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Abstract --- Distracted driving has increasingly become a national issue of concern. One of the believed major contributors to distracted driving is cell phone use. Some states have enacted laws to restrict cell phone usage while driving in an attempt to reduce the number of car accidents that result from cell phone use, and, ultimately, the number of car accident fatalities. This paper is an econometric study that seeks to determine whether cell phone laws are effective in reducing car accidents. This paper finds a statistically significant negative relationship between hands free laws and car accident fatalities.

INTRODUCTION

National awareness regarding distracted driving continues to increase. On March 23, 2010 the U.S. House of Representatives approved a bill that establishes the month of April as "Distracted Driving Month." (Hands-Free Info)[1] "Distracted Driving Month" commenced on April 1, 2011. The U.S. Department of Transportation (DOT), law enforcement, and safety advocates also came together in April 2011 to bring further awareness to the dangers of distracted driving, including cell phone use related distractions (Hands-Free Info). Law enforcement collectively declared, particularly in the month of April 2011, a more vigorous crackdown on cell phone use while driving. In addition, there are consistent reports of citizens losing family members, friends, and loved ones in car accidents that resulted from cell phone use while driving.

This burgeoning awareness has been further fueled by campaigns from celebrities like media-mogul Oprah Winfrey. Oprah Winfrey campaigned against phone use while driving with

[1] HandsFreeInfo.com is a reliable website that tracks all cell phone legislation in the United States of America and aggregates statistics surrounding distracted driving.

a "No Phone Zone" pledge in 2009, in which pledgees promise to keep their car a "No Phone Zone." To date there have been 423,330 individual pledges made under the "No Phone Zone" campaign to restrict cell phone use while driving (Oprah's No Phone Zone Pledge).

In an attempt to reduce the number of car accidents that result from cell phone use, and their incidental fatalities, state legislatures have implemented driving laws that prohibit the use of cell phones while driving, or at least restrict some manner of cell phone use. Many states have instituted a cell phone law as recent as 2010 and 2011, while others are still considering legislation. Some states still do not have a cell phone restriction; as of 2009 only 15 states have at least a texting ban. The cell phone laws that have been enacted vary in their nature and level of enforcement from state to state.

The various types of laws that restrict cell phone use include hands free usage while driving, texting bans, and the prohibition of teens, novice drivers, school bus drivers, and commercial vehicle drivers from using their cell phone while driving. In some states the laws are either categorized as a primary law or a secondary law. If the cell phone law is a primary law, being caught using a cell phone while driving is enough to be stopped by law enforcement and fined. Under the secondary law you must be found violating another law, or be found driving carelessly, and if it is discovered by law enforcement that you are using your cell phone only then will you be fined for using your cell phone.

If cell phones are actually *effective*, lives will continue to be saved as more states implement the law. In 2009, 5,474 people were killed in U.S. roadways and an estimated additional 448,000 were injured in car crashes that involved distracted driving, according to police reports (Hands-Free Info). If it is concluded empirically that cell phone laws are effective in reducing car accidents, and coincidentally the fatalities that result from them, then cell phone laws should be strengthened by increasing the consequences or prohibiting all cell phone use while driving for all citizens. Additionally, states that have not instituted a cell phone law should enact cell phone legislation swiftly. Congress is looking at several proposals that would effectively ban text messaging while driving nationwide (Hands-Free Info). If this study concludes that cell phone laws are indeed saving lives, U.S. Congress may be motivated to pass the bill enacting the texting ban as a federal law. If cell phone laws are deemed ineffective, it would be important to determine what about the law is ineffective, and possibly implement more effective ways of reducing car accidents that result from cell phone use.

Many econometric studies on this topic have suggested that cell-phone use impairs driver performance by delaying driver reaction time and decreasing awareness. The studies have used simulations, tests, and surveys to evaluate the impact of cell phone use on driving ability. Such studies have influenced much of the legislation regarding cell phone laws. One of the earliest studies done on cell phone use while driving is by Donald A. Redelmeier and Robert J. Tibshirani (1997) and titled *Association Between Cellular-Telephone Calls And Motor Vehicle Collisions*. Redelmeier and Tibshirani's study "indicates an association but not necessarily a causal relation between the use of cellular telephones while driving and a subsequent motor vehicle collision" (Redeilmeir and Tibshirani 1997). Other studies have followed suit in showing an association between cell phone use and car accidents.

