From Smeed's Single-Damage Fixed-Form Three-Variable Model to Multinational and Multiprovincial DRAG-Type Formulations : Does the Mystery of 1972-1973 Disappear?

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1. INTRODUCTION : WHY UPDATE SMEED?

Outcomes and explanatory structure. Structural models explain a dependent variable by something else than itself (lagged), or time, and a random term. Structural road safety modeling with pooled time-series and cross sectional multinational data started with Smeed (1949) and was revived by Page (1997). As implied in Table 2, it is concerned only with fatalities, and naturally cannot easily detect substitution with other outcomes, for instance injury and material damage only accidents, because only one type of outcome is analyzed. For this purpose, national models have been used: Peltzman (1975) was the first to consider three kinds of damage outcomes, thereby allowing for the proper detection of substitution among outcomes. More formally, for each kind of outcome ***d***, the problem is to explain damages in terms of factors:

(1) $\textbf{VICTIMS}_d \leftarrow f_d$ [DEMAND FOR ROAD USE, OTHER FACTORS]

Gaudry (1984) was the first to further decompose damage outcomes as products of accident frequency and accident severity measures by category, thereby allowing to identify also substitution between frequency and severity risks for each kind of outcome reported in police statistics. Formula (1) describes the risk of driving; it may be decomposed into three elements, namely exposure risk, frequency risk and severity risk, which yield damage measures if they are combined. For instance, if we define:

(2)	*exposure*:	vehicle-kilometers driven;
	accident frequency:	accidents (of a given category) per vehicle-kilometer;
	accident severity:	victims (of a given category) per accident;

then multiplying the three will result in the total loss measure: *victims (of a given category).*

This implies that an explanation of the number of victims can be efficiently derived from separate explanation of the three terms of the identity, as in the recursive system:

		DR = Demand for Road Use	← [---, OTHER FACTORS $= X_1$]
(3)	**VI** ←	**A** = Accident Frequency	← [DR, OTHER FACTORS $=X_2$]
		G = Accident Severity	← [DR, OTHER FACTORS $=X_3$]

where the symbols in bold denote vectors. The format itself allows to inquire into risk substitution among exposure, frequency and severity risks. For instance, rainfall, a factor to be included in all three equations (in X_1 as in X_2 and in X_3), may reduce road demand but, given exposure, increase accidents, which might be less severe because of lower average speed; consequently, the net impact could be either an increase or a decrease of the number of victims.

In this paper, we build comparable multi-***national*** (MNM) and multi-***provincial*** (MPM) models including Quebec in both sets of models as a distinct unit (and reference region for the expression of some results). We select subsets of the MAYNARD-DRAG database that we have built (Gaudry *et al.,* 2002) in order to be able to detect substitution among outcomes by category, thereby rejecting the usual single-damage form of (1) to study fatalities. We limit ourselves to analyses of A and G (leaving the explanation of DR to another occasion) and focus on substitution between the first moment of the selected dependent variables: higher moment Allais trade-offs considered in Gaudry (1998) are not so easily amenable to study with pooled data.

We therefore study injury accident frequency (the sum of fatal and non-fatal bodily injury accidents), morbidity (injured persons per bodily injury accident), mortality (killed persons per bodily injury accident) and the number of injured and killed victims. Limitations of the data are discussed at length in the database documentation.

Explanatory variables. Most previous DRAG-type structures have used important numbers of explanatory variables selected from many categories. A partial list is found in Table 1.

Table 1. Types of variables used in DRAG-type accident frequency and severity models

(DR)	**Demand**		-*vehicle-kilometers* by category of vehicle
			-use of public road modes and modal mix, including strikes
			- rates of vehicles *occupancy, or proxy thereof*
(P)	**Price**		- *prices of gasoline and diesel motorvehicle fuels*
			- price of vehicle maintenance
(T)			- actual speed
			- traffic density indicators: *urban/country location*
(M)	**Vehicle**	**- availability (*)**	- by type (cars, trucks, etc.)
		- characteristics	- *proportion of small cars and vehicle mix*
			- proportion equipped with safety features
			- age structure of fleet
			- vehicle defect certifications
(N)	**Network (*N-L*)**	**- legal**	- *speed limits*
			- demerit point system and penalties
			- breathalyzer test
			- *seatbelt laws*
			- police patrol frequency
		- infrastructure	- network length (*)
			- design and surface quality (including strikes)
	(*N-W*)	**- weather**	- *temperature*
			- *rainfall*
			- *snowfall and other precipitation*
			- fog
			- daylight duration and orientation to the sun
(Y)	**Consumer**	**- membership**	- driving license availability rights
			- automobile insurance schemes
		- age and sex	- age or *age structure*
			- pregnancy
		- vigilance	- weekly hours worked
			- drug and alcohol consumption
			- smoking and other distractions
		- status	- unemployment
			- per capita GNP, income or wealth measure
(A)	**Activity**	**- level (*)**	- employment activity
			- GNP global activity measure
		- composition	- intermediate activities by industrial sector
			- shopping/working/ vacation/working
(ETC)	**Administrative and measurement**		-*aggregation*
			-...

(*) If DR variables are used, quantities of vehicles, network length and activity *levels* are not appropriate for the explanation of A and G. These variables are however appropriate in the direct explanation of DR.

As we demand more information on various explanatory factors (in addition to multiple outcomes), the number of countries or provinces available for regression work rapidly decreases. This means that, in order to have common factors across the countries for a reasonable number of variables, and maintain the possibility of multiple outcomes (fatalities are usually observed, but injuries are often not), the maximum number of observations is severely restricted: in our case to 455 yearly observations pertaining to 13 countries or regions[1] over the period 1965-1998 (35 years). For the multiprovincial data set for Canada, an almost identical model can be defined for the 10 provinces (but not for the 3 current territories) over the same period, based on 350 yearly observations.

The shaded underlined variables in Table 1 indicate the variables chosen for our models. Only a handful of others (typically population shares) were available. One of our hopes, to isolate the role of government interventions from that of the rest of the factors that determine road risk, is per force very limited by the data availibility.

Form and stochastic specification. In terms of functional form, all models before Gaudry (1984) use the logarithmic variant ($\lambda_y = \lambda_x = 0$) and a spherical distribution of residuals (i.e. non autocorrelated ($\rho_1 = ... = \rho_r = 0$) and homoskedastic ($\delta_m = 0$) residuals) in the model:

$$(4.1)\quad y_t^{(\lambda_y)} = \sum_{k=1}^{K} \beta_k \cdot X_{kt}^{(\lambda_{X_k})} + u_t.$$

$$(4.2)\quad u_t = \left[\exp\left(\sum_m \delta_m Z_{mt}^{(\lambda_{z_m})}\right)\right]^{1/2} \bullet v_t.$$

$$(4.3)\quad v_t = \sum_l \rho_l v_{t-l} + w_t,$$

with the Box-Cox transformation defined for any strictly positive y, Z_m or X_k variable as :

$$(4.4)\quad X_k^{(\lambda)} = \begin{cases} \dfrac{X_k^{\lambda} - 1}{\lambda} & if\ \lambda \neq 0, \\ \ln X_k & if\ \lambda = 0. \end{cases}$$

As functional form influences not only the estimated elasticities but also their signs, it is a matter of the utmost importance to probe issues of form in order to insure the robustness of empirical results. Interestingly, all *monthly* models that probe the optimal form with this flexible econometric specification (4.1)-(4.4) find that both linear and logarithmic forms are rejected. For instance, as a rule, the authors of the models for Quebec, France, Germany, Norway, Stockholm and California found in Gaudry and Lassarre (2000) *all* reject the popular linear and logarithmic forms with Box-Cox transformations while taking due account of nonsphericalness of the distribution of the residuals using the L-1.5 algorithm (Liem *et al.,* 2000) to estimate the parameters of Equations (4.1) to (4.4). In this paper, the robust ness of our results, all obtained

[1] Austria, Belgium, Canada, Denmark, France, Germany, Norway, The Netherlands, The United Kingdom, Spain, Sweden, Switzerland, plus Quebec (added as per our terms of reference).

with yearly data, is tested. An interesting issue is whether yearly data tend to yield logarithmic models and monthly models non logarithmic ones.

Issues of autocorrelation and heteroskedasticity have not been dealt with previously in multinational models, although Page (1997) has reported that he tended to obtain first differences ($\rho_1 = 1$ in (4.3)) in his exploratory trials and consequently assumed ($\rho_1 = 0$).

Table 2. Core dimensions of structural road safety models

Model:	*Multi-national or regional*		*Mono-National or Regional*		*Regression characteristics*				
y variable:	**Severity**	**Damage**	**Severity**	**Damage**	X_k	**t (*)**	λ_y, λ_x	ρ	δ_m
Smeed (1949)	–	Killed			2	210 yp	$\lambda_y = \lambda_x = 0$	= 0	= 0
Peltzman (1975)			–	Killed 1, Killed 2 Injured, Material	6	18 y	$\lambda_y = \lambda_x = 0$	= 0	= 0
Gaudry (1984)			Mortality Morbidity	Killed, Injured, Material	43	300 m	$\lambda_y \neq \lambda_x$	$\neq 0$	$\neq 0$
Page (1997)	–	Killed			7	315 yp	$\lambda_y = \lambda_x = 0$	$\neq 0$	
Fridström (1999)	Mortality Morbidity 1 Morbidity 2	Killed Injured 1 Injured 2			48	5016 mp	$\lambda_y \neq \lambda_x$	$\neq 0$	$\neq 0$

(*) m = monthly; y = yearly; p = pooled.

Economic issues. In addition to establishing the role of government intervention within a multinational model, it would be of interest to examine in particular "the mystery of 1972-1973" (Gaudry, 1998) whereby in Israel and in most of the OECD countries, the absolute number of road fatalities reached its absolute maximum in 1972, or very close to that point, but in a few other countries of low motorization (Greece, Spain, Turkey) this did not happen and the absolute number of fatalities is still sometimes increasing thirty years later (2002). Consider the indices of road fatalities for 26 countries shown in Figure 1: (i) all countries reach their absolute maximum within the sample period except for Great Britain that had a slightly higher peak in 1940 and Greece[2]; (ii) Great Britain and Sweden peak early in 1965-1966, with indices respectively at 219 and 223, but Great Britain has a near-maximum in 1972 (213) and Sweden reaches another almost identical maximum in 1970 (222), close to the others' bulge, as listed in Table 3. In Canada, most important regions peak in 1973, as indicated in Table 3.

Appendix 1 shows that road injuries (excluding fatalities) also have a tendency to peak in 1972-1973 in about half of the countries considered, but that thereafter only about half of these continue to fall: many follow a flat or even a slowly upward slope, a few now reaching levels comparable or higher than those of 1972-1973. Clearly, the mystery of 1972-1973 carries over somewhat, but afterwards some substitution occurs as the dominant falling slopes of the indexes of killed persons are generally not reproduced.

[2] We understand that fatalities are still increasing, but could not obtain confirmation that 1998 is not the maximum to date.

A sub-issue is whether, in our sample, unobserved congestion—clearly a candidate to explain this simultaneous peaking of so many series—can be modeled indirectly through the use of Box-Cox transformations on the measure of exposure used, and whether perhaps an asymmetric inverted U-shaped effect (Gaudry *et al.*, 2000) found and used for forecasting, as in Quebec (Fournier et Simard, 1999), could be of use. Unfortunately, we could not test for this in our models, as such testing requires to have box-Cox transformations for countries with vehicle-kilometers of a similar order of magnitude: clearly, one cannot, within the same sample, assume that the maximum is associated with the same absolute number of vehicle-kilometers for Austria and The United Kingdom. The possible way around this problem, an extensive study of the (13+10)= 26 potential additional Box-Cox transformations and of the (12+9)= 21 additional associated dummy variables (to compensate for the shift implied in using Box-Cox transformations on 26 variables that contain large numbers of zeroes), could not be explored within the allocated time (30 months) of this project.

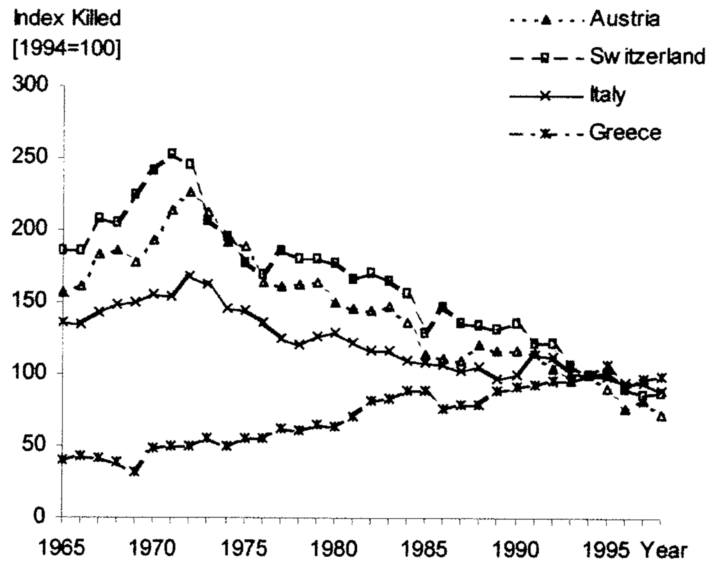
With respect to the mystery of 1972-1973, our maintained hypothesis stated earlier (Gaudry, 1998) is that a demographic break, showing up indirectly in the number of occupants per vehicle, accounts for this mystery as well as for the gradual worsening of the Smeed equation fit since the early 1970's and for many economic quandaries with break points around 1972-1973 (productivity growth, etc.) or just afterwards (rate of growth of real wages, etc.). Clearly, as vehicle-kilometres kept increasing everywhere despite higher fuel prices, something more interesting, structural and long-term than the first October 1973 OPEC crisis is involved.

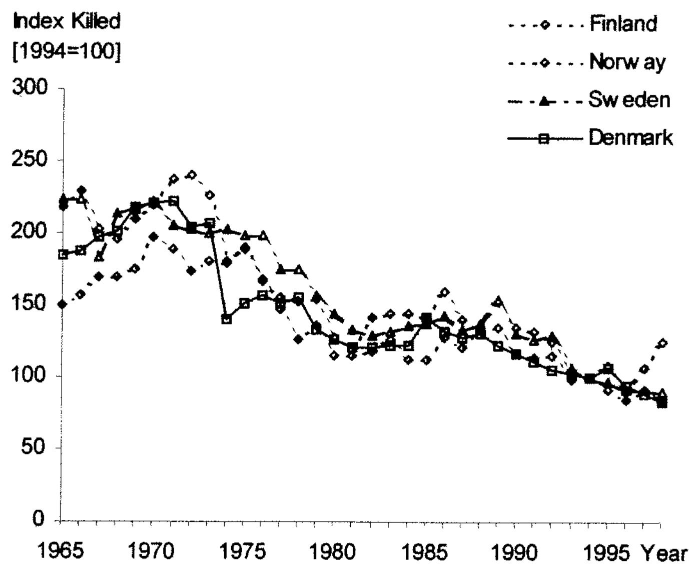
But we have not yet been able to distinguish this occupancy effect from the congestion effect. This would have been feasible if measures of vehicle-kilometres per kilometer of roadway could have been used: unfortunately, the data on road network length are not comparable enough for a meaningful traffic density measure to be defined. In these circumstances, only country-specific estimates, of the kind used by Fournier and Simard for Quebec (1999) are possible. But such studies in non linear effects would require a few additional months, because of the increased probability of local maxima as the number of competing Box-Cox, including quasi-quadratic effect, parameters increases.

