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# Modelling Different Types of Bundled Automobile Insurance Choice Behaviour: The Case of Taiwan*

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Automobile insurance policies (AIPs) are typically offered by the insurers in different bundled formats and some of which may be highly similar. This study proposes a two-component modelling system, which consists of choice of physical damage coverage and choice of non-physical damage coverage. Both multinomial logit (MNL) and paired combinatorial logit (PCL) models are attempted to explain the choice behaviours of AIP alternatives. The proposed models are tested with a large data set drawn from a Taiwanese non-life insurance company. It is found that the PCL model is structurally superior to the MNL model in analysing the choice of physical damage bundled AIP alternatives. In the context of non-physical damage coverage choice, however, the assumptions from the MNL model hold, suggesting that the use of PCL model is not required. Based on our estimation results, the insurance providers can develop marketing strategies to refine their existing AIPs or to develop new AIPs to better serve their customers.
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## Introduction

The potential risks of using an automobile involve losses or injuries to one's own and others' properties and/or bodies. Reparation for traffic-related accidents, therefore, has formed an important part of social security systems in developed countries. Many governments have promulgated laws mandating "compulsory" automobile insurance to secure the basic compensation for body injury and/or property damage caused by traffic accidents. The basic compensation, however, cannot transfer most of the risks involved with the automobile usage. As such, most car owners tend to purchase additional "voluntary" automobile insurance policies (AIPs) to cover the potential risks associated with traffic accidents.[1]

The voluntary AIPs are characterised with complicated bundle designs, which provide car owners/users with diverse coverages on traffic-related accidents. The insured

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[1] Sherden (1984).

(customers) can always make their best choices to purchase the most appropriate bundles offered in marketplace. In most developed countries, the competition of automobile insurance market is very keen due to a large number of insurance providers. Understanding the preference reactions of the insured to different AIP bundles is imperative for the insurance providers while developing or scrutinising the possible marketing strategies to enhance their competitive advantages. Developing a functional tool or modelling framework system to analyse the choice behaviours of AIPs would certainly help insurers accomplish this mission.

Over the past decades, many studies have addressed relevant automobile insurance topics such as choice between no-fault and tort systems,[2] selection of the deductible in a single policy,[3,4,5] insurance rates,[6] moral hazard and fraud,[7] adverse selection,[8] and risk perception of claims.[9] However, the underlying factors affecting the insureds' choices of bundled AIPs have not been addressed explicitly, to the best knowledge of the authors.

Theoretically, the choice of AIP bundles resembles the selection of individual features or items from a menu, for example, cable TV services, home computer features, and meal items.[10] The insurer offers bundles of AIPs that can cover different risks associated with traffic-related accidents. In order to gain insights into the insureds' choice behaviours, this paper proposes a methodological framework for analysing the determinants that significantly influence the demand for voluntary AIP products. Discrete choice modelling techniques have been widely used to examine the choice of one from a set of mutually exclusive alternatives;[11] thus this study would employ such techniques to investigate the AIPs choice behaviours.

Application of the discrete choice model in automobile insurance studies is rarely seen in literature. Artís *et al.*[12] employed discrete choice models to study fraud behaviour and assessed the effect of the personal characteristics of the insured on claims and fraud behaviour. Artís *et al.*[13] further used multinomial logit (MNL) and nested logit (NL) models to estimate the influence of customer and claim characteristics on the probability of committing fraud. Wen *et al.*[14] also employed MNL and NL models to identify variables related to the selection of bundled AIPs and to explore

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[2] Zador and Lund (1986); Carr (1989); Derrig *et al.* (1994); Harrington (1994); Schmit and Yeh (2003).
[3] Schlesinger (1981).
[4] Venezia (1984).
[5] Chiappori and Salanie (2000).
[6] Sant (1980); Jee (1989); Stroinski and Currie (1989); Dionne and Ghali (2005); Viaene *et al.* (2007); Li *et al.* (2007); Wang *et al.* (2008).
[7] Picard (1996); Viaene *et al.* (2002); Major and Riedinger (2002); Brockett *et al.* (2002); Viaene and Dedene (2004).
[8] Murray *et al.* (1994); Cummins and Weiss (1991); Dionne and Doherty (1994); Ania *et al.* (2002); Janssen and Karamychev (2005).
[9] Dellaert *et al.* (1990, 1993); Lee and Urrutia (1996); Lee and Ligon (2001); Renn (2004); Caudill *et al.* (2005).
[10] Ben-Akiva and Gershenfeld (1998); Myung *et al.* (2008).
[11] Ben-Akiva and Lerman (1985).
[12] Artís *et al.* (1999).
[13] Artís *et al.* (2002)
[14] Wen *et al.* (2005).

substitution patterns among highly similar AIP bundles. More recently, Wen *et al.*[15] further examined new car owners' choices of physical damage coverage—the most expensive AIPs and the consecutive years the insured had purchased the same types of coverage. They demonstrated the statistical and structural superiority of the NL model in explicating the insured repeated purchase behaviours.

