



The effectiveness and influencing factors of a penalty point system in China from the perspective of risky driving behaviors



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ABSTRACT

Many countries have adopted penalty point systems (PPS) to deter drivers from breaking traffic laws. To investigate the effectiveness of PPS on reducing illegal driving behavior, this study analyzed traffic violation data of a Chinese city in 2017. This analysis revealed that 1) risky driving behaviors (RDBs) are among the main causes of traffic violations and 2) almost half of the offenders with multiple violations committed the same traffic rule violations more than once. To further explain these phenomena, a survey in another Chinese city—Tianjin—was conducted. Considering the fact that most types of RDBs will, if detected by the authorities, result in traffic violations, the present study investigated the influence of a PPS, represented by penalty experience (PE), on traffic violation behaviors from the perspective of RDBs. Moreover, the impact of cognitive processes on driving behaviors via self-efficacy was considered. We found that drivers' PE is positively associated with their RDBs and that offenders with more PE are more inclined to commit RDBs; we further observed that self-efficacy partially mediates the relationship between PE and RDBs. However, no gender difference in the effect of PE on RDBs was discovered, thus indicating that PE has the same effect on male and female drivers. Based on these findings, some strategies are suggested (such as the Increasing Block Penalty Points Policy) to improve the effectiveness of the PPS.

1. Introduction

Nearly 1.35 million people die in road accidents every year, and tens of millions of people are injured in traffic accidents (WHO, 2018). Thus, reducing traffic accidents has become one of the most important health and safety issues worldwide. Traffic violations are among the key factors that have contributed to the increased risk of crashes (Ayuso et al., 2010; Factor et al., 2012; Factor, 2014; Gebers and Peck, 2003; Parker et al., 1995; Stanojević et al., 2013; Sullman et al., 2002). Drivers who had received traffic tickets were significantly more involved in traffic crashes than those without tickets (Lourens et al., 1999). In fact, drivers who received six traffic tickets per year have eleven times higher probability than drivers who received one ticket per year of being involved in a severe crash (Factor, 2014).

To reduce traffic violations, many countries have adopted a penalty point system (PPS). The PPS is a system under which several specific offenses committed by drivers earn the addition or loss of a specific number of points. Governments have their own PPS structures, including such elements as initial scores or specific deduction policies, to suit its specific circumstances. In general, when the number of points incurred reaches the maximum allowed, the driver's license is

suspended (Nolén and Östlin, 2008). Some type of PPS exists in 44 countries, including New Zealand (1967), Japan (1968), Australia (1970), Italy (2003), Spain (2006), and China (2004) (Castillo-Manzano and Castro-Nuno, 2012).

The effectiveness of PPS has been widely studied in previous research. Studies show that adopting a PPS can lead to a 12% reduction in the number of crashes and a 26% reduction in fatalities two years after implementation (DGT, 2009). Furthermore, an observational study found that PPS could promote the use of seatbelts (Zambon et al., 2008). However, an alternative perspective has emerged that calls into question the effectiveness of PPS. Recent studies have suggested a correlation between the use of a PPS and such undesirable driving behaviors as driving without a valid license (Knox et al., 2003), engaging in higher-risk driving behaviors (Mehmood, 2010), and instigating “hit-and-run” crashes (SWOV, 2010). Moreover, the positive effects of a PPS (15–20% reduction in accidents, fatalities, and injuries) will gradually diminish over time (Castillo-Manzano and Castro-Nuno, 2012; Mehmood, 2010).

A PPS is a body of traffic enforcement measures with deterrence as its theoretical basis (Armstrong et al., 2018). This theory posits that the influence of legal threats is based on the idea that the perceived risk of

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punishment is determined by a combination of the perceived risk of being apprehended and the perceived certainty, severity, and swiftness of legal sanctions associated with apprehension (Ross, 1982). The underlying premise of deterrence theory is that the perceived consequences of engaging in illegal behaviors will dissuade such behavior (Homel, 1988; Zimring et al., 1973). Thus, although some road safety countermeasures, such as high levels of publicity regarding legal sanctions, may initially enhance drivers' perceptions of being detected (Elvik and Christensen, 2007; Watling et al., 2014), these perceptions weaken over time if there is no follow-up reinforcement (Homel, 1986). Therefore, to improve the effectiveness of PPS, it is important to explore the driver's psychological perception of the PPS and to investigate the intrinsic psychological factors related to this process.

Furthermore, the measure of PPS effectiveness has not been fully developed (Castillo-Manzano et al., 2010). In some literature, crash rates, fatalities, and serious injuries have been counted as safety indicators to measure the effectiveness of a PPS (Castillo-Manzano et al., 2010; Izquierdo et al., 2011). However, these safety indicators are also affected by other factors such as exposure, infrastructure, and surveillance. Therefore, the decrease of these safety indicators is unlikely to be the only result of PPS (Izquierdo et al., 2011). Moreover, these safety indicators cannot reflect changes in drivers' behavior. Watson et al. (2015) observed that one mechanism for assessing the effectiveness of countermeasures, such as those that make up PPS, is to determine whether reductions in the target behavior occur because of their introduction. In order to reveal the behavioral changes that occur within a PPS, scholars have analyzed self-reported changes in RDBs (Gras et al., 2014; Montoro González et al., 2008). Risky driving (e.g., speeding, running red lights, weaving through traffic, or maneuvering without a signal) is characterized by types of dangerous behaviors in which drivers engage without the intent to harm oneself or others (Suh and Dula, 2017). Studies indicate that RDBs are associated with road traffic crashes (Gebers and Peck, 2003; Parker et al., 1995). Moreover, most types of RDBs, if detected by the authorities, result in a loss of points (Gras et al., 2014). However, the self-reporting of behavioral changes may be subject to social desirability effects, and thus, may not reflect the actual change (Blows et al., 2005; Ivers et al., 2009; Parker et al., 1995). Thus, this study will draw from two sets of data originating in China: a large, realistic traffic violation dataset and a self-report dataset.