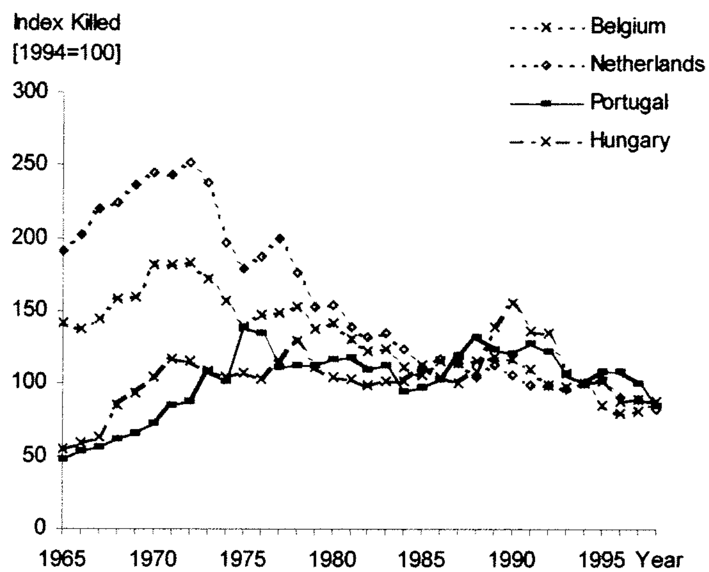
Table 3. Peak of fatalities series in 26 countries and in 12 Canadian regions

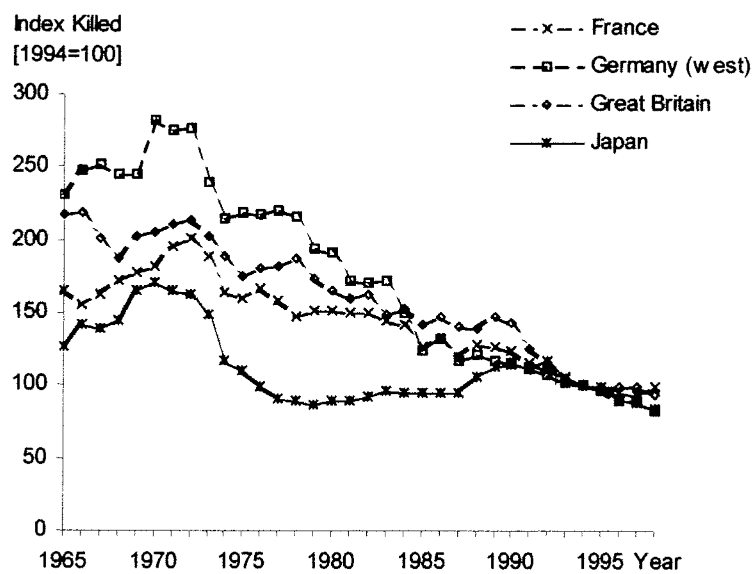
Year	N	26 Countries of Figure 1 (minus Greece, plus Israel)	N	10 Canadian provinces and 2 territories
1965-1966	2	Great Britain, Sweden		
1970	3	Luxemburg, Japan, Norway		
1971	1	Switzerland		
1972	10	(Israel), Austria, Belgium, France, Finland, Germany (W), Ireland, Italy, Netherlands, United States	1	Prince Edward Island
1973	3	**Canada**, Denmark, New Zealand	6	Nova Scotia, **Quebec**, Ontario, Manitoba, Yukon, Northwest Territories
1974			5	Newfoundland, New Brunswick, Saskatchewan, Alberta, British Columbia
1975; 1977; 1978	2 +(1/2)	Portugal, *Germany(E) before reunification*, Australia		
1988; 1989; 1990; 1991	3 +(1/2)	Iceland, Spain, Hungary, *Germany(E) after reunification*		
1993	1	Turkey		

Figure 1. Simultaneous peaking in road fatalities around 1972-1973, 26 countries






Index Killed
[1994=100]
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995 Year
Belgium
Netherlands
Portugal
Hungary


Index Killed
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1990
1995 Year
France
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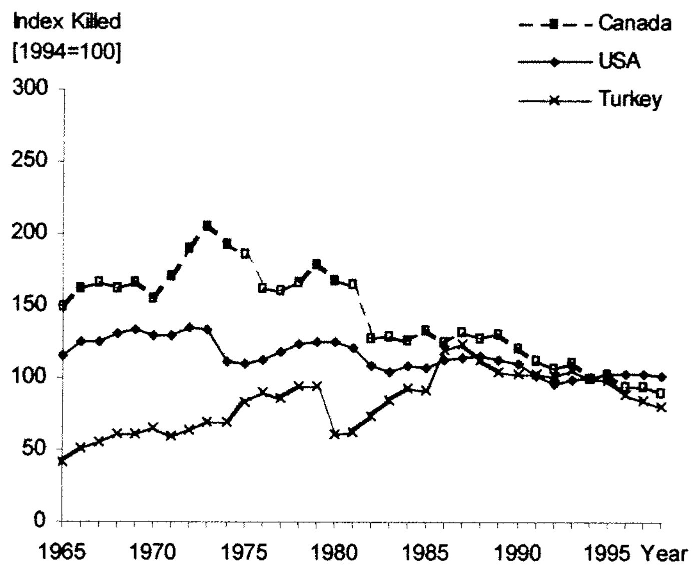
Great Britain
Japan


Index Killed
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Canada
USA
Turkey
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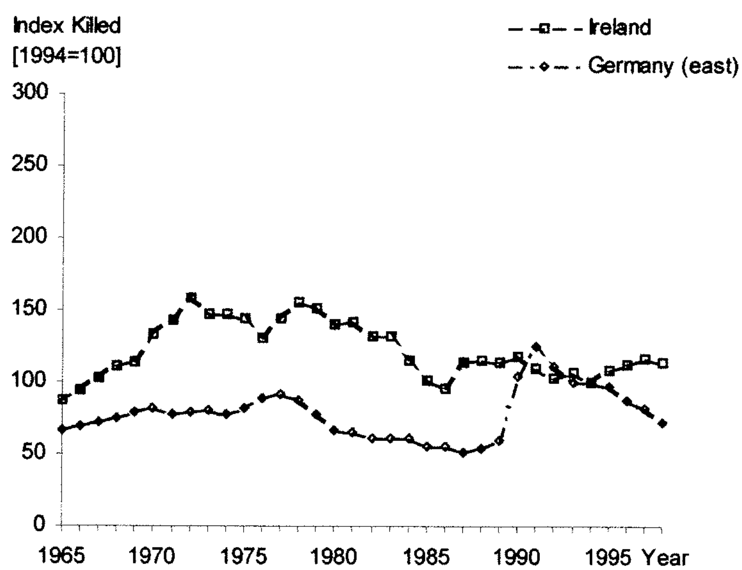
Year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Germany (east)
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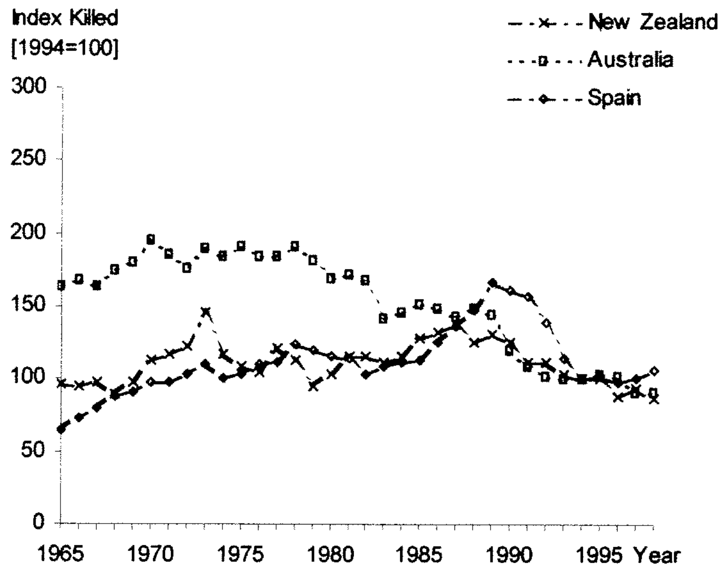
Index Killed
[1994=100]
New Zealand
Australia
Spain
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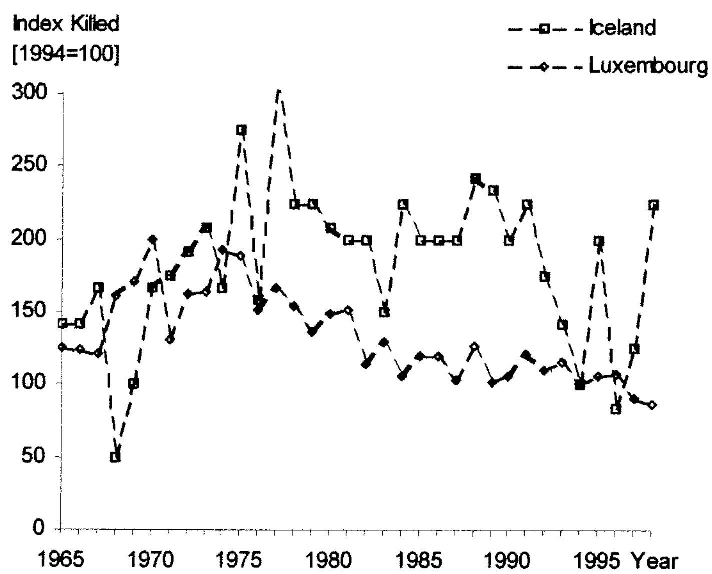
1965
1970
1975
1980
1985
1990
1995
Year


Index Killed
[1994=100]
Iceland
Luxembourg
300
250
200
150
100
50
0
1965
1970
1975
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1990
1995
Year

Normalized safety indices. In addition, we want to say something about the difficulty of constructing normalized indices of safety across countries, and about interpreting remaining country-specific residuals in the case of a model that clearly cannot have the sophistication of monthly DRAG-type models using 3 to 4 times the number of explanatory variables available to us here. In particular, the absence of daylight data, that explain a high proportion of variance in accident counts (Fridström *et al.*, 1995), and are very correlated with cultural attitudes, spending on Christmas decorations, and religious choices, leaves the door open to refinements using such daylight variables, as well as other indicators—notably of congestion—in later models.

Smeed's starting point. Smeed most famous equation S-1 found in Table 4 was obtained by log-linear regression (S-4) between the yearly number of killed individuals per registered vehicle and the number of vehicles per capita in 1938 for 20 countries (Smeed, 1949); and he declared himself satisfied with how it fitted Britain for the sample consisting in years 1909-1947 (Adams, 1985a, 1985b) and in tests for a sample of 68 countries for the period 1957-1966 (Smeed, 1968; Smeed and Jeffcoate, 1969). Adams (*op. cit.)* retested it for 62 countries in 1980 and was satisfied that the linear regression slopes had barely changed from that of (S-1), but he did not provide numerical estimates or tests: only a graph of fitted lines.

Table 4. Smeed country set data base, various samples

			Years	t	R^2
S-1	(Killed/Vehicles) =	k (Vehicles/Population) $^{-2/3}$			
S-2	(Killed) =	k (Vehicles) $^{1/3}$ / (Population) $^{-2/3}$			
S-3	(Killed) =	k (Vehicles) $^{1/3}$. (Population) $^{2/3}$			
S-4	*Ln (Killed)* =	*Ln (k)* + 0,333 *Ln* (Vehicles) + 0,667 *Ln* (Population)	1938	20	
S-5	*Ln (Killed)* =	*Ln (k)* + 0,408 *Ln* (Vehicles) + 0,699 *Ln* (Population) (16.31) (20.41)	1938- 1946	210	0,98
S-6	*Ln (Killed)* =	*Ln (k)* – 0, 058 *Ln* (Vehicles) + 1,100 *Ln* (Population) (-3.36) (55.92)	1965- 1998	918	0,88

(t-statistics are provided in parentheses). *Ln* denotes natural logarithm.

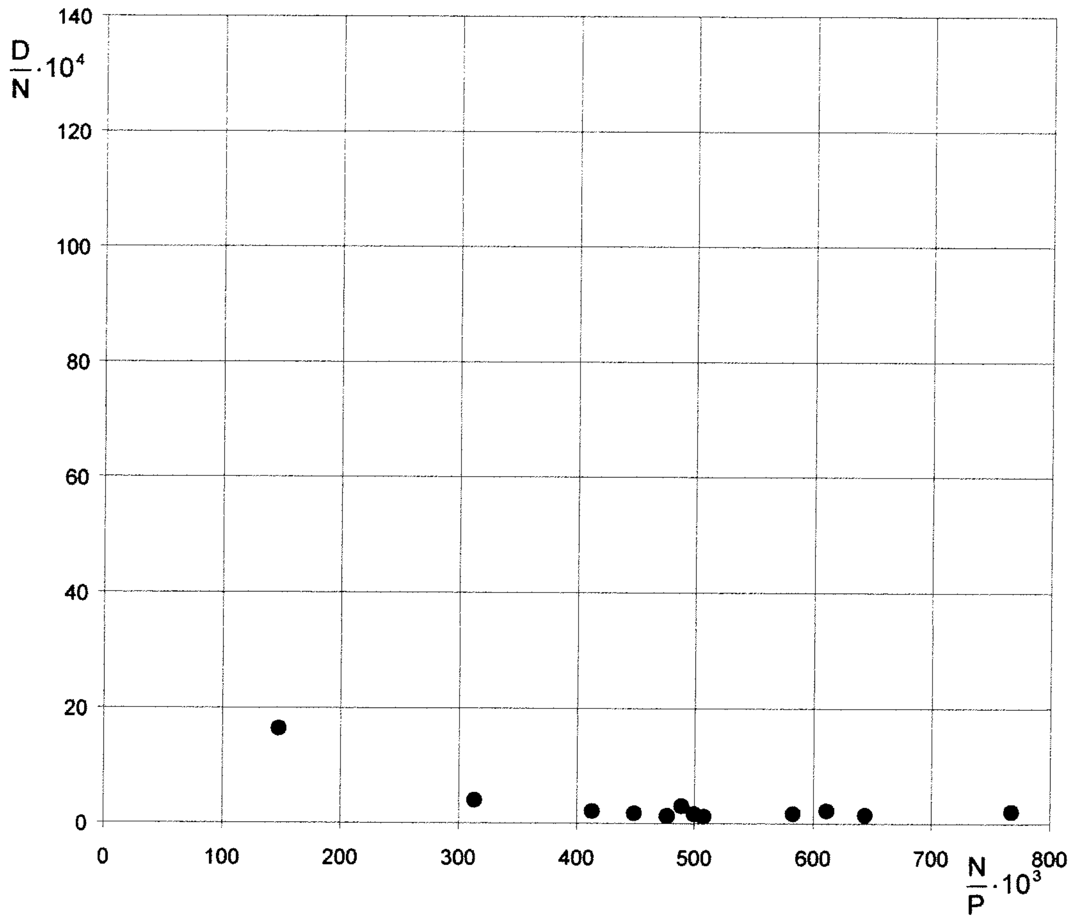
We retested it with one of Smeed's own data bases (S-5), and again with another, much more recent pooled sample (S-6): the relationship clearly breaks down. Detailed analysis (Fournier and Simard, 1999) indicates that this happens in the mid-1970's as the model (S-1) starts to grossly overpredict fatalities in advanced countries. To see how this could occur, compare the data set for S-4, found in Figure 2 with that of the complete sample (S-4) to the more recent (S-5) and (S-6) found in Figure 3.

