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Vehicle insurance and the risk of road traffic accidents

Yung-Ching Hsu [a,*], Yung-Ming Shiu [b], Pai-Lung Chou [c], Yen-Ming J. Chen [d]

[a] Ph.D. program in Management, National Kaohsiung First University of Science and Technology, 1, University Rd., Yanchao Dist., Kaohsiung, Taiwan
[b] Department of Risk Management and Insurance, Risk and Insurance Research Center, College of Commerce, National Chengchi University, 64, Sec. 2, Zhi-Nan Road, Wen-Shan District, Taipei, Taiwan
[c] Department of Risk Management and Insurance, National Kaohsiung First University of Science and Technology, 1, University Rd., Yanchao Dist., Kaohsiung, Taiwan
[d] Department of Logistics Management, National Kaohsiung First University of Science and Technology, 2, Jhuoyue Rd., Nanzih District, Kaohsiung City 811, Taiwan

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ABSTRACT

Given the upward trend in incidences of road traffic accidents (RTAs) over recent years, in order to mitigate the financial losses arising from such accidents, governments around the world nowadays generally encourage, or even require, drivers to purchase appropriate vehicle insurance. The primary aim of this study is to examine whether RTAs are directly related to the purchase of vehicle insurance, with our examination of data on vehicle damage insurance policyholders revealing that those drivers who purchase more insurance coverage have a higher probability of being involved in accidents, as a result of which, they will tend to submit more claims. This indicates that insurance coverage might contain information which can be used to assess the probability risk levels of RTAs. We also find that drivers with less safety awareness will tend to purchase more coverage, and that those who purchase more coverage will, in turn, tend to have more accidents and submit more claims. Our findings, which provide a number of road traffic policy implications, would appear to justify the use of the bonus–malus system.

1. Introduction

Despite continuous improvements in road safety levels, as well as vehicle safety and technology standards, there has been a continuing upward trend in incidences of road traffic accidents (RTAs) over recent years. In Taiwan, for example, as compared to a fairly moderate increase in the total number of vehicles, from 18,500,658 in 2003 to 22,346,398 in 2012, there have been significant increases in the total number of traffic accidents, from 120,165 to 249,465 cases, over the same period; thus, the RTA rate in Taiwan has increased from 0.65 per cent to 1.12 per cent in just ten years.[1]

RTAs ultimately give rise to various types of costs, including human losses, production losses and accident costs (De Brabander and Vereeck, 2007), with such costs undoubtedly being very high; indeed, a World Health Organization report has forecasted that by 2030, traffic accidents will have become the fifth leading cause of death (WHO, 2009), thereby clearly highlighting the crucially important issue of addressing ways of reducing the overall risk of RTAs.

Identifying ways of effectively reducing the frequency and severity of traffic accidents has therefore become one of the most important issues to be dealt with by governments and vehicle manufacturers around the world; however, despite

* Corresponding author. Tel.: +886 7 6011000x3902; fax: +886 7 6011093.
E-mail address: fenerton@gmail.com (Y.-C. Hsu).

[1] Data source: http://talas-pub.iot.gov.tw/Default.aspx.

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the amount of effort that a government may put into reducing the number or frequency of RTAs by effectively ensuring roads are made safer, and the effort that vehicle manufacturers may put into ensuring that vehicles are constructed with much higher safety specifications in an attempt to reduce the severity of the losses arising from such incidences, traffic accidents will undoubtedly continue to occur.

It therefore seems clear that there is an urgent need for governments to develop alternative means of financing the losses arising from RTAs, and indeed, one of the most commonly adopted measures is to encourage, or even legally require, drivers and motorcyclists to purchase vehicle insurance. Although buying insurance reduces neither the frequency nor the severity of accidents, it can mitigate the financial losses of drivers and motorcyclists who are involved in such accidents.

This relationship in insurance markets is appropriately described by 'adverse selection' theory, which refers to a situation in which insurance purchasers retain some of the private information relating to their overall risk level which, although important to insurers, is unavailable to them when considering their underwriting decisions; thus, important related risks are not factored into the decision-making process. If adverse selection is indeed present, then those drivers who purchase more insurance coverage are likely to be at greater risk of being involved in RTAs, thereby indicating a positive correlation between coverage and risk.

The theory of adverse selection in insurance, which was first proposed around four decades ago by Akerlof (1970) and Rothschild and Stiglitz (1976), predicts that those who purchase more insurance coverage are likely to represent a greater risk of being involved in RTAs than those who purchase less coverage. Nevertheless, despite the fact that a considerable amount of empirical research has been carried out into adverse selection, the results have been far from conclusive.