Some studies highlight that the association between cell phone use and a reduction in car accidents is not necessarily causal, acknowledging that there may be other factors that are correlated with cell phone use that may simultaneously cause car accidents. Another study by Robert W. Hahn and James E. Prieger (2006) titled *The Impact of Driver Cell Phone Use on Accidents* confirmed that there may be other factors in conjunction with cell phone use that result in car accidents. This was a comprehensive study based on a survey of over 7,000 individuals. Hahn and Prieger's study differed from previous studies in their approach by using a larger sample of individual-level data and testing for selection effects, "such as whether drivers use cell phones are inherently less safe drivers, even when not on the phone" (Hahn and Prieger 2006). Hahn and Prieger conclude that the impact of cell phone use on car accidents vary across the population, individuals who use hands-free are more careful drivers, and furthermore there is no statistically significant reduction in accidents from bans.

Not many comprehensive studies have been done to determine the impact of cell phone laws on the reduction of car accidents across all 50 U.S. states and the District of Columbia. Alexander G. Nikolaev, Matthew J. Robbins, Sheldon H. Jacobson (2010) did a study *Evaluating The Impact Of Legislation Prohibiting Hand-Held Cell Phone Use While Driving*. The econometric study was performed on counties in New York over 10 years, and they concluded their results suggested reduction in some counties, but acknowledged there may be confounding factors due to the limitations of their data. These limitations include the external validity of their results outside of New York and the difficulty in isolating car accidents that result solely from cell phone use.

The econometric study described in this paper specifically seeks to determine whether the cell phone laws enacted in states have resulted in reducing car accidents by using panel data that includes all 50 states in the U.S. and the District of Columbia over a 10-year period from 2000-2009. This study is one of the first attempts of its kind looking at the impact of cell phone laws on all states, over a ten-year period.

DATA DESCRIPTION

The variables of interest for this study include the following by state and year: car accident fatalities by states and year, cell phone laws, hands free only law, texting bans, teen bans, and intermediate license holder restrictions, the number of licensed drivers, the number of licensed teen drivers, sex ratio for all licensed drivers, and the sex ratio of teen drivers, and income. Car accident fatalities, licensed population, and income are logged because the distribution of the data for each of those variables was right-skewed. Logging the variables allowed for a normal distribution. All of the variables used in this econometric study and their sources are listed in *table 1*.

The data used in this study regarding cell phone laws and car accidents span from 2000-2009. While more states have very recently in 2010 and 2011 enacted cell phone laws they are not included in this study because the most recent car accident data from the National Highway Safety Administration (NHSTA) is from the year 2009. For the years included in this study the progression of cell phone laws in states across the U.S. is presented in *table 2*.

Table 1: Variable Description and Source

Variable	Description	Data Source
Car Accident Fatalities	Total Number of Fatalities Resulting from Car Accidents	National Highway Safety Administration (NHSTA) (2000-2009)
Hands Free	Cell Phone Use Without a Hands Free Device is Prohibited	HandFreeInfo.com & DrivingLaws.org (2011)
Text	Texting While Driving Is Prohibited	HandFreeInfo.com & DrivingLaws.org (2011)
Teen	Drivers Under the Age of 20 Are Prohibited From Using Their Cell Phone While Driving	HandFreeInfo.com & DrivingLaws.org (2011)
Intermediate License	Novice Drivers Holding an Intermediate License are Restricted From Using Their Cell Phones While Driving	HandFreeInfo.com & DrivingLaws.org (2011)

Licensed Driver Population	Total Number of Licensed Drivers	U.S. Department of Transportation - Federal High Way Administration (FHWA)(2000-2009)
Licensed Teens	Total Number of Licensed Drivers 19 and Under	U.S. Department of Transportation - Federal High Way Administration (FHWA) (2000-2009)
Licensed Sex Ratio	Computed Male-Female Ratio of All Licensed Driver 19 and Over (Total Male/Total Female)*100	U.S. Department of Transportation - Federal High Way Administration (FHWA) (2000-2009)
Teen Sex Ratio	Computed Male-Female Ratio of All Licensed Drivers 19 and Under (Total Male/Total Female)*100	U.S. Department of Transportation - Federal High Way Administration (FHWA) (2000-2009)
Income	Personal Income	Bureau of Economic Analysis (BEA) (2000-2009)

Notes: Complete references for all sources used, data and otherwise, are included in the works cited section at the end of this paper.

