Does insurance fraud in automobile theft insurance fluctuate with the business cycle?

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Abstract

Financial institutions face various cyclical risks, but very few studies have analyzed the cyclicality of operational risk. External fraud is an important operational risk faced by insurers. In this research, we analyze the empirical relationship between insurance fraud and business cycle and we concentrate our study on two insurance contracts that may create an incentive to defraud. We find that residual insurance fraud exists both in the contract with replacement cost endorsement and the contract with no-deductible endorsement in the Taiwan automobile theft insurance market. These results are consistent with previous literature on the relationship between fraud activity and non-optimal insurance contracting. We also show that the severity of insurance fraud is countercyclical. Fraud is stimulated during periods of recession and mitigated during periods of expansion. Although this last result seems intuitive, our contribution is the first to measure its significance.

Keywords: Operational risk, insurance fraud, replacement cost endorsement, no-deductible endorsement, automobile theft insurance, business cycle.

JEL codes: G22, G20, D80, D81.

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Operational risk has become an important source of risk for banks and insurance companies. According to different sources, credit risk represents 75% of banks' risk exposure, while market risk and operational risk account for 5% and 20% respectively. [1] Operational risk is the risk of loss resulting from inadequate control processes, people, and systems or from external events. Seven types of events are defined by Basel II and Solvency II. One of them is external fraud or unauthorized activities by external parties. These activities include theft and fraud.

One empirical question that has not been investigated in detail is related to the effect of business cycles on operational risk. Are the behaviors of the agents involved in operational risk management affected by recessions? Do banks and insurance companies spend less money on operational risk control when business activities are reduced? Do clients modify their behavior during recessions because their wealth or their risk aversion changes? Allen and Bali (2007) found that operational losses are related to business cycles. Chernobai et al (2011) obtain a positive dependence between economic downturns and the aggregate level of operational risk. To our knowledge, specific loss events have not been analyzed in the literature. It is not clear that business cycles affect employment practices and workplace safety, business disruption and system failures, and internal or external fraud. Knowledge of the specific factors that affect each risk type should be the basic step in strategic management of operational risk by financial institutions.

[1] We do not know the corresponding numbers for the insurance industry. As we will see later, external fraud represents about 5% of claims value in the market we study. External fraud is one of the seven risk types identified in operational risk by Solvency II. The six others are: internal fraud; employment practices and workplace safety; clients, products and business practices; damage to physical assets; business descriptions and system failures; and execution, delivery and process management.

Our paper is related to another strand of the literature on the measure of information problems in different markets (Chiappori and Salanié, 2012; Dionne, 2012). To our knowledge, only two articles have proposed methodologies to separate moral hazard from adverse selection. Dionne and Gagné (2002) propose a methodology to separate ex post moral hazard from ex ante moral hazard and adverse selection, while Dionne, Michaud and Dahchour (2011) separate asymmetric learning from adverse selection and moral hazard. In this article, we extend Dionne and Gagné's (2002) methodology by showing how business cycles can affect economic behavior in the presence of asymmetric information.

Insurance fraud has become an increasingly important issue throughout the world. Many researchers have investigated this problem, but few studies have examined the relationship between fraud and the surrounding environment.[2] This paper fills this gap and investigates the impact of the environment on fraud from a macroeconomic standpoint. It underlines the impact of the business cycle on insurance fraud.

Dionne (2012) provides many reasons for insurance fraud, such as changes in morality, poverty, intermediaries' behavior, insurers' attitude or control, and nature of insurance contracts. Although it has been pointed out that morality or poverty could affect insurance fraud,[3] no studies have provided related empirical evidence. However, fraud has been associated with morality, and morality has been linked to a country's poverty level. In addition, the poverty level of society is commonly linked to economic circumstances.

Dionne and Gagné (2002) find a particular pattern of claim timing in Quebec's automobile insurance contracts, and conclude that fraud is induced by the replacement cost endorsement. Dionne and Gagné (2001) also show how insurance fraud is affected by the deductible level in insurance contracts. Similarly, our contribution posits that insurance fraud is associated to the nature of insurance contract, and further

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[2] Boyer (2001) is one of the few researchers to discuss the impact of economic factors on insurance fraud, specifically that of the tax scheme of the insurance benefit. See also Bates et al. (2010) on health production efficiency.

[3] Dionne and Gagné (2002) underline that poverty is a possible reason for fraud. In the theoretical model of Dionne, Giuliano, and Picard (2009), the moral cost of fraud is one of the factors that affect individuals' decision to defraud.

explores the impact of the business cycle.[4] The two insurance contracts we analyze provide additional coverage to the standard insurance contracts for automobile theft: replacement cost endorsement which covers the depreciation of the vehicle and the non-deductible endorsement which covers the deductible. These two endorsements may create distortions in incentives for self-protection and even increase insurance fraud.

It is unclear whether the business cycle has a positive or negative impact on insurance fraud. From the insured's standpoint, people could become more risk-averse in a recession and hesitate to play this type of lottery. Conversely, the morality standard could decrease when the economic situation worsens. The marginal benefit from fraud could also increase because wealth decreases during a recession, and the benefit of defrauding could increase. On the insurer's side, a recession is a source of lesser economic activity and of fewer resources to control the variation of this important operational risk. Hence, competing predictions on the relationship between the business cycle and insurance fraud are worth testing.

Insurance fraud is an increasingly important problem in Taiwan. In automobile theft insurance, a significant line in the property-liability insurance market,[5] fraud accounts for about 5% of total claims. It reached 150 million NT dollars in 2008.[6] The loss ratio of auto theft insurance is over 35% each year, and fraud could be one of the reasons for such a high loss ratio in this important business line. Further, the loss ratio fluctuates over time and coincides with the business cycle.[7]

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[4] Picard (2012) claims that the severity of insurance fraud ranges from build-up to planned criminal fraud. The reason that we focus our study on insurance fraud in theft insurance is because we have selected events that correspond to an economic choice and may be related to economic conditions of the insured and the insurer. Either the insured has higher fraud incentives for economic reasons or the person's vehicle can be sold at a profit on the black market. This implies that some insured plan some fraudulent theft claims to cheat the insurance company. We suspect this behavior, but do not have evidence to prove it. Thus, some events might also be linked to opportunistic behavior. We will use the signs or signals of fraud described in the data description section. The insurer's fraud detection activity may also be affected by economic conditions.

[5] From 2000 to 2007, about 26.37% of private sedans were covered by theft insurance. The premium is over 40 billion NT dollars (about 1.33 billion US dollars) per year, and the growth rate is about 10% per year.

[6] This is roughly equivalent to 5 million US dollars.

[7] If we treat GDP as a proxy variable for the fluctuation of the business cycle, we find that the loss ratio of

Taiwan's automobile theft insurance covers the risk of vehicle loss due to total theft.[8] This contract is sold annually. Depreciation and deductible are included in this contract.[9] In the absence of any endorsement, the insurance company is liable for the loss of depreciated value of the insured vehicle less 10% deductible when the insured vehicle is totally lost due to theft. However, two kinds of endorsement can be purchased: the replacement cost endorsement and the no-deductible endorsement. The insurance company does not allow the insured to purchase these two kinds of endorsement at the same time. When the insured is covered by replacement cost endorsement, depreciation is not calculated when the vehicle is stolen. When the insured is covered by no-deductible endorsement, there is no 10% deductible if the vehicle is stolen.

We have collected automobile theft insurance data from Taiwan's largest property-liability insurance company.[10] Our monthly data span a long policy period, comprising policies written from 2000 to 2007, i.e. a study period of 96 policy months.[11] We can thus test the relationship between insurance fraud and the business cycle.

We find a particular pattern of total theft claim timing linked to the replacement cost endorsement. The month-by-month test[12] indicates that unlike partial theft claims, total theft claims under replacement cost endorsement contracts increase over time during the contract year. This finding confirms that

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automobile theft insurance is significantly negatively correlated with the level of GDP. We list the automobile theft insurance loss ratio of non-commercial vehicles and the GDP of Taiwan in Appendix A, from 1998 to 2009. The netative relationship between the loss ratio and GDP is important. The significant correlation coefficient is -0.99.

[8] This contract covers only total theft loss, not partial theft loss. For example, if only video equipment is stolen, the insurance company does not indemnify this kind of loss unless the insured had purchased the auto parts and accessories endorsement.

[9] The value of the insured vehicle is monthly depreciated. The depreciation rates are: 3%, 5%, 7%, 9%, 11%, 13%, 15%, 17%, 19%, 21%, 23% and 25% from the first month to the 12th month during the policy year. The deductible is sold as a percentage (10%) of the vehicle's value.

[10] This insurance company controls more than 20% of Taiwan's automobile insurance market.

[11] For all the contracts written from 2000 to 2007, we collect their complete claim records for the policy year. For example, the claim records of policies written in 2007 are extended to the dates in 2008.

[12] In this paper, the periods have been reorganized by policy period. Hence we test policy months instead of calendar months.

insurance fraud, rather than ex ante moral hazard or adverse selection, arises from the replacement cost endorsement. Further, testing by each policy month during the policy year points to another particular pattern of claim timing for insurance fraud induced by no-deductible endorsement. The total theft claims of no-deductible endorsement are more common during the early months of the contract year. This evidence of fraud can also be separated from ex ante moral hazard and adverse selection. These results clearly indicate that writing non-optimal contracts in presence of asymmetric information can be very costly to insurers.

Further, the empirical evidence affirms that insurance fraud fluctuates conversely with the business cycle. The claim timing patterns for the two types of contracts mentioned above are even more pronounced during a recession, which implies that a recession amplifies the incentives for insurance fraud induced by contracts.

