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Mandatory helmet legislation as a policy tool for reducing motorcycle fatalities: Pinpointing the efficacy of universal helmet laws☆

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ABSTRACT

This study uses repeated cross-sections of individual level crash data to study the effectiveness of motorcycle helmet legislation. Results suggest that motorcycle helmet laws reduce average individual fatality risks by 20.5%. From a policy standpoint, large states such as Florida and Texas can reduce annual motorcycle fatalities by an average 100 deaths through reinstating universal helmet laws. Valuing these fatality reductions at the U.S. DOT suggested $9.4 million value of a statistical life yields aggregate annual state benefits of approximately $940 million. The effectiveness of helmet legislation can be attributed to the technological efficacy of helmets as well as enhancing behavior in the form of reduced risk taking among motorcyclists. Specifically, motorcyclists who use helmets in order to comply with mandatory helmet laws are 29.8% less likely to receive a traffic citation for risky driving behavior (speeding, alcohol, etc.), travel at a 6 mph lower average speed, and have a 47.4% reduction in the probability of "severely" damaging their motorcycle in a crash.

1. Introduction

In 2015, motorcyclist fatalities accounted for 15.5% of all motor vehicle related fatalities in the U.S.; however, motorcycle registrations accounted for only 3.3% of the total vehicle registrations. The fatality rate (fatalities per registered vehicle) of motorcyclists is roughly five times the fatality rate of passenger car motorists, and using this criteria, motorcycles are consistently ranked as the most dangerous motor vehicles operated on roadways.[1] As such, state legislatures have passed numerous legislative measures designed to improve motorcycle awareness, provide motorcycle training programs, and improve the safety of motorcyclists involved in crashes. Laws requiring motorcyclists to use protective helmets are generally considered to be a viable policy tool available to state legislatures to improve motorcyclist safety.

The history of state motorcycle helmet legislation in the U.S. has largely been influenced by federal regulation providing incentives for states to adopt mandatory helmet laws. There was a steady increase in the number of state laws requiring universal motorcycle helmet use from 1967 to 1975, and by the end of 1975 48 states implemented such laws. During this period the U.S. Highway Safety Act of 1966 was in operation, and the act required states to adopt universal helmet laws in order to avoid penalties of up to 10% reductions in their federal highway construction funds (Sass and Zimmerman, 2000). The helmet law incentives established in the 1966 Highway Safety Act remained in place until Congress passed the Federal-Aid Highway Act in May of 1976. The Federal-Aid Highway Act removed penalties for states without universal helmet laws provided the states maintained partial coverage levels that at minimum required helmet use for motorcyclists 18 years of age and younger (Ruschmann, 1977). As a result of the sanction removals 28 states repealed their universal helmet laws between 1976 and 1981. The majority of states that repealed their universal coverage laws replaced the laws with age-specific helmet laws designed to meet the requirements of the Federal-Aid Highway Act.

Congress once again attempted to influence state adoption of universal motorcycle helmet laws in 1991 with the passage of the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA made provisions for states to receive federal grants upon passage of universal helmet laws and primary enforcement safety belt laws (Ulmer and

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[1] See Federal Highway Safety Administration for data on vehicle registrations: https://www.fhwa.dot.gov/policyinformation/statistics/abstracts/2015/national.cfm (last accessed October 2017). National Highway Transportation Safety Administration provides fatality counts by vehicle type: https://www-fars.nhtsa.dot.gov/Trends/TrendsGeneral.aspx (last accessed October 2017).

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Preusser, 2003). Furthermore, states that failed to enact such laws by October 1993 faced sanctions in the form of up to 3% reallocation of their 1995 Federal-aid highway funds (Sass and Zimmerman, 2000). The proposed penalties were much less severe than those in the 1966 Highway Safety Act, and the penalties were not enforced because Congress repealed the reallocation provisions in 1995 with the passage of the National Highway System Designation Act (Ulmer and Preusser, 2003). As a result of the lack of enforcement and relatively smaller penalties, California and Maryland were the only states that passed universal helmet laws between 1991 and 1995.

Overall, universal helmet law adoption has remained fairly stable post 1981. From 1981–2015 eight states have repealed their universal helmet laws, and 6 states have enacted new universal helmet legislation.[2] Currently 19 U.S. states and the District of Columbia have mandatory motorcycle helmet laws requiring universal helmet use for all motorcyclists. Another 28 states have partial coverage helmet laws with age restrictions that stipulate helmets must be worn by minors. The remaining three states consisting of Iowa, Illinois, and New Hampshire have no helmet use requirements for motorcyclists.

Studies analyzing the effectiveness of helmets in preventing motorcyclist fatalities can largely be classified in two separate groups:

1. Those analyzing the technological efficacy of motorcycle helmets (for a review, see Liu et al., 2008).
2. Studies addressing the effectiveness of motorcycle helmet legislation (summary provided in Table 1).

Estimates of technological efficacy employ individual level motorcycle crash data collected from police accident reports, and attempt to isolate the effects of helmet use on motorcyclists' likelihood of death given they are involved in a motorcycle crash. Peltzman (1975) suggests that automobile safety regulation may result in compensating behavior in the form of increased "driving intensity" and this behavior may offset some of the effectiveness of the safety regulation.[3] According to Peltzman's hypothesis, analysis of technological efficacy of motorcycle helmets is complicated by the fact that individuals' driving intensity is correlated with their decision to wear protective helmets. Stated alternatively, there is a simultaneity problem associated with the choice of helmet use and driving intensity as illustrated in the path analysis of Fig. 1.

