Primary Seat-Belt Laws and Driver Behavior: Evidence from Accident Data

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Abstract

This paper investigates the offsetting effect theory, using individual-level accident data to analyze how drivers respond to seat-belt laws. I find that drivers drive their vehicles more carefully when more stringent seat-belt laws are in effect. I also find that careful driving is not associated with pedestrian involvement in accidents. Using synthetic panel data, I find that the change in the laws results in an increased number of careful drivers and a decreased number of careless drivers in accidents. The results show that the offsetting effects are weaker than expected or may not exist in accidents.

Keywords: Offsetting Behavior, Safety Regulation, Seat Belt Laws, Vehicle Accidents
JEL Classification : D01, L62, L51

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I. INTRODUCTION

It is widely accepted that mandatory seat belt laws reduce fatalities among drivers who wear seat belts. However, there have been ongoing discussions regarding the effectiveness of these laws. According to the offsetting effect theory, suggested by Peltzman (1975), since drivers wearing seat belts feel more secure, they drive less carefully, and therefore cause more fatal accidents involving pedestrians. If seat-belt laws resulted in more pedestrian involvement in accidents and the resulting fatalities were sizeable enough to offset the decrease in the fatalities of drivers and passengers, then seat belt regulation would be considered ineffective. This paper investigates the existence of the offsetting behavior.

Many earlier studies have investigated the effects of seat-belt laws on the fatality rates of drivers and passengers. Some have directly tested the effectiveness of the seat belt laws on the fatalities of the non-occupants who are involved in fatal accidents. These tests show mixed results. Furthermore, even some supporting results do not provide direct evidence on the relationship between the laws and the offsetting (or adverse) behavior, even though many factors are appropriately controlled for in the models. This lack of direct evidence is inevitable when either aggregated state-level or survey data are used.

My paper uses individual-level accident data. There are several advantages in using individual-level data for this type of research. First, individual-level accident data can correctly control for heterogeneity among drivers and identify each driver's behavioral differences. Second, the offsetting effect theory is about a recursive relationship: The laws cause drivers' adverse behavior, and in turn, the adverse behavior leads to the frequent involvement of non-occupants in accidents. It is easier to identify this recursive structure using individual-level data. Third, disaggregate data provides rich details on individual and accident-specific characteristics, so once panel data is constructed from individual-level data through an aggregation process, we can easily control for unobservable factors without losing factors that affect the evolution of number of accidents, such as time trends.

This paper answers three major questions. First, would seat belt laws cause more-aggressive or less-careful driving behavior? By looking at individual accident data with the specific locations of crashes, I investigate if there is a direct link between the laws and the behavioral changes. Second, if the change in behavior exists, would the less-careful driving behavior result in more pedestrians and non-occupant involvement in accidents? Third, how does less-careful driving behavior play a role as a link between laws and non-occupant involvement? To answer these questions, this paper develops unique models (both cross-section and panel data models) to identify drivers' behavioral changes by observing each individual driver's response to the law changes, and see if the numbers of accidents involving less-careful drivers or non-occupants increase.

The offsetting effect theory says that the probability of accidents with protection is greater than the probability of accidents with no protection. Therefore, the theory is about either an increase or a decrease in fatality rates of non-occupants because of less-careful driving behavior, which results from more-stringent seat-belt laws. As a result, some might argue that we cannot test the effect if we only use individual accident data and that the accident data only consists of a subset of all drivers on the road, less-careful drivers. Relatively careful drivers are not involved in accidents, so these people argue that the accident data can only help identify drivers' behavioral change in the subset of the population, but not the change in fatality rates.

There are two groups of people on the roads: an accident group and a non-accident group. People in the accident group are involved in accidents, while people in the non-accident group are not. We can say that people in the accident group are relatively less careful, on average, than people in the non-accident group. The offsetting effect theory assumes that the laws make "*some drivers*" less careful and that their less-careful driving behavior causes them to have accidents involving pedestrians. Therefore, these less-careful drivers can be in both the accident and the non-accident group. If the drivers are in the accident group, they would not affect the number of accidents because they would already have caused the accidents. As the result of the law change, only the accident type would change - no pedestrian involvement to pedestrian involvement. Thus, only the accidental damages increase. If the less-careful drivers are in the non-accident group, some of them would cause their accidents and be added to the existing accidents[1]. This implies that these drivers would not have been included in the accident data, if more-stringent seat-belt laws had not been in effect. The theory implicitly assumes that there would be more accidents involving pedestrians if drivers became less careful.

[1]Not all drivers necessarily cause accidents, even if they become less careful when their level of care does not reach a certain threshold. Therefore, only some of the drivers would cause accidents.

What if the laws instead make people more careful? If the laws make some people more careful, then the same thing occurs in the opposite direction. Again, these more-careful drivers can be in both groups. If they were in the non-accident group, they wouldn't change anything when they became more careful because they were already careful enough not to cause an accident. If they were in the accident group, their more-careful driving behavior made them not cause accidents involving pedestrians. Or even if they still caused accidents, pedestrians were not involved in accidents. This means that there would be fewer accidents involving pedestrians if drivers were more careful. In other words, less-careful driving behavior pushes some additional people, who would otherwise not have been involved in accidents, into the accident data; more-careful driving behavior pulls some additional people, who otherwise would have been involved in accidents, out of the data. The necessary condition for this symmetric conclusion is whether the laws, in fact, change people's behavior, and if they do, in which direction. If I identify this behavioral change from the accident data, I could make a conclusion, with consistent logic, that there must be the same behavioral change from those who are not in the accident data. Therefore, with only individual accident data, I can still verify the implications of the offsetting theory. Two distinct questions should be answered through empirical tests. First, can we observe more- or less-careful driving behavior from the accident data because of the law change? Second, can we use the accident data to test if the number of careful or careless behavior increases or decreases? If I find that the primary seat belt laws decreased the number of more-careful drivers and increased the number of less-careful drivers in accidents, I would conclude that the seat belt laws increased the number of accidents, including fatal accidents. Then, I could confirm that the offsetting effect theory exists. Otherwise, I could conclude that the offsetting effects may not exist.

I use two steps to test above arguments. To answer the first question, I compare two groups of states - states with and without a seat-belt law change - and see if there are behavioral differences between drivers in the different states. Second, using only accident data, I produce synthetic panel data to see if the number of accidents increases or not. The main advantage of using the synthetic panel data is that we can see if the number of careless drivers involved in accidents increases or decreases when more stringent laws are applied, even if only individual accident data is available. Therefore, the synthetic panel data provides us to figure out the change in accidents on the road, as if we have data on people who are not involved in accidents too.

I find that there is a greater probability of having relatively more-careful drivers in accidents in states where stronger seat belt laws are in effect. In fact, people drive more carefully when more stringent seat-belt laws are in effect. However, drivers are less careful in neighboring states where there is no change in the laws, so there is a clear difference in behavior between people in the states with and without the law changes. I also find that careful driving is not associated with pedestrian involvement in accidents. In terms of the aggregate numbers of accidents, the change in the laws increases the number of careful drivers and decreases the number of careless drivers in accidents. Since the results show that there is no relationship between drivers' careful behavior and pedestrian involvement in accidents, it is hard to believe that the number of accidents involving non-occupants, at least, would increase when people drive more carefully. These results show that the offsetting effects are weaker than expected or may not exist in general. As a policy implication, I recommend seat-belt laws with strong punitive penalties. Governments can use this policy tool to increase the expected cost of not wearing a seat belt and thereby cause less-careful drivers to wear seat belts.

The paper consists of five sections. In the next section, I review the literature on offsetting behavior. Section III discusses empirical strategy and econometric models. The section also discusses the recursive structure of people's behavior and the construction of synthetic panel data models. Section IV describes data and provides summary statistics. Section V discusses estimation results. The last section draws conclusions and addresses policy implications.

II. LITERATURE

It is widely accepted that seat belt use reduces fatalities among people who wear seat belts. According to the 2011 survey from the National Highway Traffic Safety Administration (NHTSA), seat belt use has risen steadily, while there has been a steady decline in passenger vehicle occupant fatalities per mile traveled[2]. Most economic literature in this field has focused on whether seat-belt laws have reduced

[2]NHTSA: Occupant Protection, Traffic Safety Facts, 2011 (DOT HS 811 729). The survey says that, in 2011,

aggregate fatalities or not, regardless of the type of individuals involved in accidents. Many papers (McCarthy (1999), Derrig et al. (2002)) use time series data and analyze whether there is any statistically significant difference before and after seat-belt law enforcement. However, these studies fail to control for a time trend, and since macro effects unrelated to seat-belt laws also affect fatalities, this is an important limitation of these studies. The tests, which produce mixed results for offsetting effects, are only a secondary concern to researchers who focus on aggregate fatality rates.

Other studies try to investigate directly if the offsetting effect in fact exists[3]. Among others, Garbacz(1990) finds a positive relationship between seat belt use and non-occupant fatality. Recent studies use panel data models using state-level data. Evan and Graham (1991) use pooled data from 50 states. They find that there is weak evidence that non-occupant fatalities increase, and they conclude that offsetting behavior appears to be small relative to lifesaving effects. Cohen and Einav(2003) look at the effects of the laws on non-occupant fatalities to investigate the offsetting effect. They notice a potential endogeneity problem of using seat-belt use, and they use seat-belt laws as an instrument for use. They do not find any significant evidence of compensating behavior. These studies focus on the factors that affect fatalities and use the increase in the fatality rate as evidence of offsetting behavior.

Some of the empirical studies focus on personal characteristics of individuals. Researchers find that heterogeneity across individuals is important (Sen & Mizzen (1992 and 2007)). Loeb (1995) uses monthly accident data in only one state to remove the statewide differences in the laws. He finds that the state's seat-belt law results in a reduction in the various driver-involved injury rates. After controlling for state-specific characteristics, researchers could easily find whether the laws in different states reduce fatalities, given a fixed number of fatalities. However, it is very difficult to observe an individual driver's behavioral change and test if this behavioral change affects fatalities using state-level data. Furthermore, there is no direct link between behavioral changes and the laws. State-level data obtained from surveys is subject to serious measurement error concerns and unobserved hetereogeneity given the

21,253 occupants of passenger vehicles (passenger cars, pickup trucks, vans, and SUVs) died in motor vehicle traffic crashes. Among them, 9,439 were restrained. Restraint use was not known for 1,634 occupants. Looking at only occupants where the restraint status was known 52 percent were unrestrained at the time of the crash. Thinking that seat belt use in the same year was 84 percent, fatal crashes involve much more people not wearing seat belts.

[3]Earlier studies include Peltzman (1975, 1977), Robertson (1977), Crandall and Graham (1984), Garbacz(1990), Evans and Graham (1991), Keeler (1994), and Loeb (1995).

lack of control for individual-level characteristics of each driver, each vehicle, and the environmental conditions surrounding the accidents.

Sobel and Nesbit (2007) use individual-level data to test for individual human responses to safety improvements within a well-controlled environment. The two authors use data from the National Association for Stock Car Auto Racing (NASCAR). Their results strongly support the presence of offsetting behavioral effects. However, NASCAR drivers are constantly pushing safety limits when they drive, so it is expected that the authors would find a clear offsetting effect among these drivers. Professional racecar drivers drive on a closed course, and participate in a competition in which the objective is to beat all other drivers; they are not representative of average drivers on our roads.

