Experience Rating Mechanisms in Auto Insurance: Implications for High Risk, Low Risk and Novice Drivers

Introduction

Sustainable insurance pricing requires that the total amount of premiums collected in aggregate cover the losses generated by all policyholders, the expenses of the insurer and provide an adequate rate of return to the insurance company. The two principles for allocating these expected costs among individual policyholders are social pricing and risk-based pricing. In a true social pricing model, the premium charged to all policyholders reflects the average cost of all policyholders and in a risk-based pricing model, the premium charged reflects the underlying risk characteristics of the insured. Many pricing models for automobile insurance in practice are modified social pricing models: risk characteristics that are controllable by the insured, such as location, driving history, use of vehicle and type of vehicle, are allowed but uncontrollable characteristics, such as age and gender, are not allowed. Specifically, most jurisdictions in North America use some measure of experience rating where the premium charged reflects the driver's driving history to price insurance.

We are interested in 2 research questions: 1) Are novice drivers better off with a more extensive rating mechanism (that is one with a greater number of driving record classes)? With respect to novice drivers, experience rating does not work because they have no driving history. Many jurisdictions place novice drivers in the same experience rating category as the highest risk drivers (the class of no years of accident-free driving). It is not immediately evident that placing novice drivers in this class is reasonable or equitable.

And 2) Does a more extensive experience rating mechanism make roads safer? If a more extensive experience rating mechanism can better match premiums with losses, then moral hazard should be reduced, resulting in safer roads. Roads will also be safer if high premiums incent unsafe drivers to cease driving. Road could however also be less safe if high risk drivers, now faced with exorbitant premiums, will now choose to drive uninsured

In this paper we examine two experience rating mechanisms: one is a pure no-claims discount (as described by Dionne, *et al*, 2012) that classifies drivers from 0 to 6 or more years of at-fault claims-free driving, and the other is a bonus-malus mechanism with 32 steps or classes – a base class, 15 malus classes and 16 bonus classes.[1] The 32-class system that we examine is

[1] The schedule actually allows for an infinite number of malus classes: Each subsequent class above class +15 has a 23% increase in premiums. There are very few drivers in the higher malus classes. Between 2007 and 2012, less than 0.5% of drivers were in malus class 10 or higher.

used in the province of Alberta for predominantly novice or higher risk drivers, and is referred to as the Grid.

Because the insured risks are different between those insured in the 7-class mechanism and the 32-class mechanism, we cannot directly compare the experience rating structure. Therefore, as in the literature (see, for example, Lemaire, 1988; and Lemaire and Zi, 1994) we model claims frequency of a portfolio of drivers and build a theoretical model of an insurer's portfolio of drivers. In Canada, all private insurers must provide annually premium and loss data (including earned vehicle counts) to provincial regulators. These data are classified in several ways, including the number of years of at-fault claims-free driving. We use these data to calibrate stochastic models that analyze the movement of drivers through the two rating mechanisms.

Not surprisingly, we find that having more rating classes increases the spread of possible premiums. However we find no benefit to the lowest risk drivers (in terms of premium reductions): the difference between premiums charged to the lowest risk drivers in the 7-class no-claims discount mechanism and the 32-class bonus-malus mechanism is $3.38: $390.82 versus $394.19, with low risk drivers priced by the bonus-malus mechanism paying more than low risk drivers priced by the 7-class mechanism. And the impact on the highest risk drivers is immense: a maximum premium of $566.67 in the 7-class mechanism versus $2846.07 in the 32-class bonus-malus mechanism.

Improving the affordability and availability of auto insurance is a regulatory goal in many jurisdictions in Canada.[2] In particular, concern has been expressed by the high cost of insurance for novice drivers. Therefore we examine the impact of these different experience rating systems on the premiums charged to novice drivers. We had originally hypothesized that having more driving record classes would be advantageous to novice drivers as more driving record classes allows for the separation of drivers with no claims history from those with many at-fault claims. However we find that entry class premiums in the 7-class mechanism are significantly lower than the entry premiums in the 32-class bonus-malus mechanism: $566.67 versus $788.39.

The introduction of more driving record classes also has other possible public policy implications. Namely,

[2] North American studies have found that having access to a car (and by default being able to afford the required insurance) for low income adults dramatically increases employment opportunities and reduces the reliance on social assistance (Blumenberg and Ong, 2002; Raphael and Rice, 2002; Sullivan, 2006 and Thériault and Rosenbluth, 2002).

- Does having more driving record classes better match premiums to underlying risk? If yes, then because drivers receive the correct signal of their risk type, moral hazard should be reduced and there should be a resulting increase in road safety.
- Are high risk drivers choosing not to drive (which should lead to safer roads), or instead, because of the extremely high cost of insurance, are they driving uninsured?

