경영학 석사 학위논문

Ex-post Moral Hazard in Korean Automobile Insurance Market

한국 자동차 보험 시장의 도덕적 해이 연구

2019 년 2 월

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Abstract

Ex-post Moral Hazard in Korean Automobile Insurance Market

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This study examines the existence of ex-post moral hazard in Korean automobile insurance market, driven by the regulation change that increase insurance coverage for physical automobile accidents in 2010. Exploiting the regulation that reported claim severity that is less than or equal to the insurance coverage does not increase policyholders' insurance premium for the forthcoming year, policyholders have incentives to exaggerate and report their claim severity. Empirical analyses discover positive and significant relationship between the insurance coverage and reported claim severity, and statistically significant discontinuity are examined at chosen insurance coverage level, implying the manipulation of claim severity by the policyholders. Stronger relationship is analyzed for losses with greater policyholders' exposure, further confirming the existence of fraudulent behavior. Additionally, presence of selection on moral hazard is found and is subject to further discussions.

Keywords: automobile insurance, ex-post moral hazard, selection on moral hazard

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Contents

Figures and Tables

I. Introduction

Overview

Ex-post moral hazard can be explained with fraudulent behavior of policyholders who exaggerate their claim severity to gain greater amount of claim after the incident. This tendency is often observed in the insurance industry, where an information asymmetry between the policyholders and the insurer is common. This study, using ample and dynamic individual-level data provided by the one of the largest property and casualty insurers in Korea, investigates the impact of ex-post moral hazard in Korean automobile insurance industry, on the reported claim severity of the policyholders, as well as the aspects of selection on moral hazard.

Previous Literature

Opportunistic fraud or claim build-up have been studied by researchers in various fields of insurance market including health, employees' compensation, automobile and other insurances. Dionne and Gagné (2002) find evidence of ex-post moral hazard in automobile theft insurance which covers for the replacement of the insured vehicle. They identify that policyholders are more likely to contribute to ex-post moral hazard and file a fraudulent claim especially when there are most monetary incentives – which is near the end of the endorsement. Pao et al. (2014) also explain the presence of opportunistic fraud in Taiwanese automobile insurance market, after the typhoons hit. They extrapolate that policyholders who live in the typhoon-affected region and purchased an automobile theft insurance are more likely to claim for theft, than policyholders who live in the typhoon-affected region and purchased both automobile theft and flood insurance. This can be interpreted with the tendency of policyholders who do not own the flood insurance cover their vehicles with the automobile theft endorsement after disposing their vehicles. Also, following what Dionne and Gagné (2002) depict, there are no signs of fraud for partial claims, as monetary incentives are limited for partial claims.

Lee and Kim (2016) study Korean automobile insurance market after the regulation change in the premium surcharge threshold level in 2010 and the introduction of coinsurance in 2011. Using firm-level panel data from 13 Korean insurance companies, they show that the aggregated loss ratio sharply increases in 2010 (16.5%), then decreases by similar amount (15.9%) in 2011. The results indicate that policyholders exploit the insurance coverage increase for their benefits and this phenomenon decreases instantly when the amount of insureds' payment increases with the introduction of coinsurance the next year. Such extreme changes in loss ratio is interpreted as the ex-post moral hazard. However, as much as this study is limited to firm-level data, the interpretation of the result does not directly explain the behavior of the claimants.

Automobile Insurance in Korea

Korean automobile insurance features bonus-malus factor, which involves imposing insurance discount or premium, based on the driving history of the policyholders. Insurance discount or premium is calculated considering whether there has been an accident and its type, frequency and severity of the accident occurred during the past one year. If the accident involves human damages, depending on the severity, the accident record score ranges from 1 to 4 per accident. If the accident only involves vehicles, depending on the severity, the accident record score ranges from 0.5 to 1 per accident. If the severity is less than or equal to the certain threshold level that policyholder is endorsed with, accident record score is 0.5.

If collision is reported during the one-year insurance contract and the accident record score is 1, policyholder's insurance benefits worsen, whereas when the accident record score is 0.5, one's benefit is maintained. The certain threshold level that distinguishes the accident record score from 0.5 to 1, can be interpreted as the maximum insurance coverage. This maximum insurance coverage is explicitly applied to physical accident which only involves the damage to the vehicles. Insured amount, i.e. total loss to insurers, is the sum of physical damage to counterparty's vehicle (hereafter as PD losses) and physical damage to own vehicle (hereafter as CNC losses).

As of 2010, policyholders are allowed to select their maximum insurance coverage, i.e. threshold of either KRW500,000, KRW1,000,000, KRW1,500,000 or KRW2,000,000, from the single original amount of KRW500,000. [1] The consequences of increasing the insurance coverage from KRW500,000 to maximum of KRW2,000,000 involve a dramatic rise in insurers' loss in 2010. Due to such unexpected increase, new automobile insurance legislation is imposed in 2011. Simple requirement of KRW50,000 deductible, regardless of the claim severity, has

[1] Korea Insurance Development Institute (2015)

been replaced with either 20% or 30% of coinsurance of the reported claim severity, in order to counteract the fraudulent claims.

Proposed Approach

This paper identifies the presence of ex-post moral hazard in 2010, due to the change in automobile insurance regulation that increased maximum insurance coverage by 4 times. The study begins with comparing the arithmetic mean of loss size in 2009 and 2010. If the loss has increased due to the increase in the insurance coverage, it may explain the first hypothesis that there is a positive relationship between claim severity and the insurance coverage.

Dividing the losses into 3 categories gives clearer formation of the losses. Comparing total loss to loss with only CNC losses, loss with only PD losses and loss that involve both CNC and PD losses, it is expected that loss with only CNC losses will produce the most significant results. It is intuitive to anticipate such result as CNC-only losses are most exposed to policyholders' will, thus are most likely to be artificially increased.

Difference-in-difference analysis is performed to statistically test whether the amount of average claim severity has increased, and whether those who chose threshold level of KRW2,000,000 incur higher losses than those who remain at the threshold level of KRW500,000. Controlling all exogenous variables that may influence the claim severity, policyholders with KRW2,000,000 threshold level are found to report higher losses in 2010. Total loss and CNC-only losses show statistically positive and significant coefficients, thereby supporting the expectation that losses with more exposure to policyholder's manipulation are more likely to be exaggerated.

Confirming the first hypothesis, to show evidence of ex-post moral hazard, abnormal concentration near and at the threshold level should be detected. Starting with comparison of simple claim severity distribution histograms in 2009 and 2010, obvious peaks at KRW 500,000 and KRW 2,000,000 are observed, which produce suspicions of manipulating the claim severity amount to match the threshold level. Additionally, comparing the histograms by the choice of threshold level, peaks at the loss amount that is equal to the chosen threshold level, are also observed.

Thus, following hypothesis proposes that the annual loss distribution is dependent on the threshold level chosen by the policyholders. Using the discontinuity test indicated by McCrary (2008), significant discontinuity at the threshold levels are discovered. Discontinuity at KRW500,000 is most significant for those who chose KRW500,000 as their threshold, and discontinuity at KRW2,000,000 is most significant for those who chose KRW2,000,000. This result supports the second hypothesis and confirms the manipulation of the claim severity by the policyholders.

Not limiting the research to the effects of ex-post moral hazard, this study extends to the concepts of selection on moral hazard, which can be described as the adverse selection aspects within the moral hazard effects (Einav et al. 2013). Insurance premium/discount standards are used for this analysis and these standards indicate the policyholders' magnitude of insurance benefits based on the accident score record which is described in 'Automobile Insurance in Korea'. Studying the claim frequency of policyholders with different insurance premium/discount standards, those with most insurance discount benefits are found to report more collisions in

TH150 and TH200, less collisions in TH50 and this tendency is limited for CNC-only losses. This result can be interpreted that as policyholders decided to exploit the regulation change as the opportunity to falsely report their losses. They chose higher threshold level to gain higher claim, and thus contribute to the moral hazard effects.

Remaining segments of this paper are structured as follows. In the next section, data descriptions and important pricing variables organization are explained. Subsequent sections examine the methodologies and empirical results and confirm the proposed hypotheses. This study is concluded with main findings and suggestions for future research.

II. Data

Descriptions of data

Ex-post moral hazard is suspected with the regulation change in the maximum insurance coverage for physical collision. Thus, data is limited to such accidents only, which implies that those accidents without CNC or PD loss, are excluded. Also, one of the underlying assumptions in this study is that the policyholder with accident record score of 0.5 has most contributed to the loss increase in 2010. Once again, this is due to the fact that the insurance discount benefits are not harmed if the accident record score is less than 1. Thus, in order to comply with such arrangements, claimants with only single collision record per year are included.

To adjust for unknown data formation error, total loss (i.e. CNC loss + PD loss) less than KRW10,000 are omitted. In addition, as policyholders with reported claim severity greater than KRW200,000,000 are considered to have no incentives to manipulate their losses, losses greater than KRW2,500,000 are excluded.[2] Final sample involves 656,850 claims for the consecutive years of 2009 and 2010.

As this study attempts to capture the manipulation of policyholders, the final sample is divided into three subsamples – CNC-only losses, PD-only losses and both PD & CNC losses included. This is consistent with the hypothesis that policyholders who report CNC-only losses are more exposed to manipulation of claim severity.

Summary Statistics & Variables

Table 1 lists the variables that are used in the empirical analyses. These variables are mentioned throughout the study and the term 'loss' and 'claim severity' are used interchangeably and the term 'threshold level' and 'insurance coverage' define the same object.

[Insert Table 1: Summary of Variables]

Summary statistics of losses and other pricing variables are illustrated in Table 2. Average losses in 2010 are greater than losses in 2009. Another noteworthy observation is that higher losses are concentrated in KRW2,000,000 threshold.

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[2] Similar results are produced after extending the maximum loss amount to KRW3,000,000.

[Insert Table 2: Summary statistics of variables]

Using the final sample consisting 656,850 claims, histograms and density plots are constructed. In 2009, abnormal peaks can be observed at KRW500,000 and KRW2,000,000. For clearer demonstration, histograms and density plots in 2010 are shown for the full sample, as well as for the sample segregated by the 4 threshold levels. Figure 1 shows peaks at the according threshold level, which are not as extreme or absent in other threshold levels – for example, peak at the KRW2,000,000 is most significant for claimants who chose KRW2,000,000 as their threshold. Figure 2 illustrates the density plot of reported claim severity by the policyholders which also visualizes abnormal peaks at according threshold levels.

[Insert Figure 1: Histogram of Annual Claim Severity]

[Insert Figure 2: Density Plot of Annual Claim Severity]

III. Empirical Results

As it is observed that average loss in 2010 is greater than average loss in 2009, this study statistically tests whether such increase in loss is driven by the changes in the maximum threshold level, that is, the insurance coverage. Difference-in-difference analysis is performed to examine the first hypothesis, that there is a positive relationship between the claim severity and insurance coverage. This hypothesis can be further confirmed with stronger relationship between the claim severity and insurance coverage in CNC-only losses. The proposed relationship of CNC-only losses and insurance coverage can be explained with easier intervention of policyholders to manipulate the claim severity. Thus, it is intuitive to suggest that the possibility of manipulation is highest for CNC-only losses and the lowest for PD-only losses, as the policyholders would not be able to adjust the claim amount for counterparty's vehicles.

This test is conducted with the following regressions:

$$\begin{aligned}\log(\mathrm{TOTAL\_LOSS_{it}}) &= \beta_1\mathrm{YEAR_t} + \beta_2(\mathrm{YEAR_t}\cdot\mathrm{TH100_i}) + \beta_3(\mathrm{YEAR_t}\cdot\mathrm{TH150_i}) \\ &+ \beta_4(\mathrm{YEAR_t}\cdot\mathrm{TH200_i}) + \beta_5\mathrm{TH100_i} + \beta_6\mathrm{TH150_i} + \beta_7\mathrm{TH200_i} \\ &+ \beta_8\mathrm{X_{it}} + \varepsilon_{it}\end{aligned}$$

$$\begin{aligned}\log(\mathrm{CNC-ONLY\_LOSS_{it}}) &= \beta_1\mathrm{YEAR_t} + \beta_2(\mathrm{YEAR_t}\cdot\mathrm{TH100_i}) + \beta_3(\mathrm{YEAR_t}\cdot\mathrm{TH150_i}) \\ &+ \beta_4(\mathrm{YEAR_t}\cdot\mathrm{TH200_i}) + \beta_5\mathrm{TH100_i} + \beta_6\mathrm{TH150_i} + \beta_7\mathrm{TH200_i} \\ &+ \beta_8\mathrm{X_{it}} + \varepsilon_{it}\end{aligned}$$

$$\begin{aligned}\log(\mathrm{PD-ONLY\_LOSS_{it}}) &= \beta_1\mathrm{YEAR_t} + \beta_2(\mathrm{YEAR_t}\cdot\mathrm{TH100_i}) + \beta_3(\mathrm{YEAR_t}\cdot\mathrm{TH150_i}) \\ &+ \beta_4(\mathrm{YEAR_t}\cdot\mathrm{TH200_i}) + \beta_5\mathrm{TH100_i} + \beta_6\mathrm{TH150_i} + \beta_7\mathrm{TH200_i} \\ &+ \beta_8\mathrm{X_{it}} + \varepsilon_{it}\end{aligned}$$

$$\log(\mathrm{CNC\&PD\_LOSS}_{it}) = \beta_1 \mathrm{YEAR}_t + \beta_2(\mathrm{YEAR}_t \cdot \mathrm{TH100}_i) + \beta_3(\mathrm{YEAR}_t \cdot \mathrm{TH150}_i) + \beta_4(\mathrm{YEAR}_t \cdot \mathrm{TH200}_i) + \beta_5 \mathrm{TH100}_i + \beta_6 \mathrm{TH150}_i + \beta_7 \mathrm{TH200}_i + \beta_8 X_{it} + \varepsilon_{it}$$

where X_{it} denotes the vector of exogenous pricing variables which includes the characteristics of the policyholder i, and the insured vehicle in year t.

Positive and significant coefficients of the interaction terms i.e. in β_2, β_3 and β_4 indicate the increase in average claim severity of the policyholders in 2010 in the according threshold levels. The result of above regressions is illustrated in Table 3.

[Insert Table 3: Difference-in-Difference Regressions – Total & Subsamples of Losses]

Coefficients of YEAR_t are positive and significantly different from zero in all regressions, implying that average claim severity has increased in 2010. Positive and significant coefficients of $\mathrm{TH200}_i$ indicate that those who chose threshold level of KRW2,000,000 have reported with greater claim severity. Most importantly, positive and significant coefficients of β_4 show that, on average, policyholders with TH200 claim higher amount to insurers in 2010, compared to the previous year. The results from the Table 3 support the first hypothesis that there is a positive relationship between the claim severity and insurance coverage.

Consistent with the prediction, claims with CNC-only losses are examined with greater differences in claim severity, compared to 2009. Insignificant results in PD-only losses and CNC & PD losses suggest that the claim severity of collisions involving other vehicles tend to be similar in 2009 and 2010. In other words, claims with CNC-only losses are exposed to artificial inflation of claim severity by the policyholders. In order to confirm that this manipulation is not just a random increase in the claim amount but is concentrated on the threshold level, discontinuity of the loss distribution is formally tested.

McCrary test statistically manifests the continuity at the prespecified cutoff in the density function of the running variable (McCrary 2008). In this setting, the running variable is the loss. If discontinuity at the cutoff, in this case, the threshold level, is significant, the manipulation of the claim severity to match the threshold level is confirmed.

