

THE INCENTIVE EFFECTS OF INCREASING PER-CLAIM DEDUCTIBLE CONTRACTS IN AUTOMOBILE INSURANCE

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ABSTRACT

A new rating system of automobile insurance for vehicle damage in Taiwan was launched in 1996, introducing a deductible that increases with the number of claims. In this article, we provide a theoretical rationale for the existence of an increasing per-claim deductible system and show that the new system is most likely an optimal choice for those insured who tend to have lower claims probability when incentives are present. Using a unique dynamic data set, we are able to conduct a natural experiment to examine the incentive effects (both positive and negative) by looking at the change in claim tendency before and after switching between two deductible plans: an increasing per-claim deductible and a zero deductible. Our results provide direct evidence of the effects of deductible structures on claim behavior.

INTRODUCTION

Incentive effects in insurance contracts have been a major issue in the insurance literature for a long time. The incentives provided by insurance policies may exist due to designation by insurers, regulation by authorities, or institutional change, and their financial implications for insurers are evident. In the United States, the implementation of no fault automobile insurance is significantly associated with higher fatal accident rates (Cummins, Phillips, and Weiss, 2001). In Canada, the holders of car insurance policies with a replacement cost endorsement have a higher probability of theft near the end of this protection (Dionne and Gagné, 2002). Actually, incentive issues are the

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focus of principal-agent theory, but most articles in the insurance field discuss these topics in terms of moral hazard and usually concentrate on the negative side of the story.

In addition to theoretical analysis, many studies provide empirical examination of moral hazard in the insurance market. Among others, for example, Butler and Worrall (1991) investigate workers' compensation and conclude that benefit increases lead to increased claim filing, not necessarily to increased injuries. Cummins and Tennyson (1996) analyze the frequency of automobile bodily injury liability claims, providing evidence on moral hazard. Recent work by Dionne and Gagné (2002), Abbring et al. (2003), Abbring, Chiappori, and Pinquet (2003), and Dionne, Michaud, and Dahchour (2005) are also devoted to the automobile insurance market to test the existence of moral hazard.

However, it is well known that there is the difficulty of separating moral hazard from adverse selection (Chiappori, 2000), and the problem of distinguishing heterogeneity and state dependence (Abbring et al., 2003; Abbring, Chiappori, and Pinquet, 2003; Chiappori and Salanié, 2003). Although some literature is focused on the health insurance market, such as Browne and Doeringhaus (1993) and Cutler and Zeckhauser (1997), others examine the adverse selection problem by testing the choice of deductibles in automobile insurance markets (Puelz and Snow, 1994; Dionne, Gouriéroux, and Vanasse, 1999, 2001, 2006; Chiappori and Salanié, 2000).

In this article, by using a unique dynamic data set from an insurance authority, we are able to test incentive effects in the automobile insurance market in Taiwan. A specially designed increasing per-claim deductible system and the deregulation of deductible plans make empirical testing possible. In particular, given the risk classification of individuals, we compare the claim tendencies of homogenous groups of drivers under various deductible schemes. The incentive effects hypothesis is empirically supported.

The standard approach to moral hazard (adverse incentive) assumes that the probability of an accident depends on the level of care by the insured; for example, see Boyer and Dionne (1989). Due to asymmetric information, the level of care is unobservable. Moral hazard exists when the insured has no incentive to provide a minimal level of care after purchasing a specific insurance contract. Empirically, the existence of moral hazard can be tested by looking at the behavioral change of the insured. However, the answer is not straightforward when cross-sectional data are used. As described in Chiappori and Salanié (2003), the increasing loss ratio after purchasing automobile insurance may be due to unobserved heterogeneity (adverse selection) of the insured as well as the incentive structure provided by the insurance (moral hazard). In addition, the experience-rating system, a popular rating structure in automobile insurance, provides a strong incentive for the insured to reduce accident intensity. Although Boyer and Dionne (1989) verify empirically the proposition that past experience is a good predictor of risk using data on car drivers in Quebec, Abbring et al. (2003) conclude that "under moral hazard, the accident probability of each individual decreases with the person's number of past claims." Therefore, the problem of distinguishing the positive occurrence dependence generated by unobserved heterogeneity from the negative dependence induced by the incentive scheme is critical.

To solve the above problem, Chiappori (2000) proposes that either dynamic data or a "natural experiment" is needed to allow driving patterns under different time horizons to be identified while keeping unobserved heterogeneity constant. Dionne and Gagné (2002) apply the contract dates to separate moral hazard from adverse selection. Abbring et al. (2003) and Abbring, Chiappori, and Pinquet (2003) find no evidence of moral hazard in French car insurance using dynamic data. Recently, Dionne, Michaud, and Dahchour (2005) present a more formal test based on the Granger causality test and find evidence of moral hazard distinguished from adverse selection. In fact, to analyze the incentive effect problem, the contract form definitely plays an important role (Chiappori and Salanié, 2003). When it comes to automobile insurance, the design of deductibles is a major focus of contract forms. Other things being equal, the insured may behave differently when carrying various insurance contracts.