Separating ex post moral hazard from ex ante moral hazard and adverse selection is important for insurance companies. It allows them to better focus their attention on reducing the cost of insurance fraud and, more generally, of a significant part of their operational risk. We have insufficient information to determine the main causes of insurance fraud increase during recessions, but insurers can easily verify how their operational risk management budget varies with business cycles. Preliminary observations seem to indicate that financial institutions reduced significantly their risk management activity for operational risk during the last recession and financial crisis because this risk has significantly increased.

The paper is organized as follows. The next section analyses the empirical hypotheses. The second section describes the data and the third section discusses the empirical methodology used in this paper. The fourth section presents the empirical results. The final section concludes the article.

1. Hypotheses

Insurance fraud incentive is induced by the nature of the insurance contract.[13] Two important contract types are replacement cost endorsement and no-deductible endorsement. We posit that the degree of incentive to defraud is also affected by the business cycle. In this section, four hypotheses are proposed for the empirical tests. Before we explore the impact of the business cycle, the claim timing pattern of fraud induced by each contract is identified.[14]

There are many factors explaining insurance fraud.[15] On the demand side, maximizing their expected utility, each insured has a critical value of the probability of a fraud being successful. The lower this critical value, the greater the insured's incentive to commit fraud. One can show that this critical value decreases when the difference between the vehicle's replacement cost and the vehicle's market value increases near the expiration of the insurance contract. Accordingly, the insured would consider planning fraud near the contract's expiration with increasing probability. On the supply side, the probability of the insurer's conducting an audit also decreases near the contract's expiration because the market value of the vehicle decreases over time.[16] Hence, as Dionne and Gagné's (2002) theoretical model indicates, insurance fraud probability is higher near the expiration of the replacement cost endorsement.

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[13] Many contributions have discussed the optimal contract design that could reduce the incentive to defraud. Crocker and Morgan (1998) theoretically investigate the optimal insurance contract under costly state falsification. Crocker and Tennyson (1999) empirically test for the nature of the optimal insurance contract under costly falsification. Picard (1996), Bond and Crocker (1997) and Boyer (2004) design the optimal insurance contract under costly state verification (see Derrig, 2002, and Picard, 2012, for reviews of the literature).

[14] Identifying the existence of fraud under asymmetric information is an important aim in the literature. For example, Artis et al. (2002) adopt a new methodology to identify fraud by allowing the misclassification error in the existing method to separate fraudulent claims from honest claims.

[15] Picard (1996) built an equilibrium model between the insurer and the insured to explain the successful fraud probability in the market. Dionne and Gagné (2002) extended this model. They found that auditing does not suffice to deter fraud. Hence, the success probability of fraud does not correspond to the probability of non-audit.

[16] The stringency of audit could affect the success probability of fraud, but it is not constant over time. Dionne, Giuliano and Picard (2009) use red flags as the signals for conducting stringent audit in their optimal auditing strategy. Dionne and Gagné (2002) assume that the stringency of audit decreases near the expiration of the replacement cost endorsement.

We also infer the probability of insurance fraud under such an equilibrium model. On the demand side, the individual's expected utility model is similar to that of Dionne and Gagné (2002). On the supply side, we modify their insurer's audit probability to become flat over time.[17] The theoretical model under replacement cost endorsement is presented in Appendix B. The main result is consistent with Dionne and Gagné (2002) in that the equilibrium fraud probability is higher near the end of the policy year.

When we study the empirical link between fraud and endorsement contract, this contract is compared with the reference contract with both depreciation and deductible. We treat the contract with replacement cost endorsement as a high-coverage contract, and the reference contract as a low-coverage contract. A contract with replacement cost endorsement reimburses the total value of the car evaluated at the beginning of the contract period less the proportional deductible while the reference contract reimburses the loss of depreciated value of the vehicle less the proportional deductible. The former contract exhibits the claim timing pattern described above, whereas the latter does not. Hence, our first hypothesis:

Hypothesis 1: *If the claims are induced by fraud, individuals who choose a replacement cost endorsement contract have a higher probability of filing a claim, and this probability is even higher near the end of the contract period.*

In addition, we examine incentives to defraud induced by the no-deductible endorsement contract. Dionne and Gagné (2001) propose a theoretical model and empirically verify that the design of the deductible would increase the incentive to build up a claim. However, this conclusion cannot be applied directly to our research design because we investigate fraud related to total theft rather than build-up. We assume that people would have a greater incentive to invent fraudulent claims when there is no deductible

[17] We make this assumption because insurers in Taiwan do not, in practice, implement a particularly stringent audit at the beginning of the contract. First, the market value of a vehicle does not vary as much as in Quebec from the beginning to the end of the overall policy period, because the contract length is only for one year, and the replacement cost endorsement contract in Taiwan is not designed for new vehicles exclusively. Second, insurance companies in Taiwan rely heavily on the mechanism of deductible design in the replacement cost endorsement and a more stringent depreciation rate in the no-deductible contract. There is actually no difference in the audit approach between the beginning and the end of the policy year as a whole.

designed in the contract than with the reference contract. The incentive of fraud is higher under a no-deductible endorsement because the insurer reimburses the depreciated value of the car without deductible. We derive this result in Appendix C. We also discuss the claim timing pattern for the contract with depreciation in Appendix C. Whereas the vehicle depreciation from the insurer's indemnity is much more stringent than that in the market,[18] and when the incentive to cheat is large enough, the insured would have a stronger incentive to organize fraud at the beginning of the contract period under a contract with depreciation and the non-deductible endorsement. Hence, under a flat audit mechanism, the equilibrium fraud probability is higher at the beginning of the policy year.

To identify fraud induced by the no-deductible endorsement contract in our empirical test, we compare this contract with the reference contract, which comprises both a deductible and depreciation. The contract with depreciation and no-deductible endorsement is thus a high-coverage contract, and the reference contract is a low-coverage contract. As shown in Appendix C, the relative claim timing pattern is focused on the beginning months of the policy year. Our second hypothesis is therefore:

Hypothesis 2: *If the claims are induced by fraud, individuals who choose the non-deductible endorsement contract have a higher probability of filing claims. This probability is even higher at the beginning of the contract period.*

Although the main research concern is insurance fraud, the former parts of the above two hypotheses could evidently also result from adverse selection. Under adverse selection, high-risk individuals tend to purchase the two types of high-coverage contracts and are more likely to make a claim. However, the claim would be equally distributed among the twelve months. In contrast, only insurance fraud would create a particular pattern in the timing of the claim during the months of the policy year. This

[18] In the first three months, the depreciation rates for insurance contract and market value of the car are almost the same. However, over time, the market depreciation rate does not increase as fast as that of the insurance contract. In the last month of the year, the market depreciation rate is 15%, while the depreciation rate from the insurance company is 25%.

characteristic enables us to clearly rule out adverse selection. Hence, when the first and second hypotheses are empirically sustained, they would provide evidence of insurance fraud rather than adverse selection.

It is also important to distinguish fraud from ex ante moral hazard.[19] Insurance fraud results from an individual's decision to invent a fraudulent claim or not. Ex ante moral hazard arises from the decision to pay more or less attention to self-protection. Under the replacement cost endorsement, ex ante moral hazard could be stronger near the end of the policy year.[20] Conversely, under the no-deductible endorsement contract, ex ante moral hazard could be stronger at the beginning of the policy year.[21] Ex ante moral hazard thus has the same claim timing pattern as insurance fraud.

Dionne and Gagné (2002) show that fraud can be induced only when the benefit from fraud is sufficiently large. They maintain that the benefit from fraud based on partial theft is minor. The incentive to defraud through total theft is much stronger than that related to partial theft. This difference in incentives provides an opportunity to distinguish fraud from ex ante moral hazard. Self-protection has an equal effect in terms of reducing the probability of both total theft and partial theft, but fraud solely leads to a stronger incentive to file a total theft claim. Accordingly, fraud could emerge mainly based on the probability of a total theft claim instead of a partial theft claim. Hence, our third hypothesis distinguishes insurance fraud from ex ante moral hazard.

Hypothesis 3: *If the claim timing patterns in the first and second hypotheses emerge only in relation to the total theft claim, insurance fraud exists rather than ex ante moral hazard. If the above patterns also*

[19] In the literature, the consequences of ex ante moral hazard and fraud are often mixed. For example, when Weiss et al. (2010) discussed the distortion effect of regulated insurance pricing, they mention that regulation could cause ex ante moral hazard because drivers' safety investments may be diminished. This regulation could also cause fraudulent claims because the disincentive of filing fraudulent claims may also be reduced.

[20] As described in Dionne and Gagné (2002), the benefits of prevention decrease over time under the replacement cost endorsement. Hence, the presence of replacement cost endorsement reduces self-protection activities, increasing the probability of theft.

[21] The depreciation rate used for the insurer's indemnity is more stringent than that in the regular market. Hence, the difference between the loss indemnity and the vehicle's market value would be larger near the end of the year. This would give the insured a greater incentive to pay more attention to self-protection and to reduce the ex ante moral hazard near the end of the year in absence of replacement cost endorsement. Accordingly, under a no-deductible contract, there is greater ex ante moral hazard at the beginning of the policy year.

emerge relative to the partial theft claim, then ex ante moral hazard may exist in the market, and we cannot conclusively determine whether insurance fraud exists.

Investigating the impact of the business cycle on insurance fraud is the second objective of this research. Whether fraud will fluctuate consistently or inversely with the business cycle is unclear. Regarding risk aversion, it has been accepted that most people are risk-averse and exhibit decreasing absolute risk aversion. In an economic recession, people's wealth decreases and they become more risk-averse. This will make them more hesitant to adopt risky actions, including a fraud lottery. Hence, the probability of fraud could decrease during a recession.

Alternatively, because the individual's wealth decreases during a recession, the increment of utility from the benefit of fraud increases concomitantly, because of a direct wealth effect. Furthermore, if recession reduces individuals to the poverty level, they may feel they have much less to lose if they get caught committing fraud. This may increase people's likelihood of defrauding during a recession.

