Insurance Incentives and Road Safety: Evidence from a Natural Experiment in China

Abstract: we investigate the effects of the insurance incentives on safe driving by evaluating both the accident frequency and accident severity following the reform of the insurance pricing mechanism introduced in the city of Shenzhen in China. Our contribution to literature is a clean identification of causal effect of insurance incentives on road safety by employing the difference-in-differences methodology in the framework of a natural experiment. We find that increasing insurance incentives can reduce accident frequency significantly. These results are robust to the inclusion of controls, alternative definitions for accident frequency and the placebo experiments. Moreover, the impact of basing insurance pricing on traffic violations is bigger than on past claims. The impact of insurance incentives on accident severity is inconclusive and insignificant.
Key words: insurance incentives; experience rating; road safety; natural experiment

1、Introduction

Road safety policies use both monetary (fines, insurance premiums) and non-monetary incentives (point-record drivers' licenses) to stimulate safe driving. Bourgeon & Picard (2007) and Castillo-Manzano & Castro-Nuño (2012) address the question of whether the point-record drivers' license can boost road safety whilst many contributions have been published to empirically evaluate the effects of the insurance premiums on road safety(Boyer & Dionne, 1989; Cohen & Dehejia, 2004; Israel, 2008; Li et al., 2007; Wang et al., 2008). Dionne et al. (2011) compare the relative incentive properties of fine, insurance experience rating and point-record drivers' license. The experience-rated premium based on past claims and traffic violations used by insurance companies is one of the most important monetary incentive mechanisms. Cummins et al. (2001) conduct both the theoretical and empirical analysis of the impact of no-fault automobile insurance on fatalities in U.S. states and find that the more stringent experience rating, the lower fatality rates. The enforcement of experience rating can be justified by the potential presence of asymmetric information between insured and insurer regarding individual risks (Abbring et al., 2003; Chiappori & B.Salanié, 2000; Cohen, 2005; Dionne et al., 2013). The asymmetric information goes towards two directions: one is adverse selection and the other is moral hazard. The literature that try to disentangle these two information problems is vast and dates back as least as early as Arrow(1963). The goal of this paper is to test whether the insurance incentives the insurers employ can reduce the insurance claims and hence enhance the road safety and how efficiently the insurance incentives can improve road safety. The identification of a causal effect often can be questioned since there is a number of important limitations in the methodologies. First, the empirical analysis of the effects of the incentive mechanisms is complicated by endogeneity. And the problem of omitted variables bias always

confounds inference if unobservable characteristics both influence insurance incentives and road safety. Dionne et al. (2011) employs a reform in Quebec, Canada in 1992 to test whether experienced-rated insurance premium based on demerit points can reduce traffic violations and they find that the frequency of traffic violations fall down by 15% following the enforcement of the reform. Unfortunately they do not have access to a control group, which is necessary to identify the other changes that may contribute to decrease the traffic violations because this compulsory insurance is provided by a monopoly insurer.

Overcoming these limitations and eliminating the confounders, we contribute to the empirical literature because we can cleanly and directly identify the impact of insurance incentives on safe driving in the framework of natural experiment, which allows us to examine the reactions of drivers to plausibly exogenous incentives for safe driving. The Shenzhen Insurance Association announced that new pricing mechanisms would be introduced in Shenzhen automobile insurance market since March 1st, 2011. This reform would base the automobile insurance pricing on the past claims and traffic violations of the insured. Located in the province of Guangdong, Shenzhen is called the window of the Chinese reform and openness. The pricing mechanism in other markets in Guangdong keep unchanged as before. We regard the city of Shenzhen as the treatment group whilst the city of Foshan, also located in Guangdong and near Shenzhen can act as the control group. Figure 1 and figure 2 show the base premium and the actual premium of the two groups respectively. The base premium is the premium shown in the rate table of the insurer regardless of any discounting factor or price markup whereas the actual premium is the exact amount the insured finally pays that include all discounting factors and price markups. The main discounting factor and price markup for insurance premium is the bonus-malus coefficient(henceforth, BMC), through which the experience rating operates. We can see that the base premiums of the treatment group and the control group keep almost the synchronous movement before and after the two-stages reform from figure 1. On the contrary, we see sharp declines for the actual premium of the treatment group after the reform and there are no significant drops for the control group in figure 2. This shows that the pricing reform decreases the actual premium of the treatment group significantly as compared to the control group.

The reform in Shenzhen hence provides us an opportunity to use the methodology of difference-in-differences (henceforth, DID) that compares the effect of the reform on the city of Shenzhen, which is affected by the reform, with the city of Foshan which is unaffected or although affected, but not affected as much as the reform city to investigate the effect of insurance incentives on road safety. We find that the incentive effects of the enforcement of experience-rated premium based on past claims and on traffic violations on accident frequency are strongly significant. We conduct a series of robustness checks and placebo experiments to confirm the validity of our empirical findings. The results are robust to the inclusion of automobile controls, alternative definitions for accident frequency and the placebo tests. We also find that the results for experienced-rated premium based on traffic violations are more robust and conclusive than on past claims. Our paper also adds to the idea that whether the increase in

insurance incentives has impact on accident severity and we find that the effect is insignificant.

