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New car owners' repurchase behaviors on physical damage coverage insurance policies in Taiwan

Ming-Jyh Wang[1], Chieh-Hua Wen[2], Lawrence W. Lan[3*]

[1] *Department of Insurance, Chaoyang University of Technology, Taiwan*

[2] *Department of Transportation Technology and Management, Feng Chia University, Taiwan*

[3] *Department of Television and Internet Marketing Management, Ta Hwa Institute of Technology, Taiwan*

ABSTRACT

This paper elucidates the new car owners' repurchase behaviors on physical damage coverage (PDC)—high-premium non-compulsory auto insurance policies (AIPs) in Taiwan. A Multinomial logit (ML) and two nested logit (NL) modeling structures are attempted. The models are estimated with a five-year dataset of 7,172 insured records extracted from the data bank of a non-life insurance company in Taiwan. The ML estimation results indicate that car owner's age, vehicle brand and engine capacity are significant factors affecting the new car owners' repurchase behaviors on PDC policies in the subsequent years. Of the two NL structures, the NL(I) model statistically outperforms the NL(II) model and also statistically rejects the ML model, suggesting that the NL(I) model can best elucidate the car owners' repurchase behaviors on PDC policies for the subsequent years. The empirical results provide useful implications to the insurance companies and car dealers in developing various strategies for different targeting groups to promote the written volumes of PDC insurance policies.

Keywords: *Auto insurance policy (AIP), discrete choice model, physical damage coverage (PDC), repurchase behavior*

I. INTRODUCTION

Automobile insurance revenue represents nearly 50 percent of the property/liability insurance premium volume in many countries (Ma and Schmit, 2000). The non-life insurance companies are especially concerned about the sales of high-premium auto insurance policies (AIPs) because such policies can be the

* Email: lawrencelan@thit.edu.tw

major revenue source. It is of essential importance to look into the significant factors affecting car owners' repurchase behaviors on the high-premium AIPs so that the insurance companies can develop effective marketing strategies towards the targeted groups to better sustain in the competitive insurance market.

In Taiwan, the auto insurance market is currently operated by 16 non-life insurance companies and the insurance rates, clauses and new policies are regulated by the government. Figure 1 depicts the current practices of Taiwanese AIPs, which comprise compulsory and non-compulsory (aka voluntary or optional) policies. The compulsory AIPs provide the minimum liability to protect car users from traffic accidents with consequence of property loss, bodily injured or fatalities. All vehicles must carry compulsive AIPs for being eligible to be maneuvered on roads, according to the Compulsory Automobile Liability Insurance Law effective in 1988. On the other hand, the voluntary AIPs provide different degrees of liability covering the potential risks incurred by traffic accidents and/or unforeseen incidents (e.g., vehicle damage, fire or theft). Since the compulsory AIPs only provide very limited liability, many car owners, especially the new cars, also purchase voluntary AIPs to protect them from unexpected accidents and/or incidents. In 1996, Taiwan government made a major revision on the voluntary AIPs by dividing them into six policies, including three types of physical damage coverage (PDC) policies (hereinafter, Type A, B, C), theft loss coverage, third party liability, and passenger liability. Since the premiums of three types of PDC policies are much higher than the remaining ones (Wen et al., 2005, 2007; Wang et al., 2010), this study will focus only on the car owners' repurchase behaviors on the PDC policies.