Simplified explanation for this test starts with drawing a histogram that is defined with bins which do not include points in either below and above the specified discontinuity cutoff. Then the histogram is smoothed by deriving a weighted regression using the bin midpoints to characterize the height of the bins, in which the most weight is assigned to the bins nearest to the cutoff (McCrary 2008). The parameter that measures the significance of the discontinuity is θ, which is the log difference in height of bin just above and below the cutoff. To be consistent with the expectation, that the loss amount is manipulated upwards by the policyholders, the parameter, theta, should be negative (above – below). To support the second hypothesis that the annual loss distribution is dependent on the chosen threshold level, theta should be negative and significant at the threshold level, at the according cutoff.

Implication of McCrary test can be illustrated with the midpoints of the bins in a plot for total loss, CNC-only loss, PD-only loss and CNC&PD loss with cutoffs of KRW500,000, KRW1,000,000, KRW1,500,000 and KRW2,000,000 for two consecutive years in the Appendix A[3]. For more accurate analysis, the magnitude of discontinuity for each cutoff and sample is tabulated in Table 4.

[Insert Table 4: McCrary (2008) Test – Total & Subsamples of Losses]

Results for the overall sample, which is the total loss, show that the discontinuity at KRW1,000,000, KRW1,500,000 and KRW2,000,000 are more significant in 2010. Even though discontinuity is less significant for TH50 at KRW500,000 cutoff compared to the sample in 2009, the parameter is most significant compared to alternative threshold levels.

Comparing Panel A and B of Table 4, coefficients of discontinuity is greater in CNC-only losses, which depicts that policyholders who claim with CNC-only losses are more likely to manipulate the loss. This result is further confirmed with Panel C, which shows that the size of theta is less than CNC-only losses and total loss. As it is intuitive that PD-only losses are less exposed to policyholders' manipulation, this

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[3] The sample is extended to collisions with claim severity of up to KRW3,000,000 for more symmetric display of the plots, specifically when testing the cutoff of KRW2,000,000.

result is consistent with the previous empirical analysis, where difference-in-difference regression is performed. Overall results from the McCrary test support the second hypothesis that the annual loss distribution is dependent on the threshold level chosen by the policyholders, thereby confirming the evidence of ex-post moral hazard in the market.

IV. Discussions

Previous sections show the effects of ex-post moral hazard in Korean automobile insurance market. Using the individual-level data, this study can be further developed towards the concept of selection on moral hazard. Selection on moral hazard is first introduced by Einav et al (2013) and implies that the effects of moral hazard are heterogenous across individuals and their choice of insurance coverage is derived from their decision to enact according to the insurance coverage. In other words, this section analyzes whether few individuals initially decide to falsely report their loss, then choose their threshold level, according to their needs.

As previously mentioned, the regulation for insurance coverage increased to either KRW1,000,000, KRW1,500,000 and KRW2,000,000 depending on the policyholders' selection in 2010. If policyholders decide to falsely report their loss, it is more likely that they choose higher threshold level, such as TH150 or TH200. Incorporating bonus-malus feature, policyholders who benefit from the highest discount can be interpreted as those who have not claimed to insurers for a long period of time. Thus, if claim frequency suddenly increased in 2010, especially for those who pay the least insurance premium, the phenomenon may signal the evidence of moral hazard. Overall, if the collision frequency suddenly increased in 2010, for those who chose higher threshold than KRW500,000 and have been paying the least insurance premium, selection on moral hazard is present. Additionally, since this fraudulent behavior is driven by the policyholders' own expectations, there will be strong significance for CNC-only claims.

One of the distinct features from the previous difference-in-difference regression analysis is that the dependent variable is the claim frequency, rather than the claim severity. Thus, the dataset used for the analysis is also different, consisting all policyholders in 2009 and 2010, regardless of the occurrence of an accident. However, the sample is limited to those with a single accident count and this is due to the benefits of maintaining one's insurance premium standard (so that the insurance premium will not increase for the upcoming year) which can be exploited only when there is a single collision within one year. Therefore, the overall sample is 6,497,573 records of policyholders.

Another distinction from the previous regression is that this regression uses difference-in-difference-in-difference approach. Using the three-way interaction term for collision in 2010, those paying the least premium (highest discount) and threshold level, the analysis tests the statistical significance of the increase in collision frequency.

The test is conducted with the following regressions:

$$
\begin{aligned}
\mathrm{ACC\_CNT}_{it} = {} & \beta_1 \mathrm{YEAR}_t + \beta_2 \mathrm{STD\_HIGH}_{it} + \beta_3(\mathrm{YEAR}_t \cdot \mathrm{TH100}_i) + \beta_4(\mathrm{YEAR}_t \\
& \cdot \mathrm{TH150}_i) + \beta_5(\mathrm{YEAR}_t \cdot \mathrm{TH200}_i) + \beta_6(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it}) \\
& + \beta_7(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH100}_i) + \beta_8(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \\
& \cdot \mathrm{TH150}_t) + \beta_9(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH200}_i) + \beta_{10}(\mathrm{TH100}_i) \\
& + \beta_{11}(\mathrm{TH150}_i) + \beta_{12}(\mathrm{TH200}_i) + \beta_{13} X_{it} + \varepsilon_{it}
\end{aligned}
$$

$$
\begin{aligned}
& \mathrm{CNC\_ACC\_CNT}_{it} \\
& \quad = \beta_1 \mathrm{YEAR}_t + \beta_2 \mathrm{STD\_HIGH}_{it} + \beta_3(\mathrm{YEAR}_t \cdot \mathrm{TH100}_i) \\
& \quad + \beta_4(\mathrm{YEAR}_t \cdot \mathrm{TH150}_i) + \beta_5(\mathrm{YEAR}_t \cdot \mathrm{TH200}_i) + \beta_6(\mathrm{YEAR}_t \\
& \quad \cdot \mathrm{STD\_HIGH}_{it}) + \beta_7(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH100}_i) + \beta_8(\mathrm{YEAR}_t \\
& \quad \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH150}_t) + \beta_9(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH200}_i) \\
& \quad + \beta_{10}(\mathrm{TH100}_i) + \beta_{11}(\mathrm{TH150}_i) + \beta_{12}(\mathrm{TH200}_i) + \beta_{13} X_{it} + \varepsilon_{it}
\end{aligned}
$$

$$
\begin{aligned}
\mathrm{PD\_ACC\_CNT}_{it} = {} & \beta_1 \mathrm{YEAR}_t + \beta_2 \mathrm{STD\_HIGH}_{it} + \beta_3(\mathrm{YEAR}_t \cdot \mathrm{TH100}_i) \\
& + \beta_4(\mathrm{YEAR}_t \cdot \mathrm{TH150}_i) + \beta_5(\mathrm{YEAR}_t \cdot \mathrm{TH200}_i) + \beta_6(\mathrm{YEAR}_t \\
& \cdot \mathrm{STD\_HIGH}_{it}) + \beta_7(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH100}_i) + \beta_8(\mathrm{YEAR}_t \\
& \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH150}_t) + \beta_9(\mathrm{YEAR}_t \cdot \mathrm{STD\_HIGH}_{it} \cdot \mathrm{TH200}_i) \\
& + \beta_{10}(\mathrm{TH100}_i) + \beta_{11}(\mathrm{TH150}_i) + \beta_{12}(\mathrm{TH200}_i) + \beta_{13} X_{it} + \varepsilon_{it}
\end{aligned}
$$

where X_{it} denotes the vector of exogenous pricing variables which includes the characteristics of the policyholder i, and the insured vehicle in year t.

Positive and significant coefficients of β_7, β_8 and β_9 suggest the presence of selection on moral hazard for those who chose TH100, TH150 and TH200, respectively.

[Insert Table 5: Difference-in-Difference-in-Difference Regressions – Total and Subsamples of Records]

Table 5 shows that the aspects of selection on moral hazard do not exist in overall sample and PD-only accidents, but are present for CNC-only accidents with positive and significant coefficients in YEAR · STD_HIGH · TH150 and YEAR · STD_HIGH · TH200 variables. This result can be interpreted with policyholders with the highest insurance discount are more likely to falsely report their collision after choosing TH150 or TH200 in 2010. Negative and significant coefficient of YEAR·STD_HIGH is also notable in the table, which explains that those with the highest insurance discount and did not change their threshold level (thus still endorsed at TH50) are less likely to report their losses in 2010. In contrast, such trend is not illustrated when claim severity is set as the dependent variable in the exact same regressions, where all coefficients are insignificantly different from zero. Results of these regressions are tabulated in the Appendix B.

Overall, these results lead to the conclusion that those in STD_HIGH who select higher threshold, such as TH150 or TH200, have decided to falsely claim their collision to the insurer in 2010, thereby providing the evidence of selection on moral hazard.

V. Conclusion

This study examines the evidence of ex-post moral hazard in Korean automobile insurance market using individual-level data of two consecutive years. Regulation change that increases the insurance coverage for physical accidents in 2009 has led the insurers in Korea to experience significant losses in 2010. Thus, this paper attempts to find evidence whether the increase in loss ratio for insurers is derived from the policyholders' behavior that manipulate the size of loss, following the insurance coverage expansion.

Using difference-in-difference regression analysis, the results successfully illustrate the threshold effect, which is concentrated on TH200, the maximum insurance coverage. Also, McCrary test confirms the manipulation of losses by the policyholders. These conclusions provide evidence of ex-post moral hazard in Korean automobile insurance market and leave additional discussions in question.

Presence of ex-post moral hazard may be further extended to the selection on moral hazard, and this study simply checks for its existence using the claim frequency. Using three-way interaction terms, the results show that the claim frequency increases for those with the highest insurance discount benefits who selected high insurance coverage. Consequently, this study finds evidence of selection on moral hazard.

One year after the adoption of the new regulation, couple of regulation changes have been made in relation to the issues that are addressed above. Since 2011, 20% of coinsurance are applied for claims, in order to counteract the effects of ex-post moral hazard. Introduction of coinsurance is designated to reduce the size of fraudulent claim severity, as policyholders have incentives to exaggerate the amount to claim larger amount. Another regulation change involves adjustment of maximum insurance discount level. As selection on moral hazard effects are driven by the policyholders who have no incentives to not report their claims for insurance discount purposes, maximum insurance discount is extended to 70% from the original level of 60%[4]. The insurance discount level increases annually until 2017, when the discount rate reaches 70%. This regulation targets those with highest insurance discounts, motivating them to not falsely report their claims.

Further studies can be conducted in relation to the introduction of coinsurance and the extension of the insurance discounts provided to the policyholders. Nevertheless, this study contributes to the investigation of policyholders' behavior when the environment is naturally set for them to exploit the opportunity by falsely reporting their claims. Policymakers should consider such behavior and its consequences when adjusting and employing new terms, and should make efforts not to trigger additional opportunistic moral hazard.

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[4] Korea Insurance Development Institute (2011)

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Table 1: Summary of Variables

Variable	Definition
YEAR	Indicator variable, 1 if year of claim is 2010
STD_HIGH	Indicator variable, 1 if policyholder is at the highest insurance discount standard
TH100	Indicator variable, 1 if chosen threshold level=KRW1,000,000
TH150	Indicator variable, 1 if chosen threshold level=KRW1,500,000
TH200	Indicator variable, 1 if chosen threshold level=KRW2,000,000
ACC_CNT	Indicator variable, 1 if collision occurred
CNC_ACC_CNT	Indicator variable, 1 if collision which involves CNC-only loss occurred
PD_ACC_CNT	Indicator variable, 1 if collision which involves PD-only loss occurred
AGE	Indicator variable, grouped with age range; AGE10: 1 if policyholder's age is less than 20 AGE20: 1 if policyholder's age is less than 30 & greater than 19 AGE30: 1 if policyholder's age is less than 40 & greater than 29 AGE40: 1 if policyholder's age is less than 50 & greater than 39 AGE50: 1 if policyholder's age is less than 60 & greater than 49 AGE60: 1 if policyholder's age is less than 70 & greater than 59 AGE70: 1 if policyholder's age is greater than 70
SPORTSCAR	Indicator variable, 1 if the insured vehicle is a sportscar
FOREIGN	Indicator variable, 1 if the insured vehicle is foreign made
CNC	Indicator variable, 1 if the automobile insurance contract includes coverage for own vehicle
SEX	Indicator variable, 1 if male
CARVAL	Value of the vehicle insured by the policyholder
CRAGE_CD	Age of vehicle insured by the policyholder
Total Loss	Total loss amount, claimed by the policyholders; sum of CNC loss and PD loss
CNC Loss	Loss amount for own vehicle, claimed by the policyholder
PD Loss	Loss amount for counterparty's vehicle

Table 2: Summary statistics of variables

Panel A: Summary of Losses

Total Loss				
Year	Threshold Level	N	Mean	Std. Dev.
2009	TH50	296175	718321.31	533337.27
2010	Total	360675	794095.72	536629.62
	TH50	39378	729113.28	534661.8
	TH100	6475	726515.93	494833.77
	TH150	1142	770403.61	517834.23
	TH200	313680	803734.57	537104.52

CNC-only Loss				
Year	Threshold Level	N	Mean	Std. Dev.
2009	TH50	158193	637733.31	480559.4
2010	Total	201355	730799.41	497543.69
	TH50	20879	641298.03	477065.9
	TH100	3535	646715.86	425458.34
	TH150	628	686979.68	450720.05
	TH200	176313	743240.09	500156.77

PD-only Loss				
Year	Threshold Level	N	Mean	Std. Dev.
2009	TH50	68792	515008.93	373758.98
2010	Total	74400	567968.88	411740.2
	TH50	9640	547582.07	400212.83
	TH100	1396	542216.5	401215.13
	TH150	233	555381.5	395432.76
	TH200	63131	571697.82	413656.81

CNC&PD Loss				
Year	Threshold Level	N	Mean	Std. Dev.
2009	TH50	69190	1104717.06	587769.17
2010	Total	84920	1142292.45	558614.36
	TH50	8859	1133612.17	585123.27
	TH100	1544	1075852.22	547551.48
	TH150	281	1135138.04	566270.51
	TH200	74236	1144737.26	555481.51

Panel B1: Total Loss

Year	Threshold Level	N	Pricing Variables	Mean	Std. Dev.
2009		296175	SPORTSCAR	0.004	0.066
	TH50		FOREIGN	0.038	0.192
			CNC	0.999	0.026

			AGE10	0.000	0.012
			AGE20	0.088	0.283
			AGE30	0.250	0.433
			AGE40	0.324	0.468
			AGE50	0.237	0.425
			AGE60	0.083	0.276
			AGE70	0.018	0.134
			SEX	0.746	0.436
			CARVAL	11,235,708.890	10,908,126.090
			CRAGE_CD	4.689	3.915
2010		360675	SPORTSCAR	0.004	0.065
			FOREIGN	0.042	0.201
			CNC	0.999	0.026
			AGE10	0.000	0.014
			AGE20	0.096	0.294
			AGE30	0.253	0.435
	Total		AGE40	0.304	0.460
			AGE50	0.243	0.429
			AGE60	0.086	0.280
			AGE70	0.018	0.132
			SEX	0.743	0.437
			CARVAL	12,554,402.690	11,989,500.030
			CRAGE_CD	4.524	3.944
	TH50	39378	SPORTSCAR	0.005	0.071
			FOREIGN	0.037	0.190
			CNC	0.999	0.026
			AGE10	0.000	0.009
			AGE20	0.110	0.313
			AGE30	0.299	0.458
			AGE40	0.281	0.450
			AGE50	0.215	0.411
			AGE60	0.078	0.268
			AGE70	0.017	0.129
			SEX	0.760	0.427
			CARVAL	11,437,532.120	10,416,391.640
			CRAGE_CD	4.735	3.871
	TH100	6475	SPORTSCAR	0.004	0.062
			FOREIGN	0.027	0.161
			CNC	1.000	0.012
			AGE10	0.000	0.012
			AGE20	0.142	0.349
			AGE30	0.365	0.481
			AGE40	0.240	0.427
			AGE50	0.173	0.378
			AGE60	0.067	0.250
			AGE70	0.013	0.113
			SEX	0.757	0.429
			CARVAL	11,671,008.490	9,185,405.730
			CRAGE_CD	4.295	3.848
	TH150	1142	SPORTSCAR	0.005	0.072
			FOREIGN	0.035	0.184
			CNC	1.000	0.000
			AGE10	0.001	0.030

