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Deterrence, Incapacitation and Enforcement Design. Evidence from Traffic Enforcement in Italy

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Abstract - We investigate the deterrent effect on driving behavior due to the introduction of Demerit Point System in Italy. In addition, we measure the incapacitation effect on fatal accidents. Our findings highlight the high potential of the penalty system in reducing road fatalities through deterrence and incapacitation. Despite this, its aggregate effectiveness in Italy ultimately depended on the consistency of the enforcement design. We then suggest several policy options to increase road safety through a credible enforcement.

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Keywords: deterrence, incapacitation, law enforcement, road safety

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1 Introduction

In most developed countries traffic laws are backed by a hybrid sanction system which couples fines with a point - record mechanism (*Point Record Mechanism*, PRM henceforth). A PRM is a sanctioning system that involves the allocation to offenders of a number of penalty points increasing with the seriousness of the illegal behavior that has been detected, for a range of harmful acts. Once drivers accumulate penalty points beyond a given threshold, the license suspension occurs.

In some countries like the UK, Australia, Canada and the US (where the adoption of PRMs varies from one state to another), the assignment of penalty points takes the form of a totting - up system (where infringers accumulate penalty points up to a given threshold), while in others like Italy, Spain, and France, drivers have an initial credit of points which they may progressively lose as violations are recorded over time. In some circumstances, the number of penalty points to be imposed for a given offense may also vary according to drivers' experience or to the license class. This is the case for the US, Canada and Australia, where the number of penalty points differs according to the license category or to the number of years the license has been held. In some other countries (mainly in Europe, with the exception of Germany and the UK), the assignment of penalty points is counterbalanced by redemptive mechanisms consisting in the full or partial reinstatement of drivers' points tally, once they have kept their record clean for a given time - span or once they have completed a driving course.

The widespread adoption of the PRM to prevent traffic offenses relies mainly upon its potential to solve moral hazard and adverse selection problems through the deterrence of responsible drivers and the incapacitation of reckless ones (Bourgeon and Picard, 2007). Besides, the accumulation of penalty points in drivers' offense history may exert a warning effect (Basili and Nicita, 2005) which improves uninformed drivers' ability to assess their risk of accidents. Moreover, the provision for suspending the licenses of systematic infringers acts as an 'incapacitation tool' which may improve road safety through an increase in deterrence (Ehrlich, 1991). Actually, a PRM can be considered a mechanism that imposes higher sanctions for repeat offenders, whenever a Beckerian optimal fine may generate underdeterrence (Becker, 1968; Polinsky and Shavell, 2000; Garoupa, 2001). By tracking drivers' offense history through the progressive reduction of their endowment of points, it allows the authorities to put on a given offense a weight which increases with the number of previously detected infractions. This is because the higher the number of past detected offenses, the greater the probability, at the margin, of exceeding the established threshold of penalty points that triggers the non - monetary sanction of license suspension. Indeed, assuming that individuals maximize the sum of their payoffs over different periods, they will know that if caught committing an offense, they will incur an immediate sanction and that, because of their record, any sanction they will face in a subsequent period will be greater than it would be otherwise (Polinsky and Rubinfeld, 1991; Polinsky and Shavell, 1998).

Several country - based studies provide evidence of the mentioned virtues of the PRM showing the ability of this sanctioning system to: increase deterrence (Haque, 1990; Zaal, 1994; Vaa, 2000; Zambon et al. (2008)); improve road safety, i.e. through a decrease in the number of road accidents, deaths and people injured, and hospitalizations (Poli de Figueiredo et al. (2001); Papaioannou et al. (2002); Hussain et al. (2006); Zambon et al. (2007)); and to discriminate between different categories of drivers according to their propensity to offend.

Specifically, some analyses highlight that the PRM enables the prediction of any given driver's likelihood of being involved in accidents or receiving convictions in subsequent periods on the basis of his or her record (Chipman and Morgan, 1975; Chen et al. (1995); Diamantopoulou et al. (1997)).

Despite the extensive use of the penalty points system to prevent undesirable driving behaviors, the optimal features of a PRM, from the social welfare maximization perspective, have been investigated only recently (Bourgeon and Picard, 2007). According to this investigation, an optimal PRM that prevents normal drivers from obtaining a major utility by driving recklessly exhibits the following features: (i) a limited initial endowment of points to avoid drivers engaging in a trigger strategy consisting in no effort as long as their credit of points is greater than a critical threshold; (ii) a maximum fine - when it is adopted within a hybrid sanction mechanism - whatever is the driver's point record and whatever is the combination of the period of license deprivation and the initial endowment of points characterizing the PRM in question; (iii) an automatic license suspension when the offense that has been committed is particularly serious (because the more serious is the offense, the more likely is the chance that it has been committed by a reckless driver) - and, when reckless drivers represent a small fraction of the total population of drivers, to avoid problems of forbearance on the part of the enforcement authorities; (iv) the length of the period that has to be spent without offenses for a clean record to be reinstated (redemptive mechanism) should be determined taking into account the initial endowment of points and the length of the suspension period.

Following the mentioned theoretical analysis analysis (Bourgeon and Picard, 2007), this article provides a first empirical investigation of the optimality of the Italian PRM introduced in July 2003. Specifically, we analyze whether significant effects on road safety, as proxied by the number of road accidents occurring, have been produced through: (i) the deterrence of speeding behaviors, which according to the Italian Institute of Statistics (ISTAT, 2008b) is the driving offense most frequently detected on Italian roads and most strongly correlated with the likelihood of future accidents (Redelmeier et al. (2003); Liu et al. (2005); Williams et al. (2006)); (ii) the 'incapacitation effect', generated by the suspension of reckless drivers' licenses, on road accidents.

To the first aim, by exploiting a 'before and after' analysis (i.e. before and after the introduction of the PRM) over the period 2001 - 2008, we performed a Lowess estimate of: (a) the dynamics of the monthly number of speeding infractions per 1,000 vehicles, thus controlling for seasonal effects (i.e. ensuring that a reduction or an increase of infractions is not determined by the presence on roads of a lower or greater number of vehicles because of e.g. a holiday period); (b) the dynamics of the monthly number of accidents, also per 1,000 vehicles; and thus to detect any parallels there may be between speeding offenses and road safety. The non - parametric estimates have been employed essentially to capture the presence of statistically significant non - linearities in the dynamics of speeding offenses and accidents, i.e. decreasing and/or increasing trends, which may be ascribable to the introduction of the new sanctioning system. To ascertain whether road safety benefited from the incapacitation of dangerous drivers, we performed a 3SLS regression, taking into account the potential endogeneity between suspended licenses (which is our measure of incapacitation) and road accidents (which is our proxy for road safety).

Our findings confirm the view that the incapacitation of reckless drivers is an effective tool to improve road safety (Bourgeon and Picard, 2007), as shown by the negative and statistically significant relationship between road accidents and the number of suspended licenses. However, the adoption of the point - record driving license in Italy exerted only a temporary effect on the dynamics of both speeding offenses and road accidents. Actually, corresponding to the coming into force of the new penalty system the dynamics of speeding tickets experienced a statistically significant decreasing trend which, however, ended just a few months later when speeding offenses began an indefinitely increasing trend for the next six years. Similarly, the indefinitely decreasing trend in accidents - which appears to be common to most European countries (European Road Safety Observatory, 2008) and which was already in place before the the introduction of the PRM - appears to have benefited only temporarily from the introduction of the PRM. This result, emerging from our non - parametric estimates, is also confirmed by the estimate of a parametric model through Poisson regressions.

Moreover we observed a strong 'announcement effect' when, two years before the effective implementation of the new law, a steep decrease in the number of speeding tickets and road accidents followed the mere announcement of the project by the Italian Government. We explain both the announcement effect in 2001 and the temporary effect in 2003 as the result of drivers' expectations of an increase in the likely level of penalties and we attribute the subsequent increase in the level of infractions to drivers learning about the real value of the likely penalties, as determined by the effective detection and conviction probabilities.

What drivers have learned is that the authorities' lax attitude toward enforcement did not change with the new law and especially did not increase in consequence of the adoption of harsher penalties for traffic law infringements, as our non - parametric estimates of the dynamics of speeding controls show. In addition, the probability of having penalty points charged and thus of incurring a license suspension was, in fact, much lower than expected.

Our work is the first empirical analysis of the implementation of the optimal penalty scheme (Bourgeon and Picard, 2007), with specific reference to Italy. Our results provide new insights into the analysis of these scholars by showing the relevance of 'announcement effects', drivers' learning, and enforcement consistency (as to the optimal combination between detection and conviction probabilities) in determining the effectiveness of PRM in reducing road accidents.

The paper proceeds as follows. Section 2 describes the Italian PRM. Section 3 and 4 present, respectively, the data and the methodology employed in the empirical analyses. Section 5 illustrates and discusses the findings of our econometric investigations. Section 6 concludes.

2 The Italian point - record driving license

Italy shows one of the highest figures for road fatalities among European countries, with highways displaying a death rate (number of deaths every 100 accidents) triple that of urban roads. Road accidents, which cause a loss of 2% in terms of GDP, are responsible for 2% of the total number of deaths and represent the most frequent cause of death for people aged between 25 - 29[1] in Italy . In addition, among the several causes of road fatalities, driving behaviors such as alcohol and drug consumption and speeding have been identified as some

[1]Source: Italian Institute of Statistics (ISTAT, 2008a).

of the most important. Actually speeding, which is the main focus of our work, accounts for 30.10% and 12.03% respectively of the causes of highway and urban roads accidents attributable to the driver's behavior[2], (see Fig. 1 and Fig. 2), being therefore in line with those analyses defining speeding as the driving behavior most strongly correlated with the likelihood of future accidents (Redelmeier et al. (2003); Liu et al. (2005); Williams et al. (2006)).

The Italian PRM came into force in July 2003 [3] with the aim of tackling the question of road safety in Italy. Its adoption concluded a long as well as uncertain legislative procedure started two years earlier when Parliament empowered the Italian Government[4] to introduce this additional sanction system.

The reform of the Italian Traffic Code was characterized by several delays which often cast doubts on the timing of the actual coming into force of the PRM. Indeed, Delegated Law No. 85/2001, which authorized the Government to implement the mentioned reform, was acknowledged by the Executive only one year later with Legislative Decree No. 9/2002[5]. Legislative Decree No. 9/2002 described the main features the Italian PRM should have and stated that the new penalty system would come into force in January 2003. However, due to the delays experienced in the creation of an electronic dataset containing Italian drivers' records - the electronic dataset was necessary in order to automatically track the changes in each driver's record - it proved impossible to introduce the Italian PRM in January 2003. Despite this delay, no official communications were made about a revised date of entry into force of the PRM. The lack of any official information about the 'true' date of coming into force of the new penalty system generated uncertainty in drivers' expectations about the timing of the enforcement of the new system.

It was not until almost two months later, at the end of February 2003, that a vague hint about the date on which the PRM would come into force was given. During a session of the Parliamentary Commission on Transport, Post and Telecommunications[6], the Italian Ministry of Transport announced that, given the delays in the enforcement of the new sanctioning system, a new decree law would be enacted, probably around June 2003, in order to make the PRM effective. However, the Ministry neither specified a precise date in which the decree law would be approved nor when it, and therefore the PRM, would come into force. The decree in question was Decree Law No. 153/2003, which was enacted at the end of June 2003 and which conclusively established the date of entry into force of the Italian PRM as July 1, 2003.

The Italian PRM is characterized by assigning to each driver an initial credit of 20 points. Once a given offense is committed, the driver loses a number of points which varies according to the seriousness of the committed offense. Unlike other countries adopting a PRM, in Italy, once the initial endowment of points is exhausted, the driver's license is not automatically

[2]Source: our computation of the data provided in Italian Institute of Statistics (ISTAT, 2008b).

[3]Decree law n. 153/2003, "Modifiche ed integrazioni al codice della strada", published on the Italian Official Bulletin n. 149. Available at: `www.parlamento.it/parlam/leggi/decreti/03151d.htm`, (in Italian).