Although our work in the present study is closely connected to that of Shi et al. (2012), there are, nevertheless, a number of major differences. Firstly, the comparable study used data obtained from a vehicle insurance firm in Singapore, whereas we use data from the second largest property-casualty insurer in Taiwan. Secondly, Singapore and Taiwan have very different approaches to encouraging safe driving; insurers in Singapore rely upon the 'no claims discount' scheme, whereas the bonus–malus system is used in Taiwan. Thirdly, different econometric techniques are employed between the two studies; Shi et al. (2012) adopted a Frank copula, whereas we use a bivariate Probit model.

2. The vehicle insurance market in Taiwan

Similar to the governments in many other countries around the world, the government in Taiwan has been encouraging, and even requiring, drivers to purchase vehicle insurance in order to mitigate the potential financial consequences arising from RTAs, with vehicle insurance in Taiwan being classified into two types, 'compulsory' and 'voluntary'. Since drivers are free to determine whether or not they wish to purchase voluntary insurance, and if so, the extent of such insurance coverage, this is considered to be better suited than compulsory insurance for our analysis of adverse selection. Thus, our analysis in this study focuses on the purchasing and claims behaviour of policyholders with voluntary vehicle damage insurance.

The bonus–malus system has been in use in Taiwan since July 1996, with both vehicle damage insurance and voluntary liability insurance being operated under the system. Since vehicle damage insurance data provides the input for our subsequent analysis, we provide details here of how the system works with regard to vehicle damage insurance. Under the bonus–malus system, the vehicle damage insurance premiums of policyholders are determined by their gender, age and previous claims record; thus, female drivers aged between 30 and 60 with no claims over the previous three-year period will have the lowest premiums.

The bonus element of the system aims to encourage good driving habits. Policyholders with one claim during the previous three-year period, will see their premiums remaining the same as in the previous year; policyholders with no claims in the previous one, two or three years, will see their premiums respectively discounted by 20, 40 or 60 per cent. The malus element of the system aims to penalize bad driving habits; thus, policyholders with more than one claim in the previous three-year period will find that their premiums are increased; and indeed, for each additional claim, a 20 per cent increment is added to the premiums, with no specified upper limit. In more specific terms, policyholders with two, three or four claims will be required to pay 20, 40 or 60 per cent more than in the previous year, and so on.

As compared to the 'no claims discount' scheme described in Shi et al. (2012), the bonus–malus system currently in use in Taiwan is more appropriate for testing the presence of adverse selection. Although the 'no claims discount' scheme is essentially the same as the bonus element of the bonus–malus system, in contrast to the bonus–malus system, the 'no claims discount' scheme system provides no encouragement for safe driving habits, as in the malus element. Given that both elements can better describe the inherent risk of an insured driver, this makes the vehicle damage insurance system in Taiwan a good setting to test our hypotheses.

3. Hypothesis development

Although several prior studies, have examined whether drivers purchasing more insurance coverage have an inherently higher risk of being involved in RTAs, these studies do not clearly distinguish between the effects of risk on coverage vis-à-vis the effects of coverage on risk. For example, using a bivariate model consisting of two Probit equations, Saito (2006) examined the relationship between coverage choice and occurrences of traffic accidents, from which a correlation was calculated; the correlation calculated by Saito was found to be statistically insignificant. In similar fashion, Shi et al. (2012) computed a dependence parameter, which they found to be significantly positive, thereby implying a positive relationship between the choice of coverage and occurrences of RTAs amongst policyholders.

Based upon the argument that the inconsistent empirical results referred to above are largely attributable to the use of a dichotomous measurement approach, Kim et al. (2009) noted that such an approach gave rise to two specific problems, excessive bundling in the measurement of coverage and sample selection bias. However, despite their suggestion of the adoption of a multi-nomial measurement approach in an attempt to address these problems, we argue that the problem of sample selection bias cannot be sufficiently addressed using a multi-nomial measurement approach, and indeed, if this is the case, then selection bias may well confound the results. In the remainder of this section, we begin by discussing the causal effects of risk on coverage and then go on to examine the reverse causality effects from coverage to risk.

According to adverse selection theory, policyholders with an above average likelihood of loss will seek to purchase more than the average amount of insurance coverage (Trieschmann et al., 2005). One of the potential reasons for the existence of adverse selection is the private information possessed by policyholders with regard to their risk type and the likely losses, information which is not readily available to insurers; hence, information asymmetry exists between the two parties. It is therefore expected that policyholders with a higher inherent risk or those potentially faced with higher risks will tend to purchase more insurance coverage.

