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Workplace Safety Regulations and Worker Well-Being: The Impact of Mandatory Helmet Use on Career Length in the National Hockey League

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Abstract

In markets characterized by information asymmetries between workers and firms, profit-maximizing companies typically externalize the costs of workplace accidents and injuries. The concussion-related lawsuits initiated by NFL- and NHL-veterans suffering from repetitive concussions of the brain that eventually lead to chronic traumatic encephalopathy are an example that has recently received lots of attention. Using detailed career information on every single player drafted in the ten seasons before (1969 thru 1978) and the ten seasons after (1979 thru 1988) the implementation of mandatory helmets, we find that career length in professional hockey has increased by about two years, suggesting that adequate protective equipment contributes to player health and fitness. This positive effect, however, is somewhat reduced by specific forms of “offsetting behavior”.

Keywords: Workplace Safety, Exogenous Intervention, Worker Well-Being

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1. Introduction

In markets characterized by information asymmetries between e.g. workers and firms, profit-maximizing companies typically externalize the costs of workplace accidents and injuries. The concussion-related lawsuits initiated by NFL- and NHL-veterans suffering from chronic traumatic encephalopathy as a potential result of repetitive concussions are an example that has received lots of attention in the media not only in the US, but also outside the country (e.g. Rawlings 2013)4. Recently, the NFL has settled a class action suit with thousands of former players who developed neurocognitive deficits, dementia or other potentially concussion-related ailments by agreeing to pay $765 million to settle those claims.

In football as well as in hockey, the vast majority of player injuries in general and concussions in particular are caused by legal body-checking. Thus, the question arises whether (and to what extent) the leagues can (and should) take action to better protect players against long-term health problems. The players currently suing the NHL allege the league has "… fostered an unnecessarily violent sport" by allowing "ferocious head-snapping checks" und "vicious bare-knuckle fist fights" between players to attract fans and increase revenue5. Moreover, the NHL has been accused to have "failed to supply its players with full, accurate information about the risks of head trauma because it has continued to profit handsomely from its culture of violence, notwithstanding the brain injuries inflicted on NHL players" (Harrison 2015).

However, in early 1979, the NHL took a first step to better protect players against head injuries (concussions were not considered a problem at that time). John Ziegler, then

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4 In an already large (and still increasing) number of studies, sports medicine specialists have convincingly documented the (potentially) detrimental impact of recurrent concussions on hockey players' long-term health (see e.g. Adams et al. 2015; Benson et al. 1999, 2002, 2011; Gavett et al. 2011; Hutchinson et al. 2015; Johnson 2011; Smith et al. 2011).

5 The initially positive and statistically significant impact of violence (e.g. the number of fights per game) on ticket demand found in some early papers (e.g. Jones et al. 1993; Paul 2003; Stewart et al. 1992) has not been confirmed in more recent studies (e.g. Rockerbie 2012, 2016). Nevertheless, teams still seem to incentivize aggressive play as "enforcers" are paid more (Haisken-De New and Vorell 2008) and have longer careers (Depken et al. 2015) than observationally similar players engaging in fewer fights.

President of the NHL, announced helmets would become mandatory for incoming players: "The introduction of the helmet rule will be an additional safety factor." Thus, the question we try to answer in this paper is whether an exogenous intervention imposed by the league to better protect players indeed resulted in the anticipated (and desired) outcome, e.g. better player health[6]. Assuming that income-maximizing athletes will play as long as their health conditions allow them to be active (their second-best alternative is usually less lucrative) and that profit-maximizing team-owners will offer new contracts to senior players only if their performance is good enough to justify salaries that typically increase with NHL-experience (e.g. von Allmen et al. 2015, Vincent and Eastman 2009, Jones and Walsh 1988), we interpret career length as a valid proxy for player health and fitness[7].

The remainder of the paper is organized as follows: Section 2 reviews the available evidence on the impact of exogenously imposed safety measures on worker health and well-being and of experience-rated contributions to accident insurance on accident prevention. In section 3 we present our data and some descriptive findings. Section 4 presents the econometric evidence suggesting that mandatory helmets have increased career length by more than two years. In section 5 we conclude by discussing the managerial as well as medical implications of our findings (perhaps surprisingly, the helmet rule – which was initially highly contested by players and fans alike – has not been evaluated so far) and make some suggestions for further research.

2. Literature Review and Testable Hypothesis

The literature addressing the impact of information asymmetries on workplace hazards and injuries consists of four different, yet closely related research traditions: First, a

6 Levitt (2002), Heckelman and Yates (2003) as well as Depken and Wilson (2004) find that another exogenous intervention in the NHL – the introduction of a second referee in selected matches in the 1999/2000 season to either deter or to punish more effectively rule violations – did not affect the number of infractions committed.

7 Brandner et al. (2014) demonstrate that peak age is between 27 and 28 for forwards and 28 and 29 for defenders and that both types of skaters exhibit near-peak performance over a wide range going from about 24 to about 34.

number of studies have found financial incentives to internalize the costs of workplace accidents via experience-rated contributions to accident insurance (surcharges, rebates) to induce the desired changes in behavior (e.g. Schäfer and Kötz 1993, Tompa et al. 2013, Lengagne 2016). A second strand of literature convincingly demonstrated that workplace inspections by public institutions have a statistically significant and economically relevant effect in reducing workplace accidents (e.g. Deily and Gray 2007, Gray and Jones 1991, Haviland et al. 2012, Weil 1996, 2001). Third, the literature on the effects of exogenous interventions to reduce accidents found that they can be both, negligible (in the presence) or substantial (in the absence of "offsetting behavior", a concept developed by Peltzman 1975)8. Finally, the literature on compensating differentials has found that in the absence of information asymmetries (i.e. when workers are (fully) informed about workplace hazards and injury risks) firms have to pay a premium to workers who are willing to accept high injury or even death risks (e.g. Duncan and Holmlund 1983, Garen 1988, Hersch 1998, Kostiuk 1990, Viscusi 1978).

Taken together, this literature suggests that NHL clubs have so far succeeded in externalizing the costs of player injuries and long-term health impairments. If the players had been aware of the health risks they are exposed to, their union would have either asked owners for higher salaries as a compensating wage differential or it would have turned to the government to ask for implementation of adequate and regular forms of mandatory medical inspections, the costs of which would have to be borne by the clubs.

However, even team owners might not have been (fully) aware of the health risks the players are exposed to. On the one hand, the risks might have been completely unknown, implying that clubs had no private information that they withheld from players (similar to the situation in e.g. the construction industry, where for many years asbestos

8 A number of studies (such as e.g. Crandall and Graham 1984, Peterson et al. 1995, Keeler 1994, Conybeare 1980, Traynor 1993) find that mandatory seatbelts not only reduce traffic fatalities, but also lead to changes in driver behavior (e.g. induce "reckless driving"). Dee (2009) as well as Mayrose (2008) confirm the existence of an offsetting effect of mandatory motorcycle helmets on traffic fatalities. Finally, Sobel and Nesbit (2007), looking at changes in driver behavior in stock car racing, find offsetting behavior in NASCAR in the sense that drivers do drive more recklessly in response to the increased safety of their automobiles. Total injuries, however, still decrease because this effect is not large enough to completely offset the direct impact of increased automobile safety.

was considered a cheap, abrasion, heat and acid resistant construction material before it was considered a carcinogenic substance in the late 1980s and finally banned in the early 1990s). Since, on the other hand, the latency period between concussions and the emergence of neurocognitive deficits or even degenerative brain disease such as chronic traumatic encephalopathy, which can still only be diagnosed after death, can be quite long (the majority of players begin developing symptoms years if not decades after they have stopped playing), a causal relationship between head injuries and those disorders is difficult to establish, as many other factors (for example a person's genetic disposition or lifestyle) might also have (equally or even more) contributed to the deterioration of a player's health.

