

# **The Antecedents of Mandatory Motorcycle Helmet Legislation Enhancing Behavior**

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## **ABSTRACT:**

The effectiveness of safety legislation may be improved or negated as a result of behavioral responses. Recent empirical research suggests that the efficacy of mandatory motorcycle helmet laws is enhanced by the behavior of motorcyclists. This study uses a nationally representative survey of approximately 500 US motorcyclists to investigate the precursors of helmet law enhancing behavior. Results indicate that motorcyclists who always wear a helmet are 13 percentage points more likely to agree that helmets help prevent death. Motorcyclists also identify negative outcomes associated with helmet use, and a large percentage of helmeted (22%) and non-helmeted (33%) riders feel that wearing a helmet increases their risk of serious neck injury when involved in a crash. Non-helmeted motorcyclists are 20 percentage points more likely to agree that helmets impair vision. Overall, the results reveal that non-helmeted motorcyclists are more pessimistic regarding the safety benefits of motorcycle helmets. In order to adjust for such risks, these riders are likely to engage in risk-reducing behaviors when forced to use helmets in order to comply with mandatory helmet legislation. Non-helmeted motorcyclists attitudes toward helmet use therefore offer a plausible explanation for the enhancing behavior associated with mandatory helmet laws. [J1]

**Keywords:** enhancing behavior; motorcycle helmets; safety legislation; fatality risks

**JEL Codes:** K32, R41, I18

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## I. Introduction

Dating back to the seminal work of Peltzman (1975), traditional economic theory suggests that individuals will adjust their behavior in a risk compensating manner in response to mandatory safety legislation. This risk compensation will, in turn, partially offset the intended safety improvements of the legislation. Blomquist (1986) extended the work of Peltzman to a utility theoretic framework of driver safety optimization, and Evans (1985) developed a simple comprehensive model of behavioral feedback in safety legislation that incorporates Peltzman's theory of offsetting behavior and more restrictive theories such as Wilde's (1982) theory of risk homeostasis.<sup>1</sup> Evans's comprehensive model also allows for enhancing behavior whereby the efficacy of safety legislation can be improved if individuals reduce their risk taking activities in the presence of safety mandates. Evans hypothesizes that the act of buckling a seatbelt or fastening a motorcycle helmet may serve as a salient reminder to motorists of the inherent dangers of driving, but also notes that empirical evidence supporting the presence of enhancing behavior is scant and often statistically insignificant (Evans 1985).

In an empirical analysis of US state motorcycle helmet laws Lee (2015) finds strong empirical evidence for enhancing behavior in the form of reduced motorcycle crashes following helmet law adoption. Specifically, state fixed effects models suggest that motorcycle crashes decline by 18.4% to 31.9% following helmet law adoption, and the effect is not driven by non-classical measurement error in the number of state reported crashes (Lee 2015). Lee (2015) provides three potential explanations for the observed enhancing behavior associated with helmet laws:

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<sup>1</sup> Peltzman's hypothesis suggests that the safety efficacy of mandates will be partially to fully offset by increased risk taking among individuals affected by the laws, while Wilde's theory suggests that individuals have a firm target level of risk and any safety mandates will be fully offset as individuals increase their risk taking activities to retain their ideal risk.

1. Motorcyclists have biased perceptions of the risks associated with helmet use.
2. Helmet use can nudge motorcyclists to improve riding safety along other dimensions such as alcohol consumption and rider conspicuity.
3. Mandatory helmet laws may reduce motorcycle utilization along an intensive margin (vehicle miles traveled) which is imperfectly approximated by state-level data on motorcycle registrations.

This study employs a nationally representative survey of roughly 500 US motorcyclists in order to determine the role of the aforementioned hypotheses as determinants of motorcycle helmet legislation enhancing behavior. The survey asks respondents to report motorcycle use, helmet use, and the perceived safety efficacy of helmets.<sup>2</sup> Survey results overwhelmingly suggest that biased perceptions of helmet risk are the primary determinants of enhancing behavior following helmet law adoption. Specifically, propensity score matching estimators do not find any statistically significant differences in motorcycle vehicle miles traveled or trips to other states among helmeted and non-helmeted motorcyclists.

Helmeted motorcyclists are 12.8 percentage points and 7.6 percentage points more likely to agree that helmets reduce risk of death and injury, respectively. Non-helmeted motorcyclists are 10.1 percentage points more likely to believe that helmets increase the risk of serious neck injury, and 19.8 percentage points more likely to agree that helmets obstruct vision when motorcycling. All of the aforementioned differences in attitudes toward helmet safety efficacy are statistically significant at the 5% level or less. Roughly 63% of non-helmeted survey respondents believe that motorcycle helmets increase the risk of neck injury and/or obstruct vision. These two factors regarding motorcyclists' risk perceptions are likely key determinants of the observed enhancing behavior with respect to helmet laws.

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<sup>2</sup> The full text of the survey is available to readers in the online survey appendix.

The theory of reasoned action suggests that individuals' attitudes toward safety equipment are a key determinant of their actions (Ajzen and Fishbein 1970). Furthermore, Slovic, Fischhoff and Lichtenstein (1980) and Slovic and Fischhoff (1982) clarify that behavioral adaptations in response to safety legislation arise out of responses to risk perceptions rather than actuarial risks. Our results are therefore in line with a utility maximizing agent in the Blomquist (1986) theoretical framework choosing to reduce risky driving behavior after adoption of a mandatory helmet law in response to the perception that helmets increase risks of neck injury and vision obstruction. The rest of the paper is organized as follows: section II presents background information regarding the history of motorcycle helmet laws in the US, section III details the survey data that is used to elicit motorcyclists driving patterns and perceptions of helmet efficacy. Finally section IV presents empirical results, and section V offers concluding comments.