Although the NL model can capture substitution patterns among similar bundled AIPs, it imposes a restriction that each AIP alternative is a member of only one nest, which is sometimes inappropriate. For instance, we can place AIP alternatives A and B in a common nest to account for the degree of correlation. However, alternative A may also have a similarity relationship with the other alternatives, for example, alternative C. This is a structural relationship that cannot be accommodated by the NL model. If such a relationship exists, a misrepresentation of choice behaviour is likely to produce biased estimates. Thus, a model that can allow alternative A to correlate with both alternatives B and C and account for different degrees of similarity is required. To account for highly similar bundled AIP products, this study attempts a different discrete choice model—paired combinatorial logit (PCL), which can effectively improve representation of similar (not mutually independent) alternatives, compared with other types of discrete choice modelling.[16,17,18] The PCL formulation has a more flexible error correlation structure than the MNL or NL models do. Besides, the PCL model also allows the estimation of differential substitution patterns between each pair of alternatives while retaining the computational advantages of closed-form generalised extreme value models. Our proposed modelling framework system is empirically calibrated and tested with a large data set drawn from a non-life insurance company in Taiwan.

The remaining parts of this paper are organised as follows. The next section reviews the current practices of automobile insurance industry. The following sections describe the modelling approach, empirical data, and estimation results. The paper ends with conclusions and directions for future research.

## Automobile insurance practices

Two different systems of automobile insurance are commonly seen in the marketplace: compulsory and voluntary AIPs. Most countries impose compulsory insurance, generally defined as the minimum amount of automobile liability coverage required by law. In addition to compulsory insurance, automobile drivers have the option to purchase different amounts of liability insurance to satisfy their particular needs by transferring different degrees of possible risks associated with traffic and other related accidents to the insurers. As a result, most car owners/users would purchase physical damage insurance for their own vehicles to cover property damage, bodily injury, and other special liabilities.

There are different designs of insurance coverage for vehicle physical damage. One category covers any accidental loss to the insured on an all-risks basis. Another one

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[15] Wen *et al.* (2007).
[16] Koppelman and Wen (2000).
[17] Chen *et al.* (2003).
[18] Pravinvongvuth and Chen (2005).

(termed perils coverage) covers particular causes of loss under specific selected items; it offers no coverage for perils that are not specifically listed. The physical damage coverage on an all-risks basis in some countries includes the eight items respectively associated with collision (P1), fire (P2), lightning (P3), explosion (P4), missiles or falling objects (P5), malicious mischief or vandalism (P6), any unidentified reasons other than specific exclusions (P7), and theft (P8) (see Table 1). However, the insured can purchase an optional insurance policy that only covers collision (P1). Different countries may vary in the physical damage coverage. In the United States, for example, physical damage coverage includes the risks associated with [P2 + P3 + P4 + P5 + P6 + P7 + P8], without P1.[19] In Taiwan, there are three types of physical damage coverages, all without covering the theft loss, termed as physical damage type A coverage [PA], physical damage type B coverage [PB] and physical damage type C coverage [PC]. [PA] covers all risks of collision and non-collision losses except for theft (T); [PB] covers almost the same range of risks as PA does except for vandalism and any unidentified reasons. [PC] only covers damage in a collision (i.e., P1).

In Taiwan, automobile dealers are the primary distribution channels for voluntary AIPs, taking up 60 per cent of the market share, according to the Non-Life Insurance Association, Republic of China.[20] Automobile dealers usually encourage the insured to choose wide coverage or expensive AIPs since the dealers' commission is a fixed percentage of the insurance premium.[21] Therefore, if a customer purchases automobile insurance from a car dealer, that customer is most likely to buy the expensive AIP, such as [PA + T] or [PB + T].

In Taiwan, voluntary AIPs other than the above three types of physical damage coverages ([PA], [PB], and [PC]) consists of third-party liability, accident liability, and other special liabilities. In selected countries, third-party liability covers a third party inside or outside the vehicle; it covers property damage (L1) or bodily injury (L2). The coverage for bodily injury due to an intoxicated driver (L3) is included in L2. Spousal liability (L4) covers the liability of death or injury to the spouse. In the United States, L4 and L7 must be purchased jointly with L1 or L2, and the bundled policies [L5 + L6 + L7] and [L6 + L7] are respectively termed as "accidental death and dismemberment" and "medical payment" coverages.