To facilitate the implementation of a PPS, it is necessary to assess whether such traffic enforcement measures can effectively change drivers' behaviors. However, several factors offer challenges for assessment. First, the two dominant biological sexes show consistent differences in terms of their sensitivity to punishment (Cross et al., 2011); for example, female drivers scored higher than male drivers in measurements of punishment sensitivity (Harbeck et al., 2017). Moreover, men and women report different driving behaviors and tendencies to commit traffic violations; for example, men are involved in more accidents and self-report more traffic violations (González-Iglesias et al., 2012; Özkan and Lajunen, 2006; Rimmö and Åberg, 1999; Wickens et al., 2008;). Therefore, this study investigates whether the behavioral differences are the results of the discrepant sensitivity to punishments. In addition, addressing gender differences and trying to explore their role in the effects of a PPS might help to foster the implementation of an effective PPS. The present study attempts to investigate gender differences in the effects of a PPS on drivers' behavioral changes, because if systematic gender differences exist, related policies should take them into account.

In sum, the following issues will be investigated in the following sections: 1) the effect of a PPS on reducing drivers' RDBs, 2) the cognitive factors that influence the effectiveness of a PPS, and 3) the influence of gender difference on PPS effectiveness. To this end, section 2 analyzes the traffic violation dataset of a Chinese city. Section 3 explores whether, how, and when the penalty experience influences self-reported RDBs. Based on our results, we discuss conclusions and suggest

Table 1

The major violations and the penalty points they entail.

Violations	Penalty points
Driving while intoxicated	12
Speeding (exceeding the prescribed speed by more than 50%)	12
Driving against red traffic light	6
Speeding (exceeding the prescribed speed by between 20% and 50%)	6
Speeding (exceeding the prescribed speed by less than 20%)	3
Using cell phones while driving	2
Using headlights illegally	1

strategies for enhancing the effectiveness of PPS in section 4.

2. Background

2.1. Penalty point system in China

In May 2004, China introduced a penalty point system (PPS) nationwide to reduce illegal road behaviors. Every driver begins with twelve points on their driving license every year. Drivers caught violating traffic rules will be punished with a loss of 1, 2, 3, 6, or 12 points, depending on the severity of the violation (see Table 1). If the points lost do not add up to 12 points by the end of a scoring cycle, the lost points will be eliminated and will not be added to the next 12-month scoring period. If drivers lose twelve or more points in one-year period, their driving license will be suspended. In order to get their licenses back, drivers need to complete a seven-day course within 15 days after losing all points. Within 20 days of completing the course, they need to take an examination. If drivers pass the examination, the score is cleared, and they can get their licenses back the next day. If the driver fails the exam, he or she will continue to participate in the examination course (The Ministry of Public Security of the People's Republic of China, 2003).

In 2016, the total number of road accidents in China was 13.51% higher than that in 2015. In addition, the number of road traffic violations in China was 21.9% higher compared to that of 2015 (the data has been obtained from the Traffic Management Bureau of the Ministry of Public Security of China). To explore the effectiveness of PPS in China and discern whether people's behavior improved after losing points, we collected traffic violation data in a Chinese city and conducted the following analysis.

2.2. Multiple violations and repeat violations in traffic violation data

The data were obtained from the traffic police department of the municipal public security bureau in a Chinese city. The local government had exposed some traffic violators in this city as a warning to traffic rule-breakers and other drivers. We collected the violation data in 2017. In total, 101,394 traffic violation records for 90,340 vehicles were collected, including data regarding vehicle license number, date, and specific traffic violations. According to the government, the number of vehicles in this city was 2,030,333 by the end of 2016. At the same time, the number of drivers holding licenses in the city was 2,184,845 by the end of 2015, or just over one driver per vehicle, on average.

Countermeasure effectiveness in road safety is vital for developing safer driving environments. In road safety, we can assess countermeasure effectiveness via recidivism, primarily (Watson et al., 2015). The term recidivist is typically used to describe drivers with multiple offences (Watson et al., 2015). Other research suggests that recidivists have a number of psychological differences compared to other road users (Harrison, 2008; Styles et al., 2009). In the present study, if a vehicle is associated with more than one violation record, it will be called a multiple violation (MV) vehicle. We found that 9.87% vehicles

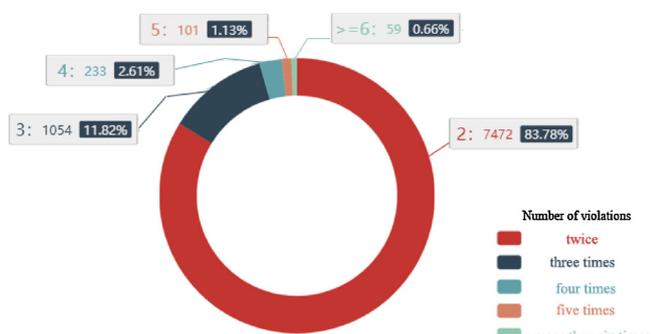


Fig. 1. Number of violations of MV vehicles.

(8919 in number) were MV vehicles. Fig. 1 presents the number of violations of MV vehicles. Among them, 83.78% vehicles had two violations, and 16.22% vehicles had more than two violations in 2017.