## **II. History of US Helmet Legislation**

According to the National Highway Traffic Safety Administration (NHTSA), there were 32,675 traffic fatalities in 2014 (NHTSA 2015). Among these, 4,586 (14%) were motorcyclists, but motorcyclists only account for 3% of all vehicle registrations during this time period (FHWA 2014; NHTSA 2016). Numerous empirical studies have documented the fatality reduction benefits of mandatory helmet laws (see, for example, Graham and Lee 1986; Sass and Zimmerman 2000; Houston and Richardson Jr 2007; Houston and Richardson 2008; Liu, et al. 2008; Dee 2009; Dickert-Conlin, Elder and Moore 2011; Lee 2015), and the NHTSA estimates that motorcycle helmets saved 1,669 lives in 2014 (NHTSA 2016). With universal helmet use, the NHTSA projected an additional 660 lives could have been saved in 2014 (NHTSA 2016).

Despite the inherent dangers associated with motorcycling, the issue of mandatory helmet laws remains a politically divisive topic, and only 20 US states currently have mandatory helmet laws covering all motorcyclists (Homer and French 2009).<sup>3</sup> State motorcycle helmet legislation has generally responded to federal incentives that link highway funding to universally applicable helmet laws. Between 1967 and 1975, 48 states adopted mandatory helmet laws in response to the US Highway Safety Act of 1966 that required helmet laws in order for states to avoid 10% reductions in their federal highway construction funding (Sass and Zimmerman 2000). In 1976, the requirements for helmet laws were dropped when Congress passed the Federal-Aid Highway Act, and by 1981 28 states repealed their mandatory helmet regulations (Ruschmann 1977). Motorcycle rights organization (MROs) are generally opposed to mandatory helmet laws, and the legislative history of state helmet regulations suggests that MROs are effective at lobbying on behalf of motorcyclists. Some MROs such as the American Motorcyclists Association (AMA) take a moderate stance supporting helmet use while simultaneously supporting motorcyclists' right to choose.<sup>4</sup> Other MROs such as A Brotherhood Against Totalitarian Enactments (ABATE) argue that helmets are ineffective at preventing death and increase the risk of serious neck injury (Teresi 1999).<sup>5</sup> The fact that the majority of US states repealed their helmet laws when penalties for federal highway funding were removed suggests that overall motorcyclists have strong concerns regarding the effects of helmet laws on safety and personal rights. The following section presents the data available to identify motorcyclists concerns that are

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<sup>3</sup> Data on universal state helmet laws is available online from the Insurance Institute for Highway Safety at the following: <http://www.iihs.org/iihs/topics/laws/helmetuse/helmethistory> (last accessed August 2016).

<sup>4</sup> The AMA stance on helmet use is available online at the following: <http://americanmotorcyclist.com/About-The-AMA/voluntary-helmet-use-1> (last accessed August, 2016).

<sup>5</sup> It should be noted that ABATE is very much a grassroots organization, and different state chapters are likely to have heterogeneous beliefs regarding helmet efficacy.

antecedents of enhancing behavior associated with mandatory helmet laws as estimated in Lee (2015).

### **III. Data**

Data on motorcyclists' helmet use and perceptions of helmet efficacy are collected from an online nationally representative survey of 573 motorcyclists that was conducted between April and May of 2014. Qualtrics was contracted by the researcher to recruit survey respondents from Research Now's national panel of paid survey participants. Survey participants are paid between \$0.85 and \$8.40 upon completion of the survey (Research Now 2014).<sup>6</sup> Qualtrics further checked the survey results to ensure response quality and flagged responses for which the survey was completed in less than 1 minute, respondents submitted multiple responses, and a large fraction of the survey questions were not answered. As an additional quality flag the survey asked respondents midway through if they were reading the questions carefully and answering truthfully. Roughly 503 (88%) of the completed surveys satisfied all of the aforementioned criteria to be considered high quality responses, and these 503 survey responses are used in the statistical analysis that follows.

Table 1 provides summary statistics for the key demographic variables used in the analysis. Overall, whites make up the largest racial group in our survey of motorcyclists (76.9%), and this composition is slightly higher than the national average where whites comprise 76.3% of the general population. Blacks, Hispanics, and other racial/ethnic groups are slightly underrepresented in our sample compared to the national average, representing 8.9%, 9.7%, and 7.4% of the survey sample, respectively. The average age for motorcyclists in our sample is 44 years, and the average annual income is \$62,048. Males represent 55.3% of our survey sample,

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<sup>6</sup> Incentive data is provided by Research Now's ESOMAR document stating that incentives range from 50p to £5. The British pounds were converted to US dollars using the exchange rates from May 2014.

which is slightly higher than the national average of 49.2%. The sample of motorcyclists is highly educated, and roughly 50% of respondents report earning a 4-year college degree or higher. Nationally, only 29% of the general population holds a college degree or higher.

Harley Davidson is the most popular brand of motorcycle in our sample, and 32.4% of respondents report owning a Harley. Sport bikes are the performance designed motorcycles that place the motorcyclist in a crouched forward position when riding. Sport bikes are the third highest reported motorcycle type at 20.1%, and although not reported in Table 1, traditional upright standard and cruiser motorcycle models (1<sup>st</sup> and 2<sup>nd</sup> largest shares) collectively account for over 58% of our sample.