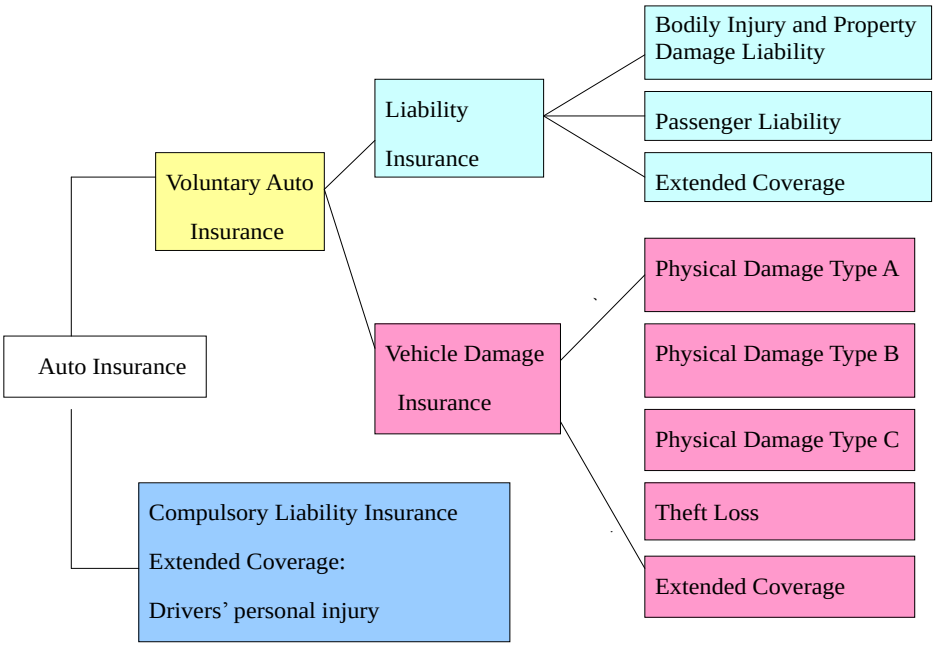

Figure 1. Current practices of AIPs in Taiwan
Source: Wen *et al.* (2007)

Figure 2 further displays the coverage of the three types of PDC policies. Type A is the most expensive

one. It covers all risks, including those associated with collision, fire, lightning, struck by lightning, explosion, missiles or fall objects, malicious mischief or vandalism, and any unidentified reasons other than the exclusions in the policy. Type B is a bit less expensive than Type A. It has the same coverage as Type A except for vandalism and any unidentified reasons other than the exclusions in the policy. Type C is the most inexpensive PDC policy. It of course provides the least coverage—only the damage in a collision. Neither of the above three types of PDC policies covers the theft loss; therefore, some car owners would purchase additional insurance to cover the theft. In Taiwan, the majority of new car owners may purchase Type A or type B policy only for few years (mostly, the first or the first two years) due mainly to the high premium concern. A significant portion of them will dwindle the coverage by shifting from Type A or B to Type C; some may even no longer purchase any of the PDC policies in the subsequent years. This would certainly reduce the premium revenues of the insurance companies, and this is why conducting an in-depth investigation of car owners' repurchase behaviors on high-premium PDC policies can be imperative to the insurance companies as well as to the car dealers.

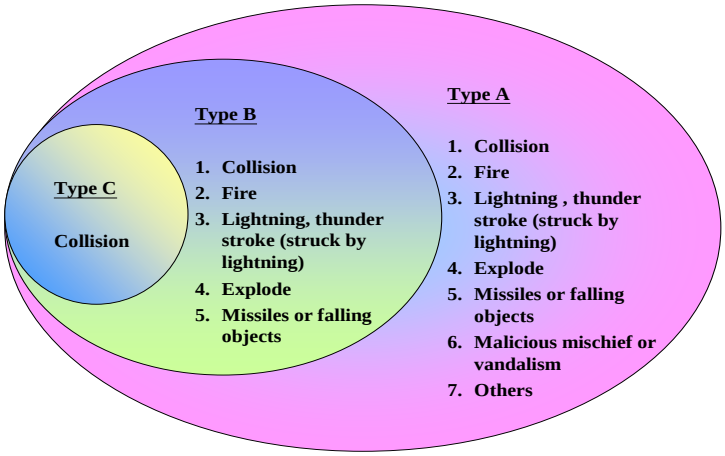

Figure 2 Three types of PDC policies in Taiwan
Source: Wen *et al.* (2007)

In the past, several works have dealt with the car owners' choice behaviors on AIPs for one-year or at most two-year periods (e.g., Sant, 1980; Artis *et al*., 1999, 2002; Wen *et al*., 2005, 2007). Few have dealt with the car owners' repurchase behaviors on high-premium PDC policies for consecutive several years. The objective of this study is to construct a discrete choice modeling framework to capture the new car owners' repurchase behaviors on the PDC policies according to their revealed purchase behaviors over five years. We also attempt to investigate the number of years that car owners would choose the PDC policies from the same insurance company. Multinomial logit (ML) and nested logit (NL) models will be employed to elucidate the repurchase behaviors on PDC policies in the subsequent years. It is hoped that the empirical results can provide useful implications to develop effective strategies in promoting the written volumes of PDC policies. The remaining parts are organized as follows. Section II introduces the discrete choice modeling framework. Section III presents the empirical analysis. Based on the results, practical implications

are discussed in section IV. Finally, concluding remarks and future studies are addressed.