In the years 2001-2003 only New York had a cell phone law, and more specifically only a hands free law. Three more states had enacted a cell phone law by 2004, including the District of Columbia, New Jersey, and Connecticut, states that with New York are pioneers in enacting cell phone laws. There are varying combinations of laws; some states pair cell phone laws with a simultaneous hands free law, a texting ban, and intermediate license restrictions in some cases. In 2009 only six states had a hands free law. On the other hand, 15 states had implemented texting laws in 2009, and at a rapid pace. Texting laws still continued to gain momentum in legislation in 2010 and 2011; this may be because texting while driving requires more attention and detracts from vision of and focus on the road.

Table 2: Number of States With Cell Phone Laws (2001-2009)

Year	Hands Free	Text	Teen	Intermediate License
2000	0	0	0	0
2001	1	0	0	0
2002	1	0	0	0
2003	1	0	0	1
2004	3	0	0	2
2005	4	0	1	3
2006	4	0	3	4
2007	4	0	6	5
2008	6	5	10	5
2009	6	15	14	7

Descriptive statistics for all of the variables used in this econometric study are listed in *table 3*, describing the nature of the data for each variable used in this study. Additionally, the correlations between all of the variables used are included in *table 4*, showing the associations between the variables used in this study. While the data for car accident fatalities by state and year were used, it would have been preferable to have data on the number of distracted driving car accidents for each state specifically in order to gauge whether cell phone laws are reducing the number of car accidents that are caused by distracted driving alone. Using the total number of fatalities that result from car accidents makes it difficult to isolate whether a potential increase or reduction is merely the result of cell phone laws or other confounding factors such as drunk driving laws, or other laws that may be directly affecting the number of car accidents.

Table 3: Descriptive Statistics of Variables Used

	Mean	Std. Dev.	Min	Max
Accident Fatalities	807.10	821.35	29	4333
Accident Fatalities (log)	6.23	1.03	3.37	8.37
Hands Free Law	0.06	0.24	0	1
Text	0.04	0.19	0	1
Teen	0.07	0.25	0	1
Intermediate License	0.05	0.22	0	1
Licensed Population	3918218	4156611	303357	2.37e+07
Licensed Population (log)	14.71	1.01	12.62	16.98
Licensed Sex Ratio	99.75	4.96	84.10	115.20
Licensed Teen Population	188098.20	181600	2866	945539
Licensed Teen Population (log)	11.70	1.02	7.96	13.76
Licensed Teen Sex Ratio	104.51	4.27	88.700	121.100
Income (log)	18.57	1.06	16.42	21.20

Notes: The cell phone laws are all binary variables; if a state has a law, the law =1, and if not, the law =0. This is why the min and the max for hands free, text, teen, and intermediate license are all 1 or 0. All of the logged variables were right skewed, and therefore logged for normal distribution. The total number of observations *N* is 510 over *n* 50 states and *t* 10 years.

Table 4: Correlation Between Variables

Variables	A.F. (log)	H.F.L	Text	Teen	I.L.	LP (log)	Lic. Sex Ratio	LT (log)	LT Sex Ratio	Income (log)
Accident Fatalities (log)	1.00									
Hands Free Law	-0.03	1.00								
Text	-0.01	0.21	1.00							
Teen	0.04	0.17	0.35	1.00						
Intermediate License	-0.14	0.28	0.18	0.22	1.00					
Licensed Population (log)	0.93	0.12	0.06	0.16	-0.08	1.00				
Licensed Sex Ratio	-0.22	0.11	0.04	-0.09	-0.11	-0.14	1.00			
Licensed Teens (log)	0.93	0.00	0.05	0.08	-0.15	0.96	-0.17	1.00		
Licensed Teen Sex Ratio	0.11	0.16	0.00	-0.09	-0.15	0.15	0.55	0.10	1.00	
Income (log)	0.85	0.21	0.11	0.17	-0.02	0.96	-0.13	0.89	0.15	1.000

Notes: The variables in the horizontal labels are abbreviated and are in the same order as the variables in the vertical labels.