Turning to the reverse causality from coverage to risk, in the present study we argue that those policyholders who purchase more coverage may tend to drive without sufficient care and attention, or indeed, prove to be totally indifferent to the losses that may occur as a result of their poor driving habits; thus, both the likelihood and magnitude of the potential losses are increased. The mental attitude of careless or accident-prone drivers is best described under the theory of 'moral hazard', and indeed, as noted by Trieschmann et al. (2005), policyholders who purchase much higher insurance coverage can sometimes actually have a subconscious desire for a loss, of which they may not be fully aware.

From their examination of individual contractual data, Puelz and Snow (1994) found that policyholders who had selected lower deductible contracts had a greater likelihood of submitting claims, and indeed, based upon a study of Israeli data, Cohen (2005) found that new clients who had selected lower deductible contracts also had more claims and higher accident losses. Li et al., 2007 examined the dynamic patterns of claims after policyholders had changed their deductible levels and found that policyholders who switched from high to low deductible levels tended to submit more claims. Li et al. (2013) also found that policyholders with higher insurance coverage tended to submit claims.

Based upon the findings of all of the above studies, we expect to find a positive relationship between insurance coverage and the risk of RTAs, which would thereby imply that policyholders with high insurance coverage contracts will be found to have a greater likelihood of submitting claims.

4. Research framework and data

4.1. Research framework

As stated earlier (in the Introduction section), coverage and risk have been simultaneously considered in a number of the prior studies (e.g., Chiappori and Salanié, 2000; Cohen, 2005; Saito, 2006; Shi et al., 2012). Many of these studies have used bivariate Probit models comprising of two equations, with both of these equations using binary variables to indicate the coverage and risk of certain policyholders. The correlations between the error terms of these two binary equations are subsequently calculated in order to determine whether there are mutual correlations between insurance coverage and risk.

Following on from these prior studies, in the present study we assume that the inherent risk of policyholders will affect both their coverage level and their future insurance claims. Our model, which is estimated based upon bivariate Probit regressions using the maximum likelihood method, is constructed as follows:

$$Coverage_i = f_1(X_i) + e_{1i} \tag{1}$$

$$Claim_i = f_2(X_i) + e_{2i} \tag{2}$$

where $Coverage_i$ refers to the coverage choice made by policyholder i; this is a dichotomous variable which takes the value of 1 for high coverage (low deductible level) and 0 for low coverage (high deductible level); $Claim_i$ is a dummy variable which takes the value of 1 if policyholder i files one or more claims; otherwise 0.

Within the extant literature, several variables are found to affect the dependent variables, $Coverage_i$ and $Claim_i$. These variables, which are denoted as X_i in the above equations, can be divided into two groups, the first of which relates directly to the inherent risk of policyholder i. The most important variable in this group is the bonus–malus coefficient, proxied by the previous claim history of this policyholder (Saito, 2006; Kim et al., 2009). *Gender* and *Age* have also been identified within the prior studies (for example, Shi et al., 2012) as having direct effects on the coverage–risk relationship; as alluded to earlier, middle-aged women are generally considered to be relatively safe drivers as compared to women in other age groups and men in all age groups.

The second group of variables relates to the insured vehicle. It is expected that the location of the insured vehicle will have direct influences on the amount of coverage purchased and occurrences of insurance claims. If the vehicle is located in a busier inner-city area for most of the time, then the likelihood of the vehicle being involved in an RTA is higher; indeed, Paefgen et al. (2014) found that urban driving was related to high risk. Thus, policyholders whose vehicles are located in urban districts are likely to purchase higher insurance coverage.

The age of the vehicle also plays an important role in determining the choice of insurance coverage, since the owner of an older vehicle would generally not choose to purchase very high insurance coverage; indeed, in order to diminish the existence of moral hazard in this area, owners are not permitted to purchase excessively high coverage for vehicles which have relatively low actual cash value. Therefore, as their vehicle depreciates over time, owners of older vehicles will become less likely to purchase excessive insurance coverage.

Conversely, since the purchase of a new car represents a substantial outlay (second only, in many cases, to the purchase of a home), drivers of new cars will tend to cherish their vehicles and, of course, would not wish to see any damage occurring to them. However, an alternative and contradictory argument may be proposed with regard to vehicle age, which is that safe drivers generally tend to drive older cars, and as a result of their safe driving habits, will be less likely to submit claims. Consequently, we have no prior expectations with regard to the direction of the effects of the age of a vehicle on the likelihood of submission of insurance claims.

In Taiwan, imported vehicles and larger vehicles are generally owned by more wealthy individuals; such drivers tend to be more risk-tolerant and therefore purchase less insurance coverage; however, once again, an alternative and contradictory argument is that wealthy people can readily afford to pay higher premiums. Thus, the net effect on insurance coverage in such group remains an empirical question, and consequently, once again, we have no prior expectations with regard to whether the size or the geographical origin of the vehicle will have any effect on the probability of being involved in traffic accidents.