Many studies only use data from fatal crashes. Using only fatal crashes may not accurately measure the effectiveness of a safety regulation and may result in sample selection bias. In order to remove this bias, some (Levitt et al. (2001)) have proposed that researchers only include crashes in which someone in a different vehicle dies. Singh and Thayer (1992) use models based on individual-specific survey data to see if seat belt use affects the number of citations for moving violations. Their results show that the compensating behavior hypothesis only applies to individuals who are not strongly risk-averse, and that individual risk preferences are an important dimension. They find that drivers' risk preferences may be irrelevant to the behavioral change, and that the existence of the offsetting behavior may not necessarily be what causes increased non-occupant involvement.

My paper does not investigate the effects of seat belt laws on traffic fatalities. The question that I address is whether I can identify the direct link between the behavioral change due to the laws and accidental harm, including fatalities. To answer this question, I use individual-level accident data over a five-year period from the National Highway Traffic and Safety Administration (NHTSA)[4].

III. EMPIRICAL STRATEGY AND ECONOMETRIC MODELS

1. Overall Estimation Strategy

[4] The detailed description of the data is discussed in section VI.

Based on the discussion in the introduction section, I address two major questions. First, to identify behavioral differences with and without the law change, I need to use the same subsets of people with the same distribution of carefulness on the road: both accident data in different states. I compare accidents in one state with accidents in its neighboring state. Therefore, I choose two groups of states: one group of states consists of the states that change their seat-belt laws over the studied period (2004 through 2008), and the other group of states consists of the neighboring states with no change in the laws during the same period. I call the first group "primary states" and the second group "non-primary states". Since both groups are made up of drivers involved in accidents, I can consider these people equally less careful drivers on average compared to drivers who are not involved in accidents, if there is no law change in both groups of states. If the primary states change their laws and people's behavior changes because of the law change, then the seat-belt laws must have played a role in altering people's driving behavior. To see this, I treat the neighboring states as if they also change laws. If drivers of these two adjacent states showed a different behavioral pattern, I will be able to conclude that the seat-belt laws do affect drivers' behavior.

Second, I develop a synthetic panel data model to answer the second question[5]. This is a technique that uses independently selected cross-sections over time to produce panel data. The technique is used when there is no actual panel data or only data for a sub-sample of a population, such as accident data. Therefore, even though I only have accident data, I can still see if the number of a certain type of accidents, involving careless or careful drivers, increases or decreases within a panel data framework, and I can determine whether the primary seat-belt laws change the number of accidents. Assuming that less-careful drivers would also cause more accidents involving pedestrians, more-careful drivers may have a greater probability of not having pedestrians involved in their accidents than less-careful drivers. Therefore, if there are more pedestrians involved in accidents, this could be indirect evidence of more accidents involving pedestrians because of the seat-belt laws. If the drivers in the subset are not related

[5]This econometric technique has recently developed and carefully used in the limited settings, depending on the nature of studies. It is essentially impossible to observe an individual driver's behavior and his or her response to seat belt laws over time. Thus, the technique groups drivers whose characteristics are similar into a type. We then track the drivers' behavior over time through these types. So, each type behaves as if it were an individual. For more details, see Deaton (1985), Deaton & Irish (1985), Verbeek & Nijman (1992), and, recently, Bae & Benítez-Silva (2011)

to the cause of accidents, their behavioral change due to the laws may lead to more or less non-occupant involvement in accidents. Therefore, the change in the number of accidents involving less-careful drivers and more non-occupant involvement, such as pedestrians, can be verified by the synthetic panel data model.

2. Behavioral Differences in Accidents

I use police accident data from the National Highway Traffic Safety Administration (NHTSA). The General Estimates System (GES) in the NHTSA gets its data from a nationally representative probability sample selected from the estimated six million police-reported crashes that occur annually. The data essentially consists of police accident reports (PAR). This data contains each detailed crash description, which includes information on the people and vehicles involved and the detailed description of the accident, including environmental factors[6].

First, I observe each accident that occurred between 2004 and 2008. During the time period, seven states have changed their seat belt laws from secondary to primary laws. I will therefore focus on the accidents that occurred in these seven states[7]. Within a state, accidents occur either before or after the enforcement date of the primary seat belt law. These are "pre-accidents" and "post-accidents," respectively. I test if there are behavioral differences among drivers who have accidents before and after the enforcement date. Each observation is a driver who is involved in an accident. The observation has one variable - the zip-code - of the driver's home address [8]. It also tells us when the accident occurred. The data tells us whether or not the accident occurs under the primary seat-belt law. Since accidents occur on different dates within a state and across the states, some occur before, and some occur after the primary seat-belt laws are adopted. I use drivers' careless behavior to measure the behavioral difference

[6] Since the GES contains a sample from all accidents, one cannot use this data to see the effects of seat belt laws on fatalities. This contains accidents with no, minor, or severe injuries, as well as deaths. Therefore, it should be understood that accidental damages include both lives lost and people injured along with property damages.

[7] The NHTSA changed many variables in 2009 and merged two data sets into one in 2010 and 2011. Therefore, I use data only between 2004 and 2008 to keep the data consistent.

[8] Some drivers cause accidents in other states rather than their states. They are travelers and commuters. However, the data set does not include information on the exact locations of crashes. There is no reason to believe that most drivers experience accidents in other states rather than their states. Thus, drivers' addresses are used.

before and after the enforcement date. Each observation shows whether or not the driver was careless at the time of crash[9]. Careless behavior includes talking on, listening to, or dialing a phone; adjusting climate control, the radio, or a CD; using other devices integral to the vehicle; sleeping, eating, or drinking; smoking-related distractions; and any other actions that take attention away from driving[10]. I will see if driver behavior, measured by careless behavior, is different before and after the enforcement date of the seat-belt law.

Second, even if the above relationship is statistically significant, the relationship itself doesn't provide anything meaningful because we are finding careless drivers among already less-careful drivers. Therefore, we should compare the same type of subsets, accidents data from seven primary and seven non-primary (neighboring) states. I select seven neighboring states that did not change the laws over the same period. I divide accidents again into two groups - pre-accidents and post-accidents - as if the neighboring states changed the seat belt laws. For example, Mississippi is a primary state that changed the law from secondary enforcement to primary enforcement on May. 27, 2006, so all accidents that occurred before this date are pre-accidents, and accidents that occurred after the date are post-accidents. I choose Louisiana as one of Mississippi's neighboring states. Louisiana adopted its primary seat-belt law in 1995, so there was no law change between 2004 and 2008. However, I grouped Louisiana accidents into pre- and post-accidents. If accidents occurred before May. 27, 2006, then they are pre-accidents; others are post-accidents. If the drivers in these two states showed the same behavioral pattern, then we could conclude that the laws failed to change people's behavior. In addition to these seven neighboring states, I also randomly choose another seven states[11]. These states are assigned to

[9]Some may argue that the GES data is not reliable because the definition of less careful behavior may differ from accident to accident, depending on where the accidents occur and who records the information. Drivers involving in accidents may tend to conceal their faulty or careless behavior, if they believe that they cause the accidents. Taking this into account, if I found that the primary seat belt laws resulted in less-careful behavior, then we could conclude that the offsetting effects would be larger than expected. If the laws led to more careful behavior, then the effects would be smaller, even if the effects existed.

[10]I use the definition of careless behavior from the NHTSA. The GES data contains information on drivers' careless behavior. The distracted data set has a variable, "*MDRDSTRD*". This variable identifies all distractions that may influence driver performance. Most distractions are caused by drivers, although some distractions are caused by outside factors, such as non-occupants. However, most of them could have been avoided if drivers had been careful while driving. See also other details from the US Department of Transportation, 2011.

[11]I use these random states because the neighboring states might be affected by the law change in the primary states, and two adjacent states might be economically integrated. As we see in the summary statistics, the drivers in the primary states are relatively less careful than those in the neighboring or randomly assigned states.

each primary state, and accidents are divided into pre- and post-accidents, as if the accidents in these random states occurred in the primary states. If the relationship between the primary seat belt laws and careless behavior in these states were similar to that in the primary states, then the offsetting effect - or any type of statistical relationship - would not prove the impact of the primary seat-belt laws whatsoever.

One thing to note is that the offsetting effect does not only explain careless driving behavior but whether more non-occupants are involved in accidents because of less-careful driving when the primary seat belt laws are in force. Therefore, there is a recursive structure for this argument: If drivers feel secure because of the seat belt laws, they may drive less carefully through careless actions, which, in turn, may result in a greater probability of causing accidents involving more non-occupants. Because this recursive relationship between laws, driving behavior, and non-occupant involvement results in simultaneity, separate estimation could cause biases, and the pooled bivariate probit model is a natural specification to employ[12]. Since this model is qualitatively different from the typical bivariate probit model, it is a recursive, simultaneous-equation model[13]. The bivariate probit model is

$$y^*_{mi} = \beta_i^{'} x_{mi} + \gamma_i y^*_{li} + \epsilon_{mi}, \qquad y_{mi} = 1 \text{ if } y^*_{mi} > 0, \quad = 0 \text{ otherwise}, \tag{1}$$

$$E[\epsilon_m] = E[\epsilon_l] = 0, \forall\ m \neq l,$$

$$Var[\epsilon_m] = Var[\epsilon_l] = 1, \forall\ m \neq l,$$

$$Cov[\epsilon_m, \epsilon_l] = \rho, \forall\ m \neq l.$$

The bivariate normal cdf, $\Phi(x_1, x_2, \rho)$, is $Prob(X_1 < x_1, X_2 < x_2) = \int_{-\infty}^{x_2} \int_{-\infty}^{x_1} \phi_n(z_1, z_2, \rho) dz_1 dz_2$.

, where $m = 1$ and 2.

If there is no recursive structure between two equations, then separate probit models should be used. In this case, factors other than seat-belt laws should explain non-occupant involvement in

[12] A panel data model is an ideal model for this research. However, it is not possible to construct panel data from the GES data set. The data set is basically repeated cross-sectional. Recent economic literature has developed an econometric technique (Synthetic (or Pseudo) panel data model) that produces panel data from cross-sectional data.

[13] See Green (2003) and Cappellari and Jenkins (2003) for more details.

accidents. As we will see later, the regression results show that there is no recursive structure. The variance-covariance matrix of the cross-equation error terms is estimated, and the null hypothesis $\rho_{12} = 0$ is tested with a Wald test at the 5 percent level. The Wald test shows that there is no correlation between the error terms[14]. Therefore, the model shows that non-occupant involvement is not linked to the primary seat-belt laws through drivers' careless behavior. Therefore, two separate probit models must be used to determine the effects of the primary seat belt laws on both careless behavior and pedestrian involvement.

3. The Number of Accidents

To answer the second question, I produce a synthetic panel data model from the accident data to see if there is a change in the number of accidents. The synthetic panel model groups drivers into several cohorts according to their personal characteristics and observes their behavioral changes over time and across the cohorts. I construct cohorts using gender, states, and four age groups. Each cohort contains drivers with similar characteristics. For instance, one cohort contains drivers who are all males between 16 and 25 years old who all live in the same state. I observe the number of drivers in this cohort over time. The number of people in the cohorts may increase or decrease across observations and over time, so I can consider this numerical change to be the increase or the decrease in a certain type of accidents. These numbers in cohorts include both careless and careful drivers. Since I need to know whether the number of careless drivers in a cohort increases or decreases, drivers in a cohort are divided into two groups: careless drivers and careful drivers. If the numbers of careless and careful drivers increase and decrease, respectively, then I can conclude that the primary seat belt laws lead to more accidents involving careless drivers[15].