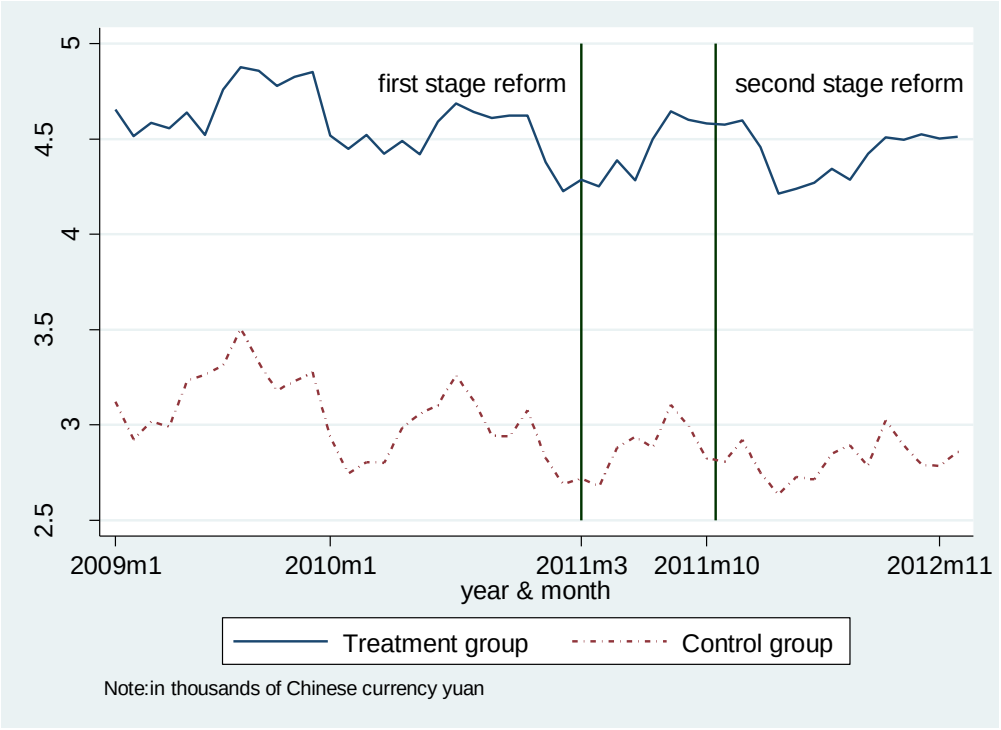

Figure 1. Base premium during insurane period. This figure depicts the time series for the base premium (in thousands of Chinese currency yuan), which is shown in the rate table of the insurer regardless of any discounting factor or price markup.

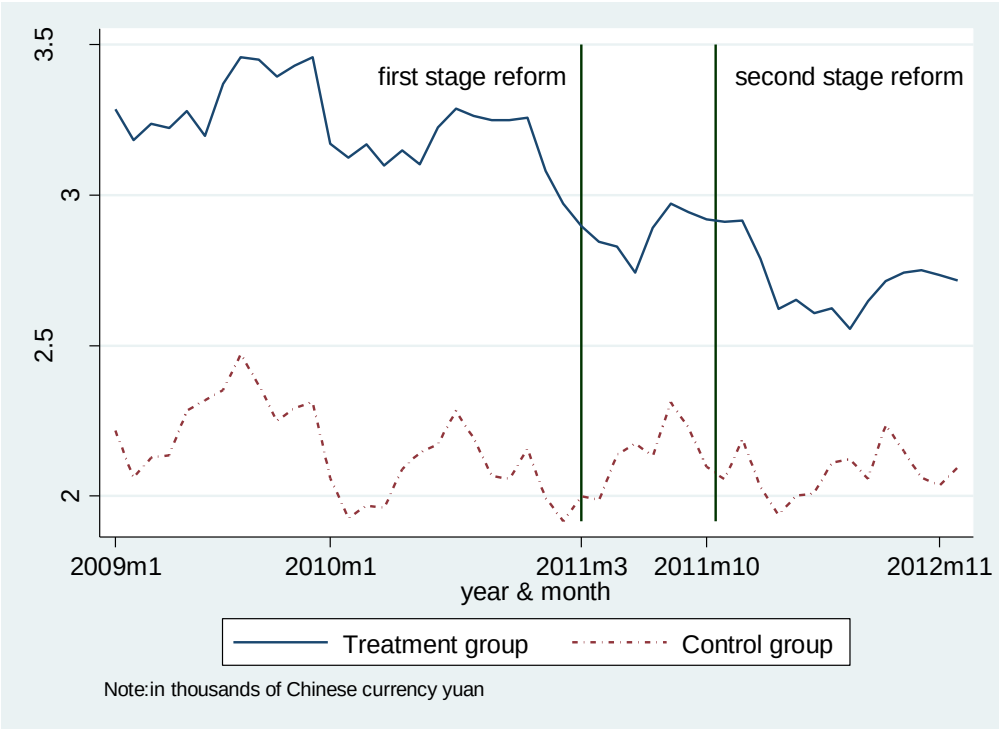

Figure 2. Actual premium during insurance period. This figure depicts the time series for the actual premium, which is the exact amount the insured finally pays that include all discounting factors and price markups. The main discounting factor and

price markup for insurance premium is the bonus-malus coefficient, through which the experience rating operates.

The remainder of this paper is organized as follows. Section 2 gives details on institutional background on the research setting. In section 3 we discuss the data, the summary statistics, and the methodology. Section 4 presents the basic analysis, the empirical results and the results for two placebo experiments. Section 5 concludes this paper.

2、Institutional Background

Automobile insurers in China offer almost the same contracts options to the market under the strictly regulated pricing rules. The automobile insurance market in China consists of two parts: one is the compulsory third party liability insurance and the other is the commercial insurance. This paper investigates the commercial insurance. The four main lines of commercial insurance are automobile damage & loss insurance, third party liability insurance, theft insurance and drivers & passengers liability insurance. Like in many other countries, insurers in China use both a priori pricing and a posteriori pricing for the one-year insurance contracts. A priori pricing is based on the observables by insurers whilst a posteriori pricing is based on BMC. Insurers compute the base-premium at the start of the contract based on the observables, such as the age of the automobile, the value of the automobile, etc. This is a priori pricing. The base-premium should be identical across insured with the same characteristics. A posteriori pricing is the mechanism of experience rating. Contracts can be renewed and premiums will be revised according to the BMC, which is based on the past claims and works as incentives for safe driving.

Although the experience-rated premium based on past claims exists in the Chinese automobile insurance market for a long time, since there is fierce competition among automobile insurers and they are not obliged to share the claims information in a certain platform, the insured has no commitment to BMC because they can escape their bad records by switching to another insurer without any punishment. The experience rating hence is only in name in China before the reform. To promote the fairness of the pricing, the Shenzhen Insurance Association announced that the pricing reform would be implemented in Shenzhen. The reform has two stages: (1)Stage one started from March 1st, 2011 and premiums will be revised according to the past claims. BMC turned steeper than before. Previously the coefficient range was from 0.7 to 1.3 and after this stage reform it is from 0.5 to 2.0. (2) Stage two started from Oct 15th, 2011 and the pricing will not only depend on the past claims but also on the traffic violations of the insured. The premium mulas coefficient is from 1.1 to 1.3 depending on the degree of the seriousness of traffic violations. It is for the first time in Chinese automobile insurance market that insurance premium will be adjusted according to the record of traffic violations of the insured. It is also the first time that the long-term nominal experience rating based on past claims is put into effect finally in China. The insurers are required by law to share the claims and traffic violations records of the insured through the commercial automobile insurance information platform. Therefore BMC could stick to the insured even if he or she switches to another insurer. Our analysis is

based on the idea that the experience rating has been put into practice in the treatment group since the pricing reform whilst there is no meaningful experience rating in the control group.