Our resulting public policy analysis is preliminary. High risk drivers in the province of Alberta are priced on the 32-class bonus-malus mechanism, whereas low risk drivers are not subject to the same premium structure. We examine both the coefficient of variation of loss ratios for drivers priced on the Grid, and those that are priced in the competitive market, and find no statistical difference between the 2 pricing mechanisms. We do not find evidence to support the claim that having more driving record classes has allowed insurers to better accurately match premiums with losses. We also find no evidence that there is a greater level of uninsured driving.

The organization of the paper is as follows. After a review of the existing literature on experience rating, we first provide an overview of experience rating in automobile insurance used in Alberta. Following this we develop our theoretical model and provide benchmark statistics. Since this work is preliminary in nature, we also provide insight as to our future research. Finally we conclude with a discussion of public policy implications relating to experience rating for auto insurance.

Literature Review

Much of the literature on experience rating for auto insurance focuses on the design and 'toughness' of bonus-malus mechanisms in different jurisdictions, and the efficacy of experience rating in creating safer roads.

The first study of experience rating mechanisms for auto insurance was undertaken by Lemaire (1988). He compared the bonus-malus mechanism of 13 European countries and using three metrics: the relative stationary average premium level, the efficiency of the bonus-malus mechanism, and the average optimal retention. The relative stationary average premium, given on a scale of 0 (lowest premium) to 100 (highest premium), measures the premium charged to the average policyholder, relative to the maximum and minimum premium that could be charged. The efficiency of the bonus-malus mechanism measures the responsiveness of the system – premiums should increase in the presence of at-fault claims and decrease for drivers with no claims. In general however, the change in premium is much less than the change or revelation of an insured's frequency of loss. The average optimal retention measures the

incentives of insureds to bear small claims and not report them to the insurer (the cost of the claim being less than the expected increase in future premiums if a claim is reported). Based on this analysis, Lemaire concludes that there are 5 guidelines for the construction of a good bonus-malus mechanism.

1. Use a large number of classes;
2. Introduce penalties for first claims as severe as possible (especially for the high risk classes);
3. Do not offer claim forgiveness;
4. Do not erase maluses quickly (i.e. the movement for a claim should be significantly greater than movements for no claims);
5. Do not introduce surcharges for young drivers, instead, place them in a higher risk class.

Lemaire and Zi (1994) extend Lemaire's original study and examined 6 East Asian countries, 14 European countries, Kenya and Brazil. They defined an additional characteristic to measure the 'toughness' for each system: the coefficient of variation of premiums. As in the Lemaire's original work, simulation was used to create stationary models for the measures and then using principal components, mechanisms were then ranked based on toughness. The find that countries that have redesigned their bonus-malus mechanism had created tougher systems. Mechanisms with the simplest rules (in this case surcharges are erased after a single claims-free year, and discounts are eliminated after a single claim) had very few drivers in high-malus classes, and the greatest under-reporting of accidents.

However charging higher premiums for unsafe driving only works when premiums (or fines) are not too big. Dionne *et al* (2012) examines both experience rating mechanism (both the no-claims discount and a bonus-malus mechanism) and a system in which drivers are charged higher premiums or fined based on the number of licensed demerit points charged by licensing authorities for moving traffic violations. They argue that insurance pricing is sufficient for designing an optimal road safety policy for 'normal' drivers, whereas the ability of governments to remove unsafe drivers from the road works best for 'risky' drivers (because at some point fines become ineffective and drivers would not or could not pay them).

Experience Rating in Practice

One practical difficulty in implementing risk-based insurance pricing is estimating a driver's expected losses before they occur. In practice, insurers set premiums based on observable characteristics that they find to be correlated with a driver's loss experience. This results in grouping drivers into categories and charging the same base premium to all drivers within a category. Risk-based pricing reduces moral hazard and adverse selection. Many

authors (Dionne, 2002; Tennyson, Weiss and Regan, 2002; Grace, Klein and Phillips, 2002; Harrington, 1991, 2002; Derrig and Tennyson, 2011) find that both claims rates and accident costs are higher when auto insurance premiums do not accurately reflect a driver's expected losses.

Even in jurisdictions where premiums are set primarily through a social pricing mechanism, to reduce moral hazard and minimize adverse selection, most jurisdictions in North America use some measure of experience rating where the premium reflects the driver's past loss experience (or driving record) to price insurance. The discount afforded to low risk drivers and the resulting surcharge to high risk drivers can be substantial. An example of the differences in average third party liability insurance premiums for the lowest risk and highest risk classes in 4 provinces in Canada for 2010 are given below.