It would also be important to isolate the impact that county level enacted laws within some states that have enacted cell phone laws may have on car accidents. The fixed effects econometric model absorbs and accounts for such unobserved differences across states, and it is the primary econometric model used in this study for empirical analysis. The next section will delve deeper into the econometric model used in this study and the reasoning behind its use.

ECONOMETRIC MODEL AND ALTERATIVE ESTIMATES

In order determine the impact of cell phone laws on car accidents we make use of panel data that spans the 50 states and the District of Columbia over the 10-year period from 2000-2009. The best econometric model for this data is the fixed effects model. In this study, we specifically use a two-way fixed effects model accounting for time and state effects. We are interested in analyzing the impact of the laws over time and across states, which makes this model optimal for our analysis. The two-way fixed effects model controls for the differences across states and years. As mentioned above, the fixed effects model also accounts for omitted variable bias for the unobserved variables. The standard errors in this model will be clustered in order to resolve bias that may arise if the error terms for the state and time effects are correlated with each other. The equation for the model is specified below:

$$Y_{it} = \beta_1 X_{1,it} \ldots + \beta_k X_{k,it} + \alpha_i + \lambda_t + u_{it}$$
$$i = 1, \ldots, N;\ t = 1, \ldots, T; k = 1, \ldots, K, (1)$$

where Y_{it} is the number of accident fatalities, $X_{k,it}$ represents all of the independent variables, the cell phone law variables (hands free, text, teen, intermediate license) and other variables we are controlling for that may have an impact on accident fatalities and are correlated with cell phone use (licensed population, licensed teens, respective sex ratios, and income); α_i is the unknown intercept for each state; and λ_t represent the time effects. With this model we restricted to assessing the impact of the law in the time period *t* included in the sample.

Random effects allows for out of sample prediction. The equation for the random effects model is specified below:

$$Y_{it} = \alpha + \beta_1 X_{1,it} \dots + \beta_k X_{k,it} + (u_i + \varepsilon_{it})$$
$$i = 1, \dots, N;\ t = 1, \dots, T; k = 1, \dots, K, (2)$$

The random effects model gives us an intercept and regression equation that can be used to predict outside of the sample used in the regression. However, the unobserved variables are not captured by the model, which may result in omitted variable bias. The random effects estimates will also be used in the study to assess the strength of the results. In order to determine whether or not we are capable of using random effects, a Hausman[2] test must be run. After a Hausman test was run using both the fixed effects specification and the random effects specification, we have concluded that we cannot use random effects because u_{it} is correlated with the regressors. The following section discusses the empirical results and findings in depth.

EMPIRICAL RESULTS

Table 5 presents all of the results for all of the estimates used to assess the impact of cell phone laws on car accident fatalities. *Column 1* uses OLS to examine the impact of cell phone laws on car accident fatalities. The hands free law coefficient is statistically significant at the 1% level, indicating that if you have a hands free law in your state car accident fatalities decrease by 23%[3], exemplified in the coefficient -22.91, controlling for all of the other variables on the regression.[4] Texting and teen restriction on cell phone use are both statistically significant under the OLS model at the 10% level, and they are both shown to have a negative impact on car accident fatalities. The licensed population (log) variable is also statistically significant at the 1%

[2] The Hausman test is a test where the null hypothesis is that the preferred model is random effects against the alternative, the fixed effects. It tests whether are correlated with the regressors, while the null hypothesis is that they are not correlated.

[3] The results reported in the body of the text are rounded.