Special coverage usually includes two policies: one is to protect against the injuries that the driver, the driver's family, or passengers might suffer in a hit-and-run accident or in an accident with an uninsured vehicle; this is called uninsured motorists' coverage (L8). Additional personal injury protection—the no-fault benefits (L9) is designed to add more no-fault protection. Each country also has unique forms of insurance (L10). For instance, in Japan there is "long-term automobile policies with a maturity refund", a recently developed product.[22]

In Taiwan, the third-party liability [TP=L1 + L2] is a basic coverage. The bodily injury due to an intoxicated driver L3 (will be renamed as I, for short) coverage,

[19] Pataki and Serio (2004).
[20] The Non-Life Insurance Association (Republic of China (2004)).
[21] Wang (2004).
[22] see Non-life Insurance Rating Organization of Japan (2004).

**Table 1** Voluntary automobile insurance systems in some selected countries

| *Coverage type* | *Japan* | *United States (New York State)* | *Taiwan* |
|---|---|---|---|
| Physical damage coverage | • P1 + P2 + P3 + P4 + P5 + P6 + P7 + P8<br>• P1 | • P2 + P3 + P4 + P5 + P6 + P7 + P8<br>• P1 | • P1 + P2 + P3 + P4 + P5 + P6 + P7 [PA]<br>• P1 + P2 + P3 + P4 + P5 [PB]<br>• P1 [PC]<br>• P8 [T] |
| Non-physical damage coverage | • L1<br>• L2<br>• L6<br>• L8<br>• L9<br>• L10 | • L1<br>• L2 + L3<br>• L1 + L4<br>• L2 + L4<br>• L5 + L6 + L7<br>• L6 + L7<br>• L8<br>• L9<br>• L10 | • L1 + L2 [TP]<br>• L1 + L2 + L3 [TP + I]<br>• L1 + L2 + L4 + L5 + L6 + L7 [TP + PL]<br>• L1 + L2 + L3 + L4 + L5 + L6 + L7 [TP + I + PL]<br>• L10 |
| Perils | P1: Collision<br>P2: Fire<br>P3: Lightning<br>P4: Explosion<br>P5: Missiles or falling objects<br>P6: Vandalism<br>P7: Any unidentified reasons other than the exclusions<br>P8: Theft<br>P9: Windscreen damage<br>PA: Physical damage type A<br>PB: Physical damage type B<br>PC: Physical damage type C<br>T: Theft loss<br>L1: Property damage<br>L2: Bodily injury<br>L3: Intoxicated driver<br>L4: Spousal liability<br>L5: Family's personal injury<br>L6: Passenger's (personal accident) or liability<br>L7: Drivers' personal injury<br>L8: Uninsured motorists<br>L9: Additional PIP (No-Fault) benefits<br>L10: Other special coverage<br>TP: Third party liability<br>I: Intoxicated driver<br>PL: Personal liability | | |

*Note*: [] denotes the AIP alternatives in Taiwan.

if purchased, should be bought jointly with L1 + L2. The personal liability [PL=L4 + L5 + L6 + L7] covers injury to any persons in the vehicle, including the driver. The laws in Taiwan do not permit the non-life insurance companies to sell any insurance coverage associated with personal risks. Hence, the non-physical damage coverage in other countries, normally including complete coverage to property damage and personal injuries, is more complex than that in Taiwan.

## Methodologies

As aforementioned, the choice of bundled AIPs is similar to the selection of features from a menu available for customisation. The insured can make several simultaneous decisions concerning which coverage options would be included in the insurance package. An AIP alternative (defined as a set of possible outcomes of the decision process) thus consists of a combination of different coverages. Hence, the total number of AIP alternatives in our choice problem can be relatively large, especially when the number of available insurance coverages increases. If the modelling process was to include all the alternatives in an individual choice model, it would increase the difficulty of model calibrations and interpretations of parameter estimates. Therefore, a two-component modelling framework system is developed in this study to simplify the complex choice problem. This representation of the choice situation can serve as a preliminary step toward a more general and behaviourally realistic model.

Our proposed modelling framework system consists of two separate components. The first component is the choice of physical damage coverages. The customer has seven possible AIP alternatives to choose from, composed by theft loss, three types of physical damage coverages, and each physical damage coverage has the option to add theft loss; namely, [T], [PA], [PB], [PC], [PA + T], [PB + T], and [PC + T], as indicated in Table 2. The second component is the choice of non-physical damage coverages. This always includes third-party liability [TP] as a basic protection plus the option to add I, PL or both; namely, [TP + I], [TP + PL], and [TP + I + PL].

