Estimating the Impact of Seat Belt Use on Traffic Fatalities: Empirical Evidence from Canada

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Ce rapport se veut une contribution à la littérature sur l'effet du port de la ceinture de sécurité et du nombre de morts de la route au Canada. Nous y analysons des données provinciales, recueillies entre 1980 et 1996. Les évaluations empiriques obtenues par les premières analyses de régression par variables instrumentales suggèrent que l'obligation du port de la ceinture de sécurité est reliée de façon significative à une augmentation de l'utilisation moyenne de la ceinture de sécurité. Les évaluations obtenues par les secondes analyses de régression indiquent pour leur part qu'une augmentation de 1 % de l'utilisation moyenne de la ceinture est corrélée à une baisse allant de 0,17 % à 0,21 % de la mortalité chez les occupants de véhicules routiers. Ces résultats suggèrent que la baisse de plus ou moins 17 % du nombre de morts de la route est donc attribuable à la mise en vigueur des règlements sur le port obligatoire de la ceinture de sécurité et à l'augmentation correspondante du port de la ceinture.

Mots clés : morts de la route, port de la ceinture de sécurité, comportement compensatoire

This study contributes to the literature by using provincial data in Canada between 1980 and 1996 to analyze the effect of seat belt use on traffic fatalities. Empirical estimates from first stage instrumental-variables regressions suggest that the enactment of mandatory seat belt laws is significantly associated with an increase in average seat belt use, while corresponding estimates from second stage regressions imply that a 1 percent increase in average seat belt use is correlated with a 0.17–0.21 percent drop in vehicle-occupant fatalities. These results suggest that roughly 17 percent of the observed decline in vehicle-occupant fatalities is attributable to the enactment of mandatory seat belt legislation and the corresponding increase in seat belt use.

Keywords: traffic fatalities, seat belt use, offsetting behaviour

Introduction

On 6 April 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 percent 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 percent. The desire of policy-makers to increase average seat belt use is not restricted to Canada. In his weekly radio address to the nation on 28 December 1996, President Clinton asked all Americans to always wear seat belts to minimize traffic injuries and fatalities. On 23 January 1997, the President directed the Secretary of Transportation to prepare a plan to increase national seat belt usage from 68 percent in 1996 to 85 percent by 2000 and 90 percent by 2005 (National Highway Traffic Safety Administration 2001).[1]

It is not surprising that increasing average seat belt use has occupied a prominent place in policy-making, given the costs that motor vehicle accidents place on society. We attempt to contribute to the literature by using provincial Canadian data between 1980 and 1996 to evaluate empirically (a) the effects of mandatory seat belt laws on average seat belt use, and (b) the efficacy of seat belt use in reducing traffic fatalities. We use an instrumental variables framework where first stage regressions estimate the effects of provincial mandatory seat belt laws on corresponding average seat belt use, and second stage regressions evaluate the effect of resulting seat belt use on traffic fatality trends. While such research is interesting from the perspective of Canadian public policy, the use of Canadian data also yields other benefits, which can be better understood from the following stylized facts.

First, Ontario and Quebec became the first North American jurisdictions to implement seat belt use laws in 1976, and were subsequently followed by all other Canadian provinces, with Alberta being the last to enact similar legislation in 1987. In contrast, seat belt laws were not passed in the United States until 1984, in New York. Forty-nine states and Washington currently possess some form of seat belt legislation. Second, Canada witnessed a significant increase in average seat belt use over the sample period, from 26 percent in 1980 to 91 percent in 1996, which coincided with the enactment of seat belt laws across all jurisdictions and surpassed corresponding seat belt use in the United States.

This rich cross-province time-series variation allows us to control for the impact of unobserved province and/or time-specific determinants of traffic fatalities as well as average seat belt use with the help of two-way fixed effects models. Further, we control for the effects of unobserved jurisdictional initiatives with province-specific trends. Simple OLS (ordinary least squares) estimates of the impact of seat belt use or mandatory seat belt legislation might otherwise be confounded to the extent that they reflect movements in other unobserved determinants of traffic fatalities within provinces through time.

Employing Canadian data may be interesting for other reasons. First, as noted above, the increase in average seat belt use has been rather dramatic with usage rates exceeding corresponding US levels. Second, while there is a significant amount of research on the efficacy of seat belt use and seat belt laws in the United States, there remains a remarkable paucity of similar research exploiting cross-jurisdictional and time-series variation on seat belt laws and average seat belt use in other countries. Hence, using Canadian data permits us to evaluate the robustness of recent US findings.

Instrumental variables (IV) coefficient estimates of the effects of increased average seat belt use on a variety of traffic fatality rates suggest that policies aimed at encouraging seat belt use result in considerable benefits for society. Specifically, empirical estimates from first stage regressions imply that the enactment of mandatory seat belt laws is significantly associated with an increase in average seat belt use. Further, second stage regression results suggest that a 1 percent increase in seat belt use generated from the enactment of seat belt laws is significantly correlated with a 0.17–0.21 percent drop in vehicle-occupant fatalities. In summary, our estimates suggest that increased seat belt use from the enactment of mandatory seat belt legislation was responsible for 17 percent of the decrease in vehicle-occupant fatality rates that occurred between 1980 and 1996.

The remainder of the paper is organized into sections on the following topics: previous research, trends in traffic fatalities and seat belt use, empirical specification and data, estimation results, important policy implications, and a concluding summary.

Previous Literature

A significant number of studies have employed aggregate data to evaluate the effects of mandatory seat belt laws and seat belt use. While some studies have found increased seat belt use and the enactment of seat belt legislation to be correlated with lower traffic fatalities, others arrive at different conclusions. For example, Garbacz (1990) finds a statistically precise and positive correlation between average seat belt usage and non-occupant death rates; Calkins and Zlatoper (2001) obtain a positive correlation between occupant and non-occupant fatalities and seat belt laws; McCarthy (1999) finds a positive correlation between mandatory seat belt laws and the number of fatal accidents; and Risa (1994) obtains a significant and positive relationship between occupant and non-occupant fatalities and seat belt usage.[2] In contrast, Garbacz (1992) does not find any significant relationship between mandatory seat belt laws and total non-occupant and occupant deaths. Derrig et al. (2002) also fail to uncover any statistically significant association between population seat belt usage and motor vehicle fatalities.[3]

The positive relationship between seat belt use/legislation and non-occupant fatalities obtained by some of these studies has been interpreted as evidence of offsetting behaviour.[4] Specifically, vehicle safety regulation could 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. Risk compensation by drivers could also result in increased harm to themselves and to other drivers and passengers. Hence, increased seat belt use may actually be associated with *more* deaths and injuries from motor vehicle accidents. Typically, the existence of offsetting behaviour is evaluated by assessing the correlation between seat belt laws/use and pedestrian fatalities.