Summarizing, we assume that the implementation of the mandatory helmet rule for newly drafted players prior to the start of the 1979 season serves to reduce head injuries and to increase workplace safety. Thus, we conjecture that players for whom the helmet was mandatory right from the start of their (professional) career enjoyed better health and, therefore, longer careers.

3. Data and Descriptive Statistics

Since the mandatory helmet rule allowed players who signed professional contracts prior to June 1, 1979 to continue to not wear a helmet provided a liability waiver was signed, we compare the career length – our preferred measure of player health and long term fitness – of all players entering the NHL via the draft in the ten seasons before (1969 thru 1978) and the ten seasons after (1979 thru 1988) the implementation of the helmet rule. In these 20 years, 3,952 players were selected by the NHL teams of whom 1,818 eventually appeared in at least one match9.

9 Thus, the majority of the players selected in the draft never played in the NHL but spent their entire careers in either one of the minor leagues in North America (such as the American Hockey League (AHL)) or in one of the professional leagues in Europe. Since fighting has been found to be more widespread in the AHL than in the NHL (Rockerbie 2017) career length of players oscillating between these two leagues should – other things equal – be shorter than for players appearing only in the NHL.

Table 1 displays the composition of the player population[10]. Our complete data set includes all players who have been selected by any of the NHL teams in any of the drafts 1969 thru 1988 who eventually appeared in at least one match. The restricted data set includes only players who were selected in draft rounds 1 thru 6 during the respective period, yielding a slightly more homogenous population in terms of games per season and points per game. To demonstrate the robustness of our findings, we estimate the models presented below (Tables 4a and 4b) once using the complete and once using the reduced data set. Throughout the descriptive as well as econometric analyses we exclude from our analysis goalkeepers (n=161 in the complete and n=115 in the reduced data set) as these players have always been obliged to wear special protective clothing that did not change with the introduction of the mandatory helmet. It appears from Tables 2a and 2b below that players are slightly more than 19 years old when drafted (older players are typically professionals entering the draft from outside North America)[11], 184 centimeters tall and 87 kg heavy.

Table 1 about here

In the ten-year-period after the introduction of the mandatory helmet, players were significantly younger when drafted (20.0 versus 18.8 years), taller (183 versus 185 cm) and heavier (85.4 versus 88.6 kg). Moreover, players appeared in significantly fewer games per season (34.2 versus 31.8)[12] and accumulated more penalty minutes per game (0.84 versus 1.07)[13] in the second half of the observation period. The difference in the number of points per game (0.37 versus 0.36) was not statistically significant (all these means were calculated using the reduced data set).

10 The data used to estimate the models presented below (the results of corresponding parametric survival models are available from the authors upon request) was retrieved from www.hockeydb.com.

11 A closer look at the data reveals that 97 percent of the players are between 18 and 20 years old by the time they are drafted which, in turn, explains the low standard deviation.

12 This is not necessarily indicative of poorer player health, but suggests that with increasing roster size players may receive more time to recover from fatigue and injuries. Controlling for draft round, age, height, weight, position, year drafted and club dummies, the number of games per season does not differ between the two regimes (the estimation results are, of course, available from the authors upon request).

13 Whether this increase is due to more aggressive play or to stricter rule enforcement by the referee(s) remains to be tested.

Comparing defenders and forwards it appears that the former have been 3 cm taller and 3 kg heavier in both periods than the latter. Both, forwards as well as defenders are taller and heavier in the second half of the observation period, i.e. when the helmet was mandatory for new players (according to the data, height increased by 3 cm and weight by 3 kg for forwards as well as for defenders).

Tables 2a and 2b about here

Our dependent variable "career length" is the time between the season when a player was drafted and the last season in which he appeared in either the NHL, another hockey league in North America or in a professional hockey league in Europe.

Table 3 about here

Table 3 shows that career length has increased considerably from less than 7 to more than 9 years in the complete as well as the reduced data set (this difference is statistically significant at $p<.01$ in both cases). The difference in career length between defenders and forwards is statistically insignificant in the "pre-helmet era", but significant (at $p<.05$ in the complete as well as the reduced data set) in the "post-helmet-period", suggesting that the former benefit more from protective equipment than the latter. Moreover, Figure 1 suggests that career length increased considerably in the first season after the mandatory helmet rule became effective and continued to rise in later years.

Figure 1 about here

The distribution of career lengths can also be described using Kaplan-Meier survivor functions (Kaplan and Meier 1958). This non-parametric estimate of the survivor function shows the probability of an individual having a career of at least *t* seasons.

Figures 2-4 about here

Figures 2-4 display Kaplan-Meier survivor function estimates for hockey players before and after the implementation of the mandatory helmet. It appears from Figure 2 that career length has significantly increased during the second half of our observation period (the "helmet era"). Moreover, the survivor functions for defenders and forwards look rather similar, suggesting that the likelihood of exiting the sport is similar for both types of players over their entire career with the exit probability of forwards being higher in every single year. However, the log rank test for equality of survivor functions reveals that, first, defenders have significantly longer careers in professional hockey than forwards[15] and that, second, the increase in career length that can be attributed to the introduction of the mandatory helmet is larger for defenders than for forwards.

4. Econometric Evidence

While this unconditional, non-parametric analysis of career length uncovers some interesting patterns, most research on career length performs conditional, parametric or semi-parametric analyses of the determinants of career length. Parametric and semi-parametric methods can condition observed career length on other observable factors like performance that are known to affect career length systematically in other settings. In this conditional analysis of career length, we pool data for defenders and forwards and assume that the baseline hazard function varies systematically across positions; this is equivalent to estimating a positions-specific effect on career length. We also explain observed career length using selected covariates (such as games played per season, points scored per game and penalty minutes per game) that reflect individual performance, because in the previous literature on career length in individual as well as in team sport (see e.g. Frick et al. 2007, Frick and Scheel 2016) performance – both absolute and relative – has been linked to career length theoretically and empirically.

The Cox proportional hazard model is the standard econometric method used to analyze duration data. Its main advantage is that it makes no assumptions about the underlying

15 The test statistics are Chi2=8.19, p<.01 for the complete and Chi2=7.86, p<.01 for the reduced sample.

survival distribution[16]. Tables 4a and 4b below contain estimates from the Cox models in the form of regression parameters. These parameter estimates must be interpreted differently from the hazard ratios from a standard Cox model that reflect an individual player's probability of exiting the league during a specific time period, conditional on having been in the league as of the beginning of that period. A hazard ratio estimate between 0 and 1 on a covariate reflects a reduction in the exit probability associated with that covariate. Hazard ratios closer to zero reflect a less likely exit associated with that covariate. Estimated hazard ratios larger than one indicate a reduction in the probability that a player continues to compete in the sport. In contrast to these hazard ratios, the parameter estimates presented below can be interpreted like the coefficient estimates from standard regression models like OLS. Positive parameter estimates indicate that a change in that particular covariate is associated with a shorter career (i.e. increases the exit probability) while a negative parameter estimate indicates that a change in that covariate is associated with a longer career (i.e. reduces the individual exit probability), other things equal.

