To Encourage or Not to Encourage Seat Belt Use: Simultaneity Bias and Offsetting Behaviour

Anindya Sen  
(Corresponding Author)  
Assistant Professor  
Department of Economics  
University of Waterloo  
1406 Avon Drive  
Mississauga, Ontario  
Canada L5N 7Z3  
Phone: (416) 927 – 0479 ext.46  
Fax: (416) 927 - 7621  
Email: asen@watarts.uwaterloo.ca

And

Brent Mizzen  
Department of Finance  
Government of Canada  
Ottawa, Ontario  
Email: Mizzen.Brent@fin.gc.ca

Abstract

Estimating the efficacy of seat belt use is important as compensating risk-taking or “offsetting behaviour” by drivers may attenuate benefits from vehicle safety regulation. However, evidence on partial-offsetting behaviour from previous studies may simply reflect simultaneity bias, as increasing deaths from traffic accidents results in tougher policies aimed at encouraging seat belt use. We find significant evidence of such measurement error. OLS estimates from Canadian provincial data between 1980 to 1996 imply partial offsetting behaviour as increased average seat belt use over the sample period resulted in a 13.42% decline in vehicle occupant fatalities, in contrast to the expected 39-46% drop. However, corresponding instrumental variables (IV) estimates imply a lack of significant risk compensation as increased seat belt use is associated with a 37% fall in occupant deaths.

Keywords: Traffic Fatalities, Seat Belt Use, Offsetting Behaviour

JEL Classification Code: H1, K0
I. Introduction

Increasing average seat belt use in order to reduce deaths and injuries has recently occupied a prominent place in policymaking. However, increased seat belt use may also be associated with more deaths and injuries from motor vehicle accidents. Peltzman (1975) demonstrated that vehicle safety regulation could actually have the perverse effect of increasing harm to pedestrians or non-occupants, as drivers respond to the reduction in the probability of death or injury by taking more risks. The safety benefits of vehicle safety regulation may then be offset through the costs imposed on society through rash driving. In contrast, partial-offsetting behaviour may also occur if risk compensation by drivers actually results in increased harm to themselves, other vehicle occupants and/or drivers. The actual fall in driver deaths/injuries due to improved seat belt use in this case, would be lower than expected.

The above discussion suggests that offsetting behaviour could potentially attenuate safety benefits from increased seat belt use. Hence, the efficacy of higher seat belt use becomes an empirical issue. Numerous papers have found evidence of offsetting behaviour from increased seat belt usage or the enactment of seat belt laws.

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1 On April 6th, 2001, Federal Transport Minister David Collenette announced the launch of Road Safety Vision 2010, a long-term plan aimed at making Canada's roads the safest in the world by reducing the number of road fatalities and serious injuries in Canada by 30 per cent over 1996-2001 average figures. This would be partly achieved through increasing the rate of seat belt use among drivers and front seat passengers from 90 to 95 per cent. In his weekly radio address to the nation on December 28, 1996, President Clinton asked all Americans to always wear seat belts to minimise traffic injuries and fatalities. On January 23, 1997, the President directed the Secretary of Transportation to prepare a plan to increase national use of seat belts. A key objective of this plan was to increase national seat belt use to 85% by 2000 and 90% by 2005 (from 68% in 1996).

2 He found the enactment of various safety regulations by the U.S. National Highway Traffic Safety Administration in 1968 to be simultaneously associated with a 10% drop in national vehicle-occupant death rates, as well as with a 25–35% increase in non-occupant death rates. Since there was no significant change in total death rates, Peltzman (1975) concluded that benefits from safety regulation might be “offset” by a compensating increase in risk taking by drivers, resulting in harm to pedestrians or non-occupants.
A key problem with the above literature is the possibility that coefficient estimates of the impact of seat belt use/legislation might be attenuated by simultaneity bias. Specifically, higher average seat belt use could be the product of stricter legislation and/or enforcement, which itself is the result of public pressure stemming from concern over high levels of traffic fatalities. Trends in traffic fatalities have certainly led public safety groups in the U.S. to aggressively campaign for stricter seat belt laws as well as for tighter enforcement. The demand for stricter legislation is also evident in the media. In an effort to control for this type of simultaneity bias, some studies on other types of safety regulation have employed two way fixed effects models to account for the effects of unobserved grass-roots movements or public campaigns for stricter penalties.

We attempt to contribute to the literature by using instrumental variables (IV) to account for simultaneity bias present in OLS estimates of the impact of seat belt use...