Year	Threshold Level	N	Pricing Variables	Mean	Std. Dev.
			AGE20	0.157	0.364
			AGE30	0.341	0.474
			AGE40	0.249	0.432
			AGE50	0.180	0.384
			AGE60	0.065	0.246
			AGE70	0.009	0.093
			SEX	0.770	0.421
			CARVAL	12,090,078.810	10,200,645.060
			CRAGE_CD	4.256	3.934
	TH200	313680	SPORTSCAR	0.004	0.064
			FOREIGN	0.043	0.204
			CNC	0.999	0.026
			AGE10	0.000	0.014
			AGE20	0.093	0.290
			AGE30	0.245	0.430
			AGE40	0.309	0.462
			AGE50	0.248	0.432
			AGE60	0.087	0.282
			AGE70	0.018	0.133
			SEX	0.741	0.438
			CARVAL	12,714,535.200	12,220,673.180
			CRAGE_CD	4.503	3.954

Panel B2: CNC-only Loss

Year	Threshold Level	N	Pricing Variables	Mean	Std. Dev.
2009	TH50	296175	SPORTSCAR	0.005	0.070
			FOREIGN	0.048	0.213
			CNC	0.999	0.032
			AGE10	0.000	0.012
			AGE20	0.086	0.281
			AGE30	0.253	0.435
			AGE40	0.324	0.468
			AGE50	0.237	0.425
			AGE60	0.083	0.276
			AGE70	0.017	0.131
			SEX	0.751	0.433
			CARVAL	12,271,656.140	11,692,135.590
			CRAGE_CD	4.329	3.814
2010	Total	360675	SPORTSCAR	0.005	0.068
			FOREIGN	0.052	0.222
			CNC	0.999	0.029
			AGE10	0.000	0.013
			AGE20	0.095	0.293
			AGE30	0.256	0.436
			AGE40	0.303	0.460
			AGE50	0.245	0.430
			AGE60	0.085	0.278
			AGE70	0.017	0.128
			SEX	0.747	0.435
			CARVAL	13,629,189.490	12,781,651.430
			CRAGE_CD	4.158	3.786
	TH50	39378	SPORTSCAR	0.006	0.076

		FOREIGN	0.044	0.204
		CNC	0.999	0.029
		AGE10	0.000	0.007
		AGE20	0.109	0.312
		AGE30	0.300	0.458
		AGE40	0.282	0.450
		AGE50	0.218	0.413
		AGE60	0.074	0.262
		AGE70	0.016	0.126
		SEX	0.762	0.426
		CARVAL	12,331,581.970	10,787,311.980
		CRAGE_CD	4.312	3.721
TH100	6475	SPORTSCAR	0.004	0.061
		FOREIGN	0.028	0.165
		CNC	1.000	0.000
		AGE10	0.000	0.000
		AGE20	0.139	0.346
		AGE30	0.368	0.482
		AGE40	0.242	0.428
		AGE50	0.177	0.381
		AGE60	0.064	0.245
		AGE70	0.011	0.103
		SEX	0.763	0.425
		CARVAL	12,273,770.860	9,402,182.190
		CRAGE_CD	4.055	3.756
TH150	1142	SPORTSCAR	0.005	0.069
		FOREIGN	0.041	0.199
		CNC	1.000	0.000
		AGE10	0.000	0.000
		AGE20	0.153	0.360
		AGE30	0.318	0.466
		AGE40	0.264	0.441
		AGE50	0.191	0.393
		AGE60	0.064	0.244
		AGE70	0.010	0.097
		SEX	0.771	0.421
		CARVAL	12,913,009.550	10,700,462.420
		CRAGE_CD	3.978	3.769
TH200	313680	SPORTSCAR	0.005	0.068
		FOREIGN	0.053	0.225
		CNC	0.999	0.030
		AGE10	0.000	0.013
		AGE20	0.092	0.289
		AGE30	0.248	0.432
		AGE40	0.307	0.461
		AGE50	0.249	0.433
		AGE60	0.086	0.281
		AGE70	0.017	0.128
		SEX	0.745	0.436
		CARVAL	13,812,578.770	13,051,598.880
		CRAGE_CD	4.142	3.794

Panel B3: PD-only Loss					
Year	Threshold Level	N	Pricing Variables	Mean	Std. Dev.
2009	TH50	296175	SPORTSCAR	0.004	0.061
			FOREIGN	0.031	0.173
			CNC	1.000	0.000
			AGE10	0.000	0.011
			AGE20	0.077	0.267
			AGE30	0.243	0.429
			AGE40	0.331	0.471
			AGE50	0.242	0.428
			AGE60	0.086	0.281
			AGE70	0.020	0.141
			SEX	0.747	0.435
			CARVAL	9,745,638.880	10,174,808.040
			CRAGE_CD	5.469	3.963
2010	Total	360675	SPORTSCAR	0.003	0.058
			FOREIGN	0.033	0.179
			CNC	1.000	0.000
			AGE10	0.000	0.015
			AGE20	0.082	0.274
			AGE30	0.247	0.431
			AGE40	0.312	0.463
			AGE50	0.247	0.431
			AGE60	0.091	0.288
			AGE70	0.021	0.142
			SEX	0.746	0.435
			CARVAL	10,623,932.390	10,979,706.520
			CRAGE_CD	5.479	4.090
	TH50	39378	SPORTSCAR	0.004	0.062
			FOREIGN	0.034	0.182
			CNC	1.000	0.000
			AGE10	0.000	0.010
			AGE20	0.096	0.295
			AGE30	0.295	0.456
			AGE40	0.290	0.454
			AGE50	0.215	0.411
			AGE60	0.086	0.280
			AGE70	0.018	0.132
			SEX	0.762	0.426
			CARVAL	10,069,870.330	10,061,841.500
			CRAGE_CD	5.578	3.941
	TH100	6475	SPORTSCAR	0.004	0.065
			FOREIGN	0.028	0.165
			CNC	1.000	0.000
			AGE10	0.000	0.000
			AGE20	0.133	0.339
			AGE30	0.370	0.483
			AGE40	0.238	0.426
			AGE50	0.164	0.370
			AGE60	0.080	0.271
			AGE70	0.016	0.125

		SEX	0.754	0.431
		CARVAL	10,695,286.530	9,025,393.070
		CRAGE_CD	4.903	3.900
TH150	1142	SPORTSCAR	0.004	0.066
		FOREIGN	0.030	0.171
		CNC	1.000	0.000
		AGE10	0.000	0.000
		AGE20	0.133	0.340
		AGE30	0.369	0.484
		AGE40	0.240	0.428
		AGE50	0.163	0.370
		AGE60	0.086	0.281
		AGE70	0.009	0.092
		SEX	0.785	0.411
		CARVAL	10,658,025.750	10,383,248.260
		CRAGE_CD	5.172	4.176
TH200	313680	SPORTSCAR	0.003	0.058
		FOREIGN	0.033	0.179
		CNC	1.000	0.000
		AGE10	0.000	0.015
		AGE20	0.078	0.268
		AGE30	0.236	0.425
		AGE40	0.318	0.466
		AGE50	0.254	0.435
		AGE60	0.093	0.290
		AGE70	0.021	0.144
		SEX	0.743	0.437
		CARVAL	10,706,833.090	11,151,924.240
		CRAGE_CD	5.477	4.115

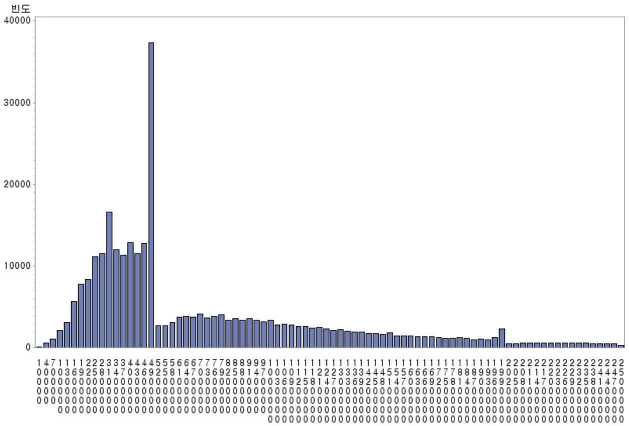
Panel B4: CNC&PD Loss

Year	Threshold Level	N	Pricing Variables	Mean	Std. Dev.
2009		296175	SPORTSCAR	0.004	0.061
			FOREIGN	0.024	0.153
			CNC	0.999	0.025
			AGE10	0.000	0.010
			AGE20	0.101	0.302
			AGE30	0.250	0.433
	TH50		AGE40	0.320	0.466
			AGE50	0.231	0.421
			AGE60	0.080	0.272
			AGE70	0.019	0.135
			SEX	0.732	0.443
			CARVAL	10,348,662.960	9,402,244.190
			CRAGE_CD	4.737	3.978
2010		360675	SPORTSCAR	0.004	0.062
			FOREIGN	0.028	0.164
			CNC	0.999	0.028
	Total		AGE10	0.000	0.016
			AGE20	0.110	0.313
			AGE30	0.253	0.434
			AGE40	0.300	0.458

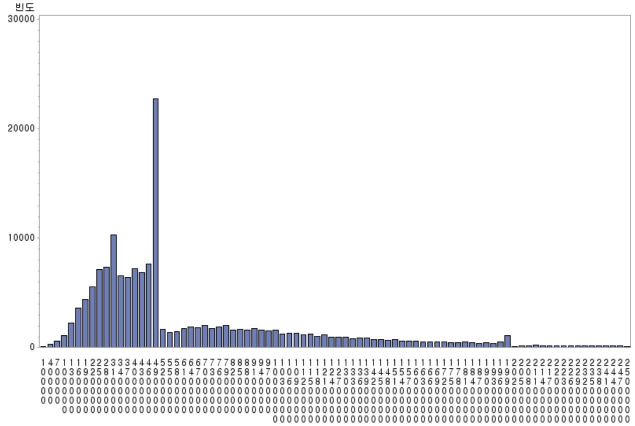
		AGE50	0.236	0.424
		AGE60	0.084	0.277
		AGE70	0.018	0.133
		SEX	0.731	0.444
		CARVAL	11,697,281.790	10,526,441.800
		CRAGE_CD	4.555	4.037
TH50	39378	SPORTSCAR	0.005	0.071
		FOREIGN	0.026	0.158
		CNC	0.999	0.034
		AGE10	0.000	0.011
		AGE20	0.128	0.334
		AGE30	0.302	0.459
		AGE40	0.271	0.444
		AGE50	0.205	0.404
		AGE60	0.076	0.265
		AGE70	0.018	0.133
		SEX	0.750	0.433
		CARVAL	10,818,657.860	9,674,007.250
		CRAGE_CD	4.814	3.984
TH100	6475	SPORTSCAR	0.004	0.062
		FOREIGN	0.022	0.147
		CNC	0.999	0.025
		AGE10	0.001	0.025
		AGE20	0.157	0.364
		AGE30	0.353	0.478
		AGE40	0.239	0.427
		AGE50	0.173	0.378
		AGE60	0.062	0.242
		AGE70	0.016	0.124
		SEX	0.747	0.435
		CARVAL	11,173,173.580	8,714,654.140
		CRAGE_CD	4.295	3.948
TH150	1142	SPORTSCAR	0.007	0.084
		FOREIGN	0.025	0.156
		CNC	1.000	0.000
		AGE10	0.004	0.060
		AGE20	0.185	0.389
		AGE30	0.367	0.483
		AGE40	0.221	0.415
		AGE50	0.167	0.374
		AGE60	0.050	0.218
		AGE70	0.007	0.084
		SEX	0.754	0.431
		CARVAL	11,438,362.990	8,639,279.160
		CRAGE_CD	4.117	3.991
TH200	313680	SPORTSCAR	0.004	0.060
		FOREIGN	0.028	0.165
		CNC	0.999	0.027
		AGE10	0.000	0.016
		AGE20	0.107	0.309
		AGE30	0.244	0.430
		AGE40	0.305	0.460

AGE50	0.241	0.428
AGE60	0.085	0.279
AGE70	0.018	0.133
SEX	0.728	0.445
CARVAL	11,814,013.690	10,659,008.090
CRAGE_CD	4.532	4.044

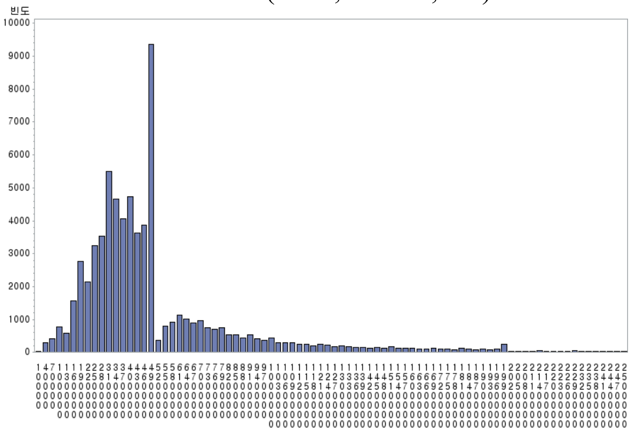
Figure 1: Histogram of Annual Claim Severity



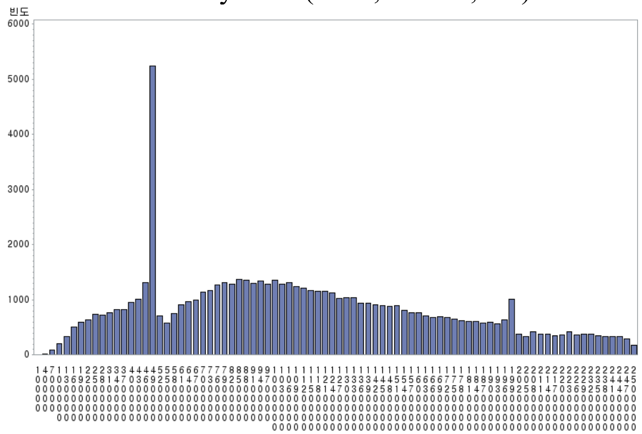
Total Loss (2009; N=296,175)



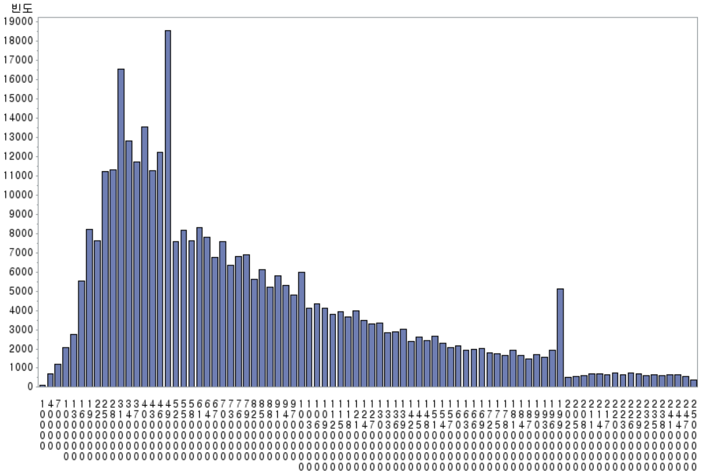
CNC-only Loss (2009; N=158,193)