By double clicking on Figure 2, one can see successive sets of values for the years 1938 (shown), 1965, 1970, 1980, 1990 and 1998: one notices how the clouds of points gradually move down to the right: Figure 3 contains all of these points. In that figure, all sample points from S-4 (1938) are to the left of 230 vehicles per 1000 persons indicated by the x-axis, but recent points drawn from S-6 (1965; 1970; 1980; 1990; 1998) are more evenly distributed.

In addition, tests of heteroskedasticity of S-6 using Equation (4.3) and the variable number of registered vehicles as Z_m variable increased the value of the log likelihood of the sample from -7609.031 to -7590.266, with a difference of two degrees of freedom...Clearly, something more sophisticated is required.

Figure 2. Relation between fatalities per capita and persons per vehicle, 1938, S-4 sample

(Smeed's data for 1938)

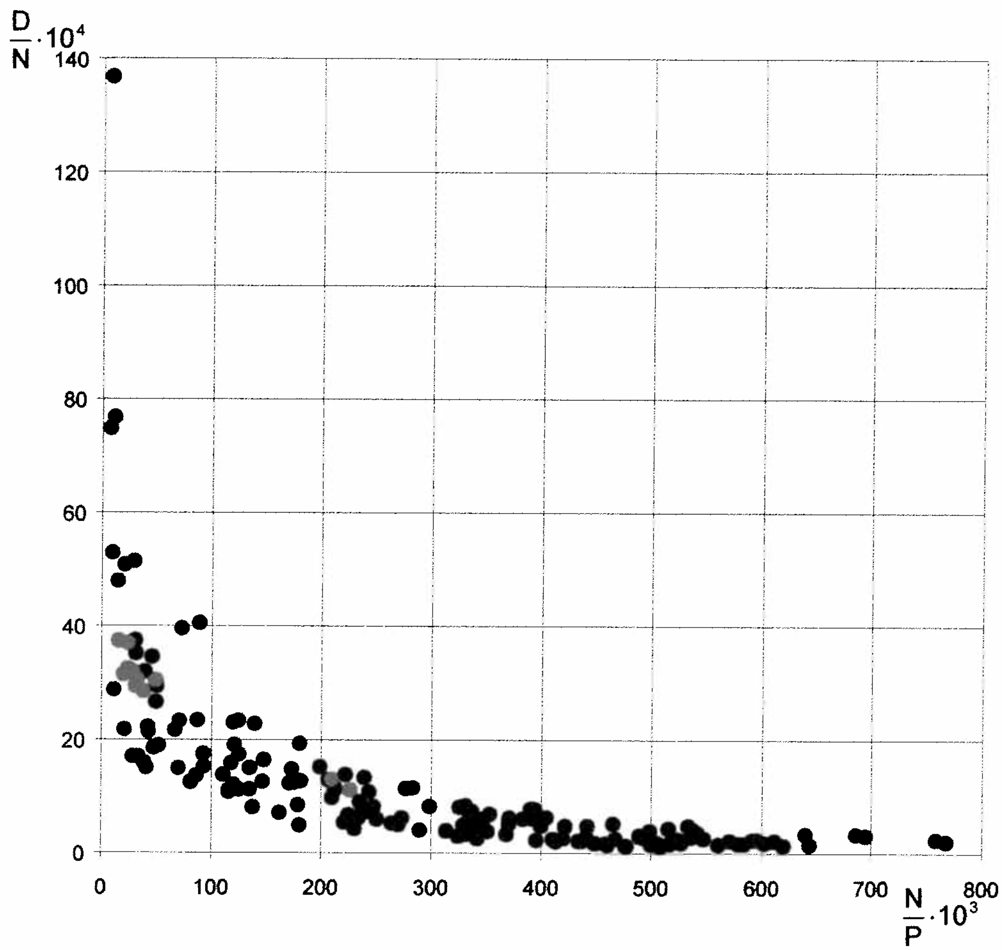


Relation between Number of Deaths per 10,000 Registered Motor Vehicles and Number of Vehicles per 1,000 Population for 1998

Great Britain	Finland	South Africa	Canada	Australia
Northern Ireland	Norway	New Zealand	Italy	Netherlands
Ireland	Sweden	Denmark		Switzerland
United States	France	Portugal		

Figure 3. Relation between fatalities per capita and persons per vehicle, S-5 and S-6 samples

(Red points: Smeed's data: 1938; Blue points: MAYNARD-DRAG data 1965; 1970;1980;1990;1998)



Relation between Number of Deaths per 10,000 Registered Motor Vehicles and Number of Vehicles per 1,000 Population for all Years

2. The MNM/MPM-DRAG basic specification

To summarize, in our basic DRAG-type specification, (i) numbers of victims by category (outcomes) are decomposed into multiplicative accident frequency and accident severity components, in order to study substitution; (ii) multiple outcomes are required to study substitution; (iii) many classes of variables intervene; (iv) estimates of form and stochastic specification must be carried out. Take these in turn, for both multinational and multiprovincial specifications together.

Multiple levels and outcomes. In our cases, as stated above, accidents ***are bodily injury*** accidents (having caused injuries or fatalities); severity is measured both as ***morbidity*** (injured persons by bodily injury accident) and ***mortality*** (killed persons per bolily injury accident). Outcomes are ***injured*** persons and ***killed*** persons. As outcomes are the product of frequency and severity measures, we have the option of estimating the components of the products and deriving values for outcomes, or of estimating equations for all elements: frequency, severity, outcome. We chose the latter because this makes it easier to compare our results with those who merely estimate equations by category of victims and because one learns something in a synoptic table from parallel estimation of frequency, severity and damage outcome equations.

Multivariate: not just vehicles, roads and drivers. Also, as indicated in Table 1, we specified a model that would have a minimum of relevant explanatory variables that have demonstrated their importance in monthly models. So we included explanatory variables[3] belonging to the following categories: ***Exposure, Price, Motorization, Network Regulations, Weather, Population socio-economic characteristics, Economic wealth, and Etc.*** Naturally, models estimated from monthly data have a strong advantage in that variance of the data is much higher that with annual data, so it was not clear from the start how many variables one could keep and still obtain robust results.

Form and stochastic specification in two steps. We decided to keep the model log linear at first, in order to have strict comparability with the previous exercises of Smeed and Page, and then to try more sophisticated generalizations according to (4.1)-(4.4), the state of the art in monthly models. The reference MNM-1.0 Multinational Model is found in Table 5 and the reference MPM-1.0 Multiprovincial Model is found in Table 6. We now proceed to make a few comments on these reference model, where each equation has been carefully checked for robustness with respect to multicolinearity using Belsley's indices, before taking each equation in turn and seeing if it is robust to more sophisticated specifications.

Reporting format. First, we note that, for each model written in a column: ► *Section I* of the table presents, elasticities, evaluated at the sample means, and the *t*-statistics of the underlying regression coefficients, estimated conditionally upon the estimates (or assumed value) of the Box-Cox transformations. All variables are continuous non-zero variables except the seatbelt regulation variable dummy and the leap year aggregation measurement dummy (in these cases the elasticity measures the percentage impact on the dependent variable of the presence of the dummy). Finally, a reminder of the identity of the Box-Cox transformation used is located under the *t*-statistic. ►*Section II* contains values of the Box-Cox transformations and of autocorrelation and heteroskedasticity parameters where applicable. ► *Section III* contains basic statistics.

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[3] As mentioned above, we do not have daylight data and congestion measures in our database.

Table 5. Reference MNM-1.0 model for 13 countries, 1965-1998, (logarithmic)

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)		accl	mbel	mtel	blel	tuel
	VERSION =	2	2	2	2	2
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	.337	-.157	-.069	.179	.268
		(3.39)	(-10.34)	(-.76)	(1.71)	(3.11)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
Vehicle-Kilometer	VehKm	1.039	-.021	-.173	1.019	.866
		(42.93)	(-5.58)	(-7.86)	(39.90)	(41.28)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
P - Price						
Minimum price per litre, gazoline	PrixEss	-.149	-.011	.489	-.160	.340
		(-2.00)	(-.93)	(7.21)	(-2.03)	(5.26)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
M - Motorization						
Percentage of cars in the total number of vehicles	PctAuto	2.179	-.229	-.857	1.950	1.322
		(6.87)	(-4.71)	(-2.97)	(5.83)	(4.81)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
Urban population (% of total population)	PctUrban	-.057	-.143	-.586	-.200	-.643
		(-.44)	(-7.22)	(-4.97)	(-1.47)	(-5.73)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
N-L - Network Regulations						
Highway speed limits	HwySpeed	1.483	.067	.113	1.550	1.596
		(10.43)	(3.07)	(.87)	(10.34)	(12.95)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
SeatBelt regulations	SeatBelt ========	-.109	-.005	-.235	-.114	-.343
		(-2.02)	(-.61)	(-4.79)	(-2.01)	(-7.37)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	-.121	-.032	-.430	-.153	-.551
		(-.89)	(-1.56)	(-3.48)	(-1.07)	(-4.68)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
Proportion pop 18-24 years old	PopYoung	.896	-.112	.457	.784	1.353
		(5.49)	(-4.47)	(3.08)	(4.56)	(9.57)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
A - Economic status						
GNP per capita	PibCapit	-.808	-.145	.016	-.954	-.792
		(-9.23)	(-10.85)	(.20)	(-10.33)	(-10.44)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
W - Weather						
Total precipitation	Ptotale	.364	-.042	-.436	.322	-.072
		(5.40)	(-4.02)	(-7.09)	(4.53)	(-1.23)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
Mean yearly temperature (Cel.)	Temp	-.144	.054	.302	-.090	.158
		(-1.86)	(4.59)	(4.29)	(-1.10)	(2.36)
		LAM 1	LAM 1	LAM 1	LAM 1	LAM 1
ETC - Other						
Leap year	AnneeBis ========	-.026	-.000	.014	-.026	-.012
		(-.73)	(-.09)	(.44)	(-.71)	(-.38)
REGRESSION CONSTANT	CONSTANT	-	-	-	-	-
		(-1.99)	(14.23)	(.64)	(.18)	(-1.63)

III.GENERAL STATISTICS

	accl	mbel	mtel	blel	tuel
LOG-LIKELIHOOD	-4777.12	585.755	1307.288	-4922.71	-3352.35
PSEUDO-R2 : - (E)	.882	.589	.530	.875	.909
SAMPLE : - NUMBER OF OBSERVATIONS	429	429	429	429	429
- FIRST OBSERVATION	27	27	27	27	27
- LAST OBSERVATION	455	455	455	455	455
NUMBER OF ESTIMATED PARAMETERS : BETAS	14	14	14	14	14

Table 6. Reference MPM-1.0 model for 10 Canadian provinces, 1965-1998, (Logarithmic)

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)	VARIANT = / VERSION = / DEP.VAR. =	CaccA 2 Accident	CmbeA 2 Morbidit	CmteA 2 Mortalit	CbleA 2 Blesses	CtueA 3 Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	.437 (3.49) LAM 1	-.055 (-1.67) LAM 1	.314 (1.91) LAM 1	.381 (2.83) LAM 1	.751 (4.54) LAM 1
Vehicle-Kilometer	VehKm	.895 (36.59) LAM 1	.016 (2.51) LAM 1	.083 (2.59) LAM 1	.911 (34.65) LAM 1	.978 (30.25) LAM 1
P - Price						
Minimum price per litre, gazoline	PrixEss	-.313 (-8.84) LAM 1	-.007 (-.71) LAM 1	-.313 (-6.75) LAM 1	-.320 (-8.40) LAM 1	-.626 (-13.38) LAM 1
M - Motorization						
Percentage of cars in total number of vehicles	PctAuto	.686 (3.99) LAM 1	.152 (3.36) LAM 1	-.269 (-1.19) LAM 1	.839 (4.54) LAM 1	.417 (1.84) LAM 1
Urban population (% of total population)	PctUrban	1.394 (9.30) LAM 1	-.215 (-5.43) LAM 1	-1.962 (-9.99) LAM 1	1.178 (7.31) LAM 1	-.568 (-2.87) LAM 1
N-L - Network Regulations						
Highway speed limits	HwySpeed	-.876 (-6.95) LAM 1	-.102 (-3.05) LAM 1	.034 (.21) LAM 1	-.977 (-7.21) LAM 1	-.841 (-5.05) LAM 1
Seatbelt regulations	SeatBelt ========	.071 (1.75)	.001 (.13)	-.105 (-1.98)	.072 (1.66)	-.034 (-.64)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	1.048 (9.23) LAM 1	-.090 (-2.98) LAM 1	-.747 (-5.02) LAM 1	.958 (7.85) LAM 1	.301 (2.00) LAM 1
Proportion pop. 18-24 years old	PopYoung	1.610 (14.37) LAM 1	-.091 (-3.08) LAM 1	.397 (2.70) LAM 1	1.519 (12.61) LAM 1	2.007 (13.55) LAM 1
A - Economic status						
GDP per capita	PibCapit	-.272 (-2.89) LAM 1	.012 (.49) LAM 1	.452 (3.66) LAM 1	-.260 (-2.57) LAM 1	.180 (1.45) LAM 1
W - Weather						
Others precipitations	Pautres	-.038 (-1.53) LAM 1	-.011 (-1.69) LAM 1	-.016 (-.51) LAM 1	-.049 (-1.84) LAM 1	-.054 (-1.66) LAM 1
Total rainfall precipitation	Ppluie	-.051 (-1.42) LAM 1	-.050 (-5.25) LAM 1	-.085 (-1.79) LAM 1	-.101 (-2.62) LAM 1	-.136 (-2.85) LAM 1
Mean yearly temperature (Far.)	TempF	.329 (1.77) LAM 1	.105 (2.14) LAM 1	.687 (2.83) LAM 1	.434 (2.18) LAM 1	1.016 (4.15) LAM 1
ETC - Other						
Leap year	AnneeBis ========	-.011 (-.43)	.004 (.64)	-.004 (-.14)	-.006 (-.25)	-.015 (-.47)
REGRESSION CONSTANT	CONSTANT	- (4.18)	- (2.62)	- (1.47)	- (4.53)	- (4.62)

III.GENERAL STATISTICS

LOG-LIKELIHOOD	-2927.80	424.449	1148.439	-3071.67	-1873.72
PSEUDO-R2 : - (E)	.964	.266	.717	.967	.872
SAMPLE : - NUMBER OF OBSERVATIONS	340	340	340	340	340
- FIRST OBSERVATION	11	11	11	11	11
- LAST OBSERVATION	350	350	350	350	350
NUMBER OF ESTIMATED PARAMETERS : BETAS	15	15	15	15	15

Comparison of the two logarithmic reference models. As the mumber of victims by category is the product of accident frequency and a particular severity rate, the sum of the accident frequency elastiticity and the elasticity of that particular severity rate should in theory be equal to the elasticity of the number of victims of that category.