Before turning to the interpretation of the coefficients that we are mostly interested in we briefly comment on the coefficients of our control variables most of which are statistically significant:

- Age at draft has a statistically positive, while draft round and body weight have a statistically negative effect on career length, suggesting that older players have a higher risk of exiting while heavier players and those drafted in early rounds have a lower risk of exiting the league.

16 In addition to a Cox hazard model, we have also estimated parametric hazard models. Parametric hazard models exploit the information about career length differently than Cox hazard models, and can be interpreted as regression models (Cleves et al. 2008). The specific form of parametric hazard models depends on the distribution of the dependent variable, i.e. career length. In our setting, the *Akaike Information Criterion* (Akaike 1974) indicates that a Gompertz model is to be preferred over its alternatives such as e.g. the log-logistic or Weibull models. The results of these models are, of course, available from the authors upon request.

- The coefficients of draft number (which is, of course, correlated with draft round) and of body height fail to reach statistical significance, suggesting that they are irrelevant for career length of professional hockey players17.

- As expected, the coefficients of the three relevant performance measures (games per season, points per game and penalty minutes per game) are statistically highly significant. Each additional game per season, each point scored and each penalty minute reduce a player's exit probability (or – in other words – help that player to extend his career).

Looking at the coefficients of the dummy variable separating the pre-helmet from the helmet era (Table 4a) it appears that both, forwards as well as defenders, have significantly longer careers in the second half of our observation period. This suggests that helmets are indeed a safety device helping players to retain their health and fitness because average career length is about two years longer in the helmet as opposed to the pre-helmet era. Thus, players seem to benefit from this special kind of protective clothing in two ways: First, helmets better protect them against concussion-related short- and long-term health impairments and, second, allow them to play longer and to maximize their lifetime income18.

To rule out that our results are driven by factors other than the mandatory helmet, we have performed a number of robustness checks:

- First, we restricted the complete as well as the reduced data set to include only players who were drafted in the six year (instead of ten year) window around the implementation of the mandatory helmet rule (three years before and three years after (1976-1981) with n=554 and 451 player observations). In the estimations – the results

17 Estimating the models presented in Tables 4a and 4b with the players' body mass index instead of body height and weight leaves the coefficient(s) of interest completely unaffected. The detailed results are, of course, available from the authors upon request.

18 The average annual player salary in the 1977-1978 season was 100,000 $ (Jones and Walsh (1988: 601), 200,000 $ in the 1989-1990 season (own calculation based on information on 520 players provided by Rod Fort on his website) and has increased to 2.9 million $ in the 2015-2016 season.

of which are available upon request – the coefficients of both, the helmet dummy as well as the interaction of the helmet and the forward dummy, retained their sign, magnitude and statistical significance[19].

- Second, we performed a number of placebo tests by moving the implementation of the mandatory helmet rule to 1976 (two years earlier) and 1980 (two years later). Our results – which are, of course, available upon request – reveal that shifting the implementation date to 1976 results in a statistically insignificant coefficient of the helmet dummy while shifting that date to 1980 results in a statistically significant, yet considerably smaller positive effect. As above, we interpret these results as confirming our initial findings.

- Third, for goalkeepers – who were unaffected by the mandatory helmet rule – we do not find a comparable increase in career length. The Kaplan-Meier survival rates differ far less between the two periods for this group (see Figure 5), suggesting that the introduction of mandatory helmets for forwards and defenders had no impact on the careers of goalkeepers.

Figure 5 about here

- Unfortunately, due to a lack of comparable data we were unable to empirically analyze the development of player career duration in another professional hockey league where the helmet has always been mandatory. Therefore, we analyzed the career lengths of players appearing at least once in the German national hockey team and of players appearing in at least one match in the first division of German football (Frick 2015). The idea here is to rule out that changes in medical care and training methods, in dietary habits and player salaries either in isolation or in combination

19 If we further restrict the data to two years around the introduction of the mandatory helmet, the coefficients again retain their sign, magnitude and statistical significance in the reduced sample with 315 observations (in the complete data set with 385 observations the coefficients also retain their magnitude, but lose their statistical significance).

explain the impact of the mandatory helmet that we observe in the NHL data. It appears that in none of the two data sets career length increases over time, suggesting that the effect we observe is indeed to be attributed to the new safety equipment.

- Finally, using a regression discontinuity design, we can clearly identify the causal effect of the introduction of the mandatory helmet on career length (separate estimations for defenders and forwards yield very similar results; these are available from the authors upon request). It appears from Figure 6 that in the ten seasons before the introduction of mandatory helmets average career length was decreasing. This development was completely reversed after the mandatory helmet rule became effective.

Figure 6 about here

This statistically significant positive effect of protective equipment on career length is, however, unequally distributed among the two types of skaters (see Table 4b): Defenders benefit from mandatory helmets nearly twice as much as forwards, suggesting that the former have changed their style of play under the new regime at the detriment of the latter (the statistically significant increase in penalty minutes between the pre-helmet and the helmet era is indicative of a change in behavior, particularly of defenders. However, it may as well only reflect stricter rule enforcement by referees who have been advised to better protect forwards against rough play)[20].

Summarizing, our results are likely to be “lower-bound estimates” of the true effect of helmet use on career length for at least two reasons: First, during the 1970s the percentage of players wearing a helmet voluntarily steadily increased following the death of Bill Masteron on January 15, 1968 as a direct result of massive head injuries suffered following a hit in a match of his Minnesota North Stars against the Oakland Seals. Thus, by the time the helmet became mandatory, a significant percentage of players had been

20 As player salaries have increased more than the salaries in the players’ next best alternative, the opportunity costs of exiting professional hockey have increased too. In order to control for this development we add year of entry dummies in models 4.1 and 4.2 (Table 4b). Although this reduces the magnitude of the helmet dummy, the coefficient retains its statistical significance.

wearing one already voluntarily, weakening the effect of the mandatory helmet. Second, following the implementation of the mandatory helmet rule, some “offsetting behavior” (e.g. rough play) has most likely occurred: Players who feel their opponents to be better protected commit more fouls, especially towards the head which, in turn, should be punished harshly given the apparent individual and social costs associated with degenerative brain conditions in general and chronic traumatic encephalopathy in particular.

5. Summary and Implications

Controlling for draft round and draft number, the individual players’ performance (games played per season, number of goals and assists per game, number of penalty minutes per game), player age, body height and weight, the year of entry and the team picking a particular player, we find that in the latter half of our observation period where helmets had become mandatory, career length significantly increased for both, forwards and defenders, suggesting that adequate equipment protects player health. Moreover, forwards – the players who usually suffer the most from body-checks and other violent actions – benefit significantly less from wearing a helmet, suggesting that defenders – who usually initiate rough play – engage in “offsetting behavior”, that is more violence.

We cannot rule out that team owners were initially better informed than players about the health risks of playing professional hockey without adequate protective equipment and can, therefore, not contribute to the debate on whether the players’ lawsuit is based on “hard facts”. However, our results clearly suggest that mandatory helmets are indispensable to better protect players against head injuries and long-term health problems. This has in the meantime been recognized not only by players and the league, but also by firms producing this kind of equipment. The competition between these firms producing helmets not only for a few hundred professional players, but also for thousands of high school, college and amateur players is likely to result in product innovations, such as lighter and more comfortable helmets with increasing protective capacity.