Basically, the modelling approach used to analyse the choice of bundled AIP alternatives is the discrete choice model. Under the principle of utility maximisation, the decision-maker (the insured) is assumed to choose a bundled AIP alternative with the highest utility. The utility function of each alternative can be decomposed into deterministic (observable) and random (error) components. Various discrete choice

**Table 2** Bundled AIP alternatives in Taiwan

| *Physical damage coverage* | *Non-physical damage coverage* |
|---|---|
| PA only | TP only |
| PB only | TP + I |
| PC only | TP + PL |
| T only | TP + I + PL |
| PA + T | |
| PB + T | |
| PC + T | |

models can be derived from different assumptions regarding error terms. Given the assumptions of independently and identically distributed errors, the MNL model[23] is the most commonly used structure due to its simple mathematical formulation and its ease of parameter estimates. However, the MNL model suffers from the independence of irrelevant alternative (IIA) property, which limits its applicability in many cases. The most widely known relaxation of the undesirable IIA property is the NL model,[24] which accounts for interdependence between pairs of alternatives in the same grouping. However, the restriction on allowing each alternative to appear in only one group may be unrealistic in some cases. In our example, we can put alternative [PB + T] and alternative [PC + T] into a nest to consider their similar unobserved characteristics. However, alternative [PC + T] may have some unobserved attributes, such as low-priced premiums and a small range of coverage, which are also similar to alternative [T].

Our proposed modelling approach—PCL model improves representation of substitution patterns among the bundled AIP alternatives. Following the previous example, the PCL model permits the unobserved utility of the [PC + T] alternative to be correlated with the utilities of [PB + T] and [T] alternatives. Thus, the PCL model has a more flexible error correlation structure than the MNL and NL models do, and, more importantly, it allows differential correlation between pairs of alternatives and includes the similarity parameters that measure correlation between pairs of alternatives. Details of PCL model formulation can be referred to Koppelman and Wen.[16]

The observed attributes in the utility function consist of the characteristics of the insured and the characteristics of the vehicle. The insured characteristics include age, claim records, and channel of purchase. Halek and Eisenhauer[25] provided empirical evidence of relative risk aversion associated with financial decision-making across age. Lemaire[26] showed a significant relationship between age and losses. Older adults perceive high risks related to severe personal injuries from traffic accidents. Thus, older drivers are expected to purchase more expensive bundled AIPs. Any driver involved with a great number of claim records has a strong incentive to buy higher amounts of coverage.[27] Schlesinger[3] pointed out that insurance demand and risk aversion are positively correlated; namely, the more risk-averse a person is, the more insurance coverage that person desires. Vehicle characteristics include vehicle age, engine capacity, and vehicle made (domestic or imported). New vehicles, vehicles with large engines, and imported vehicles in Taiwan normally have high market values. Any accidental loss to high-valued vehicles has a higher-than-average chance to result in high repair costs. Owners of such vehicles thus have an incentive to choose expensive bundled AIPs.[26,28] In contrast, owners of old or low-value vehicles may prefer to buy basic insurance only.

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[23] McFadden (1973).
[24] McFadden (1978); Daly and Zachary (1978).
[25] Halek and Eisenhauer (2001).
[26] Lemaire (1985).
[27] Boyer and Dionne (1989); Chiappori and Salanie (1997); Dionne (1984); Anderson *et al.* (1998); Lindberg (2001).

We noted that the AIP premium can be an important variable that may affect the choice of bundled AIP alternatives. Owing to confidential reasons, the non-life insurance data only include the premium for the chosen AIP alternative by the insured; there is lacking information on the premium of the non-chosen AIP alternatives in the choice set. Thus, our analysis excludes the cost of premium in the modelling. We realise that excluding the premium variable from the model may result in a specification error and that the consequence is likely to produce biased estimates and incorrect predictions. To minimise the possibility of bias, in our model, characteristics of vehicles (i.e., age and type) and insured (i.e., gender, age, and claim record) are used as proxy variables for the premium. Furthermore, this research does not produce prediction results for the AIP alternatives.

## Data

This study focuses solely on voluntary insurance policies for passenger cars. The samples used in this study are drawn from a non-life insurance company which has the second largest market share among 15 non-life companies in Taiwan. The data set contains 8,084 insured records randomly extracted from that company's 2005 database. The sample distribution of this data set concurs with the population distribution of all insured in Taiwan, based on the statistics of Taiwan Insurance Institute.[29]

Table 3 displays the number of observations and the relative percentages of the insured and vehicle characteristics. The samples show that 86 per cent of the insured age between 30 and 59, 86 per cent have no claim record, and 31 per cent own imported vehicles. In our data set, if the insured has never switched insurance companies since he/she received the driving license and purchased the AIPs, the insured's record will include all previous claims. However, if the insured has changed the insurance companies, the insured's record will consist of claims up to three years. Automobile dealers comprise the major channel of purchase for automobile insurance (80 per cent). A counterintuitive finding that 60 per cent are female is mainly because married males in Taiwan tend to use the names of their spouses or daughters when purchasing vehicles in order to enjoy lower insurance premiums.