The General Estimates System (GES) accident data is a sample. Therefore, to reach a national estimate, I should not give all accidents equal weight. The GES says that in order to calculate estimates of national crash characteristics, data from each police accident report on file must be weighted. The

[14] $\chi^2(1) = .1391$. $Prob > \chi^2 = .7091$. Convergence was not achieved, so I limited the number of iteration to 10.

[15] There is a reason why drivers in a cohort are divided into two groups. These drivers are all in accident data. It is necessary to focus on careful drivers among them because they relatively represent the entire population (all people on the road) better. However, I also calculate the ratio of less-careful drivers to all drivers in my regression. The estimation result is in Table 8.

accident data contains a weight for each accident. Therefore, the number of drivers in a cohort in my model is the weighted number.

Using this grouping, 40 different cohorts are created[16]. Since there are seven states, the total number of observation is 280. These observations are used for the synthetic panel data model[17].

The econometric equations are:

$$ln(CARELESS)_{it} = X_{it}\beta + \gamma_1 PRIMARY_{it} + c_i + \varepsilon_{it}, \quad i = 1, ..., 56 \text{ and } t = 2004, ..., 2008 \tag{2}$$

$$ln(CAREFUL)_{it} = X_{it}\beta + \gamma_2 PRIMARY_{it} + c_i + \varepsilon_{it}, \quad i = 1, ..., 56 \text{ and } t = 2004, ..., 2008 \tag{3}$$

$$ln(NON\_PEDS)_{it} = X_{it}\beta + \gamma_3 PRIMARY_{it} + c_i + \varepsilon_{it}, \quad i = 1, ..., 56 \text{ and } t = 2004, ..., 2008 \tag{4}$$

$$ln(PEDS)_{it} = X_{it}\beta + \gamma_4 PRIMARY_{it} + c_i + \varepsilon_{it}, \quad i = 1, ..., 56 \text{ and } t = 2004, ..., 2008 \tag{5}$$

where, i is a type and t is a year. The dependent variables measure the number of drivers (or accidents) in a cohort, and they are all natural logarithms of the numbers. $CAREFUL$ is the number of non-careless drivers in a cohort, while $CARELESS$ is the number of distracted drivers in a cohort. NON_PEDS and $PEDS$ are the numbers of accidents without and with pedestrians respectively. X_{it} includes independent variables that are used to group drivers. I estimate this model for careful and careless groups to find overall effects. If the offsetting effects are strong or present when the primary seat-belt laws are in effect, the number of careful drivers will decrease, and the number of careless drivers will increase. If both increase, then the result could be ambiguous[18]. I repeat the same procedure for the seven neighboring states to see if there is any difference between the primary states and the neighboring states.

[16]Each state has eight different types. Seven states are included in this model. Two states, Alaska and Maine, are dropped because of econometric issues. Both states have very few accidents in the original data set, so if I grouped them into several cohorts, the number of observations each cohort would be very small. If the size of the cohorts is too small the synthetic panel data model will result in measurement errors.

[17]There is a trade-off between the pooled probit and the panel models in terms of econometric benefits. To ameliorate individual unobserved heterogeneity that changes over time, the panel model is more desirable. However, there is no panel data. The only way is to construct the synthetic panel model, which may result in another problem. Not all the independent variables used in the bivariate probit model can be used, so we cannot control for these within the model. Only the variables that are used to make cohorts should be used. If other variables were used, by calculating their group averages, then the measurement error problem would arise.

[18]Since most accidents do not involve pedestrians, we can still measure the directional change: either increase or decrease.

IV. DATA AND SUMMARY STATISTICS

1. Data

I use two sources of data. The first source of data is about the seat-belt laws. There are two types of law enforcement: primary enforcement, in which occupants can be pulled over and ticketed simply for not using their seat belts, and secondary enforcement, in which occupants must be stopped for another violation, like speeding, before they can be ticketed for not using their seat belts[19]. Thus, primary enforcement is a much stronger regulatory tool. As of 2013, all U.S. jurisdictions except New Hampshire have some sort of seat-belt statute, primary or secondary. Many states, such as Connecticut, New York, and Texas, adopted primary seat belt laws in the mid-1980s, while some states, such as West Virginia, adopted primary laws more recently (Table 1). Now, 34 states have primary seat belt laws in effect (Table 1)[20], and the coverage of seat belt use differs from state to state. Due to changes in law enforcement, seat belt use has increased consistently over time; use reached 86 percent in 2012[21]. However, many states still adopt secondary seat-belt laws.

The second source of data is the GES accident data from the NHTSA. There are several advantages to using this data. First, it contains detailed information on individual driver's behavior, such as careless driving behavior, alcohol consumption, and non-occupant involvement, as well as other behavioral changes at the time of the crash, before the crash, and after the crash. This information allows me to observe each driver's detailed behavior. Second, the data contains vehicle characteristics, such as model year, vehicle age, and vehicle contribution factor. Previous literature shows that the vehicle age affects drivers' behavior (Crandall & Graham (1984)), so I identify what model year vehicles were involved in a particular accident. Third, each observation has a zip code, so I know the state in which the accident occurred at that particular time. The zip code for each observation is the main link between the seat belt law in the state and the accident. Furthermore, this data set includes environmental factors, road conditions, weather conditions, and personal characteristics. These char-

[19] NHTSA, "Traffic Safety Use in 2008", DOT HS 811 036.

[20] Even though many states adopt primary seat belt laws, the coverage and the maximum fines differ from state to state. For instance, Texas charges \$ 200, for a seat-belt violation, while many states only charge \$ 10.

[21] "Seat Belt Use in 2012 Use Rates in the States and Territories", NHTSA.

acteristics are unique to each observation and are used as control variables to account for individual (crash-specific) heterogeneity. For instance, even if two crashes occur in the same state on a same date, These characteristics can explain the variations between the accidents. Controlling for these factors allows me to see the effects of primary seat belt laws on drivers' behavior. Otherwise, the coefficient of the seat belt law would be biased because of the heterogeneity affecting the behavior, even though I control for state-fixed and year-fixed effects.

Since I focus on the states that have changed their seat belt laws between 2004 and 2008, I only use accidents that occurred in these states[22]. Over the time period, more than 82,000 people were involved in crashes in these states (Appendix D.). Drivers consist of 70 percent of the people (57,700 individuals). Since non-occupants do not affect drivers' behavioral change in response to the laws, I only use the observations for drivers.

2. Summary Statistics: Cross-Section Data Model (Probit Model)

Table 2 shows summary statistics for the probit models. This table is for the primary states. Since there are two equations, two dependent variables are constructed; both are dummy variables. The dependent variable $CARELESS$ measures whether the driver was distracted at the time of the accident. This behavior is caused by the driver, not by other people or objects on the road, so the variable directly measures the driver's mistakes or careless behavior. If the driver in an accident is careless, then the value is 1; otherwise, the value is zero. Careless behavior includes the driver's talking on, listening to, or dialing a phone; adjusting climate control, the radio, or a CD; eating or drinking; smoking-related distractions; using or reaching for other devices integral to the vehicle; sleeping; and any other distractions or inattention[23]. About 20 percent of the drivers were careless when accidents occurred. In the second equation, the dependent variable $NON\_OCCUPANTS$ measures the involvement of non-occupants - such as pedestrians and bikers - in the accident. If any non-occupant is involved in the accident, then the value is 1; otherwise, the value is zero. About 1.6 percent of the drivers experienced

[22] As I pointed out in the previous section, there is a data-matching problem in the GES in later years, so I use accident data until 2008 in order to classify variables consistently.

[23] Some drivers were distracted by vehicle occupants, non-occupants, or outside objects at the time of the crash. However, the drivers could have avoided these types of distractions if they had been more attentive. Note that this information is self-reported by the driver, occupants, or eyewitnesses.

non-occupant-related accidents.

Independent variables include three main factors: individual accident-level, state-fixed, and year-fixed factors along with the seat belt law[24]. The main variable $PRIMARY$ is an indicator. If an accident occurs before the enforcement date in the state, then the value is zero; otherwise, the value is 1. More than 60 percent of accidents occurred when the primary seat belt laws were in effect.

The average driver age is 38, and 60 percent of the drivers in the sample are males. $ALCOHOL$ measures whether alcohol is involved in the accident at the time of the crash. If alcohol is involved, then the value is 1; otherwise the value is zero. Slightly less than 7 percent of accidents were related to alcohol. $STRIKING$ measures the role of the vehicle in the crash. I include the vehicle age variable, $VEHICLE\_AGE$, to measure drivers' behavioral differences with regards to how old their vehicles are. The average vehicle age is 7.6 years. To account for a possible non-linear relationship, I also include $VEHICLE\_AGE\_SQ$. $NIGHT$ measures when the accident occurs. If the accident occurs between 7:00 p.m. and 5:00 a.m., then the value is 1; otherwise, the value is zero. About 23 percent of the accidents occurred at night. The variable is correlated with alcohol consumption, which may cause careless behavior. $HIGH\_POP$ is a dummy variable that indicates the density of the population. If the accident occurs in the area with 100,000 residents or more, then the value is 1; otherwise, the value is zero [25]. I expect drivers to act more carefully while driving in highly populated areas.

Many variables that reflect road and weather conditions are included. If the road surface is dry, then $DRY\_SURFACE$ is 1; if it is wet, snowy, or icy, then the value is zero. The variable measures road conditions. About 80 percent of drivers had accidents under good surface conditions. $GOOD\_WEATHER$ measures if it is rainy, snowy, sleety, or foggy. If there are no adverse conditions, the value is 1. $LIGHT$ measures visual conditions. Seventy-two percent of accidents occurred during daylight. If the accident occurs on the highway, then the variable $HIGHWAY$ has a value of 1. Most accidents occur on local roads. If the accident occurs in an interchange area, then the value of $INTERCHANGE$ is 1; otherwise, it is zero. Less than 10 percent of the accidents occurred in

[24]The definition and the description of each variable is in the appendix.

[25]The dummy variable is used because of data limitations. Furthermore, since each observation has the zip code that tells us where the vehicle owner lives, the owner's address and the place the accident occurred will be different. Thus, county-level populations cannot be used in this case. To control for regional population density, the dummy variable would be fine.

interchange areas. The variable, $SPEED\_LIMIT$, measures the maximum speed limit at the place of the accident. Since there are different maximum speed limits even within a state, this information helps determine accident-specific variations. The average speed limit is 44 mph[26].

State and year dummies are included in the equations to control for state- and year-fixed factors. The states that changed their laws are Alaska, Kentucky, Maine, Mississippi, North Carolina, South Carolina, and Tennessee. North Carolina has the most accidents during the studied time period, Tennessee has the second-highest amounts of accidents, and Alaska has the fewest accidents among these states[27].