II. METHODOLOGY

A. Identification of alternatives

A total of 16 alternatives can be identified, which is a complete combination of 15 alternatives composed by the three types of PDC policies and the number of years (1 through 5) that the car owners may repurchase the same PDC policies, plus the alternative of "not buying" any of the PDC policies. For ease of following analysis, the notation of these 16 alternatives is summarized in Table 1. For instance, AAxxx denotes the new car owners purchasing Type A policy only for the first two years; whereas CCCCC represents the new car owners purchasing Type C policy for consecutive five years.

Table 1. Notation of all possible alternatives

PDC policies	Number of years purchased	Alternative
Not buying	0	xxxxx
Type A	1A	Axxxx
	2A	AAxxx
	3A	AAAxx
	4A	AAAAx
	5A	AAAAA
Type B	1B	Bxxxx
	2B	BBxxx
	3B	BBBxx
	4B	BBBBx
	5B	BBBBB
Type C	1C	Cxxxx
	2C	CCxxx
	3C	CCCxx
	4C	CCCCx
	5C	CCCCC

B. Multinomial Logit (ML) modeling

The discrete choice model derived from random utility theory describes decision makers' choices among a set of mutually exclusive alternatives (Ben-Akiva & Lerman, 1985). In this study, each new car owner is regarded as the decision maker who faces a choice among different PDC alternatives and the number of consecutive years to purchase the same PDC alternative.

Under utility maximizing principle, the decision maker would choose an alternative with the highest utility. Mathematically, the utility function of an alternative of PDC type (t) and number of consecutive years (y) for decision maker (n) can be expressed as:

$$U_{ytn} = V_{ytn} + \varepsilon_{ytn} \quad (1)$$

where V_{ytn} and ε_{ytn} respectively represent the deterministic (observable) and random (error) components of utilities for alternative (y, t). The deterministic components of utilities can be specified as a function of observable attributes (e.g., car owner's and vehicular characteristics). Linear-in-parameters utility functions are used in this study due to computational ease and straightforward interpretation of coefficient estimates. For the decision maker (n) the deterministic components of the utilities for alternatives (y, t) can be expressed as

$$V_{ytn} = \alpha_{yt} + \sum_k \beta_k X_{ytkn} \quad (2)$$

where α_{yt} is a constant term specific to the alternative (y, t), which is to capture the average effect on utility of all variables that are excluded in the model; X_{ytkn} is an explanatory variable k for alternative (y, t); β_k is an unknown parameter, which reflects the relative importance of the variable k.

Different assumptions on the distributions of error terms result in different discrete choice models. In literature, the multinomial logit (ML) model (McFadden, 1973) is perhaps the most commonly used discrete choice modeling approach due to its simple mathematical structure and ease of estimating parameters. Thus, this study attempts the ML modeling to capture the key factors affecting the car owners' repurchase behaviors on PDC alternatives.

In Taiwan, a large portion of the new car owners may dispose of their cars to the second-hand marketplace after five years of usage; they will then replace with new cars so as to avoid the troublesome of annual inspection regulated by the government. Another reason for disposing of the five-year used-cars is that some car owners may be susceptible to an ever-increasing maintenance costs. As such, this study only analyzes the car owners' repurchase behaviors on PDC policies for five consequent years. Under the ML modeling structure, the likely choice alternatives for purchasing three types of PDC policies with one year to five years are depicted in Figure 3.

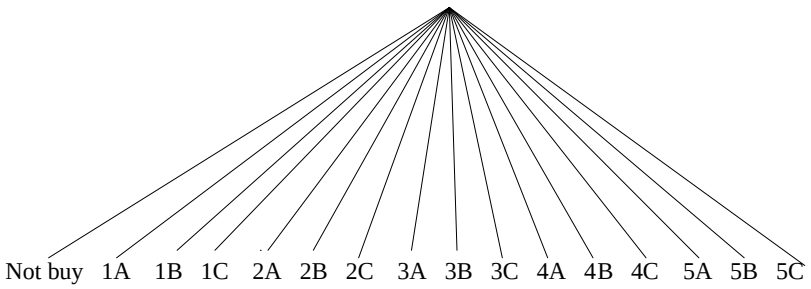

Figure 3. ML modeling structure

C. Nested Logit (NL) modeling

By assuming that the error terms are independent and identically distributed, it can be proven that the ML model exhibits a property of independence from irrelevant alternatives (Train, 2003). This property is