To further reveal the types of MV, we divide the violations into nine categories, according to the records. The first category concerns parking violations. The second includes violations of traffic signs and traffic line markings. The third includes driving outside of the regular roadway (i.e., driving in the bus-only lanes). The fourth includes violations of traffic signals. The fifth category includes speeding infractions. The sixth category includes driving without the use of a seat belt. The seventh includes purposely covered, stained, damaged, or uninstalled number plates. The eighth includes irregular overtaking. The ninth category includes other violations that account for a very small percentage of the data (e.g., motor vehicles without regular safety technical inspections). Most of these behaviors are RDBs. Analyzing the specific reasons for classifying MV vehicles, we found that 4890 vehicles, or approximately 54.83%, of the MV vehicles violated traffic rules repeatedly for the same reason, in other words, they engaged in repeat violations (RV). Fig. 2 illustrates the specific violations of RV vehicles. Driving on an irregular roadway was the most common RV, followed by violations of traffic signs and traffic line markings.

To exclude drivers who break multiple traffic rules in a short period, we have excluded those drivers with instances of repeated MV within any 24-h period. After deleting these violations, we still found that 8.85% (7995) of registered vehicles in this city were MV vehicles. After analyzing the cause, we found that 3855 vehicles of those were associated with RV. We can see that a large proportion (48.22%) of MV drivers violated traffic rules multiple times for the same reason. Despite the implementation of a PPS in this city, there are still many offenders who repeatedly violate the same exact traffic rules. These repeat offenders are a major concern of traffic safety, and they pose the greatest risk of being involved in accidents (Nadeau, 2002). The widespread use of PPS is based on an assumption of its effectiveness in preventing drivers from committing traffic violations (Sagberg and Ingebrigtsen,

2018). However, the traffic violation data gathered for this study suggest that almost half the offenders with multiple violations committed the same traffic rule violations repeatedly in spite of the PPS. A survey designed and conducted for this study to reveal further insights into such phenomena is detailed below.

3. Survey study

3.1. Theoretical background

In this section, we investigate the relationship between driver's license penalty points and violation behaviors as well as drivers' internal cognitive factors that are related to this process. Behaviors are controlled or determined both by the individual, through cognitive processes, and by the environment, through external social stimulus events (Bandura, 1986). In our local environment, a PPS plays the role of external social stimulus and can be indicated by penalty experience (PE). The more penalty experiences a person commits, the more points he or she accrues. The cognitive process is denoted by self-efficacy, since it is closely related with RDBs (Krueger and Dickson, 1994; McLernon, 2014).

3.1.1. Penalty experience

Deterrence theory proposes that drivers actively consider the consequences of their behaviors each time they are driving (Harrison, 1998; Homel, 1988) and that the perceived negative consequences will dissuade drivers from engaging in such illegal behaviors (Homel, 1988; Zimring et al., 1973). According to this theory, people who are facing negative consequences for a behavior will reduce both this behavior and related behaviors (Rachlin, 1989). Proponents of a PPS argue that it can encourage drivers to rectify of their own volition inappropriate driving behaviors (de Figueiredo et al., 2001). The penalty serves as a deterrent by creating a situation in which multiple traffic violations will lead to the suspension of the offender's license (Zambon et al., 2008). Since most RDBs will lead to penalties if detected by the authorities, according to PPS proponents, drivers will reduce RDBs in the future. In addition, as penalties accumulate, the marginal cost of incurring a penalty increases, thus enhancing its weight as a deterrent. Therefore, drivers will pay more attention to regulating their RDBs. Thus, we assume the first hypothesis.

Hypothesis 1. There is a negative relationship between PE and RDBs.

3.1.2. Self-efficacy

Meanwhile, the deterrence of PPS derives from the perceived consequences of engaging in illegal behaviors. If a person has committed a violation and lost some points, does this experience have an impact on his or her subsequent behavior? Self-efficacy is an important cognitive factor to investigate the above question. It is an individual's belief in

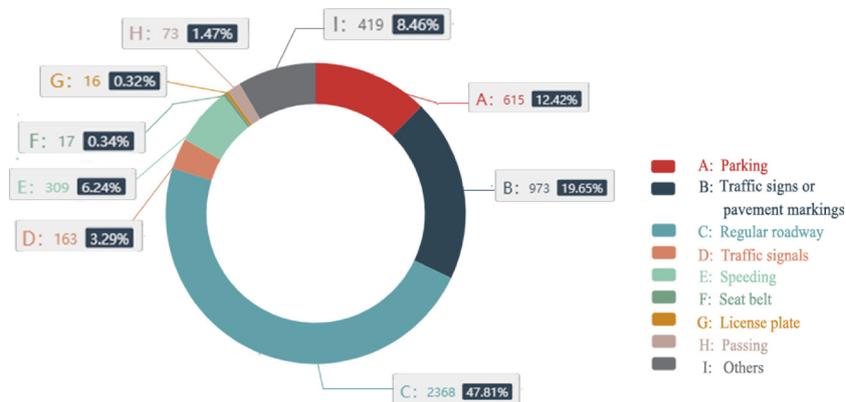


Fig. 2. Specific violations of the RV vehicle.

their ability to succeed in specific situations or to accomplish a task (Bandura, 1997), which can influence their physiological, behavioral, and psychological reactions (Schönfeld et al., 2017) and can represent their personal perceptions of the surrounding environment (Bandura, 1997). The results of previous behaviors have an effect on people’s self-efficacy (Beattie et al., 2011). And these effects will endure in later performance (Hardy, 2014). For these reasons, self-efficacy becomes a critical factor in the relationship between PE and RDBs.