Finally, as a result of the expected depreciation in the resale value of a vehicle, policyholders renewing the insurance contracts on their vehicles will tend to purchase less coverage; we therefore expect to find that the *Renew* variable will have a negative effect on insurance coverage. Details of all of the variables used in this study are provided in Table 1, along with their definitions.

4.2. Data

The data for our subsequent analyses in this study, comprising of a total of 726 observations, are obtained from the vehicle damage insurance contracts of a major insurer in Taiwan covering the 2009 policy year; this means that the policies would have been in effect from 1 January 2009 to 31 December 2010.[2] During the period under examination, the company providing these insurance policy details was the second largest property-liability insurer in Taiwan.[3]

The descriptive statistics of the variables used in the analyses in this study are presented in Table 2, from which we can see that the *Coverage* variable has a mean of 0.2824, with a standard deviation of 0.4505, whilst the *Claim* variable has a mean of 0.2245, with a standard deviation of 0.4176.

The *Bonus–Malus* variable, which ranges between −0.6 and 0.6, indicates that our sample includes both safe and dangerous drivers; this variable is found to have a mean of −0.3394, thereby indicating that the average policyholder in our sample has submitted no claims during the previous one to two-year period.

The correlation coefficients amongst all of the variables are shown in Table 3, where the correlation between *Coverage* and *Claim* is found to be 0.146, with significance at the 1 per cent level; this univariate evidence provides strong support for the assumption that policyholders with high insurance coverage are more likely to submit claims, thereby indicating the existence of adverse selection. Given that the *Bonus–Malus* variable is positively correlated with both *Coverage* and *Claim*, this is consistent with our supposition that unsafe drivers will tend to purchase higher insurance coverage and submit more claims.

A two-way cross tabulation between the choice of coverage (*Coverage*) and the claims submitted by policyholders (*Claim*), which are the two dependent variables used in our analysis, is provided in Table 4. As the table shows, those policyholders with high insurance coverage (32.20 per cent) had previously submitted one or more claims; however, those policyholders with low insurance coverage (18.62 per cent) had also submitted one or more claims.

Finally, in the test for independence, the Chi-squared value is found to be 15.58, with an associated *p*-value of 0.00008, thereby indicating a positive and significant relationship between the choice of coverage by policyholders and the number of claims submitted. This preliminary evidence indicates that policyholders with higher coverage are indeed more likely to submit insurance claims.

5. Empirical results

The maximum likelihood estimation results based upon Eqs. (1) and (2) are reported in Table 5, with a heteroskedasticity-corrected covariance matrix being used to derive the heteroskedasticity-consistent estimates (White, 1980). Our estimate for ρ is 0.1753, with a standard error of 0.0803, and an associated *p*-value of 0.0290, which indicates that the association between *Coverage* and *Claim* is significantly positive at the 5 per cent level. The null hypothesis of independence is therefore

[2] As noted by Mills et al. (2011), police records and insurance claims records can be used to obtain information on the number of collisions and the severity of any injuries; insurance data have also been extensively employed in safety studies, such as Cassidy et al. (2000) and Zheng et al. (2007).

[3] The sample insurer is one of the major insurers in Taiwan, with the company's market share in 2009, in terms of gross premiums written, standing at 11.17 per cent.

Table 1
Variable descriptions.

Variables	Description
Dependent variables	
Coverage	1 for high coverage (low deductible); 0 for low coverage (high deductible)
Claim	1 if the policyholder submits one or more claims; otherwise 0
Explanatory variables	
Bonus–malus	The bonus–malus coefficient under the bonus–malus system
Gender	1 for male; 0 for female
Age	The age of the policyholder
RN	1 if the insured vehicle is in northern Taiwan; otherwise 0
RC	1 if the insured vehicle is in central Taiwan; 0 otherwise
RS	1 if the insured vehicle is in southern Taiwan; otherwise 0
RTH	1 if the insured vehicle is in Taoyuan or Hsinchu; otherwise 0
Vehicle age	The age of the insured vehicle
Domestic	1 if the insured vehicle is produced domestically; otherwise 0
Cap1	1 if the cubic capacity of the insured vehicle is less than 1200; otherwise 0
Cap2	1 if the cubic capacity of the insured vehicle is 1201–1800; otherwise 0
Cap3	1 if the cubic capacity of the insured vehicle is 1801–2400; otherwise 0
Cap4	1 if the cubic capacity of the insured vehicle is 2401–3600; otherwise 0
Renew	1 if the insurance policy is a renewal; otherwise 0

Table 2
Summary statistics.