3、Data and methodology

(1)Data

Our data are policy information for the two cities of Shenzhen and Foshan obtained from one of the top three property and liability insurers in China, whose written premium accounted for about 19% of the automobile insurance market in China in 2014. We obtained a complete set of individual automobile policy and claims data. The data span the years 2009-2012. During this four-year-period, insured can enter and leave the insurer freely. To address sample selection and attrition issues, we only keep the automobiles who stay with this insurer for four consecutive years, which makes nearly 10 percent of the whole sample. That means we employ a balanced panel for analysis, which includes data of 20,603 automobiles after excluding missing values and there are 82,412 observations in total.

Each observation is a one-year commercial automobile insurance policy. Our sample contain detailed policy underwriting information and claims records. The underwriting data record the automobile's characteristics, such as the tonnage, the age, the value, the actual premium, and the type of the automobile. The claims data include two dimensions: one is claim frequency and the other is claim severity during the one-year insurance period, which can be regarded as proxies for accident history of the insured. The claims are all based on accidents for which the insured is fully or partially responsible. So our estimation will not be biased by the claims for which the third party's insurer is fully responsible.

The definitions for all the variables employed in this study are shown in Table 1. Three variables, once, twice, and number are employed to act as the proxies for accident frequency and the claim severity is the proxy for accident severity. Table 2 shows the summary statistics for each variable: the mean, standard deviation, the minimum value, the maximum value and the number of observations. Note that the frequency of claim at least once and twice during the insurance period is 0.358 and 0.133 respectively. The number of claims during the insurance period is 0.543. The average claim amount is 1.124(in thousands of Chinese currency yuan), with the maximum reaching 456.340. 87.7% of the policies are proposed in Shenzhen. The policies after the reform are the majority and the policies after the first stage reform and the second reform account for 71.9% and 56.5% of the total. If we look at the variables regarding the automobile's characteristics, we can see that the average tonnage of the automobile is 0.022 and the average age is 4.235 years. Only 3.1% are foreign-made automobiles. The average value of the automobile is 1.199(in hundred thousands of Chinese currency yuan) and the average actual premium is 2.935(in thousands of Chinese currency yuan). Variable type1 till type5 describes the type of the automobile and 86.6% are the regular automobile (with 6 seats and below).

Table 1

Definitions of variables

Variables	Definitions

Dependent variables	
once	A dummy variable that equals 1 when the insured has filed at least one claim during the insurance period; otherwise it equals 0
twice	A dummy variable that equals 1 when the insured has filed at least two claims during the insurance period; otherwise it equals 0
number	The number of claims during the insurance period
amount	The total amount of claims during insurance period(in thousands of Chinese currency yuan)
DID variables	
treat	A dummy variable that equals 1 when the insured signed the contract in Shenzhen; otherwise it equals 0
after0301	A dummy variable that equals 1 when the insured signed the contract after the first stage reform; otherwise it equals 0
after1015	A dummy variable that equals 1 when the insured signed the contract after the second stage reform; other it equals 0
reform0301	Interaction of the two variables of treat and after0301
reform1015	Interaction of the two variables of treat and after1015
The automobile's characteristics	
tonnage	The tonnage of the automobile
age	The age of the automobile
age^2	Age squared of the automobile
value	The value of the automobile(in hundred thousands of Chinese currency yuan)
premium	The actual premium during the insurance period(in thousands of Chinese currency yuan)
foreign	A dummy variable that equals 1 when the automobile is a foreign-made one; otherwise it equals 0.
type1	A dummy variable that equals 1 when the automobile is a truck (2 tons and below); otherwise it equals 0.
type2	A dummy variable that equals 1 when the automobile is a truck (2-5 tones); otherwise it equals 0.
type3	A dummy variable that equals 1 when the automobile is a coach (6 seats and below); otherwise it equals 0.
type4	A dummy variable that equals 1 when the automobile is a coach (6-10 seats); otherwise it equals 0
type5	A dummy variable that equals 1 when the automobile is a coach (10-20 seats); otherwise it equals 0

Table 2

The Basic Statistics of the Variables

Variables	mean	sd	min	median	max
Dependent variables					
once	0.358	0.479	0	0	1
twice	0.133	0.339	0	0	1
number	0.543	0.872	0	0	9
amount	1.124	5.403	0	0	456.34
DID variables					
treat	0.877	0.328	0	1	1
after0301	0.719	0.450	0	1	1
after1015	0.565	0.496	0	1	1
reform0301	0.632	0.482	0	1	1
reform1015	0.498	0.500	0	0	1
The automobile's characteristics					
tonnage	0.022	0.156	0	0	2.4
age	4.235	2.163	0.003	4.008	20.263
age^2	22.613	24.395	0.000	16.066	410.590
value	1.199	0.905	0	0.961	18.996
premium	2.935	1.379	0.259	2.824	26.742
foreign	0.031	0.173	0	0	1
type1	0.024	0.154	0	0	1
type2	0.000	0.005	0	0	1
type3	0.866	0.341	0	1	1
type4	0.107	0.310	0	0	1
type5	0.002	0.048	0	0	1

Note：n = 82412

(2)Methodology

We investigate the effects of the insurance incentives on safe driving by employing the methodology of DID. We could just calculate the difference of the claim frequency and severity before the reform and after the reform to examine the effect of the pricing reform on safe driving. However some other factors, both observable and unobservable, which may influence road safety as well would have changed. The existence of the control group can control for some common economic shocks. Through comparing the difference in the treatment group and the difference in the control group, DID could eliminate the bias that comes from the effects other than the reform that could affect the treatment group. Relying on measuring the differential effect of the reform across the two groups, the DID methodology is ideally suitable for establishing causal relationship in the setting of natural experiment.

In this research, because the pricing reform happens only in the city of Shenzhen, this gives us a natural treatment and control group for our analysis. We expect a reduced claim frequency or claim severity or both after the reform with the increase of insurance incentives.