However, other studies have found a statistically precise and negative relationship between deaths from motor vehicle accidents and improved seat belt use. Specifically, Garbacz (1991) finds a correlation between diminished seat belt use and greater occupant and total fatalities.[5] Other studies support the benefits of enacting mandatory seat belt laws. Asch et al. (1991), Evans and Graham (1991), Houston, Richardson, and Neeley (1995), Loeb (1995), Sen (2001), and Young and Likens (2000) all obtain a statistically significant and negative association between the introduction of seat belt laws and traffic fatalities.[6]

An important point is that much of the above findings stem from an identification strategy that either exploits cross-jurisdictional variation in mandatory seat belt laws or seat belt use over a limited time period, or relies exclusively on a simple time series. Hence, coefficient estimates of seat belt legislation or use may be confounded because of an inability to disentangle the true impact of mandatory seat belt legislation or increased seat belt use from unobserved jurisdiction-specific characteristics that are time-invariant or from year-specific shocks that are common across all jurisdictions.[7]

Of course, some of these studies have pooled cross-sections of time series. However, few of them use two-way (state and year) fixed effects, rendering it difficult to attribute any causal inference to the impact of seat belt laws or use. The few papers that have employed two-way fixed effects models focus on the impact of mandatory seat belt legislation (Sen 2001; Young and Likens 2000). However, as noted by Cohen and Einav (2003), mandatory seat belt laws have only an *indirect* effect on trends in traffic fatalities, whereas population seat belt use *directly* impacts these trends. Using a dummy variable approach to identify the effects of seat belt laws assumes that such legislation has a similar impact on motor vehicle accidents across provinces and over time upon implementation. In fact, seat belt laws will have differential effects on traffic fatalities conditional on their impact on corresponding seat belt use.

This observation suggests an empirical strategy where average seat belt use is instrumented by mandatory seat belt laws. Such an approach has the advantage of further addressing the problem of simultaneity bias. Specifically, higher average seat belt use could be the result of stricter penalties stemming from concern over high levels of traffic fatalities. In their seminal paper, Cohen and Einav (2003) address many of the above issues. The authors use cross-state data from 1983 to 1997 and employ seat belt laws as instruments for seat belt use, thus identifying the impact of enacting seat belt legislation on average seat belt use separately from the effects of seat belt use on vehicle-occupant fatalities. Their results suggest that the introduction of primary seat belt laws is correlated with a 22 percentage-point increase in average seat belt use, and that a 1 percent increase in seat belt use is associated with a 0.13 percent drop in occupant fatalities.

However, there still remains scope for contributions to the literature. From the simplest perspective, it is quite possible that these findings might not be applicable to the Canadian context. Specifically, while the enactment of Canadian mandatory seat belt laws paralleled the introduction of similar legislation in the United States, the rise in average seat belt use witnessed over the sample period is rather sharp and exceeded corresponding increases observed in the United States. These facts suggest that Canadian seat belt laws might have had a more pronounced direct impact on seat belt use and an indirect effect on traffic fatalities. Hence, exploiting the natural variation available from Canadian data possesses the further benefits of providing us with an opportunity to conduct a confirmatory exercise to test the robustness of recent US findings. Further, using cross-province and time-series Canadian data allows us to employ two-way fixed effects and province-specific linear trends. This is important, as only a few studies have accomplished this.

Canadian Traffic Fatalities, Seat Belt Laws, and Seat Belt Use

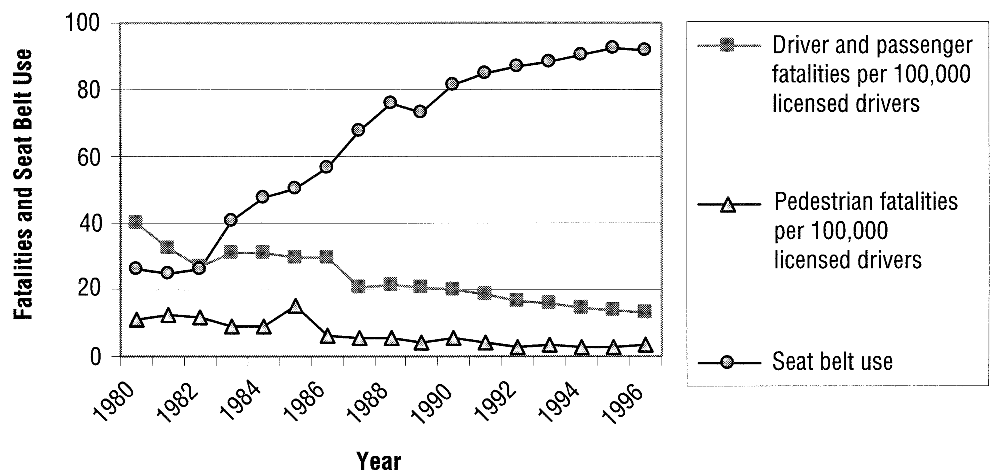
Data on traffic fatalities between 1980 and 1996 were obtained from the Traffic Injury Research Foundation (TIRF) and Transport Canada.[8] TIRF is a non-profit organization that has compiled an extensive data set of most traffic fatalities in Canada from 1973 to the present.[9] The data set was constructed by matching information from different sources, including police, coroner, and hospital reports. Fatalities are classified according to status (driver, passenger, motorcyclist, bicyclist, and pedestrian), age, gender, and time and day of accident. Unfortunately, the database does not possess information on injuries from motor vehicle accidents.

Information on average seat belt use for drivers and front seat passengers was obtained from Transport Canada's annual surveys on seat belt use in Canada. The surveys, which have been conducted biannually since 1980 (in June and December) to control for seasonal variation, are based on road surveys undertaken at over 200 sites selected by province, community size, and road type. The methodology used in these surveys has been consistent over time and, as a result, more recent data are comparable to samples used in the earlier national seat belt use surveys. The reliability of the surveys can be assessed by the fact that they are routinely cited and employed by policy-makers (e.g., Ontario Ministry of Transportation 2002).

Figure 1 shows that there has been a dramatic decline in Canadian vehicle-occupant and non-occupant fatality rates (per 100,000 licensed drivers) between 1980 and 1996. Specifically, vehicle-occupant fatalities have dropped by roughly 68 percent (39.67 – 12.95/39.67), and pedestrian death rates declined by 69 percent (10.93 – 3.34/10.93).[10] Increases in seat belt use for drivers and front seat passengers have been equally noteworthy: roughly 65 percentage points from 26.31 to 91.37 percent over the sample period. In comparison, average seat belt use in the United States increased from approximately 10 percent in 1983 to 68 percent in 1996. Of course, it is important to note that seat belt legislation in the United States can be either primary or secondary. The distinction between the two is that under secondary enforcement an offender can be charged for not wearing a seat belt only if he or she is stopped for another felony. There are no secondary seat belt laws in Canada.