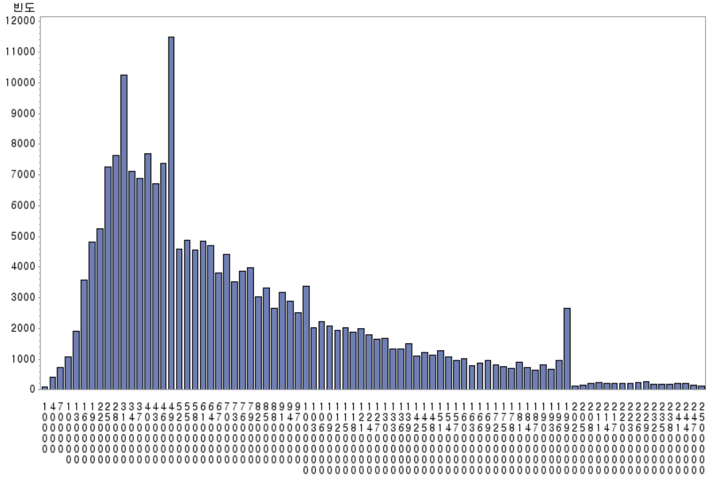
PD-only Loss (2009; N=68,792)



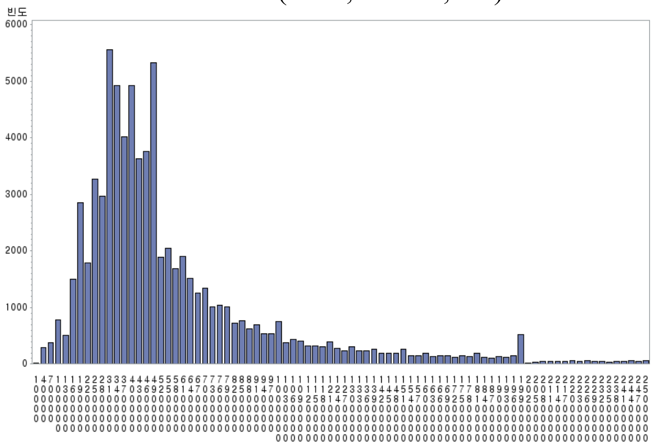
CNC&PD Loss (2009; N=69,190)



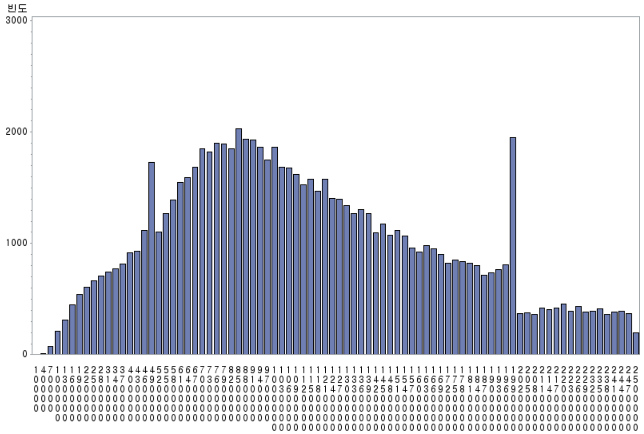
Total Loss (2010; N=360,675)



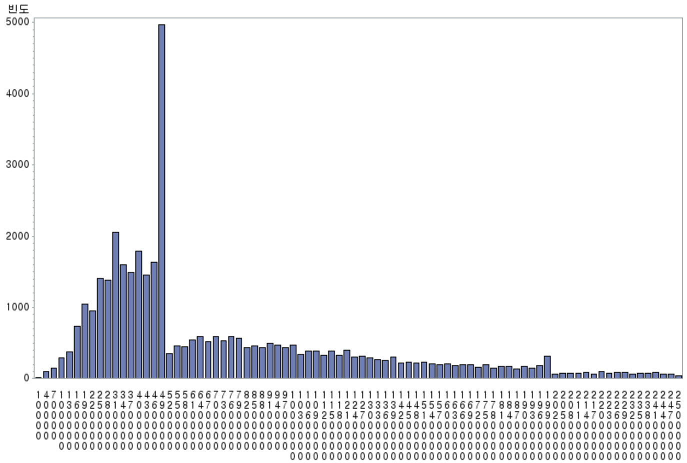
CNC-only Loss (2010; N=201,355)



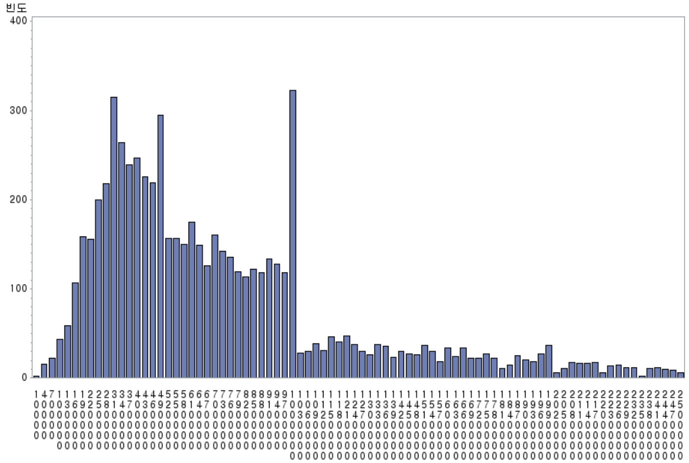
PD-only Loss (2010; N=74,400)



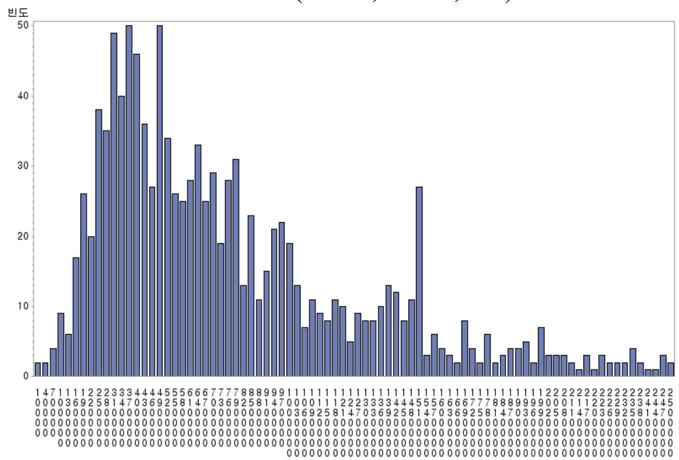
CNC&PD Loss (2010; N=84,920)



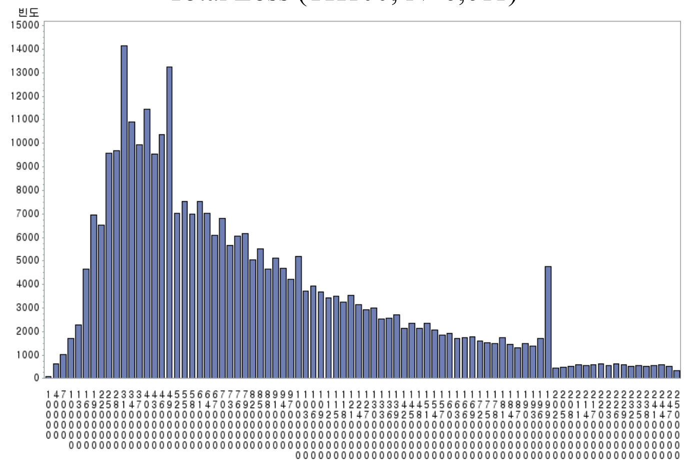
Total Loss (TH50; N=40,342)



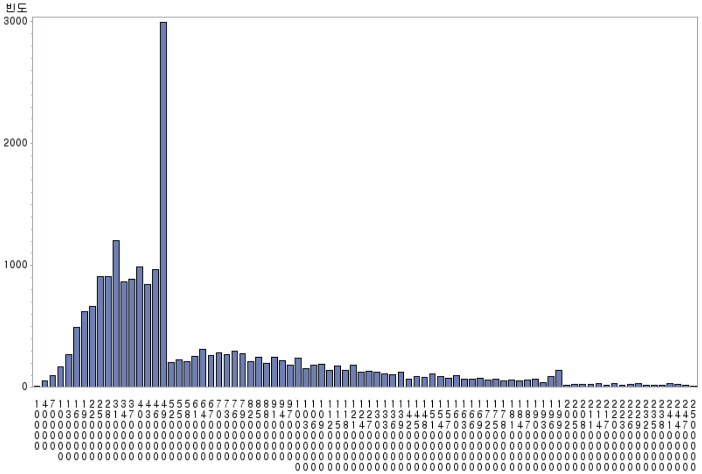
Total Loss (TH100; N=6,611)



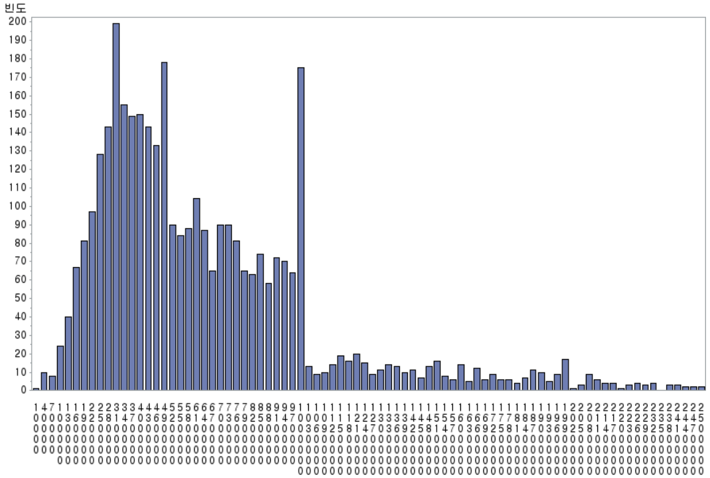
Total Loss (TH150; N=1,160)



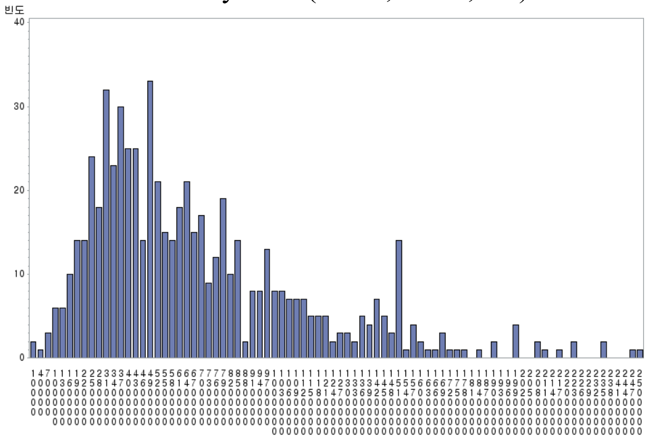
Total Loss (TH200; N=320,968)



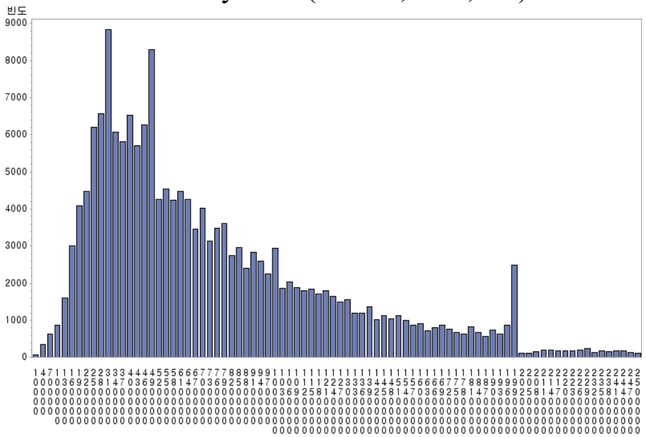
CNC-only Loss (TH50; N=20,879)



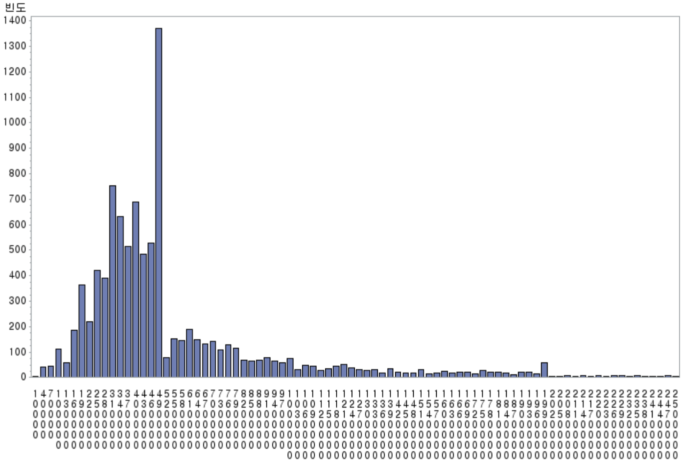
CNC-only Loss (TH100; N=3,535)



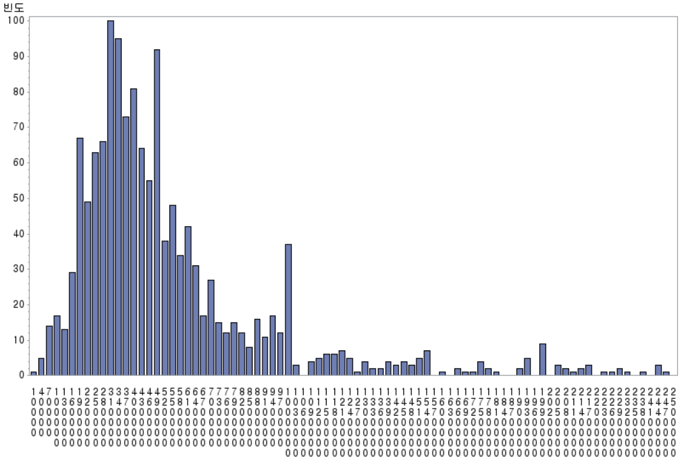
CNC-only Loss (TH150; N=628)



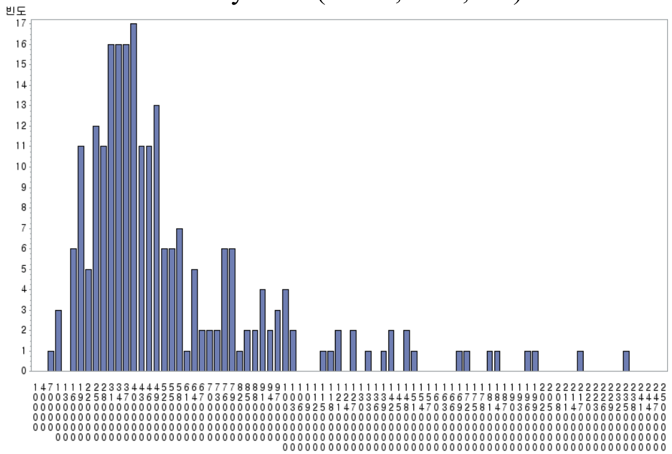
CNC-only Loss (TH200; N=176,313)



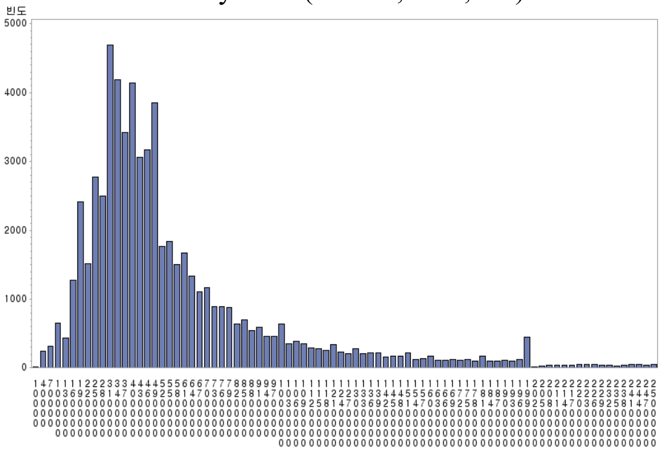
PD-only Loss (TH50; N=9,640)