Together with the (mostly anecdotal) evidence on the impact of full face (as opposed to half face) shields against head and neck injuries among amateur hockey players (e.g. Benson et al. 1999, 2002) our results clearly suggest to make the former mandatory too as this is also likely to contribute to the short- and long-term well-being of players. This, in turn, will significantly reduce the costs to society of medical treatment and rehabilitation of former hockey players.

Table 1
Players Drafted by NHL Franchises, 1969-1988

Number of Players	Total	Percent
Drafted	3,952	100
Appeared in at least one match (Complete Data Set)	1,818	46.0 = 100
Goaltender (excluded from analysis)	161	8.9
Defender	1,078	59.3
Forward	579	31.8
Drafted in Rounds 1-6 and appeared in at least one match (Reduced Data Set)	1,408	35.6 = 100
Goaltender (excluded from analysis)	115	8.2
Defender	846	60.1
Forward	447	31.7

Source: www.hockeydb.com

Table 2a
Descriptive Statistics (Complete Data Set)

Variable	n=1,643 players[#]			
	Mean	Std. Dev.	Min.	Max.
Career Length (Years)	8.22	5.24	1	28
Draft Round	4.25	3.14	1	23
Draft Number	71.70	60.00	1	252
Age at Draft	19.36	1.34	17	31
Body Height (cm)	183.6	5.0	165	198
Body Weight (kg)	87.1	6.3	70	112
Obligatory Helmet (0=no; 1=yes)	0.59	---	0	1
Games per Season	29.46	23.35	0.14	76.90
Points per Game	0.36	0.26	0	1.88
Penalty Minutes per Game	0.96	0.92	0	9.67
Defender (0=no; 1=yes)	0.35	---	0	1
Forward (0=no; 1=yes)	0.65	---	0	1

excluding goalies (n=161) and skaters with missing values on one of the explanatory variables (n=14).

Table 2b
Descriptive Statistics (Reduced Data Set)

Variable	n=1,279 players[#]			
	Mean	Std. Dev.	Min.	Max.
Career Length (Years)	8.48	5.30	1	28
Draft Round	2.88	1.64	1	6
Draft Number	45.48	32.86	1	126
Age at Draft	19.29	1.24	17	31
Body Height (cm)	183.8	4.8	165	198
Body Weight (kg)	87.2	6.2	70	112
Obligatory Helmet (0=no; 1=yes)	0.56	---	0	1
Games per Season	32.84	23.36	0.17	76.90
Points per Game	0.38	0.27	0	1.88
Penalty Minutes per Game	0.97	0.90	0	9.67
Defender (0=no; 1=yes)	0.35	---	0	1
Forward (0=no; 1=yes)	0.65	---	0	1

excluding goalies (n=115) and skaters with missing values on one of the explanatory variables (n=14).

Table 3
Career Length Before and After the Introduction of Mandatory Helmets

	Complete Data Set	
	Mean	Std. Dev.
Helmet not mandatory	6.77	4.22
Helmet mandatory	9.23	5.63
	Reduced Data Set	
Helmet not mandatory	6.91	4.25
Helmet mandatory	9.68	5.70

Table 4a
Estimation Results: Cox Regression I

	Complete Data Set			Reduced Data Set		
	Model (1.1) All skaters	Model (1.2) Forwards only	Model (1.3) Defenders only	Model (2.1) All skaters	Model (2.2) Forwards only	Model (2.3) Defenders only
Draft Round	-0.117***	-0.106**	-0.155	-0.249***	-0.238**	-0.191
	(0.0407)	(0.0515)	(0.0963)	(0.0650)	(0.100)	(0.124)
Draft Number	0.00256	0.00219	0.00348	0.00753**	0.00603	0.00601
	(0.00199)	(0.00276)	(0.00494)	(0.00306)	(0.00515)	(0.00573)
Age at Draft	0.214***	0.240***	0.220***	0.249***	0.285***	0.235***
	(0.0304)	(0.0408)	(0.0408)	(0.0336)	(0.0501)	(0.0698)
Body Height	0.00390	0.0126	0.000779	0.00405	0.0131	0.00875
	(0.00735)	(0.00931)	(0.0120)	(0.00790)	(0.0101)	(0.0167)
Body Weight	-0.0225***	-0.0171**	-0.0220**	-0.0251***	-0.0226**	-0.0284**
	(0.00601)	(0.00841)	(0.00919)	(0.00672)	(0.0103)	(0.0127)
Games per Season	-0.0384***	-0.0333***	-0.0471***	-0.0382***	-0.0328***	-0.0466***
	(0.00215)	(0.00285)	(0.00408)	(0.00255)	(0.00317)	(0.00467)
Points per Game	-0.877***	-1.341***	-0.656*	-0.934***	-1.480***	-0.632*
	(0.133)	(0.138)	(0.351)	(0.152)	(0.168)	(0.353)
Penalty Minutes per Game	-0.0925***	-0.144***	-0.0210	-0.0896***	-0.115***	-0.0203
	(0.0249)	(0.0313)	(0.0407)	(0.0297)	(0.0423)	(0.0473)
Mandatory Helmet	**-0.507*****	**-0.490*****	**-0.555*****	**-0.558*****	**-0.525*****	**-0.610*****
	(0.0983)	**(0.123)**	**(0.153)**	**(0.102)**	**(0.127)**	**(0.158)**
Club Dummies			included			
N	1,643	1,067	576	1,279	835	444
LL Null Model	-10,653.24	-6,459.76	-3,132.98	-7,972.26	-4,849.95	-2,300.14
LL Full Model	-10,028.31	-6,038.75	-2,892.58	-7,464.94	-4,501.35	-2,105.88
Wald Chi2	1249.86***	842.75***	480.79***	1,014.64***	697.20***	388.52***

Standard errors (clustered at club level) in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4b
Estimation Results: Cox Regression II

	Complete Data Set		Reduced Data Set	
	Model (3.1)	Model (4.1)	Model (3.2)	Model (4.2)
Draft Round	-0.116***	-0.0994**	-0.192***	-0.145
	(0.0396)	(0.0433)	(0.0721)	(0.0907)
Draft Number	0.00260	0.00120	0.00467	0.000917
	(0.00209)	(0.00232)	(0.00371)	(0.00471)
Age at Draft	0.217***	0.212***	0.255***	0.236***
	(0.0219)	(0.0239)	(0.0269)	(0.0317)
Body Height	0.00791	0.00909	0.00921	0.00915
	(0.00699)	(0.00717)	(0.00800)	(0.00829)
Body Weight	-0.0229***	-0.0214***	-0.0252***	-0.0232***
	(0.00562)	(0.00588)	(0.00653)	(0.00687)
Games per Season	-0.0370***	-0.0400***	-0.0364***	-0.0406***
	(0.00167)	(0.00174)	(0.00185)	(0.00196)
Points per Game	-1.024***	-1.102***	-1.080***	-1.190***
	(0.133)	(0.137)	(0.147)	(0.152)
Penalty Minutes per Game	-0.0897***	-0.128***	-0.0789**	-0.130***
	(0.0323)	(0.0336)	(0.0374)	(0.0393)
Mandatory Helmet (yes=1)	**-0.702*****	**-0.506****	**-0.737*****	**-0.591****
	(0.0876)	**(0.222)**	**(0.102)**	**(0.258)**
Helmet * Forward	**0.313*****	**0.318*****	**0.321*****	**0.347*****
	(0.0718)	**(0.0736)**	**(0.0850)**	**(0.0880)**
Year of Entry Dummies	no	yes	no	yes
Club Dummies	no	yes	no	yes
N	1,643	1,643	1,279	1,279
LL Null Model	-10,653.24	-10,653.24	-7,972.26	-7,972.26
LL Full Model	-10,048.01	-9,976.65	-7,486.68	-7,417.65
Wald Chi2	1,210.45***	1,353.18***	971.15***	1,109.21***