Researchers interested in analyzing the technological effects illustrated by the direct path from helmet use to injury severity have generally followed two types of estimation strategies. The first strategy attempts to directly control for confounding variables (i.e. crash characteristics and driving intensity) in order to isolate the direct effects of helmet usage on injury severity (see, for example, Goldstein, 1986; Hundley et al., 2004; Keng, 2005; Rowland et al., 1996; Sauter et al., 2005). This strategy is necessarily complicated by the fact that driving intensity is imperfectly measured (i.e., variables such as motorcyclist's travel speed must be proxied by posted speed-limits).

A more promising estimation strategy uses matched cohorts of drivers and passengers in which one of the matched individuals is helmeted and the other is not (see, for example, Anderson and Kraus, 1996; Dee, 2009; Evans and Frick, 1988; Norvell and Cummings, 2002). The matched pair cohort method necessarily controls for driving intensity by holding unobserved crash features constant for drivers and their matched passengers. Unfortunately, these studies may suffer from issues of external validity, because crashes involving motorcycles carrying passengers are a very small percentage of overall crashes and the characteristics of those crashes may not be representative of the population at large (Dee, 2009). In their meta-analysis, Liu et al. (2008) estimate that studies of technological efficacy find helmets to be associated with an average 42% reduction in risk of death.

A second group of studies analyzing motorcycle helmet safety employ state-level data to estimate the impact of mandatory motorcycle helmet laws on aggregate motorcycle fatalities. These studies use a variety of estimation approaches, and their main findings are summarized in Table 1. One key difference among the studies analyzing state motorcycle helmet law effectiveness is their choice of dependent variable. Specifically, the studies of helmet law efficacy generally choose between the following three alternative dependent variables: non-normalized fatality counts, fatalities per registered motorcycle, and fatalities per capita. As illustrated in Table 1, studies using non-normalized fatality counts and fatalities per capita generally estimate helmet laws to be more effective in preventing motorcycle fatalities in comparison to studies where the dependent variable is fatalities per registered motorcycle. On average across all the helmet law effectiveness studies reported in Table 1, motorcycle helmet laws are estimated to reduce motorcycle fatalities by 22.4% or roughly half the estimated risk reductions reported in the helmet technological efficacy meta-analysis of Liu et al. (2008). This result is to be expected because some motorcyclists in states without mandatory helmet laws may nonetheless choose to use protective helmets of their own volition.

The following analysis makes two key contributions to the literature on motorcycle helmet effectiveness. First, the results show that individual crash data (data typically used in technological effectiveness studies) can be used to estimate the effects of motorcycle helmet legislation on individual's probability of death and injury. From a policy standpoint this is a useful measurement, because it captures the overall effect (direct effect + induced driving intensity effect) of helmet use on motorcyclists' probability of death for the individuals who are incentivized to wear a motorcycle helmet due to passage of a mandatory helmet law. The results indicate that the adoption of a universal motorcycle helmet law is associated with a 20.5% reduction in motorcyclists' average probability of death given they are involved in a motorcycle crash. This estimated reduction in average fatality risk is remarkably similar to the average 22.4% helmet law efficacy from the state-level studies reported in Table 1. In addition, results suggest that mandatory helmet laws reduce incapacitating and non-incapacitating injury risks by 5.1% and 13.5%, respectively. The injury estimates provided herein are an important contribution to the literature, because previous state-level analyses of helmet law efficacy (summarized in Table 1) lack data on state-level injuries.

Second, the study builds upon the emerging literature using control functions in nonlinear models by employing novel bivariate and control function methods to correct for non-random selection of helmet use when examining the impact of helmets on fatality risks (see Blundell and Powell, 2004; Louviere et al., 2005; Petrin and Train, 2010; Roodman, 2011; Villas-Boas and Winer, 1999; Wooldridge, 2014 for a review).

The remainder of the analysis proceeds as follows. Section 2 presents an overview of the National Automotive Sampling System individual-level crash data used in the analysis. The empirical methodology and estimation results are given in Section 3, and Section 4 concludes the paper.

2. Data

The individual level data set used for estimating the effects of motorcycle helmet use on potential health outcomes for motorcyclists involved in crashes comes from the National Automotive Sampling System (NASS) General Estimates System (GES) for the years

[2] Louisiana and Texas had multiple changes in their motorcycle helmet laws between 1981 and 2015. Louisiana readopted a universal law in 1982, repealed that law in 1999, and reinstated universal coverage in 2004. Texas reinstated universal coverage in 1989, and then repealed its universal helmet law in 1997. A summary is available online at the following: http://www.iihs.org/iihs/topics/laws/helmetuse/helmethistory?topicName=Motorcycles#tableData (last accessed October 2017).

[3] Noland (2013) extends the theory of offsetting behavior to a more general concept of mobility that encompasses risky behavior as well as changes in vehicle utilization. In the analysis that follows the term driving intensity is used in the traditional sense posited by Peltzman to be synonymous with risk taking.