The summary statistics for both neighboring and randomly assigned states are in the appendix. Seven neighboring states are Hawaii, Ohio, New Hampshire, Louisiana, Virginia, Georgia, and Alabama. The other seven random states are Idaho, Connecticut, New York, Virginia, Pennsylvania, Florida, and Utah[28]. There are two fundamental differences between summary statistics. One is that the total numbers of observation are more in these samples than the sample with the primary states. The other is that the ratios of the number of accidents with careless drivers to the total number of accidents in the sample are quite different. Almost 20 percent of the drivers was careless in accidents in the primary state sample, while it was 15.8 percent in the neighboring state sample. Furthermore, it was 13.7 percent in the random state sample. Therefore, the seven primary states had more accidents with relatively less careful drivers. This could be one of the reasons why these states changed their laws from the secondary to primary law enforcement during the years studied.

3. Summary Statistics: Synthetic Panel Data Model

The summary statistics for the primary states are in Table 3, and the summary statistics for the neighboring states is in the Appendix. The average number of drivers in a cohort is 23,132. This

[26]Some accidents, though not many, occurred in places without any statutory limits - parking lots or alley -, so the maximum speed limits were zero.

[27]The GES data is a sampled data from the police accident reports. Therefore, each selected observation has its own weight to be used to get the national estimate. The frequencies in the sample do not have any meaning if the weight is not taken into account. However, it suffices to use the raw data to see the behavioral differences among drivers because I do calculate neither the number of accidents nor fatality rates here. The weights are used when I construct the synthetic panel data model in the later section.

[28]They were randomly chosen and assigned by *STATA*, after removing the seven primary states.

is a weighted number of drivers. Among them, the numbers of non-careless and careless drivers are 18,411 and 4,720, respectively. The dependent variables are the natural logarithms of these numbers. I also calculate the ratio of the number of careless drivers to the total number of drivers in a cohort. If this ratio rises, then more less-careful drivers are involved in accidents. About 24 percent of drivers are careless drivers; the percentage seems substantial. Since the numbers in cohorts are the weighted numbers, the accidents involving careless driver behavior might have more weight. I create another dependent variable to measure the number of accidents involving non-occupants in a cohort. Since most accidents do not have pedestrians, the number of drivers in accidents with pedestrians is quite small[29].

Most independent variables are the ones used to construct the synthetic panel data. The main independent variable $PRIMARY$ measures if the primary seat belt laws were in effect at the time of the accident. Since the observations are annual, each cohort has a value of 1 if the primary seat belt law changed in that year or in subsequent years; otherwise, the value is zero. The gender and age variables are all control variables. Year and state dummies are also used to construct the panel data. To compare the primary states with the neighboring states, I also construct the same panel data with only neighboring states. They are in the Appendix.

V. EMPIRICAL RESULTS

1. Estimation Results: Cross-Section Data Model (Probit Model)

The estimation results are presented in Tables 4 and 5. The sample for the analysis contains states. Therefore, the dependent variable might be correlated within a cluster (a state), possibly through unobserved cluster effects (Wooldridge, 2002). This is true even when some control variables are included, so I use the standard errors that allow for within-state correlation, relaxing the usual requirement that

[29] Among 200 observations, 75 observations do not have any driver in accidents with pedestrian involvement. Even though there are 125 remaining observations, the number people in the cohorts are quite small, making the estimation results less reliable. The estimation results for non-occupant involvement are only presented for reference.

the observations be independent. All the t-values are calculated using a robust variance estimate that adjusts for within-cluster correlation.

Table 4 shows the estimation results for testing if the primary seat belt laws cause drivers to drive less carefully, while Table 5 shows the estimation results for testing if the laws cause more accidents involving non-occupants. They are separately estimated using probit models. To compare drivers' behavior in different states, three models are estimated: Primary, Neighboring, and Random States.

As we see in the first column, the estimation results show that drivers drive more carefully when a primary seat-belt law is in effect in a state. Careless behavior is negatively associated with $PRIMARY$, and the variable is statistically significant at the 5 percent level. People drive more carefully under the primary seat-belt law. This finding is surprising because it is the opposite result of what the offsetting effect theory concludes. The second column shows careless driver behavior in neighboring states when the seat-belt law changes in these drivers' neighboring states, which are the same as the original primary states studied. Careless behavior is now positively associated with $PRIMARY$, and the variable is statistically significant at the 1 percent level. It seems that the offsetting effects appear in states where there is no change in the seat-belt laws. How can we explain this seemingly odd result? The variable $PRIMARY$ reflects pre- and post-primary seat belt periods in the primary states where new laws are adopted. From the perspective of the original neighboring states, primary states are their neighbor states. Therefore, drivers in the states with no law change may be affected by the states with the law change. Knowing that the neighboring state changes its law on a particular date, the drivers in a state that does not change its law may tend to drive less carefully[30]. One possible interpretation is that the drivers in the seven neighboring states had maintained a higher level of carefulness in driving. More than 20 percent of the drivers were careless in the primary states, while only 16 percent were careless in the neighboring states[31]. Therefore, when the law changed, people in the primary states became relatively more careful, while people in the neighboring states became relatively less careful.

[30]Interstate commuters may change their driving behavior once they cross the border of the states. This is not empirically proved. However, this is plausible if we consider a similar situation. With regard to maximum speed limits, drivers reduce their travel speed as they pass from the roads with higher to those with lower maximum speed limits.

[31]This could be the reason why the primary states changed their laws. Compared to the neighboring states, primary states have a higher ratio of careless drivers in accidents.

The conclusion is that the primary seat-belt laws change people's behavior in neighboring states as well as primary states. However, this must be valid only for the neighboring states. As we see in the third column, the laws do not affect people's behavior in the randomly assigned states. I calculate the marginal effects of the variable $PRIMARY$, along with other independent variables. The marginal effects for the dummy variable are explained by the change in the predicted probability for a change in $PRIMARY$ from 0 to 1. According to the post estimation from Table 4, changing the seat belt laws from the secondary to the primary decreases the probability driving carelessly by 17.6 percent in the primary states and increases the probability by 13.4 percent in the neighboring states[32].

Among other control variables, careless behavior is caused by neither age nor gender in the primary states[33]. In the neighboring states, younger, male drivers are less careful. Alcohol consumption is positively associated with careless behavior in the neighboring states. The same results are shown in the random states[34] Drunken drivers are often less careful. Therefore, there is a difference in driver behavior between the primary and the non-primary (neighboring or random) states. Drivers in striking vehicles in accidents were less careful, and it is statistically significant in all states. The older the vehicles are, the less careful the drivers are.

The signs of other control variables are what I expected. Careless behavior is found in accidents that occurred between 7:00 p.m. and 5:00 a.m. Drivers are more careful in highly populated areas. During the daylight, drivers are less careful. When it is dark, dawn, or dusk, people drive more carefully. $HIGHWAY$ is positively associated with careless behavior and statistically significant only in the neighboring states. When drivers drive on highways, they are less careful. People are more careful in interchange areas. Speed limits are not associated with careless behavior, except for people in neighboring states. This is a seemingly counterintuitive outcome. Drivers are possibly more careful

[32]The post estimation results are not reported in this paper.

[33]Most literature shows that young male drivers cause more fatal accidents. My study uses individual-level accident data. The data includes accidents with all levels of injury and property damage. Therefore, based on the police-reported accidents, the estimation results show that there is no difference in careless behavior among male and female drivers as well as young and old drivers in primary states. Typically, male drivers are less-careful drivers. However, if both male and female drivers are equally less careful, then there could be statistically no significant difference between genders.

[34]These randomly assigned states are not related to the primary states at all. Therefore, drivers' careless behavior should be explained by other factors, such as personal and accident-specific characteristics. We confirm this conjecture from the estimation results in Tables 4 and 5.

on the local roads because of frequent obstacles like pedestrians. Drivers may focus on driving when the roads have lower maximum speed limits. The coefficients of year dummies are not statistically significant in the primary states, while they are significant in other states. Most state dummies are statistically significant. For instance, drivers in North Carolina were relatively less careful than drivers in Maine.

Table 5 shows that primary seat-belt laws are not associated with non-occupant involvement. The coefficient $PRIMARY$ is not statistically significant at any level. This is also true regardless of states. Therefore, factors other than primary seat-belt laws must explain non-occupant involvement in accidents[35].

Personal characteristics affect non-occupant involvement. Older drivers cause more accidents involving non-occupants, and the age variable is statistically significant in all states. Causing accidents involving non-occupants is not related to gender. Alcohol-related accidents involve fewer pedestrians and more non-occupants are involved in accidents with striking vehicles. Vehicle age is not associated with non-occupant involvement. $NIGHT$ is associated with pedestrian involvement. More pedestrians are involved in accidents in highly populated areas. It is also natural to observe that $HIGHWAY$ is not statistically associated with $NON\_OCCUPANT$ since pedestrians are not on the highway. The coefficient, $INTERCHANGE$, is negative and statistically significant. That means fewer pedestrians are involved in accidents that occurred in the interchange areas. This is because most drivers are more careful when they approach the interchange areas. A higher speed limit is associated with less pedestrian involvement in both primary and random states; this result implies that most accidents involving pedestrians occur on roads with lower maximum speed limits, such as local roads. Both year- and state-dummies are used to control for heterogeneity in years and states.

In summary, I find that the primary seat-belt laws affect people's behavior and people in different states respond to the laws differently. This is valid only in the subset of all drivers (the accident group) on the roads. However, it is still meaningful because I find drivers' behavioral differences by comparing three subsets in different states. I also find that primary seat-belt laws are not associated

[35] We still need to be very careful in deriving a conclusion here. Non-occupant involvement is not related to the law change only in this subset of the population. The change in the number of accidents involving pedestrians due to the laws should be verified in the synthetic panel data model, which will be discussed in the next section.

with pedestrian-related accidents. The next section will discuss the effects of the laws on the increase or decrease in certain types of accidents.

2. Estimation Results: Synthetic Panel Data Model

The estimation results are presented in Tables 6 and 7. The random effect models are used. In Table 6, the first two synthetic panel models show the estimation results from primary states. The second two models show the estimation results from neighboring states. The first two models show that the number of careful drivers increases (first column) and the number of less careful drivers decreases (second column) when a primary seat-belt law is in effect in the state. The coefficient of the variable $PRIMARY$ is highly significant at the 1 percent level in the careful group and significant at the 10 percent level in the careless group. If the more stringent seat-belt laws are newly enforced, the number of careful drivers increases by 99 percent and the number of careless drivers decreases by 26 percent in accidents. These percentage changes seem quite substantial. However, the result is consistent with the results from the NHTSA. According to the Centers for Disease Control and Prevention (CDC), seat belts reduce serious crash-related injuries and deaths by about 50 percent[36]. Not all careful drivers prevent accidents involving serious injuries or death. Thus, some can avoid accidents because of their careful driving behavior. It must be below 50 percent because even more-careful drivers may still cause accidents, and most accidents include no injury or minor injuries. This result is consistent with the main estimation result from Tables 4 and 5. Therefore, the estimation results say that when a state adopts a more stringent seat-belt law, the number of careful drivers increases in both careful and careless groups on the road. The fit of this model is fairly good, with an R^2 close to 85 or 87 percent. In neighboring states, the number of careful drivers in the careful group decreases, and the variable $PRIMARY$ is statically significant (third column), while it (fourth column) is not statistically significant. The overall effects of the primary seat-belt laws on driver behavior in neighboring states is the opposite of the effects in primary states.

