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Association between increase in fixed penalties and road safety outcomes: A meta-analysis

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ABSTRACT

Studies that have evaluated the association between increases in traffic fine amounts (fixed penalties) and changes in compliance with road traffic law or the number of accidents are synthesised by means of meta-analysis. The studies were few and different in many respects. Nine studies were included in the meta-analysis of changes in compliance. Four studies were included in the meta-analysis of changes in accidents. Increasing traffic fines was found to be associated with small changes in the rate of violations. The changes were non-linear. For increases up to about 100%, violations were reduced. For larger increases, no reduction in violations was found. A small reduction in fatal accidents was associated with increased fixed penalties, varying between studies from less than 1–12%. The main pattern of changes in violations was similar in the fixed-effects and random-effects models of meta-analysis, meta-regression and when simple (non-weighted) mean values were computed. The main findings are thus robust, although most of the primary studies did not control very well for potentially confounding factors. Summary estimates of changes in violations or accidents should be treated as provisional and do not necessarily reflect causal relationships.

1. Introduction

Many motorised countries have a system of fixed penalties for common traffic offences. A fixed penalty is a fixed amount of money to be paid when a road user pleads guilty to committing a certain offence. Fixed penalties are commonly applied for speeding offences, non-use of seat belts, and other common traffic offences. Fixed penalties tend not to be continuously adjusted in line with consumer prices, but are increased steeply every few years. As an example, the Australian state of Queensland increased fixed penalties for speeding on April 17, 2003 (Watson et al., 2015). For minor violations (less than 15 km/h above the speed limit), there was a modest increase from 90 to 100 Australian dollars. For the most serious violations (speeding by more than 40 km/h), the fixed penalty increased from 255 to 700 Australian dollars.

Are increases in fixed penalties associated with a reduction in the number of traffic offences and accidents? A number of studies have been made to answer this question (Nilsson and Åberg, 1986, Andersson, 1989; Fridstrøm, 1999; Poli de Figueiredo et al., 2001, Elvik and Christensen, 2007; Wagenaar et al., 2007; Cedersund, 2008; Maffei de Andrade et al., 2008; Tavares et al., 2008; Montag, 2014; Moolenaar, 2014; Sebego et al., 2014; Bhalla et al., 2015; Elvik, 2015; Watson et al., 2015; Killias et al., 2016). The findings are, however, not entirely consistent, and no formal synthesis of the evidence provided by these studies has been found. The objective of this paper is to summarise current knowledge regarding the association between changes (mostly increases) in fixed penalties (the term traffic fines is used synonymously) and changes in road user compliance with road traffic laws and changes in the number of accidents. Before reviewing relevant studies, theoretical perspectives on the relationship between traffic fines and road user compliance with the law will be discussed.

2. Theoretical perspectives and research questions

Economic theory offers two perspectives on the effects of increasing traffic fines on road user compliance with road traffic laws. According to the standard economic model of crime, proposed by Becker (1968) in a seminal paper, offenders weigh the costs and benefits of violations. An increase in fixed penalties increases the expected cost of committing a violation and is therefore expected to deter violations.

A game-theoretic model of crime and enforcement, on the other hand (Tsebelis, 1989, 1990, 1993; Bjørnskau and Elvik, 1992), predicts that increasing fixed penalties has no effect on the rate of

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violations, because the police adapt to increased penalties by reducing enforcement, thus keeping the expected value of the cost of crime (cost = risk of detection × size of penalty) constant.

One study (Elvik and Christensen, 2007) found no support for the game-theoretic model. Another study (Elvik, 2015) found some, albeit statistically very weak, support for the game-theoretic model. Thus, the empirical studies have produced inconsistent findings as to which of the theoretical models is best supported by data.

Two stated preference studies (Hössinger and Berger, 2012; Ryeng, 2012) shed light on how drivers say they adapt to changes in fixed penalties. According to Hössinger and Berger (2012) drivers stated that doubling the fixed penalty would be associated with a reduction in speeding of about 10%. Ryeng (2012), on the other hand, did not find that increasing fixed penalties would influence speeding. Hence, the two stated preference studies also produced inconsistent findings.