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1
Average Career Length by Year of Draft

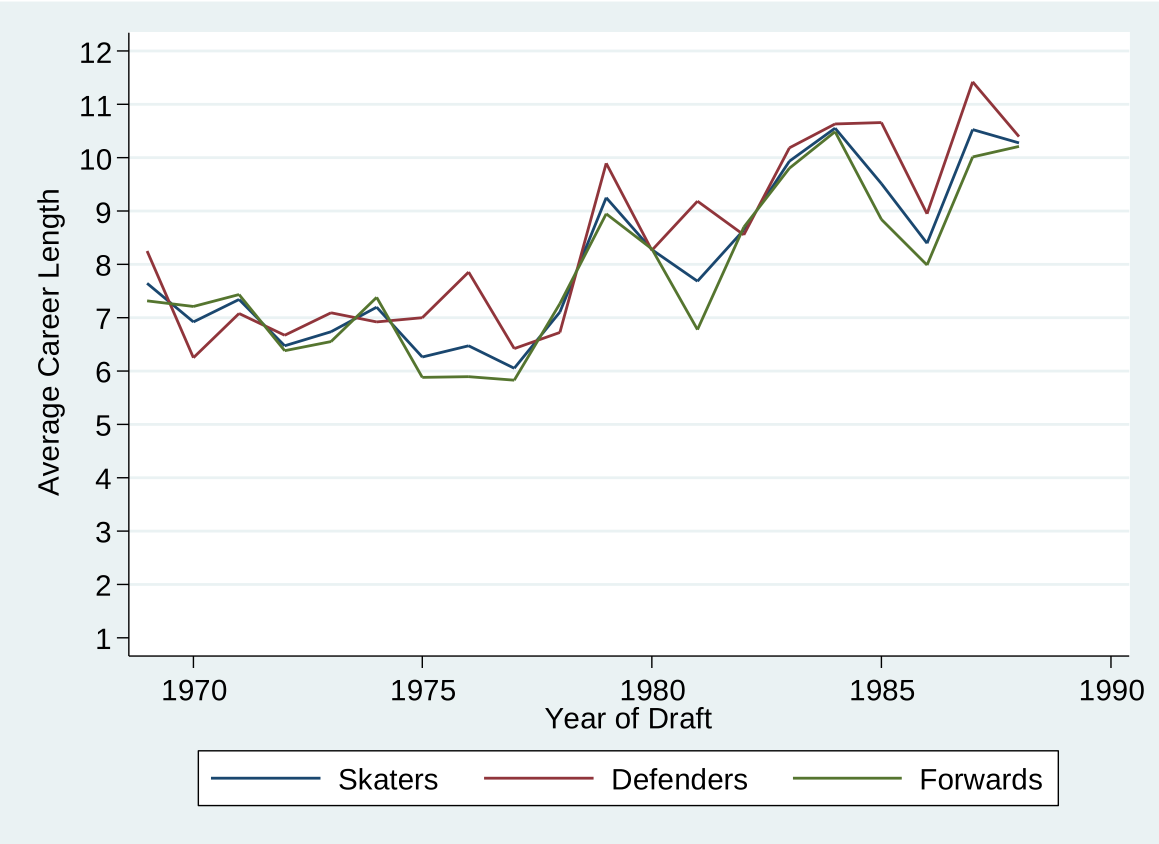


Figure 2
Kaplan Meier Survival Rate of Players before and after Introduction of Mandatory Helmet (Complete Data Set)

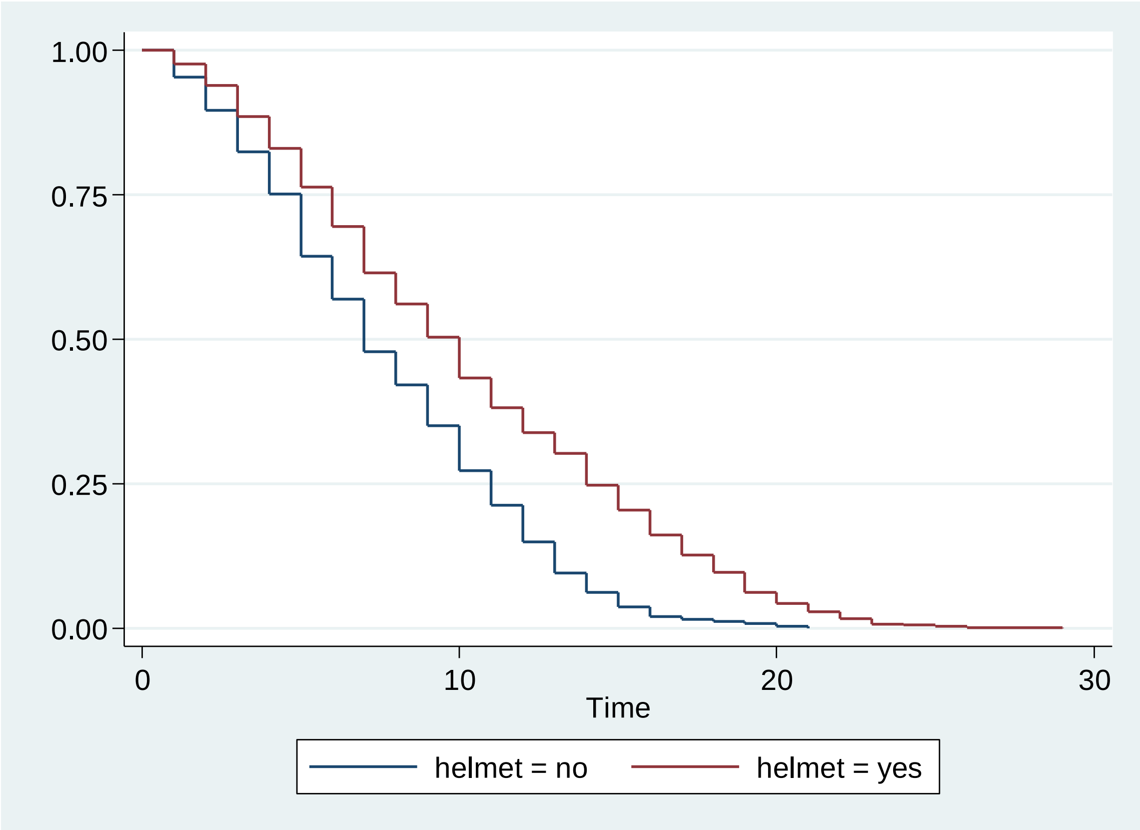


Figure 3
Kaplan Meier Survival Rate of Defenders before and after Introduction of Mandatory Helmet (Complete Data Set)