Now, I focus on other independent variables only in the first two columns (Primary States). Individual characteristics are mostly significant. With regards to $MALE$, the number of careful male

[36]Seat Belts Fact Sheet, NHTSA, 2010. http://www.cdc.gov/motorvehiclesafety/seatbelts/facts.html.

drivers in the careful group increases, while the number of them in the careless group decreases, so they are offsetting each other. Therefore, male drivers are more careful in the careful group, but female drivers are more careful in the careless group. The younger the drivers are in the careful group, the less careful they are in the careful group. The younger drivers are more careful in the careless group, so they are also offsetting. Therefore, I can conclude that both gender and age are not factors that affect the numbers of careful and careless drivers in accidents on roads in the United States. This result is also consistent with the estimation results from a later model in Table 8. Most year dummies are not statistically significant in the careful group, but they are statistically significant in the careless group. This pattern is reversed in the neighboring states. All state-dummies are statistically significant at the 1 percent level. Drivers also behave differently in different groups, the careful or careless groups. These drivers also offset each other within the groups.

We need to note one thing: the main disadvantage of the synthetic panel model, however, is that many environmental factors that are used in the probit model are no longer controlled for. However, even though the model does not control well for unobserved factors, I obtained a consistent result for drivers' behavior from different model specifications.

Table 7 shows the effects of the laws on the number of accidents involving non-occupants. I divide the driver group into two groups: one consisting of drivers whose accidents did not involve non-occupants (occupant accidents), and one consisting of drivers whose accidents did involve non-occupants (non-occupant accidents). The variable, NON_PEDS, represents the number of accidents without pedestrians involved, and $PEDS$ represents the number of accidents with pedestrians involved. The first column tests to see if the laws increase or decrease the number of occupant accidents, while the second column tests to see if the laws change the number of non-occupant accidents. As we see in the table, the primary seat belt laws are associated with neither the increase nor the decrease in the number of pedestrians. The coefficient $PRIMARY$ is not statistically significant at any level[37].

[37]The synthetic panel data model should satisfy a condition in order to use it as a valid model: the number of observation in a cell should be large enough. Since the number of accidents where pedestrians are involved is quite small, many cohorts do not have any observations. Therefore, the second and the fourth columns have only 125 and 143 observations, respectively, because the dependent variable is the natural logarithm of the number of drivers (or accidents) involving pedestrians. In this case, the effectiveness of using the synthetic panel model could be limited. However, it suffices to show that primary seat-belt laws are not affecting the number of occupant- and non-occupant accidents.

I create a new dependent variable to see the overall effects of the primary seat belt laws on driver behavior and number of accidents. Then, I run the regression using the panel data model used in Table 6. I do this because some variables are offsetting each other. The estimation results are in Table 8. The new dependent variable $CARELESS/TOTAL$ measures the total number of careless drivers to the total number of drivers in a cohort. When primary seat-belt laws are in effect, the ratio of careless drivers on the road decreases in the primary states and increases in the neighboring states. The variable is statistically significant at the 1 percent level. I also confirm that driver behavior is the opposite in primary and neighboring states.

In conclusion, the primary seat belt laws are effective in reducing the number of accidents whose drivers are less careful. However, we need to be very careful in deriving the implications of the offsetting effects. I have used the accident data. It includes all different types of accidents in terms of severity of injuries, including no injury in accidents. Therefore, as the offsetting effect theory concludes, we still do not know if fatal accidents increase or not because of the primary seat belt laws. The GES data also includes fatal accidents. However, it is not possible to construct panel data only with fatal accidents. Therefore, it is very important to draw a conclusion with caution: The offsetting effects may not exist or are weaker than expected, if we include all different types of accidents.

VI. CONCLUDING REMARKS

This paper investigates the effects of the primary seat-belt laws on driver behavior and non-occupant involvement. I find that the offsetting effects do not exist when I analyze the accidents using all injury levels. Primary seat belt laws rather reduce the predicted probability of less-careful driving behavior. The behavior does not even lead to greater non-occupant involvement. Therefore, the overall effect of the laws is still effective, assuming that the law reduces fatalities among drivers and passengers[38].

[38] A research note (2006) from the NHTSA found that states with primary enforcement laws have lower fatality rates. According to the note, the passenger vehicle occupant fatality rates were 1.03 per 100 million vehicle miles traveled (VMT) and 10.69 per 100,000 population over the period of study. This compares to 1.21 and 13.13 (respectively) for all other states.

The estimation results from the synthetic panel model also show consistent outcomes. Both the probit and the synthetic panel data models show that drivers are more careful because of the stringent law enforcement. Furthermore, the number of more-careful drivers increases, and the number of less-careful drivers decreases, when primary seat belt laws are in effect, meaning that people become more careful, regardless of whether they are careful or careless drivers on the road.

One thing to consider is whether the increase in accidental harm from the offsetting behavior is big enough to outweigh the reduction in accidental harm from the seat belt laws, even if I assume that the offsetting behavior really exists or strongly appears. By looking at the descriptive statistics of accident data (Appendix D), one could find an intuitive idea of the size of accidental harm of non-occupants. The General Estimates System (GES) has 82,055 individuals who were involved in the accidents that occurred in the primary states over the period of study[39]. Pedestrians and cyclists consisted of only 0.92 percent of them (Appendix D.1.). Drivers and passengers consisted of 98.93 percent of the sample. Therefore, even if the fatality of non-occupants increases because of the offsetting effects, it may not be sizeable. This becomes clear when I focus on the injury severity levels of non-occupants included in the sample. Among the 752 non-occupants involved in accidents over the period, only 60 people had a fatal injury (Appendix D.2.). Seventy-five percent of the drivers might have caused the accidents due to their possible mistakes or misbehavior (Appendix D.3.). If we include non-motorist vehicle operators and other or unknown actions, the percentage increases to 90 percent. Only 10 percent of them (or 6 non-occupants out of more than 82,000 people involved in accidents) had a fatal injury when they did not take any action. This percentage can be explained by drivers' mistakes or careless (or even intentionally aggressive) behavior. Even so, there is no guarantee that the seat-belt laws cause this non-occupant involvement.

From these simple descriptive statistics, it is hard to believe that drivers' less-careful behavior causes a substantial increase in the number of more-fatal accidents. However, the data set used in this paper is from the police accident reports obtained from the NHTSA. These six accidents could be even sizeable if we converted the number into the weighted sum. This weighted number could have been in

[39]There was no change in the laws in 2008. In 2009, 4 states changed their laws. By including these four states, we can compare drivers' behavioral differences between the states with and without the primary seat belt law over the years of study.

the accident data set because of the offsetting effects if any. Therefore, as I pointed out in the previous section, it is very important to draw a conclusion with caution: The offsetting effects may not exist or are weaker than expected, if we include all different types of accidents.

Currently, 34 states and the District of Columbia have primary seat-belt laws. Sixteen states have secondary laws, and New Hampshire has no seat belt law. Some people argue that drivers should choose whether to wear seat belts as a matter of "personal freedom."[40] However, primary seat belt laws save the lives of drivers as well as passengers, pedestrians, and bikers. This result, along with earlier studies, shows that primary seat belt laws play an important role in improving public safety on roads across the United States[41].

It is still true that the laws save drivers' lives. As of Jan. 1, 2010, a new state law in Georgia, the Super Speeder Law, went into effect with substantially higher fines of $ 200[42]. This law may give drivers stronger motivation to drive more carefully and strengthen the effects of primary seat-belt laws. Therefore, punitive penalties, such as higher fines, would make the laws much more effective, if used together.

For future studies, we may test if joint regulation is more effective in promoting public safety. We can perform this test by comparing different states with and without punitive (financial) penalties, given that the states have the same level safety enforcement.

Another possible study can augment my paper. The use of cellular phones has been prevalent in recent years in the United States. Some states have recently prohibited drivers from using their phones to call or send text messages while driving. Cellular-phone use could be a major distraction and a cause of careless driving behavior. My current paper does not incorporate this cellular-phone use into the model. We could therefore test if there is a relationship between primary seat-belt laws, laws banning cellular phones, and their joint impacts on road safety.

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[40] For instance, the National Motorists Association(NMA) submitted testimony against a 2003 Wisconsin bill allowing primary enforcement. Seven years later, the state of Wisconsin passed a primary seat-belt law in 2009. See more details from "http://www.motorists.org/seat-belt-laws/testimony".

[41] Not only the seat belt laws improve public safety. Vehicle recall regulation reduces accidental harm. See Bae & Benítez-Silva (2011 and 2013) for more details.

[42] See "http://www.safespeedsgeorgia.org/".

Table 1. Primary Seat Belt Laws - States

State	Initial Effective Date	Primary Seatbelt Laws?	Standard Enforcement Date	Who is Covered? In What Seats?	Maximum Fine 1st Offense
Alabama	07/18/91	Yes	12/09/99	15+ years in front seat	$ 25
Alaska	09/12/90	Yes	05/01/06	16+ years in all seats	$ 15
Arizona	01/01/91	No		15+ in front seat; 5 through 15 in all seats	$ 10
Arkansas	07/15/91	Yes	06/03/09	15+ years in front seat	$ 25
California	01/01/86	Yes	01/01/93	16+ years in all seats	$ 20
Colorado	07/01/87	No		16+ years in front seat	$ 71
Connecticut	01/01/86	Yes	01/01/86	7+ years in front seat	$ 15
Delaware	01/01/92	Yes	06/30/03	16+ years in all seats	$ 25
DC	12/12/85	Yes	10/01/97	16+ in all seats	$ 50
Florida	07/01/86	Yes	06/30/09	6+ in front seat; 6 through 17 in all seats	$ 30
Georgia	09/01/88	Yes	07/01/96	18+ in front seat; 6 through 17 in all seats	$ 15
Hawaii	12/16/85	Yes	12/16/85	18+ in front seat; 8 through 17 in all seats	$ 45
Idaho	07/01/86	No		7+ years in all seats	$ 10
Illinois	01/01/88	Yes	07/03/03	16+ in front seat; 18 and younger in all seats if driver is younger than 18 years	$ 25
Indiana	07/01/87	Yes	07/01/98	16+ years in all seats	$ 25
Iowa	07/01/86	Yes	07/01/86	11+ years in front seat	$ 25
Kansas	07/01/86	Yes	06/10/10	18+ in front seat; 14 through 17 in all seats	$ 30
Kentucky	07/15/94	Yes	07/20/06	7+ years in all seats; 6 and younger and more than 50 inches in all seats	$ 25
Louisiana	07/01/86	Yes	01/01/95	13+ years in front seat	$ 25
Maine	12/26/95	Yes	09/20/07	18+ years in all seats	$ 50
Maryland	07/01/86	Yes	10/01/97	16+ years in front seat (effective 10/01/13)	$ 50
Massachusetts	02/01/94	No		13+ years in all seats	$ 25
Michigan	07/01/85	Yes	04/01/00	16+ years in front seat	$ 25
Minnesota	08/01/86	Yes	06/09/09	all in front seat; 3 through 10 in all seats	$ 25
Mississippi	07/01/94	Yes	05/27/06	7+ years in front seat	$ 25
Missouri	09/28/85	No		16+ years in front seat	$ 10
Montana	10/01/87	No		6+ years in all seats	$ 20
Nebraska	01/01/93	No		18+ years in front seat	$ 25
Nevada	07/01/87	No		6+ years in all seats	$ 25
New Hampshire	n/a	No law		No law	No law
New Jersey	03/01/85	Yes	05/01/00	18+ in front seat; 8 through 17 in all seats; 7 and younger and more than 80 pounds	$ 20
New Mexico	01/01/86	Yes	01/01/86	18+ years in all seats	$ 25
New York	12/01/84	Yes	12/01/84	16+ years in front seat	$ 50
North Carolina	10/01/85	Yes	12/01/06	16+ years in all seats	$ 25
North Dakota	07/14/94	No		18+ years in front seat	$ 20
Ohio	05/06/86	No		15+ in front seat; 8 through 14 in all seats	$ 30
Oklahoma	02/01/87	Yes	11/01/97	13+ years in front seat	$ 20
Oregon	12/07/90	Yes	12/07/90	16+ years in all seats	$ 110
Pennsylvania	11/23/87	No		18+ in front seat; 8 through 17 in all seats	$ 10
Rhode Island	06/18/91	Yes	06/30/11	18+ years in all seats	$ 40
South Carolina	07/01/89	Yes	12/09/05	6+ in front seat; 6+ in rear seat with shoulder belt	$ 25
South Dakota	01/01/95	No		18+ years in front seat	$ 20
Tennessee	04/21/86	Yes	07/01/04	16+ years in front seat	$ 50
Texas	09/01/85	Yes	09/01/85	17+ in front seat; 5 through 16 in all seats; 4 and younger and 36 in or more	$ 200
Utah	04/28/86	No		16+ years in all seats	$ 45
Vermont	01/01/94	No		16+ years in front seat	$ 25
Virginia	01/01/88	No		16+ years in all seats	$ 25
Washington	06/11/86	Yes	07/01/02	16+ years in all seats	$ 124
West Virginia	09/01/93	Yes	07/01/13	8+ in front seat; 8 through 17 in all seats;	$ 25
Wisconsin	12/01/87	Yes	06/30/09	8+ years in all seats	$ 10
Wyoming	06/08/89	No		9+ years in all seats	$ 25