[4]Delegated law n. 85/2001, "Delega al Governo per la revisione del nuovo codice della strada", published on the Italian Official Bulletin n. 76. Available at: `http://www.parlamento.it/leggi/01085l.htm`, (in Italian).

[5]Legislative decree n. 9/2002, "Disposizioni integrative e correttive del nuovo codice della strada, a norma dellarticolo 1, comma 1, della legge 22 marzo 2001, n. 85"', published on the Italian Official Bulletin n. 36. Available at: `http://www.parlamento.it/parlam/leggi/deleghe/02009dl.htm`, (in Italian).

[6]See the Transcription of the session of the Parliamentary Commission on Transport, Post and Telecommunication held on February 27, 2003. Available at: `http://wai.camera.it`, (in Italian).

suspended. Instead, drivers are merely required to attend a driving course and to pass a written and practical test within 30 days from the zeroing of their points endowment. The suspension occurs if, and only if, within the 30 days they fail to attend the driving course or do not pass the tests. In the time span between the complete exhaustion of points and the driving tests, drivers are allowed to drive. Moreover, when several infringements are detected at once, no more than 15 points can be deducted, even though the total number of detected infractions could otherwise be enough to lead to the suspension of the driver's license.

Nonetheless, the Italian Traffic Code also provides for the crediting of points every two years for drivers who have kept a clean record. Specifically, if for two consecutive years a driver does not commit infractions entailing the deduction of points, the initial credit of 20 points is restored. When he does not commit infractions for two consecutive years and moreover he has maintained at least 20 points, he receives a further credit of two points.

This is entirely unique to Italy. Indeed, in other European countries, such as both Germany and the United Kingdom, not only does the suspension of a driver's license occur automatically once a given threshold of accumulated penalty points is reached, but also no extra points are given for good behavior (which in truth might reward not the 'good' but merely the 'lucky'), while in Spain and France, bonus points are given but less generously. In Spain, drivers get two points only after three years without committing an infraction, and just one point after another three years, up to a maximum of 15 points. The same applies to the initial score, which is a determining factor in establishing how fast one might lose all one's points, hence the opportunity cost of breaking the rules. 12 points are given in France and Spain, and 18 in Germany.

Similar remarks also apply with respect to non - European countries like Canada, Australia, and United States which adopt a totting - up system and discriminate between new and fully licensed drivers (Canada, and US), or between different classes of licenses (Australia) in the determination of both the number of penalty points to be charged for a given offense, and the duration of the license's suspension. Any of these countries' traffic laws provide for the crediting of points in case of virtuous driving behavior, and the rules governing the license's suspension appear particularly severe. For example, in Canada, the suspension of the driver's license occurs once 15 (in the case of fully licensed drivers) or nine penalty points (in the case of new drivers) have been accumulated. The suspension, which lasts respectively 30 or 60 days, is extended up to six months if the threshold of 15 or nine points is reached once again after the first suspension has occurred. In the US, where many States apply a PRM, the suspension of the driver's license may occur, e.g. in California and Colorado, when different thresholds of charged penalty points have been reached, varying according to the speed with which they have been accumulated. In Australia, drivers may be disqualified from driving after accumulating 12 or more penalty points within a three - year period. The minimum suspension period is three months, plus one further month for every extra four penalty points beyond the license's limit. Drivers may avoid the suspension by applying for a 'good behavior' period of 12 months. However, if they accumulate two further points during the good behavior period they have their license suspended for double the original period.

The possibility of distinguishing between 'good' and merely 'lucky' drivers has been further compromised by a partial reform of the Italian traffic code, introduced in 2006, which has severely affected the functioning of the PRM. Specifically, since October 2006 drivers have been allowed to avoid the reduction of their endowment of points thanks to the so - called '*salva punti*' decree[7]. This decree establishes that when the owner of the vehicle is notified of an infraction (e.g. because it was impossible to identify the person driving at the time the infraction was recorded, as in the case of speeding offenses detected by cameras), the owner has the duty, if he was not driving when the offense was committed, to provide the personal details of the person driving his vehicle at that time. If he is not able to identify them, he will be held responsible for the infraction and will have to pay a fine, but contrary to what might be expected, he does not lose points. The provisions of the '*salva punti*' decree offer drivers a very useful loophole by which to avoid the reduction of points in case of infringements. Actually in Italy it is quite common, when a sanction is notified, for drivers to lie to the authorities and declare that they were not driving at the time the offense was committed and identifying instead another person, e.g. a member of their family attaching low value to preserving points, as guilty of the traffic offense. This happens very often in the case of speeding infractions, which are mostly detected by cameras. Considering that speeding offenses are the most commonly detected violation on Italian roads and that they are among the most important causes of road fatalities, the opportunity for dangerous drivers to evade the assignment of penalty points by this means appears particularly worrying.

3 Description of the data

This Section offers an overview of the sources, the main descriptive statistics, and the motivations underlining the choice of the variables used in our econometric analyses. The performed empirical analyses aim to understand whether: (i) the introduction of a PRM to back traffic infractions has produced positive effects on speeding behaviors through general deterrence; (ii) the dynamics of speeding offenses shows parallels with that of accidents, as consequence especially, of the adoption of the new sanction system; (iii) the physical removal of dangerous drivers from roads through their license suspension, because e.g. they have lost all the points available to them, benefits road safety.

Speeding deterrence and road safety

To this end, we mainly exploited the dataset of the Italian state police which provides evidence on the daily number of: (i) recorded infractions, with reference to different types of traffic offenses; (ii) accidents; (iii) persons injured or dead in accidents; (iv) police patrol cars on duty; (v) suspended licenses; and (vi) withdrawn vehicle booklets of circulation. These data are provided with reference to both highways and other roads, i.e. state, regional, provincial, and municipal roads, as they are recorded by the Italian Police since March 1^{st} 2001[8].

Specifically, the dataset makes publicly available evidence about the following traffic law violations: (i) *speeding* (Art. 142 of the Italian traffic code, ITC henceforth); (ii) *driving at a dangerous speed* (Art. 141 of the ITC); (iii) *driving without seat belts* (Art. 172 of the ITC); (iv) *riding a motorcycle or a scooter without a helmet* (Art. 171 of the ITC); (v)

[7] Decree Law No. 162/2006, 'Disposizioni urgenti in materia tributaria e finanziaria', published in the Italian Official Bulletin No. 230. Available at: `http://www.camera.it/parlam/leggi/decreti/06262d.htm`.

[8] Italian state police dataset "Incidenti e contravvenzioni giorno per giorno", (in Italian). Available at: `http://www.poliziadistato.it/pds/stradale/archivio/index.php`, (accessed October 2008).

driving under the influence of alcohol (Art. 186 of the ITC); (vi) *driving under the influence of drugs* (Art. 186 of the ITC); (vii) *unauthorized speed competitions* (Art. 9 (ii) and (iii) of the ITC); (viii) *offenses related to vehicle lighting system use* (Art. 152 of the ITC); and (ix) *offenses related to headphone and speaker phone system use* (Art. 173 of the ITC).

We collected monthly observations on speeding infractions and with reference to highways only for the period March 2001 (the first month covered by the dataset) through September 2008 (the month before we conducted the investigation presented in the paper) inclusive. Once we adjust for the main determinants of the number of infractions recorded by the police, i.e. level of implemented enforcement and volume of traffic, this time - frame allows us to compare the dynamics of one of the types of driving behavior most responsible for accidents, i.e. speeding (Italian Institute of Statistics - ISTAT, 2008b), before and after the entry into force of the Italian PRM, which occurred in July 2003.

We decided to focus only on registered violations on highways to guarantee that the selected sample of infractions and accidents was representative. In fact, the Italian state police dataset does not represent the entire population of traffic violations occurring on roads other than highways. This is because for roads other than highways the Italian state police is one of the several bodies in charge of detecting illicit traffic behaviors: i.e. *Carabinieri*, *Vigili Urbani*, *Polizia Provinciale*, *Guardia di Finanza*, *Guardia Forestale*, etc. Conversely, the Italian state police is the main body responsible for detection of infractions occurring on highways. Moreover, data on offenses recorded by forces other than the Police are not publicly available.

We decided to focus on speeding behavior for three reasons. First, it is considered among the main causes of road fatalities across the world (World Health Organization, 2004) being thus probably the main activity governments try to prevent when adopting a PRM. Actually, speeding has ascertained to be the second most frequent cause of accidents occurred on roads other than highways (i.e. statal, regional, provincial, municipal, and urban roads) and the third main determinant of the total number of accidents occurred on highways (Italian Institute of Statistics - ISTAT, 2008b). Respectively, it accounts for 12.03% and 30.10% of the causes, attributable to driver's behavior, which have been ascertained to be responsible for accidents occurred in these two categories of roads (see Fig. 1 and Fig. 2). Second, speeding behavior has revealed to be particularly responsive to offense - history sanction mechanisms (e.g. Redelmeier et al. (2003)). Third, because of its peculiarities, speeding is more suitable than other driving conducts to investigate agents' (rational) responses to changes in the sanction policies.

First of all, for speeding, the decision about whether to comply or not with traffic laws is contextual to the activity of driving. The decision not to respect the imposed speed limits is taken while driving or immediately before starting to drive. Conversely, alcohol and drug - related offenses do not possess this peculiarity. Indeed, the decision to drink alcohol or to consume drugs may be taken in a wide time span preceding the decision to drive. Therefore, at the moment at which alcohol and/or drug consumption occurs, the act of driving might be only a possibility. In turn, this means that the cost represented by the expected sanction for driving under the effect of alcohol or drugs might not be internalized at all in the decision to drink or take drugs. In other words, the infractions recorded in respect of these driving actions might not reflect a decision about whether or not to respect traffic laws, given that at the time when agents decided to consume alcohol or drugs, they may have not planned to drive at all. Moreover, factors other than the sanction scheme appear crucial in deterring driving under the influence of alcohol or drugs. For example, the perception of what is safe alcohol consumption has been shown to play an important role in the deterrence of drunk driving (Shepeherd, 2001). And similar remarks may apply for drug consumption. For these reasons we decided to exclude from our analyses offenses like driving under the influence of drugs and driving under the influence of alcohol.

Secondly, the choice of driving speed is the result of a trade - off between time opportunity costs, the expectations about the actual level of enforcement, and the perception of accident risk - where this perception, however, does not fully internalize the possible effects that dangerous driving behavior might generate on other road users (Cohen and Einav, 2003), but only those on the driver himself (Tarko, 2009), which make it particularly suitable for testing the hypothesis of rational and strategic driving behavior. Conversely, other driving behaviors like wearing a seat belt or a helmet do not involve any negative externality on other road users, and overall, any opportunity cost similar to that mentioned for speeding behavior. What actually counts in deciding whether or not to use these safety devices are the gains in terms of personal safety and the expected sanction deriving from the violation of the related legal provisions. Moreover, once law - abiding behavior is established, i.e. people learn the importance of using helmets and safety belts for their personal safety, it is reasonable to expect that any change occurring in the related enforcement system will not affect that behavior (Benedettini and Nicita, 2010). For these reasons we decided to exclude offenses like *driving without seat belts*, and *riding a motorcycle or a scooter without a helmet.*

The offenses cited in points (vii), (viii) and (ix) are not involved in our research not only because they do not share the characteristics discussed above but also because the data on the corresponding number of infractions are available only from September 2004. This would have prevented us from conducting a 'before and after' analysis and from assessing the responses of agents to an increase in the expected sanction, associated with the coming into force of the Italian PRM, with respect to these offenses.

The traffic offense named in the Police's dataset as *driving at a dangerous speed* (Art. 141 of the ITC) is also not considered in the analyses because, despite its apparent similarities with speeding, it concerns a set of driving behaviors, very different one from another, for which it is not possible to isolate the corresponding number of infractions. In fact, behaviors considered 'dangerous', and thus prohibited, include: driving at a very low speed, holding competitions on roads, not maintaining safe distances from other vehicles, etc.