In addition, while driving, drivers constantly face challenges, make choices, and take actions. For example, when facing a yellow “caution” light, the driver has to judge whether to proceed through the crossing in hopes of “beating” the red “stop” light or to stop at the appropriate line. This decision-making may closely relate to self-efficacy, since it involves not only the individual’s ability to interact with the environment but also his or her belief of the ability to execute actions. The higher the level of self-efficacy, the more likely a driver is to perceive a low level of threat, and therefore to engage in risk-taking behavior (Krueger and Dickson, 1994). Self-efficacy is reported to be positively correlated with RDBs (McLernon, 2014). For example, drivers who overestimate their driving ability may believe that they can control any driving situation, which can heighten their feeling of security (Rumar, 1988). Thus, the second hypothesis is derived.

Hypothesis 2. There is a positive relationship between SE and RDBs.

People’s self-efficacy is malleable, and the manner in which an individual acts upon one’s efficacy beliefs and assesses the adequacy of one’s self-appraisal from achieved performance is an influential source of information in the formation of self-efficacy beliefs (Bandura, 1997). The most effective way to develop a strong sense of self-efficacy is through mastery experiences (Bandura, 1997; Ooi et al., 2018). Past success raises self-efficacy, while failure lowers it. Also, the effects of success or failure on self-efficacy will endure in later performance (Hardy, 2014). More importantly, prior behavioral performance has an important causal influence on changes in self-efficacy (e.g., Heggstad and Kanfer, 2005; Sitzmann and Yeo, 2013). Therefore, when the driver performs RDBs that result in traffic violations and penalties, this failure experience will lower his or her self-efficacy during RDBs. Hence, Hypothesis 3 is assumed.

Hypothesis 3. There is a negative relationship between PE and SE.

3.1.3. Gender difference

Many scholars have studied gender differences in traffic safety. Male drivers are involved in more accidents and receive more traffic fines, whereas female drivers tend to commit more errors (González-Iglesias et al., 2012; Özkan and Lajunen, 2006; Rimmö and Åberg, 1999; Wickens et al., 2008). In addition, men break driving rules more than women (Nolén and Östlin, 2008). Men and women also differ in driving behaviors. Male drivers are more aggressive (Sârbescu et al., 2014) and take more risks, especially during adolescence (Vavrik, 1997). These gender differences in driving behaviors may exist due to their different responses to punishment. A meta-analysis found that relative to men, women demonstrate greater punishment sensitivity compared to men (Cross et al., 2011). More importantly, the effect of PPS in reducing RDBs is larger on female drivers than on male drivers (Gras et al., 2014). Hence, the last hypothesis was deduced. Fig. 3 presents the theoretical model of the present research.

Hypothesis 4. The effect of PE on RDBs is greater among female drivers than male drivers.

3.2. Method

3.2.1. Sample

The current research investigated the relationships among drivers’ penalty experience, self-efficacy, and RDBs in a Chinese city, Tianjin. At

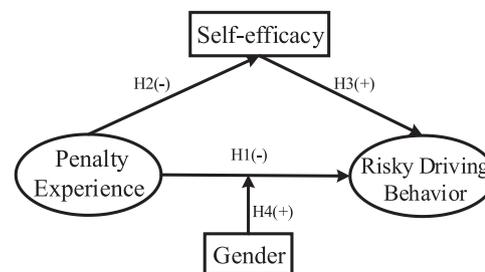


Fig. 3. Theoretical model.

Table 2 Demographics and socioeconomics of the sample.

Categorical variable	Category	Frequency	Percent
Gender	Male	204	52.04%
	Female	188	47.96%
Age	18-30	177	45.15%
	30.01-40	122	31.12%
	40.01-50	76	19.39%
	Above 50.01	15	3.83%
	Education	Junior high school and below	42
	High School	71	18.11%
	Specialist/university	256	65.31%
	Undergraduate and above	23	5.87%
Income per month	≤ 3000	144	36.73%
	3000.01-5000	130	33.16%
	5000.01-10000	87	22.19%
	≥ 10000	31	7.91%
Driving years	≤ 1	55	14.03%
	1.01-3	110	28.06%
	3.01-5	75	19.13%
	>5.01	152	38.78%
Professional driver	YES	62	15.82%
	NO	330	84.18%

the end of 2016, Tianjin, China, had a permanent resident population of 15.62 million, and there were 3.03 million motor vehicles and 4.53 million motor vehicles drivers in the city. In total, we distributed 408 questionnaires. The inclusion criteria included having a valid driver’s license and living in Tianjin, China. After eliminating ineffective questionnaires (e.g., incomplete questionnaires, questionnaires throughout which the same answer was chosen, or questionnaires with the same IP address), 392 valid responses were used for statistical analysis with an effective response rate of 96.1%. Table 2 shows the demographic and socioeconomic characteristics of the sample.

3.2.2. Measures

The survey began with a brief description of the research purpose. To reduce the common method bias, all participants were informed that the questionnaire was for the purpose of academic research and that there were no right or wrong answers. They were also informed that their responses would remain strictly confidential and that they could end participation at any time. The questionnaire consisted of two main parts: (1) demographic questions consisting 6 items and (2) a survey consisting 28 items for measuring penalty experience, self-efficacy, and RDBs.

The risky driving behaviors scale applied in the current research was developed by Ulleberg and Rundmo (2003). Many scholars have shown that it has good reliability and validity and has been applied in several prior studies (Nayum, 2008). The risky driving behaviors’ scale is a five-point Likert scale consisting three behavioral subscales: self-assertiveness (5 items), speeding (6 items), and rule violations (4 items). All the subscales have exhibited good internal consistency (self-assertiveness: Cronbach’s alpha = 0.886; speeding: Cronbach’s alpha = 0.815; rule violations: Cronbach’s alpha = 0.750). And a high score means that the driver conducts RDBs more often.

