purely formal governance – was likely facilitated by decisions made at the level of the team, a smaller pool of collective interest nested between the player and the league (for more detail on this, see Appendix A). Meso-levels of organization may offer an alternative path for the evolution of governance when population-wide interests are scarce.

Third-Order Collective Action Problems

While methods of informal sanctioning may arise in the absence of state governance, not all informal sanctioning directly contributes to said governance. In this case, fighting at times can be a forwards-looking act of signaling instead of a backwards-looking act of sanctioning. Roger Gould's analysis of vendettas in Corsica found that individuals performed violent acts on behalf of the group to signal group solidarity (Gould 2000). In the case of hockey, groups are permeable and transient, and can exclude individuals. Willingness to produce violence is a precondition for some to group entry, and consequently, violent acts are performed to establish and maintain membership. This suggests that prior work on the structure of violence between gangs (Papachristos 2009) could be advanced by looking at how violence is distributed within rather than between criminal organizations.

The emergence of the enforcer also illustrates an underexamined problem in the collective action literature. First-order collective action problems are concerned with motivating contributions to pools of public goods and deterring predation. The solution to these problems typically involves punishing deviants and rewarding altruists. Hockey solves this via fighting (punishing deviants). Second-order collective action problems focus on who takes on the costly responsibility of rewarding and punishing (Heckathorn 1989). Hockey's solution to this has evolved, as fighting has become the responsibility not of the offended player, but rather of the specialized "enforcer" who is preemptively rewarded for sanctioning behavior with a roster spot.

Just as rates of primary behavior (deviance or compliance) are influenced by secondary behavior (sanctions and rewards), rates of secondary behavior are influenced by tertiary behavior, which in this case is the rewarding (punishing) of those who (fail to) sanction. This may have the unintended side effect of (third-order) rewards motivating (second-order) sanctions, regardless of (first-order) deviance. The problems that stem from rewarding those who punish others are visible beyond the case of ice hockey, from receiving moral and social rewards for “call-outs” and “take downs” on Twitter (Bouvier 2020), to for-profit prisons bribing judges for stronger sentences.⁴

This is also relevant for policing, as those who are employed as agents of social control may have an added incentive to sanction explicitly, even in more formal control systems. While in the case of ice hockey enforcers may advertise this ability by sanctioning one another, other agents of social control will likely not pick one another as targets. Scholars of policing may be wise to build upon prior studies of how organization structure effects officer discretion (Chappel, MacDonald, and Manz 2006) and examine how rates of employee turnover and promotion criteria influence rates of officer enforcement.

Conclusion

The regular occurrence of fighting in ice hockey has attracted a fair amount of attention from sociologists of sport, journalists, and public figures over the years. Comprehensively looking at the broader ecology of hockey fighting with a quantitative lens not only deepens our understanding of the practice, but also provides insights onto the nature of sanctioning, informal control, and governance. The question of whether the risks associated with fighting are justified is beyond the scope of this paper. It is likely that fights have in some cases deterred other violent play, and in some cases, they are more directly motivated by career interests than peer-punishment. A broader question is how distinct these two explanations really are: do the self-interested career aspirations of enforcers create a generalized threat of retaliatory violence that keeps the game more peaceful? Assessing this would be an important next step for both denizens of ice hockey and scholars of collective action and conflict resolution.

⁴ <http://edition.cnn.com/2009/CRIME/02/23/pennsylvania.corrupt.judges/>

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Appendix A: The Expansion of the NHL and Team-Level Specialization

Between 1967 and 1974 the number of clubs in the NHL tripled from 6 to 18. While part of this expansion came from the NHL's absorption of lesser leagues, the standards for entering the league potentially lowered as the supply of talent caught up with demand. This caused immediate changes in the international composition of the league, which was over 90% Canadian in its earlier years.⁵ To assess these changes, players are grouped into seven different geographic categories: three regions in Canada⁶: Ontario, Western Canada, or Quebec/Atlantic Canada, the United States, the former U.S.S.R., former Czechoslovakia, and Scandinavia. (The proportion of players from other nations is rather small and excluded from the analysis presented.)

Figure A1a shows how the regional composition changed relative to the growth of the NHL. Figure A1b shows fighting rates per game by year and region. The proportion of players from each of the three regions of Canada diminished over the course of time, with more pronounced declines in the Atlantic/Quebec and Ontario regions. As the league increases in size there is an increase mainly in American talent, a relatively constant share of players from Western Canada, and a corresponding decrease in players from Ontario and Quebec/Atlantic Canada.