Our research also includes data on the monthly number of accidents occurring on highways. Specifically, the Italian state police provides evidence of: (i) the *total number of accidents*; (ii) the *number of fatal accidents*, out of the total; and (ii) the *number of accidents with only injured persons*, out of the total; and (iii) the *number of accidents only causing damages to vehicles*, out of the total. To be precise, fatal accidents are defined as those involving at least one vehicle and at least one person killed regardless of the severity of any other involved persons' injuries, while accidents with only injured persons are those involving at least one vehicle and at least one injured person, but no fatalities. Along data on accidents, the Italian state police dataset provides also data on the number of persons dead or only injuried in accidents.

The adoption of a PRM in Italy rests mainly on an attempt to reverse the dramatic primacies this country shows with reference to road safety standards and which appear to be particularly serious in the case of highways. Indeed, Italy emerged in 2007 as the country having the second highest number of fatalities per year (5,131) among the 27 countries of the European Union, ranking second only to Poland (5,583 fatal accidents per year), and ahead of the most advanced European states, like Germany, France, and UK which recorded respectively 4,949, 4,620 and 3,823 road fatalities per year (Directorate for Energy and Transport, 2009). In addition, Italy posts the highest number of fatalities due to car and motorcycle crashes, accounting respectively for 30% and 28% of the total number of European car and motorcycle deaths[9]. Looking more closely at highways, which are the focus of our article, an even more dramatic picture emerges. Not only are accidents on Italian highways characterized by particularly serious consequences - during the period 2001 - 2007 highways exhibited an average mortality rate equal to 4.63 deaths every 100 accidents, against 1.44 for urban roads (Italian Institute of Statistics - ISTAT, 2008b) - but they are also worryingly high compared to the rest of Europe. Currently, the Italian rate of highway fatalities per 1,000 km of road is equal to 100 and is thus substantially above the European average, which is about 49, and slightly below countries like Greece and Luxembourg which show a number of deaths per 1,000 km of 198.1 and 104.3 respectively[10].

In deriving our conclusions we wanted also to be sure that the results appearing from the non - parametric estimates would not be driven by changes in the implemented level of enforcement and thus in the ability of the deputed enforcement 'mechanisms' to detect traffic infractions. To this end, we constructed a composite index, called *Enforcement index*, obtained by adding together the monthly number of deployed police patrol cars and cameras. Because the Italian state police dataset does not provide information on the latter (i.e. data on patrol cars are available from September 2004 and thus do not cover the whole examined period, while data on cameras are not available at all), these figures were provided by the *Direzione della Polizia Stradale* (Traffic Police Directorate).

Finally, we wanted to be sure that our results would not be driven by the variability of the number of road users. To this end we collected data on monthly traffic volume on highways (i.e. total number of vehicles on the road: number of light vehicles plus number of heavy vehicles) during the period studied, from the dataset of the *Associazione Italiana Societa' Concessionarie Austostrade e Trafori* (Italian Association of the Societies Responsible for Highways and Tunnels). In order to adjust for variations in traffic volume, in our non - parametric regressions we divided the monthly number of recorded speeding infractions by the monthly total number of vehicles using highways, and performed our non - parametric estimates on the resulting figures. In this way we obtained the number of speeding tickets per 1,000 vehicles, and thus drivers, thereby eliminating the risk that the dynamics of speeding offenses resulting from our non - parametric estimates might in fact be driven by the dynamics of the highway traffic. Similar remarks apply for the non - parametric regression implemented to estimate the dynamics of accidents.

Incapacitation and road safety

Our research aims also to examine whether the incapacitation of dangerous drivers through the suspension of their license is an effective tool to improve road safety. To this end

[9] European Road Safety Observatory Report (2008).
[10] European Road Safety Observatory Report (2008).

we collected, from the online dataset of the Italian state police, data on the monthly numbers of suspended licenses[11]. Data on the number of suspended licenses contain aggregated values for both highways and roads other than highways, i.e. national, regional, provincial and municipal roads, thus making it impossible to obtain disaggregated data for these two types of roads. Consequently, in order to assess the impact of incapacitation on road safety, we were forced to employ a different measure of road accidents than that used for the non - parametric regressions. Specifically, we employed, as proxy for the level of road safety, the monthly number of accidents occurring on the entire Italian road network (Italian Institute of Statistics - ISTAT, 2008b). This was in order to avoid the possibility that, by using data on accidents recorded by the Italian police, we would overestimate the effects of license suspension on road safety. Now, as discussed for traffic offenses, the Italian state police are one of several bodies in charge of detecting infractions and accidents on state, regional, provincial, and municipal roads and therefore their dataset does not fully cover evidence for roads other than highways. Conversely, the only data on the number of suspended licenses are those provided in the Italian state police dataset.

Because of lack of evidence for earlier periods in the Italian state police dataset, data on the number of suspended and revoked drivers' licenses are available only from September 2004 onwards. Similarly, data on the monthly number of road accidents are available only up to December 2007. In fact, at the time of writing the Italian Institute of Statistics has yet to update data on accidents occurring in 2008. Thus our analyses refer to the period September 2004 - December 2007.

To detect the effect of incapacitation on road safety, as a control for the volume of traffic observed on the entire population of roads we use data on the monthly number of circulating vehicles (*Automobile Club d' Italia* - ACI, 2009). Actually, if in the case of highways it is possible to obtain data on the monthly volume of traffic (because these are publicly available and easier to monitor), this is not the case for other roads, e.g. it would be difficult to monitor the daily, and then monthly, volume of traffic on urban roads. For these reasons, we measured the volume of traffic by using the monthly total number of circulating vehicles as recorded in the Italian vehicle register. Specifically we took the number of vehicles in circulation at the end of 2003 and we then added, for every month, the number of new registered vehicles minus the number of vehicles that have been removed from the register.

In addition, we control for weather conditions by using the average monthly level of pre-

[11]The Italian Traffic Code establishes the suspension or the repeal of the driving license in many hypotheses, all characterized for having potentially or effectively challenged road safety. For example, the suspension of the driving license occurs in case of: (i) complete exhaustion of the initial endowment of points associated to the driving license (art. 126 bis ITC); (ii) non authorized speed competition, (art 9 bis and ter ITC); (iii) temporarily lack of the physical and psychic requisites required to confirm driving license' s validity or to obtain its review (art. 128 ITC); (iv) driving a vehicle (car, motorcycles, etc.) with a non conform driving license (art. 125 ITC); (v) breaking the imposed speed limit for a range of 40 Km/h - 60 km/h and beyond 60 Km/h (art. 142 ITC); (vi) driving in the wrong direction in roads characterized by scarce visibility (art. 143 ITC); (vii) non - respect of road signals within two years from the commission of a similar infraction (art. 146 ITC); (viii) non - respect of the rules on overtaking within two years from the commission of a similar infraction (art. 148 ITC); (ix) driving without the seat belt (art. 172 ITC) or the helmet (art. 171 ITC) within two years from the commission of a similar infraction; (x) driving under the influence of alcohol (art. 186 ITC); (xi) driving under the influence of drugs (art. 187 ITC). The driving license can be repealed, e.g., when: (a) infractions described in (ii) imply death or serious injuries for third parties (art 9 bis and ter ITC); (b) permanent lack of the physical and psychic requisites required to drive (see art. 130 ITC); (c) from the violation of one of the driving behavior rules established by the Italian traffic code (art. 140 and subsequent articles) derives deaths or serious injuries to third parties because it has been committed while driving under the influence of drugs or alcohol (art. 130 bis ITC).

cipitations in Italy. These data have been obtained by averaging the daily amount of precipitation registered by each of the 187 methereological stations located across the whole Italian territory. Data are provided by the European Climate Assessment & Dataset (ECA&D)[12].

The estimate of the effect of license suspension on road safety may be affected by simultaneity problems. This is because the suspension of the driving license may also occur when the authorities ascertain that the accident is the consequence of a driver's actions, such as drunk driving and drug driving[13], etc. which incurs the suspension of the license. To avoid endogeneity problems we implement a 3SLS regression to estimate a two - equation model in which we allow accidents to be affected by the license suspension and, simultaneously, the license suspension to be influenced by accidents. To this aim, i.e. to estimate the endogenous variable capturing the number of suspended license, we employ, besides the exogenous regressors mentioned above with regard to the estimate of the number of accidents, a group of variables accounting for: (i) the several type of offenses, available in the dataset of Italian state police, which may determine the license suspension. According to the Italian traffic code these offenses involve speeding, unauthorized speeding competitions, drug and drunk driving; (ii) the number of police patrol cars on duty, as proxies of the implemented level of controls.

In Table 1 we report the main descriptive statistics concerning highway offenses and accidents, as they result from the dataset of the Italian state police, as well as the other variables used for our non - parametric and 3SLS regressions.

4 Methodology

In this work we investigate, first, the effects produced on agents' attitudes toward compliance with traffic rules by an increase in the expected sanctions, i.e. because of the introduction of a penalty point system coupled with the existing monetary sanctions, and, second, the impact exerted on road safety by the incapacitation of dangerous drivers through the suspension of their licenses.

Speeding deterrence and road safety

To accomplish the first aim of the article we performed a Lowess estimate[14] of the dynamics over time of the number of highway speeding infractions and fatal accidents in order to detect: (i) statistically significant non - linearities in the dynamics of speeding offenses ascribable to the enforcement of the Italian PRM; and (ii) whatever the response from drivers may have been to an increase in the expected sanction, whether that response shows a parallel with accidents' dynamics.

The reason why we employ a non - parametric estimator is essentially related to the specific advantages that these methods provide compared with the traditional ones. To put it precisely, when there is no prior knowledge of the type of relationship we are interested in analyzing, or when one does not want to make any assumptions on the type of function describing this (as is the case for the traffic offense and accident dynamics), non - parametric

[12]See `http://eca.knmi.nl/`.

[13]See supranote 12.

[14] Bowman and Azzalini, 1997 for a detailed insight on non - parametric methods of estimate.

methods are a useful and straightforward tool to investigate and represent it, and to detect the existence of any statistically significant non - linearities that may be present. The implemented non - parametric estimate performs a linear least squares regression to localized subsets of the data. The size of the latter is defined by the so - called bandwidth. The bandwidth determines the smoothing of the estimated function. The larger the bandwidth is, the more smoothed is the function; whereas the smaller it is, the more closely the function fits the data.

However, when the dependent variable is a time series and, thus, the independent variable is represented by a generic function of time, it is usual to take into account the possible presence of autocorrelated errors which may influence the smoothing of the data. Indeed, when there is no prior knowledge of the function we are going to estimate and it is moreover a function of time, it is not possible to address with certainty how much of the irregularity in the collected data is due to the shape of the underlying unknown function (i.e. due to whatever is the value of its second derivative at a given point in time) and how much to the magnitude of the disturbance terms' variance, i.e. $var(e_t)$.

With this aim, and before the implementation of the local linear regression, it is praxis to implement a two - step procedure aimed at computing the optimal bandwidth value to be used for the estimate of the relationship we are interested in. This procedure consists of separating the two potential determinants of the shape of the unknown function (i.e. the irregularity in the observed data and the presence of autocorrelated error terms) by means of the following steps: (1) a preliminary estimate of the unknown function, underlying the collected data, has to be performed by choosing an arbitrary bandwidth, h, so as to oversmooth rather than undersmooth the function; (2) the residuals obtained in step (1) then have to be used to estimate the autocovariances of $var(e_t)$ and to construct the related correlation matrix $\hat{R}$; (3) with the information obtained in step (1) and (2) the optimal bandwidth h^* is then computed as that value which minimizes the generalized cross - validation criterion defined as:

$$GCV_d(h) = RSS(h)/(1 - tr(S\hat{R}))^2$$

where $RSS(h)$ is the residual sum of squares obtained in (1); S is the so - called smoothing matrix (i.e. is an $n \times n$ matrix of weights, depending on the h used in (1) to obtain a first estimate of the unknown function), and $\hat{R}$ is the correlation matrix of the collected residuals. This ratio corresponds to the *Direct Cross - Validation Criterion*, which is what we use in our analysis.