Table 1 documents cross-province variation in vehicle-occupant and non-occupant death rates, average seat belt use, and mandatory seat belt legislation in 1980 and 1996, the two end-year sample points. These figures suggest significant cross-province variation in seat belt use in 1980. Three provinces with mandatory seat belt laws—Ontario, British Columbia, and Saskatchewan—had an average seat belt use of 51.23 percent, while the corresponding figure for four provinces without such laws was 7.62 percent. Quebec also had mandatory seat belt laws in 1980, but data on traffic fatalities in Quebec are only available from 1987 onwards.

FIGURE 1
Fatalities and Seat Belt Use 1980–1996



Source: See Fatality Rates and SBELT in the Appendix.

TABLE 1

Variation in Vehicle-Occupant Fatalities, Pedestrian Fatalities, Seat Belt Use, and Mandatory Seat Belt Laws 1980–1996

Provinces	*Vehicle-Occupant Fatalities*[a]	*Pedestrian Fatalities*[a]	*Seat Belt Use (%)*	*Mandatory Seat Belt Legislation for Drivers*
1980[b]				
British Columbia	32.158	8.842	49.3	Yes
Alberta	34.192	7.665	12.7	No
Saskatchewan	36.643	7.627	60.7	Yes
Manitoba	23.377	9.563	6.0	No
Ontario	23.811	7.510	43.7	Yes
New Brunswick	48.072	14.559	5.6	No
Prince Edward Island	79.450	20.726	6.2	No
1996				
British Columbia	9.218	2.562	92.6	Yes
Alberta	14.157	2.475	89.8	Yes
Saskatchewan	15.879	3.206	94.0	Yes
Manitoba	10.189	2.791	85.0	Yes
Ontario	10.081	2.669	92.3	Yes
Quebec	14.810	4.852	93.2	Yes
New Brunswick	14.694	3.673	89.5	Yes
Nova Scotia	13.753	3.751	91.2	Yes
Prince Edward Island	18.162	2.137	91.8	Yes
Newfoundland	8.536	5.298	94.3	Yes

Notes:

[a]Per 100,000 licensed drivers.

[b]Data are not available until 1985 for New Brunswick, 1986 for Newfoundland, and 1987 for Quebec.

Source: See Fatality Rates and SBELT in the Appendix.

In terms of specific variation, Ontario and Quebec were the first provinces to enact mandatory seat belt laws in 1976, followed by British Columbia and Saskatchewan in 1977, Newfoundland in 1982, and Manitoba and New Brunswick in 1984. Nova Scotia enacted its legislation in 1985, and Prince Edward Island and Alberta finally followed suit in 1987.

A relevant question is why some provinces enacted mandatory seat belt laws later than others. One explanation is that such provinces are more conservative and view such regulation as intrusion on personal freedom and rights. This is a tempting inference given the consistent reign of the Conservative party in both Prince Edward Island and Alberta during the 1980s, and the fact that seat belt laws were enacted in Prince Edward Island in the same year the Liberals assumed power, in 1987. However, in a carefully constructed survey conducted in Alberta, Loo (1984) found strong support for the compulsory use of seat belts—specifically, 78 percent of females and 66 percent of males supported mandatory seat belt laws.

Perhaps a more consistent explanation can be found in the ambiguity of contemporary research findings on the efficacy of seat belt use. For example, studies by Peltzman (1975) and O'Neil (1977) emphasized the risk compensation aspects of seat belt use that were recognized by policy-makers. Further, Jonah and Lawson (1984) find that while the enactment of seat belt laws in Ontario, Quebec, British Columbia, and Saskatchewan did result in an immediate increase in seat belt use, this was followed by a significant decline in succeeding years and, perhaps more importantly, the corresponding reductions in casualty rates were less than expected. However, Jonah and Lawson (1984) used an extremely small sample size consisting of observations from a couple of years preceding and succeeding the enactment of seat belt laws in the four provinces. This point underscores the importance of evaluating the efficacy of seat belt laws and use over a relatively long time period and across all provinces and, of course, employing a rigorous econometric methodology.

Empirical Specification

We employ the following empirical specification to evaluate the effects of seat belt use on traffic fatalities:

$$\begin{aligned} \text{FATALITIES}_{it} = {} & b_0 + b_1\,\text{SBELT}_{it} + b_2\,\text{DRINK}_{it} \\ & + b_3\,\text{CONTROL}_{it} + \Sigma_i \text{PROV}_i \\ & + \Sigma_t \text{YEAR}_t + \Sigma_{it}\,\text{TREND}_{it} \\ & + v_{it} \end{aligned} \qquad (1)$$

where i = provinces 1 through 10 and t = the years 1980 through 1996, and $v_{it} \sim \text{NID}(0, \sigma^2)$. FATALITIES_{it} denotes different traffic fatality rates; SBELT_{it} is the province-year average percentage of drivers and front seat passengers who wear seat belts; DRINK_{it} refers to alcohol prices and the minimum legal drinking age; CONTROL_{it} includes exogenous variables that measure travelling time, demographic trends, economic conditions, and police presence; $\Sigma_i \text{PROV}_i$ are province effects; $\Sigma_t \text{YEAR}_t$ are year effects; $\Sigma_i \text{TREND}_{it}$ are province-specific linear trends; and v_{it} is an error term.[11] Summary statistics for these variables are documented in Table 2, and sources are listed in the Appendix.

Fatality rates (total, driver, passenger, and pedestrian) from motor vehicle accidents are used to assess the overall impact of provincial traffic safety initiatives. It is important to emphasize that, in accordance with previous studies, we include motorcyclists and bicyclists as non-occupants or pedestrians. All fatality rates are per 100,000 licensed drivers.

SBELT_{it} is the percentage of drivers and front seat passengers who wear seat belts. Increased seat belt use should be correlated with declining vehicle-occupant (driver and passenger) fatality rates. However, enhanced safety benefits from increased seat belt use may be offset by a rise in pedestrian deaths because of risk compensation by drivers. In this scenario, we expect pedestrian fatality rates to be positively correlated with increased seat belt use.

An increase in drinking and driving should significantly impact trends in traffic fatalities, independent of changes in average seat belt use. DRINK_{it} consists of variables representing the effects of plausible policy instruments aimed at controlling alcohol consumption. Many studies have found higher alcohol prices/taxes (ALINDEX_{it}) to be significantly correlated with fewer traffic fatalities (e.g., Chaloupka, Grossman, and Saffer 1993). However, other research suggests that the minimum legal drinking age is an important deterrent to drunk driving (Dee 1998). To capture cross-province variation we construct MINDUM_{it}, which is 1 if the minimum legal drinking age is 19, and 0 otherwise.