Fraud is highly related to an individual's morality. Morality may also vary with wealth level. Husted et al. (1999) argue that societal corruption is highly related to GDP per capita. They provide empirical evidence that indirectly shows that individuals' morality level is positively related to their wealth. Dionne, Giuliano and Picard (2009) establish in a theoretical model that moral cost affects individuals' decision to defraud. Therefore, from the standpoint of morality, recession reduces the average wealth level. A lower wealth level could weaken morality and reduce the moral cost of fraud, which raises the probability of fraud. Finally, insurers may reduce their operational risk management during recessions because they have fewer resources although they should increase them according to the previous predictions from the insured. Because our fourth hypothesis encompasses many conflicting effects that we cannot isolate, we do not make a prediction on the sign of the business cycle effect.

Hypothesis 4: *Insurance fraud could be positively or negatively affected by the business cycle.*

2. Data

Our data set includes many characteristics of the insured and the insured vehicles, such as the gender, age, marital status of the insured; the brand, age, size, registered area, usage purpose of the insured vehicle; the information on the contract, such as coverage; the selling channel of the contract; and the claim information for each policy. Regarding the claim information, we collect not only the records on the claim amount and reason, but also the records on the date of the claim. This could help identify the timing of the claim, specifically the policy month during the policy period.

Further, we use the corresponding calendar date to investigate the impact of the business cycle. Our policy data are reorganized by policy year, and the claim timing is described by policy month, whereas the business cycle index is recorded by calendar year and calendar month. Accordingly, because we investigate the relationship between business cycle and insurance fraud for each policy month, we match the calendar date of the claim to the corresponding calendar month in the monthly business cycle index.

The data examined comprise the policies written from 2000 to 2007 and their corresponding claims until the end of 2008. This length of data allows us to match the monthly variation in the macroeconomic business cycle index to test the relationship between fraud and business cycle. Hence we use the corresponding business cycle index of a potential claim's calendar month to measure the effect of the business cycle.

The business cycle index is the trend-adjusted monthly index of the composite coincident index from January 2000 to December 2008. This index, obtained from the published data of the Council for Economic Planning and Development of Taiwan, reflects the fluctuations of the business cycle. The value of the index is higher when the economy is healthier, and vice versa.

The total number of observations in our data set is 1,761,536. When we test whether insurance fraud exists under the replacement cost endorsement, we use a sub-sample of replacement cost endorsement contracts together with contracts with deductible and depreciation. The number of observations in this sub-sample is 1,715,736. When we test whether fraud exists under no-deductible contracts, we use the sub-sample of no-deductible contracts plus contracts with deductible and depreciation. The number of observations in this sub-sample is 1,170,012. Because we cannot observe the occurrence of partial theft for the contracts without the endorsement of auto parts accessories, we must use a smaller sub-sample of contracts with the endorsement of auto parts accessories when we test the relationship between coverage and claim timing for the partial theft case. This smaller sub-sample comprises 564,175 observations.

Observing the basic statistics of the variables in our empirical data can help us understand the data characteristics and their representativeness. The variables are defined in Table 1. The descriptive statistics for these variables are listed in Table 2. A total of 32.92% of theft insurance policies involve replacement cost endorsement, and only about 2.48% of the policies have zero deductible. About 40% of the policies are sold through dealer-owned agents.

(Tables 1 and 2 about here)

Regarding the nature of the insured individuals, most of the insured (91.23%) are married, between 30 and 60 years old (87.97%), and female (62.55%). Concerning the insured vehicles, 64.27% of the insured vehicles have engine capacities equal to or less than 2000 c.c., and 39.29% of the insured vehicles are concentrated in the most popular brand in the market. Concerning vehicle distribution across the registered areas, 47.95% are registered in the north of Taiwan, 27.84% in the south, and 2.29% in the east. 53.51% of the vehicles are registered in cities.

About 20% of the vehicles are brand new, and more than 70% are less than four years old. A total of 96.43% of the insured vehicles are non-commercial or long-term rental sedans. These characteristics indicate that people are more willing to purchase theft insurance for vehicles for non-commercial use and for new vehicles.

We can make two preliminary comments on insurance, observing some characteristics on those who claimed, according to their claim timing. They are presented in Table 3.

Consider first the vehicle age. 20.7% of our sample are brand new vehicles.[22] In the subsample of “stolen vehicle with replacement cost endorsement” contract, 67.28% were stolen in the last seven months of the contract, and only 32.72% were stolen in other months. In the subsample of stolen vehicle with “no-deductible endorsement” contract, 60.87% were stolen in the first three months, and only 39.13% were stolen in the remaining months.[23]

(Table 3 about here)

The second comment concerns the vehicle brand. The percentage of the most popular brand (tramak_t) vehicles in our sample is 39.29%.[24] In the subsample of “stolen vehicles with replacement cost endorsement” contract, 56.32% of these popular brand vehicles were stolen in the last seven months, and 43.68% were stolen in other months. In the subsample of stolen vehicles with “no deductible endorsement” contract, 63.41% of these popular brand vehicles were stolen in first three months, and 36.59% of these popular brand vehicles were stolen in the remaining months. It seems that an insured knowing the characteristics of the insurance contract may deliberately plan to defraud. The fraud behavior may also be opportunistic, in the sense that some market specialists may signal to an insured that it is an opportune time to defraud. Our data do not allow us to separate opportunistic fraud from planned fraud. We consequently focus the empirical analysis on insurance fraud in general.

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[22] The percentage of stolen car is 0.29% over the total population. It is 0.57% for brand new vehicles and 0.79% for popular brand vehicles, both with the replacement cost endorsement contract. It is 0.49% for brand new vehicles with non-deductible endorsement and 0.64% for popular brand vehicles with non-deductible endorsement.

[23] Generally speaking, brand new vehicle value is much higher than that of older vehicles. Hence, the brand new vehicle owner has a greater financial incentive to defraud.

24 This brand is especially often used by taxis. It accounts for over 50% of the vehicle brands of taxis. The vehicles of this particular brand can be sold very easily on the black market because there is high demand for auto parts and accessories of this brand.

3. Empirical methodology

The first empirical task in this paper is to identify whether insurance fraud exists in the automobile theft insurance market in Taiwan. We test the evidence for fraud based on the timing pattern of the conditional correlation between coverage and claims. The contract with high coverage is defined as either the replacement cost endorsement or the no-deductible contract. The claim is further identified as the total theft claim and partial theft claim.

To test the conditional correlation between coverage and claims, we use a two-stage method similar to the methodology for a conditional correlation analysis in Dionne, Gouriéroux and Vanasse (2001). To identify the time pattern of the conditional correlation between coverage and claim, we test their conditional correlation by policy month. Hence, in each model,[25] we conduct the following conditional correlation test on twelve pairs from the first policy month to the twelfth policy month.

The two-stage method is as follows. In the first stage, we estimate the claim probability of the *j*-th policy month for each policy by means of the Probit regression

$$\text{Prob}(claim_{jkit} = 1 | X_{1it}) = \Phi(X_{1it}\beta_{1jk}), \quad j = 1,...12, \quad k = h, p, \quad i = 1,..n, \quad t = 2000,...2007 \tag{1}$$

where $\text{Prob}(\cdot)$ denotes the probability function, Φ is the cumulative standard normal distribution function, $i = 1, \cdots, n$, denotes the observations. The observations represent an unbalanced panel from policy year 2000 to policy year 2007; $k = h$ is for total claim and $k = p$ is for partial claim. X_{1it} is the

[25] When we identify the existence of insurance fraud, we test the conditional correlation between claim and coverage under four models. In the first model, we test the conditional correlation between total theft claim and coverage of contract with replacement cost endorsement. In the second model, we test the conditional correlation between total theft claim and coverage of contract with no-deductible endorsement. In the third model, we test the conditional correlation between partial theft claim and coverage of contract with replacement cost endorsement. In the fourth model, we test the conditional correlation between partial theft claim and coverage of contract with no-deductible endorsement. When we identify the relationship between fraud and business cycle, we test under two additional models. In the fifth model, we test the effect of the business cycle on the conditional correlation between total theft claim and the coverage of contract with replacement cost endorsement. In the sixth model, we test the effect of the business cycle on the conditional correlation between total theft claim and the coverage of contract with no-deductible endorsement.

vector of explanatory variables that includes the characteristics of the insured and the insured vehicle, which are listed in Table 1. Some of the explanatory variables, such as sex, age of insured, and age of the insured vehicle, are invariant during policy years. Other explanatory variables could vary over policy years; these include registered area of vehicle, marriage status, and policy year variable. β_{1jk} is the corresponding parameter vector, and $claim_{jkit}$ is the variable identifying whether the insured claimed or not. $claim_{jkit}$ is defined by policy month (*j*), from first policy month to 12[th] policy month of the whole policy year, for each insured *i*. $claim_{jkit} = 1$ when insured *i* has filed a claim in j-th policy month of policy year *t*, otherwise $claim_{jkit} = 0$.

In the second stage, we run the other Probit regression for the probability of purchasing a high-coverage contract as:

$$\begin{aligned} &\text{Prob}(\text{cov}erage_{lit} = 1 \mid X_{2it}, claim_{jkit}, Pr\hat{o}b(claim_{jkit})) \\ &= \Phi(X_{2it}\beta_{2,l,j} + \beta_{c,l,j} claim_{jkit} + \beta_{ec,l,j} Pr\hat{o}b(claim_{jkit})) \end{aligned} \quad (2)$$

This regression is also based on the standard normal distribution used to estimate the probability of purchasing high coverage. The variable $coverage_{lit}$ is a choice variable of the insured; namely whether he or she purchased a high-coverage contract or not in policy year *t*. There are two definitions of high coverage (*l*) in this paper: $l = R, ND$, which denotes the replacement cost endorsement, and the no-deductible contract, respectively. The reference contracts are the contracts with depreciation and deductibles. They are defined as low-coverage. X_{2it} is the vector of explanatory variables that contains the same variables as in X_{1it}. $claim_{jkit}$ has been defined above, and $\text{Pr}\hat{o}b(claim_{jkit})$ is the estimated probability of $claim_{jkit}$. $\beta_{2,l,j}, \beta_{c,l,j}, \beta_{ec,l,j}$ are the corresponding parameter vectors for the estimation under each policy month *j*, and when we investigate the high-coverage contract as *l*=*R* or *l*=*ND*. The key estimated coefficient used to test the problems of asymmetric information is $\beta_{c,l,j}$. There is a significantly positive correlation between the *l* coverage and claim in *j*-th policy month if the estimated $\beta_{c,l,j}$ is significantly positive.

