unibz
Fakultät für Wirtschaftswissenschaften
Facoltà di Economia
Faculty of Economics and Management

BEMPS –
Bozen Economics & Management
Paper Series

NO 66/ 2019

Points or Prison? The Effects of Different Sanctions on Driving Behavior

SIlvia Bruzzone, Stefano Castriota, and Mirco Tonin

Points or Prison? The Effects of Different Sanctions on Driving Behavior

Silvia Bruzzone – ISTAT *
Stefano Castriota – University of Pisa **
Mirco Tonin – Free University of Bozen-Bolzano ***

December 2019

Abstract

This paper compares the effects of two reforms implemented in Italy in 2003 and 2016 – respectively the Penalty Points System (PPS) and the Road Homicide (RH) – aimed at reducing road accidents and mortality. In terms of the two main parameters characterizing enforcement – probability and intensity of the penalty – the two policies are opposite. In fact, with the PPS it is very easy to lose points but the maximum penalty – that is, temporary withdrawal of the license – is not dramatic. The RH, instead, introduced heavy penalties in the rare event of dead and injured people. We find a stronger decrease of dead and injured people with the PPS than with the RH. We compare the costs and benefits of the two policies and conclude that, in this context, strong penalties like incarceration are not socially beneficial.

Keywords: Road accidents, penalty points system, road homicide, crime, punishment.
JEL codes: D91, K14, K42, R41.

* Silvia Bruzzone, Istituto Nazionale di Statistica, Direzione centrale per le statistiche sociali e il censimento della popolazione, Viale Liegi 13, 00198, Roma (Italy). bruzzone@istat.it.
** Stefano Castriota, Department of Political Sciences, University of Pisa, Via Serafini 3, 56126, Pisa (Italy). stefano.castriota@unipi.it
*** Mirco Tonin, Faculty of Economics and Management, Free University of Bozen-Bolzano, piazza Università, 1, 39100, Bolzano (Italy). mirco.tonin@unibz.it

We gratefully acknowledge financial support by the Free University of Bozen-Bolzano CRC grant. We would like to thank participants at various conferences and workshops for useful comments.

1. Introduction

Road accidents are a leading cause of mortality around the world. The annual number of fatalities has reached 1.35 million (WHO, 2018) – more than the number of deaths caused by diseases like tuberculosis or AIDS – with up to 50 million injured people, many of whom disabled for life. The social costs of road accidents are injury related (medical costs, production loss, human costs, etc.) and crash related (damages to property, administrative costs, etc.) and exceed 2% of annual GDP in both developed and developing countries (Wijnen and Stipdonk, 2016). Road traffic injuries are the leading cause of death for people aged 5-29 years. According to the WHO (2018) the most important risk factors are unsafe road infrastructure or vehicles, inadequate post-crash care, speeding, driving under the influence, nonuse of safety gear (motorcycle helmets, seatbelts, and child restraints), distracted driving (e.g. smartphones).

Inadequate enforcement of traffic laws thus plays a central role and, when talking about law enforcement, the economics of crime literature generally highlights the role of both the probability of the penalty and its severity. Understanding whether agents react more to the former or to the latter is crucial for an effective implementation of public policies. Becker (1968) first applied an expected utility model to criminal behavior and concluded that risk-averse individuals should react more to penalty increases than to a higher probability of punishment, while the opposite is true for risk-loving individuals. Another conclusion of Becker's (1968) analysis is that, as

punishment, it is better to fine people as in this case there is no social loss, while other forms of punishment, like imprisonment, entail a net social loss.

The problem with pecuniary sanctions is that they could be ineffective to both people who are unable to pay (Garoupa, 2001) and to those who are very wealthy (Bourgeon and Picard, 2007). For this reason, in Finland fines are proportional to driver's income. From an empirical point of view, increasing pecuniary sanctions has unclear effects. In their extensive study on traffic enforcement in EU countries Mäkinen et al. (2003) conclude that "increasing severity of sanctions has not proved consistently effective with either recidivism or as a deterrent to others". Elvik and Christensen (2007) analyze 1995-2004 data on Norway – a period when the rates for fixed penalties for traffic offences increased substantially – and find that higher penalties reduce violations only if there is more enforcement. Grant (2010) finds that zero tolerance laws for blood alcohol content among drivers under 21 are not effective, while Cheng (2014) finds that laws prohibiting drivers from texting or talking on cell phones are effective in reducing usage (but not accidents and casualties). Furthermore, with respect to the violation of traffic laws some drivers are chronically reckless, and only more serious penalties like license revocation and incarceration with their deterrence and incapacitation effects can reduce the number of fatal crashes (Bourgeon and Picard, 2007).