Accident is measured both by accident frequency and accident severity. Three variables, namely, once, twice, and number are proxies for accident frequency whilst claim severity is a proxy for accident severity. Because the two variables of once and twice are binary dependent variables, panel logit model is adopted to test the effect of the reform on the probability of whether to claim at least once and twice, which is shown by equation (1); Since the variable of number is count number, panel poisson model is adopted to evaluate the effect of the reform on the number of claims, which is shown by equation(2). For accident severity, we employ OLS to test the effect of the reform on claim severity, which is shown by equation(3).

$$\Pr ob(once_{it}, twice_{it}=1) = \Lambda(\beta reform_{it} + X_{it}\alpha + u_i + \eta_t) = \frac{e^{\beta reform_{it} + X_{it}\alpha + u_i + \eta_t}}{1 + e^{(\beta reform_{it} + X_{it}\alpha + u_i + \eta_t)}};$$

$$\ln\left(\frac{p}{1-p}\right) = \beta reform_{it} + X_{it}\alpha + u_i + \eta_t,\ p \equiv \Pr ob(once_{it}, twice_{it} = 1) \quad (1)$$

$$\Pr ob(number_{it} = n_{it}) = \frac{e^{-\lambda_{it}} \lambda_{it}^{n_{it}}}{n_{it}!} (n_i = 0,1,2,\cdots,9);$$

$$\mathrm{E}(\mathrm{number}_{it}) = \mathrm{Var}(\mathrm{number}_{it}) = \lambda_{it};$$

$$\ln \lambda_{it} = \beta reform_{it} + X_{it}\alpha + u_i + \eta_t \quad (2)$$

$$severity_{it} = \beta reform_{it} + X_{it}\alpha + u_i + \eta_t + \varepsilon_{it} \quad (3)$$

In all the above equations subscripts i and t denote the automobile and the year(from 2009 till 2012) respectively. u_i is automobile fixed effects and η_t is year & month fixed effects. We control for the automobile characteristics, including the tonnage, the age, age squared, the value, the actual premium, and the type of the automobile, summarized in the vector of X . The reason why we include the age squared in the regression is that we wish to capture the possible non-linear effect of the age of the automobile(i.e. both the claim frequency and the severity might initially rise then decline with the increase of the automobile's age).

The main explanatory variable of interest is $reform_{it}$[1], the interaction of the two indicator variables, $treat_i$ and $after0301_t$ or $after1015_t$. $treat_i$ captures the differences in claiming behaviors of the treatment group and control group before the enforcement of the reform. $after0301_t$ and $after1015_t$ captures the difference before

[1] $reform_{it}$ is $reform0301_{it}$ when evaluating the impact of the first stage reform and $reform_{it}$ is $reform1015_{it}$ when evaluating the impact of the second stage reform.

and after the first stage reform and the second stage reform respectively for the control group. $reform_{it}$ therefore evaluates the differential effect of the reform across treatment group and control group. The DID methodology address the concerns of the omitted variables that might affect both the treatment group and the control group in the same way. The inclusion of automobile fixed effects guarantees the control of the automobile-level heterogeneity. The year & month fixed effects account for the aggregate shocks at macro level.

We can choose the model specification from the three models of the pooled model, random effects model and fixed effects model to estimate the equation (1), equation (2) and equation (3). The pooled model assumes there is no automobile fixed effects (i.e. $u_i = u$ for any automobile) and the random effects model requires that there is no correlations between the automobile fixed effects and the model regressors, both of which are hard to hold in reality. The fixed effects model, however, permits the possible correlations between the regressors and the automobile fixed effects. We therefore employ the fixed effects model to evaluate the impact of the reform on accident frequency and accident severity using automobile-level data. The fixed effects model cannot obtain the estimation for the parameters of the time-invariant variables, which is the disadvantage of the panel fixed effects model.

In Equation(1) $\Lambda(\square)$ is the logistic cumulative distribution function. $once_{it}$ (the probability of claim at least once) and $twice_{it}$ (the probability of claim at least twice) are the dependent variables of interest, which are proxies for accident frequency. The model can be estimated by conditional maximum likelihood. One disadvantage of panel logit model is that any automobile with all positive or negative outcomes is dropped since it will not contribute to the estimation of β. For logit model, β stands for the log-odds ratio (odds ratio is also called the relative risk) instead of the marginal effects. In our case 6237 automobiles (24948 observations from 2009 till 2012) are dropped for the panel logit model with the dependent vatiable of $once_{it}$ whilst 12720 automobiles (50880 observations from 2009 till 2012) are dropped for the panel logit model with the dependent variable of $twice_{it}$.

In Equation(2) $number_{it}$ (number of claims) is the dependent variable of interest, which is also the proxy for accident frequency. We call $\lambda_{it} \succ 0$ as poisson arrival rate. For poisson model, β stands for the seimi-elasticity of the reform instead of the marginal effects. The disadvantage of the panel poisson model is that any automobile with all zero outcomes is dropped. In our case, 5343 automobiles (21372 observations

from 2009 till 2012) are dropped.

In Equation(3) $severity_{it}$ is the dependent variable of interest, which is the proxy for accident severity. ε_{it} is the error term following a normal distribution.

4、The Impact of the reform on road safety

(1) Before-after analysis

In table 3 we perform the simple "pre" and "post" test by taking the time-averages before and after the reform. We get the results both for the first stage reform and the second stage reform. We note that once, twice, number and amount declined both after the first stage reform and after the second stage reform. For example, the probability of whether to claim at least once declined by 0.15 after the first stage reform. Compared with the pre-reform mean of 0.47, this is a substantial decline. The amount of claim declined similarly but not as much as once, twice and number. That is to say, much acuter drops happen to claim frequency as compared to claim severity.

Table 3

"Pre" and "Post" Claim Average Test of the Reform

This table reports the pre-after analysis of the two-stage reform. First stage reform started from Mar 1st, 2011, when insurance pricing was required by law to be based on past claims of insured. Second stage reform started from Oct 15th, 2011, when insurance pricing was further required to be based on traffic violations. Once, twice, number and amount are four proxies for accident history(once, twice, and number are proxies for accident frequency and amount is a proxy for accident severity), which stand for the probability of claim at least once, the probability of claim at least twice, number of claims, amount of claims during insurance period respectively. Standard errors are reported in brackets. *** implies significance at the 99% level.

	First stage Reform			Second Stage Reform		
	before	after	difference	before	after	difference
once	0.466	0.315	-0.151***	0.441	0.294	-0.147***
	(0.003)	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)
twice	0.207	0.104	-0.104***	0.189	0.090	-0.099***
	(0.003)	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)
number	0.762	0.457	-0.305***	0.713	0.412	-0.300***
	(0.007)	(0.003)	(0.007)	(0.005)	(0.003)	(0.006)
amount	1.220	1.087	-0.133***	1.192	1.072	-0.120***
	(0.037)	(0.022)	(0.042)	(0.029)	(0.025)	(0.038)

(2) Before-after analysis for treatment group and control group

In figure 3, 4, 5, and 6 we separately plot the time series of once, twice, number, and amount both for the treatment group and for the control group. We see that proxies for accident frequency, namely, once, twice, and number moved in the roughly same pattern before the first stage of reform. After the reform once, twice, number of both the treatment group and the control group declined significantly. But the disparity between the treatment group and the control group expands. The enlarged disparity is due to the much more decrease of the claim frequency of the treatment group than that of the

control group. This is consistent with our expectations that the more insurance incentives introduced in the treatment group will reduce accident frequency accordingly. In addition, we see that the amount of the claim seemed unaffected by the reform both for the treatment group and for the control group.