Variables	Mean	S.E.	Min.	Max.
Coverage	0.2824	0.4505	0	1
Claim	0.2245	0.4176	0	1
Bonus–malus	−0.3394	0.2454	−0.60	0.60
Gender	0.7135	0.4524	0	1
Age	44.8774	9.5597	22	78
RN	0.2452	0.4305	0	1
RC	0.2052	0.4021	0	1
RS	0.2645	0.4414	0	1
RTH	0.1281	0.3344	0	1
Vehicle age	3.7273	2.3253	0	13
Domestic	0.7961	0.4031	0	1
Cap1	0.0110	0.1045	0	1
Cap2	0.4449	0.4973	0	1
Cap3	0.4284	0.4952	0	1
Cap4	0.0826	0.2755	0	1
Renew	0.7190	0.4498	0	1

This table reports the summary statistics. Coverage is a dummy variable, which takes the value of 1 for high coverage (low deductible); 0 for low coverage (high deductible). Claims is also a dummy variable, which takes the value of 1 if the policyholder submits one or more claims; otherwise 0. Bonus–Malus represents the bonus–malus coefficient under the bonus–malus system. Gender is a dummy variable, which takes the value of 1 for male; 0 for female. Age denotes the age of the policyholder. RN, RC, RS and RTH are all location dummy variables, which take the value of 1, if the insured vehicle is in northern, central, southern Taiwan and Taoyuan/Hsinchu respectively, otherwise 0. Vehicle age is the age of the insured vehicle. Domestic is a dummy variable, which takes the value of 1 if the insured vehicle is produced domestically; otherwise 0. Cap1, Cap2, Cap3 and Cap4 are all dummy variables, which take the value of 1, if the cubic capacity of the insured vehicle is less than 1200, 1201–1800, 1801–2400 and 2401–3600 respectively; otherwise 0. Renew is a dummy variable, which takes the value of 1 if the insurance policy is a renewal; otherwise 0. ***Indicates significance at the 1 per cent level; **indicates significance at the 5 per cent level; and *indicates significance at the 10 per cent level.

rejected. Our bivariate Probit regression results are found to be consistent with the Chi-squared independence test results presented earlier, with both results revealing that drivers who purchase more insurance coverage tend to be involved in more RTAs, and therefore, are prone to submitting more claims.

Our results provide clear support for the existence of adverse selection and the supposition that drivers who purchase more insurance coverage are more likely to be involved in RTAs; thus, our results are consistent with those reported by Puelz and Snow (1994) and Shi et al. (2012) who similarly identified adverse selection. Nevertheless, our findings run contrary to those reported by Blows et al. (2003) who found that, as compared to insured drivers, uninsured drivers had a significantly higher probability of traffic accident injuries.

Although, on the face of it, our results contradict those of Blows et al. (2003), we may, nevertheless, argue that both results are actually compatible. The major difference between the present study and that of Blows et al. (2003) is that their sample included uninsured drivers whereas the sample in the present study does not. Since those who do not purchase any vehicle insurance are considered to be high risk drivers, it therefore comes as no surprise to find that uninsured drivers are more likely to sustain traffic accident injuries.

Table 3
Correlation matrix.

	Coverage	Claim	Bonus–malus	Gender	Age	RN	RC	RS	RTH	Vehicle age	Domestic	Cap1	Cap2	Cap3	Cap4
Coverage	–														
Claim	0.146***	–													
Bonus–malus	0.162***	0.174***	–												
Gender	0.032	−0.017	0.045	–											
Age	0.081**	−0.054	0.002	0.154***	–										
RN	−0.059	0.031	−0.036	−0.028	0.002	–									
RC	−0.027	−0.148***	−0.035	0.008	0.000	−0.287***	–								
RS	0.082**	0.029	0.096***	0.083**	0.059	−0.342***	−0.302***	–							
RTH	0.107***	0.258***	0.030	−0.113***	−0.092**	−0.218***	−0.193***	−0.230***	–						
Vehicle Age	−0.148***	−0.090**	−0.453***	−0.025	0.053	0.092**	−0.025	−0.063**	−0.001	–					
Domestic	−0.047	−0.096***	−0.084**	0.042	−0.009	−0.069	0.102***	0.063**	−0.174***	−0.087**	–				
Cap1	0.080**	0.006	0.006	−0.021	0.041	−0.029	−0.020	−0.003	−0.001	−0.005	0.021	–			
Cap2	−0.075**	−0.030	−0.009	0.114***	−0.029	−0.066*	0.004	0.004	−0.078**	−0.058	0.157***	−0.094**	–		
Cap3	0.001	0.008	−0.005	−0.079**	0.031	0.018	0.035	0.017	0.010	−0.003	0.099***	−0.091**	−0.775***	–	
Cap4	0.012	0.066*	0.020	−0.064*	−0.057	0.073**	−0.027	−0.033	0.080**	0.104***	−0.270***	−0.032	−0.269***	−0.260***	–
Renew	−0.084**	−0.068*	−0.355***	−0.037	0.052	0.078**	0.025	−0.021	−0.026	0.407***	0.117***	0.037	−0.026	0.052	−0.035