Based on the theoretical perspectives and the results of previous studies, the main questions the research synthesis presented in this paper seeks to answer are:

1. Is an increase in fixed penalties associated with a reduction in the rate of traffic violations?
2. Is there a dose-response relationship between the size of the increase in fixed penalties and the size of the reduction in the rate of traffic violations?
3. Is an increase in fixed penalties associated with a reduction in the number of accidents?

3. Study retrieval and coding

Studies were identified by searching Sciencedirect and the Ovid Transport Database. The following search terms were used: "traffic tickets", "fixed penalties" and "fines". In addition, studies quoted in the Handbook of Road Safety Measures (Høye et al., 2015) were examined. Table 1 list the studies that were found. There are two groups of studies: (1) Studies that use some indicator of road user compliance with road traffic law as the dependent variable, and (2) Studies that use changes in the number of accidents as dependent variable. The majority of studies use an indicator of compliance as dependent variable.

Two meta-analyses were made. The first meta-analysis included nine studies of changes in compliance. Only one study (Nilsson and Åberg, 1986) was omitted because it did not state results in sufficient detail. The second meta-analysis included four studies of changes in the number of accidents. Two studies reporting such changes were omitted from the meta-analysis. One of these studies (Poli de Figueiredo et al., 2001) relied on data for only one year before and one year after the change. A subsequent study (Maffei de Andrade et al., 2008) found these years to be atypical of long-term trends. That study included a longer period, but did not state the number of accidents precisely enough to be included (results were presented in diagrams not stating the exact number of accidents). Table 1 states for each study whether it was included in the meta-analysis or not. The following information was coded for each study:

1. Publication year.
2. Country.
3. Level of violations.
4. Potential moderator variables.
5. Percentage change in fixed penalties.
6. Study design.
7. Estimator of effect.
8. Confounders controlled for.

Table 2 shows the coding of these variables for each study. Publication year was included in order to assess whether study findings change over time. Country was included to assess the similarity of findings between countries. Fixed penalties normally vary according of the severity of a violation. Level of violation was therefore included.

A moderator variable is any variable that influences the size of an effect. The most important moderator variable with respect to increases in traffic fines is the risk of apprehension. The change in fixed penalties is stated as a percentage in order to evaluate whether there is a dose-response relationship between changes in fixed penalties and changes in the rate of violations. All changes except one were increases. The exception (Bhalla et al., 2015) was the abolition (i.e. 100% reduction) of the fixed penalty for speeding by 10–20 km/h in Russia in 2013. Study design was included in order to assess whether different study designs produce different results. The estimator of change in compliance is in most cases changes in the percent of cars speeding. This is stated as a ratio, e.g. if 45% were speeding before an increase in fixed penalties and 42% after the increase, the change is stated as 42/45 = 0.933. Finally, a list of confounding factors controlled for was made for each study.

4. Extraction of estimates of effect and their standard errors

4.1. Changes in compliance

The studies stated estimates of changes in compliance in different metrics and did not always include estimates of the standard errors. To permit a meta-analysis, all estimates must be stated in the same metric and all standard errors must be known. In general, the statistical weight assigned to an estimate in meta-analysis is:

$$\text{Fixed-effects statistical weight} = \frac{1}{SE_i^2}$$

SE_i is the standard error of the i-th estimate.

The oldest study, Andersson (1989), stated the percentage of cars speeding in four cities in Sweden before and after an increase in fixed penalties. The number of cars included in the data set was estimated by relying on Table 5 in the report. A distinction was made between speeding by less than 10 km/h and speeding by 10 km/h or more. A total of eight estimates were extracted from the study (four cities × two levels of speeding).

The standard error associated with a single data point was estimated as follows:

$$\text{Standarderror} = \sqrt{\frac{(\text{Proportion speeding}) \times (1 - \text{proportion speeding})}{\text{Number of cars measured}}} \quad (1)$$

Thus, for the city of Nässjö in the before period, 24.6% were speeding by less than 10 km/h. 8594 cars were included in the speed data. The standard error for this data point therefore becomes:

$$\text{Standard error} = \sqrt{\frac{(0.246) \times (1 - 0.246)}{8594}} = 0.00464575$$

The standard error of the data point referring to the after period was estimated as 0.00477777. The rate of speeding in the after period in the city of Nässjö was 26.8%. The estimator of effect was therefore:

$$\text{Estimate}(\hat{R}) = 26.8/24.6 = 1.089.$$

The reasons for stating effects as ratios is that they are then comparable to accident modification factors, and that they are