Concerning estimated signs, elasticity values highlighted in grey in Table 5 differ in sign from those of Table 6. Some general remarks are of interest, although our intuition is more about accident frequency (and numbers of victims) than about severity rates:

a. ►column 5 of Table 5, showing results for fatalities, is the column with the fewest number of differences between the two models. This may be related to the fact that fatalities are observed with smaller error than injuries in all countries and Canadian provinces;

b. ►the section on government interventions (N-L-Network Regulations) shows the greatest number of differences of all sections between the two models. In particular, the impact of increasing the speed limit on highways differs for all outcomes: this may be related to the fact that speed limits and highway traffic densities are much higher in Europe (11 of the 13 countries considered) than in Canadian provinces. Could it be that, with low traffic densities on Canadian highways, higher speeds complement attention in such a way as to reduce risk, such as the risk of falling asleep at the wheel? Or are we missing a confounding factor?

c. ►The rate of occupation of vehicles—a key candidate variable in explaining the 1972-1973 turning point—has clear and significant positive impacts on accident frequency and on the number of injured and killed victims. Over the time period of 35 years considered, opposite effects may be at play: the change of modal split away from buses in favour of the car should increase accidents, as cars are more dangerously driven than buses; simultaneously, a reduction in the number of occupants per vehicle should reduce accidents per kilometer because cars and buses are not driven in such a way as to equalize risk per occupant: for this to occur, full cars and buses would have to be driven at extraordinarily slow speeds! So, over time, the second effect (of falling occupancy rates) seems to dominate the first (of modal shift towards a more dangerous mode) throughout the sample period, as lower occupancy rates outweigh lower bus market shares: such falling occupancy rates per vehicle seem to have made a large contribution to falling fatalities.

   It will be of interest to ask if this monotonic effect holds throughout the sample period because, as indicated in Figure 4 and Figure 5, for the first 10 years (130 observations in Figure 4 and 100 observations in Figure 5) approximately, the number of occupants per vehicle falls very rapidly and subsequently falls very slowly. Such turns could generate a break in the series on victims. This contrasts with the implementation of new laws (wearing seatbelts, breathalizer tests, higher penalties, etc.) that typically shift a series by a certain amount but cannot achieve a turning point in a series. Note also that, within each data set, there is significant variability within a single year as well as across years. We should therefore not hesitate in testing for the presence of turning effects.

Strategy on form and nonsphericalness of residuals. We shall first introduce Box-Cox transformations (BCT) on the dependent variable and all transformable explanatory variables, relax that assumption by allowing for distinct BCTs on the y and X_k variables (λ_1; λ_2), and then select the vehicle kilometrage variable for special treatment with a distinct DCT (λ_3). We then allow the occupancy rate variable to have its own series of tests, using it once with a linear ($\lambda_4 =$ 1) BCT and, simultaneously, using it a second time with a free (λ_5) BCT.

Figure 4. Population per vehicle for the 13 countries by year, 1965-1998

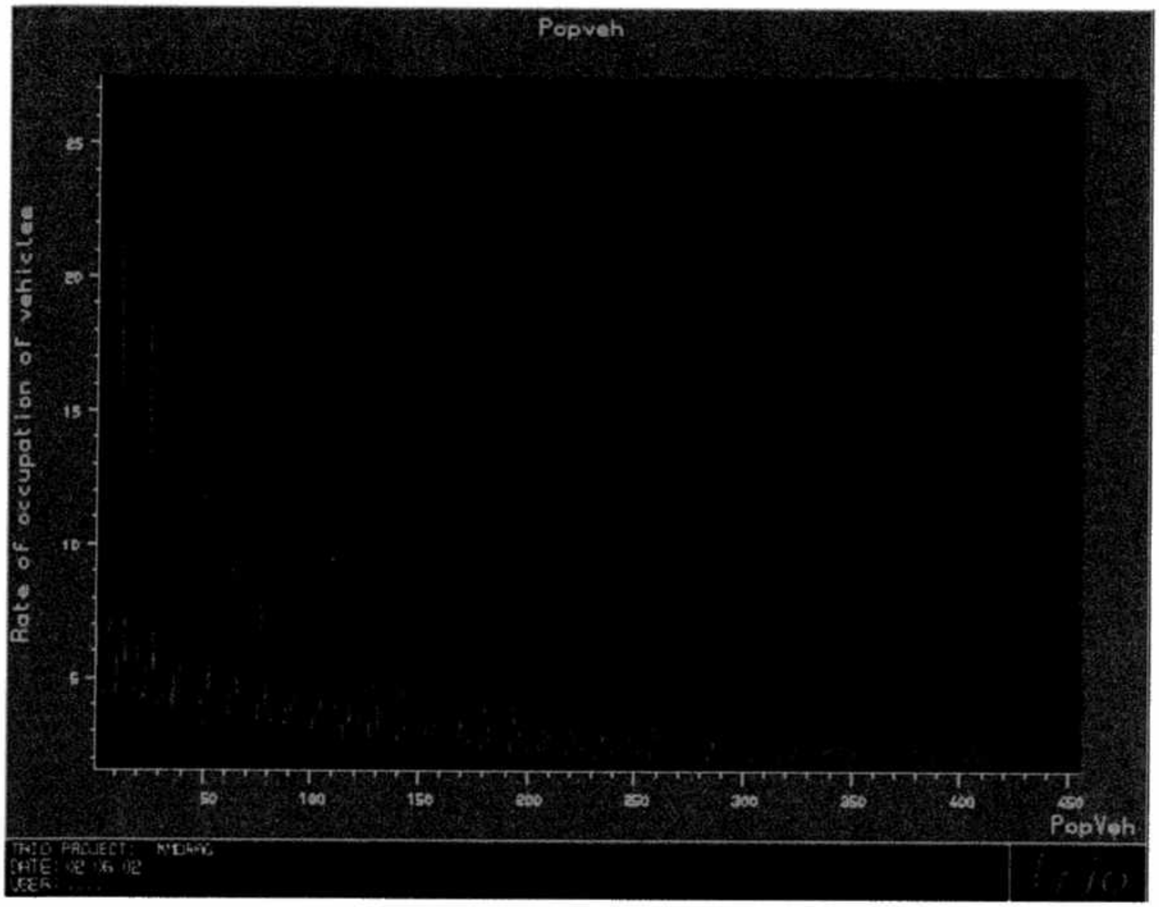
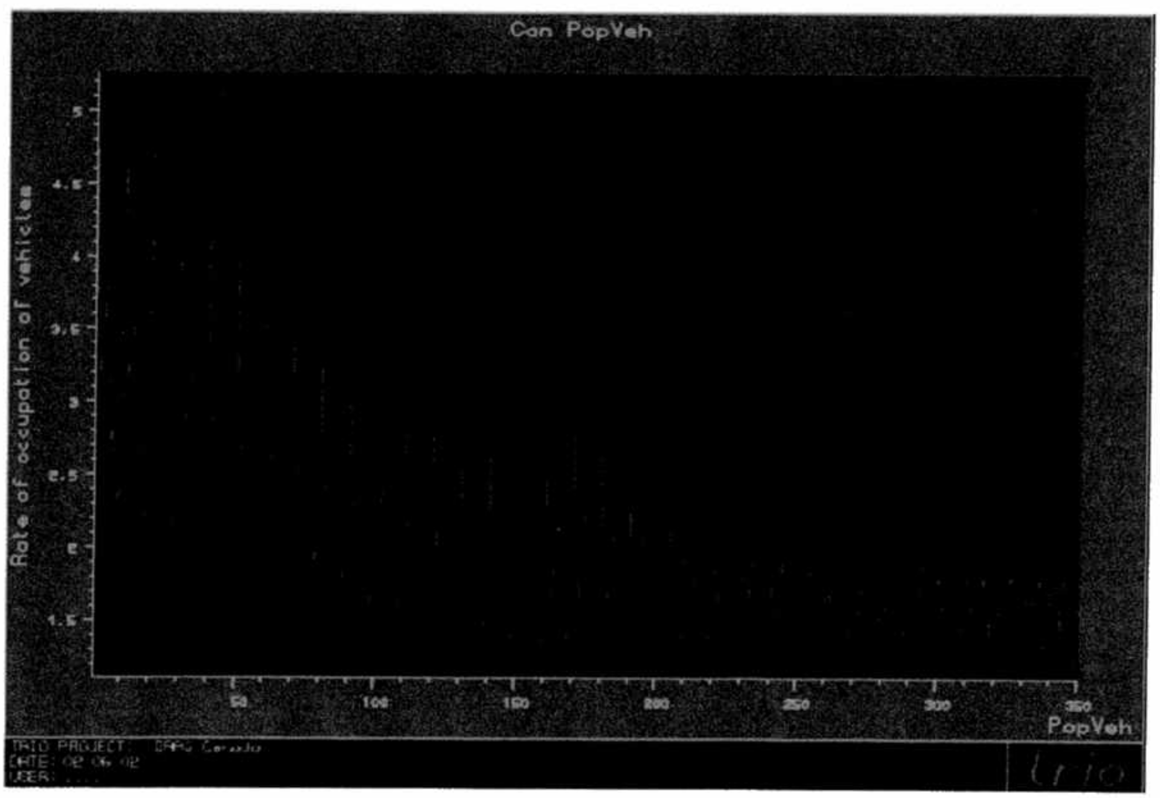


Figure 5. Population per vehicle for the 10 Canadian provinces by year, 1965-1998



We know (Gaudry *et al.*, 2000) that the resulting pattern of signs of the regression and BCT coefficients of these two forms of the occupancy rate variable (PopVeh) tells us whether there is a maximum or a minimum: the conditions for this are recalled in Table 7 where β_1 and β_2 stand for the two regression coefficients associated with the first (here $\lambda_1 = 1$) and second (here λ_2 stands for λ_4 of our tables of results) BCT on variable PopVeh. The results of this first set of tests are found in cases B and D of Table 8 for the Multinational model and in Table 9 for the Multiprovincial model. Case C adds to B first order autocorrelation and heteroscedasticity wherever feasible.

Table 7. Conditions for a maximum and a minimum with two Box-Cox transformations

CASE	β_1	β_2	$\lambda_1 - \lambda_2$	$\beta_1(\lambda_1 - \lambda_2)$ or $\beta_2(\lambda_2 - \lambda_1)$
Maximum1	+	–	–	–
Minimum1	+	–	+	+
Maximum2	–	+	+	–
Minimum2	–	+	–	+

Table 8. Log likelihood function values, Multinational model

DEPENDENT VARIABLE:	Accident	Morbidit	Mortalit	Blesses	Tues	
A. REFERENCE LOGARITHMIC MODEL	-4777.12	585.755	1307.288	-4922.71	-3352.35	(Table 5)
B. STUDY OF FUNCTIONAL FORM	-4771.26	618.378	1339.973	-4915.96	-3328.82	(Appendix 2)
BOX-COX	4	5	4	4	4	
C. PLUS AUTOCORRELATION AND HÉTÉR.	-3997.93	618.378	1371.691	-4146.52	-2769.80	(Appendix 4)
AUTOCORRELATION	1	0	0	1	1	
HÉTÉROSCÉDASTICITÉ						
DELTAS	0	0	1	0	1	
BOX-COX	0	0	1	0	1	
D. ADDING 12 COUNTRY SPECIFIC DUMMIES	-3978.60	914.580	1693.702	-4131.24	-2796.20	(Appendix 6)
FORM OF EFFECT ON OCCUPANCY RATE	U	∩	∩	U	/	

Table 9. Log likelihood function values, Multiprovincial model

DEPENDENT VARIABLE:	Accident	Morbidit	Mortalit	Blesses	Tues	
A. REFERENCE LOGARITHMIC MODEL	-2927.80	424.449	1148.439	-3071.67	-1873.72	(Table 6)
B. STUDY OF FUNCTIONAL FORM	-2909.64	477.465	1165.346	-3053.85	-1864.57	(Appendix 3)
BOX-COX	4	4	4	4	4	
C. PLUS AUTOCORRELATION AND HÉTÉR.	-2631.51	644.711	1348.013	-2813.94	-1676.86	(Appendix 5)
AUTOCORRELATION	1	1	1	1	1	
HÉTÉROSCÉDASTICITÉ						
DELTAS	1	1	1	0	1	
BOX-COX	1	1	1	0	1	
D. ADDING 9 PROVINCE SPECIFIC DUMMIES	-2616.55	577.331	1372.149	-2798.26	-1633.16	(Appendix 7)
FORM OF EFFECT ON OCCUPANCY RATE	U	U	∩	U	U	

3. CONCLUSION

Full details of the cases summarized Table 8 and Table 9 can be found in Appendix 2 to Appendix 7. Our summary of significant results is as follows:

- ► the study of functional form implies quite significant gains in log likelihood over the simple logarithmic case. However, the estimates of the BCT are not generally sufficiently different from the logarithmic case to have a great impact on the resulting elasticities. Interestingly, the logarithmic form cannot too easily be rejected, except to gain some precision in the adjustment, or fitting, to the data;

- ► by contrast, the introduction of first order autocorrelation makes many of the elasticities associated with the two Demand variables decrease considerably and yields some corner solutions in the multinational and in the multiprovincial models: the value of lambda is limited to 10 (in absolute value) for reasons of machine precision. So our results are in that sense identical to those of Page (1997). When region-specific dummies are introduced: these dummy variables do not provide relief from the problem in the multinational case (the number of corner solutions remains at 3) but provides complete relief in the multiprovincial case (the number of corner solutions goes from 4 to 0);

- ► in the cases where it is possible, accounting for heteroskedasticity according to (4-2) increases the log likelihood considerably but without affecting the elasticities very much;

- ► the massive gains in log likelihood associated with the introduction of region-specific dummy variables and the resulting tendency of results to move away from a first difference model, a little in the multicountry case and very much in the multiprovincial case, suggests that important variables are missing from the specification, because the presence in a model of autoregressive parameters tending to go beyond one indicates a mispecification. This impression is increased when the values of associated dummy variable effects is examined. As the reference in both models is Quebec, the elasticities shown indicate a significant difference with Quebec. The high values for The United Kingdom, France and Germany, for instance, indicate that we are missing important information in the model, a it is not possible that the unexplained "basic" record of these countries is almost twice as bad as the Quebec one in terms of fatalities.