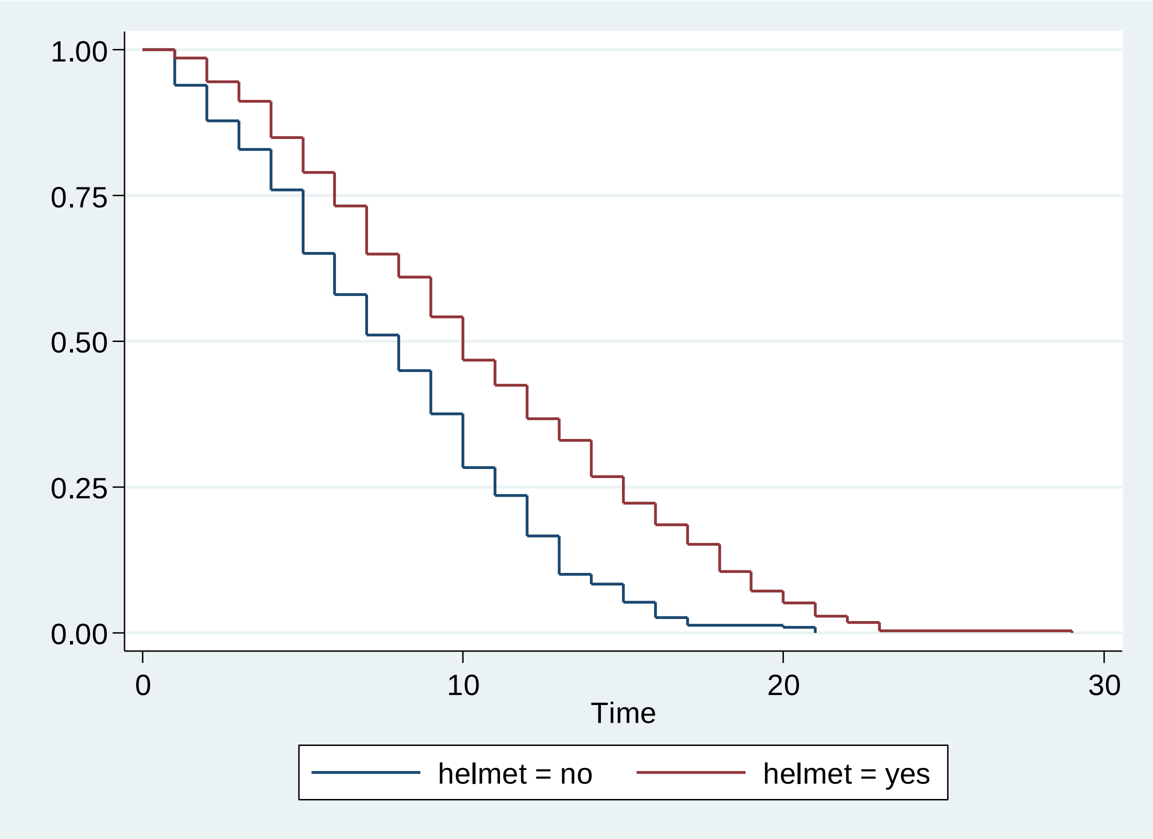


Figure 4
Kaplan Meier Survival Rate of Forwards before and after Introduction of Mandatory Helmet (Complete Data Set)

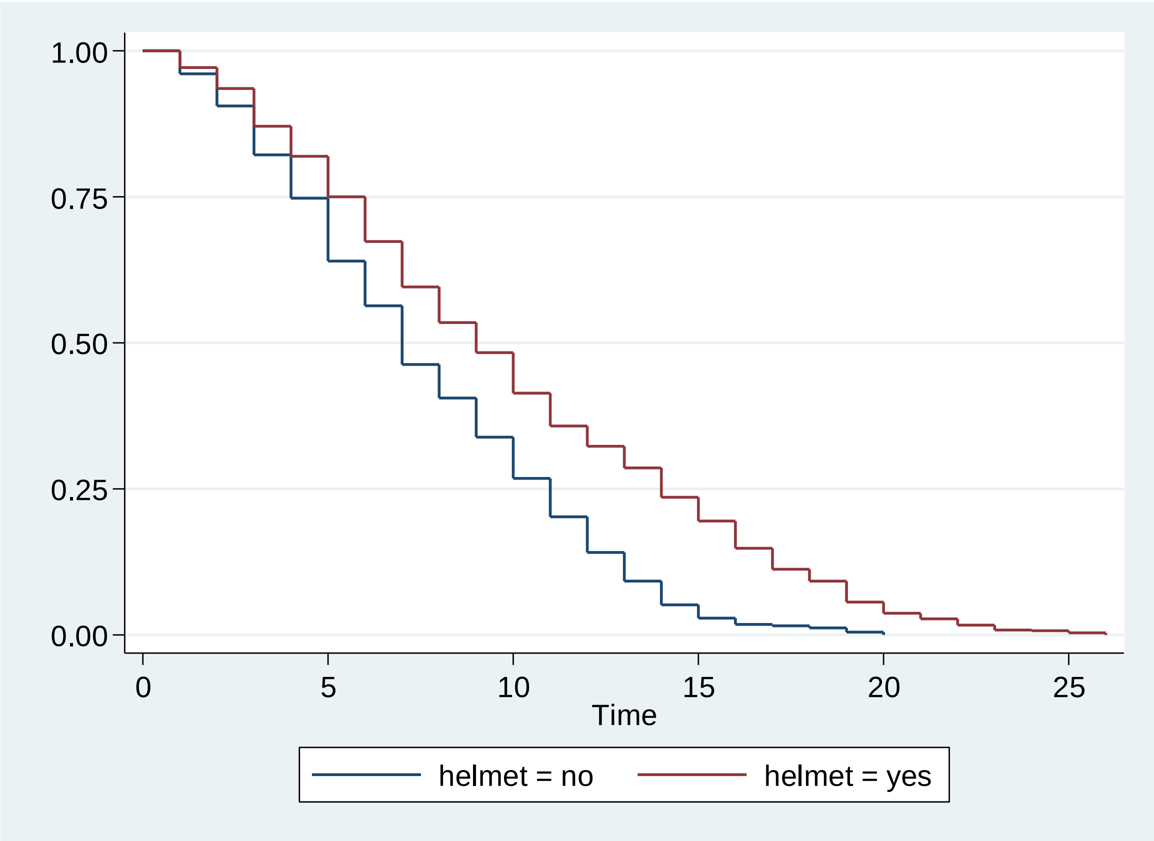


Figure 5
Kaplan Meier Survival Rate of Goalkeepers before and after Introduction of Mandatory Helmet (Complete Data Set)