The change of regulation in Taiwan's automobile insurance market since 1996 provides a good environment to examine the incentive effects of different contracts with various deductible choices. A new rating system of automobile insurance for vehicle damage in Taiwan was launched on July 1, 1996, introducing a compulsory deductible that increases with the number of claims. For the first claim the deductible is NTD3,000, for the second NTD5,000, and for the third NTD7,000 (hereafter 3/5/7 deductibles). The main purpose behind implementing the per-claim deductible system is to solve the problem of moral hazard in terms of the increasing claims ratio. However, due to fierce competition among automobile insurance agents, the amounts of per-claim deductibles may be absorbed as an implicit cost of agents. During the past several years, the compulsory regime has been gradually eased to allow the insured to choose either higher deductibles in exchange for lower premiums or a zero deductible for higher premiums. For example, the premium schedule under various deductible structures in 2002 shows that for the same coverage (comprehensive form B), the premium is 9% lower in a 3/5/7 deductible contract than in a zero deductible plan. In light of the full data set obtained from the Insurance Institute of the Republic of China (Taiwan), the changes in preferences for insurance contracts by the insured appear interesting and deserve further investigation.

In this article, we try to answer the following questions: Is an increasing per-claim deductible system an effective mechanism to solve the negative incentive problem? Do those insured who switch from an increasing per-claim deductible system to a zero deductible contract tend to have higher claims? Do people behave differently when they are covered by various deductible schemes?

To ensure the linkage between different insurance coverage and claims is mainly due to moral hazard, we performed the *t*-tests to examine the homogeneity between various groups of the insured, as presented in "Data and Sample Selection Issues." Although it seems that an increasing per-claim deductible is a good design to counteract incentive for the insured to file more claims, Li and Liu (2003) prove that the optimal per-claim deductible should be decreasing to maximize consumer welfare in the absence of moral hazard. If this is the case, then what is the rationale for an increasing per-claim deductible system? In this article, we show that the increasing per-claim deductible is most likely an optimal choice for those insured who tend to have lower claims probability when incentives are present. The empirical data support the hypothesis

that drivers choosing a zero deductible tend to have higher claims relative to those with an increasing per-claim deductible.

The rest of this article is organized as follows. The next section presents the theoretical model to show that the increasing per-claim deductible has a close connection with incentives. Then we discuss data and sample selection issues and empirical evidence. Concluding remarks are given in the last section.

THEORETICAL MODEL

Based on expected utility theory, we assume that insurers provide various insurance contracts to the public whereas individuals select specific policies to maximize expected utility. To take incentive effects into account, it is also assumed that each kind of policy induces the insured to behave differently and that insurers cannot observe the insured's behavior. In general, the insured's level of care is a major concern of most insurance contracts. We assume that the level of care affects the probability that an insured has claims but not the claim size.¹ As is the basic assumption in Shavell (1979), we allow the level of care as a contractual factor and provide credibly by an incentive compatibility constraint (Winter, 2000). In this section, we analyze the theoretical characteristics of an increasing per-claim deductible policy. We are trying to answer the question: If there are several deductible policies available, is the increasing per-claim deductible policy an optimal choice for the insured in the presence of moral hazard?

For simplicity, it is assumed that there are no more than two claims per year for the insured. For each claim $i = 1, 2$, the claim size X_i has a deductible D_i , and we assume $X_0 = 0$ and $D_0 = 0$, indicating no initial loss. Suppose that each insured is risk averse and pursues expected utility maximization. Let $E[U(W)]$ and W_0 denote the expected utility and the initial endowment, respectively. The final wealth of the insured after paying the premium, the out-of-pocket loss, and the cost of care effort (e) is

$$W = W_0 - Q(D) - Z(D) - e, \quad (1)$$

where $Z(D)$ is the out-of-pocket loss (in addition to the premium) given by

$$Z(D) = \sum_{i=0}^2 \min \{X_i, D_i\}, \quad D = (D_1, D_2) \quad (2)$$

and $Q(D)$ is the premium which can be calculated from total expected claim expense coverage $Y(D)$ as

$$Q(D) = (1 + \alpha) \cdot E[Y(D)], \quad (3)$$

where α is a loading factor.

¹ This is called self-protection by Ehrlich and Becker (1972).

The optimal contract maximizes the expected utility of the insured subject to the zero profit constraint of the insurer and the incentive compatibility of the insured:

$$\max_{\mathbf{D}, e} E[U(\mathbf{W})] \quad (4)$$

Subject to

$$Q(\mathbf{D}) = (1 + \alpha) \cdot E[Y(\mathbf{D})] \quad (5)$$

$$e = \arg \max E[U(\mathbf{W})]. \quad (6)$$

The effect of the moral hazard problem is to constrain the set of available contracts to ensure that the care level in the contract is credible. From Equation (6), we can therefore derive that the optimal care level is a function of the insurance policy deductible. This implies that we can define $e(\mathbf{D})$ as the solution in e to the incentive compatibility constraint (6). This maximizes expected utility in Equation (4) as a function of the deductible alone.

The probability of incurring claims, P_i , is negatively affected by the level of care effort, and the optimal care level is a function of the insurance policy deductible under the incentives provided by the rest of the contract. Thus, letting $P_1 = P_1(e(D_1))$ and $P_2 = P_2(e(D_1, D_2))$; that is, the probability of incurring two claims (P_2) is affected by both D_1 and D_2 , whereas the probability of incurring only one claim (P_1) is only affected by D_1 . This implies that we ignore the effect of D_2 on P_1 .