Self-efficacy was measured by asking people “how confident are you” in your ability to achieve a specific behavior (Lorig and Holman, 2003). The risky driving self-efficacy scale was a seven-point Likert scale developed by Mclernon (2014) and adapted from general self-efficacy scales (Bandura, 2006). Taking the specific skill of driving into consideration, it has ten items. The risky driving self-efficacy scale was a seven-point Likert scale developed by Mclernon (2014) and was adapted from general self-efficacy scales (Bandura, 2006). Taking the specific skill of driving into consideration, it has ten items. In our sample, the Cronbach’s alpha for the risky driving self-efficacy scale was 0.862. A high score means that a driver is more convinced of his or her capability to take risky behaviors.

Penalty experience was measured using three items by asking people “How many points have you lost in the past year?” “How many times have you been penalized in the past three months?” and “What’s the largest number of points you have lost at a time in the past three months?” Fig. 4 presents frequency distributions of the items.

3.2.3. Procedure

The questionnaire was translated into Chinese with help from independent translators and then translated back into English to ensure the concept is accurately expressed (Zhou and Poppo, 2010). As the Internet is a useful and effective tool in social research (Stanton, 1998; Weible and Wallace, 1998) and a valid tool for assessing driver behavior in China (Shi et al., 2010), an online questionnaire was distributed between October and December 2017 through Sojump¹, a popular online survey platform in China. To maximize response rate, the participants would receive 5 Yuan after finishing the questionnaire. Data were analyzed using SPSS 22 and AMOS 20.

3.3. Results

3.3.1. Items analysis

To examine the appropriateness of all items, confirmatory factor analysis (CFA) was conducted in AMOS by using Maximum Likelihood Estimation (MLE). The original items in each construct were subjected to first-order CFA to refine the number of items in each. Table 3 shows that the χ^2/df values of each construct were all less than the threshold value of 5. In addition, the Goodness of Fit Index (GFI) and Adjusted Goodness of Fit Index (AGFI) values were above the cutoff value of 0.900, and the Root Mean Square Error of Approximation (RMSEA) values were less than the threshold value of 0.080, indicating that there was a good fit in each construct (Doll et al., 1994; Hu and Bentler, 1999). The results revealed that items for self-efficacy (SE) were reduced from six to four, the items for self-assertiveness were reduced from five to four, the items for speeding were reduced from five to four, and the items for rule violations were not reduced. Because establishing model parsimony is an important element of structural equation modeling (Larwin and Harvey, 2012), a domain-representative approach (Little et al., 2002) was used in each subscale. The average scores were computed for each subscale.

3.3.2. Reliability and validity analysis

We used CFA and the Cronbach’s alpha coefficient to evaluate the construct validity and reliability of the proposed model. To test for convergent validity, this study verified the following criteria: (1) all estimated factor loadings (FL) exceeded 0.6, (2) the average variance extracted (AVE) estimate associated with each manifest variable exceeded 0.5, and (3) all composite reliability (CR) coefficients exceeded 0.7. These results indicated acceptable convergent validity (Minglong, 2009). Table 4 provides the results of tests with respect to estimated FL, AVE, and CR values for convergent validity, revealing that all estimated FL, AVE, and CR values met the criterion. Additionally, verification of

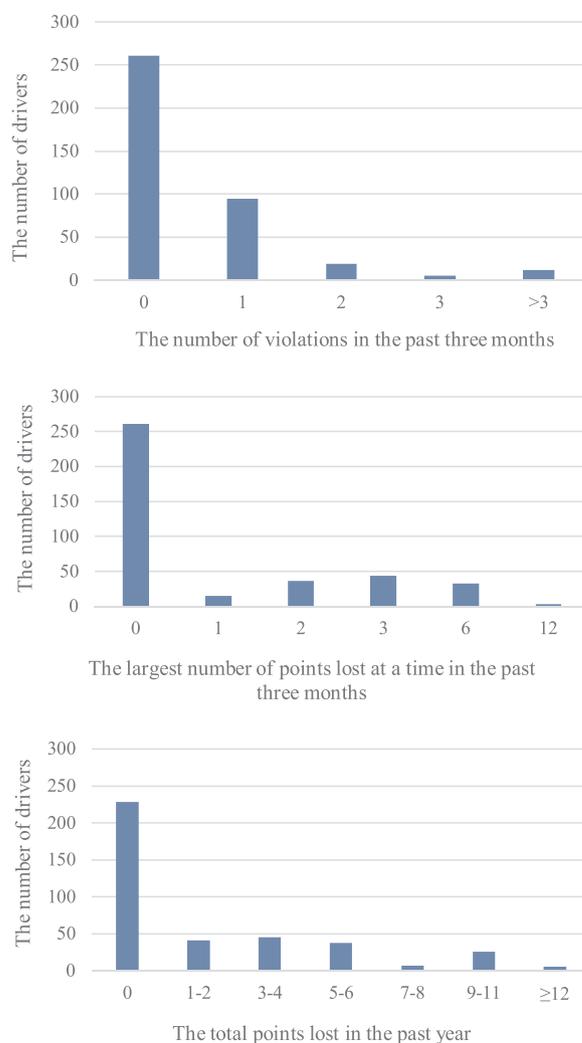


Fig. 4. Frequency distributions of the items: the number of violations in the past three months (top), the largest number of points lost at a time in the past three months (middle), the total points lost in the past year (bottom).

construct reliability was done via Cronbach’s alpha statistics generated by SPSS. Table 4 also lists the results with respect to estimated Cronbach’s alpha values for construct reliability.