Movements in traffic fatalities should be associated with the amount of average driving. Specifically, the number of deaths from traffic

TABLE 2
Summary Statistics 1980–1996

Instrument Variables	*N*	*Mean*	*SD*	*MIN*	*MAX*
Fatality rates					
Vehicle occupant	152	22.147	13.091	5.2960	85.760
Pedestrian	152	6.3032	6.6731	0	62.627
Total	152	26.979	16.726	7.3556	125.25
Passenger	152	7.0853	4.6341	1.0859	37.599
Alcohol price index ($ALINDEX_{it}$)	152	82.489	19.591	36.3	109.5
Fuel consumption per capita of population ($FUEL_{it}$)	152	1644.4	1678.8	937.40	11,786
Minimum legal drinking age ($MINDUM_{it}$)	152	0.65789	0.47598	0	1
Percentage of young males between 15–24 ($PM1524_{it}$)	152	8.3249	1.0792	6.7481	11.333
Police officers per 100,000 of population ($POLICE_{it}$)	152	5.2202	0.12077	4.9537	5.5884
Seat belt use ($SBELT_{it}$)	152	68.619	26.559	3.4	100.0
Unemployment rate ($UNEMP_{it}$)	152	10.812	3.6945	3.8	20.4

Source: See the Appendix.

accidents could increase as people drive more. Travelling time is proxied by average fuel consumption per 100,000 of population aged 15 years and over, with fuel consumption based on total gasoline sales in litres. An increase in per capita average gasoline sales ($FUEL_{it}$) should capture increases in travelling time.

Trends in traffic fatalities should also be impacted by a change in demographic profiles. Male drivers aged 15 to 24 are generally associated with risky driving and a greater probability of causing traffic accidents. In order to test this hypothesis, we include the percentage of young males aged 15 to 24 as an explanatory variable ($PM1524_{it}$).

The effects of increased police vigilance are captured by the number of police officers per 100,000 of population ($POLICE_{it}$).[12] An increase in the number of police officers should embody greater enforcement of traffic safety laws, and hence have a negative impact on traffic fatalities.[13]

Provincial unemployment rates ($UNEMP_{it}$) quantify the effects of economic conditions on traffic fatalities. The net impact of higher unemployment rates is ambiguous. An increase in economic well-being (lower unemployment rate) may be positively correlated with traffic fatalities if it captures the impact of higher alcohol consumption or more travel.[14] However, a lower unemployment rate may also lead to investment in safer, more durable vehicles, which could reduce traffic fatalities and injuries.

Estimation Results

Baseline Results

This section sets an empirical baseline for evaluating the impact of seat belt use on different traffic fatalities. Fatality rates data are available for seven provinces from 1980 to 1996 (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Nova Scotia, and Prince Edward Island), but only since 1985 for New Brunswick, 1986 for Newfoundland, and 1987 for Quebec. Consequently, our empirical results are based on an unbalanced panel data set of 152 observations.

Table 3 contains OLS estimates of equation 1 with province-level data from 1980 to 1996. The dependent variables in the columns are the natural logarithms of driver, total, passenger, and pedestrian fatality rates per 100,000 licensed drivers. With the exception of binary indicators, all variables are in natural logarithms as suggested by a Box-Cox regression. The first important result is the statistically significant coefficient estimate of seat belt use ($SBELT_{it}$) among drivers, which implies that a 1 percent increase in seat belt use is associated with roughly a 0.23 percent drop in driver deaths at 1 percent level of significance. The coefficient estimates of the percentage of young male drivers ($PM1524_{it}$) and the minimum legal drinking age ($MINDUM_{it}$) are also statistically significant and possess intuitive signs.

The question now is whether increased seat belt use also leads to significant offsetting behaviour resulting in higher pedestrian or even passenger deaths. However, the empirical results in columns 2 to 4 offer little support for offsetting behaviour. Specifically, seat belt use ($SBELT_{it}$) is statistically significant and is associated with a drop of approximately 0.23 percent in both total fatalities and passenger death rates. The percentage of young males ($PM1524_{it}$) is also statistically significant and possesses the expected positive coefficients. In terms of other variables, an increase in the number of per capita police officers ($POLICE_{it}$) leads to lower overall traffic fatalities, while a higher minimum legal drinking age ($MINDUM_{it}$) is significantly associated with fewer total and passenger deaths from road accidents. Finally, empirical estimates from column 4 show that increased seat belt use shares no statistically significant relation with pedestrian fatality rates.

The results from Table 3 suggest that safety benefits accruing from increased seat belt use outweigh the effects of possible risk compensation by drivers. Increased seat belt use has a consistently negative and significant effect on vehicle-occupant and total fatalities, and a statistically insignificant effect on pedestrian deaths. In order to evaluate the robustness of our results, we replicated the above analysis employing a levels specification and obtained very similar results, which are available upon request.

Instrumental Variables

We have so far assumed that an increase in seat belt use exogenously determines movements in fatality rates. But the increase in average seat belt use might be the result of policy initiatives stemming from public concern regarding trends in traffic fatalities. If this is true, then OLS will result in coefficient estimates that are inconsistent and biased downwards. A rigorous methodology to evaluate the possibility of simultaneity bias would use instruments that explain trends in average seat belt use

TABLE 3
OLS Estimates of the Impact of Seat Belt Use on Traffic Fatalities (Log-Log Model)

Instrument Variables	*(1) Driver*	*(2) Total*	*(3) Passenger*	*(4) Pedestrian*
Seat belt use ($SBELT_{it}$)	**−0.2354**	**−0.2329**	**−0.2389**	0.1517
	(0.0601)***	**(0.0529)*****	**(0.0884)*****	(0.3051)
Police per 100,000 of population ($POLICE_{it}$)	−0.7196	**−0.8308**	−0.3936	7.0177
	(0.4702)	**(0.4484)***	(0.7273)	(7.2021)
Per capita fuel consumption ($FUEL_{it}$)	0.0244	−0.0214	−0.3936	0.2435
	(0.0613)	(0.0639)	(0.7273)	(0.4939)
Percentage of young male drivers ($PM1524_{it}$)	**2.2821**	**1.6995**	**3.7775**	−1.2912
	(0.8302)***	**(0.8125)*****	**(1.3316)*****	(3.3802)
Unemployment rate ($UNEMP_{it}$)	−0.0540	−0.0491	−0.0045	−1.1964
	(0.1523)	(0.1322)	(0.1788)	(1.1477)
Minimum drinking age ($MINDUM_{it}$)	**−0.4363**	**−0.3585**	**−0.5578**	−0.6229
	(0.1401)*	**(0.1519)****	**(0.1742)*****	(0.7688)
Alcohol price index ($ALINDEX_{it}$)	−0.0415	−0.1792	0.8497	−1.9344
	(0.4202)	(0.4160)	(0.7013)	(2.5790)
Province fixed effects	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES
Province-specific trends	YES	YES	YES	YES
Adjusted R-square	0.8214	0.8313	0.6789	0.0898

Notes: OLS = ordinary least squares. Standard errors of the estimates are White corrected for heteroskedasticity and Newey West corrected for first-order autocorrelation.
*$p < .10$. **$p < .05$. ***$p < .01$.
Source: See the Appendix.