This table reports the correlation matrix. Coverage is a dummy variable, which takes the value of 1 for high coverage (low deductible); 0 for low coverage (high deductible). Claims is also a dummy variable, which takes the value of 1 if the policyholder submits one or more claims; otherwise 0. Bonus–malus represents the bonus–malus coefficient under the bonus–malus system. Gender is a dummy variable, which takes the value of 1 for male; 0 for female. Age denotes the age of the policyholder. RN, RC, RS and RTH are all location dummy variables, which take the value of 1, if the insured vehicle is in northern, central, southern Taiwan and Taoyuan/Hsinchu respectively, otherwise 0. Vehicle age is the age of the insured vehicle. Domestic is a dummy variable, which takes the value of 1 if the insured vehicle is produced domestically; otherwise 0. Cap1, Cap2, Cap3 and Cap4 are all dummy variables, which take the value of 1, if the cubic capacity of the insured vehicle is less than 1,200, 1,201∼1,800, 1,801∼2,400 and 2,401∼3,600 respectively; otherwise 0. Renew is a dummy variable, which takes the value of 1 if the insurance policy is a renewal; otherwise 0.

* Indicates significance at the 10 per cent level.
** Indicates significance at the 5 per cent level.
*** Indicates significance at the 1 per cent level.

Table 4
Independent Chi-squared test results.

Variables	Coverage		Total
	Low	High coverage	
Claim = 0	424	139	563
Claim = 1	97	66	163
Total	521	205	726
χ^2	15.58***		
ρ-value	0.00008		

Note: This table shows the independent Chi-squared test results. Coverage is a dummy variable, which takes the value of 1 for high coverage (low deductible); 0 for low coverage (high deductible). Claims is also a dummy variable, which takes the value of 1 if the policyholder submits one or more claims; otherwise 0.

*** Indicates significance at the 1 per cent level.

Table 5
Bivariate regression.

Variables	Coverage		Claim	
	Coeff.	S.E.	Coeff.	S.E.
Constant	−0.20661	0.44671	−1.34393***	0.44886
Bonus–malus	0.52805**	0.23924	0.78776***	0.25812
Gender	0.07700	0.12114	0.05254	0.12754
Age	0.01146*	0.00586	−0.00600	0.00612
RN	0.17449	0.17255	0.68950***	0.20311
RC	0.25475	0.17699	0.09441	0.23399
RS	0.43492**	0.16933	0.65065***	0.20427
RTH	0.65266***	0.20331	1.35939***	0.20961
Vehicle age	−0.06500*	0.02735	−0.03124	0.02823
Domestic	0.06604	0.14994	−0.21550	0.15439
Cap1	0.06902	0.59149	0.92112	0.64181
Cap2	−0.99718***	0.30982	0.75630**	0.35569
Cap3	−0.90046***	0.30693	0.74124**	0.35527
Cap4	−0.76911**	0.33351	0.82089**	0.37716
Renew	−0.00972	0.13792	0.01833	0.14835
ρ-value	0.17531***	0.08029	–	–

This table presents the bivariate regression results. The dependent variables in this regressions are coverage and claim. Coverage is a dummy variable, which takes the value of 1 for high coverage (low deductible); 0 for low coverage (high deductible). Claims is also a dummy variable, which takes the value of 1 if the policyholder submits one or more claims; otherwise 0. Bonus–malus represents the bonus–malus coefficient under the bonus–malus system. Gender is a dummy variable, which takes the value of 1 for male; 0 for female. Age denotes the age of the policyholder. RN, RC, RS and RTH are all location dummy variables, which take the value of 1, if the insured vehicle is in northern, central, southern Taiwan and Taoyuan/Hsinchu respectively, otherwise 0. Vehicle age is the age of the insured vehicle. Domestic is a dummy variable, which takes the value of 1 if the insured vehicle is produced domestically; otherwise 0. Cap1, Cap2, Cap3 and Cap4 are all dummy variables, which take the value of 1, if the cubic capacity of the insured vehicle is less than 1200, 1201–1800, 1801–2400 and 2401–3600 respectively; otherwise 0. Renew is a dummy variable, which takes the value of 1 if the insurance policy is a renewal; otherwise 0.

