THE EFFECTIVENESS OF MANDATORY MOTOR VEHICLE SAFETY INSPECTIONS: DO THEY SAVE LIVES?

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ABSTRACT

Choosing an optimal level of government involvement in the economy is a contentious issue. In both national and provincial politics, the Canadian political pendulum, between regulation and deregulation, has shifted back and forth for decades. In some cases, provinces have embarked on completely different policy choices on the basis of ideology. One example of this is motor vehicle inspections. For over 30 years Maritime Provinces (PEI, Nova Scotia, and New Brunswick) have had mandatory motor vehicle inspections on cars, light trucks, SUVs and vans. Why? Research in this paper will demonstrate that the effect of these inspections on fatality, injury, or property damage (collisions) has been minimal. However, results are sensitive to model selection and specification. Furthermore, in conversations conducted between December 2002 and February 2003, ministry officials provided little direct, independent evidence demonstrating the effectiveness of inspection programs. A sensitivity analysis is undertaken to demonstrate the accuracy of model results.

DEDICATION

This MA project is dedicated to:

My grandparents: Lena and Louis

For teaching me about family, dice, and buying things on sale.

My sisters: Ashleigh and Alexa

For your love, support, and great fashion advice.

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Earl Marshall, owner and operator for 35 years of Commercial Motors @ 6808 Victoria Drive, Vancouver, for his comments on the links between vehicle mechanical failures and motor vehicle inspections.

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1. Introduction

Motor vehicle safety is an important issue for all Canadians. Between 1970 and 1974 an average of 5,650 Canadians (25 per 100,000) died in motor vehicle collisions. During the past thirty years groups like the Canada Safety council and the Canadian Automobile Association have tried to push governments and manufacturers to improve automobil safety. These groups, and others, have suggested ways to improve motor vehicle safety that include lower speed limits, tougher drunk driving laws, and motor vehicle inspections. This Masters project examines the effectiveness of mandatory annual safety inspections on lightweight motor vehicles including passenger cars, SUV's, trucks, and minivans. The scope is limited to the ten Canadian provinces.

Mandatory inspections are not a new phenomenon. The state of Virginia implemented North America's first program in 1921[1]. Since then, mandatory inspection programs have grown. As of 1990, approximately one half of American states used some form of mandatory program[2] - checking vehicles to ensure mechanical components are safe for the road. In both the United States and Canada, the legislation of motor vehicle inspections is state or provincial jurisdiction. All ten Canadian provinces have some form of safety inspection program. Inter-provincial migration triggers a mandatory vehicle inspection in all provinces except Saskatchewan and Newfoundland[3]. Most provinces require inspections when a vehicle is sold[4]. Insurance companies view inspections as a way to reduce accidents and increase corporate profits. In British Columbia and Alberta, for example, it is the insurance companies – not the government – that require vehicles be inspected when they are sold, before they can be insured.

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[1] British Columbia Motor Vehicle Department (1994).
[2] British Columbia Motor Vehicle Department (1994).
[3] Vehicle Registration and Driver Licensing (2003).

Though the impetus for some inspections comes from insurance companies, this project focuses exclusively on government sponsored mandatory annual inspection programs. On this issue, Canadian provinces have made very divergent policy choices. Western provinces have liberalized inspection rules that require random testing of problem vehicles as identified by the police. Conversely, provinces in the Maritimes use annual mandatory inspections that include all registered vehicles, regardless of age. Inspections involve a detailed examination of a vehicle by a licensed garage. If the vehicle passes inspection, a sticker is placed on the windshield indicating the vehicle has been checked and is safe. This method of identifying inspected vehicles is common in all provinces conducting mandatory inspections. As stated earlier, the purpose of inspections is to identify mechanical failures that could contribute to an accident. The Nova Scotia Motor Vehicle Act states that inspections should "examine brakes, headlights, belts, tires, and steering." These mechanical areas of concern are supported by an interview conducted with Earl Marshall, a Vancouver garage operator and owner for 35 years. His comments are presented later in Appendix A.

History of Mandatory Programs in Canada

The first mandatory Canadian inspection program began in Nova Scotia in 1967. The program was created through an Order in Council of the Nova Scotia government. The inspection program was to be implemented in two stages: one program for passenger vehicles and the other for commercial vehicles. In its first year of implementation Nova Scotia reported that only 34.9% of passenger cars passed an inspection without requiring either repairs or adjustments[5]. In a Speech to a Canadian Health and Safety Conference D. Tully, Registrar of Motor Vehicles for Nova Scotia, claimed that "approximately 10,000 passenger vehicles have disappeared from our highways during the first year."

[4] In Alberta, the sale of vehicles over 10 years old requires an inspection for insurance purposes.
[5] Report of the 14th Annual Canadian Health and Safey Conference (1969).

He supported his argument further by claiming that 32.8 percent of *new* vehicles required inspections. This later statistic doesn't necessarily mean that new vehicles were of poor quality. Instead, it could be the result of inspectors applying standards very stringently.

In 1968 Alberta followed Nova Scotia and began building testing stations in Calgary and Edmonton. By 1969, there was widespread discontent with the program. In its haste to implement the program the province failed to account for sufficient testing stations. All Alberta residents were forced to go to Calgary or Edmonton to have the inspection completed. This made the program unnecessarily arduous and contributed to its repeal in late 1969. Other reasons for the repeal included a depressed used car market[6], a newly created black market for inspection stickers, and dishonest automotive mechanics recommending unnecessary repairs. Although the program only lasted one full year, 300,000 of the province's 650,000 vehicles were tested[7]. The province charged two dollars for an initial inspection and one dollar for each subsequent annual inspection..

New Brunswick implemented an annual mandatory program in 1968[8]. Drivers of defective cars with a value exceeding $200 were given two options. They could either repair the vehicle or receive a $10 fine and a –2 pt deduction on their operating license. Defective vehicles valued at $200 or less were pulled off the road until the repairs were completed. One reason for the program's creation may have been the high proportion of problem vehicles detected in 1967 through random roadside inspections. 60% were found to have deficiencies[9].

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[6] The Alberta motor vehicle inspection program was blamed for falling used car prices. One news story reported used car prices in Calgary falling from $500 to less than $200. (Financial Post 1969).
[7] Financial Post (1970)
[8] PEI also began its inspection program in 1968.
[9] Financial Post (1968).

British Columbia, under the authority of the Ministry of Highways, implemented a mandatory program in 1977. The program lasted until 1983, when it was eliminated due to provincial budget cuts. At the time of termination, 620,000 vehicles were inspected annually at public inspection stations in Victoria, Nanaimo, and the Lower Mainland. A further 7,400 vehicles were inspected at privately operated garages throughout the province[10]. In 1984 British Columbia replaced its safety inspection program with a pollution inspection program: AirCare. Since it began, AirCare has focused exclusively on pollution control and not on motor vehicle safety.

Currently, three Canadian provinces are using mandatory inspections: Nova Scotia, New Brunswick, and PEI. Newfoundland revoked their inspection program in the mid 1990's. Transportation ministry officials from these provinces were contacted and asked a series of questions about their inspection programs. Surprisingly, no province could produce a recent study showing that their inspection program saves lives, reduces injuries, or prevents property damage. Despite this, ministerial officials in all three provinces were confident that their inspection programs were saving lives.

British Columbia's 1994 report on inspection programs is believed to be the only Canadian study examining inspection effectiveness. It found little supporting evidence to justify inspections[11]. However, the BC report did not use econometric techniques to verify its conclusions. It is unclear if other previous research has analyzed the role of Canadian mandatory inspection programs. This is the motivation behind this MA project. What safety arguments and evidence could PEI, Nova Scotia, and New Brunswick produce to support their programs? Does such evidence exist? These are questions this MA project will attempt to answer.

[10] British Columbia Motor Vehicle Department (1994).