($SBELT_{it}$) independent of the error term in equation 1. Similar to Cohen and Einav (2003), we exploit cross-province and time-series variation in the enactment of provincial mandatory seat belt laws to create an instrumental variable ($SLAW_{it}$) that is 1 if a province has such legislation in existence, and is 0 otherwise. This identification strategy is premised on the assumption that the enactment of mandatory seat belt laws should impact traffic fatalities only through their direct effect on average seat belt use, and not indirectly.

However, it is important to acknowledge that the enactment of seat belt legislation may not be an exogenous determinant of seat belt use. Specifically, the implementation of seat belt laws might also be the result of a public demand for enhanced safety initiatives, which would then invalidate its use as an instrument. However, previous research (Ruhm 1996) suggests that the use of two-way (province year) fixed effects should help mitigate any bias in coefficient estimates to the extent that public concerns are fixed within provinces over time. Similarly, the use of linear trends should help in controlling for simultaneity bias stemming from concerns that are province specific but trending over time. But perhaps more importantly, after an extensive literature search, we could not find any evidence suggesting that the implementation of mandatory seat belt laws was actually a consequence of public demand for such legislation. Although this does not offer conclusive evidence that public concerns were not a factor, it is suggestive. In contrast, a number of studies do suggest that the enactment of anti-impaired driving laws during the 1970s and 1980s was very heavily influenced by public concerns manifested through the formation of grassroots organizations such as Mothers Against Drunk Driving (MADD; see Sen 1998).

A further instrumental variables strategy is premised on research that finds seat belt use to be significantly impacted by enforcement efforts directed at implementing mandatory seat belt laws.[15] In order to explore this hypothesis, we create another instrumental variable by interacting mandatory seat belt laws ($SLAW_{it}$) with the number of per capita police officers ($POLICE_{it}$). Of course, the number of per capita police officers is already an instrument in the first stage regression, by virtue of being an exogenous covariate in the second stage.

Empirical estimates from the first stage regression of mandatory seat belt legislation (and other exogenous covariates) on the natural logarithm of seat belt use are contained in Table 4. Column 1 exclusively focuses on the impact of mandatory seat belt legislation along with other exogenous covariates from the second stage, province and year fixed effects, and province-specific linear trends. Column 2 evaluates the effects of using mandatory seat belt laws ($SLAW_{it}$) and the interaction with the per capita number of police officers ($POLICE_{it}$) as instruments.[16]

The results in column 1 demonstrate that the introduction of mandatory seat belt laws is significantly and positively correlated with average seat belt use. Specifically, the coefficient estimate of mandatory seat belt laws (0.92) is statistically significant at 1 percent. Interestingly, the marginal impacts of mandatory seat belt laws ($SLAW_{it}$) shown in column 2 are slightly higher but comparable ($\delta SBELT_{it}/\delta SLAW_{it} = -14.732 + (3.0152) \times 5.22 = 1.01$).[17]

The chosen instruments fulfill the necessary criteria. Specifically, the coefficient estimate of seat belt laws is statistically precise at 1 percent. The interaction of seat belt legislation with the number of police officers is also statistically significant. This finding is important, as IV coefficient estimates may be inconsistent and biased if instruments are only weakly correlated with potentially endogenous variables (Bound, Jaeger, and Baker 1995; Staiger and Stock 1997).

Table 5 consists of second stage IV estimates of the impact of seat belt use on traffic fatalities. Columns 1, 3, and 5 contain empirical estimates of the impact of seat belt use instrumented by seat belt laws on vehicle-occupant, total, and pedestrian fatalities. Columns 2, 4, and 6 consist of second stage estimates of the effects of seat belt use instrumented by seat belt laws and the interaction with the number of per capita police officers on vehicle-occupant, total, and pedestrian fatalities.

The first important and reassuring result is that using seat belt laws exclusively, and interacting this instrument with the number of police officers, produces quite similar results in second stage regressions. Coefficient estimates of the effects of seat belt use ($SBELT_{it}$) on vehicle-occupant and total

TABLE 4

Estimating the Impact of Seat Belt Legislation on ln (Seat Belt Use): First Stage Regressions (IV)

Instrumental Variables	*(1) Seat Belt Laws*	*(2) Seat Belt Laws Interacted with $POLICE_{it}$*
Mandatory seat belt law ($SLAW_{it}$)	**0.9204** **(0.1883)*** **	**−14.7320** **(3.5479)*** **
Mandatory seat belt law ($SLAW_{it}$) x per capita police officers ($POLICE_{it}$)		**3.0152** **(0.6880)*** **
$POLICE_{it}$, $FUEL_{it}$, $PM1524_{it}$, $UNEMP_{it}$, $MINDUM_{it}$, $ALINDEX_{it}$	YES	YES
P values from *F* test of the null hypothesis that coefficient estimates of instruments are zero	0.0000	0.0000
Province fixed effects	YES	YES
Year fixed effects	YES	YES
Province-specific trends	YES	YES
Adjusted R-square	0.8802	0.8895

Notes: IV = instrumental variables. Standard errors of the estimates are White corrected for heteroskedasticity and Newey West corrected for first-order autocorrelation.

***$p < .01$.

Source: See the Appendix.

fatalities are statistically precise and slightly smaller in magnitude and precision than corresponding OLS estimates from Table 3. Specifically, a 1 percent increase in seat belt use ($SBELT_{it}$) is significantly associated with roughly a 0.17–0.21 percent decline in vehicle-occupant and total fatalities. An increase in the minimum legal drinking age ($MINDUM_{it}$) is also significantly correlated with a decline in total and vehicle-occupant fatalities. As was the case with OLS estimates, increased seat belt use is positively and insignificantly correlated with pedestrian fatalities.

In summary, OLS and IV coefficient estimates suggest that a 1 percent increase in average seat belt use is correlated with a 0.17–0.21 percent decrease in traffic fatalities. This is certainly higher than the comparable estimate of 0.13 percent obtained by Cohen and Einav (2003), but it is unsurprising given the considerable increase in average seat belt use experienced in Canada.