- ► strong non-monotonic effects are found in relation to the occupancy rate variable. The shape of effects is indicated under case D of Table 8 and Table 9. To establish the robustness of these effects, it would be important to carry out tests of the presence of congestion using a similar device with the vehicle-kilometer variable made specific to each country or province, as mentioned above.

We have constructed the most sophisticated multicountry model built to date, and a first model for all Canadian provinces. Both exercises show that we are missing important variables, especially in the multinational case. In the absence of available information, the best hope to improve these results is to study non monotonic effects associated with vehicle kilometers. But this is a very tall order that will require a more detailed study of functional form than that carried out here.

4. REFERENCES

Adams, J. G. U., (1985a). *Risk and Freedom*, Transport Publishing Projects, The Bottesford Press, Nottingham.

Adams, J. G. U., (1985b). Smeed's law, seat belts, and the emperor's new clothes. In Evans, L. and R.C. Schwing (eds), *Human Behavior and Traffic Safety,* New York, Plenum Press, 193-248.

Fridström, L. (1999). *Econometric Models of Road Use, Accidents, and Road Investment Decisions*, Volume II, TÖI Report 457/1999, Institute of Transport Economics, Norwegian Centre for Transport Research, Oslo, 292 p., November.

Fridström, L. Ifver, J., Ingebrigtsen, S., Kulmala, R. and L. K. Thomsen, (1995). Measuring the contribution of randomness, exposure, weather and daylight to the variation in road accident counts. *Accident Analysis and Prevention*, 23, 363-378.

Fournier, F. et R. Simard (1999). *Modèle économétrique DRAG-2 : Prévisions sur le kilométrage, le nombre d'accidents et de victimes pour la période 1997-2004.* Société de l'assurance automobile du Québec, 300 pages, juin.

Gaudry, M. (1984). *DRAG, un modèle de la Demande Routière, des Accidents et de leur Gravité, appliqué au Québec de 1956-1982.* Publication CRT-359, Centre de recherche sur les transports, et Cahier #8432, Département de sciences économiques, Université de Montréal.

Gaudry, M. (1998). Some perspectives on the DRAG approach and family of national road safety models. In Holst, H.v.., Nygren, A., and A. E. Andersson, eds., *Transportation, Traffic Safety and Health* **III**, 123-168.

Gaudry, M. Clément, A., Gelgoot. S., Noury, Y. and A. Weiske, (2002). *MAYNARD-DRAG, Version 3.0: Merged Aggregate Yearly National Accident and Road Data for DRAG-type Research*, Publication AJD-7, Agora Jules Dupuit, Université de Montréal, 443 p., May.

Gaudry, M. and S. Lassarre, (2000). *Structural Road Accident Models: The International DRAG Family*, Pergamon, Elsevier Science, Oxford, 360 p., http://www.elsevier.com/locate/isbn/0080430619.

Gaudry, M., Blum, U. and T. Liem, (2000). Turning Box-Cox, including Quadratic Forms in Regression. In Gaudry, M. and S. Lassarre, (2000). *Structural Road Accident Models: The International DRAG Family*, Pergamon, Elsevier Science, Oxford, Ch. 14, 335-346.

Liem. T., Gaudry, M., Dagenais, M. and U. Blum, (2000). The TRIO LEVEL-1.5 algorithm for BC-GAUHESEQ regression. In Gaudry, M. and S. Lassarre, (2000). *Structural Road Accident Models: The International DRAG Family*, Pergamon, Elsevier Science, Oxford, Ch. 12, 263-324.

Page,Y., (1997). La mortalité routière dans les pays de l'OCDE, *Les Cahiers de l'Observatoire*, 3, 67-122, Observatoire National Interministériel de Sécurité Routière, La Documentation Française, Paris, Juillet.

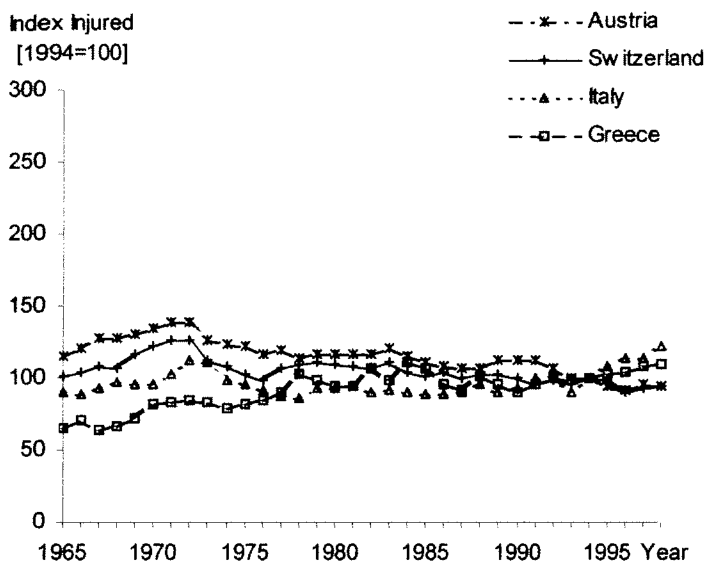
Peltzman, S. (1975). The effects of automobile safety regulation. *Journal of Political Economy*, **83**, 4, 677-725.

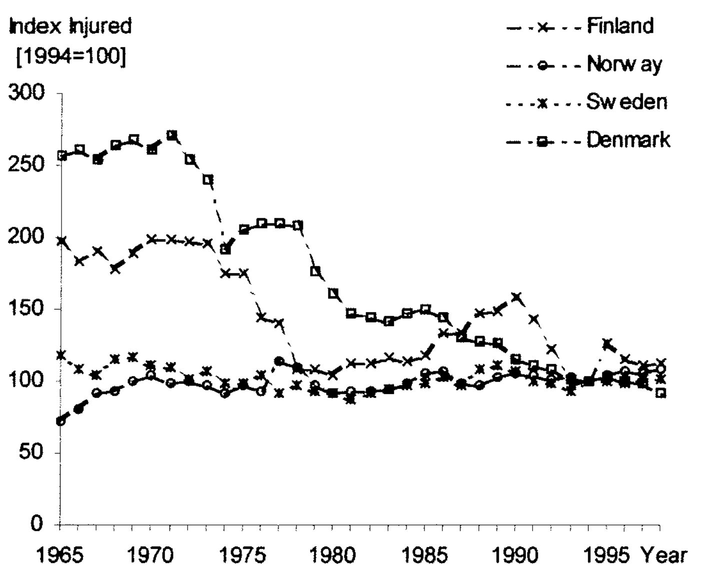
Smeed, R. J, (1949). "*Some statistical aspects of road safety research*", Journal of the Royal Statistical Society Series A, Royal Statistical Society, London, Part **I,** 1-34.

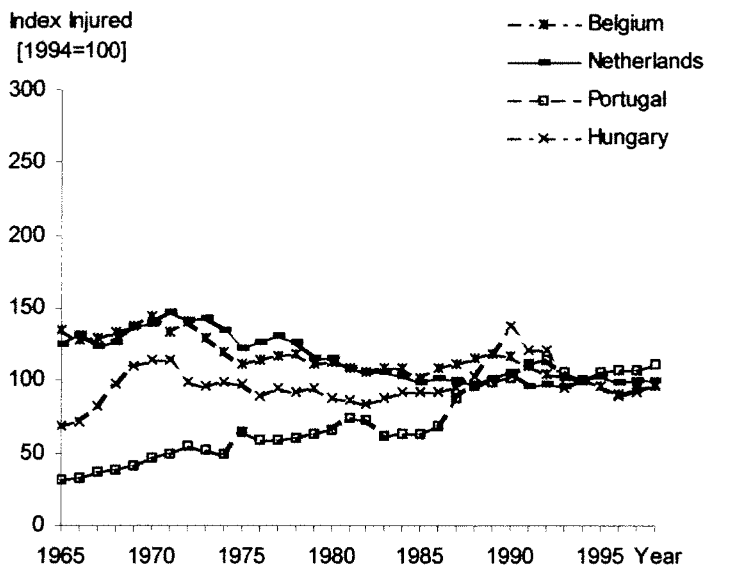
Smeed, R. J., (1968). Variations in the pattern of accident rates in various countries and their causes. *Traffic Engineering & Control*, 10, 7, 364-371.

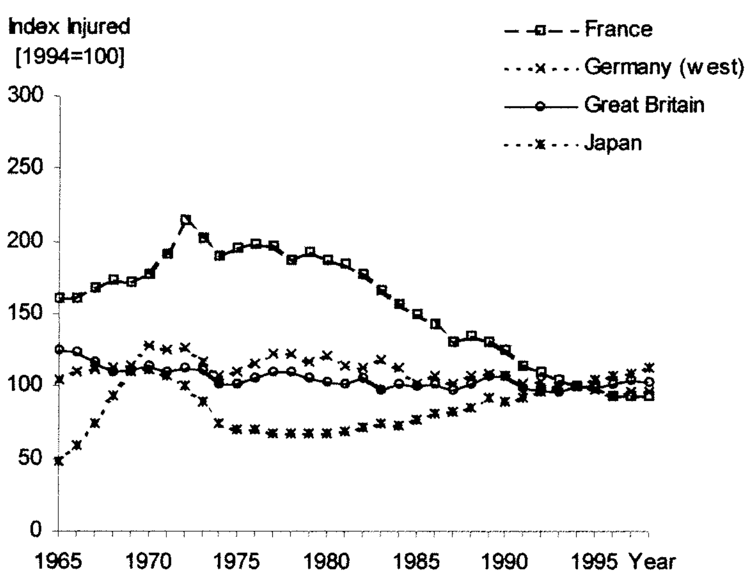
Smeed, R. J. and G. O. Jeffcoate, (1969). Conséquences de l'évolution de la motorisation de divers pays sur le nombre de décès sur la route. Compte rendu du symposium sur l'utilisation des méthodes statistiques dans l'analyse des accidents de la route, *Recherche Routière*, OCDE, 103-110.

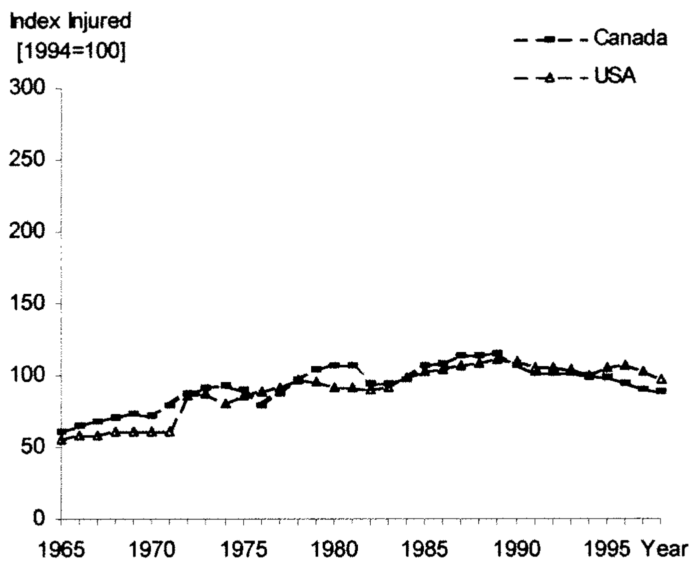
Appendix 1. Index of injured persons, 25 countries, 1965-1998

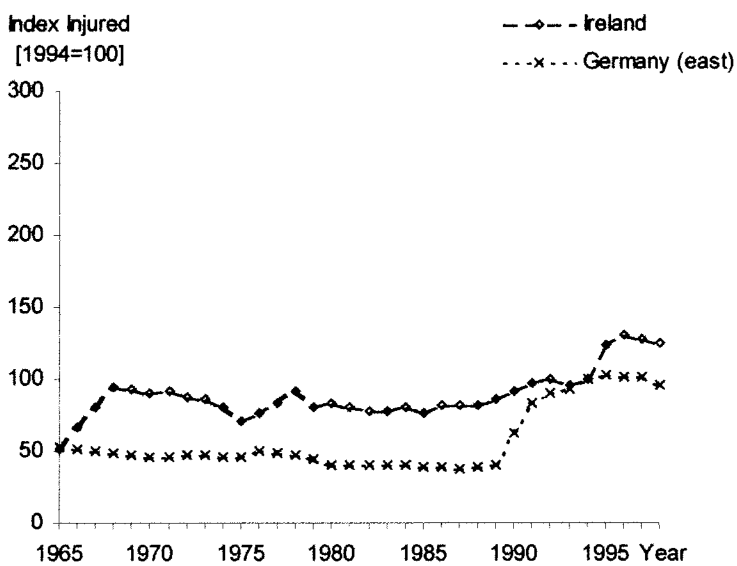


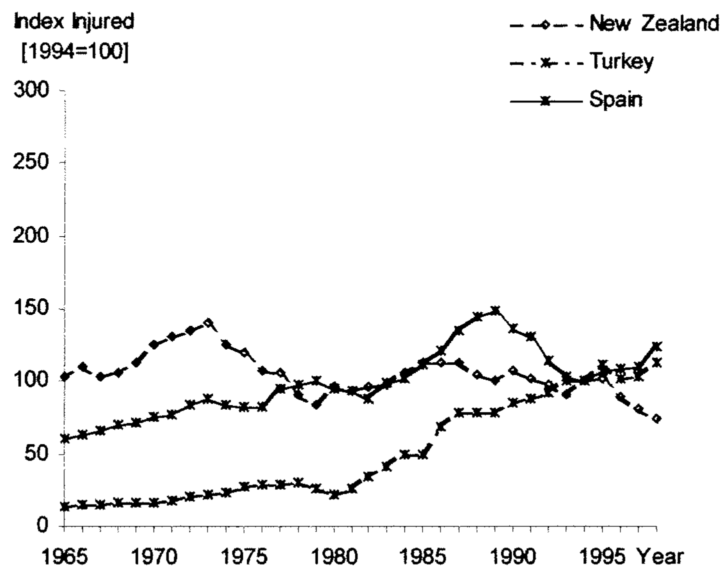



Index Injured
[1994=100]
Belgium
Netherlands
Portugal
Hungary
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995 Year