To disentangle insurance fraud from ex ante moral hazard, we test the conditional correlation between coverage and total theft claim, and between coverage and partial theft claim. Hence, the claim in the above two regressions is further defined according to total claim (k=h) or partial claim (k=p). When we conduct the above test for the conditional correlation between coverage and total theft claim, we can use the observations from the full sample. When we conduct the above test for the conditional correlation between coverage and partial theft claim, we can use only a sub-sample of insured who have also purchased the auto parts accessories endorsement. Because we are estimating total theft claims, we test only for the existing effective contracts in each policy month. In other words, the contracts for which total claims have been filed are terminated and eliminated from our sample.

According to the first hypothesis, we test for the total theft claim (k=h) and replacement endorsement (l=R). If the estimated $\beta_{c,l,j}$, l=R in equation (2) is significantly positive only for some j-th policy months near the end of the policy year, it indicates moral hazard instead of pure adverse selection. Insurance fraud could be induced by the replacement cost endorsement. According to the second hypothesis, we test for the total theft claim (k=h) and no-deductible endorsement (l=ND). If the estimated $\beta_{c,l,j}$, l=ND in equation (2) is significantly positive only for some j-th policy months occurring early in the policy year, this points to moral hazard instead of pure adverse selection. Insurance fraud could thus be induced by the no-deductible endorsement.

When the particular time pattern emerges, we distinguish insurance fraud from ex ante moral hazard. According to the third hypothesis, we test the partial theft claim (k=p) for replacement cost endorsement (l=R) as well as for no-deductible endorsement (l=ND). If estimated $\beta_{c,l,j}$s in equation (2) for all twelve policy months ($j=1,...12$) in the policy year are insignificant, we can infer that the emerging claim timing patterns are evidence of fraud instead of ex ante moral hazard.

We now have to test the relationship between insurance fraud and the business cycle. We can also test this relationship using a two-stage method. We keep the regression in the first stage unchanged. We then add the business cycle index to the explanatory variables in the regression of the second stage:

$$\begin{aligned}&\text{Prob}(\text{cov}erage_{lit}=1\,|\,X_{2it},claim_{jkit},claim_{jkit}*Buscyc_m,Pr\hat{o}b(claim_{jkit}))\\&=\Phi(X_{2it}\beta_{2,l,j}+\beta_{C,l,j}claim_{jkit}+\beta_{BC,l,j}claim_{jkit}*Buscyc_m+\beta_{ec,l,j}Pr\hat{o}b(claim_{jkit}))\end{aligned} \quad (3)$$

$Buscyc_m$ is the monthly business cycle index, which corresponds to each calendar month in each year with a potential claim. In our paper, the claim records are ranged among 108 months from January 2000 to December 2008, and are ranked from “0100” to “1208.”[26] We match each of the claim dates in our sample to its corresponding calendar date, and find the corresponding month for $Buscyc_m$. The variable $Buscyc_m$ is introduced as an interaction term with $claim_{jki}$. The key coefficients used to measure the relationship between fraud and the business cycle for contract l are $\beta_{BC,l,j}$ s during some j-th policy months. According to our fourth hypothesis, the fraud rate could rise or decline with the recession according to either of the two conflicting effects. If fraud is more severe in a recession, for high coverage contracts representing contracts with replacement cost endorsement, the $\beta_{BC,l,j}$ s (l=R) in equation (3) should be significantly negative only for those j-th policy months near the end of the whole policy year; for high coverage contracts representing the no-deductible contract, the $\beta_{BC,l,j}$ s (l=ND) in equation (3) should be significantly negative only for those j-th policy months at some beginning months of the policy year. This indicates that insurance fraud is more severe while the economy is in a recession. Conversely, if the estimated $\beta_{BC,l,j}$ s are significantly positive in the above-mentioned policy months, this affirms that insurance fraud is more severe while the economy is booming. Finally, if all the estimated $\beta_{BC,l,j}$ s are insignificant, the business cycle has no impact on insurance fraud.

[26] The first two codes of *m* represent the calendar month, and the second two codes of *m* represent the calendar year. For example, *m*=0100 is for the business cycle index of January 2000.

4. Empirical results

The first empirical task is to identify whether fraud exists in the automobile theft insurance market in Taiwan. We try to disentangle ex post moral hazard from adverse selection and ex ante moral hazard.

Table 4 shows that for total theft claims, the estimated $\beta_{c,l,j}$ s (*l*=*R*) are significantly positive only after the sixth policy month of the contract in the subsample of replacement cost endorsement contracts versus the reference contracts; the estimated $\beta_{c,l,j}$ s (*l*=*ND*) are significantly positive only before the third policy month of the contract in the subsample of no-deductible endorsement contracts versus the reference contracts.[27] The conditional correlations between coverage and claims exhibit significant time patterns under both contracts for total theft claims. The former finding is consistent with that of Dionne and Gagné (2002), and supports our first hypothesis. The second finding sustains the particular condition in our second hypothesis and its inference. Hence, these outcomes provide evidence only for the possible existence of insurance fraud rather than adverse selection.

In the case of partial theft claims, all of the estimated $\beta_{c,l,j}$ s are not significant in both subsamples, meaning that the conditional correlations between coverage and partial theft claims are all insignificant. These outcomes preclude the existence of ex ante moral hazard and confirm the evidence of fraud. Therefore, our third hypothesis is supported. All the outcomes, which support the first to third hypotheses, confirm that fraud is induced by the two contract characteristics: replacement cost endorsement and no-deductible endorsement.

(Table 4 about here)

[27] There are 48 pairs of regressions when we test the conditional correlation between two dimensions of claims (total theft claim as well as partial theft claim) and two dimensions of coverage (the coverage of contracts with replacement cost endorsement and the coverage of contracts with no-deductible endorsement). It is redundant to report complete results for all 48 pairs of regressions. Hence, we display only 48 key estimated coefficients ($\beta_{c,l,j}$) from the second-stage regression in Table 4, and report two examples of ensuing regression results in Appendix D.

Regarding the test associated with the business cycle, the empirical results of the estimated coefficients of $\beta_{C,l,j}$ and $\beta_{BC,l,j}$ in the second stage are listed in Table 5.[28] Because the test here is to identify the impact of the business cycle on insurance fraud, we need only test this relationship for total theft claims.

Table 5 demonstrates that under replacement cost endorsement, all of the estimated $\beta_{BC,l,j}$ s ($l=R$) are negative and are significant only after the 10th policy month. The estimated $\beta_{C,l,j}$ s retained their time pattern: they are significantly positive only for policy months near the end of the first policy year. Under a no-deductible contract ($l=ND$), all the estimated $\beta_{BC,l,j}$ s are still negative; they are significant only in the first two policy months. These outcomes mean that the conditional correlation between coverage and claim is stronger when economic conditions are deteriorating. The claim timing patterns for these types of contracts are reinforced by the business cycle. Such empirical evidence indicates that insurance fraud increases during a recession. The business cycle accentuates the timing pattern of the two contracts.

(Table 5 about here)

5. Conclusion

The main goal of this paper was to investigate the impact of the business cycle on insurance fraud. Few studies have associated the fraud problem with the surroundings, and none have discussed the impact of the business cycle on the severity of fraud. We find that insurance fraud is more severe during a recession.

We also test whether insurance fraud could be induced by different kinds of insurance contracts. We confirm that there are particular time patterns for total theft claims induced by replacement cost endorsement and no-deductible endorsement. We separate this evidence from adverse selection. We also

[28] There are 24 pairs of regressions when we test the relationship between business cycle and fraud. For similar reasons as before, it is redundant to report complete results for all 24 pairs of regressions. Hence, we display only the key estimated coefficients ($\beta_{C,l,j}$ and $\beta_{BC,l,j}$) from the second-stage regression in Table 5, and report two examples of these coefficients in Appendix E.

find that these particular claim timing patterns exist only in total theft claims, as opposed to partial theft claims. This additional evidence serves to differentiate insurance fraud from ex ante moral hazard. These conclusions corroborate the finding of Dionne and Gagné (2002).

Insurers can influence operational risk. They can use risk control and risk financing. For large unexpected losses such as business disruptions and computer system failures risk financing by holding capital is important and complements risk control. For small losses as consumer insurance fraud, risk control is usually sufficient. Our research has shown that business cycles affect external fraud or insurance fraud from the clients. We verified that insurance fraud increases in low economic activity or recession. We cannot separate the different causes of this result: it may be explained by a change in consumer behavior or by a change in insurer control (or both). Future research should design a methodology to disentangle the different causes in order to improve the risk management of this type of operational risk.

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References

Allen, L., Bali, T. (2007). Cyclicality in catastrophic and operational risk measurements. Journal of Banking and Finance 31, 1191-1235.

Artis, M., Ayuso, M., Guillen, M. (2002). Detection of automobile insurance fraud with discrete choice models and misclassified claims. Journal of Risk and Insurance 69, 325-340.

Bates, L.J., Mukherjee, K., Santerre, R.E. (2010). Medical insurance coverage and health production efficiency. Journal of Risk and Insurance 77, 211-229.