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3 The evaluation of offsetting behaviour has not been restricted to seat belt laws or usage. Peterson et al. (1995) analyze the impact of airbags, Chirinko and Harper (1993) focus on general automobile safety features, and Sass and Zimmerman (2000) look at motorcycle helmet laws.

4 Garbacz (1990, 1992) found a significant correlation between non-occupant death rates and average seat belt usage and mandatory seat belt laws, respectively. However, partial offsetting behaviour may occur even in the absence of any significant correlation between non-occupant death rates and safety regulation. For example, Evans and Graham (1991) attribute an 8% drop in vehicle-occupant fatalities to the enactment of state level seat belt laws in the U.S. between 1975 to 1987. However, given the 28 percentage point increase in average seat belt use and the 40-50% reduction in driver and front seat fatalities from using seat belts (National Highway Traffic Safety Administration (1984)), the introduction of seat belt laws should have led to a 11-14% (0.40 x 28, 0.50 x 28) reduction in vehicle occupant death rates. Sen (2001) finds the enactment of Canadian seat belt laws to be significantly associated with a 18 – 21% drop in vehicle occupant death rates. But the fall should have been 29% assuming that increased seat belt use leads to a 60% fall in vehicle occupant fatalities (Levitt and Porter (2001)) and the 49% increase in average seat belt use over the sample period.

5 This is of course, not a problem restricted to studies on seat belt use or legislation. As noted by Sass and Zimmerman (p.196, 2000), “Determining the efficacy of helmet laws or other safety legislation is problematic since adoption, compliance, and enforcement of such laws are inherently endogenous.”

6 For example, the National Safety Council (www.nsc.org) and the Automotive Coalition for Traffic Safety, Inc. (www.actsinc.org).


8 Ruhm (1996) attempted to capture the effects of local anti-drinking and driving grass roots initiatives with province and year fixed effects, while Sass and Zimmerman (2000) used similar two way fixed
on Canadian provincial traffic fatalities between 1980 and 1996. The use of Canadian data has several advantages. For example, time-series variation in state level average seat belt use is much lower in U.S. data as it has only been collected since nineteen ninety-four. More importantly, there is greater cross-jurisdictional and time-series variation in the enactment of seat belt use laws in Canada, which allows us to control for the impact of unobserved province and/or time specific determinants of traffic fatalities with the help of two-way fixed effects models.\(^9\) This is important because, estimates of the impact of seat belt use may otherwise be confounded.\(^10\) Another disadvantage of exploiting U.S. data on seat belt use stems from the passage of weak secondary seat belt enforcement laws. Under these laws, unbelted motorists cannot be ticketed unless they have been stopped for some other violation. In comparison, primary enforcement laws permit punishing unbelted motorists for directly violating seat belt laws.\(^11\) Given the limited deterrence effects of secondary enforcement laws, the implications of empirical estimates of the impact U.S. seat belt legislation are unclear.\(^12\) In contrast, the enactment of seat belt laws in all Canadian provinces, have focused on primary enforcement.

Our empirical results suggest significant simultaneity bias. Specifically, OLS estimates indicate that increased seat belt use across between 1980 to 1996 resulted in

\(^9\) In 1976, Ontario was the first North American jurisdiction to implement seat belt use laws, and was subsequently followed by all other Canadian provinces by 1987. New York was the first American state to pass seat belt usage laws in 1984. Currently forty-nine states and D.C. have some form of seat belt legislation.

\(^10\) As pointed out by Dee (1998), average seat belt use is likely to be impacted by unobserved year specific occurrences that are common across states, such as public dissemination of information on the benefits of seat belt use.

\(^11\) Of the forty-nine states and D.C., which have some form of seat belt legislation, only 18 jurisdictions have primary enforcement laws.
roughly a 13.42% drop in vehicle-occupant fatalities. This suggests partial-offsetting behaviour, as a counterfactual exercise implies that increased seat belt usage should have led to between a 39–46% fall in occupant deaths. However, IV estimates imply that greater average seat belt use actually led to a 37% decline in occupant fatalities. Hence, an inability to account for simultaneity bias leads to the inaccurate perception that safety benefits from increased seat belt use are compromised by significant offsetting behaviour.

This paper is organized as follows. Trends in traffic fatalities and seat belt use, as well as the empirical specification and data are presented in section II. Estimation results are contained in section III. Finally, we conclude with a summary in section IV.