Once the optimal bandwidth is computed and the non - parametric estimate is performed, we are interested in testing the statistical significance of the relationship emerging from the latter. Specifically, to test the statistical significance of any non - linearities which may appear from the non - parametric regressions, we assume the linear model as the reference. In other words, we test the null hypothesis of linearity of the resulting function against the alternative hypothesis of non - linearity. The shaded area appearing in the graphics presented in the article it is thus the reference band for the linear model. This band suggests where the estimated relationship should lie if the null hypothesis is not rejected. Therefore, if the resulting estimated function lies outside the reference band, this means that the null hypothesis is rejected and that the displayed non - linearities are statistically significant.

All the estimates were performed using the *sm* package of the statistics software R.

Incapacitation and road safety

The effect of incapacitation on road safety has been investigated by using a 3SLS regression in order to take into account the potential reverse causality concerning the accidents and the number of suspended licenses. Actually, the number of suspended licenses may be endogenous with respect to the number of occurred accidents. This is because it may happen that the authorities ascertain that the accident is the consequence of a driver's actions, such as drunk driving and drug driving, etc. which incurs suspension of the license[15]. In the presence of endogeneity the OLS estimator can produce biased and inconsistent parameter estimates.

The 3SLS method allows, in this case, to estimate a two - equation model in which we allow the number of suspended licenses to react to accidents and, contextually, accidents to react to license suspension:

$$SuspLic_t = \gamma_0 + \gamma_a Acc_t + \gamma_s Speed_t + \gamma_u UnSpeedComp + \gamma_d Alc_t + \gamma_d Drug_t + \gamma_p Pol_t + u_t \quad (1)$$

$$Acc_t = \beta_0 + \beta_s SuspLic_t + \beta_v Veic_t + \beta_p Prec_t + \beta_t Time + \beta_f Feb + \beta_j Jul + \beta_x X_t + \epsilon_t \quad (2)$$

Specifically, the 3SLS method consists of the following three steps. The first step aims to obtain the predicted value of the endogenous variable by regressing it on on all the exogenous regressors of the model. In the second step, the predictions of the number of suspended licenses found in the first stage replaces $SuspLic_t$ on the right hand side of equation (2) and OLS is applied. The residuals of the OLS regression are then used to obtain an estimate of the covariance matrix of the error terms of the two equations. In the third stage, the estimate of the correlation matrix is used as a weighting matrix to calculate the generalized least square estimator (GLS). The last two steps are iterated over the estimated disturbance covariance and parameter estimates until the parameter estimates converge.

Specifically, the endogenous variable $SuspLic_t$ has been instrumented with the monthly number of infractions relative to those traffic offenses determining the license suspension accordingly to the Italian traffic code, and with the number of police patrol cars on duty, Pol_t, on highways and roads other than highways, to account for the implemented level of controls. Precisely, those traffic offenses determining the license suspension and for which data were available in the dataset of the Italian state police are the following: (i) speeding, $Speed_t$; (ii) drunk driving offenses, Alc_t; (iii) drug driving offenses, $Drug_t$; and (iv) unauthorized speeding competitions, $UnSpeedComp_t$[16].

Variables in eq. (2) have the following meaning: Acc_t is the total number of accidents occurred on both highways and roads other than highways during month t. In particular, it

[15] Actually, the Italian traffic code provides for the license suspension when from the violation of one of the driving behavior rules it establishes by the Italian traffic code (art. 140 and subsequent articles) derives deaths or serious injuries to third parties because it has been committed while driving under the influence of drugs or alcohol. See supra note 12.

[16] See supra note 12.

concerns the whole population of accidents independent of whether they have caused harm to parties, what kind of harm they have caused in the case (i.e. death and/or non - fatal injuries), their causes, and the number of involved vehicles. This variable represents our proxy for the level of road safety. $SuspLic_t$, assumed to be endogenous, is the number of suspended license during the month t. The number of suspended license is employed as measure of the number of individuals who have been incapacitated, and thus prevented from driving, because they have revealed to represent a serious threat for road safety. This because they have lost all points available to them or because, independently from the number of points still available to them, they have been detected while committing an offense whose seriousness implies the automatic suspension of the license[17]. $Veic_t$ represents the number of circulating vehicles during month t. It is a proxy for the volume of traffic experienced by highways and roads different from highways. $Prec_t$ represents the amount of precipitation during month t. $Time$ represent the effect of time. Feb and Jul are dummy variables which take the value 1 for observations relating to the months of February and July respectively. They have been employed to take into account the seasonality characterizing the time series of the total number of accidents occurring. In fact, as emerges from Fig. 3, the time series of the monthly total number of accidents displays a negative peak every February and a positive peak every July. X_t is a group of controls. Specifically, we check for the robustness of the results of our original second - stage regression by estimating three further specifications in which we include the following controls: the number of withdrawn registration books (to capture the extent of the measures undertaken to remove unsafe vehicles from the road[18]), labeled as $Book_t$ in the model, the monthly number of infractions due to offenses related to headphone and speaker phone system use, $Phone_t$, and to vehicle lighting system use, $Light_t$. These two latter variables have been considered in order to capture the frequency of actions which may cause a loss of care and attention while driving like using hands to speak on a cellphone, as well as unsafe driving behaviors, i.e. driving without using lights at all or in a proper way.

The 3SLS regression has been performed by using the package *reg3* of STATA.

5 Empirical results

In this Section we present the results of the econometric analyses performed to investigate whether and in what way: (i) the adoption of a PRM affected agents' propensity to speed, as evidenced by the number of highway speeding tickets per driver; (ii) the dynamics of highway accidents show any parallels with the dynamics of speeding offenses as affected by the introduction of a PRM; (iii) the non - monetary sanction consisting in the suspension of drivers' license benefits road safety as measured by the monthly number of accidents occurring on highways and roads other than highways.

[17] See supra note 12.

[18] Indeed, the main function of this document is to prove that the vehicle to which it uniquely refers is safe to drive. One of the main reasons leading to the withdrawal of the registration book is the vehicle's failure to conform to the minimum required roadworthiness standards to stay on the road. Other minor causes for revoking the vehicle's registration may be, e.g., driving with an expired driver's license, riding a motorcycle without a helmet, failure to update the registration book after the vehicle has undergone some technical changes, failure to repair the vehicle when this is required by law, etc.

Speeding deterrence and road safety

Fig. 4 depicts the estimated dynamics of the monthly number of speeding offenses per driver. What immediately emerges from this figure is the steep decrease in the number of speeding infractions per driver occurring in the sub - period March 2001 - January 2002. As discussed in Section 2, in March 2001 it was announced that the Italian Parliament, by means of Delegated Law No. 85/2001, had empowered the Government to review the Traffic Code in force and to introduce the PRM as an additional sanction system. However, at that time no information about the date of coming into force of the new measure was provided. The announcement of the decision to reform the sanction system for traffic infractions informed drivers only about an upcoming increase in the sanctions imposed for illegal driving actions (i.e. the already existing fines would soon be coupled with penalty points); it neither implied the immediate formal enforcement of the new measure, nor did it stipulate the date on which the PRM would come into effect. However, despite the impossibility of formally enforcing the new sanction policy, the sharp reduction in the number of speeding tickets per driver occurring in March 2001 tells us that the policy's announcement triggered a strong reaction in drivers' behavior, which determined a reduction in speeding tickets per driver equal to 72.87%. In our opinion, the announcement of an upcoming increase in sanctions and the uncertainty about when it would come into force determined an increase in compliance with traffic laws due to a sort of 'wait and see' behavior (that can be assimilated, in a certain sense, to a 'mental accounting process' - Sunstein, 1999) which may explain the statistically significant steep decrease we observe in the dynamics of speeding offenses per driver. More precisely, the uncertainty about the period of entry into force of the new system, as well as about its salient features, induced drivers (or at least a substantial number of them) to increase the level of care they took while driving in order to avoid the possibility (because they were not perfectly informed about the date of entry into force of the PRM) of a higher sanction if caught breaking speed limits.

This instance of an announcement effect had run its course by around the end of January 2001 when the monthly number of speeding infractions per driver starts to indefinitely increase, but overall more precise information about the date of coming into force of the PRM as well as about its main features was provided. As we know from Section 2, in January 2002 the Government promulgated Legislative Decree No. 9/2002 which acknowledged the authorization to reform the Traffic Code granted by Parliament in Delegated Law No. 85/2001. The legislative decree described the main features of the new sanction system and also stipulated that it would come into force in January 2003. Once this more specific indication of the timing of entry into force of the PRM was given, drivers progressively reverted to their 'usual' level of (non -) compliance with traffic laws, leading to the progressive increase in the dynamics of speeding infractions per driver that we observe after January 2002. This happened because they realized that it was unnecessary, as well as costly, to continue to maintain a higher level of caution than usual while driving.

This indefinite rise in the monthly number of speeding offenses per driver is interrupted only about one year later when the dynamics of speeding offenses experience a second statistically significant decreasing trend (see the black line in Fig. 4). To be precise, we observe that from March 2003 the dynamics of the recorded speeding infractions experience a reduction which lasts until about December 2003, when they start again to rise indefinitely. We ascribe this temporary reduction in the number of speeding tickets per driver to a second announcement effect. Indeed, as reported in Section 2, at the end of February 2003 the Italian Ministry of Transport announced that, because of the delays experienced in the creation of an electronic dataset containing Italian drivers' records (which prevented the entry into force of the PRM in January 2003) a new decree law would be enacted, probably around June 2003, in order to put the PRM into effect. However, the Ministry specified neither a precise date by which the decree law would be approved nor when it and therefore the PRM would come into force. Thus, we believe that a mechanism similar to that experienced in March 2001 also came into play after the Ministry of Transport announcement. Once again, the uncertainty about the exact date of coming into force of the more severe sanction system made drivers adopt more cautious behavior, which resulted in a reduction of the number of recorded speeding infractions per driver.

Paradoxically, the augmented level of drivers' compliance with traffic laws triggered by the second announcement was not strengthened by the effective coming into force of the new sanction policy, which occurred in July 2003. Indeed, as already stated, we observe that speeding infractions start again to indefinitely increase a few months after the introduction of the PRM. The fact that, although the new sanction scheme was able to be formally enforced (and that - unlike during the two announcement sub - periods - more severe sanctions were effectively in force), we do not observe a corresponding sustained decrease in the number of infractions per driver, suggests to us that drivers were likely more concerned about the detection policies that would have been implemented to support the introduction of the new system rather than the resulting increase in sanctions. In fact, if this had not been the case we should have observed, after the coming into force of the PRM and thus of an effective increase in the expected sanctions associated with traffic offenses, that the number of speeding infractions per drivers would have had to stabilize around at least a constant level but would not have experienced an indefinitely increasing trend over time as actually appears from the non - parametric estimates.

In our opinion, the most plausible explanation justifying this evidence is that drivers underwent a learning process about the probability of being detected observing that, despite the adoption of more severe sanctions, the authorities' lax attitude toward enforcement did not change and especially did not increase in consequence of the adoption of harsher penalties for traffic law infringements. Indeed, as confirmed by the non - parametric estimates of the dynamics of our *Enforcement index* (see Fig. 13), the number of deployed speeding control devices appears to be decreasing over time. Actually, by considering a two - year window, before and after the coming into force of the PRM, we observe a remarkable decrease in the number of deployed speeding controls. Precisely, the average monthly number of speeding controls was equal to 21870.04 during the sub - period July 2001 - June 2003 and equal to 20415.60 during the sub - period July 2003 - July 2005, thus experiencing a reduction of 6.65%. Therefore, once they learned that the established probability of detection was independent of the increase in sanctions due to the coming into force of the penalty points system, they progressively reverted to the level of compliance with traffic laws they had maintained prior to the introduction of the PRM.

