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Examining the influence of aggressive driving behavior on driver injury severity in traffic crashes

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ABSTRACT

In this paper, we capture the moderating effect of aggressive driving behavior while assessing the influence of a comprehensive set of variables on injury severity. In doing so, we are able to account for the indirect effects of variables on injury severity through their influence on aggressive driving behavior, as well as the direct effect of variables on injury severity. The methodology used in the paper to accommodate the moderating effect of aggressive driving behavior takes the form of two models – one for aggressive driving and another for injury severity. These are appropriately linked to obtain the indirect and direct effects of variables. The data for estimation is obtained from the National Motor Vehicle Crash Causation Study (NMVCCS). From an empirical standpoint, we consider a fine age categorization until 20 years of age when examining age effects on aggressive driving behavior and injury severity.

There are several important results from the empirical analysis undertaken in the current paper based on post-crash data collection on aggressive behavior participation just prior to the crash and injury severity sustained in a crash. Young drivers (especially novice drivers between 16 and 17 years of age), drivers who are not wearing seat belt, under the influence of alcohol, not having a valid license, and driving a pick-up are found to be most likely to behave aggressively. Situational, vehicle, and roadway factors such as young drivers traveling with young passengers, young drivers driving an SUV or a pick-up truck, driving during the morning rush hour, and driving on roads with high speed limits are also found to trigger aggressive driving behavior. In terms of vehicle occupants, the safest situation from a driver injury standpoint is when there are two or more passengers in the vehicle, at least one of whom is above the age of 20 years. These and many other results are discussed, along with implications of the result for graduated driving licensing (GDL) programs.

1. Introduction

Traffic crashes are a major cause of concern in the United States. In 2007 alone, there were about 6 million police-reported crashes in the U.S., resulting in about 41,000 fatalities and 2.5 million injured persons (NHTSA, 2007). The annual number of fatalities amounts to an average of about 112 dead individuals per day in motor vehicle crashes in the U.S. or, equivalently, one fatality every 13 min. While the fatality rate per 100 million vehicle miles of travel (VMT) fell to a historic low of 1.37 in 2007 (down from 1.64 in 1997), the annual number of fatalities has seen little change over the years, remaining steady between 41,000 and 43,500. In fact, motor vehicle crashes remain the leading cause of death for people aged 1 through 34 years of age (Cook et al., 2005; NHTSA, 2007).

While there are several potential causes of traffic crashes, and the injury severity sustained in the crashes, a leading cause is aggressive driving, broadly defined as any deliberate unsafe driving behavior performed with "ill intention or disregard to safety" (Tasca, 2000; AAA Foundation for Traffic Safety, 2009; see also NHTSA, 2009).[3] A recent study by the American Automobile Association (AAA Foundation for Traffic Safety, 2009) estimated that 56% of the fatal crashes that occurred between 2003 and 2007 involved potential aggressive driving behavior, with speeding being the most common potentially aggressive action making up about 31% of total fatal crashes. Other potentially aggressive actions with contributions to fatal crashes included failure to yield right of way (11.4%

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[3] Aggressive driving is considered distinct from road rage, the latter being committed with the express intent to physically harm another individual, while the former being committed with "disregard to safety but not necessarily with the intent to cause physical harm" (AAA Foundation for Traffic Safety, 2009).

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of fatal crashes), reckless/careless/erratic driving (7.4%), failure to obey signs/control devices (6.6%), and improper turning (4.1%).

In this paper, we examine the effects of aggressive driving and other potential factors on the crash injury severity sustained by drivers in crashes that involved at least one light passenger vehicle being towed due to damage. The potential factors considered in the analysis include (1) Driver attributes (demographics, seat belt use, and drug/alcohol use), (2) Environmental and situational factors (weather, lighting conditions, time of day, day of week, number and age distribution of other vehicle occupants, traffic conditions, *etc.*), (3) Vehicle characteristics (type of vehicle(s) involved in the crash), (4) Roadway design attributes (number of lanes, type of roadway, and speed limits), and (5) Crash characteristics (manner of collision, role of vehicle in crash, whether there was a roll-over of one or more vehicles, *etc.*). It is essential to quantify the relative magnitudes of the impact of these factors on accident severity, so that effective countermeasures to reduce accident severity can be identified and implemented. The focus of the paper, more specifically and explicitly, is to capture the moderating effect of aggressive driving behavior while assessing the influence of a comprehensive set of variables on injury severity. This is very important to disentangle the effects of variables on injury severity through their influence on aggressive driving behavior (an *indirect* effect on injury severity) and through a *direct* effect on injury severity after accounting for aggressive driving effects.[4] For instance, consider the case that seat belt non-users are generally aggressive drivers, as has been suggested by, among others, Cohen and Einav (2003), and Eluru and Bhat (2007). Seat belt non-usage, even after controlling for aggressive driver behavior, is likely to increase crash injury severity because of the "lack of restraint" effect. In this case, a "reduced form" analysis (that co-mingles the *indirect* and *direct* effects of non-seat belt use) would artificially inflate the estimate of the effectiveness of seat belt use as a restraint device and may suggest, for instance, substantial money investment in "police officers on the beat" as part of a "Click it or Ticket" campaign. However, such an effort may not bring the predicted results of the "reduced-form" analysis in reducing injury severity. If non-seat belt use is a good indicator of aggressive driving behavior, as well as increases crash injury severity due to the lack of restraint in the vehicle, the policy suggestion would be to implement a "Click it, or Defensive Driving **and** Ticket" campaign. That is seat belt non-users, when apprehended in the act, should perhaps be subjected to mandatory enrollment in a defensive driving course (to attempt to change their aggressive driving behaviors) as well as a seat belt use violation fine (to increase the chances that they wear seat belts to restrain themselves).