II. Canadian Traffic Fatalities and Seat Belt Use

Figure 1 shows that there has been a dramatic decline in Canadian vehicle and non-occupant fatality rates (per 100,000 licensed drivers) between 1980 to 1996. Specifically, vehicle-occupant fatalities have dropped by roughly 200% (39.67-12.95/12.95) while the corresponding figure for pedestrian death rates is 227% (10.93-3.34/3.34). Increases in seat belt use for drivers and front seat passengers have been equally noteworthy; roughly sixty-five percentage points from 26.31% to 91.37% over the sample period. Hence, if offsetting behaviour by drivers is measured in terms of increases in harm to non-occupants, the raw numbers suggest an absence

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12 Recent studies (Evans and Graham (1991), Dee (2001)) confirm this, as they find a statistically significant and negative correlation between traffic fatalities and primary seat belt laws, but not between traffic fatalities and secondary laws.
13 Data on traffic fatalities between 1980 to 1996 were obtained from the Traffic Injury Research Foundation (TIRF) and Transport Canada. TIRF is a non-profit organization, which has compiled an extensive data set of all traffic fatalities in Canada between 1973 to the present. This database was constructed by matching information from a multitude of different sources, including police, coroner and hospital reports. Unfortunately, we could not obtain data on injuries from motor vehicle accidents.
of such behaviour as pedestrian death rates actually declined between 1980 to 1996, which also witnessed a significant increase in average seat belt use. However, partial offsetting behaviour could also occur if the actual drop in driver fatalities is less than what is expected. For example, the roughly 65 percentage point increase in average seat belt use between 1980 to 1996, implies that driver fatalities should have dropped between 39 to 46% (65 x .60, 65 x .70). This is because recent research suggests that 60-70% of driver or front seat fatalities can be prevented by seat belt use.\(^\text{14}\)

In order to resolve this ambiguity, we use the following empirical specification to estimate the impact of seat belt use on traffic fatalities.\(^\text{15}\)

\[
FATALITIES_{it} = b_0 + b_1 \text{SBELT}_{it} + b_2 \text{DRINK}_{it} + b_3 \text{CONTROL}_{it} + b_{4+i} \sum_i \text{PROV}_i + b_{4+i+t} \sum_i \text{YEAR}_i + b_{4+i+t+T} \sum_i \text{TREND}_i + \nu_{it}
\]

where \(i = 1,\ldots, 10\) and \(t = 1980, \ldots, 1996\); \(i\) being provinces and \(t\) being year.

\(FATALITIES_{it}\) denotes different traffic fatality rates; \(\text{SBELT}_{it}\) is the average percentage of drivers and front seat passengers who wear seat belts; \(\text{DRINK}_{it}\) refers to alcohol prices and minimum legal drinking ages; \(\text{CONTROL}_{it}\) includes exogenous variables that represent per capita fuel consumption, the percentage of young males, unemployment rates, and police presence; \(\text{PROV}_i\) are province effects; \(\text{YEAR}_i\) are year effects; \(\text{TREND}_i\) are province specific linear trends; and \(\nu_{it}\) is an error term.

Data description and sources for all these variables are documented in table 1. Summary statistics for all these variables are available in table 2.

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\(^\text{14}\) Levitt and Porter (2001).

\(^\text{15}\) This specification is quite similar to models employed in previous studies, which have estimated the impact of various types of safety regulations on traffic fatalities. Examples include Sass and Zimmerman (2000) and Sen (2001).
III. Estimation Results

This section sets an empirical baseline for evaluating the impact of seat belt use on different traffic fatalities. Table 3 contains OLS estimates of equation (1) using the natural logarithm of vehicle-occupant fatality rates per 100,000 licensed drivers as the dependent variable, with province level data from 1980 to 1996. Column 1 is the base empirical specification, which consists of an estimate of seat belt use (SBELT_{it}) in isolation from all other factors. Column 2 tests the robustness of this result by including provincial and year fixed effects and province specific linear trends. Anti-drinking and driving policies are added in column 3. Finally, all remaining control variables are added in column 4.