* Indicates significance at the 10 per cent level.

** Indicates significance at the 5 per cent level.

*** Indicates significance at the 1 per cent level.

Whilst risk-averse drivers will obviously be prepared to purchase insurance coverage, they will naturally avoid purchasing excessive coverage, essentially because insurance coverage is expensive. The likelihood of such risk-averse drivers being involved in traffic accidents is therefore going to be much lower, since they are more likely to drive their vehicles with sufficient care and attention. Conversely, since we have shown that those drivers who purchase excessive amounts of insurance coverage tend to be associated with excessive risk, they therefore have a greater likelihood of being involved in more traffic accidents.

We first of all examine the regression results on the choice of insurance coverage amongst policyholders and, as expected, the *Bonus–Malus* coefficient is found to be positive, with statistical significance at the 5 per cent level, thereby suggesting that policyholders with poorer previous claims records tend to purchase more comprehensive insurance coverage. Consistent with Shi et al. (2012), we find that those drivers with poor traffic accident records are likely to drive with relatively lower levels of due care and attention, and since they are probably aware that they are prone to traffic accidents, will tend to purchase more insurance.

Our results provide some evidence on the positive effects of the age of the policyholder on insurance coverage, since they indicate that older policyholders are more likely to purchase greater amounts of insurance coverage. We also provide some evidence in support of the hypothesis that the location of the insured vehicle will have some effect on the level of insurance coverage.

As regards vehicle characteristics, *Vehicle Age* is found to have a significantly negative effect on decisions amongst policyholders on the choice of coverage at the 5 per cent level, since drivers of older vehicles have a lower likelihood of purchasing higher levels of insurance coverage for such vehicles, and indeed, may be prevented from doing so. We also find evidence of vehicle capacity playing a role in determining insurance coverage. Both findings are consistent with those of Shi et al. (2012).

The results on *Claim* are also presented in Table 5, where the *Bonus–Malus* variable is found to have a significantly positive effect on the probability of claim submissions at the 1 per cent level, a finding which is consistent with our expectations and provides support for the supposition that drivers with poorer claims history have a greater likelihood of being involved in RTAs (Shi et al., 2012). This finding, which provides clear justification for the use of the bonus–malus system, more importantly, confirms that the positive relationship documented above between *Coverage* and *Claim* is a clear indication of the existence of adverse selection, as opposed to moral hazard.[4] Although both the location and the capacity of a vehicle are found to have significant effects on the occurrences of claims, we can find no evidence of any effects of *Vehicle Age* or *Age* (of the policyholder) on the likelihood of claims.[5]

6. Conclusions

Traffic policy is set by governments, whereas vehicle insurance is provided by insurance firms, and although the two issues appear to be unrelated, our research results suggest that vehicle insurance data can be instrumental in establishing traffic policy aimed at reducing road traffic accidents (RTAs). This is consistent with the argument of Hultkrantz et al., 2012 that the insurance industry may act as an agent in support of the traffic safety policy established by a government.

Our results clearly indicate that those submitting claims are more likely to have selected high-coverage contracts, and that people purchasing more insurance coverage are more likely to be involved in RTAs. Policyholders with poorer prior claims records tend to purchase more insurance coverage, and those purchasing more coverage are, in turn, found to submit more claims.

Our evidence, which provides support for the use of the bonus–malus system in vehicle insurance, also indicates the importance of paying particular attention to those who purchase high-coverage vehicle damage insurance policies, since they appear to be more likely than others to be involved in RTAs. It is therefore important to establish effective and efficient underwriting measures, particularly for high-coverage insurance purchasers. Insurers can mitigate the potential consequences of adverse selection by intensifying their underwriting procedures for high-risk individuals who choose high level (low deductible) coverage. In conclusions, our findings have at least two policy implications for relevant authorities with responsibility for traffic policy.

Firstly, traffic authorities can set policies that require high-coverage vehicle damage insurance purchasers to attend traffic safety lessons; this could be instrumental in reducing the likelihood and severity of RTAs. Secondly, they also need to pay particular attention to drivers with poor past driving records, since they are clearly more likely to be involved in traffic accidents in the future. However, how to deal with these accident-prone drivers is a rather delicate matter. It is important to identify and remove the root causes of accidents.

We should point out that the riskiness of a policyholder is reflected not only by the probability of a loss, but also its magnitude; however, in the present study, we had to use a dichotomous variable to represent whether the policyholder submits one (or more claims). Due to the limitations of our dataset, we have been unable to obtain information on the amounts that insurers pay to compensate for policyholder losses. Future research could reexamine the issues investigated in this study using a continuous variable to represent claim levels. Furthermore, in tandem with the prior works (Shi et al., 2012), our study, which simultaneously models the coverage and risk regressions, does not explicitly assume that policyholders' past risk will affect their coverage decisions, and that such coverage will influence their future risk.