Roughly 73% of our survey respondents report that they always wear a helmet when riding, and the average helmeted riding time is slightly higher at 79%. This suggests that some of the motorcyclists who report not always wearing a helmet exhibit partial helmet use for some of their rides. Columns 2 and 3 of Table 1 report summary statistics for motorcyclists with a primary or secondary residence in a universal (no age/insurance exemption) helmet law state and those who reside in states without universal helmet laws, respectively. Approximately 36% of respondents reside in a universal helmet law state, and the remainder reside in a non-helmet law state. Roughly 49% of the US population resides in a state with a mandatory universal motorcycle helmet law, and 40% of all US states have mandatory helmet legislation. This suggests that our survey sample is slightly skewed toward individuals who reside in states that have not passed mandatory helmet legislation, but further inspection reveals that approximately 39% of all motorcycle registrations in 2014 are in states with mandatory helmet laws (FHWA 2014). As a result, our survey is representative of the overall motorcycling population, and the

residential differences between this group and the general population may be due to endogenous sorting of motorcyclists to states with less restrictive motorcycle laws.

Interestingly, there are significant differences in helmet use among motorcyclists residing in universal helmet law states compared to those who live in states without mandatory helmet laws. The last two rows of Table 1 suggest that roughly 89% of survey respondents in helmet law states report that they always wear a helmet, and the average helmet utilization rate in these states is also 89%. In states without mandatory helmet legislation, however, only 64% of respondents always wear a protective helmet when riding, and the average utilization rate is 73%. Nationally available data suggests that 89% of motorcyclists wear helmets in mandatory helmet law states and 37% of motorcyclists wear helmets in states without helmet laws (NHTSA 2016). The utilization rates in non-helmet law states in our sample are much higher than the national statistics, but this may be due to the fact that the nationally available data on helmet use is only for fatal crash victims who are likely over-represented among non-helmeted riders if helmets truly are technologically effective at preventing fatalities. The results section that follows presents formal empirical estimates of the differences in helmet utilization by legislative requirements, and also tests for heterogeneous perceptions of helmet efficacy among helmeted and non-helmeted motorcyclists.

#### **IV. Results**

In order to investigate the impact of helmet use on motorcyclists' perceptions of helmet efficacy, we employ a propensity score matching estimator (PSM) suggested by Heckman, Ichimura and Todd (1997) that first matches treatment observations of individual motorcyclists who choose not to wear a helmet with a control group consisting of helmeted cyclists that share similar observable demographic characteristics. The survey respondents' weighted responses are



then compared across the treatment group and their set of matched controls in order to quantify the impact of helmet use on individual perceptions of helmet efficacy.

The propensity score matching estimator relies on an underlying conditional independence assumption that perceptions of helmet efficacy are independent of helmet use given the observable demographic characteristics of the motorcyclists. Formally, the conditional independence assumption is given by the following:

$$Y^1, Y^0 \perp D \mid X, \tag{1}$$

where  $Y^1$  is an observable vector non-helmeted motorcyclists' perceptions of helmet efficacy, and  $Y^0$  is an unobserved counterfactual vector of efficacy perceptions for non-helmeted motorcyclists if they were selected to use protective helmets. In equation (1),  $D$  is an indicator variable equal to one for non-helmeted motorcyclists and equal to zero otherwise. Finally,  $X$  is a matrix of observable demographic characteristics. Rosenbaum and Rubin (1983) show that if the conditional independence assumption given in equation (1) is satisfied, then the potential efficacy perceptions in treated and control states are also independent of treatment given the propensity score of  $X$ :

$$Y^1, Y^0 \perp D \mid P(X). \tag{2}$$

In equation (2) all variables are defined as in equation (1) except  $P(X)$  is the propensity score or the probability of motorcycling sans helmet given the observable characteristics  $X$ .

Equation (2) allows us to reduce the computational burden of the matching algorithm by reducing the set of matching characteristics from a vector of observable demographic characteristics,  $X$ , to one propensity score for each respondent,  $P(X)$ . The conditional independence assumption given in equation (2) allows us to estimate the differences in

perceptions of helmet efficacy among helmeted and non-helmeted motorcyclists using the following PSM estimator:

$$\Delta y_i = E \left[ y_i^1 - \sum_{j=1}^N W_j y_j^0 \right], i \in NH, j \in H. \quad (3)$$

In equation (3)  $\Delta y_i$  measures the average treatment effect on the treated (ATT) or the average difference in perceptions of helmet efficacy,  $y_i$ , among non-helmeted motorcyclists,  $y_i^1$ , and their set of matched controls,  $y_j^0$ . As such,  $W_j$  is an individual weight assigned to each control observation of helmeted motorcyclists that varies with respect to the difference in propensity scores between observations  $i$  and  $j$ . Controls with similar propensity scores as the non-helmeted treatment group receive a higher weight, and dissimilar controls receive a lower weight.

We use a kernel matching algorithm in our analysis, and the exact formula for the individual weight,  $W_j$ , assigned to each control is given by the following:

$$\frac{G\left(\frac{P_i - P_j}{a_b}\right)}{\sum_{k \in H} G\left(\frac{P_i - P_k}{a_b}\right)}, \quad (4)$$

where  $P$  are the estimated propensity scores for individuals  $i$  and  $j$ , and  $G(\cdot)$  is a kernel function dependent upon the difference in propensity scores among non-helmeted and helmeted motorcyclists and a bandwidth parameter,  $a_b$  (Becker and Ichino 2002). Black and Smith (2004) note that the Epanechnikov kernel function slightly outperforms other kernel matching algorithms and also outperforms simpler nearest-neighbor matching algorithms. As such, we use the Epanechnikov kernel for our analysis, but our main results are robust to alternative kernel choices.<sup>7</sup> The robustness of our estimates to choice of matching estimator is supported by Smith

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<sup>7</sup> Appendix Table A1 provides results from an alternative uniform kernel function matching estimator.