A relevant question is whether the IV regressions are fitting the data well. A simple approach would be to rely on the adjusted *R*-square, which is quite

TABLE 5

Estimating the Impact of ln (Seat Belt Use) on ln (Traffic Fatalities): Second Stage Regressions (IV)

Instrumental Variables	*Driver and Passenger Fatalities*		*Total Fatalities*		*Pedestrian Fatalities*	
	(1) Seat Belt Law	*(2) Seat Belt Law and Interaction with Police*	*(3) Seat Belt Law*	*(4) Seat Belt Law and Interaction with Police*	*(5) Seat Belt Law*	*(6) Seat Belt Law and Interaction with Police*
Seat belt use ($SBELT_{it}$)	**−0.1746 (0.1045)***	**−0.2079 (0.0940)***	**−0.1734 (0.1014)***	**−0.1714 (0.0916)***	0.4892 (0.9387)	0.8045 (0.8527)
Police per 100,000 of population ($POLICE_{it}$)	**−0.6559 (0.4101)***	**−0.6908 (0.4057)***	**−0.7682 (0.3978)***	**−0.7661 (0.3953)***	**7.3721 (3.6827)****	**7.7033 (3.6786)****
Per capita fuel consumption ($FUEL_{it}$)	0.0280 (0.0646)	0.0260 (0.0643)	−0.0179 (0.0627)	−0.0177 (0.0626)	0.2636 (0.5801)	0.2824 (0.5828)
Percentage of young males ($PM1524_{it}$)	**2.1081 (0.8313)****	**2.2035 (0.8178)****	**1.5290 (0.8063)***	**1.5232 (0.7969)***	−2.2577 (7.4650)	−3.1607 (7.4163)
Unemployment rate ($UNEMP_{it}$)	−0.0848 (0.1547)	−0.0679 (0.1523)	−0.0793 (0.1500)	−0.0803 (0.1484)	−1.3673 (1.3889)	−1.5269 (1.3815)
Minimum drinking age ($MINDUM_{it}$)	**−0.4453 (0.1058)*****	**−0.4404 (0.1052)*****	**−0.3672 (0.1026)*****	**−0.3675 (0.1025)*****	−0.6727 (0.9503)	−0.7192 (0.9537)
Alcohol price index ($ALINDEX_{it}$)	−0.1693 (0.5286)	−0.0992 (0.5179)	−0.3044 (0.5127)	−0.3087 (0.5047)	−2.6444 (4.7469)	−3.3079 (4.6966)
Province fixed effects	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Province-specific trends	YES	YES	YES	YES	YES	YES
Adjusted R-square	0.8195	0.8210	0.8295	0.8294	0.0861	0.0759

Notes: IV = instrumental variables.
*$p < .10$. **$p < .05$. ***$p < .01$.

Source: See the Appendix.

high, across first and second stage regressions. However, an alternative approach would be to evaluate the accuracy of the empirical models in predicting the actual data points. Table 6 presents the actual beginning and end sample points of seat belt use (the dependent variable of first stage regressions – Table 4, column 1) and vehicle-occupant traffic deaths (the dependent variable of second stage regressions – Table 5, column 1) for each province, along with the associated predicted values.[18] As can be seen, in most cases, the predicted values match the corresponding actual data points quite closely.

Offsetting Behaviour

As discussed above, some studies have found the benefits of seat belt use or mandatory seat belt laws to be attenuated by offsetting behaviour. This possibility might be an explanation for the relatively

TABLE 6

Evaluating the Fit of First and Second Stage Regressions

Provinces	*(1) Actual Vehicle-Occupant Fatalities*[a]	*(2) Predicted Vehicle-Occupant Fatalities*[a]	*(3) Actual Seat Belt Use (%)*	*(4) Predicted Seat Belt Use (%)*
Beginning Year: 1980				
British Columbia	32.158	32.974	49.3	44.441
Alberta	34.192	35.992	12.7	12.974
Saskatchewan	36.643	36.027	60.7	44.544
Manitoba	23.377	21.883	6.0	5.884
Ontario	23.811	22.176	43.7	44.395
Quebec	23.489	22.731	81.6	78.064
New Brunswick	48.072	52.495	5.6	10.341
Nova Scotia	23.740	21.449	80.8	69.435
Prince Edward Island	79.450	68.971	6.2	4.491
Newfoundland	15.633	16.576	61.4	51.531
End Year: 1996				
British Columbia	9.218	11.802	92.6	91.400
Alberta	14.157	16.946	89.8	87.705
Saskatchewan	15.879	18.132	94.0	93.340
Manitoba	10.189	13.902	85.0	87.917
Ontario	10.081	11.057	92.3	93.193
Quebec	14.810	16.003	93.2	88.107
New Brunswick	14.694	17.566	89.5	97.565
Nova Scotia	13.753	12.694	91.2	87.854
Prince Edward Island	18.162	15.312	91.8	111.724
Newfoundland	8.536	6.737	94.3	95.218

Notes:

[a]Per 100,000 licensed drivers.

Source: See Fatality Rates and SBELT in the Appendix.

late enactment of seat belt legislation by some Canadian provinces. In this respect it is important to note that consistent with the methodology used by recent studies, our results suggest an absence of offsetting behaviour as trends in pedestrian fatality rates share no significant correlation with shifts in seat belt use across provinces and over time.

However, relying exclusively on fatality rates might result in an underestimate of the extent of offsetting behaviour. The existence of such behaviour is premised on risky or rash driving, which may not necessarily lead to either increased death or injury rates. This possibility has been acknowledged by the literature; for example, Singh and Thayer (1992) evaluate the existence of offsetting behaviour through trends in traffic safety citations, while Peterson, Hoffer, and Millner (1995) focus on insurance claims.

In order to evaluate this possibility, we estimate the impact of increased seat belt use on various police-reported offences related to risky driving. The first offence we consider is failing to stop and assist in the event of being involved in an accident, which we take as a proxy for traffic accidents (including but not necessarily restricted to injuries). In the same vein, we use the number of police-reported incidents of dangerous driving. Dangerous driving can result from a multitude of risky behaviours such as speeding, careless lane changing, running traffic lights, and so forth.

Employing similar data and an empirical specification corresponding to the one used in Table 3, we find mixed results, as shown in Table 7. While an increase in average seat belt use is positively (and insignificantly) correlated with trends in failing to stop and assist, it is negatively (and significantly) associated with incidents of dangerous driving. However, these results are suggestive enough to imply that exclusively relying on correlations between pedestrian fatalities and average seat belt use may not yield a complete profile of the true extent of offsetting behaviour. Further, other coefficient estimates are broadly consistent with previous results. Specifically, an increase in police officers and the minimum legal drinking age are correlated with fewer incidents of failing to stop and assist and dangerous driving, while a rise in the proportion of young male drivers results in more incidents.