unrealistic in many choice problems, especially for those with similar bundles (like PDC alternatives) to choose from. The most widely used relaxation of such undesirable property is the nested logit (NL) model (McFadden, 1978), which accounts for interdependence between pairs of alternatives in the same nest. The NL model has been extensively applied in many fields (e.g., Riddington *et al*., 2000; Herriges and Phaneuf, 2002; Javier, 2002; Kang *et al*., 2004); thus, this study also attempts the NL modeling to elucidate the choice behaviors of car owners' repurchase on PDC alternatives over the five consecutive years studied.

Consider a two-level NL structure with the choice of PDC alternatives at the upper level and the choice of number of consecutive years at the lower level (hereinafter, denoted as NL(I) model) as shown in Figure 4. The probability that alternative (*y*, *t*) is chosen by car owner (*n*) can be expressed as

$$P_n(y,t) = P_n(y \mid t)P_n(t) \tag{3}$$

where the conditional and marginal probabilities in equation (3) are further denoted as:

$$P_n(y \mid t) = \frac{\exp\left(\frac{V_{ytn}}{\mu_t}\right)}{\sum_{y' \in N_t} \exp\left(\frac{V_{y'tn}}{\mu_t}\right)} \tag{4}$$

$$P_n(t) = \frac{\exp\left(\mu_t \Gamma_{tn}\right)}{\sum_{t'} \exp\left(\mu_{t'} \Gamma_{t'n}\right)} \tag{5}$$

$$\Gamma_{tn} = \ln\left(\sum_{y' \in N_t} \exp\left(\frac{V_{y'tn}}{\mu_t}\right)\right) \tag{6}$$

In equation (4), $P_n(y \mid t)$ represents the conditional probability of car owner *n* choosing for consecutive years *y* among choice set N_t, conditional on choosing coverage type *t*. $P_n(t)$ in equation (5) is the marginal probability of car owner *n* choosing for coverage type *t*; whereas Γ_{tn} in equation (6) is the logsum variable for car owner *n* choosing for coverage type *t*, where μ_t is the logsum (or inclusive value) parameter for coverage type nest *t*. The NL model is consistent with utility maximization if the conditions $0 < \mu_t \leq 1$ are satisfied for all *t*. A logsum parameter associated with a nest lying within the range from zero to one indicates that any pairs of utilities in the nest are correlated. If μ_t is equal to one for all *t*, the NL model collapses to the ML model. Another two-level NL structure with the choice of number of consecutive years at the upper level and the choice of PDC alternatives at the lower level is also attempted (hereinafter, denoted as NL(II) model), as shown in Figure 5.