Bond, E.W., Crocker, K.J. (1997). Hardball and soft touch: The economics of optimal insurance contracts with costly state verification and endogenous monitoring costs. Journal of Public Economics 63, 239-264.

Boyer, M.M. (2001). Mitigating insurance fraud: lump-sum awards, premium subsidies, and indemnity taxes. Journal of Risk and Insurance 68, 403-436.

Boyer, M.M. (2004). Overcompensation as a partial solution to commitment and renegotiation problems: the cost of ex post moral hazard. Journal of Risk and Insurance 71, 559-582.

Chernobai, A., Jorion, P., Yu, F. (2011). The determinants of operational risk in U.S. financial institutions. Journal of Financial and Quantitative Analysis, forthcoming.

Chiappori, P.A. and Salanié, B., 2012. Asymmetric information in insurance markets: Empirical assessments. In Georges Dionne (Ed.), Handbook of Insurance (second edition), Springer, forthcoming.

Crocker, K. J., Morgan, J. (1998). Is honesty the best policy? Curtailing insurance fraud through optimal incentive contracts. Journal of Political Economy 106, 355-375.

Crocker, K. J., Tennyson, S. (1999). Costly state falsification or verification? Theory and evidence from bodily injury liability claims. In: C. Laberge-Nadeau and G. Dionne (Eds.) Automobile Insurance: Road Safety, New Drivers, Risks, Insurance Fraud and Regulation (pp. 119-130). Boston, MA: Kluwer Academic Publishers.

Derrig, R. (2002). Insurance Fraud. Journal of Risk and Insurance 69, 271-287.

Dionne, G. (2012). The empirical measure of information problems with emphasis on insurance fraud and dynamic data. In Georges Dionne (Ed.), Handbook of Insurance (second edition), Springer, forthcoming.

Dionne, G., Giuliano, F., Picard, P. (2009). Optimal auditing with scoring: Theory and application to insurance fraud. Management Science 22, 58-70.

Dionne, G., Gouriéroux, C., Vanasse, C. (2001). Testing for evidence of adverse selection in the automobile insurance market: A comment. Journal of Political Economy 109(2), 444-455.

Dionne, G., Gagné, R. (2001). Deductible contracts against fraudulent claims: evidence from automobile insurance. The Review of Economics and Statistics 83, 290-301.

Dionne, G.. Gagné, R. (2002). Replacement cost endorsement and opportunistic fraud in automobile insurance. Journal of Risk and Uncertainty 24, 213-230.

Dionne, G., Michaud, P.C., Dahchour, M. (2011). Separating moral hazard from adverse selection and learning in automobile insurance: Longitudinal evidence from France. Journal of the European Economic Association (forthcoming).

Husted, B.W. (1999). Wealth, culture, and corruption. Journal of International Business Studies 30, 339-359.

Picard, P. (1996). Auditing claims in the insurance market with fraud: The credibility issue. Journal of Public Economics 63, 27-56.

Picard,P. (2012). Economic analysis of insurance fraud. . In Georges Dionne (Ed.), Handbook of Insurance (second edition), Springer, forthcoming.

Weiss, M.A., Tennyson, S., Regan L. (2010). The effect of regulated premium subsidies on insurance costs: an empirical analysis of automobile insurance. Journal of Risk and Insurance 77, 597-624.

Appendices

Appendix A: The relationship between Taiwan's auto theft insurance loss ratio of non-commercial vehicles and GDP [29]

Year	Loss ratio	GDP
1998	66.93	9,204,174
1999	62.67	9,649,049
2000	54.38	10,187,394
2001	56.64	9,930,387
2002	54.81	10,411,639
2003	49.55	10,696,257
2004	47.83	11,365,292
2005	45.87	11,740,279
2006	39.47	12,243,471
2007	35.72	12,910,511
2008	36	12,698,501
2009	36.83	12,512,678

Notes: The yearly loss ratio data come from the Taiwan Insurance Institute. The yearly GDP data come from the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, R.O.C. The unit of GDP is one million NT dollars. We estimated the correlation coefficient between the loss ratio and GDP for these twelve years. The correlation coefficient is -0.99, and is significantly different from 0 at the 1% significance level.

[29] Over the past decade, many prevention measures adopted by police authorities and by vehicle owners have generated an effective reduction in automobile burglary. Such measures include: setting a monitor at the burglary hot spots, and increasing the frequency of patrol. Further, more consciousness of self-protection and more developed burglarproof technology also helps decrease the burglary rate. Meanwhile, the premium of automobile theft insurance was not adjusted as rapidly as the burglary rate. This could be the reason why there is almost a 50% drop in the loss ratio over the past decade. However, this drop in loss ratios may not come from a drop in fraud. We do not claim that the GDP is the driving force behind insurance fraud. We simply note the loss ratio negatively fluctuates with GDP.

Appendix B: Insurance fraud under replacement cost endorsement

Assume that the consumer is risk averse. The expected utility of an insured is equal to

$$gU(W+\theta\frac{A}{h(t)}+A-D,\omega)+(1-g)U(W,\omega)\ .$$

where U is the utility function for the risk averse individual, W is the individual's wealth, not including the value of the vehicle, A is the market value of the vehicle at the beginning of the policy year, $h(t)$ is the depreciation rate for the market value of the vehicle, which is an increasing function of time t, and t denotes the month of the policy year. θ is the discount rate when the fraudulent individual starts his fraud activity, $0 \le \theta \le 1$. g is the probability of the fraud being successful. D is the deductible designed in the contract. The model assumes that the market value of the vehicle will be totally expropriated if the individual's fraudulent behavior is discovered by the insurance company. This causes the wealth level of the fraudulent individual who is caught to be limited to W. ω is the moral cost of fraud. As in Dionne et al (2009), we assume that $\partial U/\partial\omega < 0$. We also assume that $\partial^2 U/\partial W\partial\omega < 0$. The individual will defraud if

$$gU(W+\theta\frac{A}{h(t)}+A-D,\omega)+(1-g)U(W,\omega)\ge U(W+\frac{A}{h(t)},0)$$

In the absence of moral cost of fraud ($\omega = 0$), there is a critical successful fraud probability $\tilde{g}$ at which there is indifference between being honest and dishonest:

$$\tilde{g}U(W+\theta\frac{A}{h(t)}+A-D,0)+(1-\tilde{g})U(W,0)=U(W+\frac{A}{h(t)},0)$$

$0<\tilde{g}<1$. When the successful fraud probability $p>\tilde{g}$, the individual would defraud. Furthermore, this critical value of the probability of the fraud being successful is:

$$\tilde{g}=\frac{U(W+\frac{A}{h(t)},0)-U(W,0)}{U(W+\theta\frac{A}{h(t)}+A-D,0)-U(W,0)}\ .$$

The expected utility function of an individual who has a probability (α) of engaging in fraudulent behavior can therefore be written as:

$$EU = \alpha[\tilde{g}U(W + \theta \frac{A}{h(t)} + A - D, 0) + (1 - \tilde{g})U(W, 0)] + (1 - \alpha)U(W + \frac{A}{h(t)}, 0)$$

The individual has a probability equal to 1 of engaging in fraud when the probability of the fraud being successful is above $\tilde{g}$. On the contrary, the individual has a probability equal to 0 of engaging in fraud when the probability of the fraud being successful is below $\tilde{g}$. In addition, there is a probability of fraud of between 1 and 0 when the probability of the fraud being successful is equal to $\tilde{g}$. Consequently, the probability of an individual engaging in fraud decreases with $\tilde{g}$. Intuitively, $\tilde{g}$ should be very low to defraud, which means that when there is no moral cost for an individual, the threshold for the individual to defraud is very low.

When there is no moral cost for the individual, as time increases:

$$\frac{d\tilde{g}}{dt} = \{\frac{-[U(W + \frac{A}{h(t)}, 0) - U(W, 0)]U'(W + \theta \frac{A}{h(t)} + A - D, 0)[-(\theta \frac{A}{h(t)^2})]}{[U(W + \theta \frac{A}{h(t)} + A - D, 0) - U(W, 0)]^2}$$

$$+ \frac{U'(W + \frac{A}{h(t)}, 0)(-\frac{A}{h(t)^2})}{[U(W + \theta \frac{A}{h(t)} + A - D, 0) - U(W, 0)]}\}h'(t)$$

We rewrite (den) as the denominator of the above equation and obtain:

$$\frac{d\tilde{g}}{dt} = \frac{(\frac{A}{h(t)^2})}{(den)^2}\{[U(W + \frac{A}{h(t)}, 0) - U(W, 0)]U'(W + \theta \frac{A}{h(t)} + A - D, 0)\theta$$
$$-[U(W + \theta \frac{A}{h(t)} + A - D, 0) - U(W, 0)]U'(W + \frac{A}{h(t)}, 0)\}h'(t)$$

Because the incentive for an individual to engage in fraud is higher when $\theta \frac{A}{h(t)} + A - D \geq \frac{A}{h(t)}$, the first set of square brackets is smaller than the second set in the above equation, and the first derivative of the utility under $W + \theta \frac{A}{h(t)} + A - D$ is also smaller than the corresponding derivative under $W + \frac{A}{h(t)}$. In addition, θ is between 0 and 1. All of these factors make the value inside the braces negative. Moreover, $h'(t) > 0$, hence, the sign of the above equation ($\frac{d\tilde{g}}{dt}$) is negative.

The above analysis infers that $\tilde{g}$ will decrease with t, and that the probability α will increase with t. Hence, the probability (α) of an individual engaging in fraud is higher near the end of the policy year. If the audit probability of the insurance company is flat over the whole policy year, the equilibrium rate of fraud could also be higher near the end of the policy year.