Causes of Motor Vehicle Accidents

There are five main causes of motor vehicle accidents (MVA):

The two most obvious contributing factors are speed and alcohol. In 2001, the National Highway Traffic Safety Administration (NHTSA) in the United States estimated that speed and alcohol contributed to 30% and 40% of collisions respectively[12]. A 1998 study by Transport Canada estimated that alcohol contributed to 36.7% of Canadian traffic fatalities[13]. No attempt is made to estimate the role of speed and alcohol in this project. It is assumed that estimates provided by the NHTSA and Transport Canada are accurate.

Weather conditions are another important factor to consider. For example, heavy snow conditions and icy roads caused 11 deaths in January 2003 on a single stretch of the Trans Canada highway between Salmon Arm, BC and Banff, AB[14]. These fatalities are higher than average. Due to variability across provinces, quantifying the impact of weather on motor vehicle accidents is difficult. Generally speaking, on the East and West coasts, rain causes adverse conditions through fog and poor visibility. In central Canada and on the prairies, snowfall and freezing rain result in slippery roads and diminished visibility.

The importance of driver attitude toward safety cannot be understated[15]. Drivers demanding safety have been the impetus behind side impact air bags, harsh penalties for

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[11] This may explain why the NDP government, under Mike Harcourt, decided against replacing Aircare with a new annual inspection regime.
[12] Traffic Safety Facts (2000).
[13] The State of Road Safety in Canada (1998).
[14] Maclean's Magazine (2003).
[15] Education could be correlated with driver attitude. Grossman (1975) shows there is a connection between education levels and health and safey. Keeler (1994), in a panel analysis of American county road fatality data, cites Grossman's work and includes education variables measuring the percent of the population over the age of 25 with high school and college completed respectively.

impaired driving[16], and stricter Canada wide inspections of commercial vehicles[17]. Attitudes toward seatbelt legislation continue to change as a higher percentage of Canadians report using them every year[18]. Table one tracks recent attitude changes regarding seatbelt use. In addition to seatbelts, airbags, heat resistant gas tanks (to prevent explosions), and stronger vehicle frames are among the new safety features used in today's vehicles.

Table one: Percentage of all occupants wearing seat belts in cars, vans, and light trucks

Prov	1993 June (%)	1994 June (%)	1996 June (%)	1997 July (%)	1998 June (%)	1999 June (%)	2000 July (%)	2001 July (%)
Nfld.	94.5	93.6	91.9	92.4	86.4	82.9	92.7	92.1
P.E.I.	77.8	84.5	87.5	82.6	82.7	88.5	85.7	86.7
N.S.	83.5	83.2	88.2	87.1	88.5	86.6	86.5	88.0
N.B.	82.1	84.9	86.6	86.5	87.9	85.9	91.5	91.4
Que.	88.8	89.8	90.3	91.7	92.3	93.0	91.4	89.0
Ont.	79.4	86.3	89.9	89.2	89.1	91.0	91.7	92.5
Man.	80.2	82.6	82.4	84.8	84.4	85.3	84.2	82.3
Sask.	89.4	87.7	89.6	91.7	89.7	88.2	90.0	91.7
Alta.	81.0	83.1	85.1	83.7	82.4	89.3	87.2	84.9
B.C.	86.4	88.3	88.7	89.4	89.7	89.2	88.7	90.8
Canada	**83.4**	**86.8**	**88.7**	**88.9**	**88.7**	**90.1**	**90.1**	**89.9**

Source: Transport Canada, Road Safety Division, Statistics and Reports.

[16] Mothers Against Drunk Drivers (MADD) has had success changing public and government attitudes towards drunk driving.

[17] Commercial vehicle inspections (for heavy trucks) took on renewed emphasis in the mid 1990's after a series of fatal accidents, caused by semi truck tires falling off and hitting passenger vehicles, in Ontario.

[18] Legislative changes could be a key factor influencing attitudes towards seatbelt use. A working paper by Anindya Sen reports that Ontario was the first North American jurisdiction in 1976 to implement seat belt use laws, subsequently followed by all other Canadian provinces by 1987.

The final contributing factor to accidents is mechanical failure. Earl Marshall provided a list of mechanical failures, that in his opinion contribute to MVA. These failures are listed below. For a complete description please refer to Appendix A.

1) Steering or breaking problems caused by ungreased or worn out ball joints.
2) Break problems associated with either worn out rotors or uneven wear on rotors.
3) Lights that are either burnt out or improperly aligned.
4) Tires blowouts with older tires.

Mr. Marshall believes that "safety measures should be based on two things: overall vehicle mileage and the rate of mileage accumulation." He was generally in favour of mandatory annual inspection programs.

In addition to these five main variables, others such as road quality, the percentage of four lane highways, and the level of police traffic enforcement may be relevant.

Economic Theory

Any increased safety arising from motor vehicle inspection programs is usually attributed to fewer mechanically defective vehicles. However, in the spirit of Peltzman (1975), there is another explanation. Peltzman analyzes how people's behaviour changes under different policy regimes. In some cases these behavioural changes imply that people will take more risk. An example is the moral hazard problem where drivers take greater risk in response to safety measures like mandatory seatbelt laws and mandatory safety inspections. Peltzman calls these changes "offsetting behaviour".

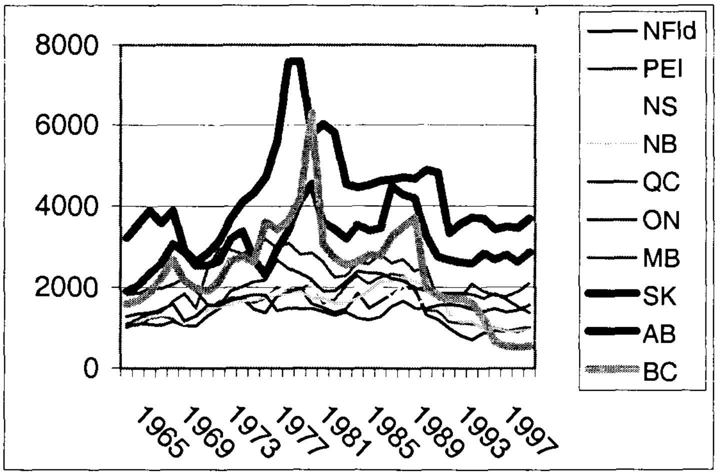
Poitras and Sutter (2002) analyze American inspection programs with the goal of distilling improvements in vehicle safety from behavioural change. The authors succeed in analyzing each effect individually by using data for the number of older vehicles on the road. If the number of older vehicles declines, ceterus paribus, the authors conclude there is evidence of offsetting behaviour. If both the number of vehicles and casualties decline there is evidence of safety improvement. The authors only consider these two cases in their model. A third case, which Poitras and Sutter do not control for, is that inspections do not contribute to improved safety or a moral hazard problem.

Poitras and Sutter provide a brief literature review that demonstrates the difficulty in analyzing vehicle safety inspections; some authors like Leob (1995) and Grossman (1997) find inspections effective, while others like Poitras (1999) and Keeler (1994) do not. These divergent conclusions reinforce the point that there are multiple models and methodologies used to analyze the effectiveness of vehicle inspection programs.

2. Data Analysis

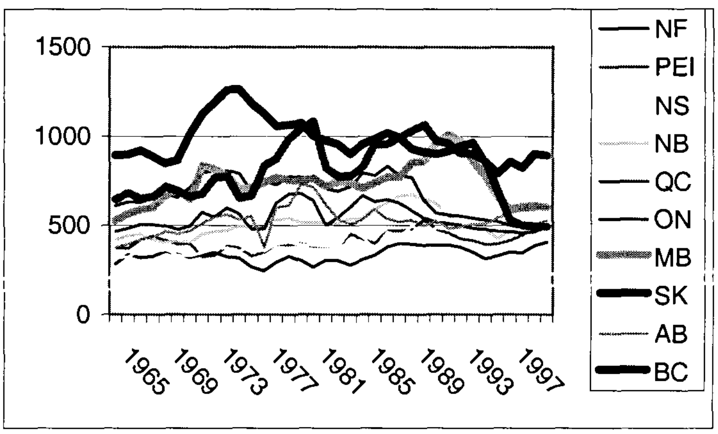
The major data source for this topic is the motor vehicle accident statistics compiled by Transport Canada. Panel data, covering the years 1965 to 2000, was obtained for ten provinces and two territories. The accident data was broken down into fatalities, injuries, and property damage. Transport Canada collects its data from police forces and provincial government transport ministries. My first step in analysis was to convert the data into a per capita form. The per capita information was then graphed for each province. These graphs are presented in figures one, two, and three.