3.3.3. Goodness-of-fit for the research model

According to Hooper et al. (2008), the GFI can be classified into three categories: (1) Absolute Fit Measures, (2) Incremental Fit Measures, and (3) Parsimonious Adjusted Measures. The GFI for the structure of the research model was examined in advance, using the measures suggested by Schreiber (2008) and Jackson et al. (2009). For Absolute Fit Measures, this research used four indices: (1) χ^2/df , wherein a χ^2/df value of less than 3 is considered a good fit (Kline, 2005); (2) RMSEA, wherein an RMSEA value of less than 0.08 indicates a good fit (Hu and Bentler, 1999); (3) GFI, wherein a GFI value exceeding 0.8 indicates an acceptable fit (Doll et al., 1994); and (4) AGFI, wherein an AGFI value exceeding 0.8 indicates an acceptable model fit (MacCallum and Hong, 1997). The results for Absolute Fit Measures generated from AMOS were as follows: $\chi^2/df = 2.581$, RMSEA = 0.064, GFI = 0.984, and AGFI = 0.957. These results indicate a good fit of the research model for the collected data.

The indexes for Incremental Fit Measures include the Normed Fit Index (NFI), the Non-Normed Fit Index (NNFI), the Comparative Fit Index (CFI), and the Relative Fit Index (RFI). NFI, NNFI, CFI, and RFI values greater than the 0.90 cutoff value are considered a good fit (Hu

¹ www.wjx.cn

Table 3
Analytical result for first-order confirmatory factor analysis.

Measurement index	Threshold	Self-efficacy	Self-assertiveness	Speeding	Rule violations
χ^2	–	4.381	3.886	2.023	4.057
df	–	2	2	2	2
χ^2/df	< 5	2.190	1.943	1.012	2.029
RMSEA	< 0.08	0.055	0.049	0.005	0.051
GFI	> 0.80	0.994	0.995	0.997	0.995
AGFI	> 0.80	0.972	0.976	0.987	0.974

Table 4
Analytical results for convergent validity.

Items of each construct	Factor loading
RDBs: Cronbach's alpha = 0.815, CR = 0.817, AVE = 0.598	
1. Self-assertiveness	0.756
2. Speeding	0.784
3. Rule violations	0.781
PE: Cronbach's alpha = 0.567, CR = 0.754, AVE = 0.511	
1. How many points have you lost in the past year	0.632
2. How many times have you been penalized in the past three months	0.855
3. What's the largest number of points have you lost at a time in the past three months?	0.636

and Bentler, 1999). The results for Incremental Fit Measures generated from AMOS were as follows: NFI = 0.972, RFI = 0.974, NNFI = 0.967, and CFI = 0.982. Additionally, the Parsimonious Adjusted Measures include the Parsimony Comparative Fit Index (PCFI) and the Parsimonious Normed Fit Index (PNFI). According to Hu and Bentler (1999), PCFI and PNFI should be above 0.50 for a good model fit. The results of this study were as follows: PCFI = 0.524, and PNFI = 0.518. In sum, all of the above-mentioned results imply that the structure of the proposed model effectively characterized the interrelationships among these research constructs.

3.3.4. Mediating effects of self-efficacy

According to the mediating effect test procedure (Preacher et al., 2006), we first tested the direct effect of PE on RDBs and then tested the fitting of the model and the significant degree of each path coefficient after adding the mediator variable. Table 5 shows the goodness-of-fit indices of the direct effect analysis, revealing that all the indices reflected the recommended values. The direct effect of PE on RDBs is significant ($\beta = 0.317$, SE = 0.017, $p < 0.01$).

Next, we added self-efficacy as a mediator variable between PE and RDBs. As can be seen from Table 5, the model fits perfectly. The path coefficient between PE and self-efficacy ($\beta = 0.153$, SE = 0.033, $p < 0.01$), self-efficacy and RDBs ($\beta = 0.487$, SE = 0.022, $p < 0.01$), PE and RDBs ($\beta = 0.239$, SE = 0.014, $p < 0.01$) are significant. Fig. 5 shows the final model with standardized path coefficient. Thus, the effects of PE on RDBs are partially mediated by self-efficacy. Hypothesis 2 posited that there is a positive relationship between SE and RDBs. The path coefficient between self-efficacy and RDBs ($\beta = 0.487$, SE = 0.022, $p < 0.01$) supported this expectation. Hypotheses H1 and H3 posited that there is a negative relationship between PE and RDBs, PE and self-efficacy. The results, in fact, show a significant relationship. However, their relationships are positive from the above analysis (shown in Fig. 5).

Table 5
Model fit of structural equation models.

Goodness-of-fit indices	CMIN/DF	NNFI	RMSEA	GFI	PCFI	PNFI	AGFI	NFI	RFI	CFI
Recommended value	< 3	> 0.8	< 0.08	> 0.8	> 0.5	> 0.5	> 0.9	> 0.9	> 0.9	> 0.9
Direct effect analysis	2.581	0.967	0.064	0.984	0.524	0.518	0.957	0.972	0.947	0.982
Mediating effects analysis	2.578	0.960	0.064	0.979	0.558	0.550	0.951	0.963	0.936	0.977

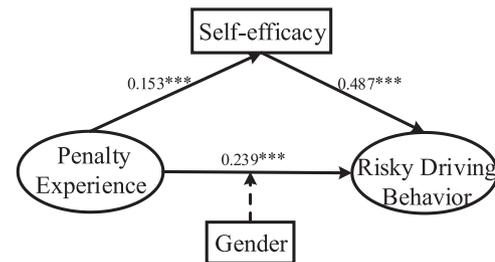


Fig. 5. Final result of the model with standardized path coefficient. Dashed lines show non-significant effects. Asterisks indicate significant difference (***) $p < 0.01$.