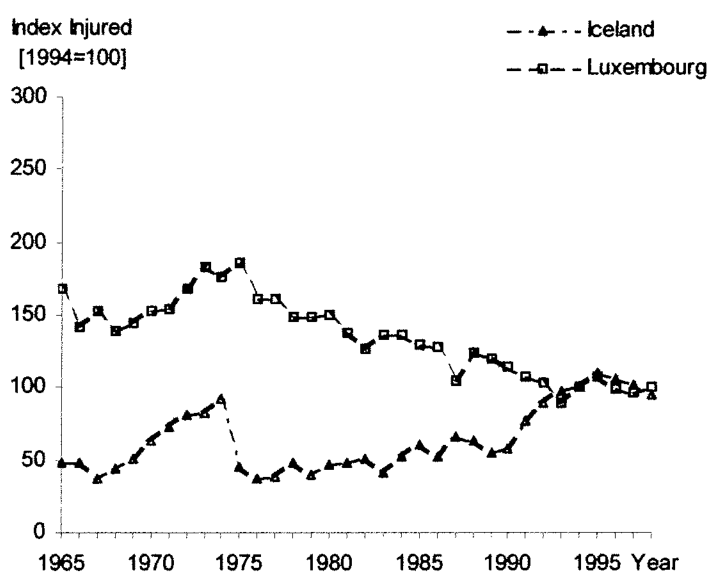

Index Injured
[1994=100]
France
Germany (west)
Great Britain
Japan
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995 Year


Index Injured
[1994=100]
Canada
USA
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995
Year


Index Injured
[1994=100]
Ireland
Germany (east)
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995
Year



Index Injured
[1994=100]
New Zealand
Turkey
Spain
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995
Year



Index Injured
[1994=100]
Iceland
Luxembourg
300
250
200
150
100
50
0
1965
1970
1975
1980
1985
1990
1995
Year

Appendix 2. Multinational model, study of functional form

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)						
	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	Bacc	Bmbe	Bmte	Bble	Btue
	VERSION =	1	1	2	1	1
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	-.127	-.061	-.112	-.144	-.153
		(-.94)	(-5.41)	(-1.18)	(-.77)	(-2.25)
		LAM 4	LAM 4	LAM 4	LAM 4	LAM 4
	POPVEH	.463	-.062	.178	.288	.700
		(1.99)	(-3.80)	(3.65)	(.98)	(4.91)
		LAM 5	LAM 5	LAM 5	LAM 5	LAM 5
Vehicle-Kilometer	VehKm	1.048	-.019	-.123	1.023	.919
		(38.68)	(-4.48)	(-5.76)	(35.50)	(40.93)
		LAM 3	LAM 3	LAM 3	LAM 3	LAM 3
P - Price						
Minimum price per litre, ordinary gazoline	PrixEss	-.158	-.006	.295	-.155	.157
		(-1.83)	(-.54)	(5.23)	(-1.74)	(2.05)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
M - Motorization						
Percentage of cars in the total number of vehicles	PctAuto	2.269	-.134	-1.055	2.091	1.115
		(6.33)	(-2.78)	(-3.06)	(5.48)	(4.43)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Urban population (% of total population)	PctUrban	-.009	-.089	-.694	-.134	-.554
		(-.07)	(-5.06)	(-3.90)	(-.97)	(-4.86)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
N-L - Network-Regulations						
Highway speed limits	HwySpeed	1.424	.044	.120	1.454	1.705
		(12.01)	(2.01)	(.72)	(11.89)	(15.92)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
SeatBelt regulations	SeatBelt	-.076	-.006	-.199	-.089	-.234
		(-1.39)	(-.70)	(-3.94)	(-1.51)	(-4.13)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	-.185	-.030	-.236	-.171	-.891
		(-1.00)	(-2.02)	(-1.55)	(-.88)	(-5.80)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Proportion of the population 18-24 years old	PopYoung	.785	-.072	.134	.702	1.121
		(4.00)	(-2.43)	(.79)	(3.43)	(6.26)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
A - Economic activity						
GNP per capita	PibCapit	-.814	-.125	.082	-.965	-.668
		(-9.31)	(-8.34)	(1.58)	(-10.34)	(-7.08)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
C - Climatic effect						
Total precipitation	Ptotale	.341	-.022	-.232	.304	-.130
		(4.77)	(-3.32)	(-3.66)	(4.13)	(-1.97)
		LAM 2	LAM 6	LAM 2	LAM 2	LAM 2
Mean yearly temperature (Cel.)	Temp	-.121	.064	.343	-.068	.283
		(-1.58)	(8.64)	(6.30)	(-.86)	(3.82)
		LAM 2	LAM 6	LAM 2	LAM 2	LAM 2

ETC - Other

Leap year	AnneeBis	-.026	-.000	.013	-.025	-.017
	========	(-.74)	(-.10)	(.44)	(-.70)	(-.53)
REGRESSION CONSTANT	CONSTANT	-	-	-	-	-
		(.45)	(8.72)	(-6.39)	(4.46)	(2.04)

II. PARAMETERS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	Bacc	Bmbe	Bmte	Bble	Btue
(COND. T-STATISTIC)	VERSION =	1	1	2	1	1
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues

BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]

LAMBDA(Y) - GROUP 1	LAM 1	.038	2.949	.272	.053	-.087
		[.97]	[6.55]	[1.92]	[1.32]	[-2.69]
		[-24.23]	[4.33]	[-5.13]	[-23.64]	[-33.53]
LAMBDA(X) - GROUP 2	LAM 2	.049	-.627	2.576	-.137	.318
		[.13]	[-2.41]	[4.40]	[-.40]	[.94]
		[-2.54]	[-6.25]	[2.69]	[-3.30]	[-2.01]
LAMBDA(X) - GROUP 3	LAM 3	.116	-.168	-.002	.145	.049
		[2.11]	[-.54]	[-.00]	[2.51]	[.89]
		[-16.04]	[-3.76]	[-2.72]	[-14.77]	[-17.22]
LAMBDA(X) - GROUP 4	LAM 4	1.000	1.000	1.000	1.000	1.000
		FIXED	FIXED	FIXED	FIXED	FIXED
LAMBDA(X) - GROUP 5	LAM 5	.157	-2.866	-4.376	.316	-.866
		[.09]	[-2.24]	[-1.80]	[.09]	[-1.08]
		[-.47]	[-3.02]	[-2.21]	[-.20]	[-2.33]
LAMBDA(X) - GROUP 6	LAM 6		2.153			
			[2.62]			
			[1.40]			

III.GENERAL STATISTICS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	Bacc	Bmbe	Bmte	Bble	Btue
	VERSION =	1	1	2	1	1
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
LOG-LIKELIHOOD		-4771.26	618.378	1339.973	-4915.96	-3328.82
PSEUDO-R2 : - (E)		.887	.617	.637	.881	.929
- (L)		.975	.633	.682	.973	.982
- (E) ADJUSTED FOR D.F.		.882	.599	.621	.876	.926
- (L) ADJUSTED FOR D.F.		.974	.616	.668	.972	.981
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)		.000	.000	.000	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS		429	429	429	429	429
- FIRST OBSERVATION		27	27	27	27	27
- LAST OBSERVATION		455	455	455	455	455
NUMBER OF ESTIMATED PARAMETERS :						
- FIXED PART :						
. BETAS		15	15	15	15	15
. BOX-COX		4	5	4	4	4
. ASSOCIATED DUMMIES		0	0	0	0	0
- AUTOCORRELATION		0	0	0	0	0
- HETEROSKEDASTICITY :						
. DELTAS		0	0	0	0	0
. BOX-COX		0	0	0	0	0
. ASSOCIATED DUMMIES		0	0	0	0	0

Appendix 3. Multiprovincial model, study of functional form

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)		TYPE = LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	CaccB	CmbeB	CmteB	CbleB	CtueB
	VERSION =	1	5	2	2	2
	DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	.198	-.300	.702	-.033	.850
		(1.02)	(-3.62)	(4.32)	(-.14)	(5.04)
		LAM 4	LAM 4	LAM 4	LAM 4	LAM 4
	POPVEH	.157	.217	-.074	.291	-.026
		(2.00)	(3.64)	(-5.26)	(2.63)	(-2.77)
		LAM 5	LAM 5	LAM 5	LAM 5	LAM 5
Vehicle-Kilometer	VehKm	.966	.018	.102	1.008	.968
		(35.69)	(2.51)	(2.86)	(31.82)	(27.94)
		LAM 3	LAM 3	LAM 3	LAM 3	LAM 3
P - Price						
Minimum price per litre, ordinary gazoline	PrixEss	-.369	-.000	-.378	-.386	-.589
		(-7.71)	(-.02)	(-6.62)	(-9.02)	(-12.24)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
M - Motorization						
Percentage of cars in total number of vehicles	PctAuto	.685	.029	-.264	.767	.463
		(3.75)	(.52)	(-1.19)	(4.02)	(2.02)
		LAM 2	LAM 3	LAM 2	LAM 2	LAM 2
Urban population(% of total population)	PctUrban	1.383	-.151	-2.296	1.170	-.673
		(9.78)	(-4.85)	(-11.25)	(7.91)	(-3.65)
		LAM 2	LAM 3	LAM 2	LAM 2	LAM 2
N-L - Network-Regulations						
Highway speed limits	HwySpeed	-.888	-.135	.038	-1.021	-.625
		(-7.60)	(-3.48)	(.22)	(-8.10)	(-3.60)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Seatbelt regulations	SeatBelt	.024	-.009	-.086	.028	-.011
		(.38)	(-1.02)	(-1.56)	(.46)	(-.18)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	1.358	-.101	-.792	1.286	.414
		(9.00)	(-2.68)	(-4.70)	(8.23)	(2.15)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Proportion of the population 18-24 years old	PopYoung	1.830	-.111	.259	1.781	2.124
		(12.38)	(-3.45)	(1.54)	(11.35)	(13.44)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
A - Economic activity						
GDP per capita	PibCapit	-.177	-.003	.620	-.104	.246
		(-1.38)	(-.17)	(5.57)	(-.77)	(1.76)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
C - Climatic effect						
Others precipitations	Pautres	-.021	-.007	-.044	-.022	-.045
		(-1.41)	(-1.16)	(-1.22)	(-1.57)	(-1.76)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Total rainfall precipitation	Ppluie	.010	-.061	-.073	-.007	-.135
		(.28)	(-7.53)	(-1.42)	(-.19)	(-3.01)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Mean yearly temperature (Far.)	TempF	-.019	.120	.651	-.069	1.070
		(-.10)	(2.51)	(2.86)	(-.33)	(4.66)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2

ETC - Other

Leap year	AnneeBis	-.015	.008	-.008	-.013	-.013
	========	(-.55)	(1.41)	(-.26)	(-.43)	(-.35)
REGRESSION CONSTANT	CONSTANT	-	-	-	-	-
		(2.33)	(-1.73)	(.95)	(1.51)	(.81)

II. PARAMETERS		TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
		VARIANT =	CaccB	CmbeB	CmteB	CbleB	CtueB
(COND. T-STATISTIC)		VERSION =	1	5	2	2	2
		DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]							
LAMBDA(Y) - GROUP 1	LAM 1		-.080	-3.463	-.050	-.085	.056
			[-3.27]	[-10.26]	[-.47]	[-3.01]	[1.99]
			[-43.93]	[-13.22]	[-9.88]	[-38.26]	[-33.67]
LAMBDA(X) - GROUP 2	LAM 2		-.208	1.584	.742	-.310	-.157
			[-.94]	[2.80]	[2.80]	[-1.38]	[-.77]
			[-5.47]	[1.03]	[-.97]	[-5.85]	[-5.69]
LAMBDA(X) - GROUP 3	LAM 3		-.063	.512	.116	-.043	.011
			[-2.54]	[1.05]	[.46]	[-1.49]	[.48]
			[-43.19]	[-1.00]	[-3.54]	[-35.76]	[-42.69]
LAMBDA(X) - GROUP 4	LAM 4		1.000	1.000	1.000	1.000	1.000
			FIXED	FIXED	FIXED	FIXED	FIXED
LAMBDA(X) - GROUP 5	LAM 5		3.132	1.559	4.708	2.722	5.118
			[1.12]	[.71]	[2.61]	[1.24]	[1.28]
			[.76]	[.25]	[2.06]	[.79]	[1.03]

III.GENERAL STATISTICS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	CaccB	CmbeB	CmteB	CbleB	CtueB
	VERSION =	1	5	2	2	2
	DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
LOG-LIKELIHOOD		-2909.64	477.465	1165.346	-3053.85	-1864.57
PSEUDO-R2 : - (E)		.960	.279	.761	.962	.899
- (L)		.996	.571	.840	.995	.987
- (E) ADJUSTED FOR D.F.		.958	.236	.747	.960	.893
- (L) ADJUSTED FOR D.F.		.996	.545	.831	.995	.986
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)		.000	.000	.000	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS		340	340	340	340	340
- FIRST OBSERVATION		11	11	11	11	11
- LAST OBSERVATION		350	350	350	350	350
NUMBER OF ESTIMATED PARAMETERS :						
- FIXED PART :						
. BETAS		16	16	16	16	16
. BOX-COX		4	4	4	4	4
. ASSOCIATED DUMMIES		0	0	0	0	0
- AUTOCORRELATION		0	0	0	0	0
- HETEROSKEDASTICITY :						
. DELTAS		0	0	0	0	0
. BOX-COX		0	0	0	0	0
. ASSOCIATED DUMMIES		0	0	0	0	0