Table 1 – Average TPL Premiums Charged in Urban Centres in 2010

	Alberta	New Brunswick	Newfoundland and Labrador	Ontario
Lowest Risk Class	$480.70	$337.13	$673.87	$572.52
Highest Risk Class	$1465.21	$999.28	$1490.33	$1193.68

Source: Author calculation for General Insurance Statistical Agency (GISA) data[3]

There are (at least) 2 distinct mechanisms for rating drivers in the province of Alberta. Low risk drivers are priced in the voluntary market, and insurers are free to use (with regulatory approval) a variety of experience rating mechanisms. The province sets the maximum premiums that can be charged, and consequentially high risk and novice drivers are priced on the 32-class bonus-malus mechanism called the Grid.

Many insurers in Alberta price coverage based on the 7-class system used for reporting purposes. This experience-rating mechanism assigns drivers to a driving record class based on the number of years of at-fault claims-free driving. Not-at-fault claims, by law, cannot be used to modify premiums and therefore do not affect the driving record class assignment. Drivers with zero years of at-fault claims-free driving are placed in driving record class 0, drivers with one year of at-fault claims free driving are placed in driving record class 1, and so on up to driving record class 5. Drivers with 6 or more consecutive years of no at-fault claims are placed

[3] The General Insurance Statistical Agency (GISA) carries out the activities of a statistical agent on behalf of nine participating insurance regulatory authorities across Canada. More information is available at http://www.gisa.ca/en/. Of the 10 provinces in Canada, 6 of them – Alberta, New Brunswick, Newfoundland and Labrador, Ontario and Prince Edward Island – offer auto insurance through the private marketplace.

in class 6. In addition, most insurers offer modified accident forgiveness for class 6 drivers. Class 6 drivers with an at-fault claim are placed in class 5*. A driver in class 5* who has an at-fault claim moves to class 0 at the next renewal. A driver in class 5* moves back to class 6 if she has 5 years of consecutive years of at-fault claims free driving. In the absence of approved driver training, novice drivers enter the system at driving record 0. Novice drivers with approved driver training enter at driving record 3. Table 2 provides an example of the differentials charged for these different driving record classes.

Table 2 –Sample Driving Record Rate Differentials 7-Class Mechanism in Alberta

Driving Record	6	5 &5*	4	3	2	1	0
Differential	1.000	1.100	1.225	1.300	1.350	1.400	1.450

Source: Kelly, Isotupa, Kleffner (2009)

The Grid pricing mechanism mandated by the provincial regulator in Alberta is given below in Table 3.

Novice drivers without approved driver education enter the system at the base class (level 0), those with a driver education course enter at base class -2. For each year with no at-fault claims, the insured moves down one class until he/he is in class -15. Each at-fault claim results in a move up of 5 classes. In 2014, the base rate charged was $2061.

Table 3 –Driving Record Rate Differentials –Alberta Grid (32-Class Bonus-Malus Mechanism)

	Claim Rated Scale Level	Insurance Surcharge & Discounts	Chargeable claim? Move up:		Claim Rated Scale Level	Insurance Surcharge & Discounts	Chargeable claim? Move up:
	+1	+23% for each additional class	5 classes		0	Base rate	5 classes
	+15	+238%	5 classes		-1	5%	5 classes
	+14	+215%	5 classes		-2	10%	5 classes
	+13	+193%	5 classes		-3	15%	5 classes
	+12	+170%	5 classes		-4	20%	5 classes
	+11	+148%	5 classes		-5	25%	5 classes
	+10	+125%	5 classes		-6	30%	5 classes
Surcharge Levels	+9	+110%	5 classes	**Discount Levels**	-7	35%	5 classes
	+8	+95%	5 classes		-8	40%	5 classes
	+7	+80%	5 classes		-9	45%	5 classes
	+6	+65%	5 classes		-10	50%	5 classes
	+5	+50%	5 classes		-11	50%	5 classes
	+4	+40%	5 classes		-12	50%	5 classes
	+3	+30%	5 classes		-13	50%	5 classes
	+2	+20%	5 classes		-14	50%	5 classes
	+1	+10%	5 classes		-15	50%	5 classes

Source: Alberta Insurance Rate Board (2014).[4]

Theoretical Experience Rating Model

We wish to examine the impact of these two experience rating mechanisms on the prices charged to high-risk, low-risk and novice drivers. A straightforward comparison is not possible as the driver characteristics are different between the two groups. Therefore, we build stochastic models to examine the impact of the experience-rating mechanisms on premiums charged.

The 32-class pricing mechanism, because it has the memoryless property, is easily adapted as a stochastic model. The 7-class driving record mechanism is adjusted to allow for the partial accident forgiveness in class 5* yet still maintain the memoryless property.[5]

[4] http://www.airb.alberta.ca/gridrate/AirbGridInfo.aspx

[5] A more detailed discussion on the stochastic model for the 7-class mechanism is found in Kelly,

Transition probabilities between the states arise from the movement of drivers according to their at-fault claims histories and the prescribed experience rating mechanisms.