In addition, we claim that the progressive increase in the number of speeding infractions per driver, triggered by the learning process drivers underwent regarding the risk of being caught after the entry into force of the PRM, was further strengthened by the learning process they also underwent with reference to the probability of being convicted under the new penalty scheme. Specifically, as time went by and they incurred infractions or they merely acquired information about the functioning of the new sanction system from the media or others drivers' experiences (Sah, 1991), they also realized that the probability of having their license suspended was not as high as expected. As discussed in the Introduction, the automatic deprivation of the license is a salient feature of PRM which aims to: (i) characterize it as an offense history - based mechanism; (ii) give credibility to authorities' willingness to enforce it; (iii) incapacitate reckless drivers. Actually, what drivers mainly learned about the new system was that the probability of having penalty points charged and thus of eventually having their license suspended was much lower than expected on the basis of the scheme's announced aims and features. First of all, we refer to one of the most important determinants concerning the effectiveness of a PRM: the amount of points initially allotted (Bourgeon and Picard, 2007). As observed, the size of the credit of points assigned to drivers is crucial in determining the speed at which they can be lost (and therefore the speed at which the suspension of the license occurs) and it has to be determined taking into account the delicate trade - off with the length of the suspension period: i.e. it has to be defined in such a way as not to undermine the incentive power of the deprivation measure (Bourgeon and Picard, 2007). In Italy, drivers are endowed with an initial amount of 20 points which, as noted in Section 2, appears to be relatively high compared with that allowed in other European and non - European countries. Thus, the availability of such a large endowment of points probably has induced drivers to adopt a trigger strategy (Bourgeon and Picard, 2007) consisting in complying with traffic laws only after a certain threshold of penalty points has been reached[19]. However, if measures like the '*salva punti*' decree[20] are adopted and coupled with redemptive mechanisms, the threshold that triggers compliance with traffic laws becomes even higher. Actually, not only has the so called '*salva punti*' decree transformed penalty points into a monetary sanction in practice; it has also prevented the PRM from exercising an effective screening function between reckless and responsible drivers. Indeed, because this provision offers individuals the possibility of avoiding the deduction of points by simply declaring that they were not at the wheel when the offense was detected, many dangerous drivers are allowed to commit infractions without these being entered on their record. Therefore, potentially reckless drivers are being treated on a par with law - abiding drivers and are paradoxically also allowed to benefit from the redemptive mechanisms provided by the Italian system which further opens the way, through the supplementing of the points endowment, for illegal driving behaviors. Moreover, if we consider that in Italy the suspension of the drivers' license does not occur automatically in the remote hypothesis (because of the redemptive mechanisms coupled with provisions like the '*salva punti*' decree) of the zeroing of the initial endowment of points, it is possible to further understand the reasons for the failure of the Italian PRM to effectively reduce undesirable driving behavior. Actually, the automatic suspension of the license is a necessary condition to ensure a credible commitment from the authorities in enforcing the new system and it appears crucial when the offense committed is particularly serious (Bourgeon and Picard, 2007).

Therefore, we can reasonably conclude that the inefficacy of the Italian PRM in per-

[19] Actually, this is what appears from a microeconometric analysis, on a sample of 50,000 drivers, concerning the effect of the Italian PRM on drivers' attitude toward compliance with traffic rules (Basili et al. (2009)).

[20] See Section 2 for an exhaustive illustration of the characteristics and implications of the '*salva punti*' decree.

manently increasing deterrence of speeding behaviors can be considered the result of an inadequate combination of the detection and conviction policies, overall, supporting its introduction. Actually, for agents to be caught while infringing the law has a great informative power about the subsequent probability of being convicted which in turn provides information about the design of the adopted sanction mechanism and therefore of its actual characteristics. Therefore, if drivers reveal to be sensitive to detection policies, as actually we argue on the basis of our findings, but they learn that the probability of being detected is independent from the introduction of the new penalty system and also that whether detected the probability of having points charged and consequently the license suspended is meagre it is reasonable to expect that the PRM loses its effectiveness in reducing traffic offenses.

It is important to note that only a divergence between expected and real apprehension and conviction probabilities may explain our findings. Actually, as already mentioned earlier in this article we have controlled for changes in the enforcement authorities' ability to detect infractions - and found that the number of speeding infractions was not correlated with the number of deployed speeding controls[21] - as well as for seasonal effects, performing our estimates on the number of infractions per vehicle.

Fig. 5 and 10 report the estimated dynamics of the monthly number on highways of accidents in total[22] and fatal accidents respectively. These pictures outline that accidents are characterized by an indefinitely decreasing trend over time. This feature, which appears to be common to most European countries and was already in play before the period we consider (European Road Safety Observatory, 2008), is the result of many contextual factors such as, e.g. drivers' experience Mayhew et al. (2003)), use of vehicle safety device (Cummings et al. (2002)), medical technologies (Noland and Quddus, 2004), media campaigns (Elder et al. (2004)), transport policies facilitating reductions in the amount of motor - vehicle traffic, road design, and the production of safer vehicles (Ameratunga et al. (2006)). However, it is unquestioned that policies aimed at improving road safety also play an important role. As may be observed in Fig. 5 and more clearly in Fig. 10, after the coming into force of the Italian PRM, the dynamics of accidents (both total and fatal) exhibited a statistically significant non - linearity (see the intervals delimited by the red and black lines in Fig. 5 and Fig. 10). Specifically, we observe that the rate at which accidents decreases became faster. Indeed, the number of fatal accidents switched from a decrease at a constant rate to a decrease at a accelerating rate. However, fatal accidents, and accidents in general, benefited only temporarily from the introduction of the PRM. Indeed, a few months later fatal accidents resumed their usual constant rate of decrease. The PRM was prevented from exerting a lasting effect on accidents because, as outlined previously, it was first prevented from exerting a lasting and positive deterrent effect on drivers' speeding behavior, which is important to remind is the main responsible for accidents, in Italy (Italian Institute of Statistics - ISTAT, (2008b)). It is fair to say that the inconsistent design of both conviction and detection policies in support of the new system weakened the chance of lasting deterrence against dangerous speeding behavior and consequently the possibility also of permanently slowing down the mortality rate.

A further evidence of the short - term effect of the PRM on accidents also emerges from the Poisson regressions represented in Table 3. Specifically, it is analyzed the effect of the

[21] The correlation coefficient is equal to - 0.1723 and is not statistically significant.

[22] According to the Italian state police dataset it involves: (i) fatal accidents; (ii) accidents causing only injuries to parties; and (iii) accidents causing only damages to vehicles. See Section 3 for further details.

introduction of the PRM on all the types of accidents occurred on highways, as they result from the Italian state Police, i.e.: (i) the total number of accidents; (ii) the number of fatal accidents, out of the total; (iii) the number of accidents with only injured persons, out of the total; and (iv) the number of accidents only causing damages to vehicles, out of the total. The monthly number of highway accidents has been regressed, in each specification, for: (i) the average monthly level of precipitation, $Prec_t$; (ii) the amount of highway traffic volume, $Veich_t$; (iii) the number of deployed police patrol cars, Pol_t; (iv) a dummy variable accounting for the positive peak accidents experience in the month of July, Jul; (v) a dummy variable accounting for the negative peak accidents experience in the month of February, Feb; (vi) a dummy variable, PRM, which takes value equal 1 for the months following the introduction of the PRM, and equal to 0 otherwise; (vii) a variable measuring the effect over time of the PRM, Dur_{PRM}. Precisely, it counts the number of months since the PRM is enforced[23]; and (viii) three variables accounting for temporal trends. Precisely, we put in each specification the trend t, t^2, and t^3.

Actually, the Poisson regressions in Table 3 highlight the occurrence of a 'discontinuity', in July 2003, in the dynamics of all the types of accidents (the coefficient of PRM is positive and statistically significant for all specifications), but also that the effect of the PRM is vanishing over time (the coefficient of Dur_{PRM} is not statistically significant for any of the four specifications). In addition, it appears that the coming into force of the PRM has exerted a stronger effect on fatal accidents (the coefficient of PRM assumes the highest value in the regression concerning fatal accidents), thus also confirming the evidence of the non - parametric estimates (i.e. the change in the accidents' rate of decrease is more pronounced for the dynamics of fatal accidents rather than that of the total amount of accidents, Fig. 5 and 10) and supporting the hypothesis of an increase in drivers' caution due to a 'wait and see' behavior determined by the necessity to understand the rules of the new sanctioning system. For purely descriptive aims, we report also graphically the evidence of a discontinuity correspondingly to July 2003 in the dynamics of accidents (see Figs. 6 - 9).

Fig. 11, which represents the time series of both fatal accidents per vehicle and speeding infractions per driver, captures another important feature of the dynamics over time of fatal accidents. Actually, from Fig. 11 it is possible to observe a remarkable parallel between the two time series, in the sub - period corresponding to the first announcement effect (i.e. March 2001 - January 2002), which does not appear from the non - parametric regressions which tend to capture only the behavior of a conditional average. What emerges is that the steep decrease in the monthly number of speeding infractions captured by the non - parametric regression in Fig. 4 and Fig. 11 is also observable in the time series of fatal accidents. When speeding infractions decreased because of the first announcement effect, the monthly number of mortal accidents sharply decreased too. Similar remarks apply for the second announcement effect.

However, a similar clear and strong parallel does not emerge with reference to the monthly total number of highway accidents (see Fig. 12), whose time series during the sub - period March 2001 - January 2002 does not experience a decrease like that of the fatal accident time series (see Fig. 11). Indeed if fatal accidents reduced by 26.42%, total accidents decreased by only 17.80%. Similarly to what found in the Poisson regressions, this reasonably strengthens

[23]Precisely, it takes value equal to 1 for July, 2003, equal to 2 for August, 2003, etc. Obviously, it takes value 0 for the months preceding July, 2003. If the PRM has had a vanishing effect over time, the coefficient of Dur_{PRM} should be not statistically significant different from zero

the hypothesis that drivers exercised increased caution due to the announcement in 2001 of the introduction of the PRM. The steep decrease that occurred during the sub - period March 2001 - January 2002 in the time series of fatal accidents certainly suggests that the reduction in speeding, induced by the announcement, exerted positive effects on the seriousness of accidents. If the number of accidents did not decline to the same extent, as a consequence of the first announcement effect, their seriousness conversely did so.

This evidence supports the idea that there is great potential for PRMs to shape agents' behavior and by this means country - road safety standards, which are a crucial aspect in governments' decisions to adopt such sanctioning schemes. However, these findings also highlight how the design of consistent conviction and detection policies plays a fundamental role in making this potential enduringly effective in improving road safety through the deterrence of undesirable behavior.

Incapacitation and road safety

Table 2 illustrates our 3SLS estimates concerning the relationship between incapacitation provisions, e.g. the suspension of drivers' licenses, and road safety. Because of lack of data on suspended licenses and on accidents for earlier and subsequent periods respectively, the analysis has been performed with reference to the time - horizon September 2004 - December 2007.

Our regressions document a positive effect on road safety of the incapacitation of dangerous drivers. As appears from Table 3, the negative coefficient of the number of suspended licenses, $SuspLic_t$ is statistically significant at 1% level.

Our estimates also point out the importance of the implementation of policies aimed at reducing traffic volume to improve road safety (Ameratunga et al. (2006)). Actually, the positive, robust and statistically significant coefficient of the variable $Veic_t$ suggests that the number of accidents in a given time span rises with an increase in the number of vehicles on the road.

Among the controls we added to account for the frequency on roads of potentially dangerous driving behaviors, $Phone_t$ and $Light_t$, it emerges that the improper use of the vehicle lighting system has a relatively higher importance, with respect to the non - use of speaker phone or headphone devices, in determining accidents. All the other types of unsafe driving behaviors which may influence the amount of occurred accidents are captured by the variable $SuspLic_t$ which is instrumented, besides the other variables represented in Table 3, by the amount of speeding infractions, drug and drunk driving offenses, and unauthorized speeding competitions. It also emerges that, *coeteris paribus*, to remove unsafe vehicles from roads does not affect the amount of occurred accidents. Actually, the coefficient of the variable $Book_t$ is not statistically significant.

Our analysis outlines that to physically remove dangerous drivers from the road benefits road safety. These findings therefore strengthen the importance of having a PRM coupled with effective conviction policies, as we have stressed with reference to the results of our non - parametric regressions. To be precise, we refer to the importance of implementing conviction policies aimed at the effective assigning of penalty points to drivers who have been caught infringing the law, given that tracking offense history with points is crucial to the removal from roads, through license suspension, of dangerous drivers.