The first important result from Table 3 is the statistically significant (at 1%) and negative correlation between seat belt use and vehicle-occupant fatalities in column 1. In isolation from other factors a 1% increase in average seat belt use (SBELT_{it}) among drivers and front seat passengers is significantly associated with a 0.3696% drop in driver and passenger deaths. Further, the adjusted R-square suggests that this simple specification explains 42.38% of the variation in driver and passenger fatalities. The coefficient estimate of seat belt use (SBELT_{it}) continues to be negative and significant with the inclusion of province and year fixed effects and province specific linear trends in column 2, but declines in magnitude to –0.24264. However, the coefficient estimate of average seat belt use (SBELT_{it}) is still statistically

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16 With the exception of binary indicators, all variables are in natural logarithms. Likelihood Ratio tests based on Box-Cox regressions reject the use of a levels specification. Standard errors of coefficient estimates are White corrected for heteroskedasticity and Newey-West corrected for first-order autocorrelation. Fatality rates data are available for seven provinces (B.C., Alberta, Saskatchewan, Manitoba, Ontario, P.E.I. and Nova Scotia) from 1980 till 1996 but only from 1987 onwards for Quebec, from 1985 onwards for New Brunswick and from 1986 onwards for Newfoundland. Consequently, results from this database are based on an unbalanced time series of cross sections.
significant at 1%. The adjusted R-square increases by 34.15 percentage points (from 0.4238 to 0.7653) indicating the need to control for unobserved determinants of traffic fatalities that are both province and time invariant and time varying within provinces.

The coefficient estimate of seat belt use (SBELT\textsubscript{it}) further declines in magnitude and statistical precision (from 1% to 5%) with the inclusion of anti-drinking and driving policies in column 3. A 1% increase in average seat belt use (SBELT\textsubscript{it}) is now significantly associated with a 0.1586% drop in driver and passenger death rates. Stricter drinking and driving laws are also associated with lower vehicle-occupant deaths. Specifically, a 1% increase in the alcohol price index (ALCPRICE\textsubscript{it}) is on average, significantly correlated with a 1% fall in vehicle-occupant fatalities (at 1% level of significance). In contrast a 1% increase in the legal drinking age (MINAGE\textsubscript{it}) is significantly correlated with a roughly 16% drop in driver and passenger fatalities.

Finally, all variables are collected together for estimation purposes in column 4. Seat belt use (SBELT\textsubscript{it}) is now statistically significant at 1%, and a 1% increase in average seat belt use is significantly associated with a 0.2065% fall in vehicle-occupant fatalities. In terms of anti-drinking and driving initiatives, MINAGE\textsubscript{it} remains statistically significant but declines slightly in magnitude size. However, alcohol prices (ALCPRICE\textsubscript{it}) are no longer significantly correlated with trends in vehicle occupant deaths. Of the control variables that were added in column 4, the percentage of young males (P1524\textsubscript{it}) is statistically significant (at 1%) and possesses the expected positive sign.

In summary, increased seat belt use is significantly correlated with reduced vehicle-occupant death rates. Increases in the minimum legal drinking age
MINAGE also shares a statistically significant relation (at 10%) with fewer vehicle-occupant death rates. Further, controlling for unobserved province and year specific attributes is critical. Failure to do so results in an upwards bias in coefficient estimates of the efficacy of increased seat belt use (SBELT). This is illustrated by the approximate 79% (0.3696-0.20654/0.20654) drop in the magnitude of SBELT (from column 2 to 4 of table 4) with the inclusion of year and province fixed effects and province specific linear trends. These results point to the benefits of the rich cross-province time-series variation available in Canadian data, as it enables us to disentangle province and time invariant as well as time varying trends in unobserved determinants of traffic fatalities from actual movements in average seat belt use.17

The above discussion suggests that increased seat belt use possesses enhanced safety benefits, which results in fewer vehicle occupant deaths. The question now is whether increased seat belt use also leads to significant offsetting behaviour resulting in higher pedestrian deaths. Offsetting behaviour by drivers could also result in higher passenger fatalities. This is explored in table 4, which analyses the impact of seat belt use on different traffic fatality rates from 1980 to 1996.18 Column 1 consists of empirical estimates of increased seat belt use (and other covariates) on all fatalities

17 The significance of province and year fixed effects could be due to grass-roots movements advocating seat belt use within provinces, or some national initiatives aimed at improving traffic safety through heightened public awareness, which has a significant effect on all provinces within a particular year. But it is also important to acknowledge that vehicle safety initiatives such as the increased instalment of air bags and anti-lock brakes or high profile public education programs may be trending over time within a province, and may not be province or time-invariant. If trends in average seat belt use are correlated with movements in such initiatives, then province fixed effects would be insufficient to mitigate the consequent bias in coefficient estimates of average seat belt use. However, it is interesting to note recent Transport Canada (2001) estimates, which suggest the number of driver and front passenger lives saved by airbags to be quite modest. Specifically, they attribute 313 lives being saved by these devices across Canada between 1990 to 2000. As a benchmark, 2367 vehicle occupants were killed because of motor vehicle accidents in 1996 alone. Recent research (Levitt and Porter (2001) also finds the efficacy of air bags to be limited relative to the impact of seat belts.