(2000) who notes that all matching estimators are theoretically consistent and asymptotically converge to the ATT.

First stage propensity scores for our PSM analyses are estimated using a probit model, where  $NH_n$  is binary indicator variable that is equal to 1 if individual  $n$  reports that they do not always wear a helmet when operating their motorcycle, and equal to 0 otherwise. Underlying the reported helmet nonuse indicator variable is a latent continuous probability of helmet nonuse,  $NH_n^*$  that is represented by the following specification:

$$NH_n^* = V_n + \varepsilon_n = a + X_n\beta + \gamma^* HL_n + \varepsilon_n, \quad (5)$$

where  $X_n$  is a vector of demographic characteristics measuring a motorcyclists' race/ethnicity, age, income, gender, education and choice of motorcycle. There are three racial group identifiers that include black, Hispanic, and "other", and the omitted category is white motorcyclists.  $HL_n$  is an indicator variable equal to 1 for motorcyclists who reside in a universal helmet law state and equal to 0 otherwise. Finally, the error component,  $\varepsilon_n$ , is a normally distributed random error term.

Reported helmet nonuse can therefore be classified by the following:

$$NH_n = \begin{cases} 1 & \text{if } V_n > -\varepsilon_n, \\ 0 & \text{otherwise} \end{cases} \quad (6)$$

The probit estimator for the probability of motorcyclists reporting that they do not always wear a helmet ( $NH_n=1$ ) is given by the following:

$$P_n = \int_{\varepsilon_n \in E} \phi(\varepsilon_n) d\varepsilon_n, \quad (7)$$

where  $E$  denotes the set of all possible error terms,  $\varepsilon$ , that satisfy the inequality  $V_n > -\varepsilon_n$ , and  $\phi(\cdot)$  is the probability density function for the normal distribution. The first stage probit model is

formally estimated by finding the values of  $a$ ,  $\beta$ , and  $\gamma$  that maximize the following log-likelihood function (Train 2009):

$$LL(a, \beta, \gamma) = \sum_n [NH_n \ln(P_n) + (1 - NH_n) \ln(1 - P_n)]. \quad (8)$$

Results from the first-stage probit estimates given in equation (5) are presented in column 1 of Table 2. The results suggest that higher income individuals are more likely to report that they always wear a helmet when riding, but the effect is statistically indistinguishable from zero at any conventional level of significance. Men are more likely to ride their motorcycles without a helmet in comparison to women, and the gender differences in helmet use are statistically significant at the 5% level. Race and education do not have any statistically significant impact on helmet use in Table 2.

Columns 2 and 3 of Table 2 report similar results for an alternative logit and fractional response logit estimator of the probability of helmet nonuse. The logit estimator utilizes the same indicator dependent variable for helmet nonuse as the probit model, and the fractional response logit model uses an alternative continuous measure of helmet nonutilization ranging from 0% to 100% of a survey respondent's motorcycle travel time.<sup>8</sup> Sport bike owners are generally more likely to wear a helmet when riding, and the effect is statistically significant at the 10 percent level or less across all estimation strategies reported in Table 2. Focusing on the probit results in column 1, the average partial effect of sport bike ownership on helmet use is a

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<sup>8</sup> In addition to respondents being asked if they "always" wear a motorcycle helmet, they were asked the following: "On a scale of 0% to 100%, how often do you wear your motorcycle helmet when riding? (0 indicates that you never wear a helmet and 100 indicates that you always wear a helmet when riding your motorcycle)." The fractional response logit model uses the respondents reported helmet utilization rates to estimate propensity scores. The underlying log-likelihood function for the fractional response model utilizes a logistic distribution with the same log-likelihood function reported in equation (8) except the indicator variable for helmet nonuse is replaced by the continuous measure of the fraction of time spent riding without a helmet. A more detailed overview of the fractional response logit model is provided by Papke and Wooldridge (1996).

12.4 percentage point increase in helmet utilization among sport bike owners.<sup>9</sup> Alternatively, Harley Davidson owners are less likely to wear a helmet, but this effect is only statistically significant in the fractional response logit model reported in column 3 of Table 2.

Across all first-stage propensity score estimators reported in Table 2, universal helmet laws are the single best predictor of helmet use and average partial effects of helmet laws are estimated to significantly increase the posterior probability of motorcycle helmet utilization by 15.1 to 24.4 percentage points (statistically significant at the 1% level). These estimated differences in the posterior probabilities of helmet use are on par with the average reported helmet use in Table 1 where respondents in universal helmet law states are 24.6 percentage points more likely to report that they always wear a helmet and helmet utilization rates are 16 percentage points higher in universal helmet law states on average. Finally, it is also worth noting that the sample size for the fractional response model in column 3 of Table 2 is approximately 5 percent smaller than the sample sizes from the probit and logit models using the discrete measure of helmet use. This difference in sample sizes is attributed to survey respondents nonresponse to the survey question regarding the fraction of motorcycling time where a helmet is utilized.