6 Conclusions

Speeding is deemed to be one of the main causes of road traffic injuries. By measuring deterrence and incapacitation effects, we investigated whether, as a consequence of the introduction of the point - record driver's license in Italy, drivers have become law - abiding and improvements in road safety have occurred.

Our findings confirm the high potential of the PRM, as outlined by Bourgeon and Picard, 2007, in three respects:
(i) deterrence increased, but only temporarily, due to the announcement effects;
(ii) a discontinuity in the dynamics of accidents;
(iii) incapacitation by means of license suspension reduces fatalities at the margin.

However, our results dramatically outline the crucial role of enforcement consistency on adaptive strategies of rational drivers. In Italy the introduction of the new system was not accompanied by an increase in drivers' perception of the effective probability of being caught: the total number of fixed and mobile speed traps, such as cameras and patrol cars, did not change after the introduction of the new law.

Paradoxically, as mentioned above, upon the coming into force of the PRM and in the following months the number of controls was substantially reduced. As a consequence, Italian motorists with a propensity to break traffic laws - who had demonstrated respect for the new laws when they first came into force - soon learned that the real probability of being punished had not changed at all, and in Becker - like fashion adapted their behavior to the information acquired, thus reducing their level of compliance with the rules of the road.

As for the PRM, which more than all other measures was meant to increase penalties and 'punish' the worst offenders, its efficacy as a deterrent was also compromised by the factors that make it unique with respect to those in other countries. Such factors include bonus points for drivers who theoretically abide by the law, the fact that licenses are not suspended automatically when they no longer have any points, and the so - called '*salva punti*' decree. This last, by removing the threat of lost points if the owner of the vehicle does not say who was driving at the time of the infraction, is hardly different from a return to the old, pre - demerit point system for violations (like speeding) whose real perpetrator cannot be easily identified by the police. It has provided individuals with the chance to commit infractions, lie by saying they were not behind the wheel at the time, and save points - thus weakening not only the deterrent effect but also the function of limiting the efficient number of infractions, while keeping one's score intact and actually earning bonus points for good conduct that is anything but. Under these circumstances, even the harshening of non - monetary penalties after 2003 appears to have had no additional deterrent effect.

Once again, it appears, the failure of measures that have actually had quite an impact on existing law is explained by the lack of a coherent enforcement policy, which changes individuals' perception of the likelihood of being caught and reduces the cost associated with breaking traffic rules.

Given the above, we can make some observations on possible countermeasures that might be taken to improve the deterrent effect of efforts such as the point - record driver's license which try to make roads safer by altering driving habits. Obviously, in consideration of what we have learned, an important starting point is to achieve better enforcement of the law. Many empirical studies have found that the use of adequate controls, in the case of new laws designed to impose harsher penalties, is fundamental to the success of road safety programs

(Tay, 2005; Zambon et al. (2008); Davis et al. (2006)) and to cause positive spillovers in driving habits that are not directly influenced by those programs (Tay, 2005).

With specific reference to the PRM, it also seems wise to increase the cost associated with especially dangerous conduct and therefore with the loss of points. All other conditions remaining equal, for example, we believe that the number of points deducted for highly dangerous actions such as speeding should be increased. Likewise, the number of points should be raised when the infraction is committed at times when the fatality rate is highest, e.g. nights and weekends.

It goes without saying that making the Italian PRM more like those in other European countries would also be beneficial. Suspending licenses automatically, reducing or eliminating bonus points (especially since the '*salva punti*' decree damaged the credibility of safe driver status), and lowering the number of starting points are all measures that would help make the loss of points more costly and perhaps the whole system more effective.

Since detection and conviction probabilities both positively affect deterrence and incapacitation for speed limits infractions we suggest that in order to avoid drivers' adverse learning phenomena, the introduction of a penalty points system should be coupled not just with harsher fines, but also with significantly higher rates of apprehension and conviction.

Table 1
Descriptive statistics

Italian state police data on highways					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Speed. infractions	91	37349.53	11985.63	12794	58407
Driving at dangerous speed infr.	91	2203.11	320.0496	1522	3105
Driving. without seat belts infr.	91	3602.33	1718.183	1668	7456
Riding without the helmet infr.	91	315.5275	337.7164	29	1474
Driving under the infl. of alch. infr.	91	417.5275	69.57943	257	636
Driving under the infl. of drugs infr.	91	44.50549	16.25517	19	101
Unauthorized speed. competitions [24]	49	7	11.41089	0	72
Vehicle light. system use infr.	49	1072.898	290.8417	606	2427
Headph. and speaker ph. system use infr.	9	1420.816	207.8817	1022	1866
Tot. accidents	91	3509.791	466.0103	2438	4731
Fatal acc. (out of the total)	91	40.1978	12.02056	21	70
Acc. with injured persons (out of the total)	91	1053.978	169.6131	680	1452
Acc. with veich. damages (out of the total)	91	2421.824	313.1201	1734	3230
Deaths	91	47.34066	14.79731	23	86
Injured persons	91	1739.275	333.5847	1079	2790
Highway circulating vehicles[25]	91	6629.104	867.9919	5005.2	8465.9
Police patrol cars	91	19713.33	2370.91	17438	40542
Cameras	91	1096.78	204.943	704	1586
Enforcement Index	91	20810.11	2337.85	18359	41344
Suspended licenses	49	6153.816	874.9193	4557	8285
Withdrawn vehicle booklets of circulation	49	6999.02	1359.983	4198	10570
3SLS regressions data					
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Total accidents[26]	40	19573.85	2212.953	15922	23734
Suspended licenses	40	6104.875	944.3472	4557	8285
Speeding infractions	40	82694.77	13303.81	58222	109379
Driving under the infl. of alc. infr	40	2221.25	499.7635	1473	3410
Driving under the infl. of drugs infr	40	167.35	51.39767	69	304
Unauthorized speed. competitions	40	22.725	22.39275	0	104
Light. system infr.	40	2714.3	2714.3	1430	4587
Headph. and speaker ph. system use infr.	40	3393.075	496.9538	2509	4657
Police patrol cars	40	43316.43	1923.386	39409	47006
Circulating vehicles[27]	40	4.68e+07	940061.8	4.53e+07	4.82e+07
Withdrawn booklet of circulation	40	6838.875	1367.49	4198	10570
Precipitation	40	24.56	13.18	3.62	55.09

Notes: 1. Variables with 49 observations are those for which the dataset of the Italian state police provides evidence only since September 2004; 2. Source: AISCAT (2009); 3. Source: ISTAT (2008b); 4. Source: our computation of the data provided by ACI (2009).

Table 2

The effect of PRM on accidents

Poisson regressions

Standard errors (corrected for heteroskedasticiy) in parenthesis.

	Tot. Acc.	Fat.	Inj.	Dam.
$Prec_t$	0.002^{***} (0.000)	0.001^{***} (0.001)	0.002^{***} (0.001)	0.002^{***} (0.000)
$Veich_t$	0.001^{***} (0.000)	0.001^{***} (0.000)	0.001^{***} (0.000)	0.001^{***} (0.000)
Pol_t	$-1.63e-06$ $(1.92e{-}06)$	$-5.18e-06$ $(3.57e{-}06)$	$-6.52e-06$ $(2.37e{-}06)$	$4.20e-07$ $(1.33e{-}06)$
Feb	0.121^{***} (0.025)	-0.050 (0.073)	-0.138^{***} (0.037)	-0.123^{***} (0.023)
Jul	0.124^{***} (0.030)	0.235^{***} (0.068)	0.126^{***} (0.025)	0.140^{***} (0.025)
PRM	-0.099^{***} (0.027)	-0.293^{***} (0.084)	-0.206^{***} (0.037)	-0.055^{**} (0.005)
Dur_{PRM}	0.001 (0.001)	-0.012 (0.017)	0.008 (0.008)	0.001 (0.001)
Obs.	91	91	91	91
Pseudo R sq.	0.70	0.27	0.59	0.67
Wald test	0.000	0.000	0.000	0.000

Table 3

Incapacitation and road safety

3SLS regressions
Standard errors in parenthesis

Equation 1	I	II	III	IV
$SuspLic_t$	-0.411 (0.310)	-0.520 (0.349)	-1.081^{**} (0.422)	-1.106^{***} (0.418)
$Veic_t$	0.010^{***} (0.002)	0.010^{***} (0.003)	0.009^{***} (0.002)	0.010^{***} (0.003)
Feb	-2973.226^{***} (922.912)	-2756.842^{***} (954.740)	-2816.71^{***} (906.337)	-2913.50^{***} (900.422)
Jul	2918.083^{***} (1014.444)	2780.177^{***} (954.740)	2408.643^{**} (976.202)	2395.406^{**} (964.640)
$Precip_t$	-15.86 (20.344)	-18.922 (20.56)	-3.606 (20.531)	-12.610 (21.990)
$Time_t$	-806.926^{***} (213.301)	-245.834^{***} (213.415)	-718.033 (204.348)	-789.124^{***} (213.540)
$Book_t$		0.185 (0.225)	-0.007 (0.222)	0.042 (0.225)
$Light_t$			1.755^{**} (0.694)	1.383^{*} (0.767)
$Phone_t$				0.842 (0.812)
Equation 2	I	II	III	IV
$Speed_t$	0.015^{***} (0.005)	0.015^{***} (0.005)	0.009^{**} (0.005)	0.008^{*} (0.005)
$UnSpeedCom_t$	3.322^{*} (1.997)	3.368^{*} (1.980)	3.331^{*} (1.755)	3.375^{*} (1.753)
Alc_t	1.794^{***} (0.137)	1.751^{***} (0.144)	1.614^{***} (0.133)	1.612^{***} (0.132)
$Drug_t$	-1.684 (1.208)	-1.898 (1.242)	-1.349 (1.116)	-1.171 (1.120)
Pol_t	0.134^{***} (0.031)	0.135^{***} (0.031)	0.121^{***} (0.028)	0.116^{***} (0.030)
$Veic_t$	0.003^{***} (0.001)	0.03^{***} (0.001)	()	0.003^{***} (0.001)
Feb	758.602^{***} (199.152)	780.102^{***} (197.913)	0.002^{***} (0.001)	646.542^{***} (182.886)
Jul	-581.837^{***} (207.401)	-598.185^{***} (205.554)	670.638^{***} (177.810)	-642.987^{***} (181.778)
$Precip_t$	-5.023 (4.299)	-5.776 (4.349)	-1.711 (4.020)	-2.449 (4.078)
$Time_t$	-245.834^{***} (46.493)	-240.072^{***} (46.835)	-210.92^{***} (42.102)	-219.472^{***} (43.929)
$Book_t$		0.038 (0.043)	-0.023 (0.04)	-0.022 (0.042)
$Light_t$			0.396^{***} (0.0.114)	0.357^{***} (0.124)
$Phone_t$				0.107 (0.163)
Obs.	40	40	40	40
R. sq. first stage	0.92	0.92	0.94	0.61
R. sq. first stage	0.55	0.56	0.60	0.94
Sargan test [H_0 at 1% level]	accepted	accepted	accepted	accepted
Wald test first stage	0.000	0.000	0.000	0.000
Wald test second stage	0.000	0.000	0.000	0.000

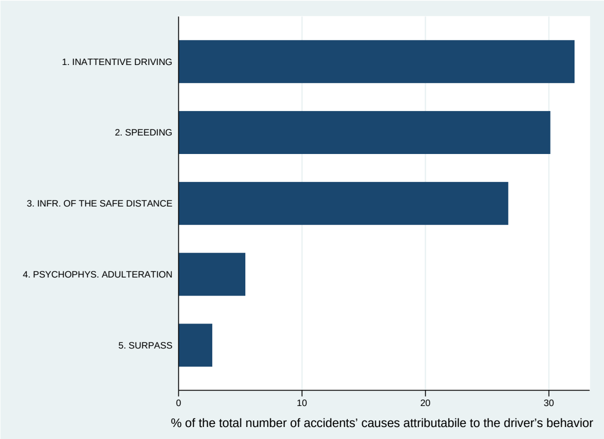

Figure 1: **Causes of highway accidents.** Ranking of the five most frequent causes of accidents attributable to the driver's behavior. Source: our computation of the data provided by the Italian Institute of Statistics - ISTAT (2008b).