Policy Implications

It is now important to place these results within a public policy context. Recall that IV estimates suggest that (a) the enactment of seat belt laws is correlated with a 92 percent increase in average seat belt use, and (b) a 1 percent increase in seat belt use is associated with a 0.17–0.21 percent drop in vehicle-occupant death rates in a province in a given year. Hence, given that the presence of seat belt laws increased by roughly 60 percent (sample mean of 0.4 in 1980 to 1 in 1996) over the sample period, average seat belt use should have increased by 55 percent (0.92 x 0.60). If a 1 percent increase in seat belt use is correlated with a 0.21 percent drop in vehicle-occupant death rates, then a 55 percent increase in seat belt use should have resulted in an 11.55 percent drop in vehicle-occupant deaths from motor vehicle accidents.

From a policy perspective, it would be interesting to calculate how much of the observed increase in seat belt use is a result of the enactment and presence of mandatory seat belt legislation over the sample period. We know that the percentage increase in average population seat belt use was roughly 247 percent (91.37 – 26.31/26.31). On the other hand, as noted above, average seat belt use should have increased by 55 percent. Therefore, the enactment and presence of seat belt laws explains roughly 22 percent (55/247 * 100) of the actual increase in population seat belt use.

The next logical question is this: How much of the actual decline in vehicle-occupant fatalities can

TABLE 7
Estimating the Impact of ln (Seat Belt Use) on ln (Failure to Stop and Assist) and ln (Dangerous Driving) – (IV)

Instrumental Variables	*(1)* *Failure to Stop and Assist*[a]	*(2)* *Dangerous Driving*[a]
Seat belt use ($SBELT_{it}$)	0.1787	**−0.2166**
	(0.1489)	**(0.0755)*** **
Police per 100,000 of population ($POLICE_{it}$)	**−3.0770**	**−0.6850**
	(0.7553)*	**(0.3830)***
Per capita fuel consumption ($FUEL_{it}$)	**−0.5571**	0.0086
	(0.1283)**	(0.0650)
Percentage of young male drivers ($PM1524_{it}$)	**3.9478**	**6.2108**
	(1.1874)**	**(0.6020)*** **
Unemployment rate ($UNEMP_{it}$)	**2.1954**	**1.0679**
	(0.2419)* **	**(0.1227)*** **
Minimum drinking age ($MINDUM_{it}$)	**−2.1557**	**−0.8360**
	(0.2133)* **	**(0.1082)*** **
Alcohol price index ($ALINDEX_{it}$)	1.3004	**2.3773**
	(0.9140)	**(0.4634)*** **
Province fixed effects	YES	YES
Year fixed effects	YES	YES
Province-specific trends	YES	YES
Adjusted R-square	0.9350	0.9697

Notes: IV = instrumental variables.
[a]These offences are per 100,000 licensed drivers.
*$p < .10$. **$p < .05$. ***$p < .01$.
Source: See the Appendix.

then be attributed to seat belt laws and corresponding increases in seat belt use? Since vehicle-occupant fatalities fell by 68 percent (from a sample mean of 39.67 per 100,000 licensed drivers in 1980 to 12.95 per 100,000 licensed drivers in 1996), the implementation of seat belt legislation and the rise in seat belt use over the sample period explains roughly 17 percent (11.55/68 * 100) of the observed decline in vehicle-occupant fatality rates.

These results should offer reassurance to policy-makers, given the somewhat conflicting results of some earlier research, that enacting seat belt laws and encouraging seat belt use have unambiguously saved lives, with some possibly modest attenuation from offsetting behaviour. But at the same time, a significant portion of the decline in vehicle-occupant fatalities cannot be attributed to the implementation of seat belt laws and the consequent rise in average seat belt use.

In this respect, the other covariate of clear policy interest is the minimum legal drinking age. Second stage IV coefficient estimates (Table 5) suggest that the enactment of a minimum legal drinking age of 19 years is correlated with roughly a 44 percent drop in vehicle-occupant fatalities. The 25 percentage point increase in the minimum legal age from 1980 to 1996 implies that this legislation resulted in a (0.44 x 0.25) 11 percent decline in vehicle-occupant fatalities. These results suggest that (a) roughly 30 percent of the fall in vehicle-occupant fatalities can be linked to seat belt laws and a higher minimum legal drinking age (17 + 11 percent), and hence (b) other unobserved factors (such as societal attitudes to road safety) clearly played a role with respect to the observed decline in deaths from motor vehicle accidents.

In this context, given that population seat belt use is currently at quite high levels, the more important policy implication is perhaps from the statistically significant coefficient of the interaction of the seat belt law with the number of per capita police officers (Table 4, column 2). Specifically, this result underscores the importance not only of enacting legislation but also of effective enforcement. Hence, in order to preserve high levels of seat belt use, programs such as police spot checks are not only effective but also necessary.

Simple trends in fatality rates yield other policy conclusions. Specifically, Table 1 suggests that Saskatchewan and Prince Edward Island were among the top three provinces with the highest fatality rates in 1980. Despite dramatic reductions that can be correlated to the significant rise in seat belt use, Saskatchewan and Prince Edward Island (along with New Brunswick) were still among provinces with higher fatality rates in 1996. Interestingly enough, recent government literature also suggests that these provinces are experiencing rather high fatality rates relative to other provinces despite average seat belt use well in excess of 90 percent. Hence, there are obviously other unobserved factors that impact trends in fatality rates apart from seat belt use and an obvious scope for alternative programs to be of consequence for these specific provinces. Results in Table 6 support this conclusion, as there are some differences between actual and predicted values for Prince Edward Island and Saskatchewan relative to corresponding values for other provinces.

The results of this study should also be of considerable interest to US policy-makers. As noted earlier, average seat belt use in the United States is much lower relative to Canada. Available 2001 data still clearly demonstrate that average seat belt use continues to be much lower in states with only secondary enforcement laws (Automotive Coalition for Traffic Safety 2001). This fact, coupled with the statistical significance of coefficient estimates of the interaction of seat belt laws with the number of per capita police officers (with respect to seat belt use), again emphasizes the importance of enforcement in ensuring high levels of seat belt use and, consequently, in lowering fatality rates from motor vehicle accidents.

Conclusion

This paper contributes to the literature by exploiting the natural cross-province time-series variation available in Canadian data to identify the impact of increased seat belt use on traffic fatalities. Given the considerable variation in the enactment of seat belt laws and the consequent increase in average seat belt use witnessed in Canada, this study is a useful confirmatory analysis to recent findings focused on US data.

Our study suggests that the introduction of seat belt laws has had a greater impact on average seat belt use and consequently on vehicle-occupant fatality rates than implied by recent studies. Specifically, IV coefficient estimates suggest that the enactment of mandatory seat belt laws resulted in a significant increase in population seat belt use, and that the 1 percent increase in seat belt use generated from the introduction of mandatory seat belt legislation is correlated with a 0.17–0.21 percent drop in vehicle-occupant fatalities. In tandem, these findings suggest that 17 percent of the observed decline in vehicle-occupant fatality rates in provinces that actually enacted seat belt laws during the sample period (between 1980 and 1996) is attributable to the corresponding increase in seat belt use.