When there is a moral cost ($\omega > 0$), there is also a critical successful fraud probability $\hat{g}$ at which there is indifference between being honest and dishonest:

$$\hat{g}U(W+\theta\frac{A}{h(t)}+A-D,\omega)+(1-\hat{g})U(W,\omega)=U(W+\frac{A}{h(t)},0)$$

We can derive the critical value of the probability of the fraud being successful $\hat{g}=\hat{g}(\omega)$. For each ω level, there is a corresponding $\hat{g}(\omega)$. When the successful fraud probability is $p>\hat{g}$, the individual would defraud. We can verify that $0<\tilde{g}<\hat{g}<1$. When the successful fraud probability is $p>\hat{g}$, the individual would defraud, where $\hat{g}$ solves:

$$\hat{g}(\omega)=\frac{U(W+\frac{A}{h(t)},0)-U(W,\omega)}{U(W+\theta\frac{A}{h(t)}+A-D,\omega)-U(W,\omega)}$$

As time increases:

$$\frac{d\hat{g}}{dt}=\{\frac{-[U(W+\frac{A}{h(t)},0)-U(W,\omega)]U'(W+\theta\frac{A}{h(t)}+A-D,\omega)[-(\theta\frac{A}{h(t)^2})]}{[U(W+\theta\frac{A}{h(t)}+A-D,\omega)-U(W,\omega)]^2}$$

$$+\frac{U'(W+\frac{A}{h(t)},0)(-\frac{A}{h(t)^2})}{[U(W+\theta\frac{A}{h(t)}+A-D,\omega)-U(W,\omega)]}\}h'(t)$$

We also find that $\frac{d\hat{g}}{dt}<0$, which means that the critical successful fraud probability would decrease over time. We can also analyze the effect of moral cost on $\frac{d\hat{g}}{dt}$. We do not present this relationship here because we do not have data to test its sign. The theoretical result is available from the authors.

Appendix C: Insurance fraud under the no-deductible contract

First, we examine whether the incentive of insurance fraud is higher under a no-deductible endorsement. We still assume the individual is risk-averse,

$$gU(W+\theta\frac{A}{h(t)}+\frac{A}{k(t)}-D,\omega)+(1-g)U(W,\omega)\ .$$

The individual's insurance contract is indemnified with depreciation. The depreciation rate ($k(t)$) increases with time t. Furthermore, the depreciation rate from the indemnity of the insurance company ($k(t)$) is more stringent than that in the market ($h(t)$), i.e., $k(t)>h(t)$ and $\frac{1}{k(t)^2}k'(t)>\frac{1}{h(t)^2}h'(t)\ \forall t$. The definitions of g, W, θ, A, and ω are the same as those in the model in Appendix B. The totally expropriated constraint is also the same as in Appendix B.

There exists a critical value of the probability ($\tilde{g}$) of the fraud being successful at which there is indifference between being honest and dishonest:

$$\tilde{g}U(W+\theta\frac{A}{h(t)}+\frac{A}{k(t)}-D,\omega)+(1-\tilde{g})U(W,\omega)=U(W+\frac{A}{h(t)})\ .$$

The expected utility function of an individual who has the probability (α) of engaging in fraud is therefore expressed as follows:

$$EU=\alpha[\tilde{g}U(W+\theta\frac{A}{h(t)}+\frac{A}{k(t)},\omega)+(1-\tilde{g})U(W,\omega)]+(1-\alpha)U(W+\frac{A}{h(t)})\ .$$

The individual has a probability of 1 of engaging in fraud when the probability of the fraud being successful is above $\tilde{g}$. Conversely, the individual has a probability of 0 of engaging in fraud when the probability of the fraud being successful is below $\tilde{g}$. Finally, the individual has a probability of fraud of between 1 and 0 when the probability of the fraud being successful equals $\tilde{g}$. To summarize, the probability of the individual's engaging in fraud decreases with $\tilde{g}$.

Furthermore, this critical value of the probability of the fraud being successful is:

$$\tilde{g}=\frac{U(W_2)-U(W_3,\omega)}{U(W_1,\omega)-U(W_3,\omega)}=\frac{\Delta_2}{\Delta_1}\ .$$

where $W_1 = W + \theta \frac{A}{h(t)} + \frac{A}{k(t)} - D$, $W_2 = W + \frac{A}{h(t)}$, $W_3 = W$; $\tilde{g}$ is the relative utility of no cheating. It is the utility difference between no cheating and being caught cheating, compared with the utility difference between cheating and being caught cheating.

As the deductible increases:

$$\frac{d\tilde{g}}{dD} = \frac{\Delta_2}{\Delta_1}[-\frac{1}{\Delta_1}U'(W_1,\omega)(-1)],$$

we find that $\tilde{g}$ is affected by the comparative utility of no cheating ($\frac{\Delta_2}{\Delta_1}$), and the relative marginal effect of deductible ($\frac{1}{\Delta_1}U'(W_1,\omega)$). The above derivative is positive, which means that when the deductible increases, the critical value of the probability of successful fraud also increases, and the incentive to defraud decreases. Hence, people who purchase no-deductible contracts have a stronger incentive to defraud.

We now discuss the relative claim timing pattern for the contract with depreciation and no-deductible endorsement in contrast to the reference contract. We consider the impact of timing on the incentive induced by the no-deductible endorsement. In other words, we consider the impact of t on $\frac{d\tilde{g}}{dD}$. Let $H = \frac{d\tilde{g}}{dD}$, then

$$\frac{dH}{dt} = \frac{d}{dt}(\frac{\Delta_2}{\Delta_1})[-\frac{1}{\Delta_1}U'(W_1,\omega)(-1)] + (\frac{\Delta_2}{\Delta_1})\frac{d}{dt}[-\frac{1}{\Delta_1}U'(W_1,\omega)(-1)]$$

$$= \frac{1}{(\Delta_1)^2}(\Delta_1 U'(W_2)(-\frac{A}{h(t)^2}h'(t)) - \Delta_2 U'(W_1,\omega)(-\theta\frac{A}{h(t)^2}h'(t) - \frac{A}{k(t)^2}k'(t)))[-\frac{1}{\Delta_1}U'(W_1,\omega)(-1)]$$
$$+ (\frac{\Delta_2}{\Delta_1})[\frac{1}{\Delta_1}U''(W_1,\omega) - \frac{1}{{\Delta_1}^2}(U'(W_1,\omega))^2](-\theta\frac{A}{h(t)^2}h'(t) - \frac{A}{k(t)^2}k'(t))$$

The first term in the above equation means that the relative utility of no cheating is varying with time. Regardless of whether cheating occurs, the utility will decrease because of depreciation. If the difference in wealth level between no deductible and deductible contracts is sufficient, this first term will be negative. This means that over time, the utility of the no deductible contract will decrease more under no cheating, but it will decrease less under cheating. The incentive of fraud induced by no-deductible contracts would decrease over time.

The second term means that the marginal utility affected by the deductible is varying over time. It is positive, and it contrasts with the first term whereby the fraud incentive from a no-deductible contract increases over time, because the marginal utility of wealth is higher when the wealth level depreciates over time. However, if the difference in wealth level between no deductible and deductible contract is sufficient, the whole equation would still be negative. This means that the critical value of probability of successfully defraud induced by no deductible contract is mitigated over time. This corresponds to the second part of our second hypothesis, which states that the probability of fraud (for no-deductible endorsement contracts) is higher at the beginning of the policy year. We can also explore the theoretical relationship between moral cost of fraud and $\frac{dH}{dt}$. Results are available from the authors.

Appendix D: Complete empirical results of the 12th policy month and the 1st policy month of Equations (1) and (2)

Variable	*12th policy month*				*1st policy month*			
	1st stage		*2nd stage*		*1st stage*		*2nd stage*	
	Estimate	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*
intercept	-17.253	0.890	-0.481	<.0001	-18.772	0.845	-0.561	<.0001
E (total theft)			0.121	0.063			1.972	0.001
total theft			1.703	<.0001			0.894	0.022
female	-0.065	0.087	0.129	<.0001	-0.138	<.0001	0.226	0.008
married	0.067	0.290	-0.288	<.0001	-0.037	0.547	0.087	0.001
age 20-25	4.402	0.001	-0.812	0.036	3.379	0.995	-7.157	0.001
age 26-30	4.241	0.003	-0.398	0.293	3.085	0.995	-6.724	<.0001
age 31-60	3.957	0.007	-0.193	0.596	2.852	0.996	-6.411	<.0001
age 61-70	3.978	0.007	-0.228	0.534	2.883	0.996	-6.472	<.0001
age above 70	-0.997	0.999	0.312	0.252	2.809	0.996	-6.231	<.0001
car age 0	0.673	0.011	0.164	<.0001	0.285	<.0001	-0.768	<.0001
car age 1	0.377	0.002	0.339	<.0001	0.257	<.0001	-0.340	0.032
car age 2	0.233	0.004	0.340	<.0001	0.256	<.0001	-0.454	0.004
car age 3	-0.032	0.771	0.265	<.0001	0.200	0.006	-0.361	0.004
car age 4	0.171	0.070	0.160	<.0001	0.157	0.045	-0.300	0.002
city	0.100	0.009	-0.303	<.0001	0.083	0.041	-0.169	0.001
north	-0.143	0.003	0.931	<.0001	-0.295	0.000	0.565	0.002
south	0.045	0.340	-1.298	<.0001	-0.089	0.055	0.162	0.004
east	-0.327	0.093	-1.283	<.0001	-0.060	0.591	0.345	<.0001
Nissan	-0.021	0.943	0.776	<.0001	-5.230	0.988	10.338	0.001
Ford	-0.058	0.386	-0.468	<.0001	-0.094	0.178	0.086	0.149
Honda	0.176	0.003	-0.172	<.0001	0.204	<.0001	-0.469	<.0001
Toyota	-0.081	0.073	1.205	<.0001	-0.056	0.254	-0.094	0.008
Mitsubishi	0.180	0.006	-0.209	<.0001	0.079	0.228	-0.200	0.021
sedan	0.356	0.014	0.798	<.0001	0.022	0.820	-0.617	0.003
freight truck	0.457	0.023	-0.548	0.003	0.307	0.023	-0.334	0.019
2000 cc engine	-0.031	0.879	-0.237	0.147	-0.028	0.879	-0.512	0.008
car dealer agent	-0.002	0.913	-0.688	0.006	-0.007	0.801	-0.341	0.011
rental company	-0.082	0.213	0.439	0.012	-0.069	0.277	0.397	0.010