For the insurer, the total expected claim expense could be expressed as the expected value of coverage:

$$\begin{aligned} E[Y(\mathbf{D})] = & \left\{ \int_{D_1}^{\bar{x}} [1 - F(X)] dX \right\} \cdot P_1(e(D_1)) \\ & + \left\{ \int_{D_1}^{\bar{x}} [1 - F(X)] dX + \int_{D_2}^{\bar{x}} [1 - F(X)] dX \right\} \cdot P_2(e(D_1, D_2)), \end{aligned} \quad (7)$$

where $F(X)$ denotes the common distribution function of claims with density $f(X)$ and P_i represents the probability of i accident claims in a given time period, $i = 0, 1, 2$ (so that P_0 is the probability of no claims). To avoid the problem of personal bankruptcy, we assume that each claim has support $[0, \bar{x}]$ and that $\bar{x}$ is less than the initial wealth. The signs of the first-order derivatives of $Q(\mathbf{D})$ with respect to D_i are obtained as follows:

$$\begin{aligned} \frac{\partial Q(\mathbf{D})}{\partial D_1} = & -(1 + \alpha) \cdot [1 - F(D_1)] \cdot (1 - P_0) + \int_{D_1}^{\bar{x}} [1 - F(X)] dX \left[\frac{\partial P_1(e(\mathbf{D}))}{\partial D_1} + \frac{\partial P_2(e(\mathbf{D}))}{\partial D_1} \right] \\ & + \int_{D_2}^{\bar{x}} [1 - F(X)] dX \left[\frac{\partial P_2(e(\mathbf{D}))}{\partial D_1} \right] \leq 0 \end{aligned} \quad (8)$$

$$\begin{aligned} \frac{\partial Q(\mathbf{D})}{\partial D_2} = & -(1 + \alpha) \cdot [1 - F(D_2)] \cdot (1 - P_0 - P_1) \\ & + \left\{ \int_{D_1}^{\bar{x}} [1 - F(X)] dX + \int_{D_2}^{\bar{x}} [1 - F(X)] dX \right\} \left[\frac{\partial P_2(e(\mathbf{D}))}{\partial D_2} \right] \leq 0. \end{aligned} \quad (9)$$

The first terms in Equations (8) and (9) indicate the direct effect of the deductible on the expected expense. The second term can be treated as the indirect effect of the deductible on the expected expense due to incentives. Since it is assumed that $\partial P_j / \partial D_i < 0$, we have nonpositive signs for both Equations (8) and (9), where $i, j = 1, 2$, and $j \leq i$. These inequalities have real-life implication: higher deductibles are associated with lower premiums.

We can derive the optimal contract in Equation (4) by substituting the solution to the incentive compatibility constraint (6) $P_1 = P_1(e(D_1))$ and $P_2 = P_2(e(D_1, D_2))$ into the objective function. Thus, the first-order conditions can be obtained by applying Lemma 1 in Li and Liu (2003) as follows:

$$D_1^*: - \left[\frac{\partial Q(\mathbf{D})}{\partial D_1} + \frac{\partial e(\mathbf{D})}{\partial D_1} \right] \cdot \{E[U'(\mathbf{W})]\} - [1 - F(D_1)] \cdot \{E[U'(\mathbf{W}_1)]\} = 0, \text{ and} \quad (10)$$

$$D_2^*: - \left(\frac{\partial Q(\mathbf{D})}{\partial D_2} + \frac{\partial e(\mathbf{D})}{\partial D_2} \right) \cdot \{E[U'(\mathbf{W})]\} - [1 - F(D_2)] \cdot \{E[U'(\mathbf{W}_2)]\} = 0, \quad (11)$$

where $W_i = \mathbf{W}_0 - Q(\mathbf{D}) - Z_i(\mathbf{D}) - e(\mathbf{D})$ and

$$Z_i(\mathbf{D}) = \sum_{\substack{k=0 \\ k \neq i}}^2 \min(X_k, D_k) + D_i, \quad i = 1, 2.$$

We utilize the ratio of expected marginal utilities $E[U'(W_i)]$ to find the relationship between D_1 and D_2 from (10) and (11) as follows:

$$\frac{E[U'(W_1)]}{E[U'(W_2)]} = \frac{\frac{\partial Q(\mathbf{D})}{\partial D_1} + \frac{\partial e(\mathbf{D})}{\partial D_1}}{\frac{\partial Q(\mathbf{D})}{\partial D_2} + \frac{\partial e(\mathbf{D})}{\partial D_2}} \cdot \frac{1 - F(D_2)}{1 - F(D_1)}. \quad (12)$$

The term on the left-hand side of (12) indicates the marginal rate of substitution of D_1 and D_2 for the insured, whereas the factors on the right-hand side represent the relative prices of D_1 and D_2 for the insurer when the deductible affects the size of the expected claim expense. Therefore, Equation (12) represents the equilibrium condition in the insurance market by considering both the insured and the insurer. It then can be derived from Proposition 1 that an increasing per-claim deductible in automobile insurance is an optimum policy under certain conditions.

Proposition 1: Assume that the probabilities of incurring claims $P_i (i \leq 2)$ in the policy period are functions of per-claim deductibles $D_i (i \leq 2)$. For an increasing per-claim deductibles policy ($D_2 > D_1$) to satisfy the expected utility maximization of the insured, sufficient conditions are $|\frac{\partial P_2}{\partial D_2}| > |\frac{\partial P_2}{\partial D_1}|$, and $|\frac{\partial P_2}{\partial D_2}| - |\frac{\partial P_2}{\partial D_1}| \geq \delta$, where δ is a positive critical value of sufficient magnitude.²

² A complete proof is available upon request.