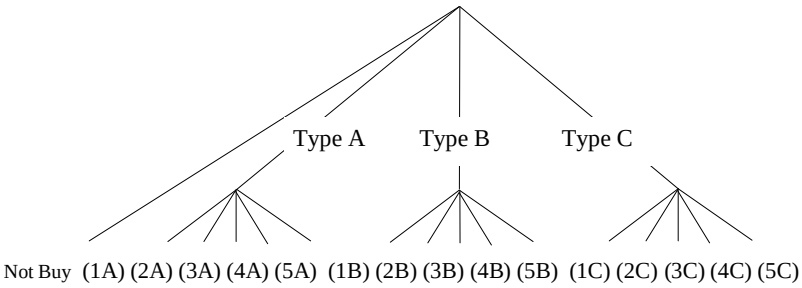

Figure 4. NL (I) modeling structure

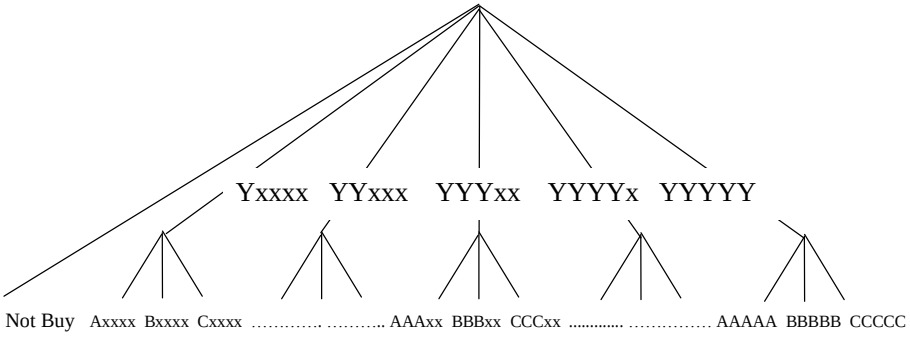

Figure 5 NL(II) modeling structure

III. EMPIRICAL ANALYSIS

A. Data

In Taiwan, about 97 percent of autos are for non-commercial purposes and the written premiums have been the main revenue sources for many non-life insurance companies (Wang *et al*, 2010). Hence, this study only focuses on the owners of non-commercial cars. Theoretically, the observed attributes in the utility function (i.e., explanatory variables) consist of car owners' characteristics (e.g., gender, occupation, income, education, age, marital status, claim records) and vehicular characteristics (e.g., brand model, age, engine capacity, among others). Due to data confidentiality, however, the available attributes in this study are very limited—only restricted to those can be released legally, including car owners' age, gender, and marital status as well as the vehicle age and engine capacity. Individual attributes such as name, address, telephone number, income, education, occupation, purchase channels, and claim records are either prohibited by laws for privacy or protected by companies for confidential reasons. In this study, gender is regarded as an irrelevant explanatory variable because most of married Taiwanese males have exploited lower premiums by registering cars under their spouses' or daughters' names. Besides, the vehicle age is not of our concern because we only analyzed the cars not older than five years.

The cost of premium is supposed to be an important variable affecting the choice of AIPs; however, the exact premium cost to each car owner is confidential and it can vary across car owners even if they have

purchased the same policy. The premium is mainly reflected by the market value of a car, which can be highly related to engine capacity, brand model and age of vehicle, thus these variables are used as proxy variables for the cost of premium in this study. It is reasonable to postulate that new imported vehicles with larger engines normally have higher market values, thus owners of such vehicles tend to choose expensive alternatives (e.g., Type A) for more years. In contrast, vehicles of lower market values may only go with less expensive alternatives (e.g., Type C) for fewer years. It is also reasonably believed that drivers with long-time or large exposure to traffic situations (e.g., taxi drivers) shall demand more expensive AIPs to obtain more coverage than those with short-time or little exposure to traffic situations (e.g., casual drivers). As for the age of car owners, the elder may perceive higher risk than the younger, thus the elder are expected to purchase expensive Type A or Type B alternative for more years than the younger. In Taiwan, the main channel for purchasing AIPs is from car dealers, not directly from insurance agents. Most car dealers will sell the new cars bundled with two-year PDC policies. An increasing number of car dealers even bundle the new car sales with five-year PDC policies.

The insured records were directly extracted from the data bank of a non-life insurance company (called H for anonymousness), which takes about 20 percent of the market share in terms of the gross non-life insurance volume—the largest market share among 16 non-life insurance companies in Taiwan. The terms of AIPs are usually designed for one year; car owners can renew the same policy or switch to different policies from the same or different companies in the following years. A total of 7,172 insured records were extracted from the five-year dataset of H Company. These data represent the car owners bought the new cars in 2000 and may or may not purchase the PDC policies from Company H afterward.

B. Estimation results

The ML modeling was first attempted to identify the important explanatory variables associated with the choice of PDC alternatives and of consecutive years purchasing the PDC policies. “Not buying” any PDC policy is treated as the referent alternative. None of the explanatory variables vary over the alternatives; namely, all are treated as alternative specific variables. The estimation results of the ML model are summarized in Table 2. It shows that older adults prefer to purchase expensive bundles for five consecutive years (5A: 0.0280, t=0.025). The estimated coefficients of vehicle brand indicates that owners of imported cars are more likely to purchase Type A coverage for five consecutive years (5A: 0.7992, t=3.2), followed by Type B (5B: 0.6318, t=6.8). Vehicles with larger engines favor Type A coverage for four and five consecutive years (4A: 0.9824, t=2.8; 5A: 0.9411, t=4.7).