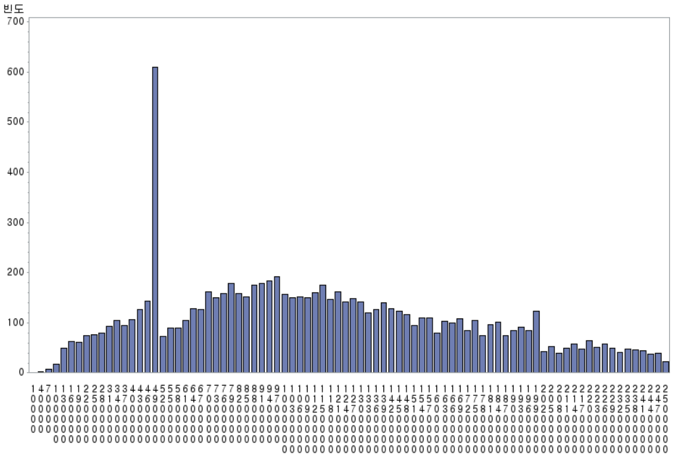
PD-only Loss (TH100; N=1,396)



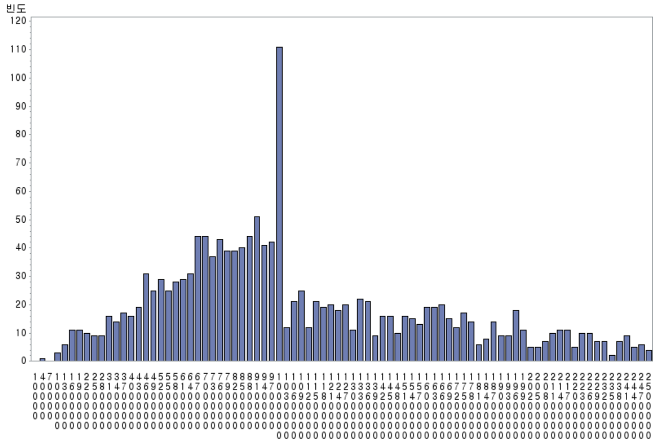
PD-only Loss (TH150; N=233)



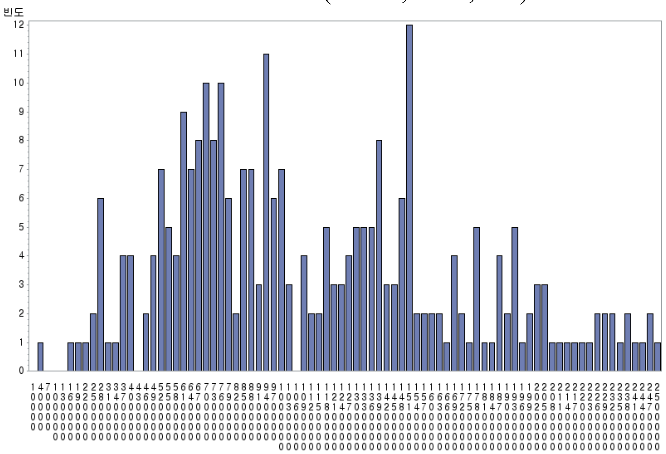
PD-only Loss (TH200; N=63,131)



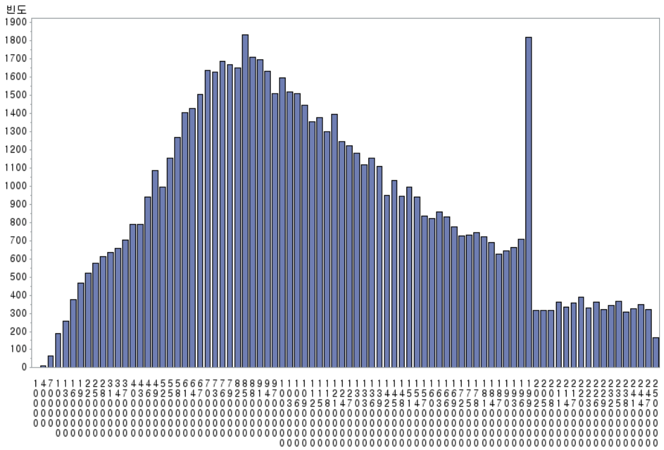
CNC&PD Loss (TH50; N=8,859)



CNC&PD Loss (TH100; N=1,544)

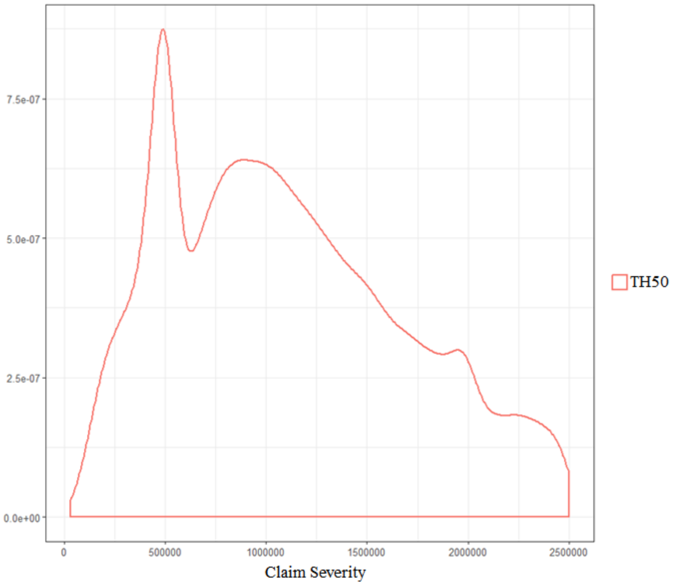


CNC&PD Loss (TH150; N=281)

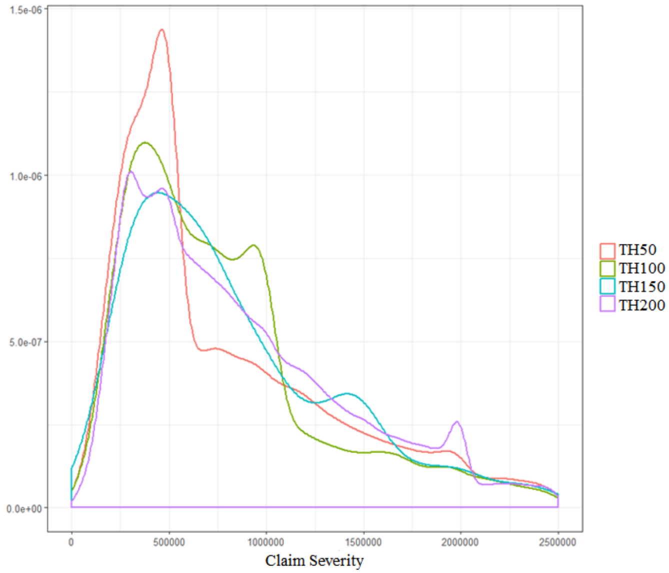


CNC&PD Loss (TH200; N=74,236)

Figure 2: Density Plot of Annual Claim Severity



2009



2010

Table 3: Difference-in-Difference Regressions – Total & Subsamples of Losses

	log(TOTAL_LOSS)			**log(CNC-ONLY_LOSS)**			**log(PD-ONLY_LOSS)**			**log(CNC&PD_LOSS)**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
YEAR	0.132***	0.052***	0.074***	0.147***	0.039***	0.066***	0.104***	0.095***	0.117***	0.072***	0.053***	0.047*
	(0.004)	(0.010)	(0.013)	(0.005)	(0.013)	(0.017)	(0.007)	(0.017)	(0.023)	(0.007)	(0.018)	(0.025)
YEAR*TH100		-0.007	0.016		0.004	0.029		-0.014	-0.049		-0.059	0.009
		(0.023)	(0.032)		(0.028)	(0.040)		(0.049)	(0.063)		(0.039)	(0.059)
YEAR*TH150		0.007	-0.073		-0.013	-0.097		-0.074	-0.151		0.094	0.122
		(0.054)	(0.073)		(0.067)	(0.097)		(0.118)	(0.140)		(0.084)	(0.117)
YEAR*TH200		0.091***	0.065***		0.121***	0.090***		0.011	-0.013		0.022	0.027
		(0.010)	(0.014)		(0.013)	(0.017)		(0.017)	(0.024)		(0.018)	(0.026)
TH100			-0.023			-0.025			0.034			-0.068
			(0.023)			(0.028)			(0.040)			(0.045)
TH150			0.079			0.085			0.077			-0.028
			(0.049)			(0.069)			(0.075)			(0.082)
TH200			0.026***			0.032***			0.024			-0.005
			(0.010)			(0.012)			(0.017)			(0.019)
SPORTSCAR	0.030	0.031	0.031	0.054	0.053	0.053	-0.063	-0.063	-0.063	0.023	0.023	0.022
	(0.034)	(0.034)	(0.034)	(0.042)	(0.042)	(0.042)	(0.073)	(0.073)	(0.073)	(0.054)	(0.054)	(0.054)
FOREIGN	0.373***	0.373***	0.373***	0.496***	0.497***	0.497***	0.059**	0.058**	0.058**	0.195***	0.195***	0.195***
	(0.011)	(0.011)	(0.011)	(0.013)	(0.013)	(0.013)	(0.026)	(0.026)	(0.026)	(0.022)	(0.022)	(0.022)
CNC	0.033	0.036	0.036	0.089	0.093	0.092				0.078	0.078	0.079
	(0.076)	(0.076)	(0.075)	(0.087)	(0.086)	(0.086)				(0.102)	(0.102)	(0.102)

AGE10	0.110	0.106	0.104	-0.449**	-0.449**	-0.453**				0.223	0.221	0.221
	(0.323)	(0.322)	(0.323)	(0.203)	(0.203)	(0.203)				(0.193)	(0.193)	(0.193)
AGE20	0.055***	0.056***	0.057***	0.100***	0.102***	0.103***	0.003	0.004	0.004	-0.063*	-0.063*	-0.062*
	(0.019)	(0.019)	(0.019)	(0.024)	(0.024)	(0.024)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)
AGE30	-0.018	-0.017	-0.017	0.031	0.032	0.032	-0.029	-0.029	-0.028	-0.113***	-0.113***	-0.113***
	(0.017)	(0.017)	(0.017)	(0.022)	(0.022)	(0.022)	(0.029)	(0.029)	(0.029)	(0.031)	(0.031)	(0.031)
AGE40	-0.014	-0.015	-0.015	0.017	0.016	0.015	-0.011	-0.011	-0.010	-0.091***	-0.092***	-0.092***
	(0.017)	(0.017)	(0.017)	(0.022)	(0.022)	(0.022)	(0.029)	(0.029)	(0.029)	(0.030)	(0.030)	(0.030)
AGE50	0.004	0.003	0.003	0.044**	0.043*	0.042*	0.001	0.001	0.001	-0.080***	-0.080***	-0.080***
	(0.017)	(0.017)	(0.017)	(0.022)	(0.022)	(0.022)	(0.029)	(0.029)	(0.029)	(0.030)	(0.030)	(0.030)
AGE60	-0.015	-0.016	-0.016	0.009	0.008	0.007	-0.016	-0.016	-0.016	-0.068**	-0.069**	-0.069**
	(0.018)	(0.018)	(0.018)	(0.023)	(0.023)	(0.023)	(0.030)	(0.030)	(0.030)	(0.032)	(0.032)	(0.032)
SEX	-0.015***	-0.015***	-0.015***	-0.021***	-0.021***	-0.021***	0.003	0.003	0.003	0.00003	-0.0002	-0.0003
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
log(CARVAL)	0.115***	0.115***	0.115***	0.179***	0.178***	0.178***	0.117***	0.117***	0.117***	0.106***	0.106***	0.106***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
CRAGE_CD	0.030	0.030***	0.030***	0.048***	0.048***	0.048***	0.025***	0.025***	0.025***	0.026***	0.026***	0.026***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	11.243***	11.247***	11.224***	9.941***	9.955***	9.928***	10.995***	10.994***	10.969***	11.996***	11.997***	12.005***
	(0.113)	(0.113)	(0.113)	(0.138)	(0.137)	(0.138)	(0.158)	(0.158)	(0.159)	(0.180)	(0.180)	(0.181)
Observations	133,220	133,220	133,220	72,650	72,650	72,650	29,061	29,061	29,061	31,509	31,509	31,509
R^2	0.031	0.032	0.032	0.068	0.070	0.070	0.017	0.017	0.017	0.016	0.017	0.017
Adjusted R^2	0.031	0.032	0.032	0.068	0.069	0.070	0.016	0.016	0.016	0.016	0.016	0.016

Residual Std. Error	0.734 (df = 133206)	0.734 (df = 133203)	0.734 (df = 133200)	0.693 (df = 72636)	0.692 (df = 72633)	0.692 (df = 72630)	0.630 (df = 29049)	0.630 (df = 29046)	0.630 (df = 29043)	0.640 (df = 31495)	0.640 (df = 31492)	0.640 (df = 31489)
F Statistic	327.786^{***} (df = 13; 133206)	272.852^{***} (df = 16; 133203)	230.440^{***} (df = 19; 133200)	409.514^{***} (df = 13; 72636)	339.866^{***} (df = 16; 72633)	286.805^{***} (df = 19; 72630)	44.507^{***} (df = 11; 29049)	35.073^{***} (df = 14; 29046)	29.025^{***} (df = 17; 29043)	40.370^{***} (df = 13; 31495)	33.183^{***} (df = 16; 31492)	28.078^{***} (df = 19; 31489)
Note:	Standard errors are in parentheses. *p<0.1, **p<0.05 & ***p<0.01											

Table 4: McCrary (2008) Test – Total & Subsamples of Losses

Panel A: Total Loss

	2009	2010	2010 (TH50)	2010 (TH100)	2010 (TH150)	2010 (TH200)
Cutoff			**500000**			
θ	-1.170***	-0.346***	-1.015***	-0.473***	-0.230*	-0.234***
Standard error	0.008	0.008	0.022	0.051	0.135	0.009
z-value	-142.795	-41.199	-45.706	-9.351	-1.708	-25.267
N	303506	369081	40342	6611	1160	320968
Cutoff			**1000000**			
θ	-0.036**	-0.038***	-0.050	-1.192***	-0.370*	-0.006
Standard error	0.015	0.012	0.040	0.089	0.195	0.013
z-value	-2.385	-3.034	-1.257	-13.390	-1.901	-0.414
N	303506	369081	40342	6611	1160	320968
Cutoff			**1500000**			
θ	0.027	0.068***	0.081	0.960***	-0.600**	0.070***
Standard error	0.020	0.018	0.056	0.165	0.261	0.019
z-value	1.380	3.839	1.439	5.808	-2.297	3.655
N	303506	369081	40342	6611	1160	320968

Cutoff			2000000			
θ	-1.001***	-1.226***	-0.907***	-0.957***	-0.721*	-1.254***
Standard error	0.029	0.026	0.075	0.231	0.431	0.027
z-value	-34.100	-47.983	-12.060	-4.145	-1.671	-46.332
N	303506	369081	40342	6611	1160	320968

Panel B: CNC-only Loss

	2009	2010	2010 (TH50)	2010 (TH100)	2010 (TH150)	2010 (TH200)
Cutoff			**500000**			
θ	-1.126***	-0.278***	-1.033***	-0.502***	-0.167	-0.155***
Standard error	0.011	0.011	0.030	0.067	0.179	0.012
z-value	-102.842	-24.600	-34.857	-7.464	-0.932	-12.517
N	160637	204058	21164	3580	634	178680
Cutoff			**1000000**			
θ	-0.062***	-0.064***	-0.012	-1.351***	0.055	-0.039**
Standard error	0.022	0.017	0.058	0.130	0.256	0.018
z-value	-2.797	-3.713	-0.213	-10.356	0.214	-2.135
N	160637	204058	21164	3580	634	178680
Cutoff			**1500000**			