The rationale behind these sufficient conditions can be explained intuitively. Due to the decreasing marginal utility of wealth, a risk-averse individual prefers a less expensive second deductible when per-claim deductibles are independent of the probability of claims as proposed in Li and Liu (2003). However, by assuming that deductibles affect the probability of claims, if the effect of D_2 on the probability of a second claim is significantly greater than that of D_1 , then a higher value of D_2 effectively reduces the probability of a second claim. Therefore the insured has a lower expected net expense and hence higher expected wealth. Since the change in D_2 has a larger effect on the change in the probability of a second claim, choosing a higher value of D_2 (that is, an increasing per-claim deductible) is beneficial for those insured who are willing to provide a higher level of care and in so doing reduce claim risk. In contrast, not selecting an increasing deductible implies that a higher D_2 cannot effectively reduce the probability of a second claim. In this case, which is most likely faced by those unwilling to exert additional care and so reduce claim risk, an increasing deductible policy induces a higher expected net expense and hence lower expected wealth.

In sum, the choice of different deductible contracts may serve as a screening mechanism to identify individual risk attitudes. Those who exercise greater care tend to choose increasing per-claim deductible contracts whereas those who are relatively indifferent to the possibility of loss tend to select nonincreasing deductibles.

The sufficient conditions for the increasing per-claim deductible scheme to be optimal, as suggested above, imply an incentive effect for drivers to drive carefully. If such effect exists, then we would predict that policyholders who switch from an increasing per-claim deductible system to a zero deductible contract have a tendency to claim more, and vice versa. This suggests that people will behave differently when they are covered by various deductible schemes. The remainder of this article will test this incentive effects hypothesis.

DATA AND SAMPLE SELECTION ISSUES

In general, as required by law, all property and liability insurance companies in Taiwan are members of the Non-Life Insurance Association and offer the same automobile insurance contract options under highly regulated pricing rules. Each insurer may use direct agents or brokers, and compete on the bases of underwriting and services. Sometimes, price competition exists in terms of "commission rebates" between brokers. Because the Non-Life Insurance Association, under the authorization from the Ministry of Finance, conducts most of the regulations, insurers basically comply with the institutional rules. Automobile insurance policy is usually a 1-year contract. An insured is free to move from one insurer to another carrying his bonus-malus record.

To test the hypothesis empirically, we obtained the complete set of individual automobile policy and claims data for the years 2000 to 2001 from the Taiwan Insurance Institute, a semigovernmental organization responsible for the collection and management of the insurance data information system. There are three major types of coverage for damages to vehicles: comprehensive form A, comprehensive form B, and moving collision coverage.

The comprehensive form A policy, sold with compulsory increasing per-claim deductibles, covers all of the specified risks; the moving collision policy, sold with no

deductibles, covers only the one specific risk. We may assume that high-risk individuals prefer the former whereas low risk individuals prefer the latter. To examine the incentive effects of various deductible contracts on claim behavior, comprehensive form B policies, with the same coverage but different deductibles, are relevant and appropriate for our purpose. It is not suitable to simply compare the claim behavior of comprehensive (form A) and (form B) policyholders, because different scopes of coverage complicate and obscure the effects of deductibles.

The comprehensive (form B) contract has two types of deductible plans, one with an increasing deductible and the other with no deductible. Recently, policyholders have also been allowed to choose a high-deductible provision in exchange for premium reduction, but the available data indicate that very few drivers have chosen this option. Thus, we focus on increasing and zero deductible policies.

As pointed out by Chiappori and Salanié (2000), moral hazard and adverse selection may mix with each other in the empirical analysis of cross-sectional insurance data. That is, a higher propensity for claims under one deductible policy may be due to moral hazard, but may also result because high-risk drivers tend to choose that policy. Therefore, it is not appropriate to merely compare the claim patterns of these two groups of drivers; even though they have the same coverage, differences in deductibles prevent direct comparison. To identify the incentive effects of different insurance contract choices on driving patterns, dynamic data are needed to keep the unobserved heterogeneity constant (Chiappori, 2000). Fortunately, due to recent deregulation, dynamic data in Taiwan's automobile insurance market is obtainable.

Inspired by Chiappori (2000), our sample is constructed as follows.

1. We select drivers who purchased comprehensive (form B) policies in 2000 and 2001 by matching policy numbers in the 2 years when information on the previous year's policy is available. We exclude group policies for company vehicles and multiple-car owners because we want to consider single-policy drivers. We also exclude those policies with period longer or shorter than 1 year. Under these criteria, we obtain 10,767 comprehensive (form B) insurance contracts effective in both 2000 and 2001 (with and without deductibles).
2. We construct a contingency table of these drivers by their deductible choices over the 2 years. The data indicate 4,929 drivers (group A) chose increasing deductibles for both years, whereas 690 drivers (group B) chose increasing deductibles in 2000 but switched to a zero deductible in 2001. On the other hand, there were 228 drivers (group C) with a zero deductible in 2000 but that switched to increasing deductibles in 2001 and 4,920 drivers (group D) with a zero deductible for both years, as shown in Table 1.
3. Now we have a sample of 5,619 drivers who chose increasing deductibles in 2000. Presumably, these people have a similar risk type and risk preferences. Of these, the 4,929 that kept the same deductible structure represent the "reference sample," and the remaining 690 represent the "switching sample." Similarly, of those who chose a zero deductibles in 2000, the reference and switching samples contain of 4,920 and 228 drivers in 2001, respectively.
4. The focus is to observe the claim behavior of drivers in these switching groups to see whether they have a lower tendency to file claims when carrying increasing

TABLE 1
Deductible Choice Pattern in 2000–2001

Group	Deductible Choice in 2000	Deductible Choice in 2001	Sample Size
A	Increasing	Increasing	4,929
B	Increasing	Zero	690
C	Zero	Increasing	228
D	Zero	Zero	4,920

per-claim deductibles (group B in 2000 and group C in 2001). If so, that would suggest that increasing deductibles indeed encourage careful driving.