Table 4 shows the sample frequencies of the chosen alternatives. Initially, eight alternatives were included in the choice set for physical damage coverages. Three AIP alternatives (i.e., [PA], [PB], and [PC]) were excluded because only a small number of the insured have chosen these alternatives. Thus, for the physical damage coverages, we have five alternatives, which were chosen by 7,957 insured customers. For the non-physical damage coverage, on the other hand, we have four alternatives with a total of 8,084 insured customers.

[28] Retzlaff-Roberts and Puelz (1966).
[29] Taiwan Insurance Institute (2005).

**Table 3** Frequency analysis of the insured customers and vehicle characteristics

| *Characteristics* | *Number of observations* | *Per cent* |
|---|---|---|
| *Gender* | | |
| Female | 4,283 | 60.26 |
| Male | 2,825 | 39.74 |
| *Age of the insured* | | |
| 0–20 yrs | 5 | 0.07 |
| 20–29 yrs | 683 | 9.60 |
| 30–39 yrs | 2,555 | 35.95 |
| 40–49 yrs | 2,185 | 30.74 |
| 50–59 yrs | 1,373 | 19.32 |
| 60–69 yrs | 260 | 3.66 |
| 70–79 yrs | 43 | 0.60 |
| 80+ yrs | 4 | 0.06 |
| *Marital status* | | |
| Married | 6,408 | 90.15 |
| Single | 700 | 9.85 |
| *Number of previous claims* | | |
| 0 | 6,116 | 86.04 |
| 1 | 676 | 9.51 |
| 2 | 228 | 3.20 |
| 3 | 57 | 0.82 |
| 4+ | 31 | 0.43 |
| *Purchase channel* | | |
| Automobile dealer | 5,680 | 79.90 |
| Insurance salesman | 1,428 | 20.10 |
| *Vehicle made* | | |
| Domestic | 4,883 | 68.70 |
| Imported | 2,225 | 31.30 |
| *Vehicle age* | | |
| 1 yr | 804 | 11.31 |
| 2 yrs | 1,730 | 24.34 |
| 3 yrs | 731 | 10.28 |
| 4 yrs | 543 | 7.64 |
| 5+ yrs | 3,300 | 46.43 |
| *Engine capacity* | | |
| < 1,000 cc | 35 | 0.49 |
| 1,000–1,999 cc | 4,536 | 63.82 |
| 2,000–2,999 cc | 1,989 | 27.98 |
| 3,000+ cc | 548 | 7.71 |

**Table 4** Frequency analysis for the samples choosing the bundled AIP alternatives

| *Alternatives* | *Number of observations* | *Per cent* |
|---|---|---|
| *Physical damage coverage* | | |
| None (baseline) | 3,093 | 38.85 |
| [T] | 2,238 | 28.01 |
| [PC + T] | 541 | 7.00 |
| [PB + T] | 1,859 | 23.36 |
| [PA + T] | 226 | 2.78 |
| Total | 7,957 | 100.00 |
| *Non-physical damage coverage* | | |
| None (baseline) | 2,560 | 31.67 |
| [TP + PL] | 1,196 | 14.79 |
| [TP + I] | 2,015 | 24.93 |
| [TP + PL + I] | 2,313 | 28.61 |
| Total | 8,084 | 100.00 |

## Empirical results

Estimation results for physical damage coverages are summarised in Table 5. We use "no purchase of physical damage coverage" as the reference alternative (baseline); therefore, the four alternative specific constants (ASCs) shown in the remaining alternatives reflect a relative preference for the alternative when the values of all explanatory variables are zero. Note that where $N$ is the total number of alternatives, it is possible to include $N-1$ ASCs. The insured driver and vehicle characteristics that do not vary across alternatives are specified as alternative specific variables. Analogous to alternative constants, one can estimate at most four parameters associated with insured driver characteristics; the same holds for vehicle characteristics.

The estimated coefficients and *t*-values of the preferred PCL model are reported in Table 5. The PCL models were estimated with the GAUSS constrained maximum likelihood procedure,[30] subject to restrictions on the similarity parameters to keep the estimated coefficients within a reasonable range. Two likelihood ratio indices measure how well the model fits the data. The first compares the log-likelihood value at convergence with the log-likelihood values at zero (i.e., when all the parameters are zero). The second compares the log-likelihood value at convergence to the log-likelihood values at constants (only ASCs are included). The likelihood ratio at zero is 0.3626 and the likelihood ratio at market share is 0.2388. Nevertheless, these two indices are informal goodness-of-fit measures. For evaluation of overall goodness-of-fit of the model it is preferable to use the likelihood ratio test.[11] Two of the most common null hypotheses are: (1) all the coefficients are zero, and (2) all the

[30] Aptech Systems (2002).