θ	0.020	0.107***	0.164**	0.100	-0.493	0.097***
Standard error	0.031	0.026	0.081	0.236	0.385	0.028
z-value	0.656	4.055	2.034	0.422	-1.280	3.489
N	160637	204058	21164	3580	634	178680
Cutoff			**2000000**			
θ	-1.387***	-1.361***	-1.007***	-0.918***	-1.014	-1.384***
Standard error	0.052	0.038	0.123	0.341	0.898	0.040
z-value	-26.692	-35.667	-8.195	-2.690	-1.128	-34.423
N	160637	204058	21164	3580	634	178680

Panel C: PD-only Loss

	2009	2010	2010 (TH50)	2010 (TH100)	2010 (TH150)	2010 (TH200)
Cutoff			**500000**			
θ	-1.325***	-0.437***	-1.060***	-0.186	-0.771***	-0.322***
Standard error	0.018	0.017	0.045	0.119	0.295	0.020
z-value	-73.821	-24.965	-23.764	-1.561	-2.614	-16.466
N	69249	75013	9711	1408	234	63660
Cutoff			**1000000**			
θ	0.068	0.122***	0.013	-0.928***	-0.435	0.186***

Standard error	0.049	0.041	0.118	0.258	0.578	0.044
z-value	1.389	3.014	0.109	-3.598	-0.753	4.229
N	69249	75013	9711	1408	234	63660
Cutoff			**1500000**			
θ	0.237***	0.125**	0.315	0.462	N/A	0.115*
Standard error	0.065	0.055	0.194	0.478	N/A	0.059
z-value	3.617	2.258	1.630	0.968	N/A	1.942
N	69249	75013	9711	1408	234	63660
Cutoff			**2000000**			
θ	-1.331***	-1.088***	-1.334***	-0.525	N/A	-1.066***
Standard error	0.111	0.083	0.247	0.482	N/A	0.088
z-value	-12.029	-13.185	-5.405	-1.090	N/A	-12.058
N	69249	75013	9711	1408	234	63660

Panel D: CNC&PD Loss

	2009	2010	2010 (TH50)	2010 (TH100)	2010 (TH150)	2010 (TH200)
Cutoff			**500000**			
θ	-0.815***	-0.110***	-0.654***	-0.096	0.970***	0.031
Standard error	0.023	0.029	0.063	0.163	0.298	0.033

z-value	-36.179	-3.740	-10.387	-0.589	3.252	0.937
N	73620	90010	9467	1623	292	78628
Cutoff			**1000000**			
θ	-0.040**	-0.069***	-0.026	-0.964***	-1.280***	-0.031
Standard error	0.020	0.019	0.052	0.123	0.456	0.021
z-value	-2.012	-3.591	-0.497	-7.840	-2.809	-1.496
N	73620	90010	9467	1623	292	78628
Cutoff			**1500000**			
θ	-0.033	0.012	-0.092	0.335*	-0.559	0.021
Standard error	0.024	0.026	0.072	0.197	0.367	0.028
z-value	-1.337	0.450	-1.278	1.700	-1.524	0.750
N	73620	90010	9467	1623	292	78628
Cutoff			**2000000**			
θ	-0.630***	-1.077***	-0.653***	-0.667**	-0.212	-1.107***
Standard error	0.035	0.036	0.092	0.292	0.480	0.038
z-value	-18.134	-29.630	-7.126	-2.285	-0.443	-28.765
N	73620	90010	9467	1623	292	78628

Table 5: Difference-in-Difference-in-Difference Regressions – Total & Subsamples of Records

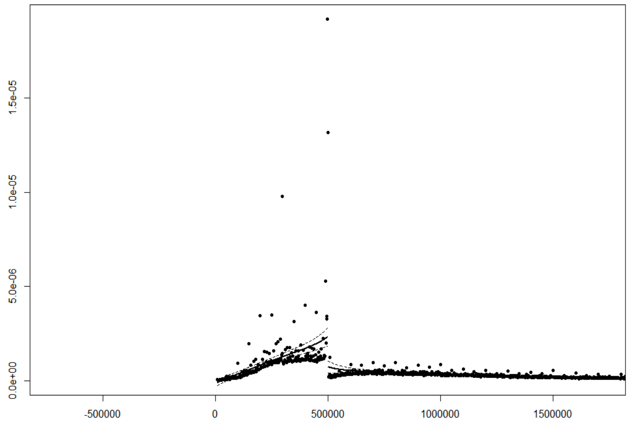
	ACC_CNT			**CNC_ACC_CNT**			**PD_ACC_CNT**		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Intercept	0.0253***	0.0277***	0.0277***	-0.0395***	-0.0373***	-0.0373***	0.0177***	0.0174***	0.0174***
	(0.0039)	(0.0039)	(0.0039)	(0.0030)	(0.0030)	(0.0030)	(0.0024)	(0.0025)	(0.0025)
YEAR	0.0054***	0.0004	0.0009	0.0043***	-0.0002	0.0003	-0.0003**	0.0004	0.0004
	(0.0002)	(0.0008)	(0.0009)	(0.0002)	(0.0006)	(0.0007)	(0.0001)	(0.0005)	(0.0006)
STD_HIGH	0.0006***	0.0006**	0.0006*	0.0059***	0.0059***	0.0059***	-0.0048***	-0.0048***	-0.0047***
	(0.0003)	(0.0003)	(0.0004)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0002)	(0.0002)
YEAR*TH100		-0.0034**	-0.0030**		-0.0027***	-0.0026**		-0.0001	0.0002
		(0.0014)	(0.0015)		(0.0010)	(0.0011)		(0.0009)	(0.0009)
YEAR*TH150		-0.0043	-0.0057*		-0.0028	-0.0046*		-0.0011	-0.0011
		(0.0033)	(0.0035)		(0.0025)	(0.0026)		(0.0021)	(0.0022)
YEAR*TH200		0.0056***	0.005***		0.005***	0.0044***		-0.0007	-0.0008
		(0.0008)	(0.0009)		(0.0006)	(0.0007)		(0.0005)	(0.0006)
YEAR*STD_HIGH			-0.0022			-0.0024**			-0.0004
			(0.0015)			(0.0011)			(0.0009)
YEAR*STD_HIGH*TH100			-0.0019			-0.0005			-0.0014
			(0.0022)			(0.0017)			(0.0014)
YEAR*STD_HIGH*TH150			0.0070			0.0089**			0.0002

			(0.0055)			(0.0042)			(0.0035)
YEAR*STD_HIGH* TH200			0.0024			0.0026**			0.0002
			(0.0014)			(0.0011)			(0.0009)
TH100	-0.0006	0.0013	0.0013	-0.0001	0.0014*	0.0014*	-0.0009**	-0.0008	-0.0008
	(0.0007)	(0.001)	(0.001)	(0.0005)	(0.0008)	(0.0008)	(0.0004)	(0.0006)	(0.0006)
TH150	0.0014	0.0038	0.0038	0.0019	0.0035*	0.0035*	-0.0013	-0.0007	-0.0007
	(0.0016)	(0.0024)	(0.0024)	(0.0012)	(0.0019)	(0.0019)	(0.0010)	(0.0015)	(0.0015)
TH200	0.0007	-0.0019***	-0.0019***	0.0008***	-0.0015***	-0.0015***	-0.0012***	-0.0009**	-0.0009**
	(0.0004)	(0.0006)	(0.0006)	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0004)
SEX	-0.0054***	-0.0054***	-0.0054***	-0.0023***	-0.0024***	-0.0024***	-0.0020***	-0.0020***	-0.0020***
	(0.0003)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
log(CARVAL)	0.0063***	0.0063***	0.0063***	0.0070***	0.0070***	0.0070***	0.0011***	0.0011***	0.0011***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0001)	(0.0001)	(0.0001)
CRAGE_CD	-0.0032***	-0.0032***	-0.0032***	-0.0033***	-0.0033***	-0.0033***	0.0014***	0.0014***	0.0014***
	(0.0001)	(0.0001)	(0.0001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AGE10	-0.0349***	-0.0350***	-0.0350***	-0.0247***	-0.0248***	-0.0248***	-0.0051	-0.0050	-0.0050
	(0.0125)	(0.01245)	(0.0125)	(0.0095)	(0.0095)	(0.0095)	(0.0077)	(0.0077)	(0.0077)
AGE20	-0.0270***	-0.0270***	-0.0271***	-0.0117***	-0.0117***	-0.0118***	-0.0125***	-0.0125***	-0.0125***
	(0.0010)	(0.0010)	(0.0010)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)
AGE30	-0.0207***	-0.0207***	-0.0207***	-0.0053***	-0.0054***	-0.0054***	-0.0134***	-0.0133***	-0.0134***
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)

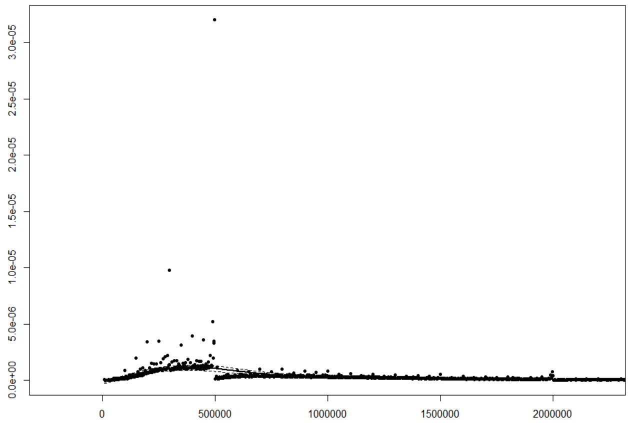
AGE40	-0.0182***	-0.0182***	-0.0182***	-0.0046***	-0.0046***	-0.0046***	-0.0121***	-0.0121***	-0.0121***
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)
AGE50	-0.0114***	-0.0114***	-0.0115***	-0.0010	-0.0007	-0.0007	-0.0097***	-0.0097***	-0.0097***
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)
AGE60	-0.0058***	-0.0058***	-0.0059***	0.0010	0.0009	0.0009	-0.0063***	-0.0063***	-0.0063***
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)	(0.0006)
Observations	6,497,573	6,497,573	6,497,573	6,231,881	6,231,881	6,231,881	6,129,899	6,129,899	6,129,899
R^2	0.0063	0.0063	0.0063	0.0119	0.0119	0.0120	0.0014	0.0014	0.0014
Adjusted R^2	0.0063	0.0063	0.0063	0.0119	0.0119	0.0119	0.0014	0.0014	0.0014
Residual Std. Error	0.0000065 (df=6497558)	0.0000065 (df=6497555)	0.0000065 (df=6497551)	0.00000623 (df=6231866)	0.00000623 (df=6231863)	0.00000623 (df=6231859)	0.00000613 (df=6129884)	0.00000613 (df=6129881)	0.00000613 (df=6129877)
F Statistic	2924.06*** (df=14; 6497558)	2411.53*** (df=17; 6497555)	1952.45*** (df=21; 6497551)	5377.87*** (df=14; 6231866)	4433.46*** (df=17; 6231863)	3589.49*** (df=21; 6231859)	598.36*** (df=14; 6129884)	492.89*** (df=17; 6129881)	399.08*** (df=21; 6129877))

Note: Standard errors are in parentheses. *p<0.1, **p<0.05 & ***p<0.01

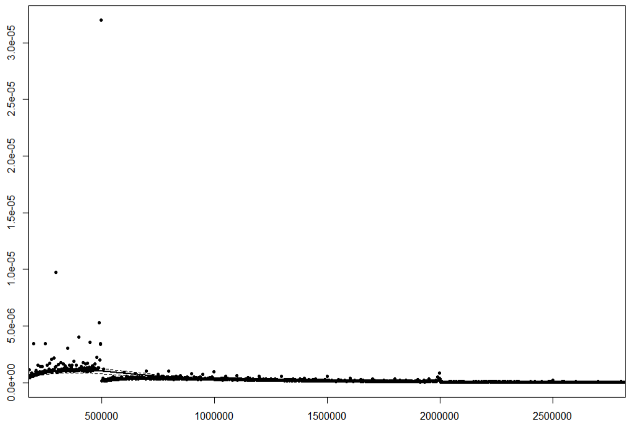
Appendix A: McCrary (2008) Test Plots



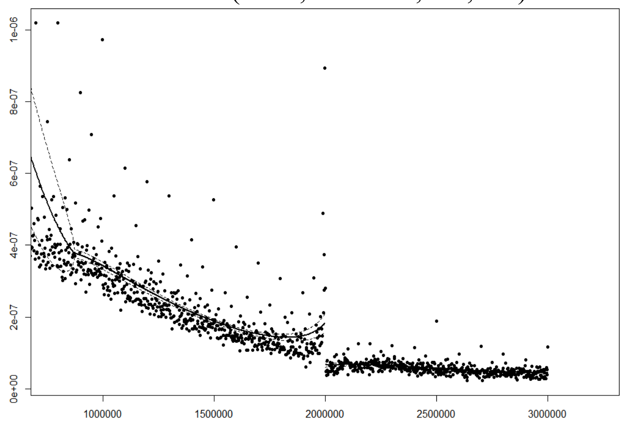
Total Loss (2009; cutoff=500,000)



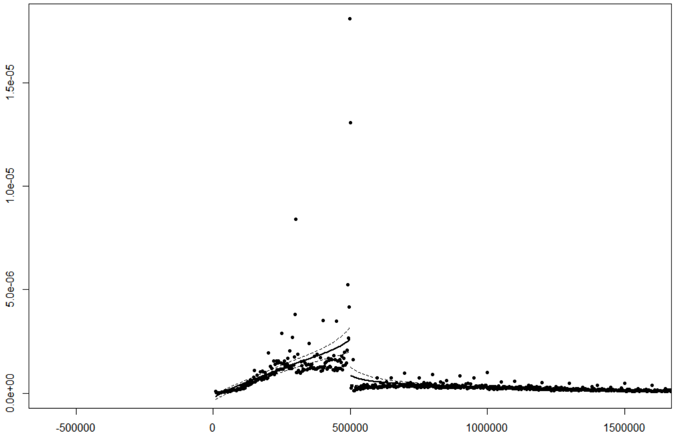
Total Loss (2009; cutoff=1,000,000)



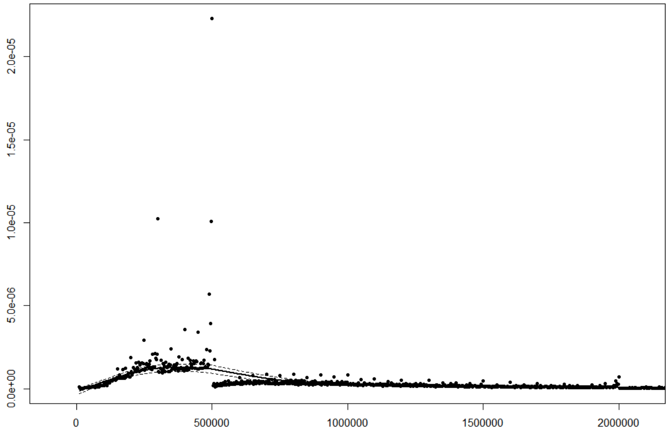
Total Loss (2009; cutoff=1,500,000)