18 The results in this table consist of OLS estimates. Standard errors of coefficient estimates are White corrected for heteroskedasticity and Newey-West corrected for first-order autocorrelation.
from motor vehicle accidents. Columns 2 and 3 use a similar empirical specification to estimate the effects of increased seat belt use on passenger and pedestrian death rates from traffic accidents, respectively.\textsuperscript{19,20}

Empirical results across columns 1 (all fatalities) and 2 (passengers) share similarities. Seat belt use (SBELT\textsubscript{it}) is statistically significant and is associated with a 0.219 and 0.154\% drop in total fatalities and passenger death rates, respectively. The percentage of young males (P1524\textsubscript{it}) is also statistically significant across both columns and possesses the expected positive coefficients. In terms of other variables, an increase in the number of per capita police officers (POLICE\textsubscript{it}) leads to lower overall traffic fatalities while higher minimum legal drinking ages (MINAGE\textsubscript{it}) are significantly associated with fewer passenger deaths from road accidents. Finally, empirical estimates from column 3 show that increased seat belt use (SBELT\textsubscript{it}) shares no statistically significant relation with pedestrian fatality rates.

The results from tables 3 and 4 suggest that safety benefits accruing from increased seat belt use outweigh the effects of possible risk compensation by drivers. This is because of the consistently negative and significant effect of increased seat belt use on vehicle-occupant and total fatalities along with the statistically insignificant relation between pedestrian deaths and seat belt use. However, partial-offsetting behaviour might occur even in the absence of a significant correlation between trends in pedestrian fatalities and seat belt use, if the decline in traffic fatalities is less than expected, given the increase in average seat belt use.

Specifically, average seat belt use among front seat vehicle occupants increased by 65 percentage points (26.31\% to 91.37\%) from 1980 to 1996. Therefore,

\textsuperscript{19} All fatality rates are per 100,000 licensed drivers.
vehicle-occupant death rates should have dropped between 39 to 46% (65 x 0.60, 65 x 0.70). The coefficient estimate of seat belt use (SBELT$_{it}$) from column 4 in table 4 implies that a 1% increase in seat belt use leads to a 0.2065% fall in driver and passenger fatalities. Hence, a 65 percentage-point increase in average seat belt use is associated with a 13.4 % (0.65 x 0.2065) fall in driver and passenger fatalities. Therefore, we find evidence of partial offsetting behaviour as the actual fall in driver and passenger deaths due to increased seat belt use is less than expected. In other words these results suggest that risk compensation by drivers led to some vehicle occupant fatalities, which attenuated the expected full benefits from increased seat belt use.

However, this evidence of risk compensation may simply be an artifact of simultaneity bias. OLS estimates of seat belt use might be biased downwards because of the introduction of initiatives aimed at improving average seat belt use by provinces with high per capita fatality rates, in an effort to reduce deaths from motor-vehicle accidents. Hence, OLS coefficient estimates of seat belt use (SBELT$_{it}$) would be inconsistent because of a contemporaneous correlation with the right hand side error term from equation (1). In order to account for this possible simultaneity bias we construct instruments aimed at explaining trends in average seat belt use (SBELT$_{it}$) independent of the error term.

As discussed earlier, regulators may implement policies encouraging seat belt use, as a result of efforts by public safety groups. A key tool used by these groups is past trends in traffic fatalities. An upward trend in deaths and injuries among vehicle

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20 Pedestrians in this study also include bicyclists, and motorcyclists.
21 As mentioned above, this is Levitt and Porter’s (2001) estimate of a reduction in the probability of dying, with seat belt use.
22 This is demonstrated in Automotive Coalition for Traffic Safety, Inc. (2001).
occupants supports policies aimed at improving average seat belt use. Hence lagged values of deaths and injuries among vehicle occupants from motor vehicle accidents could be used as instruments as they should not be contemporaneously correlated with the right hand side error term. Unfortunately we could not find data on injuries from motor vehicle accidents. One option is to rely on lagged values of vehicle-occupant fatality rates. However, this would result in a loss of observations from our model, along with statistical power.