Figure one: number of motor vehicle property damage incidents per 100,000 people



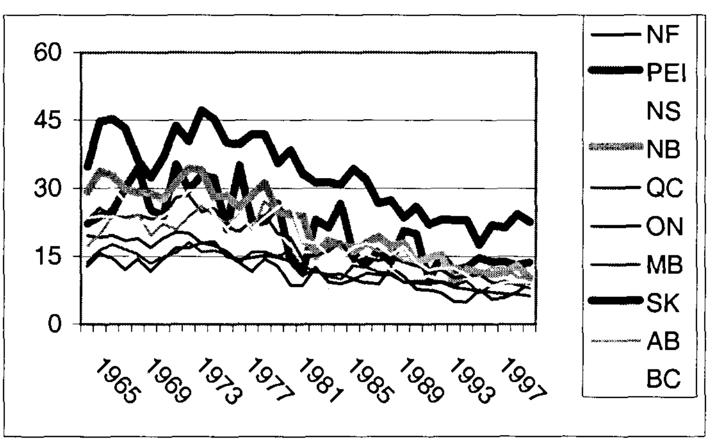
Highest Property Damage Rates are in Saskatchewan, Alberta, and British Columbia

Figure two: number of motor vehicle injuries per 100,000 people



Highest Injury rates are in Saskatchewan, British Columbia, and Manitoba

Figure three: number of motor vehicle fatalities per 100,000 people



Highest Fatality rates are in Saskatchewan, PEI, and New Brunswick

(figures one, two, and three are all by author)

There are two immediate surprises in the data. Quebec continues to be one of only three provinces still allowing 18 year olds to buy and consume alcohol[19]. In addition Quebec requires lower minimum vehicle liability insurance[20]. As a result, an a priori hypothesis was that accident rates in Quebec would be higher than other provinces. This was not obvious in the graphed data. In fact, relative to other provinces, Quebec's property damage (PD), bodily injury (BI) or fatality rates (F) do not stand out. Table two demonstrates this.

Table two: Quebec vs. Canada

Per 100,000 People	**Entire Period**			**Partial Periods**								
Province/Region	**1971 – 2000**			**1971 – 1980**			**1981 – 1990**			**1991 – 2000**		
	PD	BI	F	PD	BI	F	PD	BI	F	PD	BI	F
Quebec	2000	550	17	2100	570	24	2200	600	15	1700	480	11
Rest of Canada	2200	610	17	2300	610	24	2600	630	16	1800	570	12
Eastern Provinces	1500	480	15	1700	460	23	1800	510	14	1200	460	10
Western Provinces	3100	780	20	3300	810	26	3700	810	20	2400	730	14

(table by author)

Broadly speaking, the trends in the data are related to geography. Relative to the rest of Canada, Quebec has lower fatalities, injuries, and property damage. However, relative to other Eastern Canadian provinces (Ontario, New Brunswick, PEI, Nova Scotia) Quebec has higher accident rates. Over the period 1971 to 2000 there were was an average 2,000 accidents causing property damage in Quebec compared to only 1,500 in other Eastern Provinces. As table two shows, all periods of study indicate that property damage, injury, and fatality rates in Quebec are lower than the national average.

[19] As of 1998, the other provinces are Alberta and Manitoba. (International Center for Alcohol Policies 1998).
[20] Minimum liability is $200,000, except in Quebec, where it is $50,000. (US and Canadian Border Regulations 2001)

Western provinces have PD, BI, and F rates that are above the national average. A major surprise was Saskatchewan's consistently high rates. This is a puzzle that could be related to weather, road quality, or the rural nature of the province. For the period 1971 to 2000 Saskatchewan's property damage and fatality rates were double rates in the Rest of Canada (ROC). Bodily injury rates were 1.6 times greater than those in the ROC.

Table three: Saskatchewan vs. Canada

Per 100,000 People	**Entire Period**			**Partial Periods**								
Province/Region	**1971 - 2000**			**1971 - 1980**			**1981 – 1990**			**1991 - 2000**		
	PD	BI	F	PD	BI	F	PD	BI	F	PD	BI	F
Saskatchewan	4500	990	32	4600	1140	41	5000	960	30	3800	900	22
Rest of Canada	2300	605	16	2400	600	23	2700	650	15	1700	570	11
Eastern Provinces	1600	490	15	1700	480	22	1800	520	15	1300	470	10
Western Provinces	2700	710	15	2900	700	21	3200	750	16	2000	680	11

(table by author)

Table eight in appendix D illustrates that there are currently a higher percentage of older vehicles in use in Western Provinces than in other parts of the country.

3. The Model

Methodology

Fixed or Random Effects

In selecting an appropriate model it is important to think about the type of data being analyzed. Cross sectional time series data suggests panel data modeling, which is advantageous because the researcher remove either time invariant or cross section invariant effects (Balgati 2001). Standard panel data analysis suggests using either a fixed effects or random effects model. There are numerous reasons to use a fixed effects model:

1) A random effects model would require a Hausman test to demonstrate that corr(X, 0) = 0. It is unlikely this condition would be met. Income variables (in the error term) would almost certainly be correlated with the number of registered vehicles. In addition, speeding and impaired driving convictions are almost certainly correlated with the urban proportion variable.

2) The property damage, bodily injury, and fatality data *is* the population of data for all ten provinces. Generally, a random effects model is used when the data set is a sample *from* a population. Data for all ten provinces is the entire population – not a sample.

3) Fixed effects estimation allows models to account for unobserved state specific effects. State specific effects may include geography, road pavement quality, and the percentage of highways that are four lanes.

The existence of statistically significant cross section intercepts further justifies a fixed effects approach. Fixed effects are used in the results section because such intercepts are found to exist[21].

Conventional Panel Data Analysis vs. Beck and Katz

All of the dependent variables (PD, BI, and F) have 30 years of time series and ten cross sections. In panel data situations where the number of time series exceeds the number of cross sections Beck and Katz (1995) recommend performing standard OLS followed by an adjustment to the variance covariance matrix to obtain more accurate standard errors. Fixed effect estimation is still valid in this context[22]. It is not clear if Beck and Katz' recommendation applies to all panel data models or only to a SUR model.

Poisson Modelling

The nature of the dependent variable suggests a count data model using Poisson estimation techniques. Rose (1990) uses Poisson modeling to measure the relationship between airline accident rates and airline financial health. Accident rates among the 25 firms in Rose's sample are fairly small. This "small number" phenomena justifies Rose's use of a Count Data model. The key statistic to examine is the population mean, as measured by an expectation of the number of fatalities & injuries. This expectation is calculated by: E[fatality|a collision has occurred] = number of collisions * probability of dying if you are in a collision. If the expected number of fatalities and injuries is large, a normal distribution can be used[23] in place of a Poisson distribution. Mean values in the accident data are fatalities (300), injuries (1100) and collisions (29,000). These large nominal values suggest using a normal distribution to analyze the panel. Keeler (1994),

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[21] F tests on cross section intercepts reject the pooling hypothesis for dependent variables: fatalities (F= 40.3, P-value=0.00), injuries (I=59.8, P-value=0.00), and property damage (PD=40.8, P-value=0.00).
[22] Kennedy (1998).

Wooldridge (2001), and Kennedy (1998) all support the conclusion that Poisson modeling is inappropriate if your dependent variable is "large-count". Keeler seems to circumvent this problem by converting his dependent variable fatality data into per capita terms. The literature isn't clear on the appropriateness of this technique.