**Table 5** Estimation results of the physical damage coverage models

| *Variables* | *Paired combinatorial logit model* | |
|---|---|---|
| | *Coefficient* | *t-value* |
| *Alternative specific constants* | | |
| [T] | 0.4079 | 1.53 |
| [PC + T] | 0.6287 | 0.98 |
| [PB + T] | −0.0602 | −0.17 |
| [PA + T] | −7.0673 | −11.32 |
| *Age of the insured* | | |
| [PB + T] | 0.0132 | 3.74 |
| [PA + T] | 0.0221 | 2.76 |
| *Number of previous claims* | | |
| [PC + T] | 0.6536 | 4.52 |
| [PB + T] | 1.5862 | 13.57 |
| [PA + T] | 1.5691 | 5.74 |
| *Channel source* (*1 = automobile dealer, 0 = otherwise*) | | |
| [T] | 0.5622 | 6.62 |
| [PB + T] | 0.7357 | 5.61 |
| [PA + T] | 0.8624 | 2.40 |
| *Vehicle made* (*1 = imported, 0 = domestic*) | | |
| [T] | 0.2300 | 2.97 |
| [PC + T] | −0.2677 | −1.79 |
| [PB + T] | −0.1066 | −1.13 |
| [PA + T] | 2.3565 | 7.96 |
| *Vehicle age* | | |
| [T] | −0.3466 | −10.19 |
| [PC + T] | −0.6714 | −5.93 |
| [PB + T] | −0.8903 | −15.39 |
| [PA + T] | −0.4253 | −3.45 |
| *Engine capacity* | | |
| [T] | −0.0029 | −0.03 |
| [PC + T] | 0.0191 | 0.06 |
| [PB + T] | 0.1176 | 0.91 |
| [PA + T] | 1.0878 | 6.98 |
| *Engine capacity* × *vehicle age* | | |
| [T] | 0.0369 | 2.18 |
| [PC + T] | 0.0922 | 1.62 |
| [PB + T] | 0.1475 | 5.63 |
| *Vehicle made* × *number of previous claims* | | |
| [PC + T] | 0.9498 | 3.29 |
| [PB + T] | 0.5466 | 2.18 |
| [PA + T] | 0.8067 | 2.25 |

**Table 5** (*continued*)

| *Variables* | *Paired combinatorial logit model* | |
|---|---|---|
| | *Coefficient* | *t-value* |
| *Similarity parameter* | | |
| [T], [PC + T] | 0.6747 | 3.64 |
| [T], [PB + T] | 0.9015 | 32.28 |
| [PC + T], [PB + T] | 0.6009 | 4.43 |
| *Log-likelihood value* | | |
| At convergence | −8163.10 | |
| At zero | −12806.30 | |
| At market share | −10723.72 | |
| *Likelihood ratio index* | | |
| At zero | 0.3626 | |
| At market share | 0.2388 | |

coefficients, except for the alternative-specific constants, are zero. Comparing the test statistics with the critical chi-square values, both hypotheses can be rejected at the 0.05 significance level, indicating that the PCL model has a good fit.

A series of $t$ tests were performed to identify whether or not any coefficient was significantly different from zero. The explanatory variables as the insured age, vehicle made, vehicle age, channel source, engine capacity, and claim records are significantly related to the choice of bundled AIPs. The positive sign of the insured age variable specific to [PA + T] and [PB + T] alternatives indicates that as the age of insured increases, all else remaining unchanged, [PA + T] and [PB + T] are more likely to be chosen relative to the other alternatives. Older adults and those who perceive high risks from severe traffic injuries are more likely to buy extensive and expensive coverages than younger people. As expected, positive coefficients are associated with the claim records. The estimates of [PB + T] and [PA + T] (1.5862 and 1.5691, respectively) are greater than that of [PC + T], suggesting that customers with more claims favour extensive coverages. This result provides evidence that "adverse selection" does exist in the Taiwanese automobile insurance market. The channel source is a dummy variable which divides the insured into two groups: 1 denotes that the insured purchased insurance from an automobile dealer; 0 indicates purchasing from other channels. The positive signs of the three parameter estimates associated with [T], [PB + T], and [PA + T] imply that customers who acquire insurance from automobile dealers, as opposed to other sources, are more likely to select expensive AIPs, such as [PA + T] and [PB + T], to have wider coverage, or to buy only basic protection. Correspondingly, owners of imported cars prefer to purchase either basic protection or the most extensive AIP (i.e., [PA + T]). Imported new vehicles usually have high values; thus the vehicle owners tend to buy the most expensive coverage [PA + T] to claim for greater compensation, if necessary. Owners of imported cars are less likely to buy [PC + T] or [PB + T] coverage.