- To control for the possible time trend effect, we analyze the claim patterns for drivers in the reference groups. It is found that there is no significant difference in the claim behavior of drivers in group A over the 2-year period. However, drivers in group D exhibit a higher tendency to file claims in 2001 than in the previous year. To avoid the time trend effect, we pool drivers in groups C and D using a group dummy, a year dummy, and an interaction term in the analyses.

The data used in this article are for vehicle damage insurance contracts with comprehensive coverage (form B) that exclude unknown perils. Therefore the claims are exclusively fault claims. Based on data constraints, the variables used in our analysis are as follows.

Deductible: a dummy variable that equals 1 if the insurance policy has an increasing deductible, and 0 otherwise.

Age: the age of the policyholder.

Male: a dummy variable that equals 1 if the policyholder is male and 0 if female.

Married: a dummy variable that equals 1 if the policyholder is married, and 0 otherwise.

Car_age: the age of the insured automobile in years.

Capacity: cubic capacity of the automobile.

Clmcoef: the claim coefficient, an indicator of past driving record.

Area1–Area19: a set of dummy variables taking the value 1 if the automobile is registered in district i , $i = 1, 2, \dots, 19$, and 0 otherwise.

Premium: automobile insurance premium paid by policyholder.

No_Claim: a dummy variable that equals 1 if no claim is filed in the policy period, and 0 otherwise.

Frequency: the number of claims filed in the policy period.

Amount: the dollar amount of the claims paid in the policy period.

Table 2 presents summary statistics of the key variables for these four groups. Age, gender, marital status, registration area, claim coefficient of the insured, vehicle age,

TABLE 2
Summary Statistics of Key Variables for Various Groups

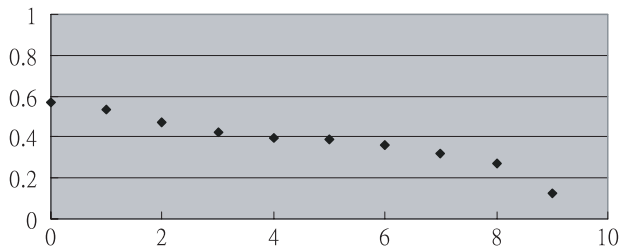
	Group A Mean (Std. Dev.)	Group B Mean (Std. Dev.)	Group C Mean (Std. Dev.)	Group D Mean (Std. Dev.)
Age	41.741 (9.174)	41.441 (8.979)	42.737 (8.668)	41.616 (9.024)
Male	0.370 (0.483)	0.314 (0.464)	0.307 (0.462)	0.281 (0.449)
Married	0.900 (0.300)	0.932 (0.252)	0.930 (0.256)	0.918 (0.275)
Car_age	2.414 (1.933)	2.247 (1.782)	1.805 (1.707)	1.883 (1.687)
Capacity	1.937 (0.626)	1.905 (0.474)	1.855 (0.497)	1.856 (0.754)
Clmcoef_01	-0.042 (0.132)	-0.039 (0.126)	-0.028 (0.083)	-0.023 (0.091)
Premium_00	23300.665 (12337.046)	21284.352 (9852.625)	24336.632 (10146.346)	23285.999 (9770.614)
Premium_01	18951.854 (10808.599)	18278.864 (8678.842)	19171.618 (9140.469)	19134.754 (8666.596)

and cubic capacity have been considered in past studies (e.g., Lemaire, 1985; Chiappori and Salanié, 2000); we also consider the premium paid for the coverage.

Three variables in Table 2 are worth noting. First, the *Male* variable shows that the proportions of male policyholders in all groups are relatively low (from 28.1% to 37.0%). Since the base premium for males in the Taiwan's automobile insurance market is higher than that for females, the insurance policy in a typical family is usually under the name of a female member of the household. This kind of "premium evasion" behavior does not violate the law but does distort the gender information about policyholders. However, this behavior does not affect the unobserved heterogeneity of specific drivers related to each insurance policy. Second, the average car age in groups A and B are relatively higher than those in groups C and D. In fact, it is very common for individuals to reduce their insurance coverage after the car becomes a certain age, and certainly to raise deductibles. Figure 1 shows the relationship between car age and deductible choice indicating that owners of newer cars are more likely to buy policies with higher coverage (zero deductible). Third, there is an approximate 20% reduction in the average premium from 2000 to 2001 for all groups. In Taiwan, the insurance authority determines the automobile insurance basic premium, except for the loading. Based on the loss ratio in general, the premium formula is adjusted every 3 years. The reduction in the standard premium rate in 2001 reveals an improved loss pattern in the previous 3 years.

The claim coefficient, an indicator of past driving record, is based on a bonus-malus scoring conversion formula. The coefficient is only available starting in 2001. Therefore, we are not aware of potential differences in past driving records between these four groups when they purchased their 2000 policies. The multiple comparison *t*-tests indicate that the null hypotheses (that the claims coefficients between group A and

FIGURE 1
Percentage of Zero Deductible Policies Versus Car Age



B, and between C and D are the same) cannot be rejected, with the p -value equal to 0.5454 and 0.2070, respectively. However, the null hypothesis that four groups' claim coefficients are the same is rejected (p -value < 0.0001).

The t -test indicates that group B has lower premiums than group A in 2000 (p -value = 0.0001) and that their premiums in 2001 are not statistically significant at the 5% level (p -value = 0.0652). Given that group A has less coverage, this fact seems to contradict intuition. However, comparing with group B, group A has significantly (p -value = 0.0001) higher level of males, who would have to pay higher premium rates. Therefore, on average, the difference of premiums between groups A and B can be explained by premium evasion behavior.