In order to derive the steady-state equilibrium, we do not allow for entry and exit of drivers from the portfolio of 10,000 independent drivers. Each driver has a probability of an accident, $\lambda \sim \text{gamma}(\alpha,\beta)$, that is constant over time and independent of other drivers in the portfolio.[6] For each of the 10,000 drivers in the portfolio, an accident probability λ_k is chosen at random from the underlying risk distribution. The steady state probability for each driver is derived and by summing across all outcomes we are able to generate the insurer's portfolio of 10,000 drivers.

We calibrate our model (i.e. the gamma distribution of accident frequencies) by matching the observed accident frequencies by driving record class for urban Alberta in 2010 to those calculated in the simulation. The observed accident at-fault accident frequency for third party liability (TPL) claims frequencies are given in Table 4. These data provide by driving record class. This allows us to determine transition probabilities between the driving record classes that arise from the movement of drivers according to their claims histories.

Table 4 – Frequency of TPL Claims by Driving Record Class for Alberta

Driving Record	6	5 &5*	4	3	2	1	0
Accident Frequency	3.16%	4.57%	5.75%	7.28%	4.89%	6.74%	6.11%
Observed Percentage of Drivers in Each Class	77.3%	8.1%	4.0%	5.8%	1.6%	2.0%	1.2%
Theoretical Percentage of Drivers in Each Class	83.19%	14.06%	0.51%	0.53%	0.55%	0.57%	0.59%

Source: General Insurance Statistical Agency

As can be seen in Table 4, although we anticipate class 0 to have the highest frequency and then frequencies should be decreasing until class 0, there are some anomalies. We have two possible explanations: first, for some vehicle classes, there are highest driving record class in class 3; and second, new drivers with approved driver training are placed into driving record class 3. Although we are able to match the distribution of accident frequencies across the

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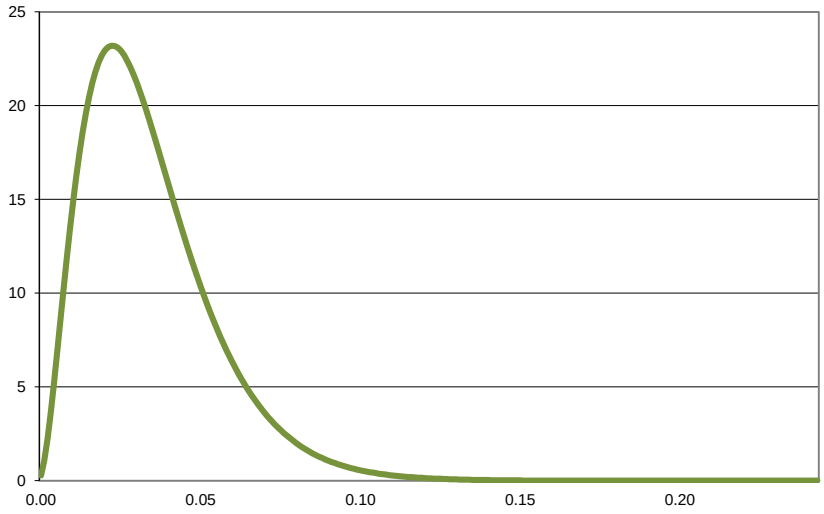
Isotupa and Kleffner (2009).

[6] In order to derive the steady-state equilibrium, we do not allow for changes in accident frequencies over time. However empirically novice drivers, as a class, do improve over time. The literature suggests that it takes 6 to 10 years to become fully competent in driving. Our brief analysis of GISA data supports this supposition: the 3 year average annual claim frequency for those licensed less than 1 year was 6.2%, and the average annual claim frequency for those licensed more than 6 years was 3.2%.

driving record classes (for most classes), the gamma distribution gives rise to a great percentage of low risk (high driving record) drivers than observed in practice. [7] The overall average accident frequency of 3.5 percent matches what is observed for the province.

Specifically, the gamma distribution used to simulate the at-fault accident probabilities for the portfolio of drivers is given in Figure 1, with parameters $\alpha = 0.035/3$ and $\beta = 3$.

Figure 1 – Gamma Distribution of Accident Frequencies for Portfolio of Drivers Model (α=0.0167 and β=3)



Model Results

To calculate theoretical premiums that must be charged, we assume an average claims cost per earned vehicle of $400.[8] After assigning an expected severity per earned vehicle, we can derive the expected losses for the entire portfolio of drivers and for each cohort of drivers in each of the different states. Using the differentials supplied by both the private insurer and by the grid, we can calculate the actuarially fair base premium that must be charged to all drivers, and the premiums that must be charged to each of the driving record classes. The

[7] We have tried fitting a gamma distribution to the 32-class bonus-malus. We find similar results, in that our fitted model overestimates the proportion of good drivers. Other distributions, including the negative binomial distribution as well as mixed distributions intended to create 'fatter' tails provide no better fit.