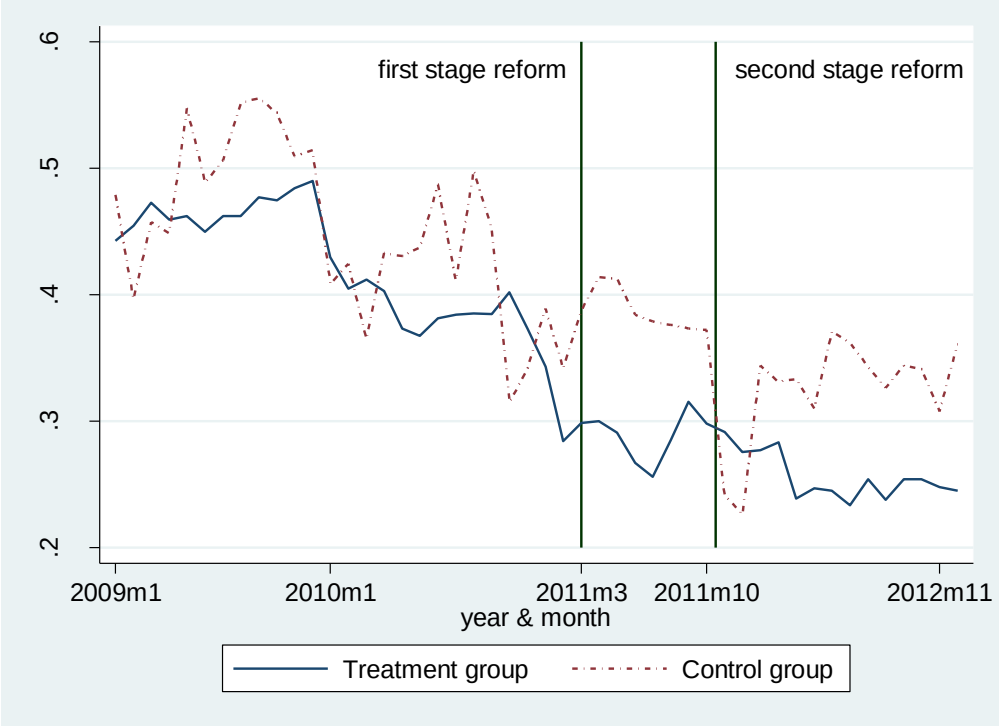

Figure 3. Claim frequency: probability of claim at least once. Here, we plot the time series for the variable of once, the probability of claim at least once during insurance period both for the treatment group and for the control group.

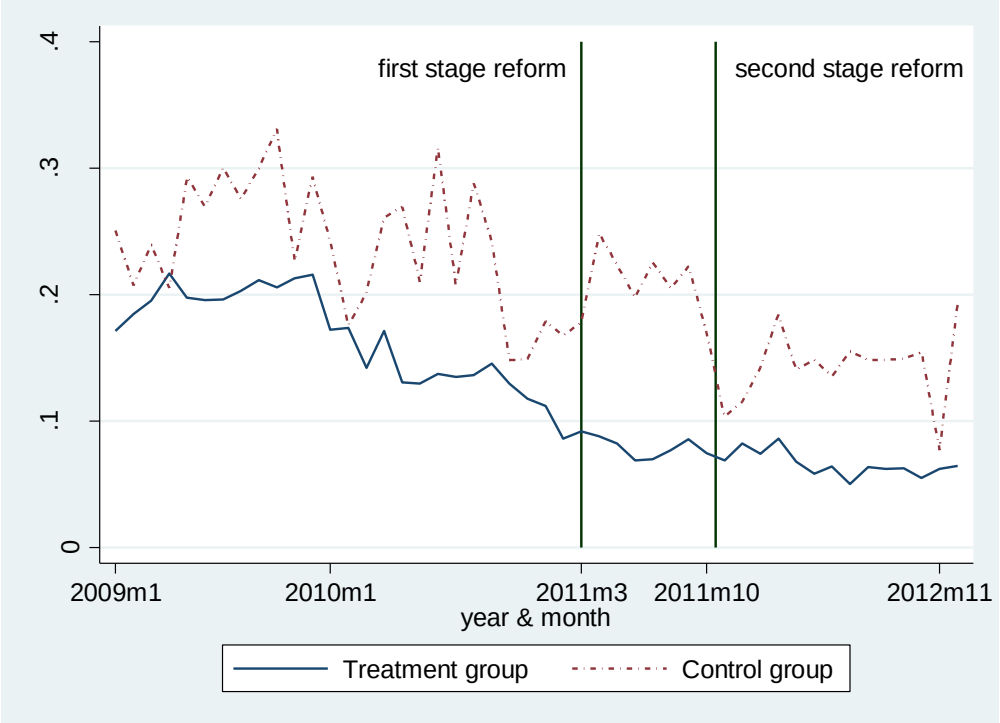

Figure 4. Claim frequency: probability of claim at least twice. Here, we plot the

time series for the variable of twice, the probability of claim at least twice during insurance period for both the treatment group and for the control group.