As an alternative we employ one year lagged province level data on a variety of police reported traffic related offences. The common thread binding these offences is that they either wholly or in part comprised of behaviour resulting in accidents, and should therefore, be quite closely associated with trends in fatalities and injuries from motor vehicle accidents. First, there is dangerous driving, which consists of speeding, careless lane changing, running traffic lights etc. Second, there is the failure to stop and assist in the event of being involved in an accident. Third, there is impaired driving.\textsuperscript{23, 24} All these offences are per 100,000 licensed drivers. Before we proceed, a clarification is in order. Specifically, a police reported incident of dangerous driving or impaired driving is not necessarily due to an accident. For example, an offender may actually be apprehended before causing an accident. Further, an individual charged with behaviour leading to either injury or death in a motor vehicle accident will usually be charged under any of these three offences. Finally, the use of lagged incidents of traffic safety violations enables us construct more than one instrument, and therefore conduct a test of overidentifying restrictions.

\textsuperscript{23} All these data were obtained from Statistics Canada.
\textsuperscript{24} An individual may be charged with impaired driving if he/she possesses a blood alcohol content level in excess of 0.08\% and/or refusing to take a breathalyzer test.
The appropriateness of the above instruments is tested using $F$-tests of the null hypothesis that the true relationship between these instruments and potential endogenous variables is zero.\(^{25}\) However, the null hypothesis is rejected quite strongly ($F$ test statistic = 5.2933; $p < 0.01$). Further the Hausman test also rejects at the 1\% level, the null hypothesis that seat belt use (SBELT\(d\)) is exogenous ($F$ test statistic = 8.4010; $p < 0.01$).\(^{26}\) Finally, we perform a test of the overidentifying restrictions as suggested by Hansen (1982).\(^{27}\) The null hypothesis of exogeneity of the instruments cannot be rejected ($F$ test statistic = 0.00020; $p > 0.10$).

IV estimation results are given in column 4 of table 4. The coefficient estimate of seat belt use increases by roughly three times over the corresponding OLS coefficient estimate. Specifically, a 1\% increase in average seat belt use is significantly associated with a 0.567\% drop in vehicle occupant death rates (at 5\% level of significance). Hence a 65 percentage point rise in average seat belt use leads to a 37\% fall in driver and passenger fatalities (65 x 0.70), which is quite close to the expected drop of between 39 to 46\%. These findings suggest that benefits from increased average seat belt use are not significantly attenuated as a result of risk

\(^{25}\) The test statistic is distributed with $r$ and $n - k$ degrees of freedom, where $r$ = number of instruments, $n$ = number of observations, and $k$ = number of explanatory variables. As pointed out by Bound et al. (1995) and Staiger and Stock (1997), IV coefficient estimates may be inconsistent and biased, if instruments are only weakly correlated with potential endogenous variables.

\(^{26}\) We use the following form of the Hausman test. Suppose $Y = \chi\beta + \varepsilon$ and $Z$ is a set of instruments for $X$. With some algebraic manipulation, it can be shown that $\beta^{IV} - \beta^{OLS} = (Z\chi)\left(Z^{\prime}Z\right)^{-1}(Z\varepsilon)^{OLS}$, which will be zero if $Z$ and $\varepsilon^{OLS}$ are uncorrelated. This can be tested by running the regression $Y = \chi\beta + Z\theta + \varepsilon$ and testing $\theta = 0$ with an $F$ test. The test statistic is distributed with $r$ and $n - k$ degrees of freedom, where $r$ = number of variables in $Z$, $n$ = number of observations, and $k$ = number of explanatory variables. Please see Kennedy (1997) for further details.

\(^{27}\) The test statistic is given by $O = s^{2}(Z\varepsilon)(Z^{\prime}Z)^{-1}(Z\varepsilon)$, where $Z$ is the matrix of instruments, $\varepsilon$ is the vector of error terms from the second-stage IV estimation routine and $s^{2}$ is the estimated variance of the error terms from this regression. Under the null hypothesis of exogeneity of the instruments, $O$ is distributed $\chi^{2}$ with degrees of freedom given by the number of overidentifying restrictions ($J + 1$), where $J$ is the number of endogenous variables.
compensation by drivers. Evidence of partial-offsetting behaviour found by previous studies may therefore, be inaccurate and simply be a product of simultaneity bias.