The bootstrapping mediation test method was used to test the mediating effects (Preacher et al., 2006). Through the application of bootstrapped confidence intervals (CIs), the test can directly address mediation. The data were bootstrapped 2000 times. Results showed that self-efficacy has a significant mediating role at the confidence level of 95% [PE: indirect effect, bias corrected (BC) CI = (0.005, 0.036); percentile CI = (0.005, 0.035); direct effect, bias corrected (BC) CI = (0.026, 0.097); percentile CI = (0.025, 0.097)]. Thus, the effects of PE on RDBs are partially mediated by self-efficacy.

3.3.5. Moderating effects of gender

To test the moderating effects of gender on the association between PE and the RDBs (i.e., Hypothesis H4), a multi-group analysis was performed to examine whether the effects of PE on RDBs varied as a function of gender. Although the results showed that the variant group model

$$(\chi^2(21) = 46.007, p < 0.05, \frac{CMIN}{DF} = 2.191, CFI = 0.972, GFI = 0.963, TLI = 0.960, RMSEA = 0.055; 90\% \text{ confidence interval } [0.033, 0.077])$$

4. Discussion and conclusion

4.1. Research contributions

This paper has combined both official traffic violation data and self-reported data to examine the effectiveness of a penalty point system on driver behaviors and to investigate drivers' internal cognitive factors that relate to this process. Real traffic violation data show that many drivers violate traffic rules repeatedly within a year of the first ticketed offense. This finding was also validated by a research report, the Metropolis's Road Traffic Report in China, stating that each driver violates traffic rules twice a year on average. Furthermore, our analysis of the causes of violations found that many drivers (48.22%) make the same violations even after losing points. Similar findings were observed

in a study conducted in Spain, which found that drivers with previous penalty points in fact had a higher probability of incurring new points than drivers without previous points (Roca and Tortosa, 2008). To investigate the relationship between penalty points and violation behaviors, we conducted an Internet survey, the results of which indicated a positive correlation between penalty experience and risky driving behaviors. In addition, our research examined explanatory variables that might account for this relationship. Using mediation analysis, the effects of penalty experience on risky driving behaviors could be partially explained by an important cognition factor, i.e., self-efficacy. That is, there was a higher likelihood that many offenders exhibited higher self-efficacy, which, in turn, was associated with more risky driving behaviors. This finding may explain why so many drivers made the same violations even after losing points. It is also in accordance with the finding (Rumar, 1988) that drivers who overestimate their driving ability may believe that they can control any driving situation, which can heighten their feeling of security, and thus lead to more frequent engagement in risky driving behaviors.

Specifically, Sagberg and Ingebrigtsen (2018) analyzed data from the Norwegian driver's license penalty point register over a three-year period and found an inverted U-shaped relationship between the number of penalty points incurred in one period, and the probability of new points in the subsequent period. These findings are very instructive. Specifically, they found a "driving style effect" (drivers with previous penalty points have a higher probability of incurring new points than drivers without previous points) and a "deterrence effect" (drivers with more than four points have a reduced probability of incurring new points, due to impending risk of license revocation) (Sagberg and Ingebrigtsen, 2018). On the other hand, in our present research, we found a positive relationship between having incurred penalty points and a tendency to commit risky driving behavior. These discrepancies are likely due to several reasons. These two studies were conducted in different countries. In Norway, drivers with eight or more points in a three-year period have their licenses revoked for six months (and all previous points are deleted), and, after four penalty points, the driver will receive a warning letter with information about the consequences of further penalty points (Sagberg and Ingebrigtsen, 2018). In China, however, if drivers lose twelve or more points in a one-year period, their driving licenses will be suspended. In order to get their license back, drivers need to complete a seven-day course and take a test within 30 days. If they pass the test, they will get their license back with and all previous points will be deleted. For drivers with less than twelve points in a one-year period, if they pay the fine in time, their previous points will be deleted in the next period. During the scoring period, they will not receive a warning letter. In addition, there are two types of drivers in Norway: full and probationary-license drivers. The same violations for probationary-license drivers entail more penalty points. In China, all drivers follow the same penalty point rules. The only exceptions are drivers in their first year of driving: if they lose all their twelve points, their driving license will be withdrawn directly. According to the above comparison and analysis, drivers in China have more points compared to Norwegian drivers. Comparing drivers from each country in the same three-year period, Chinese drivers have four times more opportunities for penalty points than Norwegian drivers. From this perspective, Norway's PPS is more stringent. As Fig. 4 shows, most drivers in our survey have less than six points in a one-year period. Therefore, based on Sagberg and Ingebrigtsen (2018), we infer that the "deterrence effect" may not be as significant in China compared to Norway and that most drivers are in a process of "driving style effect." Therefore, future research can explore the effectiveness of PPS in China for people with six or more points in one-year period.

Moreover, the present study also investigated gender difference in the relationship between penalty experience and risky driving behaviors. However, the results suggested no significant difference between men and women. After analyzing the cause, scholars found that gender roles appear to be a better predictor than sex for risky behavior (Gueho

et al., 2013; Özkan and Lajunen, 2006). According to Bem (1974), we can distinguish between males and females on the basis of gender roles (e.g., femininity and masculinity). Femininity and masculinity refer to the degree to which people see themselves as masculine or feminine based on what it means to be a man or woman in the society. For example, a person with a more masculine identity would probably engage in behaviors considered more dominant, competitive, and autonomous. A person with a more feminine identity would be most likely to act in a more expressive, warm, and submissive manner (Stets and Burke, 2000). Therefore, future research can explore gender difference in the effectiveness of PPS by considering gender roles.