Appendix 4. MNM: Adding first order autocorrelation and heteroskedasticity

I. ELASTICITY S(y) (EP)	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	Cacc	Bmbe	Dmte	Cble	Dtue
(COND. T-STATISTIC)	VERSION =	1	1	3	1	1
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	.001	-.061	-.053	.015	1.479
		(.02)	(-5.41)	(-1.41)	(.26)	(1.02)
		LAM 4	LAM 4	LAM 4	LAM 4	LAM 4
	POPVEH	-.192	-.062	.598	-.213	-1.778
		(-1.82)	(-3.80)	(9.32)	(-1.70)	(-1.12)
		LAM 5	LAM 5	LAM 5	LAM 5	LAM 5
Vehicle-Kilometer	VehKm	-.000	-.019	-.122	.254	.464
		(-.35)	(-4.48)	(-4.43)	(5.94)	(2.56)
		LAM 3	LAM 3	LAM 3	LAM 3	LAM 3
P - Price						
Minimum price per litre, gazoline	PrixEss	-.089	-.006	.066	-.080	-.075
		(-4.74)	(-.54)	(.98)	(-3.40)	(-2.52)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
M - Motorization						
Percentage of cars in the total number of vehicles	PctAuto	.109	-.134	-1.681	.124	.170
		(.75)	(-2.78)	(-6.87)	(.76)	(.89)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Urban population (% of total population)	PctUrban	1.049	-.089	-.294	1.086	.667
		(1.57)	(-5.06)	(-2.60)	(1.51)	(.64)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
N-L - Network-Regulations						
Highway speed limits	HwySpeed	-.006	.044	.006	.005	-.025
		(-.26)	(2.01)	(.05)	(.21)	(-.68)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
SeatBelt regulations	SeatBelt	-.038	-.006	-.030	-.039	-.041
	========	(-2.87)	(-.70)	(-.73)	(-2.88)	(-1.91)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	.587	-.030	-.230	.279	.292
		(2.62)	(-2.02)	(-2.25)	(.96)	(.73)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Proportion pop. 18-24 years old	PopYoung	-.022	-.072	.059	-.021	.188
		(-.19)	(-2.43)	(.41)	(-.16)	(1.25)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
A - Economic activity						
GNP per capita	PibCapit	.293	-.125	.271	.268	.164
		(3.34)	(-8.34)	(4.42)	(2.42)	(1.29)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
C - Climatic effect						
Total precipitation	Ptotale	.002	-.022	-.481	.003	-.005
		(.20)	(-3.32)	(-9.01)	(.21)	(-.30)
		LAM 2	LAM 6	LAM 2	LAM 2	LAM 2
Mean yearly temperature (Cel.)	Temp	.048	.064	.020	.044	.174
		(2.45)	(8.64)	(.36)	(1.71)	(4.63)
		LAM 2	LAM 6	LAM 2	LAM 2	LAM 2
ETC - Other						
Leap year	AnneeBis	.002	-.000	.001	.000	.003
	========	(.60)	(-.10)	(.03)	(.04)	(.56)
REGRESSION CONSTANT	CONSTANT	-	-	-	-	-
		(-.01)	(8.72)	(-3.78)	(-.52)	(-1.85)
DELTA COEFFICIENTS						
Vehicle-Kilometer	VehKm			-.122		.464
				(8.96)		(-3.50)
				LAM		LAM

II. PARAMETERS		TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
		VARIANT =	Cacc	Bmbe	Dmte	Cble	Dtue
(COND. T-STATISTIC)		VERSION =	1	1	3	1	1
		DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]							
LAMBDA(Z)	VehKm				.930		.189
					[2.70]		[.33]
					[-.20]		[-1.41]
LAMBDA(Y) - GROUP 1	LAM 1		.091	2.949	-.516	.085	.038
			[2.88]	[6.55]	[-2.91]	[2.85]	[.79]
			[-28.82]	[4.33]	[-8.55]	[-30.78]	[-20.04]
LAMBDA(X) - GROUP 2	LAM 2		-.160	-.627	-.658	.242	1.254
			[-.33]	[-2.41]	[-1.70]	[.39]	[2.61]
			[-2.38]	[-6.25]	[-4.28]	[-1.21]	[.53]
LAMBDA(X) - GROUP 3	LAM 3		5.849	-.168	1.008	-.077	-.060
			[.28]	[-.54]	[1.60]	[-.31]	[-.17]
			[.23]	[-3.76]	[.01]	[-4.42]	[-3.04]
LAMBDA(X) - GROUP 4	LAM 4		1.000	1.000	1.000	1.000	1.000
			FIXED	FIXED	FIXED	FIXED	FIXED
LAMBDA(X) - GROUP 5	LAM 5		-1.053	-2.866	-3.222	-.833	.912
			[-.55]	[-2.24]	[-3.66]	[-.41]	[.48]
			[-1.07]	[-3.02]	[-4.79]	[-.91]	[-.05]
LAMBDA(X) - GROUP 6	LAM 6			2.153			
				[2.62]			
				[1.40]			
AUTOCORRELATION							
ORDER 13	RHO 13		1.000			.999	.993
			(396.75)			(329.37)	(245.74)

III.GENERAL STATISTICS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	Cacc	Bmbe	Dmte	Cble	Dtue
	VERSION =	1	1	3	1	1
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
LOG-LIKELIHOOD		-3997.93	618.378	1371.691	-4146.52	-2769.80
PSEUDO-R2 : - (E)		.997	.617	.548	.996	.993
- (L)		.999	.633	.726	.999	.999
- (E) ADJUSTED FOR D.F.		.997	.599	.526	.996	.993
- (L) ADJUSTED FOR D.F.		.999	.616	.713	.999	.999
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)		.000	.000	.001	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS		429	429	429	429	429
- FIRST OBSERVATION		27	27	27	27	27
- LAST OBSERVATION		455	455	455	455	455
NUMBER OF ESTIMATED PARAMETERS :						
- FIXED PART :						
. BETAS		15	15	15	15	15
. BOX-COX		4	5	4	4	4
. ASSOCIATED DUMMIES		0	0	0	0	0
- AUTOCORRELATION		1	0	0	1	1
- HETEROSKEDASTICITY :						
. DELTAS		0	0	1	0	1
. BOX-COX		0	0	1	0	1
. ASSOCIATED DUMMIES		0	0	0	0	0

Appendix 5. MPM: Adding first order autocorrelation and heteroskedasticity

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)		TYPE	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
		VARIANT	CaccD	CmbeD	CmteD	CbleD	CtueD
		VERSION	1	3	2	3	2
		DEP.VAR.	Accident	Morbidit	Mortalit	Blesses	Tues
D - Demand							
Rate of occupation of vehicles	PopVeh		-.875	-.030	.250	-6.860	.079
			(-.55)	(-.89)	(1.12)	(-.60)	(.49)
			LAM 4	LAM 4	LAM 4	LAM 4	LAM 4
	POPVEH		.978	-.003	-.014	6.882	-.005
			(.62)	(-5.92)	(-1.51)	(.60)	(-.69)
			LAM 5	LAM 5	LAM 5	LAM 5	LAM 5
Vehicle-Kilometer	VehKm		.391	.027	-.084	.492	.525
			(3.80)	(3.64)	(-1.22)	(4.08)	(3.72)
			LAM 3	LAM 3	LAM 3	LAM 3	LAM 3
P - Price							
Minimum price per litre, gazoline	PrixEss		-.137	-.019	-.143	-.115	-.212
			(-2.35)	(-2.04)	(-1.97)	(-1.63)	(-2.66)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
M - Motorization							
Percentage of cars in total number of vehicles	PctAuto		.159	-.053	-.241	.237	.029
			(.75)	(-1.13)	(-1.15)	(1.18)	(.12)
			LAM 2	LAM 3	LAM 2	LAM 2	LAM 2
Urban population(% of total population)	PctUrban		-.917	-.057	-1.319	-.331	.284
			(-1.20)	(-.79)	(-5.21)	(-.33)	(.40)
			LAM 2	LAM 3	LAM 2	LAM 2	LAM 2
N-L - Network-Regulations							
Highway speed limits	HwySpeed		.107	-.040	-.447	.156	-.183
			(1.00)	(-.96)	(-2.00)	(1.33)	(-.65)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Seatbelt regulations	SeatBelt		.006	-.017	-.024	-.011	-.070
			(.33)	(-1.70)	(-.61)	(-.56)	(-2.12)
Y - Socio-economic							
Percentage of the population 65 and older	Pop65		.317	.050	-1.508	.934	-.348
			(.70)	(.97)	(-3.70)	(1.62)	(-.50)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Proportion pop. 18-24 years old	PopYoung		.542	.028	-.362	.567	.677
			(2.44)	(.56)	(-1.09)	(2.43)	(1.95)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
A - Economic activity							
GDP per capita	PibCapit		.090	.017	.163	.216	.330
			(.80)	(.61)	(1.04)	(1.71)	(1.85)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
C - Climatic effect							
Others precipitations	Pautres		.004	.000	-.013	.010	-.023
			(.46)	(.05)	(-1.48)	(1.26)	(-1.39)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Total rainfall precipitation	Ppluie		.014	.005	-.001	.019	.015
			(.71)	(1.78)	(-.04)	(.82)	(.53)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Mean yearly temperature (Far.)	TempF		-.114	-.046	.264	-.064	.205
			(-1.06)	(-1.45)	(1.64)	(-.53)	(1.23)
			LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
ETC - Other							
Leap year	AnneeBis		-.008	.000	-.023	-.013	-.033
			(-1.05)	(.02)	(-2.15)	(-1.65)	(-2.94)
REGRESSION CONSTANT	CONSTANT		-	-	-	-	-
			(4.59)	(-.60)	(.20)	(-.22)	(.56)
DELTA COEFFICIENTS							
Vehicle-Kilometer	VehKm		.391	.027	-.084		.525
			(-4.67)	(-23.84)	(-10.95)		(-1.92)
			LAM	LAM	LAM		LAM

II. PARAMETERS (COND. T-STATISTIC)		TYPE = LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	CaccD	CmbeD	CmteD	CbleD	CtueD
	VERSION =	1	3	2	3	2
	DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
HETEROSKEDASTICITY STRUCTURE						
BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]						
LAMBDA(Z)	VehKm	10.000	-.099	.177		-.715
		[3.01]	[-1.22]	[1.42]		[-.59]
		[2.71]	[-13.48]	[-6.59]		[-1.41]
BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]						
LAMBDA(Y) - GROUP 1	LAM 1	-.024	-2.228	.132	.103	.250
		[-.82]	[-6.51]	[1.67]	[5.29]	[4.09]
		[-35.50]	[-9.44]	[-10.93]	[-46.20]	[-12.27]
LAMBDA(X) - GROUP 2	LAM 2	.107	-.966	-.387	-.094	.139
		[.13]	[-1.12]	[-.73]	[-.15]	[.26]
		[-1.05]	[-2.29]	[-2.63]	[-1.79]	[-1.63]
LAMBDA(X) - GROUP 3	LAM 3	.194	.481	10.000	.238	.166
		[.61]	[1.21]	[.65]	[1.04]	[.67]
		[-2.52]	[-1.30]	[.58]	[-3.33]	[-3.39]
LAMBDA(X) - GROUP 4	LAM 4	1.000	1.000	1.000	1.000	1.000
		FIXED	FIXED	FIXED	FIXED	FIXED
LAMBDA(X) - GROUP 5	LAM 5	1.173	-10.000	-10.000	1.025	-10.000
		[.13]	[-3.24]	[-1.25]	[.10]	[-.55]
		[.02]	[-3.56]	[-1.38]	[.00]	[-.61]
AUTOCORRELATION						
ORDER 10	RHO 10	.995	.808	.847	.991	.962
		(297.46)	(20.75)	(26.33)	(166.41)	(57.34)

III.GENERAL STATISTICS	TYPE = LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
VARIANT =	CaccD	CmbeD	CmteD	CbleD	CtueD
VERSION =	1	3	2	3	2
DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
LOG-LIKELIHOOD	-2631.51	644.711	1348.013	-2813.94	-1676.86
PSEUDO-R2 : - (E)	.993	.359	.860	.992	.985
- (L)	.999	.839	.946	.999	.996
- (E) ADJUSTED FOR D.F.	.992	.314	.851	.991	.984
- (L) ADJUSTED FOR D.F.	.999	.828	.942	.999	.995
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)	.000	.000	.000	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS	340	340	340	340	340
- FIRST OBSERVATION	11	11	11	11	11
- LAST OBSERVATION	350	350	350	350	350
NUMBER OF ESTIMATED PARAMETERS :					
- FIXED PART :					
. BETAS	16	16	16	16	16
. BOX-COX	4	4	4	4	4
. ASSOCIATED DUMMIES	0	0	0	0	0
- AUTOCORRELATION	1	1	1	1	1
- HETEROSKEDASTICITY :					
. DELTAS	1	1	1	0	1
. BOX-COX	1	1	1	0	1
. ASSOCIATED DUMMIES	0	0	0	0	0

Appendix 6. MNM: adding 12 country specific dummies

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)		TYPE = LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
		VARIANT = acc7	mbe7	mte7	ble7	tue7
		VERSION = 10	4	4	8	9
		DEP.VAR. = Accident	Morbidit	mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	.061 (1.07) LAM 4	-.028 (-3.75) LAM 4	-.021 (-.70) LAM 4	.105 (1.31) LAM 4	.035 (.20) LAM 4
	POPVEH	-.142 (-.92) LAM 5	.011 (1.01) LAM 5	.686 (14.00) LAM 5	-.309 (-1.53) LAM 5	.246 (2.23) LAM 5
Vehicle-Kilometer	VehKm	.176 (5.53) LAM 3	.032 (2.28) LAM 3	.007 (8.07) LAM 3	.203 (5.97) LAM 3	-.023 (-1.32) LAM 3
P - Price						
Minimum price per litre, ordinary gazoline	PrixEss	-.064 (-2.72) LAM 2	.001 (.18) LAM 2	-.005 (-2.08) LAM 2	-.070 (-2.78) LAM 2	-.054 (-1.71) LAM 2
M - Motorization						
Percentage of cars in the total number of vehicles	PctAuto	.139 (.94) LAM 2	-.111 (-2.42) LAM 2	-.036 (-.22) LAM 2	.177 (1.09) LAM 2	.135 (.65) LAM 2
Urban population (% of total population)	PctUrban	1.599 (1.72) LAM 2	.006 (.06) LAM 2	.630 (2.48) LAM 2	1.630 (1.64) LAM 2	-1.740 (-1.92) LAM 2
N-L - Network-Regulations						
Highway speed limits	HwySpeed	.001 (.05) LAM 2	.009 (.39) LAM 2	-.098 (-3.17) LAM 2	-.004 (-.13) LAM 2	-.039 (-.73) LAM 2
SeatBelt regulations	SeatBelt	-.031 (-2.53)	-.004 (-1.11)	-.065 (-3.16)	-.033 (-2.77)	-.063 (-2.84)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	.166 (.52) LAM 2	-.170 (-6.58) LAM 2	-.033 (-1.00) LAM 2	.047 (.13) LAM 2	-.286 (-.91) LAM 2
Proportion of the population 18-24 years old	PopYoung	.163 (1.43) LAM 2	-.100 (-8.46) LAM 2	.124 (5.06) LAM 2	.124 (.98) LAM 2	.487 (3.32) LAM 2
A - Economic activity						
GNP per capita	PibCapit	.302 (2.44) LAM 2	-.028 (-2.36) LAM 2	.000 (-.42) LAM 2	.332 (2.39) LAM 2	-.132 (-1.05) LAM 2
C - Climatic effect						
Total precipitation	Ptotale	-.003 (-.27) LAM 2	.001 (6.01) LAM 6	.002 (.11) LAM 6	.002 (.13) LAM 2	-.008 (-.43) LAM 2
Mean yearly temperature (Cel.)	Temp	.086 (3.25) LAM 2	-.000 (-2.27) LAM 6	.046 (.79) LAM 6	.059 (2.06) LAM 2	.163 (3.97) LAM 2