The predicted posterior probabilities of helmet nonutilization from the alternative estimators reported in Table 2 provide the propensity score estimates that are required to construct the necessary weights to calculate the ATT as specified in equation (3). The results from our PSM estimator of the ATT are presented in Table 3. Lee (2015) offers several hypotheses for a statistically significant enhancing behavior effect as evidenced by a reduction in motorcycle crashes following adoption of mandatory helmet laws. One of those hypotheses is

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<sup>9</sup> Average partial effects are calculated as the difference in predicted posterior probabilities of helmet use when everyone in the sample is treated as if they own a sport bike versus when no one in the sample is treated as they own a sport bike.

the perceived inefficacy, or even increased risk of harm associated with helmet use. The results in Table 3 explore this possibility directly by providing estimates of the differences in helmeted and non-helmeted motorcyclists' beliefs regarding helmet safety. Overall, motorcyclists who report that they always wear a protective helmet have a much higher opinion of helmet safety. Focusing on the results using the probit propensity scores, helmeted motorcyclists are 12.8 percentage points (95% confidence interval of 4.6 to 21.0) more likely to agree that helmets help prevent death, and 7.6 percentage points (95% confidence interval of 1.0 to 14.2) more likely to believe that helmets help prevent injury during a crash.

It is somewhat surprising to see that a significant portion of helmeted (22.5%) and non-helmeted (32.6%) motorcyclists believe that a helmet increases their risk of serious neck injury when involved in a crash. Once again, non-helmeted motorcyclists have a more pessimistic view of helmet efficacy regarding neck injury risks and the 10.1 percentage point difference in opinions among the two groups of motorcyclists is statistically significant at the 5% level. A similar pattern is evident regarding motorcyclists' beliefs that helmets are an obstruction of vision. Roughly 46.7% of non-helmeted motorcyclists hold this belief, and they are 19.8 percentage points (95% confidence interval of 9.5 to 30.1) more likely to agree that helmets obstruct vision in comparison to their helmeted counterparts.

Given that motorcyclists who choose not to wear a helmet have such strong beliefs regarding vision obstruction, it is very surprising to see that there is no statistically significant difference in opinions regarding helmet use and increased crash risks among the two groups of motorcyclists. Specifically, roughly 9.0% of non-helmeted motorcyclists and 11.3% of helmeted motorcyclists believe that helmets increase the risk of crashing a motorcycle, and the difference in beliefs among the two groups is statistically indistinguishable from zero. The vision

obstruction and crash risk questions were asked in sequential order in the survey. One possible explanation for the seemingly paradoxical responses to the two questions is that motorcyclists are acknowledging their ability to compensate for vision obstruction by taking less risk. This behavioral pattern is consistent with enhancing behavior following adoption of universal helmet laws. Specifically, non-helmeted motorcyclists' (those directly affected by helmet laws) may reduce their risk taking in response to the belief that helmets increase neck injury and vision obstruction related motorcycle risks.

Lee (2015) also suggest that the perceived inefficacy of motorcycle helmets among non-helmeted riders may be driven in part by membership to motorcycle rights groups such as ABATE. Specifically, these groups perpetuate the belief that helmets are ineffective in reducing fatality risks and increase the risk of serious neck injury (Teresi 1999). Our survey results, however, find no statistically significant evidence regarding the impact of motorcycle rights organizations. Specifically, we find no statistically significant differences in overall motorcycle rights group membership rates, and non-helmeted motorcyclists are only 4.2 percentage points more likely to be a member of an ABATE group and the difference in ABATE group membership is also statistically indistinguishable from zero. Overall, roughly 6% of our surveyed sample are members of ABATE, and such a small membership rate cannot explain the roughly 47% of respondents (63% of non-helmeted motorcyclists) who believe that motorcycle helmets increase the risk of neck injury and/or obstruct vision.

Although not reported, we also asked motorcyclists to report their annual motorcycle vehicle miles traveled and whether they take motorcycling trips to other states. The propensity score matching estimates for these particular questions did not find any statistically significant differences in travel patterns among helmeted and non-helmeted motorcyclists. As a result, it

seems unlikely that differences in utilization rates are driving the enhancing behavior outcomes documented in Lee (2015).

The motorcycle survey also asks respondents questions concerning their underlying health risk preferences. On average, non-helmeted motorcyclists are 4.2 percentage points more likely to consume alcohol during a motorcycle ride, but this effect is not statistically significant at any conventional level. Although not reported in Table 3, survey respondents also report their average quantity of alcoholic drinks consumed during a motorcycle ride, and the estimated ATT for the continuous measure of alcohol consumption is statistically significant. Specifically, the results suggest that nonhelmeted motorcyclists consume roughly 0.29 (95% confidence interval of 0.08 to 0.51) additional alcoholic beverages per trip on average in comparison to helmeted motorcycle riders. Non-helmeted motorcyclists are also estimated to be 15.4 percentage points more likely to smoke cigarettes in comparison to motorcyclists who always use a helmet, and the effect is statistically significant at the 1% level. These results are consistent with our a priori expectations and suggest that motorcyclists who always choose to wear a helmet are likely to be more risk averse than their non-helmeted counterparts.

Finally, the propensity score matching results using alternative logit and fractional response logit first-stage propensity score estimates are largely the same as the probit results discussed above in terms of sign, magnitude, and significance. In particular the estimated ATTs for any given survey question are generally all within 1 percentage point of one another, and they are all of the same significance level. Appendix Table A1 presents alternative propensity score matching estimates using a uniform kernel rather than the epanechnikov kernel used in Table 3. All of the results from Table 3 are robust to kernel choice.