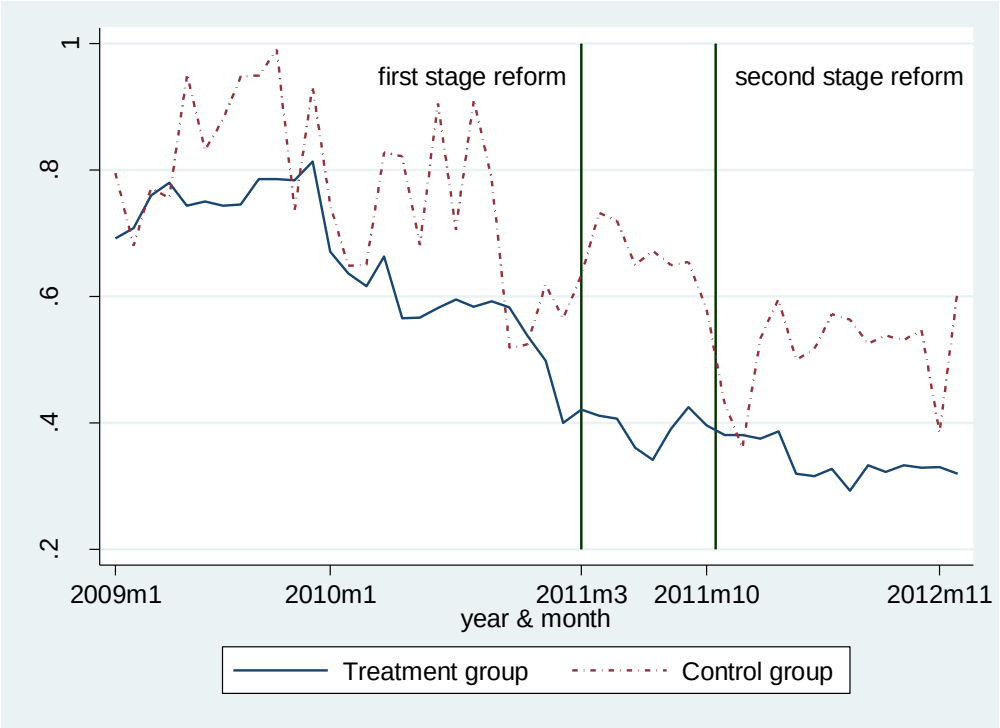

Figure 5. Claim frequency: number of claims. Here, we plot the time series for the variable of number, the number of claims during insurance period both for the treatment group and for the control group.

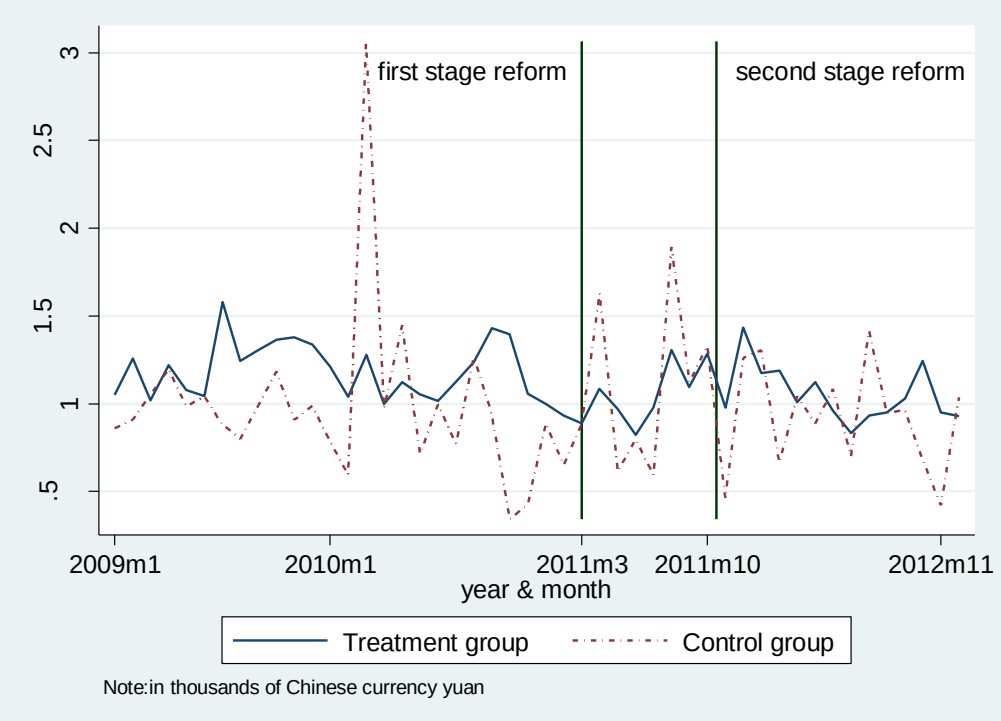

Figure 6. Claim severity: amount of claim. Here, we plot the time series for the variable of amount, the amount of claim during insurance period both for the

treatment group and for the control group.

Table 4 displays the averages for the treatment group and the control group, before and after the reform, for the four abovementioned variables. The differences of mean tests and DID estimates, which are the pooled versions of equation(1), (2), and (3) are also provided. Panel A, Panel B, Panel C and Panel D report the results for once, twice, number and amount respectively. As can be seen in Panel A, once declined by 0.04 and 0.03 more for the treatment group as compared to the control group for the first stage reform and the second stage reform, respectively. In Panel B the variable of interest is twice, it can be seen that the difference between the treatment group and the control group declined 0.03 and 0.01, respectively. However, it is not significant for the second stage reform. The results of number is in Panel C and it once again shows the bigger drop for the treatment group than for the control group. Panel D reports the results for amount of claim, which declined by 0.27 and 0.04 respectively after the first stage reform and the second stage reform, but for the second stage reform the decline is not statistically significant.

Table 4

"Pre" and "Post" Claim Average Test of the Reform for the Treatment Group and the Control Group

This table reports the pre-after results both for the treatment group and for the control group. First stage reform started from Mar 1st, 2011, when insurance pricing was required by law to be based on past claims of insured. Second stage reform started from Oct 15th, 2011, when insurance pricing was further required to be based on traffic violations. Once, twice, number and amount are four proxies for accident history(once, twice, and number are proxies for accident frequency and amount is a proxy for accident severity), which stand for the probability of claim at least once, the probability of claim at least twice, number of claims, amount of claims during insurance period respectively. Standard errors are reported in brackets. *** implies significance at the 99% level.

	First stage Reform			Second Stage Reform		
			Panel A: once			
	before	after	difference	before	after	difference
control	0.494	0.377	-0.117***	0.477	0.356	-0.121***
	(0.009)	(0.006)	(0.011)	(0.007)	(0.006)	(0.010)
treatment	0.462	0.307	-0.156***	0.435	0.285	-0.150***
	(0.004)	(0.002)	(0.004)	(0.003)	(0.002)	(0.004)
difference	-0.031***	-0.070***	-0.039***	-0.041***	-0.071***	-0.029***
	(0.010)	(0.006)	(0.012)	(0.008)	(0.007)	(0.010)
	before	after	difference	before	after	difference
			Panel B: twice			
control	0.267	0.192	-0.075***	0.262	0.173	-0.089***
	(0.008)	(0.005)	（0.009）	(0.006)	(0.005)	(0.008)
treatment	0.198	0.092	-0.107***	0.178	0.078	-0.099***
	(0.003)	(0.001)	(0.003)	(0.002)	(0.001)	(0.002)
difference	-0.068***	-0.100***	-0.032***	-0.084***	-0.095***	-0.011
	(0.008)	(0.004)	(0.010)	(0.006)	(0.004)	(0.007)

	before	after	difference	before	after	difference
			Panel C: number			
control	0.851	0.633	-0.217***	0.832	0.584	-0.248***
	(0.019)	(0.011)	(0.021)	(0.015)	(0.012)	(0.019)
treatment	0.749	0.433	-0.316***	0.695	0.389	-0.306***
	(0.007)	(0.003)	(0.007)	(0.006)	(0.004)	(0.006)
difference	-0.102***	-0.201***	-0.099***	-0.137***	-0.195***	-0.058***
	(0.020)	(0.010)	(0.023)	(0.016)	(0.011)	(.021)
			Panel D: amount			
	before	after	difference	before	after	difference
control	0.947	1.051	0.104	1.067	0.983	-0.084
	(0.050)	(0.072)	(0.116)	(0.080)	(0.070)	(0.106)
treatment	1.260	1.092	-0.168***	1.211	1.084	-0.127***
	(0.042)	(0.023)	(0.045)	(0.031)	(0.027)	(0.041)
difference	0.313***	0.041	-0.272***	0.144*	0.102	-0.043
	(0.111)	(0.067)	(0.100)	(0.086)	(0.077)	(0.114)