transport service	0.019	0.233	-0.511	0.006	0.013	0.201	-0.486	<.0001
finance house	-0.071	0.308	-0.398	0.017	-0.054	0.429	-0.217	0.020
financial institution	0.009	0.879	-0.487	0.021	0.011	0.711	-0.610	0.005
insurance agent	-0.121	0.137	-0.508	0.010	-0.175	0.168	-0.113	0.042
y 2000	0.217	0.781	-1.021	<.0001	0.303	0.500	0.998	<.0001
y 2001	0.268	0.645	1.130	<.0001	0.191	0.712	0.716	<.0001
y 2002	0.277	0.598	-1.044	<.0001	0.301	0.511	0.823	<.0001
y 2003	0.262	0.523	-1.211	<.0001	0.198	0.698	0.645	<.0001
y 2004	0.227	0.618	1.037	<.0001	0.288	0.516	0.811	<.0001
y 2005	0.213	0.790	-1.002	<.0001	0.192	0.689	0.930	<.0001
y 2006	0.298	0.433	-0.581	<.0001	0.411	0.322	0.752	<.0001
Hausman test	2.83		1.97		2.07		1.33	

Notes:

In model (1), we estimate the conditional correlation between total theft claim and the contract coverage replacement cost endorsement.

In model (2), we estimate the conditional correlation between total theft claim and the contract coverage no-deductible endorsement.

We applied the Hausman test and did not reject the random effect model. The computed chi-square statistics are reported in the table.

This table presents the explanatory variables used as controls in the regressions of our analysis. A 12th policy month regression is linked more closely to the replacement cost endorsement clause, while the 1st policy month is linked more closely to the non-deductible endorsement. In each regression, the first dependent variable is the probability of having a vehicle stolen (1st stage) and the second variable is the probability of choosing an endorsement (2nd stage). The predicted variable of the first stage (*E (total theft)*) is used as explanatory variable in the second stage to control for non-linearity and misspecification. Total theft claim dummy variable (*total theft*) is the explanatory variable used to measure the conditional correlation. The other variables presented in Table 1 control for sex (*female*), marriage *(married)*, insured age (*age x*), the age of the car (*car age y*), city or not (*city*), region (*north, south*, *east*), type of car (*Nissan*, *Ford, Honda, Toyota*, *Mitsubishi*), use of vehicle (*sedan* or *freight truck*), sales channel (*car dealer agent*, *rental company*, *transport service*, *finance house, financial institution*, *insurance agent*), and year of the insurance polity (*year t*). Estimate is the estimated coefficient and P-value is for statistical significance.

Appendix E: Complete empirical results of the 12th policy month and the 1st policy month of Equation (3)

Variable	*12th policy month*				*1st policy month*			
	1st stage		*2nd stage*		*1st stage*		*2nd stage*	
	Estimate	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*	*Estimate*	*P-value*
intercept	-17.253	0.890	-0.875	<.0001	-18.772	0.845	-0.766	<.0001
E (total theft)			2.836	0.524			5.448	0.481
total theft			15.000	0.025			9.276	0.018
interaction			-0.148	0.038			-0.093	0.016
female	-0.065	0.087	0.011	<.0001	-0.138	<.0001	-0.861	0.421
married	0.067	0.290	-0.537	<.0001	-0.037	0.547	-0.190	0.536
age 20-25	4.402	0.001	-12.562	0.145	3.379	0.995	22.629	0.362
age 26-30	4.241	0.003	-11.727	0.907	3.085	0.995	21.096	0.436
age 31-60	3.957	0.007	-10.872	0.644	2.852	0.996	19.963	0.489
age 61-70	3.978	0.007	-10.929	0.670	2.883	0.996	20.050	0.484
age above 70	-0.997	0.999	2.345	0.921	2.809	0.996	20.099	0.491
car age 0	0.673	0.011	-1.394	<.0001	0.285	<.0001	1.296	0.550
car age 1	0.377	0.002	-0.907	<.0001	0.257	<.0001	1.101	0.573
car age 2	0.233	0.004	-0.720	<.0001	0.256	<.0001	1.133	0.562
car age 3	-0.032	0.771	0.007	<.0001	0.200	0.006	1.028	0.505
car age 4	0.171	0.070	-0.609	<.0001	0.157	0.045	0.494	0.677
city	0.100	0.009	-0.425	<.0001	0.083	0.041	0.415	0.517
north	-0.143	0.003	1.472	<.0001	-0.295	0.000	-1.507	0.508
south	0.045	0.340	-0.594	<.0001	-0.089	0.055	-0.554	0.430
east	-0.327	0.093	-0.011	<.0001	-0.060	0.591	-0.389	0.458
Nissan	-0.021	0.943	0.868	<.0001	-5.230	0.988	-34.947	0.997
Ford	-0.058	0.386	-0.038	<.0001	-0.094	0.178	-0.477	0.521
Honda	0.176	0.003	-1.222	<.0001	0.204	<.0001	1.230	0.440
Toyota	-0.081	0.073	0.940	<.0001	-0.056	0.254	-0.445	0.332
Mitsubishi	0.180	0.006	-0.491	0.017	0.079	0.228	0.387	0.502
sedan	0.356	0.014	0.836	<.0001	0.022	0.820	-0.745	0.002
freight truck	0.457	0.023	-0.620	<.0001	0.307	0.023	-0.869	<.0001
2000 cc engine	-0.031	0.879	-0.125	<.0001	-0.028	0.879	-0.238	<.0001
car dealer agent	-0.002	0.913	-0.701	0.001	-0.007	0.801	-0.544	0.002
rental company	-0.082	0.213	0.537	0.007	-0.069	0.277	0.312	0.011

transport service	0.019	0.233	-0.562	0.007	0.013	0.201	-0.076	0.065
finance house	-0.071	0.308	-0.427	0.010	-0.054	0.429	-0.297	0.114
financial institution	0.009	0.879	-0.672	0.006	0.011	0.711	-0.581	0.003
insurance agent	-0.121	0.137	-0.629	0.005	-0.175	0.168	-0.267	0.218
y 2000	0.217	0.781	-1.345	<.0001	0.303	0.500	0.839	<.0001
y 2001	0.268	0.645	1.394	<.0001	0.191	0.712	0.764	<.0001
y 2002	0.277	0.598	-1.907	<.0001	0.301	0.511	1.011	<.0001
y 2003	0.262	0.523	-1.720	<.0001	0.198	0.698	0.876	<.0001
y 2004	0.227	0.618	1.007	<.0001	0.288	0.516	0.882	<.0001
y 2005	0.213	0.790	-1.609	<.0001	0.192	0.689	0.988	<.0001
y 2006	0.298	0.433	-0.425	<.0001	0.411	0.322	1.032	<.0001
Hausman test	2.83		2.05		2.07		1.98	

Notes:

In model (1'), we estimate the conditional correlation between total theft claim and the contract coverage replacement cost endorsement.

In model (2'), we estimate the conditional correlation between total theft claim and the contract coverage no-deductible endorsement.

We applied the Hausman test and did not reject the random effect model. The computed chi-square statistics are reported in the table.

This table presents the explanatory variables used as controls in the regressions of our analysis. A 12th policy month regression is linked more closely to the replacement cost endorsement clause, while the 1st policy month is linked more closely to the non-deductible endorsement. In each regression, the first dependent variable is the probability of having a vehicle stolen (1st stage) and the second variable is the probability of choosing an endorsement (2nd stage). The predicted variable of the first stage (*E (total theft)*) is used as explanatory variables in the second stage to control for non-linearity and misspecification. The total theft claim dummy variable (*total theft*) is the explanatory variable used to measure the conditional correlation. *Interaction* is the interaction between total theft and business cycle. The other variables discussed in Table 1 control for sex (*female*), marriage (*married*), insured age (*age x*), the age of the car (*car age y*), city or not (*city*), region (*north*, *south*, *east*), type of car (*Nissan*, *Ford*, *Honda, Toyota, Mitsubishi*), use of vehicle (*sedan* or *freight truck*), sales channel (*car dealer agent*, *rental company*, *transport service*, *finance house*, *financial institution*, *insurance agent*), and year of the insurance polity (*year t*). Estimate is the estimated coefficient and P-value is for statistical significance.