[8] Using GISA data, the average third party liability claims cost per earned vehicle between 2008 and 2010 in Urban (Rural) Alberta is $428.87 ($315.47).

resulting premiums are given in Table 5 (for the 7-class no-claims discount mechanism) and Table 6 (for the 32-class bonus-malus mechanism).

Table 5 – Actuarially Fair Premiums for 7-Class No-Claims Discount Mechanism

Driving Record	6	5 &5*	4	3	2	1	0
Theoretical % of Drivers	83.19%	14.06%	0.51%	0.53%	0.55%	0.57%	0.59%
Theoretical Premium Charged	$390.81	$429.86	$478.74	$508.05	$527.59	$547.13	$566.67

Table 6 – Actuarially Fair Premiums for the 32-Class Bonus-Malus Mechanism.

DR Class	Observed % of Drivers[9]	Theoretical % of Drivers	Theoretical Premium Charged	DR Class	Observed % of Drivers	Theoretical % of Drivers	Theoretical Premium Charged
16	0.01%	0.00%	$2846.07	0	0.98%	0.06%	$788.39
15	0.01%	0.00%	$2664.74	-1	1.13%	0.07%	$748.97
14	0.00%	0.00%	$2483.42	-2	2.48%	0.10%	$709.55
13	0.01%	0.00%	$2309.97	-3	1.60%	0.13%	$670.13
12	0.00%	0.01%	$2128.64	-4	1.68%	0.16%	$630.71
11	0.01%	0.01%	$1955.20	-5	1.92%	0.29%	$591.29
10	0.02%	0.01%	$1773.87	-6	1.99%	0.41%	$551.87
9	0.02%	0.01%	$1655.61	-7	2.04%	0.52%	$512.45
8	0.05%	0.01%	$1537.35	-8	2.14%	0.61%	$473.03
7	0.05%	0.01%	$1149.09	-9	2.24%	0.69%	$433.61
6	0.06%	0.01%	$1157.35	-10	3.22%	3.27%	$394.19
5	0.11%	0.02%	$1182.58	-11	3.26%	3.13%	$394.19
4	0.14%	0.02%	$1103.74	-12	2.96%	2.99%	$394.19
3	0.27%	0.03%	$1024.90	-13	2.73%	2.86%	$394.19
2	0.28%	0.03%	$946.06	-14	2.65%	2.73%	$394.19
1	0.29%	0.04%	$867.22	-15	65.67%	81.78%	$394.19

[9] Although only high risk drivers are priced on the Grid, the Alberta government collects data on the Grid driving record classes for low risk drivers. Low risk drivers are charged premiums from the voluntary insurance market, but statistics are collected as to what driving record class they would be in based on their accident history.

As with the 7-class no-claims discount mechanism, we also observe a greater percentage of drivers in the lowest risk class in our theoretical model for the 32-class bonus-malus mechanism.

The 32-class mechanism has the ability to discriminate between those drivers with no driving history (class zero drivers) and those that have a poor driving record, whereas in the 7-class mechanism, novice drivers and those with poor driving records are in the same class. Thus we had originally anticipated that novice drivers would be charged lower premiums in the 32-class bonus-malus mechanism, as opposed to the 7-class no-claims discount mechanism. However, as can be seen in a comparison of Table 5 and Table 6, this is clearly not the case – novice drivers would be charged a premium of $566.67 in the 7-class mechanism and $788.39 in the 32-class mechanism – an increase of almost 40 percent.

In fact, even the lowest risk drivers are worse off in the 32-class mechanism, paying a premium of $394.19 instead of $390.81 in the 7-class mechanism. This occurs because even a greater percentage of insureds pay the lowest premium (classes – 10 to -15) in the 32-class mechanism than in the 7-class mechanism (97 percent as opposed to 83 percent), and there is not enough premium dollars collected from the higher risk classes. The highest risk drivers clearly are worse off in the 32-class mechanism, although both in practice (1.33 percent) and in the theoretical distribution (0.21 percent) there are very few drivers in the malus classes.

Future work

The work presented in this proposal is preliminary. We have three avenues of research that we are currently investigating as given below.

Improvements in the Stochastic Model

There are two key improvements that need to be made to the model. As can be seen in both Table 4 and Table 6, our theoretical model places too many drivers in the lower risk classes. We continue to investigate different distributions to model the accident frequency for the portfolio of drivers. Our hope is to be able to more closely match the observe proportion of drivers in each class.