4.2. Implications for practice and policy

The real traffic violation data shows that there are many repeat offenders among the multiple violation vehicles in China, and this survey study indicates there is a positive relationship between PE and RDB. This suggests that drivers with previous penalty points have a higher probability of incurring new points than drivers without previous points. Thus, the PPS seems less effective in changing drivers' behaviors. Moreover, the positive relationship between PE and RDB is partly mediated by SE. The analysis conducted above shows that improving the effectiveness of a PPS should involve increasing the power of its deterrence and weakening drivers' self-efficacy toward risky driving behaviors. Thus, from these perspectives, the following strategies are suggested to enhance the effectiveness of PPS.

4.2.1. Adopting an increasing block penalty points policy to stop repeat violations

The official traffic violation data show that there are many repeat offenders among the multiple violation vehicles in China. Thus, preventing people from making repeat violations may be a thorny issue for policy makers. Von Hirsch et al. (1999) show that the efficacy of increased penalties in deterring risky driving behavior lies in making drivers aware that the penalties have increased. Thus, we suggest adopting the Increasing Block Penalty Points Policy (IBPPP) to reduce repeat violations in each scoring cycle, such as in the regular 12-month period. When the driver has made a traffic violation, he/she will be informed that if the same traffic violation happens again, more points will be penalized. In the new scoring cycle, the Increasing Block Penalty Points will be restarted. For example, when the driver is speeding for the first time, he or she will be penalized 1 point. But as to the second speeding incident, he or she will be penalized 2 or more points, and for the third incidence of speeding, he or she will be penalized 3 or more points, etc. Obviously, repeated offenders will perceive the increasing marginal cost for the repeated violations. The details of IBPPP and implementing it efficiently and scientifically in different countries and regions requires further research.

4.2.2. Densify traffic cameras and show drivers

Punishment avoidance is the most important factor affecting the deterrent process (Stafford and Warr, 1993). Many people have a psychological inclination wherein they commit illegal actions and avoid the repercussions. With this in mind, if people's perceptions of the certainty of punishment weaken, they will increase engagement in illegal behaviors (Paternoster and Piquero, 1995). A number of studies have found that punishment avoidance has the strongest relationship with the likelihood of offense (Freeman and Watson, 2006; Paternoster and Piquero, 1995; Piquero and Pogarsky, 2002; Sitren and Applegate, 2007). In addition, intensified traffic enforcement has been shown to be an important means of improving road safety (Yannis et al., 2007) because it can promote people's adherence to traffic laws (Stanojević et al., 2013). Therefore, strengthening supervision and letting drivers know that any RDBs will be punished are probably useful measures for enhancing the deterrence of a PPS. In China, traffic cameras are primarily installed on main roads, at intersections, and on important

traffic nodes throughout the country. Off-site traffic monitoring and management mainly occurs through traffic cameras trained on both sides of the road. Adding more cameras and informing drivers that they are being monitored can increase the awareness among them as any of their violations may be caught on camera. This awareness of being constantly monitored, coupled with the awareness that infractions that have been recorded will result in loss of points, will probably encourage drivers to constantly self-monitor and restrain their behavior.

4.2.3. If violation happens, notify the offender as soon as possible

Ross (1982) points out that the perceived risk of punishment for violating traffic laws is an effective deterrent. Usually, this deterrence can be enhanced by high levels of publicity regarding legal sanctions, including special operations involving highly visible enforcement (Elvik and Christensen, 2007; Watling et al., 2014). However, Homel (1986) says that the effectiveness of such measures declines over time, yet people's perception of the risk of punishment is also affected by the swiftness of legal sanctions (Ross, 1982). In addition, immediate punitive consequences have a greater impact on behaviors than delayed consequences (Hogarth, 1987). Because the loss of points can be considered to be an immediate behavioral consequence, on-site traffic monitoring is more effective than off-site monitoring for ultimately changing an offender's driving behavior (Gras et al., 2014).

In fact, drivers are quite often notified that they have been cited for a violation long after the violation actually occurred. The Traffic Management Bureau of the Ministry of Public Security of China investigated 36 large Chinese cities and discovered the proportion of illegal investigation and punishment of off-site traffic violations accounted for 80% of all violations between 2014 and 2016. The off-site traffic violations are mainly those that have been caught by the traffic camera. Corresponding to this are on-site traffic violations, which refer to traffic police directly penalizing the traffic offenders. However, according to Chinese laws, records of violations should be available online within 13 working days after the violation occurred. The law only stipulates the longest time that can be taken, but 13 working days may be too long a processing time in many cases. If an offender receives a notice 13 working days after the violation occurs, the effect of the penalties may be weakened. Although with delayed enforcement the driver will be able to associate the risky behavior with the penalty, the impact on behavior is likely to be weaker than immediate punitive consequences. More importantly, reducing the delay of notification of violations is more effective than increasing the severity of the penalties (Hogarth, 1987). Thus, to increase the effectiveness of a PPS, if violations happen, drivers should be notified as soon as possible.

4.3. Limitations and outlook

Due to data limitations, we only collected the traffic violation records of vehicles. And because of the limitations of conditions and sources of data, ease of implementation, and convenience of data collection, we collected the traffic violation data and conducted the survey study in different Chinese cities. Future research should extend this preliminary study to each driver's violation record, within the scope of confidentiality, and to larger and wider geographical samples, such as different legal systems, systems of government, and so on. Additionally, ways of implementing IBPPP more efficiently and scientifically in different countries and regions requires further research in the future.

Declaration of Competing Interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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