Other models

A few dependent variables could be analyzed simultaneously by adopting the methodology of Zellner (1962), using the SUR (Seemingly Unrelated Regression) technique. This is appealing because motor vehicle safety inspections have value if they lead to a reduction in fatalities ***or*** bodily injuries ***or*** property damage. In addition, SUR would provide an ability to correlate errors between a fatality, bodily injury, and property damage. This is sensible since omitted variables for speeding and drunk driving legislation would include all three (F, BI, and PD).

Variable Selection

Dependent Variables

The motivation behind motor vehicle inspection programs is safety. It makes sense therefore to use PD, F, and I as dependent variables. Most previous studies examining vehicle inspection effectiveness have focused exclusively on fatalities[24]. However, injuries and property damage result in individual and social costs. Inspection programs that do not reduce fatalities may still be valid if a reduction in injury or collision rates (property damage) can be shown.

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[23] David I. Sales, a researcher at Heriot-Watt University in Edinburgh, suggests using a normal distribution if μ (the expected value) > 20. If $\mu \leq 20$, a Poisson distribution is appropriate.
[24] Merrell, Poitras and Sutter (1999).

Independent Variables

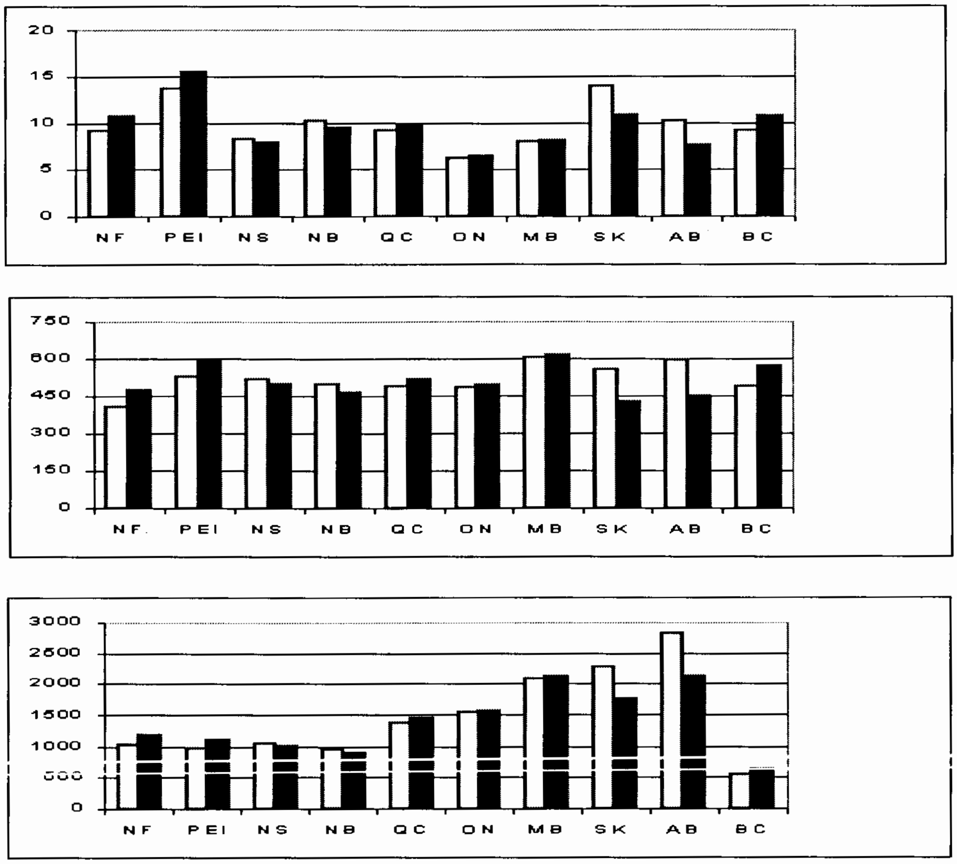
Number of Registered Vehicles

Quantifying the frequency and distance of driving on roads is important to the analysis presented. Data can be used in two ways:

1) Vehicle Kilometers Travelled (VKT). In a world with perfect data availability this would be the best variable to use. However, Statistics Canada does not have historical VKT estimates. They could only provide VKT estimates for 2001. VKT is recommended as a better metric than population, which means it is preferable to report fatalities per VKT and not fatalities per capita. Using fatality data for 2000, VKT data for 2001, and population data for 2001, figure four compares fatalities per VKT with and fatalities per capita. It must be stressed that only 2001 VKT data was available to derive figure four.

Lighter bars in figure four mean "per 100,000 people" while darker bars indicate "per 100,000,000 kilometers traveled." The three graphs in figure four compare these two metrics for fatalities, injuries, and property damage respectively. The largest variability between the two metrics appears to occur in Western provinces. This isn't entirely surprising since British Columbia, for example, has approximately one million *more* people than Alberta; yet BC had *less* vehicle kilometers traveled in 2001 (35,308,000,000 KM compared to Alberta's 40,421,000,000 KM).

Figure four: Comparing VKT and Population



(figure by author)

2) Number of Registered Motor Vehicles. The lack of VMT data[25] necessitates the use of registration statistics. A one percent rise in motor vehicle registrations does not mean there is a one percent rise in traffic or automobile use[26]. The rise in registrations could be attributed to someone purchasing and registering an additional vehicle, while at the same time continuing to register an older, "parked" vehicle. Under this scenario, increased registrations would be accompanied by a flat increase in the

[25] Transport Canada (Beverly Curran) was only able to supply VMT data for a single year (2001). According to Ms. Curran there is no significant VMT Canadian time series that is in provincial form.

number of vehicles on the road. Figure four indicates that population or the number of registrations, are appropriate alternatives proxy vehicle kilometers traveled.

Weather: Snowfall and Rainfall Data

As stated previously, weather is a challenging variable to quantify. The cross sections in this project are provinces. Unfortunately, it makes no sense to report the total provincial rainfall or snowfall. Instead, Environment Canada's weather data comes from meteorological stations located in cities across the country. Annual rainfall (mm) and snowfall (mm) accumulation is extracted for two cities from each province. Cities with larger populations were preferred to smaller ones. To ensure the data more accurately represents intra-provincial weather variations, an effort was made to select cities that were at least 200 km apart. The list of selected cities is in table 4.

[26] Even with VMT statistics there may not be a one to one correspondence.

Table four: Weather variable cities

Vancouver, BC	Rimouski[27], QC
Kelowna, BC	Seven-Islands, QC
Edmonton, AB	Moncton, NB
Calgary, AB	Fredricton, NB
Saskatoon, SK	Truro, NS
Regina, SK	Halifax, NS
Brandon, MB	Charlottetown, PEI
Winnipeg, MB	Summerside, PEI
Toronto, ON	St. Johns, NFLD
Ottawa, ON	Cornerbrook, NFLD

(table by author)

Weather: Missing data

Missing data for both rainfall and snowfall was problematic. Fortunately, out of 600 observations (30 years of data * 20 cities) only ~5% of the data or 30 observations were missing. Following the advice in Kennedy's forthcoming edition (Applied Data chapter), these missing data values are estimated. Estimates for a missing weather data point are calculated by taking the average of the two previous years and two future years.

Urban vs. Regional Population Estimates (inter-censal)

This variable is included to explain higher accident rates in a province like Saskatchewan. Unfortunately, obtaining a complete data set has proven difficult[28]. Data that tracks the proportion of a province's population living in cities larger than 10,000, 25,000 and 100,000 people could demonstrate, through a sensitivity analysis, the relationship between accident rates and rural

[27] Both Rimouski and Seven-Islands are used in place of Quebec City and Montreal because of insufficient data for major Quebec cities.
[28] Data for this variable, constructed and sent to me by Anindya Sen, contained numerous missing values making it extremely difficult to include in the model.

populations.[29] Sen (2001) constructs his urban proportion series using Statistics Canada Annual Demographic Reports and the Revised Intercensal Population and Family Estimates, 1971-1991. Further research that includes this variable, or a proxy thereof, is suggested.