(3) Empirical results

Since the results in Table 4 are the pooled estimates for the differences, the individual unobserved heterogeneity across automobile and time could not be accounted for. The results hence could be biased if, for instance, insured could decide their accident propensity in some degree based on their type. To assess the significance of the pricing reform on road safety, we estimate equation (1), (2), and (3) which include the automobile fixed effects and the time fixed effects to absorb the heterogeneity. The DID methodology is best captured by Table 5. Panel A reports the results of the effects of the first stage reform in which the pricing is based on the past claims. The results for the second stage reform, in which the pricing is further based on traffic violations besides past claims, are shown in Panel B. Column 1 and column 2 reports the results for once. Column 3 and column 4 reports the results for twice. Column 5 and column 6 reports the results for number. Column 7 and column 8 reports the effects of reform on amount of claim. In column 1, column 3, column 5 and column 7 we report the basic regression results without the inclusion of automobile controls. We further add automobile characteristics controls in column 2, column 4, column 6 and column 8. From column 2 it can be seen that the coefficient on the interaction term is -0.05 and -0.13 in panel A and panel B respectively. But the decrease for the first stage reform is not significant. The coefficient for twice is -0.35 and -0.32 respectively in column 4. The coefficient for number is -0.18 and -0.19 in column 6, which means the number of claims dropped by 18% and 19% following the implementation of the first stage reform and the second stage reform respectively. These regressions reveal a negative and strongly significant relation(except the only 10% significance level in column 1 and insignificance in column 2 for panel A) between the accident frequency and the interaction of the treatment group dummy variable and the reform period dummy variable. We conclude that the insurance incentives the reform introduce have reduced the accident frequency significantly. Compared with the first stage reform, the second stage reform provides bigger and more incentives on road safety. We repeat the same

analysis for amount of claim. The coefficient on the interaction in Column 8 of Panel A is -0.22, which is only significant at the 10% significance level. The coefficient on the interaction in Column 8 of Panel B is -0.11, which is not statistically significant. We therefore conclude that the effects of the reform on accident severity is inconclusive and insignificant.

(4) Placebo Test

We rerun the regressions in table 5 and perform two placebo experiments to see whether the empirical results we obtain in the previous section are at odds with the data. Table 6 reports the results for the placebo reform that shift the first stage reform date by one year in the past, namely, March 1st, 2010. The reason why we do not conduct a placebo reform that shift the second stage reform by one year in the past, namely, Oct 15, 2010, is that the Shenzhen Insurance Association announced that it would seek advice publicly for the forthcoming reform on Nov 4, 2010, which was very close to that date. The driving behaviors of the public may be affected by the announcement although it takes time for the reform to be taken into true practice. In Table 7 we further conduct a placebo experiment where we randomly assigned the automobiles from the pool of the treatment group and the control group into the placebo treatment group. These placebo experiments are meant to show that the decreasing claim frequency is the effect of the reform and not the effect of some artefact of other factors. This is confirmed by table 6 and table 7 since we do not find any significant effects both for the placebo reform experiment and for the placebo treatment group experiment except in Table 6 the negative coefficient on the interaction of the treatment group dummy variable and the reform period dummy is only significant at the 10% significance level.

Table 5

Effects of insurance incentives on claim frequency and claim severity

This table reports the results for the significance of the reform. Panel logit model(Equation 1) is employed to get the results from column 1 till column 4. Panel poisson model(Equation 2) is employed to get the results in column 5 and column 6. OLS(equation 3) is employed to get the results in column 7 and column 8. Panel A reports the results for the first stage reform and Panel B reports the results for the second stage reform. First stage reform started from Mar 1st, 2011, when insurance pricing was required by law to be based on past claims of insured. Second stage reform started from Oct 15th, 2011, when insurance pricing was further required to be based on traffic violations. Once, twice, number and amount are four proxies for accident history(once, twice, and number are proxies for accident frequency and amount is a proxy for accident severity), which stand for the probability of claim at least once, the probability of claim at least twice, number of claims, amount of claims during insurance period respectively. The results for accident frequency are shown from column 1 till column 6. Column 1 and column 2 reports the results for once, column 3 and column 4 reports the results for twice, column 5 and column 6 reports the results for number. Column 7 and column 8 reports the results for amount. Automobile cluster robust standard errors are employed and t statistics are reported in brackets. ***,**, and * implies significance at the 99% level, 95% level, and 90% level respectively.

	Accident frequency						**Accident severity**	
	1	2	3	4	5	6	7	8
Panel A: first stage	-0.107*	-0.045	-0.441***	-0.353***	-0.231***	-0.182***	-0.216*	-0.223*
reform	(-1.85)	(-0.77)	(-6.69)	(-5.28)	(-7.80)	(-6.17)	(-1.67)	(-1.71)
automobile controls	No	Yes	No	Yes	No	Yes	No	Yes
individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Automobiles	14,366	14,366	7,883	7,883	15,260	15,260	20,603	20,603
observations	57,464	57,464	31,532	31,532	61,040	61,040	82,412	82,412
log likelihood/ R^2(within)	-20597.903	-20496.504	-10467.112	-10391.221	-38984.09	-38831.43	0.0014	0.0026
Panel B: second stage	-0.173***	-0.129**	-0.388***	-0.321***	-0.238***	-0.192***	-0.067	-0.109
reform	(-3.46)	(-2.55)	(-6.41)	(-5.22)	(-8.63)	(-6.98)	(-0.59)	(-0.96)
Automobile controls	No	Yes	No	Yes	No	Yes	No	Yes