## **V. Conclusion**



This study surveys US motorcyclists regarding their use of protective helmets, travel patterns, risk preferences, and beliefs regarding helmet efficacy. Overall, motorcyclists who choose not to use protective helmets exhibit a lower aversion to risk as evidenced by an increased consumption of alcohol and likelihood of smoking cigarettes. Nonhelmeted motorcyclists are also generally more pessimistic regarding the safety benefits of motorcycle helmets. Specifically, nonhelmeted motorcyclists are 13 percentage points less likely to believe that helmets reduce fatality risks and 8 percentage points less likely to believe that helmets reduce risk of injury. Perhaps most surprising, the survey results also suggest that 33% of nonhelmeted motorcyclists believe that helmets increase the risk of serious neck injury and 47% of nonhelmeted motorcyclists say that helmets obstruct vision. Only 23% and 27% of helmeted motorcyclists share these beliefs, respectively. Combined, roughly 63% of all nonhelmeted motorcyclists agree with one of the aforementioned beliefs regarding increased risks of neck injury and vision obstruction associated with helmet use.

Contrary to traditional economic theory that suggests individuals will exhibit offsetting (increased risk taking) behavior in response to safety legislation, Lee (2015) finds evidence of enhancing behavior following universal helmet law adoption in the form of reduced motorcycle crashes. The research presented herein suggests there is likely to be an increase in perceived risks following mandatory helmet law adoption for motorcyclists that are currently non-helmeted. These individuals are therefore likely to compensate by reducing their risk taking behaviors when motorcycling, which in turn can help explain the aforementioned estimates of enhancing behavior associated with helmet laws.

ABATE groups frequently cite Goldstein (1986) as providing statistical evidence that motorcycle helmets are ineffective in preventing death and actually increase the risk of serious

neck injury. Motorcyclists and their MROs appear to be an adept group of individuals that are genuinely interested in promoting rider safety. Liu, et al. (2008) note that the overwhelming majority of statistical analyses of motorcycle helmet efficacy find that helmets significantly reduce risk of death, but there are fewer quality studies regarding the risks of neck injuries. Perhaps policy makers can do a better job with community outreach among motorcyclists divulging the vast empirical literature providing statistically significant estimates of the technological efficacy of helmets in preventing rider fatalities.

None-the-less, there is a significant void in the literature regarding neck injuries that researchers can address with better data on police accident reports linked with hospital patient outcomes such as the National Highway Traffic Safety Administration's Crash Outcome Data Evaluation System. Furthermore, visually evoked response tests have been used to detect delayed optic responses to identify multiple sclerosis, and these tests can be used to test for helmet vision obstruction and formulate best practices with regards to helmet design (Halliday, McDonald and Mushin 1973). Given the fact that motorcyclists overwhelmingly express concerns for injury risks and vision obstruction it is imperative that researchers address these topics in order to provide reliable estimates of the associated risks.

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Table 1. Survey Respondent Demographics by State Motorcycle Helmet Requirements.

<b>Variable Name</b>	<b>Full Sample</b>	<b>Universal Helmet Law</b>	<b>No Universal Helmet Law</b>	<b>US Average<sup>a</sup></b>
<i>Black</i>	0.089	0.128	0.068	0.137
<i>Hispanic</i>	0.097	0.117	0.086	0.169
<i>Other</i>	0.074	0.095	0.062	0.100
<i>White</i>	0.769	0.687	0.815	0.763
<i>Age</i>	43.87	43.70	43.97	37.4
<i>Income</i>	\$62,048	\$63,128	\$61,451	\$74,596
<i>Male</i>	0.553	0.626	0.512	.492
<i>College</i>	0.495	0.543	0.468	29.3
<i>Harley Davidson Owner</i>	0.324	0.272	0.353	---
<i>Sport Bike Owner</i>	0.201	0.212	0.195	---
<i>Percent Who Always Use Helmet</i>	0.730	0.888	0.642	---
<i>Percent of Time Helmet Used</i>	0.791	0.894	0.734	---
<b>Number of obs. (% of Total)</b>	<b>503 (100%)</b>	<b>179 (35.6%)</b>	<b>324 (64.4%)</b>	<b>314,107,084</b>

<sup>a</sup>US demographics collected from the 2014 American Community Survey. Available online at the following:  
<http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF> (last accessed August, 2016).

Table 2. First-stage Propensity Score Estimation Results for Helmet Nonuse.<sup>a</sup>

Variable Name	Estimated Coefficients (Std. Errors)		
	(1) Probit	(2) Logit	(3) Fractional Response Logit
<i>Universal Helmet Law</i>	-0.867*** (0.142)	-1.512*** (0.261)	-1.070*** (0.239)
<i>Black</i>	-0.018 (0.245)	-0.078 (0.445)	0.224 (0.392)
<i>Hispanic</i>	-0.099 (0.242)	-0.257 (0.433)	-0.360 (0.319)
<i>Other</i>	-0.048 (0.262)	-0.111 (0.453)	0.136 (0.384)
<i>Age</i>	1.65e-04 (0.005)	4.23e-05 (0.008)	0.006 (0.008)
<i>Income</i>	-2.72e-06 (1.82e-06)	-4.41e-06 (3.10e-06)	-3.59e-06 (2.62e-06)
<i>Male</i>	0.309** (0.126)	0.487** (0.213)	-0.027 (0.193)
<i>College</i>	-0.060 (0.134)	-0.128 (0.226)	-0.323 (0.207)
<i>Harley Davidson Owner</i>	0.123 (0.132)	0.218 (0.220)	0.363* (0.202)
<i>Sport Bike Owner</i>	-0.448** (0.176)	-0.757** (0.314)	-0.456* (0.270)
<i>Constant</i>	-0.281 (0.268)	-0.433 (0.457)	-0.962** (0.431)
Number of obs.	503	503	478

<sup>a</sup>Statistical significance at the 1 percent, 5 percent, and 10 percent level are represented by \*\*\*, \*\*, and \*, respectively.