V. Conclusion

OLS estimates of the impact of seat belt use on Canadian traffic fatalities suggest the presence of partial offsetting behaviour, as increased seat belt use is only associated with a 13.42% decline in vehicle-occupant deaths in comparison to the expected 39-46%. However, further investigation reveals OLS estimates to be attenuated because of simultaneity bias. Specifically, IV estimates imply that increased average seat belt use is correlated with a 37% fall in driver and passenger deaths, which is very close to the expected drop. Therefore, prior findings of partial-offsetting behaviour may simply be a product of simultaneity bias.
Figure 1: Traffic Fatalities and Average Seat Belt Use

- Seat Belt Use
- Occupants
- Pedestrians
### Table 1: Compilation of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description and Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALCPRICE&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Real alcohol price index. Obtained from Statistics Canada.</td>
</tr>
<tr>
<td>FUEL&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Gross sales of gasoline to on and off road vehicles per 100,000 of population. Data on gasoline sales available from “Road Motor Vehicles: Fuel Sales” Statistics Canada Cat. No. 53 218.</td>
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<tr>
<td>MINAGE&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Province specific minimum legal drinking age. Obtained from provincial statutes.</td>
</tr>
<tr>
<td>PM1524&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Percentage of males between fifteen to twenty-four years of age. Obtained from Statistics Canada.</td>
</tr>
<tr>
<td>POLICE&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Number of police officers per 100,000 of population. Obtained from Statistics Canada.</td>
</tr>
<tr>
<td>SBELT&lt;sub&gt;it&lt;/sub&gt;</td>
<td>The percentage of car diver’s wearing seat belts. Data available from Transport Canada’s annual surveys of seat belt use in Canada.</td>
</tr>
<tr>
<td>UNEMP&lt;sub&gt;it&lt;/sub&gt;</td>
<td>Provincial unemployment rates available from Statistics Canada.</td>
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Table 2: Summary Statistics 1980 - 1996

<table>
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<tr>
<th>Variable</th>
<th>Acronym</th>
<th>N</th>
<th>MEAN</th>
<th>ST. DEV</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
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<tr>
<td>Vehicle-Occupant Fatality Rate</td>
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<td>22.196</td>
<td>13.210</td>
<td>6.7481</td>
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<td>Passenger Fatality Rate</td>
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<td></td>
<td>7.1150</td>
<td>4.6738</td>
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<td>Total Fatality Rate</td>
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<td>27.024</td>
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<td>Pedestrian Fatality Rate</td>
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<td></td>
<td>6.2957</td>
<td>6.7399</td>
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<td>62.6275</td>
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<td>Average Seat Belt Use by Drivers and Front Seat Passengers</td>
<td>SBELT&lt;sub&gt;f&lt;/sub&gt;</td>
<td>149</td>
<td>68.504</td>
<td>26.807</td>
<td>3.4</td>
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<td>Legal Minimum Drinking Age</td>
<td>MINAGE&lt;sub&gt;f&lt;/sub&gt;</td>
<td>149</td>
<td>18.658</td>
<td>0.47607</td>
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<td>Percentage of Young Males (15-24)</td>
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<td>149</td>
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<td>Average Fuel Consumption</td>
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<td>Police Per 100,000 of Population</td>
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<td>149</td>
<td>186.65</td>
<td>22.851</td>
<td>141.70</td>
<td>267.30</td>
</tr>
<tr>
<td>Alcohol Price Index</td>
<td>ACPRICE&lt;sub&gt;f&lt;/sub&gt;</td>
<td>149</td>
<td>82.674</td>
<td>19.736</td>
<td>36.300</td>
<td>109.50</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>UNEMP&lt;sub&gt;f&lt;/sub&gt;</td>
<td>149</td>
<td>10.740</td>
<td>3.6594</td>
<td>3.8000</td>
<td>20.400</td>
</tr>
</tbody>
</table>


Table 3: Estimates of the Impact of Seat Belt Use on Driver and Passenger Fatalities 1980 – 1996 28