Automobile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of automobiles	14,366	14,366	7,883	7,883	15,260	15,260	20,603	20,603
observations	57,464	57,464	31,532	31,532	61,040	61,040	82,412	82,412
log likelihood/ R^2(within)	-20593.667	-20493.564	-10469.143	-10391.607	-38977.903	-38826.436	0.0013	0.0026
Specification	Logit	Logit	Logit	Logit	Poisson	Poisson	OLS	OLS

Table 6

Placebo test: shift the reform by one year in the past to Mar 1st, 2010

This table reports the results for the placebo reform date experiment, in which we shift the reform by one year in the past to Mar 1st, 2010. Panel logit model(Equation 1) is employed to get the results from column 1 till column 4. Panel poisson model(Equation 2) is employed to get the results in column 5 and column 6. OLS(equation 3) is employed to get the results in column 7 and column 8. Once, twice, number and amount are four proxies for accident history(once, twice, and number are proxies for accident frequency and amount is a proxy for accident severity), which stand for the probability of claim at least once, the probability of claim at least twice, number of claims, amount of claims during insurance period respectively. The results for accident frequency are shown from column 1 till column 6. Column 1 and column 2 reports the results for once, column 3 and column 4 reports the results for twice, column 5 and column 6 reports the results for number. Column 7 and column 8 reports the results for amount. Automobile cluster robust standard errors are employed and t statistics are reported in brackets. ***,**, and * implies significance at the 99% level, 95% level, and 90% level respectively.

	Accident frequency						**Accident severity**	
	1	2	3	4	5	6	7	8
reform	-0.126	-0.0757	-0.135	-0.0722	-0.142*	-0.093	-0.064	-0.068
	(-0.86)	-0.146	(-0.78)	-0.174	(-1.91)	-0.075	(-0.20)	(-0.21)
Automobile controls	No	Yes	No	Yes	No	Yes	No	Yes
Automobile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
automobiles	14,366	14,366	7,883	7,883	15,260	15,260	20,603	20,603
obs	57,464	57,464	31,532	31,532	61,040	61,040	82,412	82,412
log likelihood/ R^2(within)	-20599.237	-20496.669	-10489.109	-10405.005	-39143.519	-38939.609	0.0013	0.0026
Specifacation	Logit	Logit	Logit	Logit	Poisson	Poisson	OLS	OLS

Table 7

Placebo test: a random draw from the pool of the treatment group and the control group as the treatment group

This table reports the results for the placebo treatment group experiment, in which we randomly assigned the automobiles from the pool of the treatment group and the control group into the placebo treatment group. Panel logit model(Equation 1) is employed to get the results from column 1 till column 4. Panel poisson model(Equation 2) is employed to get the results in column 5 and column 6. OLS(equation 3) is employed to get the results in column 7 and column 8. Panel A reports the results for the first stage reform and Panel B reports the results for the second stage reform. First stage reform started from Mar 1st, 2011, when insurance pricing was required by law to be based on past claims of insured. Second stage reform started from Oct 15th, 2011, when insurance pricing was further required to be based on traffic violations. Once, twice, number and amount are four proxies for accident history(once, twice, and number are proxies for accident frequency and amount is a proxy for accident severity), which stand for the probability of claim at least once, the probability of claim at least twice, number of claims, amount of claims during insurance period respectively. The results for accident frequency are shown from column 1 till column 6. Column 1 and column 2 reports the results for once, column 3 and column 4 reports the results for twice, column 5 and column 6 reports the results for number. Column 7 and column 8 reports the results for amount. Automobile cluster robust standard errors are employed. t statistics are reported in brackets. ***,**, and * implies significance at the 99% level, 95% level, and 90% level respectively.

	Accident frequency						**Accident severity**	
	1	2	3	4	5	6	7	8
Panel A: first stage								
reform	0.047	0.047	0.048	0.054	0.026	0.028	-0.027	-0.03
	-1.28	-1.26	-1	-1.12	-1.28	-1.42	(-0.32)	(-0.35)
Automobile controls	No	Yes	No	Yes	No	Yes	No	Yes
Automobile fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
obs	57,464	57,464	31,532	31,532	61,040	61,040	82,412	82,412
automobiles	14,366	14,366	7,883	7,883	15,260	15,260	20,603	20,603
log likelihood/ R^2(within)	-20598.795	-20496.007	-10488.914	-10404.46	-39144.541	-38939.377	0.0013	0.0026
Panel B: second stage								

reform	0.017	0.016	-0.022	-0.018	-0.001	0.001	-0.049	-0.049
	(0.50)	(0.47)	(-0.46)	(-0.38)	(-0.03)	(0.04)	(-0.64)	(-0.64)
Automobile controls	No	Yes	No	Yes	No	Yes	No	Yes
individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
obs	57,464	57,464	31,532	31,532	61,040	61,040	82,412	82,412
automobiles	14,366	14,366	7,883	7,883	15,260	15,260	20,603	20,603
log likelihood/ R^2(within)	-20599.485	-20496.689	-10489.303	-10405.018	-39145.365	-38940.386	0.0013	0.0026
Specification	Logit	Logit	Logit	Logit	Poisson	Poisson	OLS	OLS

6、Conclusion

This paper exploits a natural experiment in China, namely, a reform in Shenzhen automobile insurance market to investigate the effects of insurance incentive mechanisms on road safety. The approach taken in this paper permits a unique identification of the causal effect of insurance incentives on safe driving. We take advantage of the fact that only Shenzhen in the province of Guangdong introduced the new pricing mechanism. Arguing that the treatment, i.e., introducing the new pricing mechanism is exogenous, we can use the difference-in-differences approach to obtain the causal effect of the insurance incentives on road safety. We find strong behavioral effects of the reform. The results show that increasing the insurance incentives can reduce the accident frequency. This conclusion is robust to alternative definitions for accident frequency. The conclusion also passes the placebo experiments. Moreover, we find that the effect of the second stage reform is more robust and conclusive as compared to the first stage reform, which means that basing pricing on traffic violations has the bigger incentive effects on safe driving than on past claims. The possible reason is due to the presence of the asymmetric learning when the insured learn about their risk by observing their accidents more rapidly than the insurer who can only observe the claims instead of the accidents. Although being implemented with great difficulty before the true set-up of the commercial automobile insurance information platform, the experience-rated premium based on past claims has existed in China for a long time and it is nothing new to the insured when it is put into effect by law. The insured has enough time to learn and hence we see the comparatively smaller effects of the first stage reform. Conversely, the experience-rated premium based on traffic violations is completely new to insured. Hence the impact of basing pricing on traffic violations is bigger than on past claims. We also evaluate the effects of the insurance incentives on accident severity and we find that the effects are insignificant.

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