[4] All of the coefficient results are reported controlling for the other variables in the regression.

level, estimating that a 1% increase in the number of licensed drivers will result in a 93% increase in car accidents controlling for the other variables in the regression, which is a staggering result. The simple OLS is not a sufficient model for determining the impact of cell phone laws on all states over time. Fixed effects is the most appropriate model to analyze the panel data being used, as aforementioned.

Column 2 is the fixed effects estimation without time effects. Under this specification the hands free law coefficient is significant at the 10% level and estimated to reduce car accident fatalities by 5%. The texting restriction coefficient under the state fixed effects is significant at the 1% level, estimating an 11% decrease in car accident fatalities. Teen cell phone use restrictions also have a negative impact on car accident fatalities, estimated to reduce them by 7%, and are statistically significant at the 5% level. The intermediate license law coefficient is not statistically significant under this specification, but also is estimated to have a negative effect on car accident fatalities. This model does not account for the differences over time.

Column 3 is the two-way fixed effects, accounting for the state and time effects. Under this specification the hands free law coefficient is significant at the 5% level, in comparison to the 10% level with time effects. The negative impact of the law is also estimated to be higher in the two-way fixed effects model. The hands free law is estimated to decrease car accident fatalities by 7%. Texting went from being statistically significant and negative in the state fixed effects model to being statistically insignificant at all of the standard significance levels and positive. The intermediate license law is significant at the 10% level and is estimated to decrease car accident fatalities by 7%. As aforementioned, the two-way fixed effects model though effective does not allow us to make out of sample predictions with our estimates.

Column 4 presents the results for the random effects specification. A Hausman test determined that we cannot use random effects; the χ^2 probability was less than .05 therefore fixed effects is the preferred model. The results of the Hausman test are presented below:

$$\begin{aligned} \chi^2(18) &= (b-B)'[(V\,b - V\,B)\text{^}(-1)](b-B) \\ &= \quad 40.85 \\ Prob > \chi^2 &= \quad 0.0016 \end{aligned} \tag{3}$$

The two-way fixed effects specification is the most effective model to evaluate the impact of cell phone laws on car accident fatalities in this study.

Table 5: Car Accident Fatalities: Estimation Comparisons

Note: Coefficients & Standard Errors (x100)				
Dependent Variable:	**OLS**	**Fixed Effects**	**Two Way- FE**	**Random Effects**
Car Accidents Fatalities (log)	(1)	(2)	(3)	(4)
Regressor	Estimates	Estimates	Estimates	Estimates
Cell Phone Law				
Hands Free	-22.91***	-4.67*	-6.78**	-8.43***
	(6.34)	(2.67)	(3.08)	(3.66)
Texting	-13.01*	-11.39***	0.19	0.54
	(7.06)	(2.76)	(3.08)	(3.22)
Teen	-10.12*	-7.06**	-0.74	-0.19
	(5.39)	(3.17)	(2.57)	(2.56)
Intermediate License	0.48	-8.20	-6.91*	-6.61*
	(4.84)	(3.11)	(3.46)	(3.69)
Licensed Population				
Licensed Population (log)	93.45***	-75.04***	-8.84	72.05***
	(21.55)	(10.23)	(17.42)	(6.65)
Female Ratio	-1.92***	0.10	-0.33*	-0.70***
	(0.34)	(0.22)	(0.19)	(0.22)
Licensed Population (19 and Under)				
Teens Licensed (log)	33.11***	4.84	4.88	11.42**
	(6.59)	(6.53)	(5.26)	(5.44)
Teen Sex Ratio	0.89	-0.55*	-0.32	-0.24
	(0.36)	(0.30)	(0.23)	(0.26)
Income (log)	-31.97*	0.29	3.11*	3.04
	(16.51)	(2.82)	(1.59)	(2.28)
Intercept	-443.77***	1714.03***	706.93***	-525.77***
	(56.59)	(141.94)	(241.46)	(73.54)
State Effects	No	Yes	Yes	Yes
Year Effects	No	No	Yes	Yes
N	510	510	510	510
		F 28.85	F 28.31	χ^2 1126.02
R^2	0.91	0.84	0.00	0.89

** significant at the 10% level;* *** significant at the 5% level;* **** significant at the 1% level*

Notes: These regressions were estimated using panel data from U.S. from 2000 to 2009 (509 observations). The coefficients and standard errors are multiplied by (x100). R^2 is the "overall" R^2 of the regression for each specification, fixed effects and random effects. *N* is the total number of observations; the total number of groups is 51 equivalent with the number of states including the District of Columbia. The number of years (t) is 10 from the year 2000 to 2009. Cell Phone Laws are all binary variable 1=yes; 0=no. The standard errors are in parenthesis and are clustered at the state level. FE refers to Fixed Effects, and RE refers to Random Effects.