* Source: Insurance Institute for Highway Safety (IIHS), "http://www.iihs.org/laws/SafetyBeltUse.aspx#OR."

Table 2. Summary Statistics for 7 states with the Primary Seat Belt Laws

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variables:						
Careless Action	34236	.1965	.3974	0	1	*CARELESS*
Involvement of Non-Occupants	53461	.0161	.1259	0	1	*NON_OCCUPANT*
Independent variables:						
Primary Seat Belt Law	53461	.6035	.4892	0	1	*PRIMARY*
Age	53461	37.6043	16.0054	16	100	*AGE*
Sex	53461	.6016	.4896	0	1	*MALE*
Alcohol Consumption	53461	.0670	.2501	0	1	*ALCOHOL*
Striking Vehicle	53461	.6198	.4854	0	1	*STRIKING*
Vehicle Age	53461	7.5683	5.5573	0	61	*VEHICLE_AGE*
Vehicle Age Square	53461	88.1623	133.7913	0	3721	*VEHICLE_AGE_SQ*
Hour of Crash	53461	.2330	.4227	0	1	*NIGHT*
Population Density	53461	.4215	.4938	0	1	*HIGH_POP*
Road Condition	53461	.8109	.3916	0	1	*DRY_SURFACE*
Weather Condition	53461	.8526	.3545	0	1	*GOOD_WEATHER*
Light Condition	53461	.7178	.4501	0	1	*LIGHT*
Inter-State Highway	53461	.0986	.2981	0	1	*HIGHWAY*
Relation to Junction	53461	.0325	.1774	0	1	*INTERCHANGE*
Maximum Speed Limit	53461	43.9987	10.4049	0	75	*SPEED_LIMIT*
Year Dummy 2004	53461	.2193	.4138	0	1	*YEAR*_2004
Year Dummy 2005	53461	.1888	.3914	0	1	*YEAR*_2005
Year Dummy 2006	53461	.2081	.4059	0	1	*YEAR*_2006
Year Dummy 2007	53461	.2036	.4027	0	1	*YEAR*_2007
Year Dummy 2008	53461	.1802	.3844	0	1	*YEAR*_2008
State Dummy Alaska	53461	.0008	.0290	0	1	*ALASKA*
State Dummy Kentucky	53461	.0862	.2807	0	1	*KENTUCKY*
State Dummy Maine	53461	.0014	.0374	0	1	*MAINE*
State Dummy Mississippi	53461	.0216	.1455	0	1	*MISSISSIPPI*
State Dummy North Carolina	53461	.4991	.5000	0	1	*NORTH_CAROLINA*
State Dummy South Carolina	53461	.0162	.1263	0	1	*SOUTH_CAROLINA*
State Dummy Tennessee	53461	.3746	.4840	0	1	*TENNESSEE*

* Summary statistics for both neighboring and randomly assigned states are in the appendix.

Table 3. Summary Statistics - Synthetic Panel Model (Primary State)

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variable:						
# of Non-Careless Drivers	200	18411.52	21653.58	0	94366.76	*CAREFUL*
# of Careless Drivers	200	4720.65	5335.46	0	22137.74	*CARELESS*
Total # of Drivers†	200	23132.18	25626.48	4.8	116439.20	*TOTAL*
Ln_CAREFUL	199	8.7246	1.9005	1.5686	11.4549	*Ln_CAREFULL*
Ln_CARELESS	193	7.4637	1.8367	1.2119	10.0050	*Ln_CARELESS*
CARELESS/TOTAL	200	.2403	.1755	0	1	*CARELESS/TOTAL*
# of Drivers with No Peds	200	34934.62	35195.97	342.13	129455.7	*NON_PEDS*
# of Drivers with Peds	200	210.10	284.02	0	1632.96	*PEDS*
Total # of Drivers‡	200	35144.72	35394.92	342.13	129814.9	*TOTAL*
Ln_NON_PEDS	200	9.5670	1.5965	5.8352	11.7711	*Ln_NON_PEDS*
Ln_PEDS	125	5.3312	1.1363	2.5688	7.3981	*Ln_PEDS*
PEDS/TOTAL	200	.0061	.0114	0	.0884	*PEDS/TOTAL*
Independent variables:						
Primary Seat Belt Law	200	.6	.4911	0	1	*PRIMARY*
Sex	280	.5	.5009	0	1	*MALE*
Age between 16 and 25	280	.25	.4338	0	1	*AGE_1*
Age between 26 and 35	280	.25	.4338	0	1	*AGE_2*
Age between 36 and 45	280	.25	.4338	0	1	*AGE_3*
Age over 46	280	.25	.4338	0	1	*AGE_4*
Year Dummy 2004	280	.2	.4007	0	1	*YEAR_2003*
⋮						
Year Dummy 2008	280	.2	.4007	0	1	*YEAR_2007*
State Dummy Alaska	280	.1428	.3506	0	1	*ALASKA*
State Dummy Kentucky	280	.1428	.3506	0	1	*KENTUCKY*
State Dummy Maine	280	.1428	.3506	0	1	*MAINE*
State Dummy Mississippi	280	.1428	.3506	0	1	*MISSISSIPPI*
State Dummy N. Carolina	280	.1428	.3506	0	1	*N_CAROLINA*
State Dummy S. Carolina	280	.1428	.3506	0	1	*S_CAROLINA*
State Dummy Tennessee	280	.1428	.3506	0	1	*TENNESSEE*

* Summary statistics for neighboring states are in the appendix.

† Sum of careless and non careless drivers in accidents.

‡ Sum of drivers with pedestrian and no pedestrian involvement in accidents.

Table 4. Primary Seat Belt Law and Careless Behavior

	Probit Model		
	Primary States	**Neighboring States**	**Random States**
Dependent Variable		**CARELESS**	
PRIMARY	-.5901 (.2950)**	.7112 (.1563)***	-.0572 (.0413)
AGE	-.0008 (.0006)	-.0014 (.0003)***	-.0006 (.0011)
MALE	-.0062 (.0129)	.0686 (.0203)***	.0602 (.0139)***
ALCOHOL	-.0340 (.0631)	.4627 (.1538)***	.2531 (.1229)**
STRIKING	.1195 (.0320)***	.3633 (.0707)***	.1414 (.0301)***
VEHICLE_AGE	.0077 (.0014)***	.0151 (.0015)***	.0027 (.0015)*
VEHICLE_AGE_SQ	-.0002 (.0001)**	-.0005 (.0000)***	-.0001 (.0001)
NIGHT	.1143 (.0234)***	.3010 (.0148)***	.1588 (.0373)***
HIGH_POP	-.1610 (.0311)***	-.0195 (.1249)	.0294 (.0676)
DRY_SURFACE	.1562 (.0439)***	.1150 (.0529)**	.1930 (.0227)***
GOOD_WEATHER	.0687 (.0218)***	.1373 (.1018)	.1348 (.0578)**
LIGHT	-.0050 (.0351)	.0928 (.0233)***	.0012 (.0150)
HIGHWAY	-.0412 (.0886)	.0684 (.0380)*	.0397 (.0710)
INTERCHANGE	-.1069 (.0751)	-.2550 (.0785)***	-.1198 (.0449)***
SPEED_LIMIT	-.0022 (.0024)	.0021 (.0011)*	.00004 (.0006)
YEAR_2004	.0092 (.3076)	1.1694 (.4386)***	.3718 (.0846)***
YEAR_2005	.1373 (.1276)	.9592 (.2982)***	.1401 (.0512)***
YEAR_2006	-.0303 (.1428)	.4227 (.0631)***	-.1850 (.0640)***
YEAR_2007	-.0190 (.0335)	.0244 (.0286)	-.0855 (.0237)***

(Continued)

	Probit Model		
	Primary States	**Neighboring States**	**Random States**
Dependent Variable		**CARELESS**	
ALASKA	-.4157 (.0520)***	-	-
KENTUCKY	.0154 (.0551)	-	-
MAINE	-	-	-
MISSISSIPPI	-.1076 (.0754)	-	-
NORTH_CAROLINA	.2458 (.0778)***	-	-
SOUTH_CAROLINA	.2274 (.1087)**	-	-
TENNESSEE	-.1301 (.1345)	-	-
HAWAII	-	-.5164 (.0126)***	-
OHIO	-	-.4122 (.0667)***	-
NEW_HAMPSHIRE	-	-	-
LOUISIANA	-	-.2246 (.0327)***	-
VIRGINIA	-	-.1453 (.0293)***	-
GEORGIA	-	-.1945 (.0230)***	-
ALABAMA	-	-.2552 (.0436)***	-
IDAHO	-	-	.0222 (.0063)***
CONNECTICUT	-	-	-.0238 (.0039)***
NEW_YORK	-	-	.0516 (.0064)***
VIRGINIA	-	-	.0060 (.0056)
PENNSYLVANIA	-	-	-.1011 (.0052)***
FLORIDA	-	-	-.4841 (.0256)***
UTAH	-	-	-
NUM of OBS	34236	40786	66951

† Standard errors are in parentheses.
‡ Robust variance estimate that adjusts for within-cluster correlation is used.
§ **: Significant at the 5-percent level. ***: Significant at the 1-percent level.