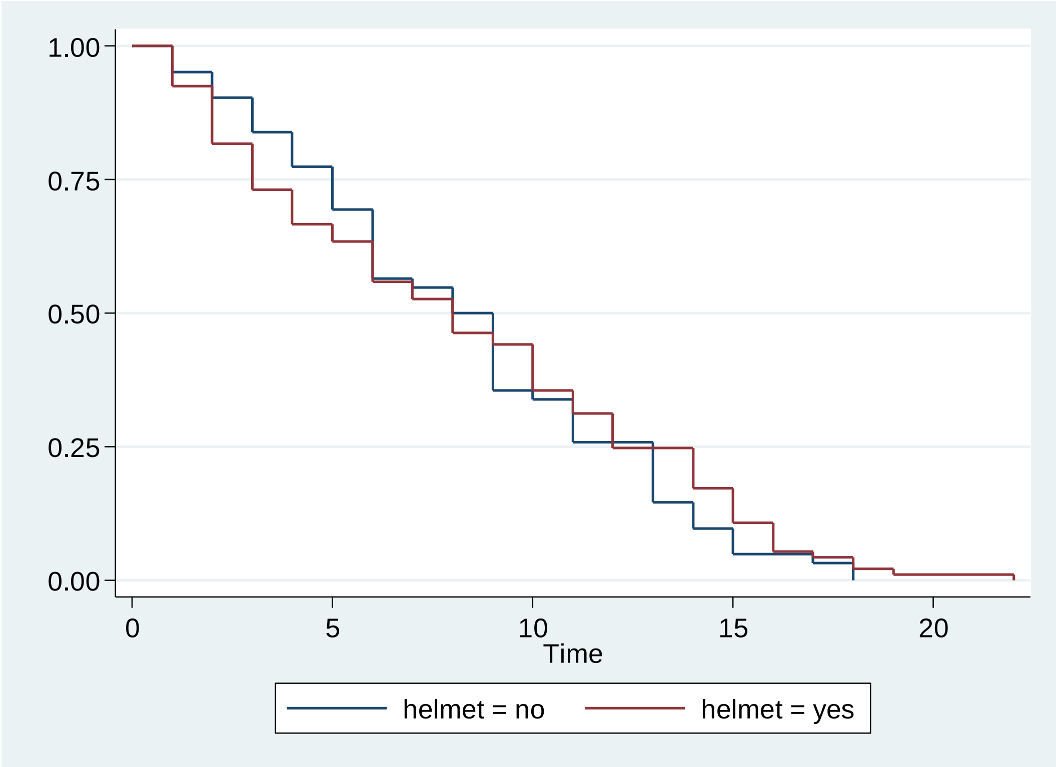
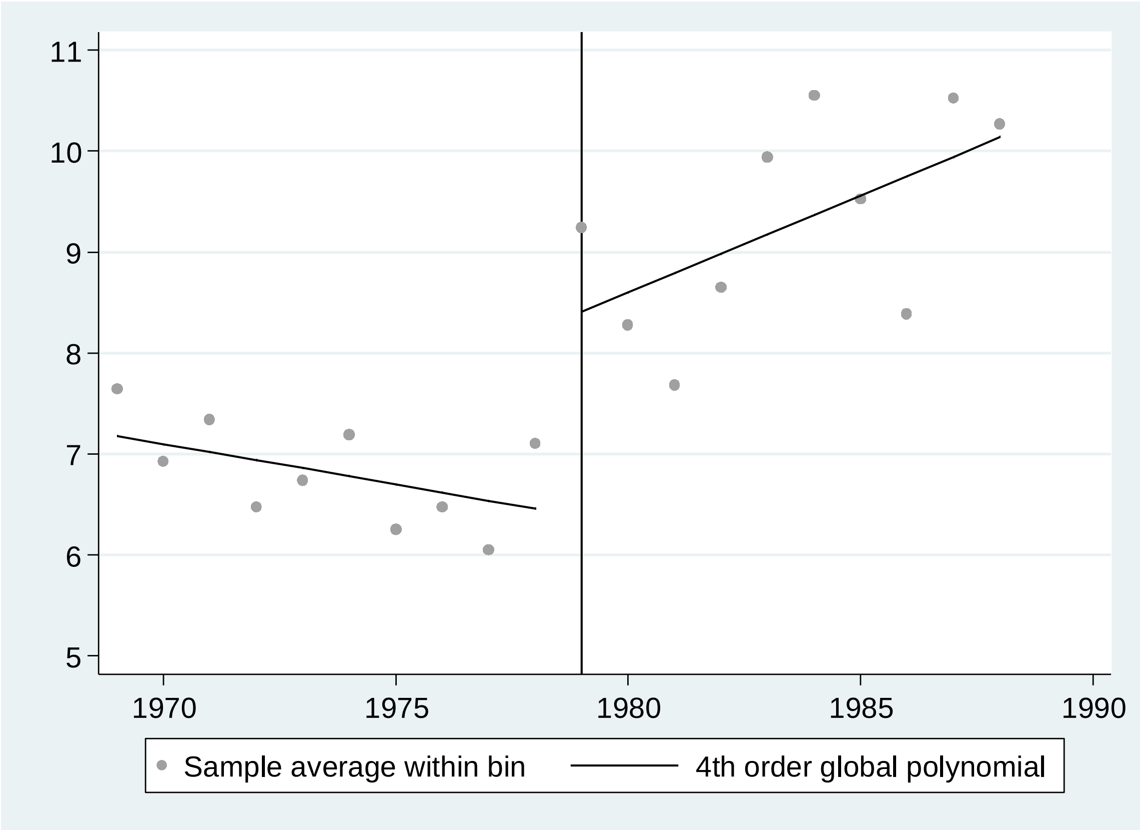


Figure 6
Regression Discontinuity Estimation (Function Fit)



Literature

Adams, S., C.W. Mason and M.A. Robidoux (2015): “If You Don’t Want to Get Hurt, Don’t Play Hockey”: The Uneasy Efforts of Hockey Injury Prevention in Canada. Sociology of Sport Journal, 32, pp. 248-265.

Akaike, H. (1974): A New Look at the Statistical Model Identification. IEEE Transactions on Automatic Control, 19(6), pp. 716-723.

Benson, B.W., N.G.H. Mohtadhi, S. Rose and W.H. Meeuwisse (1999): Head and Neck Injuries among Ice Hockey Players Wearing Full Face Shields vs Half Face Shields. Journal of the American Medical Association, 282(24), pp. 2328-2332.

Benson, B.W., S. Rose and W.H. Meeuwisse (2002): The Impact of Face Shield Use on Concussions in Ice Hockey: A Multivariate Analysis. British Journal of Sports Medicine, 36, 27-32.

Benson, B.W., W.H. Meeuwisse, J. Rizos, J. Kang and C.J. Burke (2011): A Prospective Study of Concussions among National Hockey League Players during Regular Season Games: The NHL-NHLPA Concussion Program. Canadian Medical Association Journal, 183(8), pp. 905-911.

Brandner, J.A., E.J. Egan and L. Yeung (2014): Estimating the Effects of Age on NHL Player Performance. Journal of Quantitative Analysis in Sports, 10(2), pp. 241-259.

Cleves, M.A., W.W. Gould and R.G. Gutierrez (2008): An Introduction to Survival Analysis Using Stata. College Station, TX: Stata Press.

Conybeare, J.C.A. (1980): Evaluation of Automobile Safety Regulations: The Case of Compulsory Seat Belt Legislation in Australia. Policy Sciences, 12, pp. 27-39.

Crandall, R.W. and J.D. Graham (1984): Automobile Safety Regulation and Offsetting Behavior: Some New Empirical Estimates. American Economic Review, 74(2), pp. 328-331.

Dee, T.S. (2009): Motorcycle Helmets and Traffic Safety. Journal of Health Economics, 28, pp. 398–412.

Deily, M.E. and W.B. Gray (2007): Agency Structure and Firm Culture: OSHA, EPA, and the Steel Industry. Journal of Law, Economics and Organization, 23(3), pp. 685-709.

Depken, C.A. and D.P. Wilson (2004): Wherein Lies the Benefit of the Second Referee in the NHL? Review of Industrial Organization, 24, pp. 51-72.

Depken, C.A., J. Ducking and P.A. Groothuis (2015): Career Duration in the NHL: Bias against Europeans? Working Paper 15-09, Department of Economics, Appalachian State University.

Duncan, G.J. and B. Holmlund (1983): Was Adam Smith Right After All? Another Test of the Theory of Compensating Wage Differentials. Journal of Labor Economics, 1(4), pp. 366-379.

Frick, B. (2015): The Impact of Labor Market Deregulation on Worker Careers: Evidence from German Soccer, mimeo, Management Department, University of Paderborn.