Table 2. Estimation results of ML model

Variable	Coefficient	*t*-value
Alternative Specific Constant		
1A	-2.1481	-10.4
2A	-3.0584	-30.2
3A	-4.0198	-24.9
4A	-6.3784	-8.6

5A	-6.5907	-10.8
1B	0.3889	2.6
2B	-1.4931	-29.8
3B	-3.1356	-11.5
4B	-2.6624	-27.3
5B	-1.9667	-10.0
1C	-0.5516	-1.8
2C	-1.7743	-4.3
3C	-4.3152	-9.0
4C	-3.9945	-25.0
5C	-1.9613	-9.8
Age of the Car owner		
1A	0.0157	3.2
5A	0.0280	2.5
3B	0.0253	4.0
5B	0.0100	2.1
1C	-0.0121	-2.2
2C	-0.0309	-2.8
Vehicle Brand		
5A	0.7992	3.2
1B	-0.4235	-5.6
4B	0.3746	2.3
5B	0.6318	6.8
Engine Capacity		
4A	0.9824	2.8
5A	0.9411	4.7
1B	-0.3318	-4.0
1C	-0.3235	-2.4
3C	0.5020	2.1
5C	0.2925	2.8
Log-likelihood value		
At convergence	-15161.45	
At zero	-19885.01	
Likelihood ratio index	0.2375	

Table 3 reports the estimation results of two NL models. In the NL(I) model (corresponding to the nested structure with choice of PDC alternatives at the upper level and choice of number of consecutive years at the lower level), the estimates of the logsum parameters for all three nests (Types A, B and C) lied

within the reasonable range and were significantly different from one at the 5% level. In contrast, most of the estimates of the logsum parameters in the NL(II) model (corresponding to the nested structure with choice of number of consecutive years at the upper level and choice of PDC alternatives at the lower level) fell outside the zero to one range. Obviously, the NL(I) model statistically outperformed the NL(II) model, implying a high correlation between any two utilities for the number of consecutive year alternatives. In this case, the substitution effects within the same coverage type are significant. Moreover, the NL(I) model has statistically rejected the ML model, according to the likelihood ratio test of chi-square 21.36, larger than the critical value 7.81 with three degrees of freedom.

Table 3. Estimation results of two NL models

Variable	NL(I) model		NL(II) model	
	Coefficient	*t*-value	Coefficient	*t*-value
Alternative Specific Constant				
1A	-2.7734	-7.8	-2.4524	-3.7
2A	-5.0550	-4.1	-1.6530	-1.2
3A	-6.9919	-3.8	-3.7758	-3.8
4A	-10.8524	-3.5	-13.0700	-1.3
5A	-10.6253	-4.2	-6.6138	-4.9
1B	-0.2072	-0.3	0.3494	1.9
2B	-5.4064	-2.5	-1.2275	-4.8
3B	-9.7603	-2.7	-3.0815	-7.1
4B	-9.1052	-2.5	-3.3794	-2.9
5B	-6.4462	-2.7	-1.9864	-6.7
1C	-1.1723	-1.0	-0.7361	-1.6
2C	-4.5132	-1.4	-1.1834	-6.0
3C	-10.0445	-1.5	-4.0745	-3.7
4C	-9.7699	-1.5	-7.9113	-1.2
5C	-3.8418	-1.7	-1.9721	-7.2
Age of the Car Owner				
1A	0.0209	3.2	0.0180	2.5
5A	0.0423	1.9	0.0281	2.2
3B	0.0590	2.5	0.0249	3.1
5B	0.0183	1.6	0.0104	2.1
1C	-0.0116	-1.1	-0.0135	-1.9
2C	-0.0645	-1.6	-0.0115	-0.4
Vehicle Brand				
5A	1.5568	2.6	0.7971	2.7
1B	-1.2615	-2.5	-0.4432	-4.6

4B	1.3291	1.8	0.4439	2.2
5B	2.1979	2.4	0.6324	5.8
Engine Capacity				
4A	1.4739	1.8	1.8404	1.4
5A	1.3577	3.1	0.9461	3.3
1B	-0.6748	-4.5	-0.3403	-3.5
1C	-0.9320	-1.4	-0.3166	-2.1
3C	1.0338	1.2	0.4647	1.7
5C	0.5587	1.4	0.2966	2.7
Logsum parameter (t value vs. 1)				
Type A	0.4905	3.4		
Type B	0.3190	5.7		
Type C	0.3699	2.4		
1 year (Yxxxx)			0.8870	0.5
2 years (YYxxx)			3.6848	-0.3
3 years (YYYxx)			1.1207	-0.2
4 years (YYYYx)			0.3124	1.9
5 years (YYYYY)			0.9953	0.1
Log-likelihood value				
At convergence	-15150.77		-15158.37	
At zero	-19885.01		-19885.01	
Likelihood ratio index	0.2381		0.2377	