The premium structures in both Table 4 and Table 6 are calculated using the differentials provided by the private insurer (for Table 4) and with the government prescribed differentials (for Table 6). It is possible to recalculate premiums using differentials from the theoretical model. In practice, insurance companies use differences in observed accident frequencies to develop rate class differentials. Following this practice, differentials for each driving record class in Table 4 can be calculated as the class accident frequency divided by the accident frequency

for driving record class 6 (as it has the greatest proportion of drivers). Similarly, differentials for Table 6 would be calculated as the accident frequency for each grid class divided by the accident frequency for class -15. A new premium structure can then be derived using the calculated differentials.

Hybrid Driving Record Class / Bonus – Malus Model

Although all insurers in Canada must report (and therefore categorize) accident histories for drivers based on the seven driving record classes, private insurers are permitted to use more extensive experience rating models to price insurance. For example, one large insurer has recently provided us with their hybrid pricing model that classifies drivers by both the number of at-fault claims in the last 6 years, and the time since the last at-fault claim. They use this mechanism to price third party liability coverage in Alberta.

The differentials for this model are given in two separate tables in Table 7.

Table 7 – Differentials for Driving Record (Third Party Liability) from Private Insurer

Number of Claims in last 6 years	Months Since Last At-Fault Claim										
	0-11	12-23	24-35	36-47	48-59	60-71	72-83	84-95	96-107	108-119	120+
0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.980	0.960	0.940	0.920
1	1.435	1.247	1.126	1.047	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2	2.295	1.947	1.685	1.489	1.341	1.231	1.000	1.000	1.000	1.000	1.000
3	2.984	2.567	2.234	1.967	1.753	1.583	1.000	1.000	1.000	1.000	1.000
4	3.978	3.422	2.978	2.622	2.338	1.464	1.000	1.000	1.000	1.000	1.000
5	4.774	4.107	3.574	3.147	2.805	1.464	1.000	1.000	1.000	1.000	1.000
6+	5.728	4.928	4.288	3.776	3.367	1.464	1.000	1.000	1.000	1.000	1.000

Number of Years Since Last At-Fault Claim								
0	1	2	3	4	5	6	7	8
1.831	1.806	1.806	1.702	1.446	1.221	0.931	0.931	0.931

The differentials are multiplicative in nature; the base premium for each driver is multiplied by both the differential for the number of years since the last at-fault claim, and the number of at-fault claims within the last 6 years. A novice driver would be at a driving record 0, and would have had no claims in the past 6 years. Therefore he would be charged a differential of 1.000 x 1.813 = 1.813.

An individual who would have been driving for 5 years without a claim would be charged a differential of 1.000 (no claims in the last 6 years and 48 to 59 months since last chargeable claim) x 1.221 (driving record class 5) = 1.221. In he has an at-fault claim in that year, upon renewal his new differential would be 1.435 (1 chargeable claim and 0 to 11 months since last chargeable claim) x 1.831 (driving record class 0) = 2.6275. If he has no accident within that year, then his differential would be 1.247 (1 chargeable claim and 12 to 23 months since last chargeable claim) x 1.806 (driving record class 1) = 2.252. However if he has an accident that year, his differential would be 2.295 (2 chargeable claims and 0 to 11 months since last chargeable claim) x 1.831 (driving record class 0) = 4.2021.

Unlike the straight forward 7-class mechanism, new drivers, as can be seen, are not charged the highest differential. And the differentials in this model, unlike the 32-class bonus-malus model presented earlier, are capped: the lowest possible differential is 0.920 (no chargeable claims and at least 10 years since last chargeable claim) x 0.931 (driving record class 8) = 0.8565; and the largest differential is 5.728 (over 6 chargeable claims and 0 to 11 months since last chargeable claim) x 1.831 (driving record class 0) = 10.48797.

Although this rating mechanism does not have the memoryless property (it will be necessary to track accident history for 10 years), it will still be possible to model this within the stochastic framework. We therefore will build a stochastic model for this hybrid mechanism and compare the results to our 2 existing experience rating mechanisms – the 7-class no-claims discount mechanism and the 32-class bonus-malus model.

A Comparison of the Three Mechanisms

Lemaire (1988) and Lemaire and Zi (1994) compared the 'toughness' of experience rating mechanisms using four metrics: the relative stationary average premium level, the coefficient of variation, the efficiency of the bonus-malus mechanism, and the average optimal retention. Our goal is to provide a similar analysis of the three experience rating mechanisms presented in this paper. This will provide further insight into the strengths and weakness of these mechanisms. Because of the simplicity of rules, we predict that the 7-class mechanism will reveal the greatest under-reporting of accidents, particularly for those drivers in the 5* category. In theory, the 32-class bonus-malus mechanism should be the "best" system

according to Lemaire's 5 guidelines. However, there are very few drivers in the higher risk categories; it unclear as to whether there are too many malus categories, whether these high risk drivers stop driving or whether they simply drive uninsured.