Frick, B. and F. Scheel (2016): Fly Like an Eagle: Career Duration in the FIS Ski Jumping World Cup, 1979-2011. Journal of Sports Economics, 17(8), pp. 813-831

Frick, B., G. Pietzner and J. Prinz (2007): Career Duration in a Competitive Environment: The Labor Market for Soccer Players in Germany. Eastern Economic Journal, 33(3), pp. 429-442.

Garen, J. (1988): Compensating Wage Differentials and the Endogeneity of Job Riskiness. Review of Economics and Statistics, 70(1), pp. 9-16.
Gavett, B.E., R.A. Stern and A.C. McKee (2011): Chronic Traumatic Encephalopathy: A Potential Late Effect of Sport-Related Concussive and Sub-Concussive Head Trauma. Clinical Sports Medicine, 30(1), pp. 179-188.
Gray, W.B. and C.A. Jones (1991): Are OSHA Health Inspections Effective? A Longitudinal Study in the Manufacturing Sector. Review of Economics and Statistics, 73, 504-508.
Haisken-de New, J.P. and M. Vorell (2008): Blood Money: Incentives for Violence in NHL Hockey, Ruhr Economic Papers 47, Essen: RWI.
Harrison, S. (2015): NHL May Follow Football's Lead on Concussion. Business Insurance, 49(11), May 25.
Haviland, A.M., R.M. Burns, W.B. Gray, T. Ruder and J. Mendeloff (2012): A New Estimate of the Impact of OSHA Inspections on Manufacturing Injury Rates, 1998-2005. American Journal of Industrial Medicine, 55, pp. 964-975.
Heckelman, J. and A. Yates (2003): And a Hockey Game Broke Out: Crime and Punishment in the NHL. Economic Inquiry, 41, pp. 705-712.
Hersch, J. (1998): Compensating Differentials for Gender-Specific Job Injury Risks. American Economic Review, 88(3), pp. 598-607.
Hutchison, M.G., P. Comper, W.H. Meeuwisse and R.J. Echemendia (2015): A Systematic Video Analysis of National Hockey League (NHL) Concussions, Part I: Who, When, Where and What? British Journal of Sports Medicine, 49, pp. 547-551.
Johnson, L.S.M. (2011): Concussions in Youth Ice Hockey: It's Time to Break the Cycle. Canadian Medical Association Journal, 183(8), pp. 921-924.
Jones, J.C.H. and W.D. Walsh (1988): Salary Determination in the National Hockey League: The Effects of Skills, Franchise Characteristics, and Discrimination. Industrial and Labor Relations Review, 41(4), pp. 592-604.
Jones, J.C.H., D. Ferguson and K. Stewart (1993): Blood Sports and Cherry Pie: Some Economics of Violence in the National Hockey League. American Journal of Economics and Sociology, 52, pp. 63-78.
Kaplan, E.L. und P. Meier (1958): Nonparametric Estimation from Incomplete Observations. Journal of the American Statistical Association, 53(282), pp. 457-481.
Keeler, T.E. (1994): Highway Safety, Economic Behavior, and Driving Environment. American Economic Review, 84(3), pp. 684-693.
Kötz, H. and H.-B. Schäfer (1993): Economic Incentives to Accident Prevention: An Empirical Study of the German Sugar Industry. International Review of Law and Economics, 13, pp. 19-33.
Kostiuk, P.F. (1990): Compensating Differentials for Shift Work. Journal of Political Economy, 98(5), pp. 1954-1075.
Langagne, P. (2016): Experience Rating and Work-Related Health and Safety. Journal of Labor Research, 37(1), pp. 69-97.
Levitt, S.D. (2002): Testing the Economic Model of Crime: The National Hockey League's Two-Referee Experiment. Contributions to Economic Analysis & Policy, 1(1), Article 2.

Mayrose, J. (2008): The Effects of a Mandatory Motorcycle Helmet Law on Helmet Use and Injury Patterns among Motorcyclist Fatalities. Journal of Safety Research, 39, pp. 429-432.

Paul, R.J. (2003): Variations in NHL Attendance: The Impact of Violence, Scoring, and Regional Rivalries. American Journal of Economics and Sociology, 62(2), pp. 345-364.

Peltzman, S. (1975): The Effect of Automobile Safety Regulations. Journal of Political Economy, 83(4), pp. 677-726.

Peterson, S., G. Hoffer and E. Millner (1995): Are Drivers of Air-Bag-Equipped Cars More Aggressive? A Test of the Offsetting Behavior Hypothesis. Journal of Law & Economics, 38(2), pp. 251-264.

Rawlings, N. (2013): Retired Hockey Players Sue NHL over Concussions. Time.com, November 26.

Rockerbie, D.W. (2012): The Demand for Violence in Hockey, in: Kahane, L. and S. Shmanske (eds.): The Economics of Sport, Vol. 2, Oxford: Oxford University Press, pp. 159-176.

Rockerbie, D.W. (2016): Fighting as a Profit-Maximizing Strategy in the National Hockey League: More Evidence. Applied Economics, 48(4), pp. 292-299.

Rockerbie, D.W. (2017): Fighting as a Profit-Maximizing Strategy in the American Hockey League, in: Frick, B. (ed.): Breaking the Ice: The Economics of Hockey, Heidelberg: Springer.

Smith, A., M.J. Stuart, R.M. Greenwald, B.W. Benson, D.W. Rodick, C.A. Emory, J.T. Finnoff, J.P. Mihalik, W.O. Roberts, C.-A. Sullivan and W.H. Meeuwisse (2011): Proceedings from the Ice Hockey Summit on Concussion: A Call to Action. Clinical Journal of Sport Medicine, 21(4), pp. 281-287.

Sobel, R.S. and T.M. Nesbit (2007): Automobile Safety Regulation and the Incentive to Drive Recklessly: Evidence from NASCAR. Southern Economic Journal, 74(1), pp. 71-84.

Stewart, K., D. Ferguson and J. Jones (1992): On Violence in Professional Team Sport as the Endogenous Result of Profit Maximization. Atlantic Economic Journal, 20, pp. 55-64.

Tompa, E.,S. Hogg-Johnson, B.C. Amick, Y. Wang, E. Shen, C. Mustard, L. Robson and R. Saunders (2013): Financial Incentives of Experience Rating in Workers' Compensation: New Evidence from a Program Change in Ontario, Canada. Journal of Occupational and Environmental Medicine, 55(3), pp. 292-304.

Traynor, T.L. (1993): The Peltzman Hypothesis Revisited: An Isolated Evaluation of Offsetting Driver Behavior. Journal of Risk and Uncertainty, 7(7), pp. 237-247.

Vincent, C. and B. Eastman (2009): Determinants of Pay in the NHL: A Quantile Regression Approach. Journal of Sports Economics, 10(3), pp. 256–277.

Viscusi, W.K. (1978): Wealth Effects and Earnings Premiums for Job Hazards. Review of Economics and Statistics, 60(3), pp. 406-418.

Von Allmen, P., M. Leeds and J. Malakorn (2015): Victims or Beneficiaries? Wage Premia and National Origin in the National Hockey League. Journal of Sport Management, 29, pp. 633-641.

Weil, D. (1996): If OSHA is so Bad, Why is Compliance so Good? Rand Journal of Economics, 27(3), pp. 618-640.

Weil, D. (2001): Assessing OSHA Performance: New Evidence from the Construction Industry. Journal of Policy Analysis and Management, 20(4), pp. 651-674.