To summarize, injury severity "reduced form" models that do not consider aggressive driving behavior can provide inadequate/misinformed guidance for policy interventions. This is because of two related considerations. First the reduced form model "masks" *indirect* and *direct* effects, each of which individually may provide important information for the design of intervention strategies. Second, and econometrically speaking, not including aggressive driving behavior as a determinant of injury severity leads to an omitted-variable bias that can leave all variable effects estimated in the "reduced form" model inconsistent. Given this situation, it is indeed surprising that there has been little research on disentangling the *indirect* and *direct* effects of variables on crash injury severity.

The methodology used in the paper to accommodate the moderating effect of aggressive driving behavior takes the form of two models – one for aggressive driving and another for injury severity. These are appropriately linked to obtain the *indirect* and *direct* effects of variables. Once estimated, the model can be used in prediction mode without having any information on aggressive driving. The data for estimation is obtained from the National Motor Vehicle Crash Causation Study (NMVCCS), which includes a binary indicator for whether an individual was driving aggressively just prior to a crash in addition to an ordinal-level characterization of the injury severity level sustained by drivers involved in the crash.

The rest of this paper is structured as follows. The next section provides an overview of the relevant literature, and positions the current study in the context of earlier studies. Section 3 presents the econometric framework. Section 4 discusses the data source and sample used in the empirical analysis. Section 5 presents the empirical results. Section 6 concludes the paper by summarizing the important findings and identifying policy implications.

2. Earlier research

2.1. Aggressive driving studies

Tasca (2000) was probably the first to attempt to formally characterize aggressive driving behavior, defining driving as being aggressive if "*it is deliberate, likely to increase the risk of collision and is motivated by impatience, annoyance, hostility and/or attempt to save time*." Since Tasca's paper, several other studies have also attempted to characterize aggressive behavior. Some of these use a relatively narrow definition of aggressive driving as behavior that is intended to hurt others (for example, Galovski and Blanchard, 2002), while others use a more broad definition of an act that disregards safety, whether with the deliberate intent of endangering others or not (AAA Foundation for Traffic Safety, 2009).

Overall, while a single standard definition of aggressive driving has not been adopted in the traffic safety literature, there have been studies that have used different ways to characterize and measure aggressive behavior and study the determinants of this behavior. These studies typically use surveys to elicit information on indicators of aggressiveness such as (a) self-reported frequency (per month or per week) of participating in such acts as "excessive speeding", "making threatening maneuvers with the car", "failure to signal", "tailgating", "driving 20 mph over the speed limit", and "driving after a few drinks (Vanlaar et al., 2008; Beck et al., 2006; Millar, 2007), (b) self-reported responses of how one may respond (for instance, "doing nothing" or "bumping the other person's car") when in hypothetical situations that may trigger aggressive driving behavior (see Agerwala et al., 2008), (c) personality inventories such as the Driver Anger Expression Inventory and the Driver Angry Thoughts Questionnaire (see Benfield et al., 2007), and (d) self-reported frequency of being in crash-related conditions (such as loss of concentration and loss in vehicle control) over a specified time interval and number of lifetime traffic citations and major/minor accidents (see Dahlen and White, 2006). These indicators are then combined and converted (typically) into a single binary indicator of aggressiveness, and correlated with various personality traits and some demographic/situational attributes. However, the effectiveness of these studies in studying human behavior is limited because respondents are prone to suppress undesirable responses in surveys to appear more socially pleasing. A few aggressive driving studies have used traffic crash reports filed by police officers or field observations (rather than respondent surveys) as a means to determine whether or not the driver engaged

[4] The indirect and direct effects are with respect to the aggressive driving behavior. It is possible to undertake a similar analysis with respect to other behavioral or psychological factors such as distraction and level of social responsibility. However, unlike aggressive driver behavior that can be more easily established and imputed based on post-crash data collection, information on other behavioral factors such as distraction and social responsibility are difficult to ascertain based on post-crash data collection. At the least, data on such behavioral factors are more prone to mis-classification and mis-recording.