Owners of vehicles with large engine capacities are more likely to buy wider coverage than those with small engines. This may be due to the fact that large-engine vehicles are generally more expensive, and have higher repair costs than small vehicles. In particular, owners of vehicles with a very large engine favour the most extensive coverage. There is a low probability that owners of older vehicles will buy expensive AIPs because the market value of any vehicle decreases with the vehicle age.

The interaction effects of engine capacity, vehicle age, vehicle made, and claim record are further explicated in Table 5. The results reveal that owners of old cars with large engines prefer to purchase expensive policies, especially the [PB + T] coverage. In Taiwan, insurers rarely sell physical damage insurance coverage to imported car owners because the reparation for such cars, once involved with accidents, are generally high. In addition, imported vehicle owners who reported more claims have a greater-than-average likelihood of purchasing extensive AIPs because repair costs for imported vehicles are high as well.

Three of six similarity parameters fall within the zero-one range and statistically differ from zero at the 0.05 significance level. This implies that, from the perspective of the insured, the paired alternatives of {[T] and [PC + T]}, {[T] and [PB + T]}, and {[PC + T] and [PB + T]} all have high degrees of similarity. It should be noted that this PCL model specification eliminates the similarity parameters for [PA + T] and other alternatives. This may be due to the fact that the [PA + T] alternative is the most expensive coverage, and is less likely to be selected, except by owners of new vehicles in the first year of ownership, at which [PA + T] and other alternatives do not share common unobserved attributes. These results demonstrate that the PCL model is capable of analysing the choices of customers who face different physical damage AIP bundles.

Table 6 gives the estimation result of the preferred MNL model for non-physical damage coverage choice as the PCL model did not outperform the MNL model. In the context of non-physical damage coverage choice, the assumptions of MNL model hold, and the use of PCL model, in this case, is not required. "No purchase of non-physical damage coverage" was the reference alternative. Three ASCs were estimated for the remaining alternatives. The insured driver and vehicle characteristics were also specified as alternative specific variables. The estimation result of the MNL model shows that the insured age, vehicle made, vehicle age, channel source, number of previous claims, and engine capacity are the determinants of non-physical damage AIP choice. As expected, older drivers, owners of imported or large engine vehicles, customers purchasing from auto dealers, and drivers with many filed claims, prefer to purchase expensive AIPs, such as [TP + PL + I], in order to have the wide coverage. This is consistent with previous findings regarding physical damage coverage choice.

## Conclusions and discussions

This paper has demonstrated the useful capabilities of a discrete choice modelling approach in analysing customer choice behaviour when faced with different bundled AIP alternatives. The results of the AIP choice model have shown that various AIP bundles, in particular the physical damage coverages, have a high degree of similarity,

**Table 6** Estimation results of non-physical damage coverage model

| *Variables* | *Multinomial logit model* | |
|---|---|---|
| | *Coefficient* | *t-value* |
| *Alternative specific constants* | | |
| [TP + PL] | −2.0674 | −10.25 |
| [TP + I] | −0.8696 | −4.99 |
| [TP + PL + I] | −2.4746 | −12.94 |
| *Age of the insured* | | |
| [TP + PL] | 0.0072 | 2.05 |
| [TP + PL + I] | 0.0141 | 4.67 |
| *Vehicle made (1 = imported, 0 = domestic)* | | |
| [TP + PL + I] | 0.1965 | 3.13 |
| *Vehicle age* | | |
| [TP + PL + I] | −0.1021 | −11.75 |
| *Channel source (1 = automobile dealer, 0 = otherwise)* | | |
| [TP + PL + I] | 0.4315 | 5.05 |
| *Number of previous claims* | | |
| [TP + PL] | 0.1750 | 2.50 |
| [TP + PL + I] | 0.4252 | 7.78 |
| *Engine capacity* | | |
| [TP + PL] | 0.5261 | 6.60 |
| [TP + I] | 0.3956 | 5.53 |
| [TP + PL + I] | 0.8496 | 11.59 |
| *Log-likelihood value* | | |
| At convergence | −10543.94 | |
| At zero | −11206.80 | |
| At market share | −10922.86 | |
| *Likelihood ratio index* | | |
| At zero | 0.0591 | |
| At market share | 0.0347 | |

indicating that the MNL or NL models may not be appropriate for analysing customer choice behaviour. This research has illustrated the usefulness of the PCL model in analysing such AIPs selection. Additionally, the estimation results confirm our expectations and contribute to an understanding of the bundled AIP preferences of the insured. This study identifies important variables in terms of insured and vehicle characteristics, along with differential segments of the automobile insurance market. The insurers thus can use the findings to target their customers. Furthermore, the insights provided by the analysis of insured preferences can be used to evaluate existing AIPs. Based on our findings, the insurance providers may develop marketing strategies, design new bundles of insurance coverage or modify the existing bundles to better serve the customer needs.