Table 1 Definitions of variables

Variable	Definition
claim jki_t	A variable that equals 1 when policy-holder_i has filed a *k*-type theft claim in the *j*-th month during the policy year *t*, *j*=1 to 12, *k*=*h* or *p*, (*h* means total theft, and *p* means partial theft), and 0 otherwise.
replacement cost	A variable that equals 1 when the theft insurance contract has a replacement cost endorsement, and 0 otherwise (depreciation).
non-deductible	A variable that equals 1 when the theft insurance contract is a no-deductible contract, and 0 otherwise (deductible).
female	A variable that equals 1 if the insured is female, and 0 otherwise (male).
married	A variable that equals 1 if the insured is married, and 0 otherwise (not married).
age 20-25	A variable that equals 1 if the insured is between the ages of 20 and 25, and 0 otherwise.
age 26-30	A variable that equals 1 if the insured is between the ages of 25 and 30, and 0 otherwise.
age 31-60	A variable that equals 1 if the insured is between the ages of 30 and 60, and 0 otherwise.
age 61-70	A variable that equals 1 if the insured is between the ages of 60 and 70, and 0 otherwise.
age above 70	A variable that equals 1 if the insured is over 70 years old, and 0 otherwise.
car age 0	A variable that equals 1 when the car is under one year old, and 0 otherwise.
car age 1	A variable that equals 1 when the car is one year old, and 0 otherwise.
car age 2	A variable that equals 1 when the car is two years old, and 0 otherwise.
car age 3	A variable that equals 1 when the car is three years old, and 0 otherwise.
car age 4	A variable that equals 1 when the car is four years old, and 0 otherwise.
city	A variable that equals 1 when the owner of the car lives in a city, and 0 otherwise.

north	A variable that equals 1 when the car is registered in the north of Taiwan, and 0 otherwise.
south	A variable that equals 1 when the car is registered in the south of Taiwan, and 0 otherwise.
east	A variable that equals 1 when the car is registered in the east of Taiwan, and 0 otherwise.
brand vehicle	A variable that equals 1 when the vehicle is brand *q*, *q*=*n*, *f*, *h*, *t*, *c*, and 0 otherwise (other brands).
sedan	A variable that equals 1 when the car is a sedan and is for non-commercial or for long-term rental purposes, and 0 otherwise (all other usages).
freight truck	A variable that equals 1 when the vehicle is a small freight truck used for non-commercial purposes, and 0 otherwise (all other usages)
2000 cc engine	A variable that equals 1 when the insured car has an engine capacity of 2000 c.c. or less, and 0 otherwise (above 2000 c.c.).
distribution channel m	A variable that equals 1 when the policy is sold through the *m* channel, *m*=*D*, *R*, *T*, *L*, *F*, *A*, and 0 otherwise (directly from insurance company).
year t	A variable that equals 1 when the data belong to the policy year *t*=2000 to 2006, and 0 otherwise (2007).

Notes:

The reference group of variables *age* is the group of insured whose age is under 20.

The reference group of variables from *car age* is the group of cars over four years old.

The reference group for the three variables of area includes the cars registered in central Taiwan.

The reference group for the policy year variables is the group of data from the policy year 2007.

Brand vehicle: n = Nissan; f = Ford; h = Honda; t = Toyota; c = Mitsubishi.

Chanel: D = car dealer agent; R = rental company; T = transport service company; L = finance house, F = financial institution, A = insurance agent.

Table 2 Descriptive statistics

Variable	Mean	Std. Dev.
replacement cost	0.3358	0.4699
non-deductible	0.0260	0.1554
female	0.6255	0.4840
married	0.9123	0.2828
age 20-25	0.0091	0.0949
age 26-30	0.0639	0.2446
age 31-60	0.8797	0.3253
age 61-70	0.0410	0.1986
age above 70	0.0066	0.0773
car age 0	0.2070	0.3942
car age 1	0.1545	0.3694
car age 2	0.1371	0.3462
car age 3	0.1190	0.3213
car age 4	0.1014	0.2978
city	0.5351	0.4988
north	0.4795	0.4996
south	0.2784	0.4482
east	0.0229	0.1496
Nissan	0.0062	0.0743
Ford	0.1049	0.3064
Honda	0.0788	0.2585
Toyota	0.3929	0.4884
Mitsubishi	0.0823	0.2773
sedan	0.9643	0.1817
freight truck	0.0183	0.1237
2000 cc engine	0.6427	0.4792
car dealer agent	0.4177	0.4971
rental company	0.0004	0.0201
transport service	0.0040	0.0594
finance house	0.0330	0.1417
financial institution	0.0145	0.1224
insurance agent	0.0278	0.1726

Table 3 Relationship between age and type of vehicle with respect to period of the year they are stolen

	In whole sample	Subsample of stolen vehicles with replacement cost endorsement contract		Subsample of stolen vehicles with no-deductible endorsement contract	
		Last 7 months	Other months	First 3 months	Other months
Brand new vehicles	20.7%	67.28%	32.72%	60.87%	39.13%
Popular brand vehicles	39.29%	56.32%	43.68%	63.41%	36.59%

Table 4 Conditional correlation between coverage and claim

Policy month	Total theft claim (*k*=*h*)		Partial theft claim (*k*=*p*)	
	Model (1) Replacement (*l*=*R*)	Model (2) No-deductible (*l*=*ND*)	Model (3) Replacement (*l*=R)	Model (4) No-deductible (*l*=*ND*)
1st policy month (*j*=*1*)	0.287 (0.221)	0.894 (0.022)	0.213 (0.211)	0.097 (0.623)
2nd policy month (*j*=*2*)	0.301 (0.192)	0.507 (0.040)	0.165 (0.332)	0.209 (0.301)
3rd policy month (*j*=*3*)	0.141 (0.541)	0.389 (0.079)	0.194 (0.272)	0.174 (0.283)
4th policy month (*j*=*4*)	0.230 (0.188)	0.198 (0.299)	0.091 (0.609)	0.097 (0.531)
5th policy month (*j*=*5*)	0.092 (0.681)	0.168 (0.395)	0.062 (0.478)	0.109 (0.238)
6th policy month (*j*=*6*)	0.523 (0.023)	0.114 (0.422)	0.097 (0.581)	0.074 (0.652)
7th policy month (*j*=*7*)	0.965 (<0.0001)	0.138 (0.321)	0.100 (0.270)	0.039 (0.884)
8th policy month (*j*=*8*)	0.683 (0.002)	0.045 (0.761)	0.081 (0.613)	0.052 (0.688)
9th policy month (*j*=*9*)	0.731 (0.003)	0.039 (0.812)	0.122 (0.297)	0.189 (0.258)
10th policy month (*j*=*10*)	0.552 (0.019)	0.005 (0.974)	0.013 (0.899)	0.047 (0.768)
11th policy month (*j*=*11*)	1.356 (<0.0001)	0.094 (0.592)	0.057 (0.682)	0.005 (0.923)
12th policy month (*j*=*12*)	1.703 (<0.0001)	0.211 (0.228)	0.079 (0.672)	0.075 (0.691)

Notes: The P-values are in parentheses. All the values displayed in the above table are the estimated coefficients of $\beta_{c,l,j}$. We test the conditional correlation between coverage and claim by $\beta_{c,l,j}$. For each policy month (j, j=1~12), we estimate the conditional correlation between claim (k, k=h represents total theft claim; k=p represents partial theft claim) and contract coverage (l, l=R represents replacement cost endorsement; l=ND represents no-deductible contract) using the two-stage method. In model (1), we estimate the conditional correlation between total theft claims and the coverage of contracts with replacement cost endorsement. In model (2), we estimate the conditional correlation between total theft claims and the coverage of contracts with no-deductible endorsement. In model (3), we estimate the conditional correlation between partial theft claims and the coverage of contracts with replacement cost endorsement. In model (4), we estimate the conditional correlation between partial theft claims and the coverage of contracts with no-deductible endorsement.

When we conducted a two-stage conditional correlation analysis on the above 48 pairs, we applied the Hausman test to each of the 96 regressions. In all cases, the results do not reject the random effect model.

Table 5 Relationship between insurance fraud and the business cycle

Policy month	Model (1') replacement (*l*=*R*)		Model (2') no-deductible (*l*=*ND*)	
	Coefficient $\beta_{C,l,j}$	Coefficient $\beta_{BC,l,j}$	Coefficient $\beta_{C,l,j}$	Coefficient $\beta_{BC,l,j}$
1st policy month	0.203	-0.003	9.276	-0.093
(*j*=*1*)	(0.962)	(0.946)	(0.018)	(0.016)
2nd policy month	2.073	-0.018	14.667	-0.153
(*j*=*2*)	(0.656)	(0.695)	(0.065)	(0.062)
3rd policy month	3.013	-0.030	6.171	-0.064
(*j*=*3*)	(0.561)	(0.565)	(0.213)	(0.207)
4th policy month	4.924	-0.053	6.348	-0.065
(*j*=*4*)	(0.347)	(0.314)	(0.261)	(0.260)
5th policy month	2.947	-0.030	3.139	-0.033
(*j*=*5*)	(0.526)	(0.515)	(0.256)	(0.221)
6th policy month	3.019	-0.033	8.242	-0.088
(*j*=*6*)	(0.541)	(0.511)	(0.293)	(0.274)
7th policy month	2.706	-0.030	2.621	-0.023
(*j*=*7*)	(0.614)	(0.573)	(0.460)	(0.461)
8th policy month	0.552	-0.007	1.952	-0.018
(*j*=*8*)	(0.924)	(0.908)	(0.562)	(0.596)
9th policy month	5.540	-0.052	2.222	-0.023
(*j*=*9*)	(0.375)	(0.407)	(0.619)	(0.629)
10th policy month	11.620	-0.125	2.140	-0.023
(*j*=*10*)	(0.063)	(0.093)	(0.692)	(0.680)
11th policy month	13.658	-0.145	1.216	-0.009
(*j*=*11*)	(0.050)	(0.040)	(0.666)	(0.737)
12th policy month	15.000	-0.148	0.707	-0.007
(*j*=*12*)	(0.025)	(0.038)	(0.871)	(0.879)

Notes: P-values are in parentheses. All the values displayed above are the estimated coefficients of $\beta_{C,l,j}$ and $\beta_{BC,l,j}$. We test the conditional correlation between coverage and claim by $\beta_{C,l,j}$. We test the correlation between insurance fraud and the business cycle by $\beta_{BC,l,j}$. For each policy month (j, j=1~12), we estimate the condition correlation between claim (we test only for total theft claim here, hence k=h only.) and contract coverage (l, l=R represents replacement cost endorsement; l=ND represents no-deductible contract) using the two-stage method. In model (1'), we estimate the conditional correlation between total theft claim and the coverage of contracts with replacement cost endorsement. In model (2'), we estimate the conditional correlation between total theft claims and the coverage of contract with no-deductible endorsement. When we conducted the two-stage conditional correlation analysis on the above 24 pairs, we applied the Hausman test to each of the 48 regressions. In all cases, the results do not reject the random effect model.