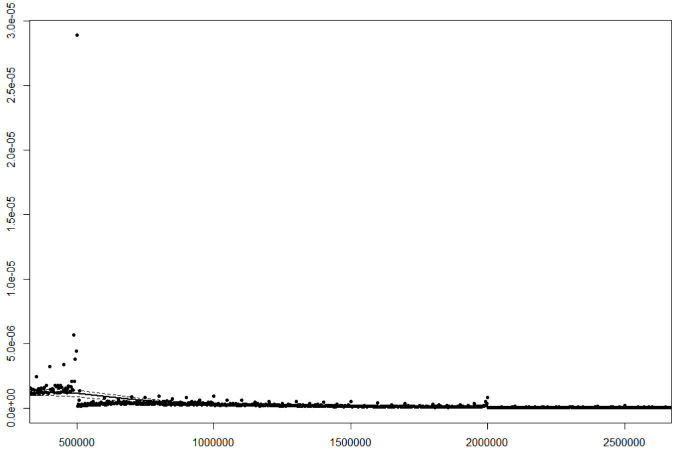
Total Loss (2009; cutoff=2,000,000)



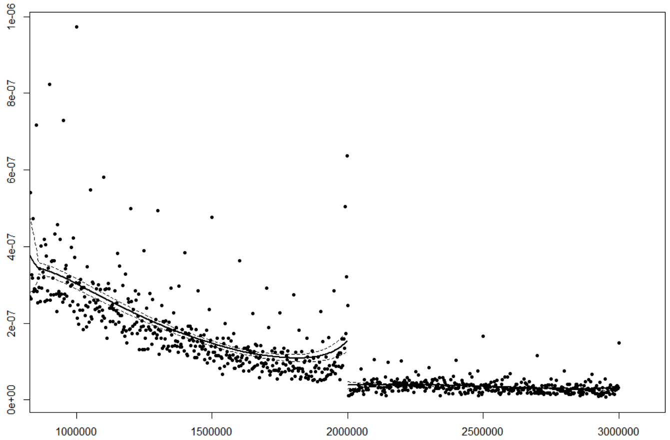
CNC-only Loss (2009; cutoff=500,000)



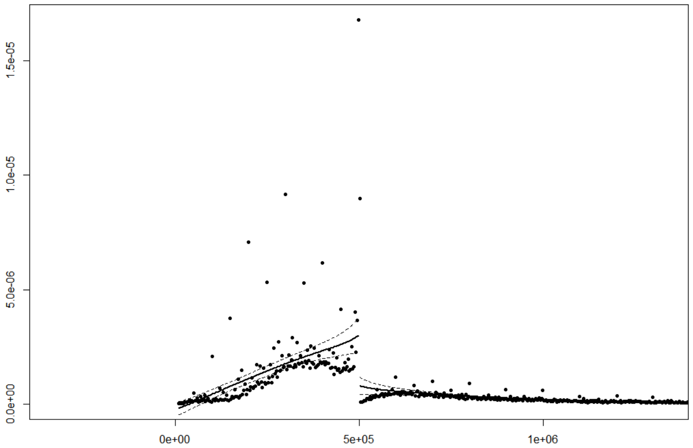
CNC-only Loss (2009; cutoff=1,000,000)



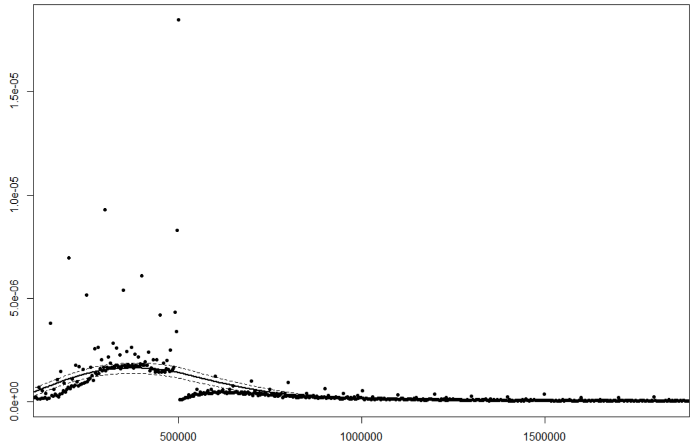
CNC-only Loss (2009; cutoff=1,500,000)



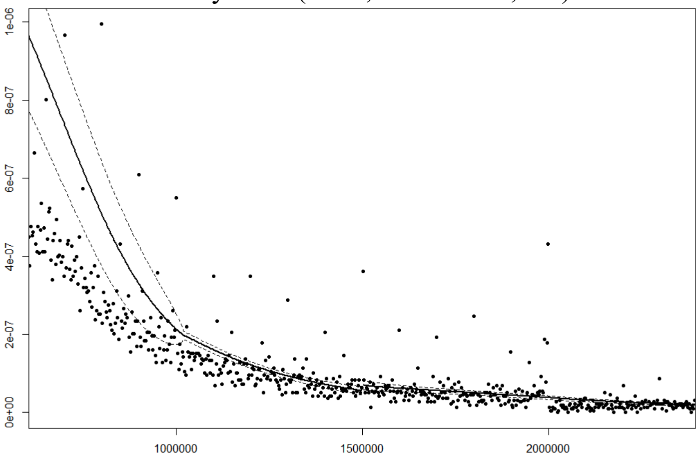
CNC-only Loss (2009; cutoff=2,000,000)



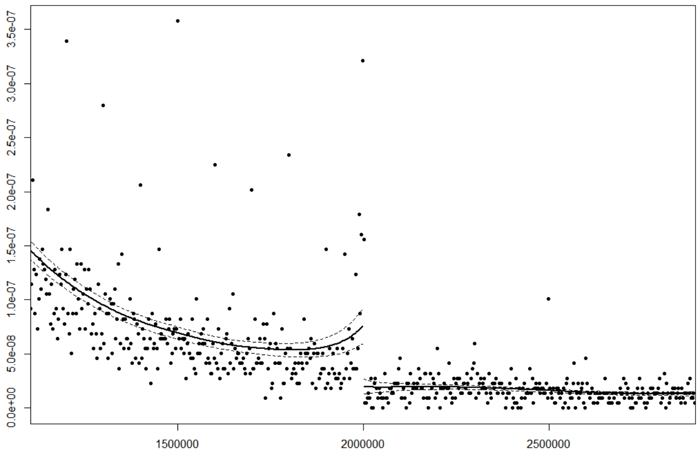
PD-only Loss (2009; cutoff=500,000)



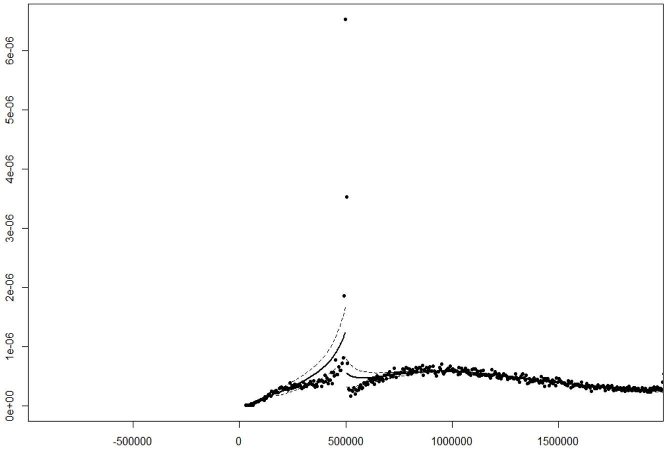
PD-only Loss (2009; cutoff=1,000,000)



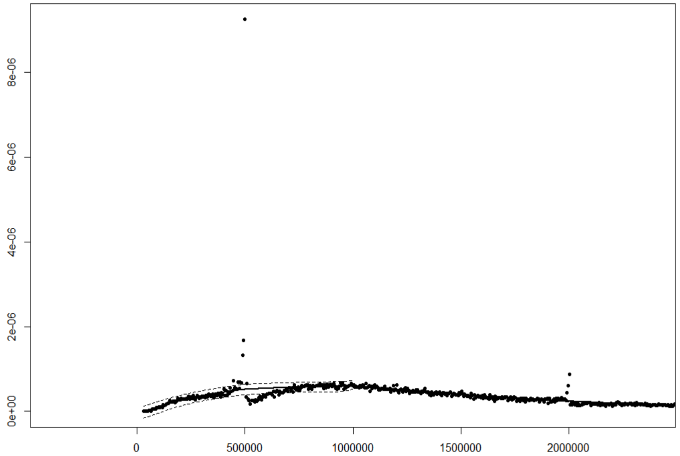
PD-only Loss (2009; cutoff=1,500,000)



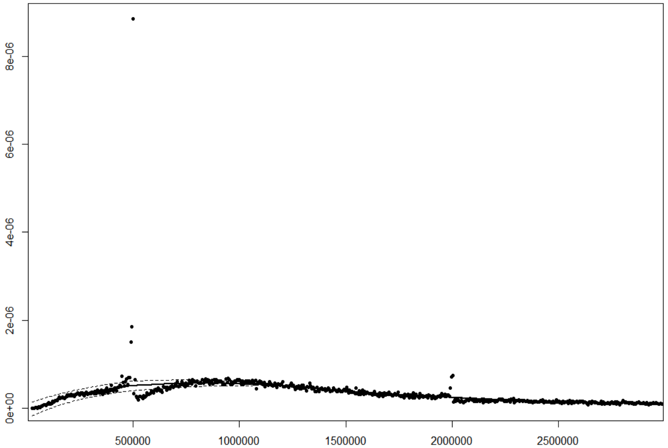
PD-only Loss (2009; cutoff=2,000,000)



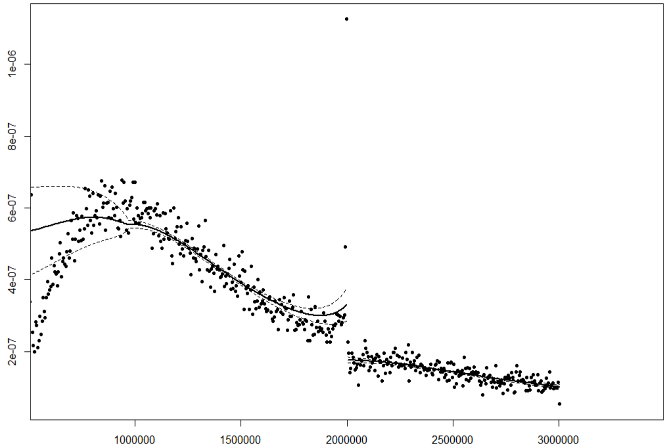
CNC&PD Loss (2009; cutoff=500,000)



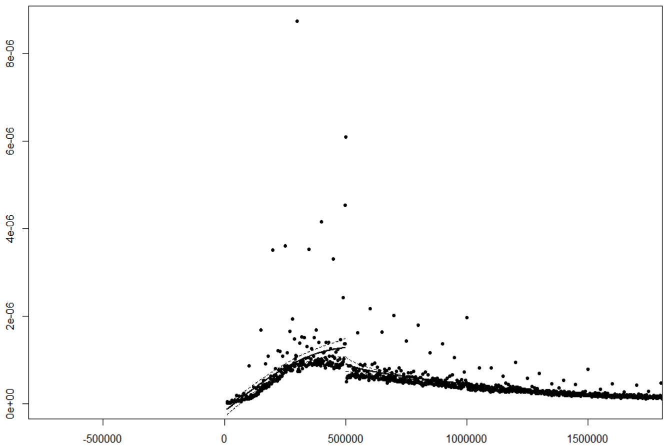
CNC&PD Loss (2009; cutoff=1,000,000)



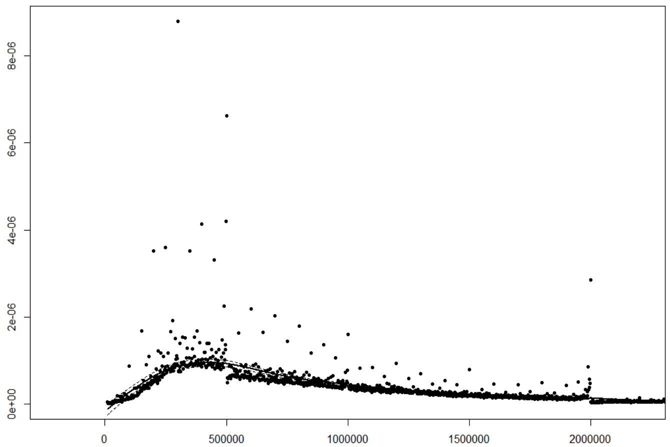
CNC&PD Loss (2009; cutoff=1,500,000)



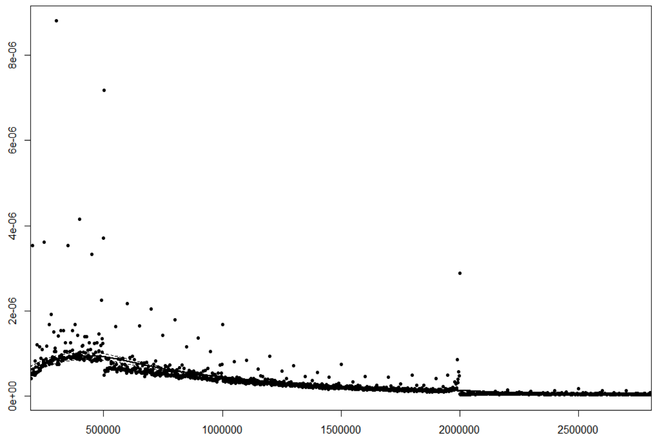
CNC&PD Loss (2009; cutoff=2,000,000)



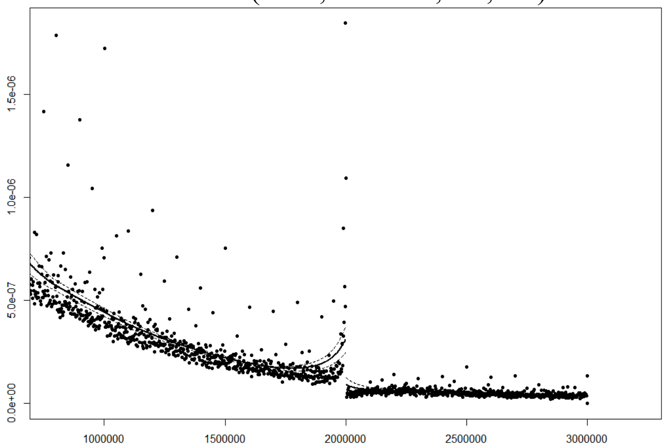
Total Loss (2010; cutoff=500,000)



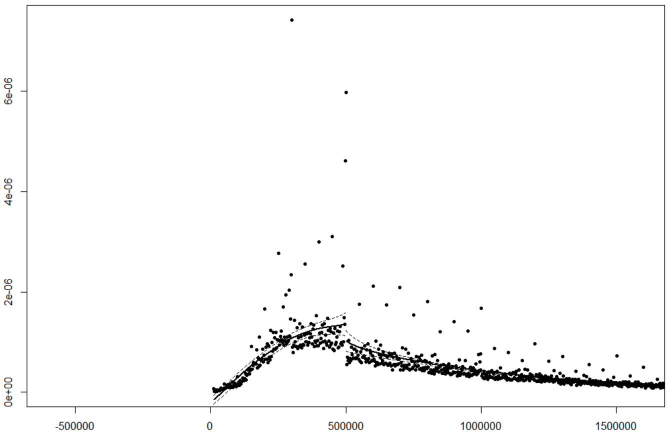
Total Loss (2010; cutoff=1,000,000)