It seems that group C has higher premiums than D in 2000, and they remain higher after the switch to what would be a lower premiums policy in 2001. With relatively higher percentage of males for group C, premium evasion behavior may still play some role. But the t -test indicates that the premiums of group C and D are not significantly different in 2000 (p -value = 0.1271) and 2001 (p -value = 0.9525). Also, the levels of males in these two groups are not significantly different (p -value = 0.2340).

In terms of policyholder's age, the t -tests show statistical significance that drivers of group C are older than those of the other three groups. But age differences among the other three groups are not significant. When it comes to marital status, group A has a significantly higher percentage of single drivers than any other three groups. But percentage of marital status in the other three groups is not significantly different.

The raw data seem to support the incentive effects hypothesis. Claim frequency and amount for the four groups of insured are shown in Table 3. Although groups A and B had almost the same average claim counts (p -value = 0.4479) in the year they both purchased coverage with increasing deductibles, drivers in group B tended to have substantially more claims (p -value = 0.0001) in terms of both frequency and amount after switching to zero deductible policies. Similarly, for groups C and D, whereas both had zero deductible policies in 2000, the former had substantially higher claim counts (p -value = 0.0004) in 2000 and significantly fewer claims (p -value = 0.0001) in 2001 after choosing increasing deductibles compared with the latter, who kept zero deductible policies. This pattern cannot be due to the effects of adverse selection because both groups B and D had lower claim counts in 2000. The theory of adverse selection would predict these drivers buy less coverage (increasing deductibles) and not more coverage (zero deductibles) than they actually did. Therefore, the substantial

TABLE 3
Claim Patterns for Various Groups—Mean and Standard Deviation

Group Year	A		B		C		D	
	2000	2001	2000	2001	2000	2001	2000	2001
Type of deductibles	3/5/7	3/5/7	3/5/7	Zero	Zero	3/5/7	Zero	Zero
No claim	0.634	0.675	0.653	0.552	0.521	0.644	0.616	0.552
Frequency	0.465 (0.698)	0.420 (0.686)	0.443 (0.705)	0.652 (0.879)	0.706 (0.874)	0.465 (0.717)	0.496 (0.722)	0.655 (0.863)
Amount	13197.25 (33193.42)	11887.48 (33984.23)	10266.86 (25612.74)	14218.39 (33412.48)	16168.11 (29341.05)	15309.59 (59402.95)	11567.34 (28514.31)	13133.59 (25045.70)

Notes: Standard deviation in parentheses.

differences in the claims data in 2001 do not tell a “higher risks have higher claims” story. On the contrary, there is another explanation: the presence of increasing per-claim deductibles could provide an incentive to exercise a greater level of care and thereby reduce moral hazard.

EMPIRICAL METHODS AND RESULTS

The hypotheses to be tested in this article are (1) the tendency of file claims increases for those insured who switch from increasing per-claim deductibles to a zero deductible, and (2) the tendency of file claims decreases for those insured who switch from a zero deductible to increasing per-claim deductibles. Following the theoretical setting in the previous section, we consider the empirical model that $P = f(X, D)$, where P is the probability of an accident, D is the indicator of increasing per-claim deductibles, and X is the exogenous variables. To test the incentive effect hypothesis empirically, we fit the generalized linear model:

$$P_i = f(X_i' \cdot \alpha + D_i \cdot \beta),$$

where $E(P_i)$ is the expected accident probability for observation i with exogenous variables X_i and deductibles provisions D_i . As reported in the previous section, X_i includes age, gender, marital status, and registration area of the insured, vehicle age, and cubic capacity. It may be questionable to include past driving records in the estimation, as this variable may be correlated with the deductible choice.³ Therefore, we estimate models with and without the claim coefficient. To conduct the empirical analysis, accident probabilities are proxied by the tendency to file no claims.⁴

We also follow Dionne and Gangé (2002) and Dionne, Gouriéroux, and Vanasse (2001) and take into account the potential nonlinear effects of D by considering the more general model:

$$P_i = f(X_i' \cdot \alpha + D_i \cdot \beta + (E(D_i | X_i) \cdot \gamma),$$

where $E(D_i | X_i)$ is the approximated regressor of the expected value of D_i computed from the initial exogenous information X_i .

The empirical results are shown in Tables 4 to 6. The incentive effects after switching or renewing insurance policies are examined by using binomial logit regression on a binary variable of no claims for switching samples (Table 4) and for the reference samples (Table 5). Three versions of the model are estimated: the basic model (Model 1), the model including claim coefficient (Model 2), and the model including nonlinear effect (Model 3). In general, we find strong support for the incentive effects hypothesis. Drivers in group B (with an increasing deductible in 2000) are highly significantly associated with a higher tendency to have no claims compared with the group switching to a zero deductible in 2001 whether or not past driving records are taken into

³ Probit estimation of D_i on X_i does not reject the hypothesis that past driving records have no influence on the choice of deductibles.

⁴ We also used claim frequency and amount as dependent variables in the Poisson and Gamma regression setups, respectively; the results are essentially the same.