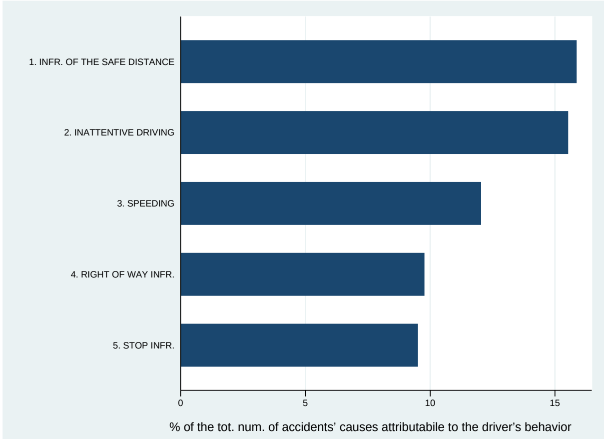

Figure 2: **Causes of accidents occurring on roads other than highways.** Ranking of the five most frequent causes for accidents occurring on roads other than highways attributable to the driver's behavior. Source: our computation of the data provided by the Italian Institute of Statistics - ISTAT (2008b).

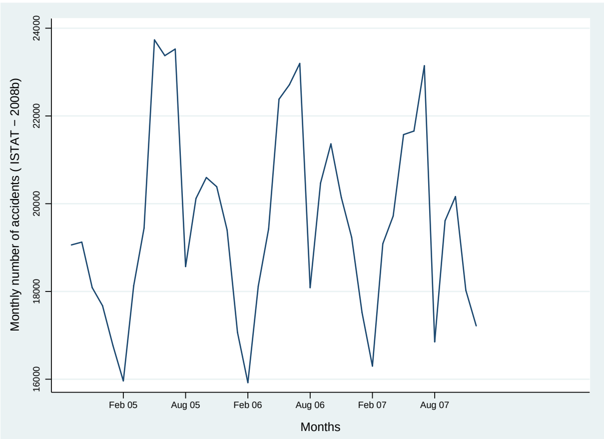

Figure 3: **Time series of road accidents.** Time series of the monthly number of total accidents occurred on the whole Italian road network. Source: Italian Institute of Statistics - ISTAT (2008b).

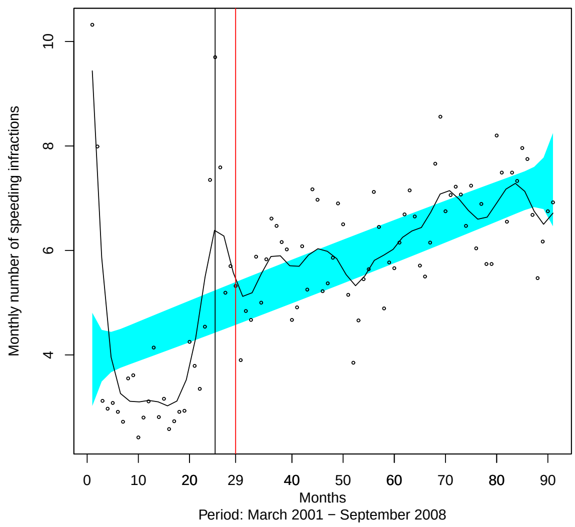

Figure 4: **Estimated dynamics of speeding offenses.** Non - parametric estimate of the monthly num. of speeding infractions every 1000 vehicles recorded on highways. Period: March 2001 - September 2008. Smoothing parameter: 2.3 . The shaded area represents the reference band for the linear model. Test of linear model: significance = 0. The red and the black line individuate, respectively, the month in which the PRM came into force and exhausted its short - term deterrent effect.

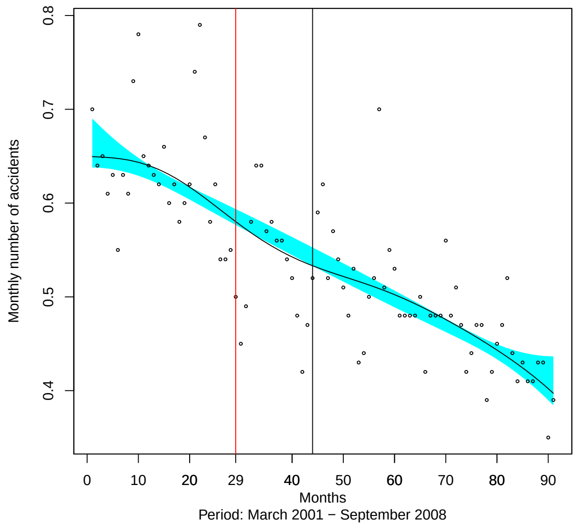

Figure 5: **Estimated dynamics of accidents.** Non - parametric estimate of the monthly num. of total accidents every 1000 vehicles recorded on highways. Period: March 2001 - September 2008. Smoothing parameter: 10. The shaded area represents the reference band for the linear model. Test of linear model: significance = 0.03. The red and the black line individuate, respectively, the month in which the PRM came into force and exhausted its short - term deterrent effect.

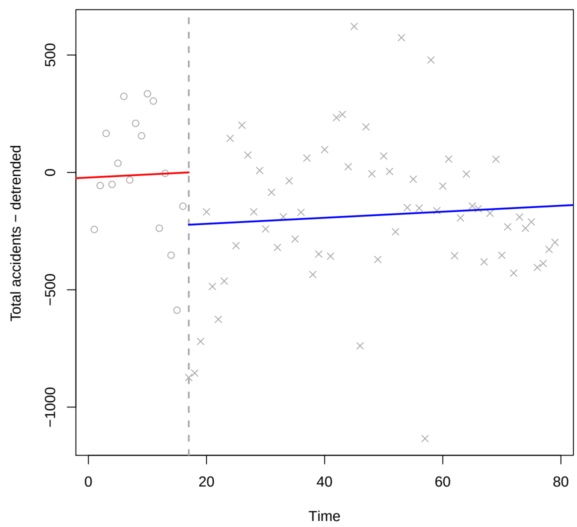

Figure 6: **PRM and discontinuity in accidents' dynamics.** Plot of the deseasonalized values of the total number of highway accidents against time. The vertical dashed line, at July 1, 2003, denotes the day in which the PPS was introduced. The predicted values from a first order polynomial trend estimated separately on each side of the cutoff point are also represented.

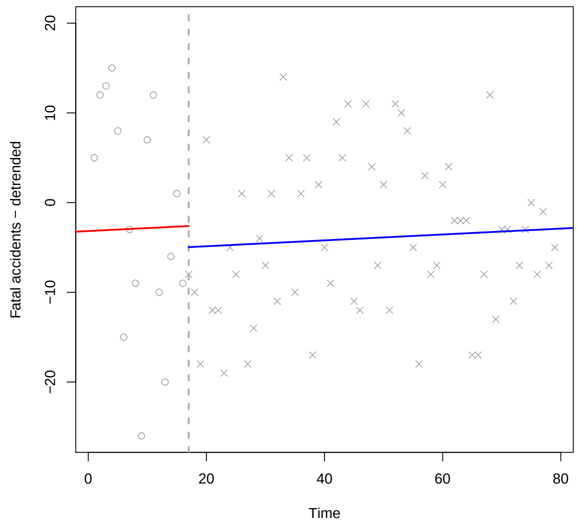

Figure 7: **PRM and discontinuity in fatal accidents' dynamics..** Plot of the deseasonalized values of the total number of fatal highway fatal accidents against time. The vertical dashed line, at July 1, 2003, denotes the day in which the PPS was introduced. The predicted values from a first order polynomial trend estimated separately on each side of the cutoff point are also represented.

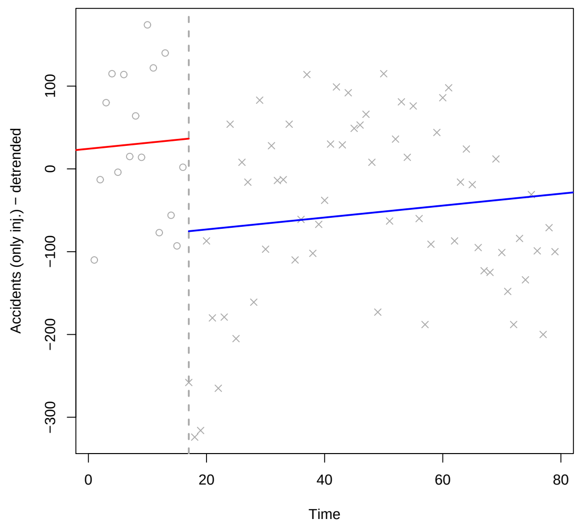

Figure 8: **PRM and discontinuity in the dynamics of accidents with only injured persons.** Plot of the deseasonalized values of the total number of highway accidents causing only non - fatal injuries against time. The vertical dashed line, at July 1, 2003, denotes the day in which the PPS was introduced. The predicted values from a first order polynomial trend estimated separately on each side of the cutoff point are also represented.

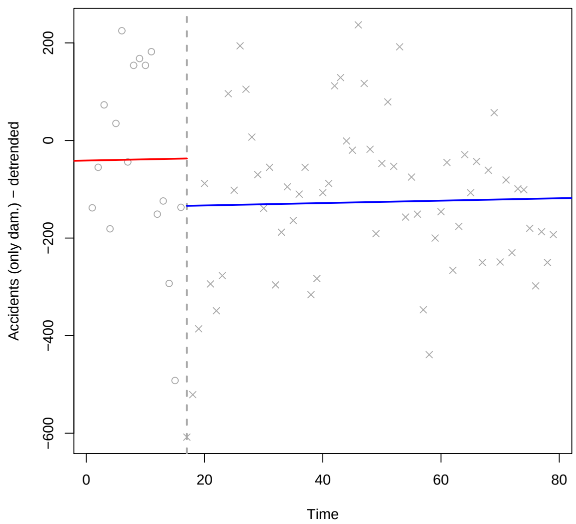

Figure 9: **PRM and discontinuity in the dynamics of accidents causing only damages to vehicles.** Plot of the deseasonalized values of the total number of highway accidents causing only damages to vehicles against time. The vertical dashed line, at July 1, 2003, denotes the day in which the PPS was introduced. The predicted values from a first order polynomial trend estimated separately on each side of the cutoff point are also represented.

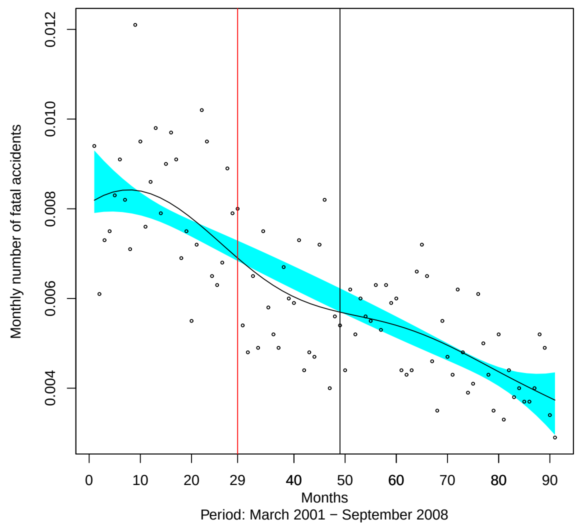

Figure 10: **Estimated dynamics of fatal accidents.** Non - parametric estimate of the monthly num. of fatal accidents per vehicle recorded on highways. Period: March 2001 - September 2008. Smoothing parameter: 10. The shaded area represents the reference band for the linear model. Test of linear model: significance = 0.03. The red and the black line individuate, respectively, the month in which the PRM came into force and exhausted its short - term deterrent effect.