Table 6 presents the two-fixed effects estimation of the impact of cell phone laws on car accidents solely. The hands free law, intermediate license law, and teen law all have a negative impact on car accident fatalities, causing fatalities to decrease by 7%, 7%, and .7% respectively. However, only the hands free law and intermediate license laws are statistically significant at the 5% and 10% level respectively. The texting law is estimated to increase car accident fatalities by .19%; it is not statistically significant however. This econometric model and its results suggest that there is a negative relationship between hands free laws, intermediate laws and car accident fatalities in the sample used for the estimation. These results indicate that there is a causal relationship between the laws and the reduction in car accidents.

Table 6: Car Accident Fatalities: Two-Way Fixed Effects

	Note: Coefficients & Standard Errors (x100)	
Dependent Variable:		
Car Accidents Fatalities (log)	**Two Way- Fixed Effects**	
	(1)	
Regressor	Estimates	Standard Errors
Cell Phone Law		
Hands Free	-6.78**	(3.08)
Texting	0.19	(3.08)
Teen	-0.74	(2.57)
Intermediate License	-6.91*	(3.46)
Licensed Population		
Licensed Population (log)	-8.84	(17.42)
Sex Ratio	-0.33*	(0.19)
Licensed Population (19 and Younger)		
Teen Licensed Population (log)	4.88	(5.26)
Teen Sex Ratio	-0.32	(0.23)
Income (log)	3.11*	(1.59)
Intercept	706.93***	(241.46)
State Effects	Yes	
Year Effects	Yes	
N	510	
F	28.31	

R^2	0.00

** significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level*
Notes: These regressions were estimated using panel data from U.S. from 2000 to 2009 (509 observations). The coefficients and standard errors are multiplied by (x100). R^2 is the "overall" R^2 of the regression for each specification, fixed effects and random effects. *N* is the total number of observations; the total number of groups is 51 equivalent with the number of states including the District of Columbia. The number of years (t) is 10 from the year 2000 to 2009. Cell Phone Laws are all binary variable 1=yes; 0=no. The standard errors are clustered at the state level.

These findings are similar to those in Alexander G. Nikolaev, Matthew J. Robbins, and Sheldon H. Jacobson's (2010) paper *Evaluating The Impact Of Legislation Prohibiting Hand-Held Cell Phone Use While Driving*. Though their paper focused primarily on New York and its counties they had very similar limitations in their data that also hinder us from reporting that there is an actual causal relationship between the reduction in car accidents and the implementation of a cell phone law.

CONCLUSION

The results suggest that cell phone laws are indeed reducing car accident fatalities. The fixed effects model does indeed account for the unobserved variables making it a prime model to determine causality, but the limitations in the data hinder us from making such absolute conclusions. As stated, there may be many other confounding factors that account for the decrease in car accident fatalities. Furthermore, data for car accidents that resulted from distracted driving in order to determine whether the cell phone laws are reducing car accidents that result from cell phone use based on its impact on distracted driving. Additionally, many states have implemented the law very recently, and it may be difficult to gauge the impact of the law without allowing the laws to take effective and leave enough time to assess impact of the law. With richer data in 5-10 years this will be a worthwhile study to research further.

Legislators have at their disposal studies that indeed show that cell phone use impairs driving, and we have many examples of lives that have been lost due to cell phone use while driving. State legislation of cell phone laws should continue to be passed at its recent high rate. However, it is also important that sound research illustrating the impact of the law be performed in order to determine its effectiveness so that changes can be made in the enforcement of the law or alternative measures be employed in order to reduce car accident fatalities that result from cell phone use.

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