TABLE 4
Binomial Logit Regression on No Claim—Switching Samples

Group Variable	B			C		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Intercept	0.4574 (0.5908)	0.5575 (0.5958)	0.8556 (1.9679)	2.3289** (1.0847)	1.8637* (1.0939)	2.4718 (2.9535)
Deductible	0.4762*** (0.1193)	0.4705*** (0.1200)	0.4732*** (0.1212)	0.7777*** (0.2232)	0.8183*** (0.2264)	0.8299*** (0.2325)
Age	−0.0012 (0.0068)	−0.0010 (0.0068)	−0.0023 (0.0104)	−0.0170 (0.0127)	−0.0158 (0.0128)	−0.0150 (0.0133)
Male	0.0814 (0.1314)	0.0693 (0.1323)	0.0810 (0.1514)	−0.1911 (0.2263)	−0.1154 (0.2295)	−0.1044 (0.2346)
Married	0.1034 (0.2379)	0.1180 (0.2388)	0.1624 (0.3675)	0.0135 (0.4125)	0.0401 (0.4165)	0.0235 (0.4232)
Car-age	−0.0930** (0.0417)	−0.0807* (0.419)	−0.1201 (0.2521)	−0.1821** (0.0723)	−0.1906*** (0.0739)	−0.1382 (0.2476)
Capacity	0.4012** (0.1599)	0.2977* (0.1610)	0.3162 (0.1989)	−0.2701 (0.3158)	−0.2291 (0.3228)	0.0078 (1.1164)
Premium	−0.0401*** (0.0086)	−0.0327*** (0.0087)	−0.0314*** (0.0122)	0.0011 (0.0171)	0.0066 (0.0176)	−0.0144 (0.0963)
Clmcoef	− (0.0086)	−2.2346*** (0.5541)	−2.2860*** (0.6418)	− (0.0171)	−4.0598*** (1.4084)	−3.8012** (1.8275)
Dhat	− (0.0086)	− (0.5541)	−0.5120 (3.2199)	− (0.0171)	− (1.4084)	−1.1317 (5.1067)
19 area dummies (estimates suppressed)	− (0.0086)	− (0.5541)	− (3.2199)	− (0.0171)	− (1.4084)	− (5.1067)
Observations	1380	1380	1380	456	456	456
Log likelihood	−888.5172	−879.2634	−879.2506	−283.0698	−278.5140	−278.4896

Notes: Standard errors in parenthesis.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

TABLE 5
Binomial Logit Regression on No Claim—Reference Samples

Group Variable	A		D	
	Model 1	Model 2	Model 1	Model 2
Intercept	1.4025*** (0.4553)	1.2439*** (0.4614)	1.1327*** (0.2309)	1.0715*** (0.2312)
Year01	0.0418 (0.0455)	0.0545 (0.0457)	−0.4182*** (0.0443)	−0.4165*** (0.0444)
Age	0.0013 (0.0025)	0.0013 (0.0025)	−0.0098*** (0.0024)	−0.0098*** (0.0024)
Male	0.1166** (0.0475)	0.1073** (0.0477)	0.1314*** (0.0492)	0.1276*** (0.0493)
Married	−0.0492 (0.0765)	−0.0535 (0.0767)	0.2195*** (0.0793)	0.2146*** (0.0794)
Car_age	−0.0434*** (0.0144)	−0.0401*** (0.0145)	0.0243 (0.0158)	0.0287* (0.0158)
Capacity	0.2131*** (0.0526)	0.1759*** (0.0528)	0.1029** (0.0510)	0.0869* (0.0492)
Premium	−0.0418*** (0.0025)	−0.0386*** (0.0026)	−0.298*** (0.0030)	−0.0279*** (0.0030)
Clmcoef	—	−1.5172*** (0.1950)	—	−1.8271*** (0.2673)
19 area dummies	(Estimates suppressed)	—	—	—
Observations	9858	9858	9840	9840
Log likelihood	−6054.2461	−6020.9010	−6515.7105	−6489.5122

Notes: Standard errors in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

account. On the other hand, drivers in group C (with an increasing deductible in 2001, but a zero deductibles in 2000) also exhibit a strong positive tendency away from filing claims. Finally, the nonlinear effects of deductibles on claim frequencies and amounts for groups B and C are not significant.

Most of the exogenous control variables are in line with our expectations. Since the average ages and proportions of married policyholders are almost the same for groups B and C, the estimated coefficients of age and marital status are all insignificant in explaining the no-claim behavior. Gender also has no effect on the dependent variable, which may be due to the premium evasion behavior described above. The age of the vehicle in both groups B and C is significantly inversely related to the no-claim tendency, indicating that relatively older automobiles increase the probability of claims. It is possible that drivers with older cars tend to care less about minor collisions, whereas those with newer car drivers are more sensitive to smaller incidents caused by collisions. The estimated coefficients of cubic capacity are significant for group B but insignificant for group C.

It is interesting to examine the different roles of the premium on the dependent variable for the various groups in our sample. For group B, all three models estimate significant

negative signs for premium, indicating that the cost of insurance does provide strong incentive to those who change from an increasing deductible to a zero deductible. For group C, the effects of the premium are all positive but insignificant in the three models. Since the basic premium for group B is around 10 percent higher than that for group C in exchange for greater coverage (under the zero deductible policy), this provides evidence of a negative relationship between the premium (coverage) and the probability of no claims for group B and hence supports the incentive effects hypothesis.

Drivers with poorer driving records (i.e., a higher claim coefficient) are expected to have more claims, as the significant negative coefficients confirm in the results of Model 2 shown in Table 4. Nonlinear effects, incorporated to catch unobserved characteristics of the drivers, are all insignificant and do not change the general results. The overall picture indicates that the most relevant information on the drivers is considered in our basic model. Since most estimated coefficients of the 19 dummy variables included to account for registration area in our regressions are insignificant, we omit their results.