Table 5. Primary Seat Belt Law and Pedestrian Involvement

	Probit Model		
	Primary States	**Neighboring States**	**Random States**
Dependent Variable		**NON_OCCUPANT**	
PRIMARY	-.0292 (.0372)	.0919 (.0608)	.0054 (.0067)
AGE	.0050 (.0007)***	.0024 (.0006)***	.0045 (.0007)***
MALE	-.0056 (.0216)	-.0085 (.0275)	.0353 (.0279)
ALCOHOL	-.2302 (.0424)***	-.2001 (.0854)**	-.5755 (.0533)***
STRIKING	.6213 (.0549)***	.5378 (.0168)***	.7055 (.0285)***
VEHICLE_AGE	-.0055 (.0052)	.0028 (.0011)**	-.0045 (.0035)
VEHICLE_AGE_SQ	.0001 (.0004)	-.0001 (.0001)	.0001 (.0001)
NIGHT	.0746 (.0430)*	.1080 (.0278)***	.0743 (.0344)**
HIGH_POP	.1719 (.0183)***	.1536 (.0660)**	.4653 (.1875)**
DRY_SURFACE	.1670 (.0845)**	.1852 (.0450)***	.2178 (.0733)***
GOOD_WEATHER	.0792 (.0864)	.0742 (.0543)	.0264 (.0855)
LIGHT	-.1408 (.0187)***	-.0546 (.0171)***	-.0023 (.0594)
HIGHWAY	.1468 (.0927)	.2380 (.1723)	-.0591 (.1586)
INTERCHANGE	-.5535 (.0537)***	-.0827 (.1151)	-.5098 (.1153)***
SPEED_LIMIT	-.0245 (.0017)***	-.0290 (.0027)	-.0211 (.0083)**
YEAR_2004	-.1288 (.0134)***	.0215 (.0859)	-.0798 (.0645)
YEAR_2005	-.0621 (.0099)***	.0259 (.0894)	-.0809 (.0391)**
YEAR_2006	-.1300 (.0228)***	.0396 (.0677)	-.0361 (.0350)
YEAR_2007	.0139 (.0135)	-.0169 (.0399)	-.0074 (.0252)

(Continued)

	Probit Model		
	Primary States	**Neighboring States**	**Random States**
Dependent Variable		**NON_OCCUPANT**	
ALASKA	-	-	-
KENTUCKY	-.0413 (.0123)***	-	-
MAINE	-	-	-
MISSISSIPPI	-	-	-
NORTH_CAROLINA	.1780 (.0093)***	-	-
SOUTH_CAROLINA	-.0195 (.0053)***	-	-
TENNESSEE	.0052 (.0289)	-	-
HAWAII	-	-	-
OHIO	-	.0591 (.0154)***	-
NEW_HAMPSHIRE	-	-	-
LOUISIANA	-	-.3274 (.0679)***	-
VIRGINIA	-	-.0523 (.0314)*	-
GEORGIA	-	-.0374 (.0896)	-
ALABAMA	-	-.5195 (.0646)***	-
IDAHO	-	-	-.3245 (.0295)***
CONNECTICUT	-	-	-.0246 (.0314)
NEW_YORK	-	-	-.1821 (.0391)***
VIRGINIA	-	-	-.3188 (.0472)***
PENNSYLVANIA	-	-	.1196 (.0448)***
FLORIDA	-	-	.1562 (.0463)***
UTAH	-	-	-
NUM of OBS	53341	78504	100013

† Standard errors are in parentheses.
‡ Robust variance estimate that adjusts for within-cluster correlation is used.
§ **: Significant at the 5-percent level. ***: Significant at the 1-percent level.

Table 6. Synthetic Panel Data Model: Careful vs. Careless Group

	Primary States		Neighboring States	
Dependent Variables	**CAREFULL**	**CARELESS**	**CAREFUL**	**CARELESS**
PRIMARY	.9989 (.1794)***	-.2644 (.1487)*	-1.0558 (.1726)***	.1300 (.1637)
MALE	.5254 (.1085)***	.3574 (.0981)***	.4478 (.0946)***	.2954 (.1156)**
AGE_1	-.3717 (.1624)**	.1773 (.1078)	.0025 (.1422)	.0153 (.1600)
AGE_2	-.4324 (.1339)***	-.0824 (.1368)	-.3208 (.1426)**	-.1212 (.1417)
AGE_3	-.5912 (.1329)***	-.4008 (.1532)***	-.6102 (.1465)***	-.6656 (.1675)***
YEAR_2004	-.4905 (.2434)**	-.5606 (.2037)***	-2.4161 (.2126)***	-.0190 (.2811)
YEAR_2005	-.1734 (.1485)	-.2956 (.1620)*	-1.7999 (.1807)***	-.1322 (.2133)
YEAR_2006	-.1859 (.1340)	-.4844 (.2009)**	-.6594 (.1091)***	.0718 (.2209)
YEAR_2007	-.0380 (.1080)	-.0744 (.1639)	-.0439 (.1617)	.3650 (.2030)*
ALASKA	-	-	-	-
KENTUCKY	-.7229 (.1398)***	-.9300 (.0753)***	-	-
MAINE	-	-	-	-
MISSISSIPPI	-3.6230 (.1601)***	-4.2661 (.1941)***	-	-
N_CAROLINA	-	-	-	-
S_CAROLINA	-3.9119 (.1867)***	-3.8927 (.1423)***	-	-
TENNESSEE	-.7767 (.1562)***	-1.1799 (.0890)***	-	-
HAWAII	-	-	-	-
OHIO	-	-	4.9764 (.1896)***	4.1348 (.2904)***
NEW_HAM	-	-	-	-
LOUISIANA	-	-	-	-
VIRGINIA	-	-	3.9992 (.1771)***	3.8626 (.2981)***
GEORGIA	-	-	1.5633 (.1856)***	1.0895 (.3416)***
ALABAMA	-	-	4.9399 (.1975)***	4.7880 (.2803)***
Num. of Obs.	199	193	199	184
Num. of Groups	8	8	8	8
R^2:within	.8466	.8725	.9100	.8386
R^2:between	.9912	.9100	.9778	.9462
R^2:overall	.8508	.8730	.9116	.8418

Note : Robust standard errors are in parentheses.
Two states, Alaska and Maine, are not used for this estimation
because the number of observations in each cohort is too small.

: Significant at the 5-percent level. *: Significant at the 1-percent level.

Table 7. Synthetic Panel Data Model: Non-Pedestrian vs. Pedestrian Group

	Primary States		Neighboring States	
Dependent Variables	**NON_PEDS**	**PEDS**	**NON_PEDS**	**PEDS**
PRIMARY	.0525 (.0637)	.2306 (.2813)	-.0842 (.0694)	-.0605 (.2226)
MALE	.4690 (.0384)***	.5026 (.1457)***	.4118 (.0707)***	.2644 (.1072)**
AGE_1	-.1630 (.0538)***	-.0701 (.1903)	.0345 (.0821)	-.3841 (.1472)***
AGE_2	-.3672 (.0482)***	-.5351 (.2230)**	-.3575 (.1094)***	-.5772 (.1455)***
AGE_3	-.5470 (.0581)***	-.4225 (.1958)**	-.5912 (.0848)***	-.8924 (.1470)***
YEAR_2004	.1367 (.0841)	.3706 (.3748)	-.0604 (.1151)	.1931 (.2728)
YEAR_2005	.1757 (.0672)***	.1449 (.3141)	.0576 (.0810)	-.0554 (.2294)
YEAR_2006	.1807 (.0558)***	.1331 (.2760)	.0196 (.0691)	-.0197 (.2067)
YEAR_2007	-.0046 (.0613)	.4239 (.2338)*	.0137 (.0738)	.2639 (.1545)*
ALASKA	-	-	-	-
KENTUCKY	-1.3101 (.0412)***	-.5571 (.2171)**	-	-
MAINE	-	-	-	-
MISSISSIPPI	-3.4005 (.0511)***	-2.4554 (.3324)***	-	-
N_CAROLINA	-	-	-	-
S_CAROLINA	-3.8466 (.0737)***	-2.4955 (.3054)***	-	-
TENNESSEE	-.5204 (.0554)***	-.6413 (.1905)***	-	-
HAWAII	-	-	-	-
OHIO	-	-	4.7743 (.1016)***	2.9639 (.6682)***
NEW_HAM	-	-	-	-
LOUISIANA	-	-	-	-
VIRGINIA	-	-	3.6391 (.1067)***	2.0912 (.6714)***
GEORGIA	-	-	1.4244 (.1119)***	.0142 (.6800)
ALABAMA	-	-	5.1465 (.1028)***	2.5844 (.6742)***
Num. of Obs.	200	125	200	143
Num. of Groups	8	8	8	8
R^2:within	.9749	.5050	.9738	.7319
R^2:between	.9888	.8806	.9670	.9041
R^2:overall	.9754	.5206	.9736	.7505

Note : Robust standard errors are in parentheses.
Two states, Alaska and Maine, are not used for this estimation
because the number of observations in each cohort is too small.

: Significant at the 5-percent level. *: Significant at the 1-percent level.

Table 8. Synthetic Panel Data Model: Ratios

	Primary States	Neighboring States
Dependent Variable	$(\frac{CARELESS}{TOTAL})$	$(\frac{CARELESS}{TOTAL})$
PRIMARY	-.2168 (.0346)***	.1948 (.0350)***
MALE	-.0109 (.0251)	.0127 (.0214)
AGE_1	.0536 (.0328)	.0275 (.0312)
AGE_2	.0406 (.0337)	.0402 (.0327)
AGE_3	.0250 (.0324)	.0033 (.0316)
YEAR_2003	-.0123 (.0444)	.3506 (.0479)***
YEAR_2004	-.0329 (.0287)	.2412 (.0383)***
YEAR_2005	-.0076 (.0279)	.0864 (.0328)***
YEAR_2006	.0117 (.0207)	.0273 (.0338)
ALASKA	-	-
KENTUCKY	-.0551 (.0207)***	-
MAINE	-	-
MISSISSIPPI	-.0722 (.0295)**	-
N_CAROLINA	-	-
S_CAROLINA	-.0076 (.0389)	-
TENNESSEE	-.0415 (.0267)	-
HAWAII	-	-
OHIO	-	-.0875 (.0427)**
NEW_HAM	-	-
LOUISIANA	-	-
VIRGINIA	-	.0048 (.0410)
GEORGIA	-	-.0106 (.0467)
ALABAMA	-	.0323 (.0469)
Num. of Obs.	200	199
Num. of Groups	8	8
R^2:within	.3673	.2597
R^2:between	.4756	.8559
R^2:overall	.3705	.2672

Note : Robust standard errors are in parentheses.
Two states, Alaska and Maine, are not used for this estimation because the number of observations in each cohort is too small.

: Significant at the 5-percent level. *: Significant at the 1-percent level.