Although our analysis excludes the cost of premiums, the AIP premium is an important variable affecting the choice of bundled AIP alternatives. Moreover, as identified by the MNL and PCL models, the proxy variables for the premium such as age of the insured, vehicle made, vehicle age, claim records, channel source, and engine capacity as well as their interaction effects were statistically significant. Accordingly, the insurers can adopt pricing strategies for their current and potential customers. For instance, young adults have been reluctant to pay higher premiums to cover their risks. Thus, the insurer could offer young adults more premium discounts or free gifts to increase purchase intentions for physical damage coverage. Similarly, in order to motivate the domestic, old, or small-engine vehicle owners to pay higher premiums, insurers can also provide incentives such as steeper discounts on the premiums. In particular, if the insurer chooses to increase the market share of a specific AIP alternative, steeper discount on the premiums for that AIP should be offered.

The estimation results indicate that the insured with more claims favours extensive coverages, providing evidence that adverse selection exists in the Taiwanese automobile insurance market. This situation is primarily caused by vandalised vehicles with physical damage Type A coverage; it has been found that the vehicle owners typically file a claim in collaboration with a repair workshop near the end of the insurance period.[21] Insurance companies must improve underwriting performance and efficiency to reduce losses caused by the adverse selection problem. In addition, Taiwan adopts an experience rating system in which the premium for the insured will change from year to year in relation to claim records.[31] The surcharge is added to the premium if the insured experienced a single claim in the previous year. If no claims occur, the following year's premium is discounted by a fixed amount. In order to encourage the low-risk insured to purchase physical damage coverage in subsequent years, we suggest that the insurers should increase premium discounts from year to year instead of by a fixed amount, if the insured has a safe driving record without any single claim for many years.

In Taiwan, automobile dealers comprise the major channel of purchase for automobile insurance. Most customers do not appear to be concerned with the details of the insurance policies; instead, they rely on automobile dealers to make the selection decisions for them, or at least, to provide recommendations on the matters of insurance limits, deductibles and other coverage.[21] Furthermore, Schlesinger and Schulenburg[32] found that insurance information regarding product substance and quality are usually unavailable to the consumer at the time of purchase. Since automobile dealers are rewarded by a commission that is a fixed percentage of the insurance premium, the loss ratio under physical damage Type A coverage has been extremely high, and it continues to increase. Thus, automobile dealers tend to promote more expensive coverage. Insurers should urge automobile dealers to offer appropriate AIPs to the customers based on their needs. Insurers should also consider other

[31] Lemaire and Zi (1994); Li *et al.* (2006).
[32] Schlesinger and Schulenburg (1993).

distribution channels for their insurance products, such as e-commerce or direct marketing.

The insurance providers may design new bundles of insurance coverage to better serve the customer needs. The PCL model indicates that the paired alternatives of {[T] and [PC + T]}, {[T] and [PB + T]}, and {[PC + T] and [PB + T]} have high degrees of similarity while [PA + T] does not correlate with other alternatives due to the high premium and wide coverage. If the insurer initiates a new AIP that is very similar to [PC], this new AIP only covers damage in a collision during weekends and its premium is cheaper than [PC]. The new AIP will attract the current insured of [T], [PC + T], and [PB + T], and policy-holders of [PA + T] are less likely to be affected.

To secure market share for a particular coverage, the insurer could develop loyalty programs that target its primary customer segments. The insurance company should develop good relationships with their customers and should enhance customer satisfaction and loyalty. On the other hand, to enlarge the market share of one particular coverage plan at the expense of other types of coverage, the insurer could offer sufficient incentives to encourage the insured to switch coverage types.

A number of possible directions for future investigation are identified. First, this study focuses on voluntary insurance only for passenger cars. Application of the proposed modelling approach to other types of vehicles, such as commercial vehicles and motorcycles, would be straightforward. Second, we model the choice of bundled AIPs by two separate components (physical damage and non-physical damage coverages), due to the large number of alternatives in the choice set. In general, insurance consumers can simultaneously choose different coverages for their insurance bundles. To better represent the insurance consumer's decision-making process, a joint-choice model of physical and non-physical damage coverages could be further developed and tested. Finally, this paper has successfully applied the discrete choice modelling approach to analyse consumer choice behaviour in Taiwanese automobile insurance market. Similar research in other countries deserves further exploration to verify our proposed modelling approaches.

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