<table>
<thead>
<tr>
<th></th>
<th>(1) Base Specification</th>
<th>(2) Province and Year Fixed Effects &amp; Trends</th>
<th>(3) Drinking and Driving</th>
<th>(4) All Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat Belt Use ((SBELT_{it}))</td>
<td>-0.36956 (0.5422E-01)***</td>
<td>-0.24264 (0.666E-01)***</td>
<td>-0.15860 (0.7086E-01)**</td>
<td>-0.20654 (0.7653E-01)***</td>
</tr>
</tbody>
</table>
| Percentage of Young Males \(-15 to 24 (PM1524_{it})\) Police Per 100,000 of Population \((POLICE_{it})\) Per Capita Fuel Consumption \((FUEL_{it})\) Unemployment Rate \((UNEMP_{it})\) Minimum Legal Drinking Age \((MINAGE_{it})\) Alcohol Price Index \((ALCPRICE_{it})\) PROVINCE FIXED EFFECTS NO YES YES YES YES
| Police Per 100,000 of Population \((POLICE_{it})\) | -0.71100 (0.51463) | -0.27199E-01 (0.54516E-01) | 0.21685E-02 (0.15236) | -0.71100 (0.51463) |
| Per Capita Fuel Consumption \((FUEL_{it})\) | -0.27199E-01 (0.51463) | -0.27199E-01 (0.54516E-01) | 0.21685E-02 (0.15236) | -0.71100 (0.51463) |
| Unemployment Rate \((UNEMP_{it})\) | -0.27199E-01 (0.51463) | -0.27199E-01 (0.54516E-01) | 0.21685E-02 (0.15236) | -0.71100 (0.51463) |
| Minimum Legal Drinking Age \((MINAGE_{it})\) | -0.27199E-01 (0.51463) | -0.27199E-01 (0.54516E-01) | 0.21685E-02 (0.15236) | -0.71100 (0.51463) |
| Alcohol Price Index \((ALCPRICE_{it})\) | -0.27199E-01 (0.51463) | -0.27199E-01 (0.54516E-01) | 0.21685E-02 (0.15236) | -0.71100 (0.51463) |
| PROVINCE FIXED EFFECTS NO YES YES YES YES |
| YEAR FIXED EFFECTS NO YES YES YES YES |
| PROVINCE LINEAR TRENDS NO YES YES YES YES |
| Adjusted R-Squared | 0.4238 | 0.7653 | 0.8152 | 0.8233 |

28The dependent variable is the natural logarithm of total vehicle-occupant fatalities per 100,000 of licensed drivers. Standard errors are included in parentheses. The data set is comprised of 149 observations from annual provincial data between 1980 to 1996 for British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, and Prince Edward Island, and from 1987 onwards for Quebec, from 1985 onwards for Nova Scotia, and from 1986 onwards for Newfoundland. Standard errors of the estimates are White corrected for heteroskedasticity and Newey West corrected for first-order autocorrelation.
Table 4: Estimates of the Impact of Seat Belt Use on Different Traffic Fatalities 1980 – 1996

<table>
<thead>
<tr>
<th></th>
<th>(1) All Fatalities</th>
<th>(2) All Passengers</th>
<th>(3) Pedestrians</th>
<th>(4) IV – Drivers and Passengers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seat Belt Use (SBELTi)</td>
<td>-0.21938</td>
<td>-0.15433</td>
<td>-0.20371</td>
<td>-0.56645</td>
</tr>
<tr>
<td></td>
<td>(0.75233E-01)***</td>
<td>(0.74819E-01)***</td>
<td></td>
<td>(0.21611)**</td>
</tr>
<tr>
<td>Percentage of Young</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males –15 to 24</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(PM1524it)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Police Per 100,000 of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population (POLICEit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per Capita Fuel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consumption (FUELit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(UNEMPi)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum Legal Drinking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (MINAGEit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol Price Index</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ALCPRICEit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROVINCE FIXED EFFECTS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>YEAR FIXED EFFECTS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>PROVINCE LINEAR TRENDS</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.8298</td>
<td>0.6824</td>
<td>0.0825</td>
<td>0.7630</td>
</tr>
</tbody>
</table>

Standard errors are included in parentheses. The data set is comprised of 149 observations from annual provincial data between 1980 to 1996 for British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, New Brunswick, and Prince Edward Island, and from 1987 onwards for Quebec, from 1985 onwards for Nova Scotia, and from 1986 onwards for Newfoundland. Standard errors of the estimates are White corrected for heteroskedasticity and Newey West corrected for first-order autocorrelation.
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Transport Canada, “Estimates and Lives Saved Among Front Seat Occupants of Light-Duty Vehicles Involved in Collisions Attributable to the Use of Seat Belts and
Air Bags in Canada.”, TP13187E Fact Sheet RS 2001-03 E, Road Safety and Motor Vehicle Regulation: October 2001