References

Akerlof, G.A., 1970. The market for 'Lemons': qualitative uncertainty and the market mechanism. Quart. J. Econ. 84, 488–500.
Blows, S., Ivers, R.Q., Connor, J., Ameratunga, S., Norton, R., 2003. Car insurance and the risk of car crash injury. Accid. Anal. Prev. 35, 987–990.
Cassidy, J.D., Carroll, L.J., Côté, P., Lemstra, M., Berglund, A., Nygren, A., 2000. Effect of eliminating compensation for pain and suffering on the outcome of insurance claims for whiplash injury. N. Engl. J. Med. 342, 1179–1186.
Chiappori, P.A., Salanié, B., 2000. Testing for asymmetric information in insurance markets. J. Pol. Econ. 108 (1), 56–78.
Cohen, A., 2005. Asymmetric information and learning: evidence from the vehicle insurance market. Rev. Econ. Stat. 87 (2), 197–207.
Cohen, A., Siegelman, P., 2010. Testing for adverse selection in insurance markets. J. Risk Insur. 77 (1), 39–84.
De Brabander, B., Vereeck, L., 2007. Valuing the prevention of road accidents in Belgium. Transport Rev. 27 (6), 715–732.
Hultkrantz, L., Nilsson, J., Arvidsson, S., 2012. Voluntary internalization of speeding externalities with vehicle insurance. Transp. Res. Part A 46, 926–937.

[4] It should be noted that there are differences between adverse selection and moral hazard in the relationship between past and future claims (Cohen and Siegelman, 2010). In the case of adverse selection, prior claims, denoted in the present study by the *Bonus–Malus* variable, reflect the risk type of a policyholder, where we expect to find that the relationship between past and future claims will be positive; under moral hazard, this relationship is expected to be negative.

[5] For robustness check, we also run a Probit regression of Claim on Coverage with the explanatory variables used in Eqs. (1) and (2). Consistent with our earlier results, *Coverage* is found to have a significantly positive effect on *Claim* at the 5 per cent level (*Coverage* coefficient = 0.30608, *p*-value = 0.014), thereby providing support for the view that policyholders with higher coverage are more likely to submit claims, and again suggesting the existence of adverse selection.

Kim, H., Kim, D., Im, S., Hardin, J.W., 2009. Evidence of asymmetric information in the vehicle insurance market: dichotomous versus multinomial measurement of insurance coverage. J. Risk Insur. 76 (2), 343–366.
Li, C., Liu, C., Yeh, J., 2007. Incentive effects of increasing per-claim deductible contracts in vehicle insurance. J. Risk Insur. 74, 441–459.
Li, C., Liu, C., Peng, S., 2013. Bundled vehicle insurance coverage and accidents. Accid. Anal. Prev. 50, 64–72.
Mills, B.N., Andrey, J., Hambly, D., 2011. 'Analysis of precipitation-related motor vehicle collision and injury risk using insurance and police record information for Winnipeg, Canada'. J. Saf. Res. 42, 383–390.
Paefgen, J., Staake, T., Fleisch, E., 2014. Multivariate exposure modeling of accident risk: insights from pay-as-you-drive insurance data. Transp. Res. Part A 61, 27–40.
Puelz, R., Snow, A., 1994. Evidence on adverse selection: equilibrium signaling and cross-subsidization in the insurance market. J. Pol. Econ. 102 (2), 236–257.
Rothschild, M., Stiglitz, J., 1976. Equilibrium in competitive insurance markets: an essay on the economics of imperfect information. Quart. J. Econ. 90, 629–649.
Saito, K., 2006. Testing for asymmetric information in the vehicle insurance market under rate regulation. J. Risk Insur. 73 (2), 335–356.
Shi, P., Zhang, W., Valdez, E.A., 2012. Testing adverse selection with two-dimensional information: evidence from the Singapore auto insurance industry. J. Risk Insur. 79 (4), 1077–1114.
Trieschmann, J.S., Hoyt, R.E., Sommer, D.W., 2005. Risk Management and Insurance, 12th ed. Thomson South-Western, New York, NY.
White, H., 1980. A heteroskedasticity-consistent covariance matrix estimator and a direct test of heteroskedasticity. Econometrica 48, 817–838.
Zheng, Y.Y., Cooper, P.J., Dean, C.B., 2007. Modeling the contribution of speeding and impaired driving to insurance claim counts and costs when contributing factors are unknown. J. Saf. Res. 38 (1), 25–33.