Table 3. ATT Estimates of Survey Respondents Answering “Yes” to Helmet Efficacy and Risky Behavior Questions.<sup>a</sup>

Survey Question	Probit First Stage			Logit First Stage			Fractional Response	Logit First Stage	
	Non-helmeted	Helmeted	ATT (Std. Error)	Non-helmeted	Helmeted	ATT (Std. Error)		Non-helmeted	Helmeted
Do you believe a helmet is effective in preventing death during a motorcycle crash?	77.4%	90.2%	-12.8*** (4.17)	77.4%	90.3%	-12.9*** (4.18)	77.4%	90.2%	-12.8%*** (4.15)
Do you believe a helmet is effective in preventing injury during a motorcycle crash?	86.7%	94.3%	-7.59** (3.35)	86.7%	94.3%	-7.63** (3.35)	86.7%	94.7%	-8.00** (3.32)
Do you believe a helmet increases your risk of serious neck injury if involved in a motorcycle crash?	32.6%	22.5%	10.1** (4.92)	32.6%	22.5%	10.5** (4.93)	32.6%	23.2%	9.38** (4.87)
Do you believe a helmet obscures your vision?	46.7%	26.8%	19.8*** (5.28)	46.7%	26.8%	19.9*** (5.29)	46.7%	27.2%	19.5*** (5.22)
Do you believe a helmet increases your risk of crashing your motorcycle?	8.96%	11.3%	-2.33 (3.22)	8.96%	11.22%	-2.27 (3.24)	8.96%	11.1%	-2.10 (3.19)
Do you ever consume alcohol during a motorcycle ride?	14.8%	10.6%	4.17 (3.79)	14.8%	10.5%	4.30 (3.80)	14.8%	12.1%	2.71 (3.76)
Do you smoke cigarettes?	49.3%	33.8%	15.4*** (5.35)	49.3%	33.6%	15.6*** (5.37)	49.3%	34.0%	15.2*** (5.30)
Do you belong to the ABATE motorcycle advocacy group?	8.82%	4.61%	4.21 (2.79)	8.82%	4.64%	4.18 (2.79)	8.82%	5.03%	3.80 (2.77)

<sup>a</sup>Statistical significance at the 1 percent, 5 percent, and 10 percent level are represented by \*\*\*, \*\*, and \*, respectively. Epanechnikov kernel used for estimation.



Table A1. ATT Estimates of Survey Respondents Answering “Yes” to Helmet Efficacy and Risky Behavior Questions.<sup>a</sup>

Survey Question	Probit First Stage			Logit First Stage			Fractional Response	Logit First Stage	
	Non-helmeted	Helmeted	ATT (Std. Error)	Non-helmeted	Helmeted	ATT (Std. Error)		Non-helmeted	Helmeted
Do you believe a helmet is effective in preventing death during a motorcycle crash?	77.4%	90.1%	-12.6*** (4.17)	77.4%	90.3%	-12.9*** (4.18)	77.4%	90.2%	-12.8%*** (4.14)
Do you believe a helmet is effective in preventing injury during a motorcycle crash?	86.7%	94.1%	-7.44** (3.34)	86.7%	94.3%	-7.61** (3.35)	86.7%	94.6%	-7.90** (3.32)
Do you believe a helmet increases your risk of serious neck injury if involved in a motorcycle crash?	32.6%	22.4%	10.2** (4.91)	32.6%	22.3%	10.3** (4.93)	32.6%	23.4%	9.22** (4.85)
Do you believe a helmet obscures your vision?	46.7%	27.2%	19.5*** (5.27)	46.7%	26.8%	19.8*** (5.29)	46.7%	27.2%	19.5*** (5.20)
Do you believe a helmet increases your risk of crashing your motorcycle?	8.96%	11.4%	-2.41 (3.22)	8.96%	10.9%	-1.97 (3.20)	8.96%	10.9%	-1.97 (3.18)
Do you ever consume alcohol during a motorcycle ride?	14.8%	10.8%	4.02 (3.78)	14.8%	10.6%	4.25 (3.80)	14.8%	12.2%	2.66 (3.74)
Do you smoke cigarettes?	49.3%	34.0%	15.2*** (5.34)	49.3%	33.6%	15.6*** (5.36)	49.3%	33.8%	15.4*** (5.28)
Do you belong to the ABATE motorcycle advocacy group?	8.82%	4.62%	4.20 (2.79)	8.82%	4.57%	4.26 (2.79)	8.82%	5.15%	3.68 (2.76)

<sup>a</sup>Statistical significance at the 1 percent, 5 percent, and 10 percent level are represented by \*\*\*, \*\*, and \*, respectively. Uniform kernel used for estimation.

## Online Motorcycle Survey Appendix.

Q1 You are being invited to participate in a research study titled “The Determinants of Motorcycle Helmet Use” being conducted by XXXXXXXXX, an Assistant Professor at XXXXXXXX in the XXXXXXXX department. The goal is to survey 500 individuals in/at Qualtrics Panel. The survey will take approximately 15 minutes to complete. It is hoped that this information will assist us to better understand the determinants of motorcycle helmet use and the impacts of helmet laws on motorcyclists’ travel and riding behavior. The survey is anonymous, so please do not write your name. Your participation in the research is voluntary. You may choose not to answer any or all questions, and you may stop at any time. There is no penalty for not taking part in this research study. Please call XXXXXXXX at XXX-XXX-XXXX for any research related questions or the Office of Research Integrity & Compliance (ORIC) at XXX-XXX-XXXX for questions about your rights as a research participant.