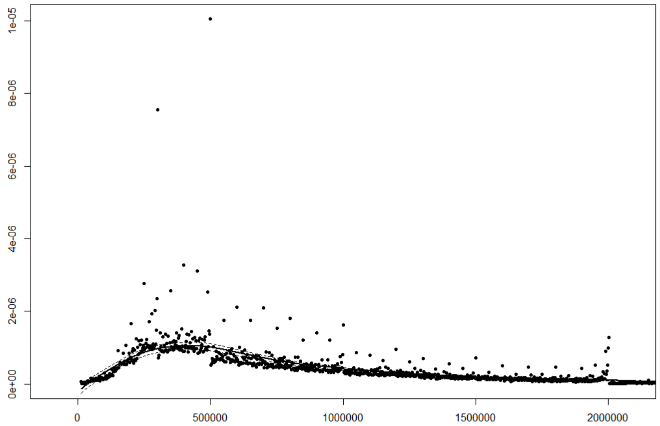
Total Loss (2010; cutoff=1,500,000)



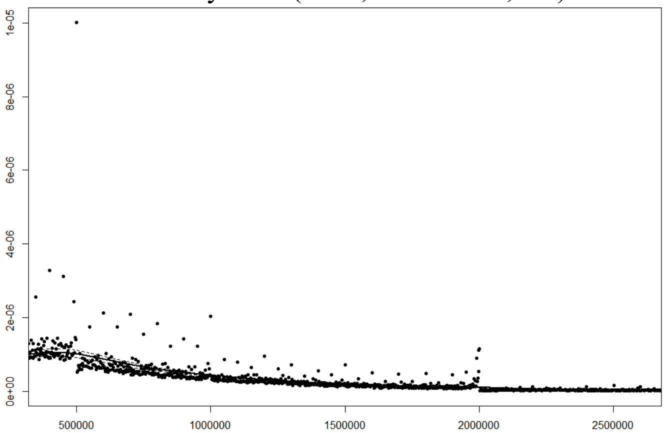
Total Loss (2010; cutoff=2,000,000)



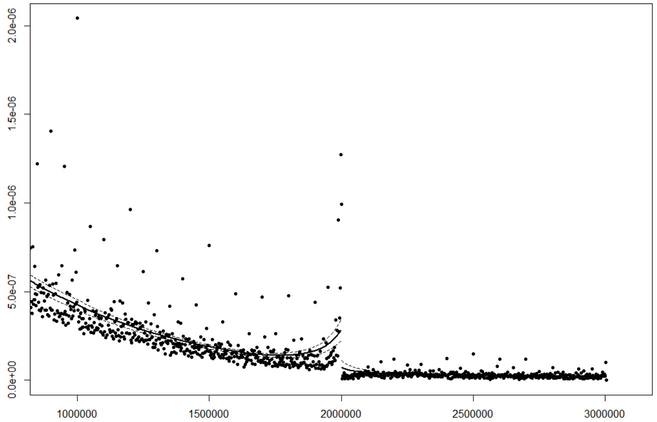
CNC-only Loss (2010; cutoff=500,000)



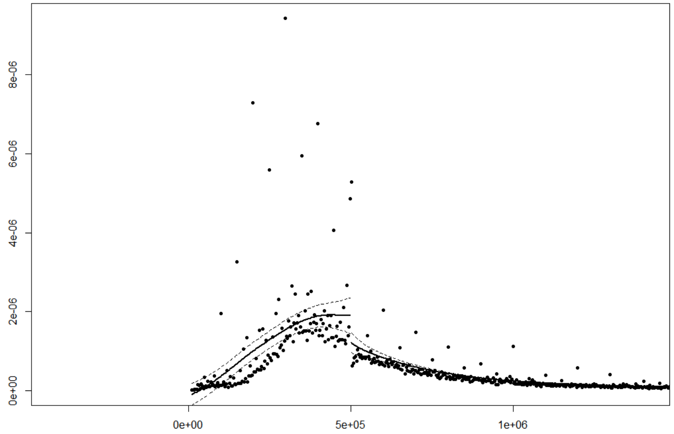
CNC-only Loss (2010; cutoff=1,000,000)



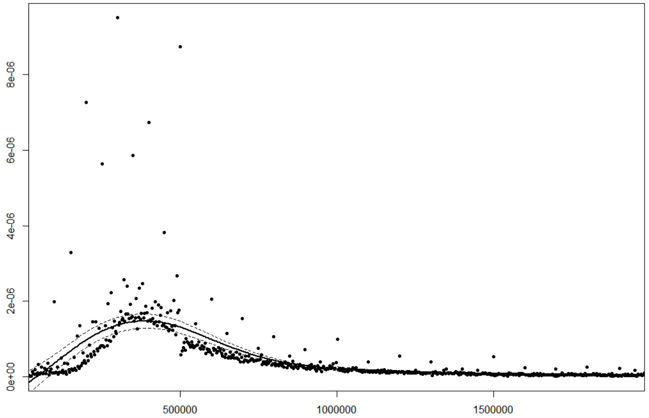
CNC-only Loss (2010; cutoff=1,500,000)



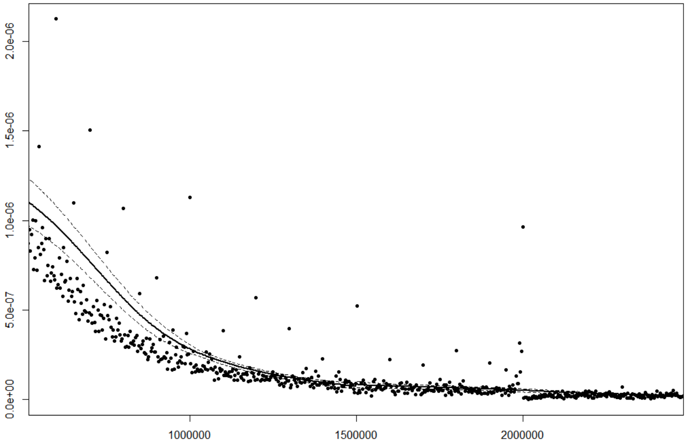
CNC-only Loss (2010; cutoff=2,000,000)



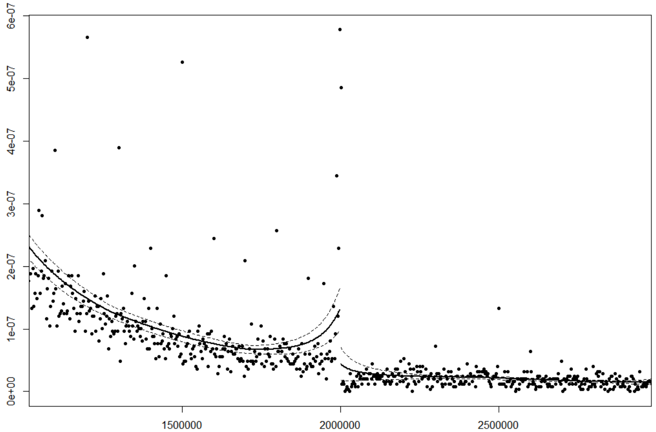
PD-only Loss (2010; cutoff=500,000)



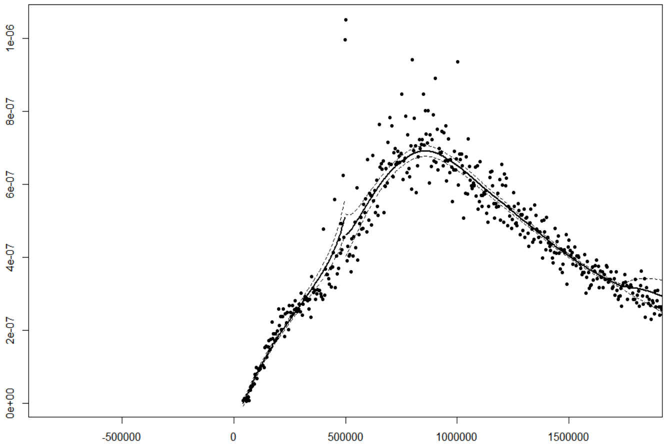
PD-only Loss (2010; cutoff=1,000,000)



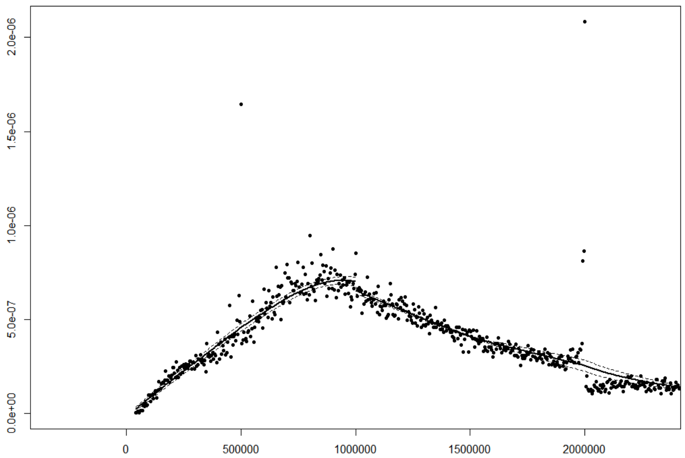
PD-only Loss (2010; cutoff=1,500,000)



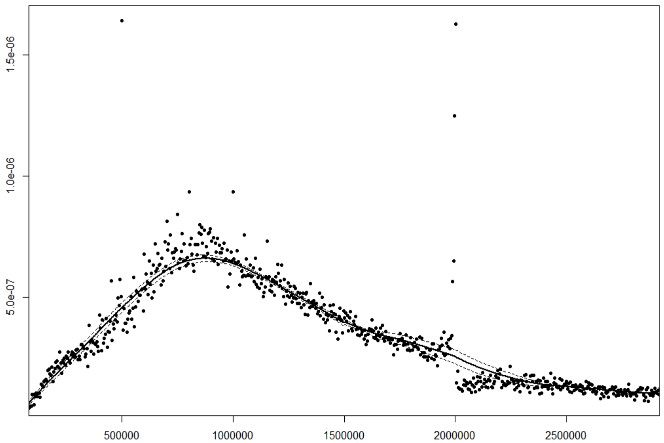
PD-only Loss (2010; cutoff=2,000,000)



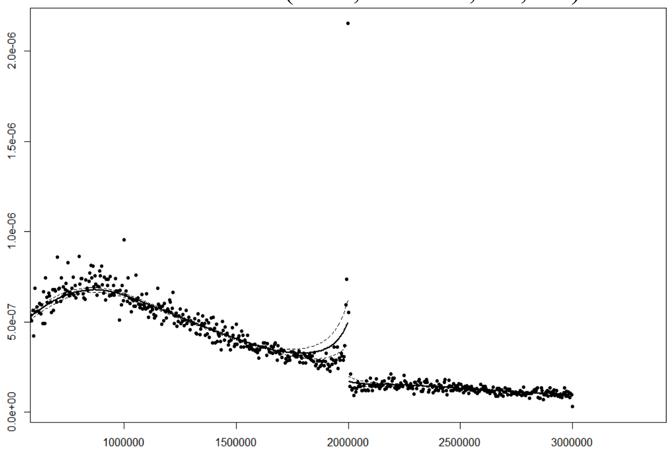
CNC&PD Loss (2010; cutoff=500,000)



CNC&PD Loss (2010; cutoff=1,000,000)



CNC&PD Loss (2010; cutoff=1,500,000)



CNC&PD Loss (2010; cutoff=2,000,000)

Appendix B: Difference-in-Difference-in-Difference Regressions using Claim Severity

	log(TOTAL_LOSS)	**log(CNC-ONLY_LOSS)**	**log(PD-ONLY_LOSS)**
	(1)	**(2)**	**(3)**
Intercept	10.146***	8.301***	10.833***
	(0.078)	(0.098)	(0.149)
YEAR	0.071***	0.060***	0.108***
	(0.014)	(0.018)	(0.025)
STD_HIGH	-0.123***	-0.151***	-0.045***
	(0.007)	(0.009)	(0.012)
YEAR*TH100	-0.006	0.021	-0.053
	(0.034)	(0.043)	(0.069)
YEAR*TH150	-0.053	-0.111	-0.061
	(0.078)	(0.103)	(0.156)
YEAR*TH200	0.059***	0.082***	-0.005
	(0.015)	(0.019)	(0.026)
YEAR*STD_HIGH	-0.002	0.002	0.041
	(0.023)	(0.029)	(0.04)
YEAR*STD_HIGH*TH100	0.086	0.007	0.016
	(0.056)	(0.069)	(0.11)
YEAR*STD_HIGH*TH150	-0.136	0.131	-0.505***
	(0.131)	(0.17)	(0.178)
YEAR*STD_HIGH*TH200	0.03	0.032	-0.038
	(0.023)	(0.029)	(0.041)
TH100	-0.02	-0.023	0.036
	(0.023)	(0.028)	(0.04)
TH150	0.071	0.07	0.075

	(0.049)	(0.07)	(0.075)
TH200	0.026***	0.031***	0.024
	(0.01)	(0.012)	(0.017)
AGE10	0.117	-0.430**	
	(0.313)	(0.19)	
AGE20	0.027	0.061**	-0.005
	(0.019)	(0.025)	(0.033)
AGE30	-0.041**	-0.003	-0.035
	(0.017)	(0.022)	(0.029)
AGE40	-0.023	-0.002	-0.01
	(0.017)	(0.022)	(0.029)
AGE50	-0.003	0.028	0.001
	(0.017)	(0.022)	(0.029)
AGE60	-0.021	-0.006	-0.015
	(0.018)	(0.023)	(0.03)
SEX	-0.012***	-0.020***	0.007
	(0.005)	(0.006)	(0.009)
log(CARVAL)	0.185***	0.285***	0.125***
	(0.004)	(0.006)	(0.009)
CRAGE_CD	0.043	0.068***	0.027***
	(0.001)	(0.001)	(0.002)
Observations	133,220	72,650	29,061
R^2	0.028	0.058	0.017
Adjusted R^2	0.028	0.058	0.017
Residual Std. Error	0.736 (df = 133198)	0.697 (df = 72628)	0.630 (df = 29040)

F Statistic	180.676*** (df = 21; 133198)	213.819*** (df = 21; 72628)	25.610*** (df = 20; 29040)
Note:	Standard errors are in parentheses. *p<0.1, **p<0.05 & ***p<0.01		

요약 (국문초록)

본 연구는 2010 년에 물적사고 할증 기준이 증가한 것에 기반하여 한국 자동차 보험 시장의 사후 (ex-post) 도덕적 해이를 검증하고자 한다. 물적사고 할증 기준 금액보다 작거나 같은 사고 금액을 신고하는 경우에 다음 해의 보험료가 할증되지 않는다는 규정을 악용하는 보험계약자의 행동을 분석하고 보험계약자는 증가한 할증 기준과 함께 사고 금액을 부풀려 보고할 요인이 있다는 것을 찾아냈다. 실증분석을 통해 기존의 물적사고 할증 기준 금액보다 더 높은 할증 기준에 가입한 보험계약자의 신고 금액이 더 크다는 것을 확인하고 할증 기준 금액과 신고 금액 간의 양의 상관관계를 나타냈다. 또한 신고 금액의 분포가 할증 기준 금액에 집중되어 있는 것을 분석하여 보험계약자가 인위적으로 사고 금액을 할증 기준에 맞추어 보고했다는 것을 확인했다. 특히 보험계약자가 통제하기 쉬운, 즉, 자기차량손해액만 포함되어 있는 사고에서 상관관계가 더욱 크게 나타난 것을 발견하여 사후 도덕적 해이를 검증했다. 또한 기존에 사고를 보고하지 않아 최대 보험료 할인 혜택을 누리는 보험계약자들의 자기차량손해만 포함한 물적사고 빈도가 급등한 것은 선택적 도덕적 해이 (selection on moral hazard) 현상으로 볼 수 있다. 개별 데이터를 이용하여 한국 자동차 보험 시장에서의 사후 도덕적 해이 및 선택적 도덕적 해이 현상이 검증되면서 향후 연구 대상이 된다.

주요어 : 자동차 보험, 도덕적 해이, 보험 사기, 역선택

학 번 : 2017-20212