Inspection Dummy

This variable is coded one when inspection programs existed and zero otherwise. Merrell, Poitras, and Sutter (1999) use spot check (SPOT) and annual inspection (ANNUAL) dummies to test the influence of inspections on United States fatality and injury data.

Time Trend

The existence of either included or omitted variables - that have positive correlation - is a good reason to include a time trend. As table four demonstrates, seatbelt use per 100 people has been increasing in *all* provinces. Seatbelt and drunk driving laws have continuously become tougher in *all* provinces over the past three decades. In addition Merrell, Poitras, and Sutter(1999) argue that road engineering and quality has continuously improved over time. The presence of these positive correlations justifies a time trend in the model.

[29] Cameron Stout, an analyst with Statistics Canada, Demographic Estimates Section, reported that he is aware of no Statistics Canada time series data tracking proportional urban data. He referred me to Statistics Canada publication 91-537, Revised Intercensal Population and Family estimates, July 1, 1971-1991. The most recent data available ends in 1996.

Table five: Summary of project data sources

Accident Data	Transport Canada, Beverly Curran[30]
Intercensal City Estimates	Statistics Canada, Demography Division
Urban Proportion	Anindya Sen, University of Waterloo
Vehicle Kilometers Traveled (2001)	Transport Canada, Beverly Curran
Number of Vehicle Registrations	Transport Canada, Beverly Curran
Rainfall and Snowfall Accumulations	Historical Adjusted Climate Database for

(table by author)

[30] Special thanks to Beverly Curran, an analyst in Statists Canada's Transportation division, for providing the accident data. Beverly also provided estimates of 2001 VKT (vehicle kilometers traveled) for each province.

4. Specification and Results

The following base model is initially used:

f = reg + s1 + s2 + r1 + r2 + inspect + time [31] (1)

OLS results from this specification are compared to fixed effect results. Two fixed effects models are used: a non-weighted standard model and a weighted GLS adjusted version. Ideally results from the OLS and GLS weighted model would be compared to a SUR analysis. Unfortunately, reliable SUR estimates could not be obtained because of the nature of the data (where the number of time series observations exceeds the number of cross sectional observations). Both Kennedy (2003) and Beck and Katz (1995) indicate that SUR estimation may prove difficult under long narrow path conditions.

Results for model (1) are presented in table six. Estimates are computed for three dependent variables (fatalities, injuries, and property damage) using three methods: OLS, Fixed Effects, and Fixed effects weighted least squares. The use of weighted least squares is justified in the presence of autocorrelation or heteroscedasticity. Heteroscedasticity is tested using a standard LM test in which the sum squared residuals from the "fixed effects: no weights" method in table six are regressed against "inspect" and "reg." All three models showed evidence of heteroscedasticity. Test statistics for heteroscedasticity are presented in appendix E.

[31] fatalities(f), # registrations(reg), snowfall city1 (s1), snowfall city2 (s2), rainfall city1(r1), rainfall city2(r2).

Table six: Result's from the main model

		Registrations	Inspect Dummy	Snow1	Rain1	Snow2	Rain2	Time Trend
F	*OLS No Effects*[32]	0.029 (30.46)	-3504.96 (-0.81)	2.39 (1.22)	2.16 (1.17)	8.25 (0.78)	-22.86 (-4.43)	10.92 (6.42)
	Fixed Effects (no weights)	0.017 (7.11)	20443 (4.90)	-0.04 (-0.03)	-1.42 (-1.10)	-0.41 (-0.04)	-0.20 (-0.03)	-180 (-1.49)
	Fixed Effects (GLS weighted)	0.018 (8.97)	3926 (1.09)	0.215 (0.911)	0.800 (0.105)	1.95 (0.94)	0.08 (0.055)	-120 (-5.00)
I	*OLS No Effects*	0.012 (42)	-1697 (-1.34)	-0.24 (-0.42)	1.05 (1.93)	4.15 (1.34)	0.25 (0.17)	-0.86 (-1.73)
	Fixed Effects (no weights)	0.001 (1.74)	671 (0.63)	-0.029 (-0.08	-0.14 (-0.41)	-5.08 (-1.81)	0.23 (0.13)	43 (1.38)
	Fixed Effects (GLS weighted)	0.003 (6.71)	284 (1.08)	0.04 (0.68)	-0.01 (-0.17)	-0.91 (-1.68)	-0.36 (-1.09)	9.74 (1.42)
P	*OLS No Effects*	0.028 (30.1)	-5097 (-1.18)	2.68 (1.37)	1.97 (1.06)	9.6 (0.91)	-18.4 (-3.6)	10.2 (6.03)
D	*Fixed Effects (no weights)*	0.017 (7.16)	21,987 (5.31)	-0.04 (-0.033)	-1.18 (-0.92)	-1.17 (-0.11)	-1.61 (-0.24)	-180 (-1.50)
	Fixed Effects (GLS weighted)	0.018 (9.00)	6350 (1.84)	0.22 (0.93)	0.21 (0.28)	1.85 (0.87)	-0.16 (-0.01)	-122 (-5.00)

Note: Values in brackets are t statistics. R^2 was typically between 0.85 and 0.95. (table by author)

Comparison of the three estimation methods:

- *Rain and snow variables are generally individually insignificant under OLS, fixed effects (no weights), and fixed effects (GLS weighted).* The joint significance of these variables (S1, S2, R1, and R2) is tested using a Wald Statistic. The variables have joint significance in OLS regressions with fatalities and property damage as dependent variables. In all other cases, including fixed effects, the Wald test accepts the null hypothesis that the weather variables do not have joint significance. Despite these results, weather variables are left in the model for

[32] Recall that a justification for the fixed effects approach was provided in the methodological section. This includes tests demonstrating the validity of fixed effects vs. pooling cross sectional intercepts.

theory reasons. Few would argue that weather does not contribute to motor vehicle accidents. Wald test statistics are presented below. Additional information can be found in appendix B.

Table seven: Wald test results

Testing the joint significance of S1, S2, R1, R2	*OLS No Effects*	*Fixed Effects (no weights)*	*Fixed Effects (GLS weighted)*
F	0.0002	0.87	0.72
I	0.29	0.35	0.52
PD	0.005	0.91	0.72

Note: numbers in table seven are p values. (table by author)

- Heteroscedasticity in present in all three models. LM test statistics of 45 (fatalities), 134 (injuries), and 45 (property damage) are statistically significant at a 5% level with chi-square distribution and three degrees of freedom. The presence of heteroscedasticity in all three models model and the risk of not correcting possible autocorrelation problems justifies the presentation of both weighted and unweighted fixed effects. Test results indicating no autocorrelation (ie. the Durbin Watson statistic) should not be considered absolutely definitive[33].

- *OLS coefficient estimates for inspections are negative for F, I, and PD in table six.* This result suggests that inspection regimes are effective. When the estimation procedure is changed to fixed effects, coefficient estimates for F, I, and PD become positive - suggesting inspection regimes are ineffective. Positive estimates exist in both weighted and unweighted fixed effect estimation. These results are consistent with Merrell, Poitras, and Sutter (herein referred to as MPS)

[33] Note that MPS also present weighted and unweighted fixed effect results.

who obtain negative estimates for both SPOT and ANNUAL[34] under OLS and positive estimates under fixed effects[35]. Based on these results, model specification and estimation technique appears to be important. The results are not robust.

- The magnitude of the inspection dummy changes dramatically when GLS weighted estimation is used compared to no weighting. Magnitudes of other variables, such as snowfall, rainfall and time trend, are not affected significantly.

- Another concern is the insignificance of the inspection dummy coefficient estimates. The inspection variable in table six is generally insignificant across all estimations (OLS, fixed effects) and across all dependent variables (F, I, and PD). This problem also occurs frequently in MPS' model.

Are Inspections Effective?

As with previous inspection literature, there is no clear indication that inspection programs are effective. United States motor vehicle inspection literature contains some models that find inspections effective and others that do not. Two primary results have been uncovered in this project.

1) This project finds supporting evidence in favour of inspections under an OLS model. Results similar to MPS' are obtained. OLS models are prone, however, to missing variable bias. It is difficult to know how accurate OLS coefficient estimates are.