CS - Country Specific effect						
Specific effect:Austria	DumAus	-.046	.041	.045	-.104	.093
	======	(-.09)	(1.57)	(.77)	(-.19)	(.41)
Specific effect:Belgium	DumBel	-.591	.061	-.552	-.502	.979
	======	(-1.10)	(2.23)	(-3.21)	(-.92)	(3.38)
Specific effect:Canada	DumCan	1.413	.013	.084	1.457	1.358
	======	(4.62)	(.85)	(1.93)	(4.53)	(10.84)
Specific effect:Denmark	DumDen	-2.237	-.030	.329	-2.148	-.240
	======	(-3.34)	(-1.50)	(6.98)	(-3.72)	(-1.20)
Specific effect:France	DumFra	.574	.004	.532	.632	2.379
	======	(1.24)	(.15)	(9.35)	(1.50)	(14.25)
Specific effect:Great-Britain	DumGbr	1.203	-.048	-.778	1.229	1.721
	======	(2.66)	(-1.76)	(-9.16)	(2.74)	(8.07)
Specific effect:Germany	DumGer	1.146	-.020	-.075	1.080	2.549
	======	(2.35)	(-.78)	(-1.19)	(2.15)	(15.62)
Specific effect:Netherland	DumNet	-.773	-.135	-.270	-.717	.507
	======	(-1.69)	(-6.41)	(-3.57)	(-1.58)	(2.66)
Specific effect:Norway	DumNor	-1.710	.056	.208	-1.610	-.910
	======	(-3.59)	(2.11)	(4.63)	(-3.59)	(-4.64)
Specific effect:Spain	DumSpa	.712	.135	.626	.769	1.404
	======	(2.20)	(7.69)	(3.78)	(2.37)	(8.42)
Specific effect:Sweden	DumSwe	-1.095	.034	.417	-1.052	.009
	======	(-2.41)	(2.19)	(7.76)	(-2.50)	(.05)
Specific effect:Switzerland	DumSwi	-.663	-.027	.215	-.571	-.298
	======	(-1.36)	(-.67)	(3.17)	(-1.44)	(-.98)
ETC - Other						
Leap year	AnneeBis	.003	-.001	.007	.001	.004
	========	(.82)	(-.60)	(.54)	(.12)	(.68)
REGRESSION CONSTANT	CONSTANT	-	-	-	-	-
		(-5.37)	(2.04)	(-37.23)	(-5.83)	(4.62)
HETEROSKEDASTICITY STRUCTURE						
DELTA COEFFICIENTS						
Vehicle-Kilometer	VehKm		.032			-.023
			(-12.71)			(-3.25)
			LAM			LAM

II. PARAMETERS (COND. T-STATISTIC)		TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
		VARIANT =	acc7	mbe7	mte7	ble7	tue7
		VERSION =	10	4	4	8	9
		DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues

HETEROSKEDASTICITY STRUCTURE

BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]

		acc7	mbe7	mte7	ble7	tue7
LAMBDA(Z)	VehKm		-.074			2.662
			[-.37]			[1.33]
			[-5.33]			[.83]
LAMBDA(Y) - GROUP 1	LAM 1	.065	.121	.396	.062	.068
		[2.00]	[.38]	[3.08]	[2.03]	[1.38]
		[-28.89]	[-2.77]	[-4.70]	[-30.77]	[-19.05]
LAMBDA(X) - GROUP 2	LAM 2	.822	1.323	10.000	.684	1.314
		[1.40]	[3.10]	[3.84]	[1.05]	[2.18]
		[-.30]	[.76]	[3.46]	[-.48]	[.52]
LAMBDA(X) - GROUP 3	LAM 3	-.519	.126	3.862	-.524	2.947
		[-2.40]	[.58]	[4.18]	[-2.62]	[.71]
		[-7.03]	[-4.07]	[3.10]	[-7.62]	[.47]
LAMBDA(X) - GROUP 4	LAM 4	1.000	1.000	1.000	1.000	1.000
		FIXED	FIXED	FIXED	FIXED	FIXED
LAMBDA(X) - GROUP 5	LAM 5	-.122	-2.598	-2.327	.226	-2.601
		[-.05]	[-.68]	[-7.07]	[.16]	[-1.26]
		[-.42]	[-.94]	[-10.11]	[-.56]	[-1.74]
LAMBDA(X) - GROUP 6	LAM 6		10.000	3.327		
			[3.25]	[.82]		
			[2.92]	[.57]		

AUTOCORRELATION

		acc7	mbe7	mte7	ble7	tue7
ORDER 13	RHO 13	.968			.966	.852
		(85.63)			(93.30)	(29.81)

III.GENERAL STATISTICS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	acc7	mbe7	mte7	ble7	tue7
	VERSION =	10	4	4	8	9
	DEP.VAR. =	Accident	Morbidit	mortalit	Blesses	Tues
LOG-LIKELIHOOD		-3978.60	914.580	1693.702	-4131.24	-2796.20
PSEUDO-R2 : - (E)		.997	.861	.925	.996	.993
- (L)		.999	.908	.939	.999	.998
- (E) ADJUSTED FOR D.F.		.997	.850	.919	.996	.992
- (L) ADJUSTED FOR D.F.		.999	.900	.934	.999	.998
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)		.000	.000	.000	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS		429	429	429	429	429
- FIRST OBSERVATION		27	27	27	27	27
- LAST OBSERVATION		455	455	455	455	455
NUMBER OF ESTIMATED PARAMETERS :						
- FIXED PART :						
. BETAS		27	27	27	27	27
. BOX-COX		4	5	5	4	4
. ASSOCIATED DUMMIES		0	0	0	0	0
- AUTOCORRELATION		1	0	0	1	1
- HETEROSKEDASTICITY :						
. DELTAS		0	1	0	0	1
. BOX-COX		0	1	0	0	1
. ASSOCIATED DUMMIES		0	0	0	0	0

Appendix 7. MPM: adding 9 province specific dummies

I. ELASTICITY S(y) (EP) (COND. T-STATISTIC)						
	TYPE	= LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT	= CaccE	CmbeE	CmteE	CbleE	CtueE
	VERSION	= 1	9	2	4	2
	DEP.VAR.	=Accident	Morbidit	Mortalit	Blesses	Tues
D - Demand						
Rate of occupation of vehicles	PopVeh	-.237	.097	.066	-.312	.014
		(-1.14)	(2.05)	(.24)	(-1.17)	(.13)
		LAM 4	LAM 4	LAM 4	LAM 4	LAM 4
	POPVEH	.274	-.111	-.242	.301	-.049
		(1.93)	(-2.30)	(-1.65)	(1.38)	(-1.82)
		LAM 5	LAM 5	LAM 5	LAM 5	LAM 5
Vehicle-Kilometer	VehKm	.285	.019	-.476	.375	.077
		(4.20)	(1.56)	(-5.41)	(4.29)	(1.27)
		LAM 3	LAM 2	LAM 3	LAM 3	LAM 3
P - Price						
Minimum price per litre, ordinary gazoline	PrixEss	-.005	-.016	-.127	-.045	-.190
		(-.43)	(-1.07)	(-2.03)	(-.95)	(-4.26)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
M - Motorization						
Percentage of cars in total number of vehicles	PctAuto	.097	.002	-.096	.160	-.122
		(.40)	(.02)	(-.42)	(.81)	(-.46)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Urban population(% of total population)	PctUrban	-.710	-.287	1.088	-.518	.839
		(-1.30)	(-2.88)	(1.97)	(-1.02)	(1.85)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
N-L - Network-Regulations						
Highway speed limits	HwySpeed	.037	-.043	-.191	.050	-.004
		(.30)	(-.41)	(-.88)	(.36)	(-.02)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Seatbelt regulations	SeatBelt	.017	.003	-.033	.008	-.009
	========	(.73)	(.25)	(-.81)	(.32)	(-.26)
Y - Socio-economic						
Percentage of the population 65 and older	Pop65	-.329	-.093	-1.266	-.065	-1.264
		(-1.47)	(-1.02)	(-3.48)	(-.19)	(-4.81)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Proportion of the population 18-24 years old	PopYoung	.124	-.107	-.337	.429	.342
		(.79)	(-1.99)	(-1.43)	(1.85)	(1.93)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
A - Economic activity						
GDP per capita	PibCapit	.027	.058	.192	.094	.090
		(1.65)	(1.60)	(1.59)	(.86)	(.88)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
C - Climatic effect						
Others precipitations	Pautres	.000	.001	-.032	.003	-.019
		(1.04)	(.22)	(-1.76)	(1.49)	(-1.03)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Total rainfall precipitation	Ppluie	-.003	.004	.017	.018	.014
		(-.73)	(.37)	(.46)	(1.11)	(.54)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2
Mean yearly temperature (Far.)	TempF	-.013	-.054	.182	-.059	.173
		(-.10)	(-.79)	(.92)	(-.48)	(.78)
		LAM 2	LAM 2	LAM 2	LAM 2	LAM 2

PS - Province specific						
Specific effect:Alberta	DumAlb	-.943 (-6.33)	.024 (.54)	-.393 (-3.10)	-.808 (-5.48)	-1.282 (-9.17)
specific effect:British-Columbia	DumBC	-.159 (-.91)	.049 (1.14)	-.535 (-5.27)	-.117 (-.78)	-.676 (-5.85)
Specific effect:Manitoba	DumMan	-1.048 (-4.13)	.032 (.83)	-.761 (-5.62)	-.876 (-4.24)	-1.543 (-8.70)
Specific effect:New Brunswick	DumNB	-2.007 (-5.92)	-.035 (-.64)	.182 (.74)	-1.638 (-5.77)	-1.324 (-5.86)
Specific effect:Newfoundland	DumNF	-2.579 (-8.45)	-.036 (-.66)	-.624 (-2.88)	-2.017 (-7.60)	-2.333 (-10.66)
Specific effect:Nova Scotia	DumNS	-1.956 (-5.92)	-.082 (-1.92)	.090 (.46)	-1.660 (-6.64)	-1.404 (-6.72)
Specific effect:Ontario	DumOnt	.402 (2.82)	.093 (3.26)	-.360 (-5.77)	.528 (4.20)	-.017 (-.25)
Specific effect:Prince-Edward Island	DumPEI	-3.394 (-6.99)	.028 (.28)	-.361 (-.89)	-2.605 (-5.42)	-2.158 (-5.90)
Specific effect:Saskatchewan	DumSas	-1.559 (-4.47)	.017 (.32)	.148 (.81)	-1.246 (-4.76)	-1.093 (-5.12)
ETC - Other						
Leap year	AnneeBis	-.007 (-.90)	.002 (.51)	-.019 (-1.32)	-.012 (-1.25)	-.030 (-1.95)
REGRESSION CONSTANT	CONSTANT	- (.80)	- (-.60)	- (-1.97)	- (-.84)	- (4.17)
HETEROSKEDASTICITY STRUCTURE						
DELTA COEFFICIENTS						
Vehicle-Kilometer	VehKm	.285 (-4.29) LAM		-.476 (-8.55) LAM		.077 (-2.78) LAM

II. PARAMETERS (COND. T-STATISTIC)	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	CaccE	CmbeE	CmteE	CbleE	CtueE
	VERSION =	1	9	2	4	2
	DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues

HETEROSKEDASTICITY STRUCTURE

BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]

LAMBDA(Z)	VehKm	10.000 [2.48] [2.23]		.108 [.72] [-5.96]		-.430 [-.72] [-2.41]

BOX-COX TRANSFORMATIONS: UNCOND: [T-STATISTIC=0] / [T-STATISTIC=1]

LAMBDA(Y) - GROUP 1	LAM 1	-.043 [-1.43] [-34.58]	-3.567 [-13.12] [-16.80]	.105 [1.24] [-10.50]	.080 [4.08] [-46.66]	.145 [2.80] [-16.47]
LAMBDA(X) - GROUP 2	LAM 2	4.858 [1.43] [1.14]	-.416 [-1.05] [-3.57]	.036 [.09] [-2.44]	-.862 [-.88] [-1.90]	1.502 [2.73] [.91]
LAMBDA(X) - GROUP 3	LAM 3	-.180 [-1.16] [-7.58]		-.342 [-3.04] [-11.95]	-.053 [-.36] [-7.18]	-.048 [-.13] [-2.77]
LAMBDA(X) - GROUP 4	LAM 4	1.000 FIXED	1.000 FIXED	1.000 FIXED	1.000 FIXED	1.000 FIXED
LAMBDA(X) - GROUP 5	LAM 5	2.624 [.91] [.57]	-.616 [-.21] [-.56]	2.848 [.67] [.44]	2.324 [.54] [.31]	-6.110 [-.86] [-1.00]

AUTOCORRELATION

ORDER 10	RHO 10	.814 (24.75)	.347 (7.07)	.488 (9.63)	.780 (18.87)	.404 (7.43)

III.GENERAL STATISTICS	TYPE =	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1	LEVEL-1
	VARIANT =	CaccE	CmbeE	CmteE	CbleE	CtueE
	VERSION =	1	9	2	4	2
	DEP.VAR. =	Accident	Morbidit	Mortalit	Blesses	Tues
LOG-LIKELIHOOD		-2616.55	577.331	1372.149	-2798.26	-1633.16
PSEUDO-R2 : - (E)		.992	.481	.883	.992	.986
- (L)		.999	.761	.953	.999	.997
- (E) ADJUSTED FOR D.F.		.991	.434	.871	.991	.985
- (L) ADJUSTED FOR D.F.		.999	.740	.948	.999	.996
AVERAGE PROBABILITY (Y=LIMIT OBSERV.)		.000	.000	.000	.000	.000
SAMPLE : - NUMBER OF OBSERVATIONS		340	340	340	340	340
- FIRST OBSERVATION		11	11	11	11	11
- LAST OBSERVATION		350	350	350	350	350
NUMBER OF ESTIMATED PARAMETERS :						
- FIXED PART :						
. BETAS		25	25	25	25	25
. BOX-COX		4	3	4	4	4
. ASSOCIATED DUMMIES		0	0	0	0	0
- AUTOCORRELATION		1	1	1	1	1
- HETEROSKEDASTICITY :						
. DELTAS		1	0	1	0	1
. BOX-COX		1	0	1	0	1
. ASSOCIATED DUMMIES		0	0	0	0	0