As the NHL becomes larger and more violent, players from Western Canada and the United States begin to shoulder relatively higher fighting rates. This drops off for players from the United States in the 1980s, but rates from Western Canada remain consistently high (see Figure A1b). Overall, this suggests that increased opportunities in the league may have created opportunities for less skilled and more violent players, who were often from underrepresented parts of North America (outside of Ontario/Quebec/Atlantic Canada).

In the 1990s and 2000s there is an increase in players from non-North American countries. These players have tended to have lower rates of fighting per game. This may partly be due to different styles of play in different parts of the world, but non-North American players also tended to record

⁵ While only one of the additional 12 teams was located in Canada as of the 1974-75 season (Vancouver), only two of the "original six" franchises were located in Canada (Montreal and Toronto). The shifting nationality of franchises themselves is likely not a major contributor.

⁶ In addition to making group sizes more comparable, this division reflects the current division of the Canadian Hockey League, a main incubator for hockey talent for 16-21 year old players. The league is divided into three separate leagues that draw players from western provinces (WHL), Ontario (OHL), and Quebec/Atlantic Canada (QMJHL).

more goals and assists per game. As more players from outside North America enter the league, fighting becomes increasingly specialized and concentrated, but fighting rates decrease overall.

Overall, the historical trends in the data indicate that violence became more prominent in the league as more opportunities became available for arguably less-talented players, suggesting that violent play and fighting behavior became an alternative player strategy for success. As time went on and the supply of skilled players increased, the game retained much of its violent character, but teams sought to assign this responsibility to a smaller number of relatively low-skill players.

Distribution of Fights Across Teams

The transition to increased violence and specialized enforcement was facilitated by the shifting personnel strategies of NHL Franchises. The selection of players is made separately by competing teams, not the league, and the shifting changes in the number of teams and the talent available likely led to team-level changes of interest. Re-calculating the correlation of fights per game and goals per game and the Gini coefficient for fighting concentration within each team, the patterns exhibited by each organization mirror the overall patterns for the entire league. The shifting talent pattern in the NHL, therefore, was not simply a small number of unsuccessful teams hiring enforcers to entertain fans with violence, but was rather a shared norm adopted by teams.

The parallel specialization of enforcement across teams is shown visually in Figure A2, which shows the specialization trajectory of teams in aggregate, and the trajectory of each of the ‘original’ six franchises that have been present through the entirety of the dataset. Each dot shows the level of fighting inequality (green) and the Kendall correlation between fighting and scoring within each team (purple). Consistent with other findings, fighting became more concentrated in the hands of players on each team, particularly from the mid 1980’s through 1990’s, and more gradually fighting became inversely correlated with scoring rates on each separate NHL Franchise.

Specialization processes seem to have occurred primarily at the within-team level, as opposed to the across-team level. There are a finite number of spots afforded to players on each team who are disproportionately willing to fight, but otherwise less skilled. This creates a situation where enforcers need to fight to maintain the violent reputation necessary for employment.

Figure A1a (top) - The shifting composition of the NHL by player nationality and region over the years. Labeled vertical lines indicate increases (and one decrease) in the number of teams (and therefore roster spots) in the NHL over the years. Figure A1b (bottom) indicates the number of fights per game for players by regional/national background and season. LOWESS smoothing with confidence intervals is included to emphasize trends.

Figure A2a (top) – Rate of fighting concentration (Gini coefficient) and specialization (Kendall correlation) within each NHL team from 1947-2019, with LOWESS smoothing included to emphasize overall trends. Figure A2b shows how this pattern is replicated for each of the “original 6” NHL franchises. These trends appear mostly parallel across teams.

Appendix B: Coefficients from Negative Binomial Regression Models

Figure B1 – Coefficients and 95% confidence intervals for Log (Assists/Game) and Log(Goals/Game) for negative binomial models of fighting rate by year and model. Columns are grouped by type of fight and rows are grouped by whether Plus-Minus is included in the model.

Figure B2 – Coefficients and 95% confidence intervals for Violent Penalties Per Game and Plus-Minus Per Game for negative binomial models of fighting rate by year and model. Columns are grouped by type of fight and rows are grouped by whether Plus-Minus is included in the model.

Figure B3 – Coefficients and 95% confidence intervals for binary variables for players who are Left Wings or Right Wings relative to the reference group of defenders by year and model. Columns are grouped by type of fight and rows are grouped by whether Plus-Minus is included in the model.