[34] Recall that these are the inspection dummies used by MPS (1999).

[35] Obtaining similar results to MPS (1999) is likely a combination of coincidence and model structure. It is an indication that the model chosen for this paper is consistent with previous research.

2) The insignificance of the inspection dummy clouds the issue of inspection effectiveness. Only one inspection variable was significant in MPS (1999)[36].

[36] MPS's ANNUAL dummy had a coefficient estimate of –0.023 with standard error 0.009. Note however that MPS used logFATALITIES and logINJURIES as dependent variables.

5. Conclusion

On balance the results in this project are inconclusive. The results are not strong enough to argue for or against mandatory annual motor vehicle inspection programs in Canada. This ambiguity is consistent with results in the inspection literature. The lack of conclusive evidence may explain why provinces without inspection programs have no plans to implement new ones and why Nova Scotia, New Brunswick, and PEI have no plans to remove their programs. In fact, all three Maritime provinces reported popular support for their inspection programs[37]. It is likely that these programs will continue to be enforced in these provinces. Future research that could incorporate a larger data set, perhaps with monthly fatality, injury, and property damage statistics may be able to resolve this question.

[37] One Maritime official stated his belief that inspection programs are worthwhile if they help people "feel safe".

BIBLIOGRAPHY

Akerlof, G. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." Quarterly Journal of Economics. 84.3 (1970): 488-500.

Baltagi, B. Econometric Analysis of Panel Data, Second Edition, London : John Wiley, 2001.

Beck, N. & Katz, J. "What to do (and not to do) with Time Series Cross Section Data." American Political Science Review. 89(3) (1995): 634-47.

British Columbia Motor Vehicle Department. Review of a mandatory vehicle inspection program: project report. Victoria : Ministry of Transportation & Highways, Motor Vehicle Branch, 1994.

Cameron, C. & Trivedi, P "Econometric models based on count data: comparisons and applications of some estimators and tests." Journal of Applied Econometrics. 1.1 (1986): 29-53.

Drinking Age Limits 1998. International Center for Alcohol Policies. 24 March 2003 <http://www.icap.org/publications/report4.html>.

Financial Post. "Alberta to Junk its compulsory car-testing plan." Financial Post. February 28, 1970: 3.

Financial Post. "New Brunswick's Car repair System". Financial Post. April 20, 1968: 38.

Greene, W. Econometric Analysis, Second Edition, Upper Saddle River, N.J. : Prentice Hall, 2000.

Historical Adjusted Climate Database for Canada: version December 2002. Environment Canada. 15 November 2002. <http://www.cccma.bc.ec.gc.ca/hccd/data/access_data.html>.

Keeler, T. "Highway safety, economic behaviour, and driving enforcement." American Economic Review, 84 (1994): 684-93.

Kennedy, P. A Guide to Econometrics, Fourth Edition, Cambridge, Massachusetts: The MIT Press, 1998.

Kennedy, P. "Applied Econometrics". A Guide to Econometrics. 5th ed. (forthcoming).

Maclean's Magazine. "How safe is the backcountry?" 116.7: (17 February 2003). 25.

Merrell, Marc Poitras and Daniel Sutter. "The effectiveness of vehicle safety inspections: an analysis using panel data," Southern Economic Journal. 65 (1999), pp.571-583.

"Notes on Beck & Katz, what to do (and not to do) with time series cross section data." 16 January 2003 <http://lark.cc.ukans.edu/~pauljohn/ps909/Fall-2001/BeckKatz2.pdf>

Peltzman, S. "The Effects of Automobile Safety Regulation." Journal of Political Economy. 83.4: (1975). 677-725.

Poitras, M. & Sutter, D. "Policy ineffectiveness or offsetting behaviour? An analysis of vehicle safety inspections." Southern Economic Journal. 68.4: (2002). 922-934.

Poitras, M. & Sutter, D. "The political economy of automobile safety inspections." Public Choice, 113: (2002), 367-387.

Romaine, E. "Will Alberta Scrap auto testing program?" Financial Post. 35: (September 27, 1969).

Rose, N. "Profitability and Product Quality: Economic Determinants of Airline Safety Performance". The Journal of Political Economy, 98.5: (1990). 944-964.

Saffer, H & Grosman, M. "Drinking age laws and highway mortality rates: Cause and effect." Economic Inquiry 25.3:(1987). 403-17.

Sales, D. "Poisson Distributions". 8 February 2003. <http://www.ma.hw.ac.uk/~davids/f71xc1/oh7_web.pdf>

Sen, A. "To encourage or not to encourage seat belt use: simultaneity bias and offsetting behaviour." Unpublished working paper. 5 February 2003. <http://economics.uwaterloo.ca/sen/traffic%20paper-RESTAT.pdf>

Sen, A. "An Empirical Test of the Offset Hypothesis." Journal of Law and Economics, 44.2: (2001). 481-510.

The State of Road Safety in Canada (1998). 24 November 2002. <http://www.ccmta.ca/english/pdf/roadsafety.pdf>

Statistics and Reports. 7 November 2002. Transport Canada, Road Safety Division .<http://www.tc.gc.ca/roadsafety/stats/statsi_e.htm>

Traffic Safety Facts (2000). 24 November 2002. <http://www-nrd.nhtsa.dot.gov/pdf/nrd-30/NCSA/TSF2000/2000alcfacts.pdf>

US Canadian Border Regulations. 2001. accessed 24 March 2003. <http://www.necromantic.net/deadparrot/border01.html>

Vehicle registration and driver licensing. 2003. Canadian Relocation Systems. 11 December, 2002 <http://relocatecanada.com/driverslicence.html>

Wooldridge, Jeffrey M. Introductory econometrics : a modern approach. Cincinnati, Ohio : South-Western College Pub. 2003.

Wooldridge, Jeffrey M. Econometric analysis of cross section and panel data Cambridge, Mass. : MIT Press, 2002.

APPENDIX A

Comments from Earl Marshall

Earl Marshall identified four mechanical vehicle failures that, in his opinion, contribute to motor vehicle accidents.

Table eight: Mechanical Vehicle Failures

Tires	➢ Wheel alignment causes different wear patters. ➢ Right front tire is most likely to experience blow-out. ➢ Tires in the 1960's and 1970's were bike tube style (meaning more blowouts occurred).
Brakes	➢ Rotors need to be a certain thickness. If this minimum thickness is not maintained, heat stress could crack a thin rotor: leading to break failure. ➢ Break pads and tires need to be of equal size and quality for ABS breaking systems to be effective.
Lights	➢ Headlights should be set a little to the right to avoid blinding oncoming traffic.
Steering and Ball Joints	➢ Well lubricated ball joints are essential to ensuring smooth steering and responsive breaking. Adding lubrication is difficult on newer vehicles as ball joints are not equipped with oil nipples.

(table by author)

APPENDIX B

Wald Test Results

Fatalities: OLS

Equation: F_EQ1

Null Hypothesis:	C(3)=0		
	C(4)=0		
	C(5)=0		
	C(6)=0		
F-statistic	5.571175	Probability	0.000246
Chi-square	22.28470	Probability	0.000176

Fatalities: Fixed Effects (no weighting)

Wald Test:

Equation: F_EQ1

Null Hypothesis:	C(3)=0		
	C(4)=0		
	C(5)=0		
	C(6)=0		
F-statistic	0.318451	Probability	0.865540
Chi-square	1.273802	Probability	0.865804

Fatalities: Fixed Effects (weighting)

Wald Test:

Equation: F_EQ1

Null Hypothesis:	C(3)=0		
	C(4)=0		
	C(5)=0		
	C(6)=0		
F-statistic	0.521195	Probability	0.720226
Chi-square	2.084781	Probability	0.720169

APPENDIX C
Robustness Analysis

Coefficient robustness has been identified as a potential shortcoming of this analysis. A few different specifications are presented below. Results below demonstrate that removing the weather variables produces negative inspection coefficient estimates ***only*** under OLS. With weather removed, the inspection variable is more frequently statistically significant.