The insured may have an incentive to underreport their accidents in order to maintain a good record. Hence we adjusted those policies with a zero deductible, as if the claims are adjusted with an increasing deductible. Then we rerun the regression by excluding the first claim indemnity less than NT\$3,000, the second claim indemnity less than NT\$5,000 and so on. Such adjustments weaken the result a little bit, but do not change the significance at all.

We may also be curious about the claim patterns of those groups of drivers who did not switch policies in 2001 (groups A and D). The results are shown in Table 5. The basic message shown there is that there were hardly any differences in the effects of the premium and the claim coefficient on claims between the two groups, indicating the homogeneous nature of these drivers in terms of their claim patterns gauged by premium and claim coefficients. Since claim behavior may vary over the 2 years even though there was no change in the selected deductible plan, we include the *Year01* variable to explore the role of a time trend. It is worth noting that time trend does not have a significant role in the claim pattern of group A, those who chose increasing per-claim deductible policies in consequent years. However, the coefficients of time trend for group D are positively significant at the 1 percent level. This demonstrates that those who chose zero deductible insurance policies expect to file more claims, which is direct evidence of the incentive effects hypothesis. In other words, without the "incentive" of increasing deductibles to exert a higher level of care, these drivers apparently have a higher tendency to file claims compared to their counterparts who renewed increasing deductible policies.

The significant role of the *Year01* variable brings up another critical question: Is it possible the no-claim tendency would have decreased no matter what deductible policy the insured chose? The effect of time trend on the no-claim tendency should not be ignored for those who switched policies. To investigate this question, we constructed Table 6 by taking the *Year01* effect into account. The results show that, controlling for the time trend, *B_Year01* is significantly negative; that is, group B drivers were less likely to be no-claim drivers (i.e., less likely to exercise care) when they switched

TABLE 6

Binomial Logit Regression on No Claim—Controlled by Year Effect

Group Variable	A & B		Group Variable	C & D	
	Model 1	Model 2		Model 1	Model 2
Intercept	1.3196*** (0.3391)	1.2635*** (0.3433)	Intercept	1.1659*** (0.2288)	1.0958*** (0.2292)
B	−0.0524 (0.0889)	−0.0435 (0.0892)	C	−0.3959*** (0.1389)	−0.4037*** (0.1395)
Year01	0.0472 (0.0453)	0.0607 (0.0455)	Year01	−0.4023*** (0.0441)	−0.4000*** (0.0442)
B_Year01	−0.5728*** (0.1211)	−0.5825*** (0.1216)	C_Year01	0.7400*** (0.1990)	0.7449*** (0.1998)
Age	0.0012 (0.0023)	0.0012 (0.0023)	Age	−0.0100*** (0.0024)	−0.0099*** (0.0024)
Male	0.1170*** (0.0445)	0.1073** (0.0446)	Male	0.1246*** (0.0479)	0.1229** (0.0480)
Married	−0.0397 (0.0725)	−0.0432 (0.0727)	Married	0.2125*** (0.0776)	0.2078*** (0.0778)
Car_age	−0.0487*** (0.0135)	−0.0449*** (0.0136)	Car_age	0.0116 (0.0153)	0.0158 (0.0153)
Capacity	0.2290*** (0.0497)	0.1868*** (0.0500)	Exhaust	0.0972* (0.0497)	0.0823* (0.0480)
Premium	−0.0417*** (0.0024)	−0.0382*** (0.0025)	Premium	−0.0298*** (0.0029)	−0.0278*** (0.0029)
Clmcoef	—	−1.6020*** (0.1836)	Clmcoef	—	−1.9051*** (0.2629)
19 area dummies	(Estimates suppressed)	—	19 area dummies	(Estimates suppressed)	—
Observations	11238	11238	Observations	10296	10296
Log likelihood	−6960.1883	−6918.0382	Log likelihood	−6826.8136	−6797.3410

Notes: Standard errors in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

to a zero deductible in 2001 compared to drivers in group A who had increasing deductibles for both years. Similarly, controlling for the time trend, *C_Year01* is still significantly positive, indicating that group C drivers were more likely to be no-claim drivers (i.e., more likely to exercise care) when they switched to increasing deductibles in 2001 compared to drivers in the group D who had a zero deductibles for both years.

CONCLUDING REMARKS

Inspired by the deregulation of automobile insurance in Taiwan, we provide a theoretical rationale for the existence of an increasing per-claim deductible system and test the incentive effects of various insurance contracts based on this theory. We prove that under certain conditions, the increasing per-claim deductible contract is the optimal choice for the insured when incentive effects are taken into account. In addition, this type of automobile insurance contract tends to be chosen by those who prefer to put forward a greater level of care.

Empirical results are obtained using a unique dynamic data set. To analyze the changing behavior of the insured, we partition the available data set into four groups by contract choice over two different deductible forms, an increasing per-claim deductible and a zero deductible, over 2 consecutive years. Incentive effects are examined by looking at the change in claim tendency before and after switching between the two deductible plans. By running binomial logit regressions on binary variables of no-claims for switching samples and for reference samples, we find strong support for the incentive effects hypothesis: drivers with an increasing deductible scheme are highly significantly associated with a greater tendency to file no claims. After controlling for time trend, the qualitative results remain the same, indicating that the incentive effects of increasing per-claim insurance policy exist regardless of the time period.

Our results provide direct evidence of the effects of deductible structures on claim behavior. Further research may address the relevance of these findings to identifying risk groups and pricing policies, and it is clear that insurers should consider incentive effects when designing insurance policies. Finally, in addition to the traditional experience-rating system, monitoring the dynamic patterns of claim behavior should play an important role in the development of insurance policies in the future.

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