Figure B4 – Coefficients and 95% confidence intervals for binary variables for players who are Centers relative to the reference group of defenders and the theta overdispersion coefficient (values of less than 1 indicate more variance than expected by a Poisson model). Columns are grouped by type of fight and rows are grouped by whether Plus-Minus is included in the model

Model	1	2	3	4	5	6
Fight Type	All	All	Retaliatory	Retaliatory	Calculated	Calculated
Constant						
Constant	-7.553*** (0.24)	-7.645*** (0.25)	-7.974*** (0.31)	-7.904*** (0.31)	-9.517*** (0.41)	-9.797*** (0.43)
Player Performance Metrics						
Log(Goals Per Game)	-0.592*** (0.12)	-0.604*** (0.12)	-0.243 (0.16)	-0.233 (0.16)	-0.866*** (0.19)	-0.932*** (0.19)
Log(Assists Per Game)	-0.811*** (0.13)	-0.860*** (0.13)	-0.546*** (0.16)	-0.501** (0.16)	-0.835*** (0.19)	-0.936*** (0.20)
Violent Penalties Per Game	9.938*** (0.86)	9.913*** (0.86)	9.957*** (0.90)	10.040*** (0.91)	8.894*** (1.29)	8.806*** (1.28)
Plus Minus Per Game		0.754* (0.43)		-0.606 (0.56)		1.879** (0.72)
Player Position						
Position = Left Wing	0.700*** (0.15)	0.732*** (0.15)	0.1 (0.19)	0.084 (0.19)	1.233*** (0.24)	1.359*** (0.25)
Position = Right Wing	-0.384** (0.14)	-0.404** (0.14)	-0.034 (0.18)	-0.017 (0.17)	-0.462* (0.21)	-0.536* (0.22)
Position = Center	-0.018 (0.13)	-0.022 (0.13)	0.097 (0.17)	0.101 (0.17)	0.016 (0.21)	0.044 (0.21)
Oversipersion						
Theta	0.732**	0.741**	3.385	4.048	0.483***	0.496***
(Below 1 = Overdispersed)	(0.088)	(0.089)	(2.213)	(3.12)	(0.099)	(0.101)
Observations	675	675	675	675	675	675

Significance: *p<0.1; **p<0.05; ***p<0.01

Table B1 – Coefficients for negative binomial regression models for fighting penalties in the 2011-12 National Hockey League Season. Models are estimated for all fighting penalties, fighting penalties thought to stem from a retaliatory situation, and fighting penalties thought to be the result of a calculated fighting event

Appendix C: Coefficients from Exponential Random Graph Models

Figure C1 - Exponential random graph model coefficients and 95% confidence intervals for structural parameters of edge formation, isolates, and geometrically weighted edgewise shared partner distribution. Coefficients are organized by season and model type (whether actual or predicted fighting rates are used in dyadic/nodal terms). Positive terms indicate that edges are more likely to exist when they create these structural features.

Figure C2 - Exponential random graph model coefficients and 95% confidence intervals for node level tendency to form edges based on actual or predicted fighting rates, dyadic tendency to form edges based on the absolute difference of fighting rank percentile between the nodes. Coefficients are organized by season and model type (whether actual or predicted fighting rates are used in dyadic/nodal terms). Positive terms indicate edges are more likely to form when nodal or dyadic values of given variables are higher.

Model	1	2
Measure of Fighting Tendency	Actual Fighting Penalties	Predicted Fighting Penalties
Structural Parameters		
Edges	-5.344*** (0.14)	-5.153*** (0.11)
Isolated	1.443*** (0.14)	1.897*** (0.15)
GWESP (0.25)	-0.072 (0.08)	0.824*** (0.08)
Nodal Covariates		
Fighting Penalties	0.162*** (0.01)	0.346*** (0.03)
Dyadic Covariates		
Percentile Rank Difference in Fighting Rate	-5.843*** (0.42)	-1.237*** (0.26)
Akaike Inf. Crit.	4,135.07	4,760.92
Bayesian Inf. Crit.	4,186.75	4,812.59

*p<0.05; **p<0.01; ***p<0.001

Table C1 –Coefficients for exponential random graph models for fighting edges in the 2011-12 season. The first model uses the actual number of fighting penalties given to each player and actual differences in fighting rates to estimate the likelihood of edge formation, the second model uses the numbers of fighting penalties predicted by the negative binomial models.