Public Policy Issues

Our examination of these experience rating models arose from our interest in the impact of auto insurance on the decision whether or not to drive, whether to drive with insurance and on the choices made while (e.g. road safety and moral hazard). We briefly outline the public policy issues below, acknowledging that further analysis is required.

Novice Driver Evidence and Treatment

Unlike much of Europe and even large cities in North America, many Canadian cities and towns do not have access to adequate or reliable public transit. Access to an automobile (and therefore the ability to insure that vehicle) is of interest to policy makers particularly those interested in poverty and social assistance policies (see Taylor, 2009). New drivers often face affordability and accessibility issues in purchasing auto insurance, as there are few observable characteristics that can be used to price auto insurance for these drivers. For novice drivers, the problem is exacerbated as many are young drivers without an income. And, as noted above, in many provinces, the premium charged for novice drivers is not distinguished from the premium charged for higher-risk drivers.

It is not evident that this pricing mechanism is reasonable. Although it is well-known that undercharging drivers with respect to their risk level increases moral hazard, Weiss, Tennyson and Regan (2010) also find that overcharging drivers increases moral hazard. Therefore several provinces have developed mechanisms to better align premiums to risk and to promote affordability for novice drivers. Some of these mechanisms are detailed in Table 8. We briefly outline the mechanisms below, their impact on affordability and availability and potential impact on road safety.

Table 8 - Novice Driver Treatment in Different Canadian Jurisdictions

Jurisdiction	With driver's education	Without driver's education
Alberta	Grid driving record class -2 (10% reduction)	Grid driving record class 0
British Columbia	Driving record class 0	Driving record class 0
New Brunswick	Driving record class 6 premium within Risk Sharing Pool	Driving record class 3 premium within Risk Sharing Pool
Nova Scotia	Driving record class 6 premium within Risk Sharing Pool	Driving record class 3 premium within Risk Sharing Pool
Ontario	Driving record class 3	Driving record class 0

Most provinces offer a premium reduction (lower risk driving record class) for approved driver education classes. As can be inferred from Table 4, it is not evident that driver education classes reduces crash risk. In fact the literature shows that driver education classes increases crash risk if it reduces the time that it takes to get a license (see, for example, Hirsch and Maag, 2006 Mayhew, Simpson, Desmond and Williams, 2003).

The pricing grid, presented in Table 3 legislates the maximum premium that can be charged to any driver. These premiums are often below what the voluntary market would charge, and therefore the grid has become the *de facto* pricing structure for novice drivers. Although we find that in our theoretical model, the grid pricing mechanism increases the premiums charged to entry level drivers, in practice entry level premiums on the grid are set below what would be charged in the voluntary market. This would serve to increase the number of high risk drivers in the market.

In British Columbia, insurance is provided by the government monopoly insurer using a strict social pricing model. Young drivers pay far below what young drivers pay in private market provinces: there are no affordability or availability concerns. However Kovacs and Leadbetter (2004) note a sharp increase in the frequency of accidents since the introduction of the social pricing model, and estimate that total accident costs rose by 36 percent over what would have been incurred if risk-based pricing were still used.

In the Maritime provinces of New Brunswick and Nova Scotia, all new drivers (less than 6 years driving experience) with no at-fault claims are placed in a provincial risk sharing pool. Premiums are set by individual insurers, but losses are shared across all insurers in the province. Insureds with driver's education are priced in the lowest risk class, and if there are no at-fault claims, they remain in the risk sharing pool at that premium for 6 years. Drivers without driver's education, are priced in driving record class 3, and, if they do not have any claims,

move to driving record class 4, then 5 and then 6 for the next 3 years. They remain in the risk sharing pool for 3 more years. If any driver has a claim, he/she is removed from the pool and is priced at driving record 0. The pool allows for the sharing of the uncertainty about the driver's true risk class across all insurers in the province until information is revealed about the quality of the driver. Unfortunately the risk sharing pool does not collect or report data about the loss experience of these novice drivers, and as such it is difficult to examine the impact on road safety.

Uninsured Drivers and Experience Rating Mechanisms

We wish to examine the impact of the introduction of Grid pricing on the number of uninsured drivers in Alberta. This is somewhat problematic as insurers in the province do not track the number of uninsured motorist claims. Therefore we collect statistics on the number of earned vehicles (those that have purchased insurance) to the number of vehicles registered with the province's Ministry of Transportation. A decrease in this ratio suggests an increase in the number of uninsured drivers. We also collect statistics from Statistics Canada on the percentage individuals charged with driving without insurance in Alberta. Results are shown in Table 9.