NOTES

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[1]According to National Highway Traffic Safety Administration (2001) estimates, increasing average seat belt use from 68 to 85 percent would prevent an estimated 4,194 fatalities and 102,518 injuries annually, and result in economic savings of approximately $6.7 billion annually (1996 dollars).

[2]Garbacz (1990) uses 1987 survey data from the Behavior Risk Factor Surveillance System; Calkins and Zlatoper (2001) employ two years of state-level US data, 1987 and 1997; McCarthy (1999) uses city-level US data on a monthly basis from 1981 to 1989; and Risa exploits county-level Norwegian data from 1980 to 1986.

[3]Garbacz (1992) employs state-level data from 1987. Derrig et al. (2002) study population cross-state seat belt use from 1983 to 1996.

[4]The detection of significant offsetting behaviour can be attributed to Peltzman (1975). He found the enactment of various safety regulations by the US National Highway Traffic Safety Administration in 1968 to be simultaneously associated with a 10 percent drop in national vehicle-occupant death rates, as well as with a 25–35 percent increase in non-occupant death rates. These results were interpreted as evidence 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. The evaluation of offsetting behaviour has not been restricted to seat belt laws or usage. Peterson, Hoffer, and Millner (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.

[5]These findings are based on a time series of New Zealand traffic fatalities from 1960 to 1974.

[6]Asch (1991) uses time-series variation from New Jersey; Evans and Graham (1991) exploit state-level seat belt laws in the US between 1975 and 1987; Houston, Richardson, and Neeley (1995) examine cross-state data from 1967 to 1991; Loeb (1995) uses monthly variation in seat belt laws in Texas; Young and Likens (2000) employ cross-state data from 1982 to 1990; and Sen (2001) evaluates the impact of Canadian seat belt laws from 1976 to 1992.

[7]A good example is an increase in public awareness of the safety benefits associated with seat belt use or federal/provincial policies designed to promote relevant education. Further, coefficient estimates of increased seat belt use/regulation could also be biased to the extent that they are correlated with unobserved initiatives (air bags, antilock brakes, running lights, etc.) that are time trending within jurisdictions.

[8]Our sample size is basically dictated by the fact that while there are data on province-specific traffic fatalities from the 1970s, information on average seat belt use is only available from 1980 onwards. We did attempt to extend the dataset beyond 1996. But obtaining additional data on traffic fatalities from TIRF proved quite expensive. Further, the benefits of using such data are probably limited as variation in average seat belt use is restricted in comparison to the relative increases in the 1980s and early 1990s.

[9]The data set specifically does not have information on traffic fatalities before 1987 in Quebec, before 1986 in Newfoundland, and before 1985 in New Brunswick. Further details on the data can be obtained from the TIRF website at http://www.trafficinjuryresearch.com.

[10]The literature broadly defines pedestrians as including bicyclists and motorcyclists. In terms of raw figures, vehicle-occupant fatalities fell from 4,091 to 1,540 from

1980 to 1996, while non-occupant deaths dropped from 1,167 to 643 over the same time period.

[11]Our results remained the same irrespective of whether province-specific trends were constructed by simply interacting province fixed effects with a linear trend or with the year in question.

[12]Sass and Zimmerman (2000) employed a similar variable to capture enforcement efforts in their study.

[13]One might be surprised that we do not employ an explicit covariate for highway speed limits. However, there is virtually no cross-province or time-series variation in speed limits; 100 km/hour is the limit across Canada. The only exception is Quebec, which in addition to the maximum of 100 km/hour also has a minimum of 60 km/hour. Further, unlike data employed by some US studies, there exists no Canadian data on average highway speed of vehicles. The absence of such data is unlikely to impact coefficient estimates of seat belt use, as relevant impacts should be captured by province-specific fixed effects and trends.

[14]Evans and Graham (1991) found unemployment rates to be positively and significantly associated with traffic fatalities.

[15]Please see Watson (1986) for further details. We are extremely grateful to a very knowledgeable referee for this insight.

[16]A valid concern is that seat belt use is essentially a limited dependent variable bound between 1 and 0. Employing the natural logarithm of seat belt use releases the lower bound but still leaves an upper bound. Therefore, predicted values might lie outside these bounds. In order to verify this I ran separate levels regressions using seat belt use as the dependent variable, but dividing it by 100 and thus converting it into a proportion. Predicted values of seat belt use always remained within the 1–0 interval, thus giving some reassurance of the reliability of OLS estimates. We thank an anonymous referee for suggesting this exercise.

[17]5.22 is the sample mean of $POLICE_{it.}$

[18]Since the dependent variables of the first and second stage regressions are in natural logarithms, the values in Table 6 have been derived by taking the natural exponents, and therefore obtaining the actual raw data points.

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Appendix
Data Description and Sources

Fatality Rates

Fatality rates are for driver, driver and passenger (occupant), total, and pedestrian fatalities per 100,000 licensed drivers.

Source: Information on traffic fatalities from 1980 to 1992 was obtained from the Traffic Injury Research Foundation (TIRF). Fatalities data from 1993 to 1996 were procured from Transport Canada, "Preliminary Fatality Statistics: Road Safety." Data on licensed drivers were compiled from Statistics Canada, "Road Motor Vehicles: Registrations," Catalogue No. 53 219.

$ALINDEX_{it}$ = real alcohol price index.
Source: Statistics Canada. CANSIM (vectors v533824, v533960, v534097, v534234, v534372, v534510, v534648, v534786, v534923, v535061).

$FUEL_{it}$ = Gross sales of gasoline to on- and off-road vehicles per 100,000 of population.
Source: Statistics Canada. 1980–1996. "Road Motor Vehicles: Fuel Sales." Catalogue No. 53 218.

$MINDUM_{it}$ = 1 if province-specific minimum legal drinking age is 19; 0 otherwise.
Source: Provincial statutes.

$PM1524_{it}$ = Percentage of male drivers between 15 and 24 years of age.
Source: Statistics Canada. CANSIM (vectors v467053, v467074, v467368, v467389, v467683, v467704, v467998, v468019, v468313, v468334, v468628, v468649, v468943, v468964, v469258, v469279, v469573, v469594, v469888, v469909).

$POLICE_{it}$ = Number of police officers per 100,000 of population.
Source: Statistics Canada. CANSIM (vectors v8932, v8939, v8940, v8941, v8942, v8943, v8944, v8945, v8946, v8933).

$SBELT_{it}$ = Percentage of car drivers wearing seat belts.
Source: Transport Canada. 1980–1996. Annual surveys of seat belt use in Canada.

$UNEMP_{it}$ = Provincial annual unemployment rates.
Source: Statistics Canada. CANSIM (vectors v2461854, v2462484, v2463114, v2463744, v2464374, v2465004, v2465634, v2466264, v2466894, v2467524).