Alternative Specification #1: Remove all weather variables

Fatalities: OLS

Dependent Variable: ?F
Method: Pooled Least Squares
Date: 02/22/03 Time: 15:41
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.028742	0.000837	34.35226	0.0000
?INSP	-10418.43	2628.577	-3.963524	0.0001
?TIMETREND	6.593191	1.070504	6.158957	0.0000

R-squared	0.831947	Mean dependent var	47400.85
Adjusted R-squared	0.830995	S.D. dependent var	50914.45
S.E. of regression	20931.02	Sum squared resid	1.55E+11
Log likelihood	-4045.475	F-statistic	873.7667
Durbin-Watson stat	0.232259	Prob(F-statistic)	0.000000

Fatalities: Fixed Effects (no weighting)

Dependent Variable: ?F
Method: Pooled Least Squares
Date: 02/22/03 Time: 15:45
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.019087	0.001785	10.69175	0.0000
?INSP	10072.55	2777.893	3.625967	0.0003
?TIMETREND	-176.4738	91.06930	-1.937797	0.0535
Fixed Effects				
BC_--C	381578.7			
AB_--C	389531.4			
SK_--C	361549.6			
MB_--C	362192.4			
ON_--C	392117.9			
QC_--C	424910.9			
NB_--C	344614.0			
NS_--C	345519.5			
PEI_--C	341190.3			
NFLD_--C	339033.8			

R-squared	0.932141	Mean dependent var	47400.85
Adjusted R-squared	0.929767	S.D. dependent var	50914.45
S.E. of regression	13493.14	Sum squared resid	6.24E+10
Log likelihood	-3884.058	F-statistic	2355.784
Durbin-Watson stat	0.535520	Prob(F-statistic)	0.000000

Fatalities: Fixed Effects (weighting)

Dependent Variable: ?F
Method: GLS (Cross Section Weights)
Date: 02/22/03 Time: 15:46
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.019226	0.001434	13.41158	0.0000
?INSP	1695.987	787.7561	2.152934	0.0320
?TIMETREND	-113.4003	23.79590	-4.765539	0.0000
Fixed Effects				
BC_--C	257918.0			
AB_--C	264978.7			
SK_--C	236417.0			
MB_--C	237097.1			
ON_--C	266437.1			
QC_--C	299482.2			
NB_--C	227199.8			
NS_--C	228325.1			
PEI_--C	223816.0			
NFLD_--C	219496.1			

Weighted Statistics			
R-squared	0.908954	Mean dependent var	54195.20
Adjusted R-squared	0.905769	S.D. dependent var	38107.55
S.E. of regression	11697.93	Sum squared resid	4.69E+10
Log likelihood	-3560.739	F-statistic	1712.159
Durbin-Watson stat	0.437546	Prob(F-statistic)	0.000000

Unweighted Statistics			
R-squared	0.930147	Mean dependent var	47400.85
Adjusted R-squared	0.927703	S.D. dependent var	50914.45
S.E. of regression	13689.93	Sum squared resid	6.43E+10
Durbin-Watson stat	0.516229		

Injuries: OLS

Dependent Variable: ?I
Method: Pooled Least Squares
Date: 02/22/03 Time: 15:49
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.011719	0.000235	49.77047	0.0000
?INSP	-521.1538	739.7660	-0.704485	0.4816
?TIMETREND	-0.022876	0.301274	-0.075929	0.9395

R-squared	0.903429	Mean dependent var	15347.05
Adjusted R-squared	0.902882	S.D. dependent var	18902.28
S.E. of regression	5890.662	Sum squared resid	1.22E+10
Log likelihood	-3594.116	F-statistic	1651.173
Durbin-Watson stat	0.120178	Prob(F-statistic)	0.000000

Injuries: Fixed Effects (no weighting)

Dependent Variable: ?I
Method: Pooled Least Squares
Date: 02/22/03 Time: 15:50
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.004100	0.000476	8.605505	0.0000
?INSP	446.4952	741.3270	0.602292	0.5474
?TIMETREND	19.75241	24.30336	0.812744	0.4169
Fixed Effects				
BC_--C	-23320.12			
AB_--C	-33406.90			
SK_--C	-36404.77			
MB_--C	-33755.81			
ON_--C	2336.198			
QC_--C	-15684.54			
NB_--C	-37454.74			
NS_--C	-37823.14			
PEI_--C	-39331.29			
NFLD_--C	-38498.51			

R-squared	0.964937	Mean dependent var	15347.05
Adjusted R-squared	0.963710	S.D. dependent var	18902.28
S.E. of regression	3600.870	Sum squared resid	4.45E+09
Log likelihood	-3413.780	F-statistic	4719.659
Durbin-Watson stat	0.280427	Prob(F-statistic)	0.000000

Injuries: Fixed Effects (weighting)

Dependent Variable: ?I
Method: GLS (Cross Section Weights)
Date: 02/22/03 Time: 15:50
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.005340	0.000342	15.61910	0.0000
?INSP	73.26813	85.80937	0.853848	0.3938
?TIMETREND	-3.436320	3.527379	-0.974185	0.3307
Fixed Effects				
BC_--C	20532.42			
AB_--C	10749.00			
SK_--C	8771.837			
MB_--C	11461.44			
ON_--C	42338.67			
QC_--C	26563.41			
NB_--C	8419.807			
NS_--C	7947.779			
PEI_--C	6898.591			
NFLD_--C	7435.245			

Weighted Statistics			
R-squared	0.888818	Mean dependent var	23632.91
Adjusted R-squared	0.884928	S.D. dependent var	9635.279
S.E. of regression	3268.498	Sum squared resid	3.66E+09
Log likelihood	-2942.242	F-statistic	1371.019
Durbin-Watson stat	0.469608	Prob(F-statistic)	0.000000

Unweighted Statistics			
R-squared	0.964110	Mean dependent var	15347.05
Adjusted R-squared	0.962854	S.D. dependent var	18902.28
S.E. of regression	3643.076	Sum squared resid	4.55E+09
Durbin-Watson stat	0.277745		

Property Damage: OLS

Dependent Variable: ?PD
Method: Pooled Least Squares
Date: 02/22/03 Time: 16:02
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.028524	0.000825	34.56107	0.0000
?INSP	-9610.962	2592.850	-3.706717	0.0002
?TIMETREND	6.949407	1.055955	6.581161	0.0000

R-squared	0.832429	Mean dependent var	48118.31
Adjusted R-squared	0.831480	S.D. dependent var	50294.62
S.E. of regression	20646.54	Sum squared resid	1.50E+11
Log likelihood	-4040.604	F-statistic	876.7876
Durbin-Watson stat	0.238834	Prob(F-statistic)	0.000000

Property Damage: Fixed Effects (no weighting)

Dependent Variable: ?PD
Method: Pooled Least Squares
Date: 02/22/03 Time: 16:02
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.019144	0.001781	10.74878	0.0000
?INSP	11039.11	2771.379	3.983254	0.0001
?TIMETREND	-178.6254	90.85574	-1.966033	0.0501
Fixed Effects				
BC_--C	385555.8			
AB_--C	393631.7			
SK_--C	365778.6			
MB_--C	366422.7			
ON_--C	396109.4			
QC_--C	429005.1			
NB_--C	347973.2			
NS_--C	348846.6			
PEI_--C	344565.8			
NFLD_--C	349948.1			

R-squared	0.930783	Mean dependent var	48118.31
Adjusted R-squared	0.928362	S.D. dependent var	50294.62
S.E. of regression	13461.50	Sum squared resid	6.22E+10
Log likelihood	-3883.222	F-statistic	2306.232
Durbin-Watson stat	0.541638	Prob(F-statistic)	0.000000

Property Damage: Fixed Effects (weighting)

Dependent Variable: ?PD
Method: GLS (Cross Section Weights)
Date: 02/22/03 Time: 16:02
Sample: 1965 2000
Included observations: 36
Number of cross-sections used: 10
Total panel (unbalanced) observations: 356