Table 9 – Uninsured Drivers in Alberta: Pre and Post Grid Pricing

Before the introduction of the Grid	2000	2001	2002	2003	2004	2005	2006
# of Earned / # of registered Vehicles	0.88	0.90	0.92	0.91	0.91	0.90	0.89
Driving without insurance / 10,000 population	16.39	16.48	17.60	18.65	19.15	17.44	17.66
After the introduction of the Grid	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	
# of Earned /# of registered Vehicles	0.90	0.90	0.92	0.92	0.92	0.92	
Driving without insurance / 10,000 population	17.43	18.25	17.82	15.74	14.07	13.45	

Source: Statistics Canada and author calculation from GISA and Alberta Ministry of Transportation data

Although we had originally expected a decrease in the ratio of earned to registered vehicles after the introduction of the grid, the opposite is observed. The ratio of earned vehicles to registered vehicles increased after the introduction of the grid pricing model, and the

increase is statistically significant at a 5 percent level. Statistically there is no difference in the percentage of individuals charged with driving without insurance after the introduction of the grid pricing model. Although the introduction of the Grid increased the premiums that could be charged to high risk insureds, it can be seen from Table 6, that there are very few insureds in the malus classes and as such very few individuals would be impacted by the high premiums. However the Grid offered lower premiums to those in bonus classes than what was offered voluntarily by insurers. This potentially increased the number of drivers purchasing insurance. The impact of this on road safety still needs to be analyzed.

Better Matching of Premiums to Losses

One cited advantage of having more driving risk classes is that insurers should be able to better match premiums to losses: there should be less heterogeneity with respect to losses within each driving record class and more heterogeneity between classes. The coefficient of variation, which is ratio of the standard deviation the mean, is a standardized measure of dispersion. If having more driving record classes allows insurers to better match premiums to losses, then we would expect seeing lower coefficients of variation for the 32-class mechanism. This is not evident in Table 10.

Table 10 – Coefficient of Variation of Loss Ratios for 7-Class and 32-Class Experience Rating Mechanisms 2007 - 2012

Year	2007	2008	2009	2010	2011	2012
7-Class Mechanism	0.37	0.76	0.32	0.25	0.12	0.13
32-Class Mechanism	0.42	0.43	0.33	0.34	0.41	0.31

Source: Author calculated using Alberta Insurance Rate Board data.

In fact for every year except 2008, coefficients of variation were smaller for the 7-class mechanism than the 32-class mechanism. We have two possible explanations. The 32-class mechanism sets maximum premiums that can be charged by insurers. These premiums therefore may not reflect accurately the risks of the underlying insureds. This explanation is supported by an examination of the underlying loss ratios in fact reveals that the lower risk classes in general have higher loss ratios than the higher risk classes.[10] Also, as noted in Table 6, there are very few drivers in the malus classes, which would also increase the variability of loss ratios in those classes.

[10] The average 6 year loss ratio for classes -11 to -15 is 59.2 percent, for classes -10 to -6 is 61.6 percent, for classes -5 to -1 is 55.5 percent, for 0 to 4 is also 55.5 percent, for 5 to 9 is 41.8 percent and for classes greater than 10, 25 percent.

Thus our initial observation is that the increased number of classes (with very few drivers) combined with the artificial pricing of the 32-class experience rating mechanism does not provide drivers with a better signal of their risk type.

Discussion and Conclusion

Many pricing models, even if they are predominantly social pricing models, include a mechanism to account for the past driving record of the insured. In this paper we examine the impact of two different experience rating models on premiums charged to low risk, high risk and novice drivers. Using stochastic modelling techniques, we find, contrary to our expectations that having a greater number of driving record classes does not result in lower prices to both the lowest risk insureds or to new drivers. And not surprisingly, with an increasing number of malus classes, the highest risk insured pay a premium that perhaps is not sustainable in reality.

We were motivated by public policy issues surrounding accessibility of auto insurance and road safety: Are novice drivers better off in the driving record scheme with more driving risk classes? Our preliminary observation is **no**. We also provide an overview of other mechanisms in place to improve affordability and availability of insurance for young drivers. However, due to a lack of data, we cannot measure the impacts of these mechanism on road safety.

We are also interested in how the spread of premiums between the lowest and highest risk drivers impacts both road safety (i.e. do higher risk drivers stop driving) and the incentives to drive uninsured. Again, we do not yet have the data to answer these questions.

Out hope is that this research will have public policy implications as to the best way to price insurance for young drivers. From a policy perspective, the point to emphasize is that mechanisms that promote affordability should not lessen incentives for safe driving since strengthening the responsiveness of changes in insurance premiums to driving or accident experience has been shown to reduce moral hazard and adverse selection without violating social pricing objectives.

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