Q2 Do you currently own a motorcycle that is legal to operate on public roads?

- Yes
- No

Q3 What brand of motorcycle do you currently own? (If you own more than one street legal motorcycle, answer in regards to the motorcycle that you ride most often).

- Honda
- Yamaha
- Kawasaki
- Suzuki
- Harley Davidson
- Buell
- Triumph
- Ducati
- BMW
- Other (please fill in box below) \_\_\_\_\_

Q4 What type of motorcycle do you currently own? (If you own more than one street legal motorcycle, answer in regards to the motorcycle that your ride most often).

- Standard
- Cruiser
- Sport bike
- Touring
- Sport Touring
- Dual-sport
- Other (please fill in box below) \_\_\_\_\_

Q5 What color is your motorcycle? (If you own more than one street legal motorcycle, answer in regards to the motorcycle that your ride most often).

- White
- Black
- Blue
- Green
- Purple
- Yellow
- Red
- Silver/Grey
- Brown
- Maroon
- Orange
- Other (please fill in box below) \_\_\_\_\_

Q6 What is the engine displacement of your motorcycle? (If you own more than one street legal motorcycle, answer in regards to the motorcycle that your ride most often).

- 0-250cc
- 250cc-500cc
- 500cc-750cc
- 750cc-1000cc
- more than 1000cc

Q7 On average, how many miles do you travel each year on your street legal motorcycle(s)?

- 0
- 1mile -1,000 miles
- 1,001 miles - 2,500 miles
- 2,501 miles - 5,000 miles
- 5,001 miles - 10,000 miles
- 10,001 miles - 20,000 miles
- more than 20,000 miles

Q8 Is your motorcycle your primary means of travel?

- Yes
- No

Q9 Do you take motorcycle trips to states other than the state of your primary residence?

- Yes
- No

Q10 During the past year how many motorcycle trips have you taken to other states?

- 0
- 1
- 2
- 3
- 4 or more

Q11 During the past year, which state(s) did you visit on your motorcycle other than the state of your primary residence? (If you took multiple trips to some states list the states in order of the most frequently visited to the least frequently visited).

Q12 Do you ever use a motorcycle helmet?

- Yes
- No

Q13 What color is your helmet?

- White
- Black
- Blue
- Green
- Purple
- Yellow
- Red
- Silver/Grey
- Brown
- Maroon
- Orange
- Other \_\_\_\_\_

Q14 On a scale of 0% to 100%, how often do you wear your motorcycle helmet when riding? (0 indicates that you never wear a helmet and 100 indicates that you always wear a helmet when riding your motorcycle)

Q15 On your motorcycle rides do you wear a helmet always, sometimes, rarely, or never?

- Always
- Sometimes
- Rarely
- Never

Q16 Do you believe a helmet is effective in preventing death during a motorcycle crash?

- Yes
- No

Q17 Do you believe a helmet is effective in preventing injury during a motorcycle crash?

- Yes
- No

attn Have you been reading the questions carefully and answering truthfully?

- Yes
- No

Q18 Do you believe a helmet increases your risk of serious neck injury if involved in a motorcycle crash?

- Yes
- No

Q19 Do you believe a helmet obscures your vision?

- Yes
- No

Q20 Do you believe a helmet increases your risk of crashing your motorcycle?

- Yes
- No

Q21 Do you ever consume alcohol during a motorcycle ride?

- Yes
- No

Q22 On average, how many alcoholic drinks do you consume on a motorcycle ride (1 can of beer = 1 glass of wine = 1 shot of 80-proof liquor)?

- 0
- 1
- 2
- 3
- 4
- 5 or more drinks

Q23 Do you smoke cigarettes?

- Yes
- No

Q24 Do you belong to any of the following motorcycle advocacy groups? (Select all that apply).

- ABATE
- American Motorcyclist Association (AMA)
- Help for Bikers
- Motorcycle Riders Foundation
- Ride 2 Repeal
- Ride it Right
- Right to Ride
- Road 2 Recovery
- Other (please fill in box below) \_\_\_\_\_

Q25 How would you describe yourself? (Choose one or more from the following racial or ethnic groups).

- American Indian or Alaska Native
- Asian
- Black or African American
- Hispanic or Latino
- Native Hawaiian or other Pacific Islander
- White

Q26 What is your age category?

- 18 to 25 years old
- 26 to 35 years old
- 36 to 45 years old
- 46 to 55 years old
- 56 to 65 years old
- 66 to 75 years old
- 76 or more years old

Q27 What is your gender?

- Male
- Female

Q28 What is your annual income before taxes from all sources in 2013?

- less than \$20,000
- \$20,001 to \$30,000
- \$30,001 to \$50,000
- \$50,001 to \$70,000
- \$70,001 to \$100,000
- \$100,001 to \$150,000
- more than \$150,000

Q29 What is the highest level of education that you have achieved?

- High School or Less
- Some College or Technical School
- College or Technical School Graduate
- Masters Degree
- Ph.D, J.D, or M.D.

Q30 What state is your primary residence (where you spend the majority of your time)?

Q31 Does your state of primary residence have a mandatory helmet law covering all riders?

- Yes
- No

Q32 Do you have a secondary residence (e.g. a vacation home that you can visit, but not occupied rental property)?

- Yes
- No

Q33 What state is your secondary residence?