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	0.019417	0.001445	13.43751	0.0000
?INSP	2472.828	799.9902	3.091072	0.0022
?TIMETREND	-121.7227	24.64633	-4.938777	0.0000
Fixed Effects				
BC_--C	273929.3			
AB_--C	281129.3			
SK_--C	252794.0			
MB_--C	253478.0			
ON_--C	282016.3			
QC_--C	315406.6			
NB_--C	242919.4			
NS_--C	244005.7			
PEI_--C	239590.3			
NFLD_--C	242736.5			

Weighted Statistics			
R-squared	0.896630	Mean dependent var	55431.43
Adjusted R-squared	0.893013	S.D. dependent var	35615.86
S.E. of regression	11649.52	Sum squared resid	4.65E+10
Log likelihood	-3587.598	F-statistic	1487.586
Durbin-Watson stat	0.465923	Prob(F-statistic)	0.000000

Unweighted Statistics			
R-squared	0.928657	Mean dependent var	48118.31
Adjusted R-squared	0.926161	S.D. dependent var	50294.62
S.E. of regression	13666.75	Sum squared resid	6.41E+10

APPENDIX D

Registration and Vehicle Age

Using data from the 2000 edition of the Canadian vehicle survey I calculate the proportion of registered vehicles on the road in 2000 that were model year 1981 or older. As table eight below shows: western provinces have the highest proportion of older vehicles on roads.

According to Transport Canada, the *"Canadian Vehicle Survey is funded by Transport Canada and undertaken by Statistics Canada, with the cooperation of the Registrars of Motor Vehicles in all Provinces and Territories in providing access to their files of vehicle registrations for sampling purposes. The survey began in 1999, and results for 2000, the first complete calendar year of surveying, were released in August 2001."*

Table nine: Percentage of provincial vehicles with certain model year.

Model Years	NF	PE	NS	NB	QU	ON	MA	SK	AL	BC
	Percent of total									
1981 or older	**1.6**	**3.6**	**3.4**	**3.1**	**2.1**	**3.0**	**6.8**	**12.6**	**9.4**	**8.7**
1982	0.3	0.4	0.4	0.4	0.2	0.4	1.1	2.0	1.4	1.2
1983	0.4	1.0	0.7	0.9	0.4	0.6	1.4	2.3	1.6	1.5
1984	0.9	2.1	1.6	1.8	1.2	1.4	2.6	3.4	2.6	2.5
1985	1.4	2.8	2.2	2.5	1.9	2.1	3.4	3.9	3.3	3.2
1986	2.1	3.7	3.1	3.5	2.8	3.2	4.7	5.0	4.5	4.5
1987	3.0	5.1	4.0	4.5	4.0	3.9	4.5	4.3	3.9	4.6
1988	5.7	7.4	5.7	6.5	5.8	5.7	5.5	5.2	5.1	5.5
1989	6.8	7.7	6.2	7.0	6.1	6.2	5.5	5.1	5.4	6.0
1990	6.6	8.0	6.4	7.0	6.3	6.2	6.0	5.3	5.7	6.5
1991	6.7	7.0	6.2	0.7	6.5	6.0	6.2	5.4	5.6	6.3
1992	7.0	7.7	6.7	7.4	7.3	6.5	6.3	5.5	5.5	6.3
1993	7.3	7.2	6.5	6.6	6.6	6.1	5.6	5.0	5.0	5.8
1994	7.3	7.0	6.6	6.6	6.2	6.1	5.5	5.3	5.2	5.5
1995	6.8	7.0	6.7	6.8	6.6	6.5	5.9	5.6	5.5	5.6
1996	5.1	5.4	5.5	5.5	5.3	5.4	5.1	4.6	4.6	4.4
1997	6.8	5.6	6.7	6.6	6.6	6.8	6.5	5.9	6.3	5.6
1998	8.7	4.4	7.5	7.8	8.0	7.7	6.8	5.8	7.1	5.7
1999	8.6	3.4	7.1	7.3	8.0	7.9	5.8	4.3	6.2	5.3
2000	7.0	3.3	6.9	7.4	8.1	8.3	4.9	3.7	6.1	5.2

(table by author)

APPENDIX E

Heteroscedasticity Testing

In appendix E, R^2 values are calculated by regressing the sum squared residuals on the number of registrations and the inspection dummy variable. These regressors were chosen because they are likely to have a relationship to the errors.

Fatalities: $R^2 = 0.146$, n=306 so the LM statistic is: 44.67

Dependent Variable: ?RESID2F
Method: Pooled Least Squares
Date: 03/27/03 Time: 23:32
Sample(adjusted): 1970 2000
Included observations: 31 after adjusting endpoints
Number of cross-sections used: 10
Total panel (balanced) observations: 306

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	-15.02079	76.30047	-0.196864	0.8441
?INSP	3.01E+08	1.64E+08	1.830061	0.0683
Fixed Effects				
BC_--C	7.02E+08			
AB_--C	2.50E+08			
SK_--C	53181292			
MB_--C	25232541			
ON_--C	3.06E+08			
QC_--C	3.60E+08			
NB_--C	-2.89E+08			
NS_--C	-2.89E+08			
PEI_--C	-2.98E+08			
NFLD_--C	-1.17E+08			

R-squared	0.146867	Mean dependent var	1.67E+08
Adjusted R-squared	0.114947	S.D. dependent var	5.97E+08
S.E. of regression	5.61E+08	Sum squared resid	9.27E+19
Log likelihood	-6592.734	F-statistic	50.61216
Durbin-Watson stat	1.824322	Prob(F-statistic)	0.00000

Injuries: $R^2 = 0.44$, n=306 so the LM statistic is: 134.6

Dependent Variable: ?RESID2I
Method: Pooled Least Squares
Date: 03/27/03 Time: 23:39
Sample(adjusted): 1970 2000
Included observations: 31 after adjusting endpoints
Number of cross-sections used: 10
Total panel (balanced) observations: 306

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	11.53081	2.777004	4.152247	0.0000
?INSP	-11552595	5983143.	-1.930857	0.0545
Fixed Effects				
BC_--C	13004927			
AB_--C	-14402086			
SK_--C	-7207665.			
MB_--C	-6101033.			
ON_--C	-7309177.			

QC_--C	-17436786		
NB_--C	7696925.		
NS_--C	6259071.		
PEI_--C	11227078		
NFLD_--C	5869686.		
R-squared	0.442743	Mean dependent var	11085265
Adjusted R-squared	0.421893	S.D. dependent var	26873139
S.E. of regression	20432549	Sum squared resid	1.23E+17
Log likelihood	-5578.862	F-statistic	233.5839
Durbin-Watson stat	0.930748	Prob(F-statistic)	0.000000

Property Damage: $R^2 = 0.148$, n=306 so the LM statistic is: 45.28

Dependent Variable: ?RESID2PD
Method: Pooled Least Squares
Date: 03/27/03 Time: 23:40
Sample(adjusted): 1970 2000
Included observations: 31 after adjusting endpoints
Number of cross-sections used: 10
Total panel (balanced) observations: 306

Variable	Coefficient	Std. Error	t-Statistic	Prob.
?REG	-13.49495	74.85727	-0.180276	0.8571
?INSP	3.00E+08	1.61E+08	1.857328	0.0643
Fixed Effects				
BC_--C	6.87E+08			
AB_--C	2.47E+08			
SK_--C	51843111			
MB_--C	24110754			
ON_--C	2.99E+08			
QC_--C	3.55E+08			
NB_--C	-2.89E+08			
NS_--C	-2.88E+08			
PEI_--C	-2.97E+08			
NFLD_--C	-1.24E+08			

R-squared	0.148588	Mean dependent var	1.65E+08
Adjusted R-squared	0.116733	S.D. dependent var	5.86E+08
S.E. of regression	5.51E+08	Sum squared resid	8.92E+19
Log likelihood	-6586.891	F-statistic	51.30890
Durbin-Watson stat	1.825683	Prob(F-statistic)	0.000000