IV. DISCUSSION AND IMPLICATIONS

As identified by the ML model, important explanatory variables affecting car owners' choices of PDC alternatives and number of consecutive years to repurchase the same alternative from the same company consist of age of car owner, vehicle brand and engine capacity. Elder car owners, imported, large engine vehicles are more likely to go with expensive PDC policies for more years. Accordingly, the insurance company can develop strategies targeting two distinct groups. One group is the elder drivers with large engine or imported cars and the other group is the younger drivers with small engine or domestic cars. To encourage the former group to repurchase the high-premium PDC policies, the insurance companies may consider offering them additional consulting services, such as tax saving, wealth management or other risk managements, without extra service charges. As for the younger group, since they are reluctant to pay higher premiums, the insurance companies may consider offering them attractive gifts to lure them to the PDC policies or offer them substantial premium discounts if they go for a longer period (e.g., five years) of PDC policies.

We also found that the majority of the car owners who purchased PDC policies for three consecutive

years hold a status of "natural person," whereas most of the "legal persons" purchased expensive PDC policies for five consecutive years. In Taiwan, if the cars are registered under the "legal person," the organizations can always take the premiums with full tax deduction. Besides, the organizations can also protect their employees whenever they use the company cars. It suggests that the insurance companies should differentiate the premiums among these two groups—charging full premiums (without any discounts) to the "legal persons" group and offering the "natural persons" group with reasonable premium discounts or incentive programs.

In Taiwan, it is quite extraordinary that car dealers have played the most important role in auto insurance market. Due to heavy commissions, car dealers have strong incentives to bundle the expensive PDC policies with the new car sales. Most of the new car buyers are not concerned about the details of the insurance policies due to the asymmetric property of insurance information; they normally rely on the dealers to make the insurance decisions for them or to provide recommendations on the issues of insurance limits, deductibles and other coverage (Wang, 2004). If the car owners would buy expensive insurance policies for consecutive several years, the car dealers should consider offering a range of free services (e.g., maintenance) or additional insurance policies (e.g., theft loss coverage) as free gifts to obtain long-term contracts. Since most dealers control the new cars business only for three years, they may consider providing the new car owners with some incentives to renew the PDC policies in the fourth or fifth year. For instance, offering larger discounts of five-year PDC policies (Type A or B) bundled with the new car sales. Of course, in addition to the purchasing channel from car dealers, the insurance companies may consider other channels such as e-commerce or direct marketing to promote their auto insurance products.

V. CONCLUSIONS

This paper has made important contributions to the understanding of the Taiwanese car owners' choice of expensive auto insurance—the physical damage coverage (PDC) policies and the number of years repurchasing the same alternative from the same insurance company. The proposed multinomial logit (ML) and nested logit (NL) models used the panel data to capture the dynamic aspects of PDC repurchase behaviors, which enabled us to compare different model structures and to select a favorable model that better elucidates the actual choice behaviors on the high-premium PDC policies.

Based on the findings, the insurance companies are suggested to target on the young drivers, with domestic or small engine vehicles, by offering them long-term PDC policies with steeper premium discounts. As for the group of elder drivers, with imported or large engine vehicles, the premiums can remain relatively high with less discount. Among all, for legal persons' cars (those registered under the names of organizations), the premiums of PDC policies should remain the highest without any discounts. As such, the insurance companies would enjoy the maximal premium yields. The insurance companies can also consider introducing loyalty programs or other incentive programs (e.g., higher deductibles or free additional coverage) to keep those who may purchase only one or two years of PDC policies but in the subsequent years may potentially switch to cheaper or not even buying any PDC policies.

This paper inevitably has some limitations and thus calls for further studies. First, the empirical study

only analyzed the non-commercial cars. Motorcycles and other types of privately-owned vehicles have been excluded in the analysis. Future research can apply the proposed modeling framework to analyze the excluded vehicle owners' repurchase behaviors on different PDC policies over time. Second, the dataset consists of the car owners who bought their new cars in 2000 and may have repurchased the PDC policies from Company H since then. The insurance purchase behaviors for those who bought new cars before or after 2000 were not analyzed. Future work can expand the sample size by analyzing the new car owners over different time horizons. Finally, the data source used for empirical analysis was only drawn from a company. In the future, a comparative study of the behavioral differences across different insurance companies deserves to explore.

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