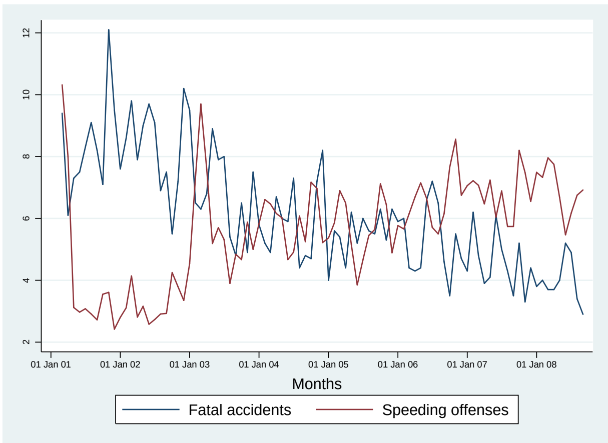

Figure 11: **Time series of speeding offenses and fatal accidents.** Time series of the monthly number of fatal accidents and speeding infractions every 1000 vehicles. The red line individuates the month in which the PRM came into force: July 2003.

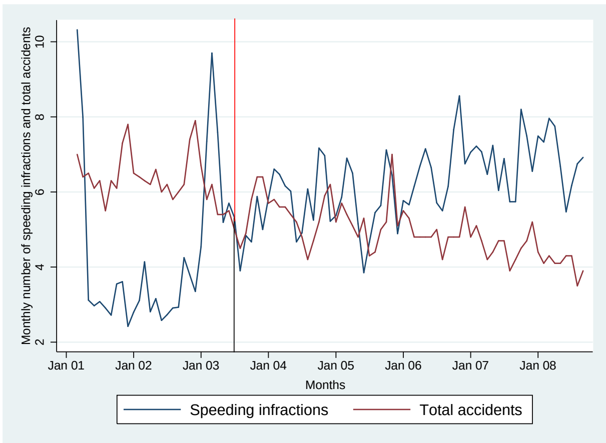

Figure 12: **Time series of speeding offenses and total accidents.** Time series of the monthly number of total accidents and speeding infractions every 1000 vehicles. The red line individuates the month in which the PPS came into force: July 2003.

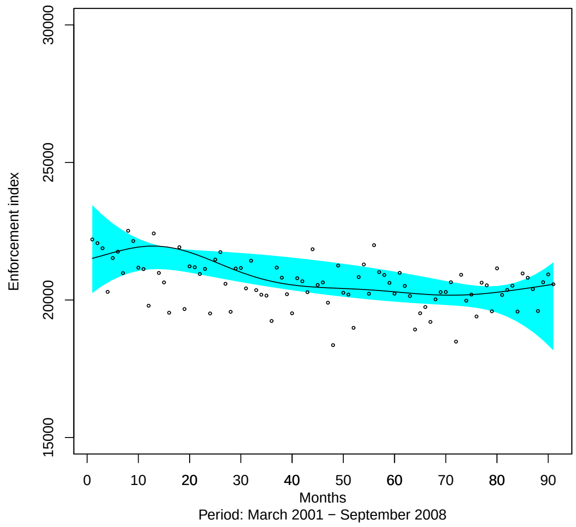

Figure 13: **Estimated dynamics of the *Enforcement index.*** Non - parametric estimate of the aggregated monthly num. of police patrol cars and cameras. Period: March 2001 - September 2008. Smoothing parameter: 10. The shaded area represents the reference band for the linear model. Test of linear model: significance = 0.52.

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References

Associazione Italiana Societa' Concessionarie Autostrade e Trafori (AISCAT), 2009. Informazioni su Traffico e Sicurezza, Edizione Mensile, (in Italian). Available at: `http://www.aiscat.it/pubblicazioni.htm?ck=1\&nome=pubblicazioni\&idl=4`, (accessed October 2008).

Ameratunga, S., Hijar, M., Norton, R., 2006. Road - traffic injuries: confronting disparities to address a global - health problem. Lancet, 366, 1533 - 1540.

Automobile Club d' Italia (ACI), 2009. Dati e statistiche, (in Italian). Available at: `http://www.aci.it/index.php?id=54`, (accessed October 2008).

Basili, M., Nicita, A., 2005. Deterrence and compliance in a demerit point system. Quaderni del dipartimento di economia politica, n. 458. University of Siena. Available at: `http://www.econ-pol.unisi.it/dipartimento/it/node/274`.

Basili, M., Benedettini, S., Nicita, A., 2009. Compliance with traffic laws under a demerit point system: a microeconometric evaluation from Italian data. University of Siena, Mimeo.

Becker, G., 1968. Crime and punishment: An economic approach. J. of Political Economy, 76, 169 - 217.

Benedettini, S., Nicita, A., 2010. Selective compliance with traffic laws: the case of Italy. Mimeo.

Bowman, A.W., Azzalini, A., 1997. Applied Smoothing Techniques for Data Analysis: The Kernel Approach with S - Plus Illustrations, Clarendon Press, Oxford.

Bourgeon, J.M., Picard, P., 2007. Point - record driving license and road safety: an economic approach. J. of Public Economics. 91, 235 - 258.

Chen W., Cooper, P., Pinili, P., 1995. Driver accident risk in relation to the penalty point system in British Columbia. J. of Saf. Res. 26, 9 - 18.

Chipman, M.L., Morgan, P., 1975. The role of driver demerit points and age in the prediction of motor vehicle collisions. Br. J. of Preventive and Soc. Medicine. 29, 190 - 195.

Cohen, A., Einav, L., 2003. The effects of mandatory seat belt laws on driving behavior and traffic fatalities. The Rev. of Economics and Statistics. 85, 828 - 843.

Cummings, P., McKnight, B., Rivara, P., Grossman, D., 2002. Association of driver air bags with driver fatality: a matched cohort study. Br. Méd. J. 324, 1119 - 1122.

Davis, J.W., Bennink, L.D., Pepper, D.R., Parks, S.N., Lemaster, D., Townsend, R., 2006. Traffic enforcement: a simple and effective injury prevention program. J. of Trauma - Injury Infection & Critical Care. 60, 342 - 342.

Diamantopoulou, K., Cameron, M., Dyte, D., Harrison, W., 1997. The relationship between demerit points accrual and crash involvement. Report No. 116. Monash University Accident Research Centre.

Directorate General for Energy and Transport, 2009. EU energy and transport in figures. Statistical pocketbook 2009. Available at: http://ec.europa.eu/transport/publications/statistics/doc/2009_energy_transport_figures.pdf, (accessed April 2009).

Ehrlich, I., 1991. On the usefulness of controlling individuals: an economic analysis of rehabilitation, incapacitation and deterrence. American Economic Rev. 71, 307 - 322.

Elder, R., Shults, R., Sleet, D., Nichols, J., Thompson, R., Rajab, W., 2004. Effectiveness of mass media campaigns for reducing drinking and driving and alcohol - involved crashes. A systematic review. American J. of Preventive Medicine. 27, 57 - 65

European Road Safety Observatory, 2008. Annual Statistical Report 2008. Available at: http://www.erso.eu/safetynet/fixed/WP1/2008/SafetyNet\%20Annual\%20Statistical\%20Report\%202008.pdf, (accessed December 2008).

Friehe, T., 2009. Escalating penalties for repeat offenders: a note on the role of information. J. of Economics. 97, 165 - 183.

Garoupa, N., 2001. Optimal magnitude and probability of fines. European Economic Rev. 45, 1765 - 1771.

Haque, M.O., 1990. Evaluation of the demerit point system in deterring traffic offenses. Evaluation Rev. 14, 22 - 41.

Hussain, O.T., Nayyar, M.S, Brady, F.A., Beirne, J.C., Stassen, L.F.A., 2006. Speeding and maxillofacial injuries: Impact of the introduction of penalty points for speeding offences. Br. J. of Oral and Maxillofac. Surg. 44, 15 - 19.

Italian Institute of Statistics (ISTAT), 2008a. Incidenti Stradali, Anno 2007, (in Italian). Available at: http://www.istat.it/salastampa/comunicati/non_calendario/20081120_00/testointegrale20081120.pdf, (accessed January 2009).

Italian traffic code, 2009. Updated version at August 2009, (in Italian). Available at: http://poliziadistato.it/pds/file/files/CDS_aggiornato_8_agosto_2009.pdf, (accessed October 2009).

Italian Institute of Statistics (ISTAT), 2008b. Tavole di dati, (in Italian). Available at: http://www.istat.it/salastampa/comunicati/non_calendario/20081120_00/, (accessed January 2009).

Italian state police dataset. Incidenti e contravvenzioni giorno per giorno, (in Italian). Available at: http://www.poliziadistato.it/pds/stradale/archivio/index.php, (accessed October 2008).

Liu, C., Chen, C.L., Subramanian, R., Utter, D., 2005. Analysis of speeding - related fatal motor vehicle traffic crashes. Report No. DOT HS-809-839. National Highway Traffic Safety Administration. Washington, DC.

Mayhew, D.R., Simpson, H.A., Pak, A., 2003. Changes in collision rates among novice drivers during the first months of driving. Accid. analysis and prevention. 35, 683 - 691.

Noland, B.D., Quddus, M.A., 2004. Improvements in medical care and technology and reductions in traffic - related fatalities in Great Britain. Accid. analysis and prevention. 36, 103 -113.

Papaioannou, P., Mintsis, G., Taxiltaris, C., Basbas, S., 2002. Enforcement and traffic accidents: Recent experience from Greece. Proceedings of the 15th International Cooperation on Theories and Concepts in Traffic Safety.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A.A., Jarawan, E., Mathers, C., 2004. World report on road traffic injury prevention. World Health Organization. Geneva.

Poli de Figueiredo, L. F., Rasslan, S., Bruscagin, V., Cruz Jr, R., Rocha e Silva, M., 2001. Increases in fines and driver licence withdrawal have effectively reduced immediate deaths from trauma on Brazilian roads: First - year report on the new traffic code. Injury. 32, 91 - 94.

Polinsky, A.M., Rubinfeld, D.L., 1991. A model of optimal fines for repeat offenders. J. of Public Economics. 46, 291 - 306.

Polinsky A.M, Shavell, S., 1998. On offense history and the theory of deterrence. International Rev. of Law and Economics. 18, 305 - 324 .

Polinsky, AM and Shavell, S., 2000. The economic theory of public enforcement of law. Journal of Economic Literature. 38, 45 - 76.

Redelmeier, D.A., Tibshirani, R.J., Evans, L., 2003. Traffic - law enforcement and risk of death from motor - vehicle crashes: case - crossover study. Lancet. 361, 2177 - 2182.

Sah, R.J., 1991. Social osmosis and patterns of crime. J. of Political Economy. 99, 1272 - 1295.

Sunstein, C.R., 1999. Behavioral law and economics: a progress report. American Law and Economics Rev. 1, 115 - 157.

Shavell, S., 1987. The optimal use of nonmonetary sanctions as a deterrent, American Economic Rev. 77, 584 - 592.

Shepherd, J.P., 2001. Criminal deterrence as a public health strategy. Lancet. 358, 1717 - 1722.

Tarko, P.A., 2009. Modeling drivers speed selection as a trade - off behavior. Accid. analysis and prevention. 41, 608 - 616 .

Tay, R., 2005. General and specific deterrent effects of traffic enforcement: Do we have to catch offenders to reduce crashes?. J. of Transport Economics and Policy. 41, 608 - 616 .

Vaa, T., 2000. Effects of police enforcement measures on accidents and levels of injury. Working paper No. SM/1104/2000. Institute for Economics of Transport (Toi). Oslo.

Williams, A.F., Kyrychenko, S. Y., Rettinga, R. A., 2006. Characteristics of speeders. J. of Saf. Res. 37, 227 - 232 .

Zaal, D., 1994. Traffic law enforcement: a literature review. Report No. 53. Monash University, Australia.

Zambon, F., Fedeli, U., Visentin, C., Marchesan, M., Avossa, F., Brocco, S., Spolaore, P., 2007. Evidence - based policy on road safety: the effect of the demerit points system on seat belt use and health outcomes. Accid. analysis and prevention. 40, 231 - 237.

Zambon, F., Fedeli, U., Milan, G., Brocco, S., Marchesan, M., Cinquetti, S., 2008. Sustainability of the effects of the demerit points system on seat belt use: A regionwide before - and - after observational study in Italy. J. of Epidemiology and Community Health. 61, 877 - 881.