APPENDIX A. Description of Variables

Variable	Description	Dummy
Dependent variables:		
CARELESS §	Careless driving behavior:	Y
	1 if the driver shows careless driving behavior, 0 otherwise	
NON_OCCUPANT	Non-occupants' involvement	Y
	1 if non-occupants are involved, 0 otherwise	
Independent Variables:		
PRIMARY §	Primary seat belt law: 1 if an accident occurs	Y
	in the state with the law, 0 if otherwise	
AGE	Age of the person (years)	Y
MALE §	Gender: 1 if male, 0 if female	Y
ALCOHOL	Police-reported alcohol involvement in accidents	Y
	1 if the person had consumed an alcoholic beverage, 0 if not	
STRIKING	Vehicle's role in accidents: 1 if a vehicle is striking	Y
VEHICLE_AGE	Difference between the current year and the model year	N
VEHICLE_AGE_SQ	Square of *VEHICLE_AGE*	N
AGE_1 §	Age: 1 if the driver's age is between 16 and 25	Y
AGE_2 §	Age: 1 if the driver's age is between 26 and 35	Y
AGE_3 §	Age: 1 if the driver's age is between 36 and 45	Y
AGE_4 §	Age: 1 if the driver's age is over 46	Y
NIGHT	Hour of crash	Y
	1 if accident occurs between 7:00 p.m. and 5:00 a.m.	Y
HIGH_POP	Population Density:	Y
	1 if within area of population of 100,000 +, 0 if less than 100,000	
DRY_SURFACE	1 if condition of road surface at the time of crash is dry, 0 otherwise	Y
GOOD_WEATHER	General weather conditions:	Y
	1 if it is good, 0 if there was any adverse condition	Y
LIGHT	General light conditions: 1 if daylight, 0 otherwise	Y
HIGHWAY	Interstate Highway	Y
	1 if the crash occurred on an interstate highway, 0 otherwise	
INTERCHANGE	1 if the first harmful event is located	Y
	within an interchange area, 0 otherwise	
SPEED_LIMIT	Actual posted speed limit (miles per hour)	N
YEAR_2004 §	Year dummy	Y
⋮	⋮	
YEAR_2008 §	Year dummy	Y
ALASKA §	State dummy	Y
⋮	⋮	
UTAH §	State dummy	Y

Note : § indicates that the definition of the variable is same in the synthetic panel data model.

Appendix B-1. Summary Statistics for 7 Neighboring States

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variables:						
Careless Action	40786	.1581	.3648	0	1	*CARELESS*
Involvement of Non-Occupants	78535	.0157	.1242	0	1	*NON_OCCUPANT*
Independent variables:						
Primary Seat Belt Law	78535	.6669	.4713	0	1	*PRIMARY*
Age	78535	36.9222	16.1927	16	97	*AGE*
Sex	78535	.5802	.4935	0	1	*MALE*
Alcohol Consumption	78535	.0662	.2486	0	1	*ALCOHOL*
Striking Vehicle	78535	.6357	.4812	0	1	*STRIKING*
Vehicle Age	78535	7.3715	5.3895	0	82	*VEHICLE_AGE*
Vehicle Age Square	78535	83.3862	130.3187	0	6724	*VEHICLE_AGE_SQ*
Hour of Crash	78535	.2426	.4287	0	1	*NIGHT*
Population Density	78535	.2999	.4582	0	1	*HIGH_POP*
Road Condition	78535	.7790	.4149	0	1	*DRY_SURFACE*
Weather Condition	78535	.8428	.3640	0	1	*GOOD_WEATHER*
Light Condition	78535	.6925	.4615	0	1	*LIGHT*
Inter-State Highway	78535	.1305	.3368	0	1	*HIGHWAY*
Relation to Junction	78535	.0471	.2118	0	1	*INTERCHANGE*
Maximum Speed Limit	78535	45.0702	12.4350	0	75	*SPEED_LIMIT*
Year Dummy 2004	78535	.2164	.4118	0	1	*YEAR_2004*
Year Dummy 2005	78535	.1915	.3935	0	1	*YEAR_2005*
Year Dummy 2006	78535	.1991	.3993	0	1	*YEAR_2006*
Year Dummy 2007	78535	.2075	.4055	0	1	*YEAR_2007*
Year Dummy 2008	78535	.1855	.3887	0	1	*YEAR_2008*
State Dummy Hawaii	78535	.0004	.0199	0	1	*HAWAII*
State Dummy Ohio	78535	.3223	.4674	0	1	*OHIO*
State Dummy New Hampshire	78535	.0021	.0458	0	1	*NEW_HAM*
State Dummy Louisiana	78535	.0050	.0708	0	1	*LOUISIANA*
State Dummy Virginia	78535	.1759	.3808	0	1	*VIRGINIA*
State Dummy Georgia	78535	.0183	.1341	0	1	*GEORGIA*
State Dummy Alabama	78535	.4759	.4994	0	1	*ALABAMA*

Appendix B-2. Summary Statistics for 7 Randomly Assigned States

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variables:						
Careless Action	66951	.1366	.3434	0	1	*CARELESS*
Involvement of Non-Occupants	100013	.0483	.2144	0	1	*NON_OCCUPANT*
Independent variables:						
Primary Seat Belt Law	100013	.4407	.4965	0	1	*PRIMARY*
Age	100013	39.6177	16.7371	16	106	*AGE*
Sex	100013	.6318	.4823	0	1	*MALE*
Alcohol Consumption	100013	.0586	.2349	0	1	*ALCOHOL*
Striking Vehicle	100013	.6059	.4887	0	1	*STRIKING*
Vehicle Age	100013	6.8711	5.2272	0	92	*VEHICLE_AGE*
Vehicle Age Square	100013	74.5358	118.0511	0	8464	*VEHICLE_AGE_SQ*
Hour of Crash	100013	.2567	.4368	0	1	*NIGHT*
Population Density	100013	.2882	.4529	0	1	*HIGH_POP*
Road Condition	100013	.8026	.3980	0	1	*DRY_SURFACE*
Weather Condition	100013	.8638	.3430	0	1	*GOOD_WEATHER*
Light Condition	100013	.6963	.4598	0	1	*LIGHT*
Inter-State Highway	100013	.0909	.2875	0	1	*HIGHWAY*
Relation to Junction	100013	.0290	.1679	0	1	*INTERCHANGE*
Maximum Speed Limit	100013	39.4604	12.4995	0	75	*SPEED_LIMIT*
Year Dummy 2004	100013	.2100	.4073	0	1	*YEAR_2004*
Year Dummy 2005	100013	.1937	.3952	0	1	*YEAR_2005*
Year Dummy 2006	100013	.1932	.3948	0	1	*YEAR_2006*
Year Dummy 2007	100013	.2142	.4103	0	1	*YEAR_2007*
Year Dummy 2008	100013	.1890	.3915	0	1	*YEAR_2008*
State Dummy Idaho	100013	.0014	.0377	0	1	*IDAHO*
State Dummy Connecticut	100013	.0046	.0677	0	1	*CONNECTICUT*
State Dummy New York	100013	.3303	.4703	0	1	*NEW_YORK*
State Dummy Virginia	100013	.1382	.3451	0	1	*VIRGINIA*
State Dummy Pennsylvania	100013	.1654	.3716	0	1	*PENNSYLVANIA*
State Dummy Florida	100013	.3587	.4796	0	1	*FLORIDA*
State Dummy Utah	100013	.0014	.0377	0	1	*UTAH*

APPENDIX C. Summary Statistics - Synthetic Panel Model (Neighboring State)

Variable	Obs	Mean	SD	Min	Max	Acronym
Dependent variable:						
# of Careless Drivers	200	20772.10	29002.95	0	152340.70	*CARELESS*
# of Non-Careless Drivers	200	3209.45	3795.36	0	22592.63	*CAREFUL*
Total # of Drivers†	200	23981.55	32123.29	0	171330.00	*TOTAL*
Ln_CARELESS	199	8.5495	2.1657	1.5261	11.9339	*Ln_CARELESS*
Ln_CAREFUL	184	7.1085	1.9672	.6931	10.0254	*Ln_CAREFUL*
CAREFUL/TOTAL	199	.1850	.1699	0	.9783	*CAREFUL/TOTAL*
# of Drivers with Peds	200	46709.71	51196.47	51.96	189921.30	*PEDS*
# of Drivers with No Peds	200	303.99	363.34	0	2146.27	*NON_PEDS*
Total # of Drivers‡	200	47013.70	51450.19	51.96	190512.5	*TOTAL*
Ln_PEDS	200	9.5091	2.0400	3.9505	12.1544	*Ln_PEDS*
Ln_NON_PEDS	143	5.5489	1.2101	1.6506	7.6715	*Ln_NON_PEDS*
NON_PEDS/TOTAL	200	.0069	.0099	0	.0963	*NON_PEDS/TOTAL*
Independent variables:						
Primary Seat Belt Law	200	.6	.4911	0	1	*PRIMARY*
Sex	280	.5	.5009	0	1	*MALE*
Age between 16 and 25	280	.25	.4338	0	1	*AGE_1*
Age between 26 and 35	280	.25	.4338	0	1	*AGE_2*
Age between 36 and 45	280	.25	.4338	0	1	*AGE_3*
Age over 46	280	.25	.4338	0	1	*AGE_4*
Year Dummy 2004	280	.2	.4007	0	1	*YEAR_2003*
⋮						
Year Dummy 2008	280	.2	.4007	0	1	*YEAR_2007*
State Dummy Hawaii	280	.1428	.3506	0	1	*HAWAII*
State Dummy Ohio	280	.1428	.3506	0	1	*OHIO*
State Dummy New Hampshire	280	.1428	.3506	0	1	*NEW_HAM*
State Dummy Louisiana	280	.1428	.3506	0	1	*LOUISIANA*
State Dummy Virginia	280	.1428	.3506	0	1	*VIRGINIA*
State Dummy Georgia	280	.1428	.3506	0	1	*GEORGIA*
State Dummy Alabama	280	.1428	.3506	0	1	*ALABAMA*

* Summary statistics for neighboring states are in the appendix.

† Sum of careless and non careless drivers in accidents.

‡ Sum of drivers with pedestrian and no pedestrian involvement in accidents.

APPENDIX D.1. People Involved in Accidents in 7 States over the 5 Years

Person Type	Freq	Percent
Driver of a Motor Vehicle in Transport	57700	70.32
Passenger of a Motor Vehicle in Transport	23475	28.61
Occupant of a Motor Vehicle Not in Transport	108	.13
Occupant of a Non-Motor Vehicle Transport Device	14	.02
Pedestrian	508	.62
Cyclist (Pedalcyclist)	244	.30
Person in or on a Working Vehicle	4	.00
Other or Unknown	2	.00
Total	82055	100.00

Note : The data set comes from the GES.

Since the GES data are from a probability sample of police-reported traffic crashes, national estimates can be made from these data. Refer to "NASS GES Analytical Users Manual, 1988 - 2013" regarding the methodology for this.

APPENDIX D.2. Injury Severity of Individuals

	All individuals		Pedestrians & Cyclists	
Severity level	Frequency	Percent	Frequency	Percent †
No injury	52072	63.46	11	.01
Possible injury	13356	16.28	43	.06
Non-incapacitating injury	10491	12.79	458	.61
Incapacitating injury	5042	6.14	176	.23
Fatal injury	949	1.16	60	.08
Injured, Severity Unknown	138	.17	4	.01
Died Prior to Crash	7	.01	0	.00
Total	82055	100.00	752	100.00

† All individuals involved.

APPENDIX D.3. Non-Occupant Action with Fatal Injury

Non-Occupant Action	Pedesrtians & Cyclists	
	Frequency	Percent
No Action	6	.10
Non-motorist vehicle operator	1	.17
Darting or running into road	12	.20
Improper Crossing of roadway or intersection (Jaywalking)	13	.22
Jogging	1	.02
Walking with or against traffic	11	.18
Playing, working, sitting, lying, standing, etc in roadway	8	.13
Other or unknown action	7	.12
Total	60	100.00

† All individuals involved.

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