This paper contributes to this important debate over the best way to structure enforcement as to reduce the incidence of car accidents by comparing two policies implemented in Italy over the years. In particular, we investigate whether it is more

effective to implement policies which punish offenders for relatively frequent events like minor traffic violations, but low intensity, or rather policies which introduce severe penalties in very rare events like road accidents with dead or injured people. As to the former, in line with other European countries, in 2003 the Italian Parliament issued a law introducing the Penalty Points System (PPS). Novoa et al. (2010) and Catillo-Manzano et al. (2010) use Spanish data and find that the introduction of the PPS decreased fatalities and serious injuries by 10-12%, while De Paola et al. (2013) use a sample of Italian road accidents and find a 30% reduction in deaths. Castillo-Manzano and Castro-Nuño (2012) provide a review of the existing studies and find a prevalent decrease of 15-20% in accidents and fatalities. Sagberg and Ingebrigtsen (2018) show with Norwegian data that the deterring effect is higher for drivers who are at high risk of losing their license at the next infraction. Regarding the latter, the extremely severe penalties, including long jail sentences, introduced by the law on Road Homicide (RH) in 2016 are, instead, peculiar to the Italian legal system and empirical evidence on the effects is to the best of our knowledge missing. In our work, we apply a Regression Discontinuity in Time (RDiT) approach to the universe of Italian road accidents with injured and dead people between 1996 and 2016. We find that the PPS was more effective than the RH reform in reducing the number of deaths and injured per day (PPS: -2.3 deaths and -58 injured; RH: -1.0 deaths and -8 - not statistically significant - injured). Next, we estimate under three different scenarios the monetary costs and benefits of the two reforms and find that the PPS led to more substantial gains than the RH, which in some scenarios brings

significant losses. Therefore, in the context of violations of the traffic code leading to severe car accidents, our results suggest that incarceration is not a socially optimal penalty.

The paper is structured as follows. The second section describes the database used, the trend of road accidents and mortality in Italy and the main reforms implemented to reduce fatal crashes, focusing in particular on the Penalty Points System and the Road Homicide. The third section carries out the impact evaluation of the two aforementioned policies on the number of dead and injured people using Regression Discontinuity in Time (RDiT), first with parametric and then with non-parametric methodologies. Developing a number of different scenarios, the fourth section performs a cost-benefit analysis of the Penalty Points System and the Road Homicide to check whether they increase or reduce social welfare and analyses the policy implications. The last section concludes.

2. The database and the two policies to reduce road accidents

2.1 The database

The study is based on data collected by the Italian Institute of Statistics (ISTAT) on the universe of road accidents resulting in death or injury that occurred in Italy between January 1996 and December 2016. According to Italian rules, in case of a serious accident – that is, with injured or dead people – the police has to intervene and fill in a detailed form, which is then transferred into the electronic database of ISTAT. Each record reflects a road accident and provides information on the time (up

to the hour), place (province) and nature of the crash, the number and type of transport vehicles involved, the age and gender of the drivers, the characteristics of the road, and the number of injured and dead people. Information on the probable cause of the accidents (e.g. alcohol or drug use) is not available.

Over this time period, we have over 4,5 million observations. To carry out the econometric analysis, we aggregate the data at the daily level, and we enrich the dataset with additional variable. In particular, we add the price of oil (Brent in 2016 constant Euro terms) and create dummy variables to take into account seasonality (day of the week and month) and national public holidays which affect traffic and drunk driving. In fact, an extensive literature has shown that road fatalities increase when fuel prices fall and during the weekends, national holidays and the Summer. Burke and Nishitateno (2015) provide international evidence on the effect of gasoline prices on road fatalities in 144 countries from 1991 to 2010, while ERSO-EU (2016) documents seasonality in road fatalities in EU countries over the period 2005-2014.

We further create polynomial time trends to control for long-term structural changes that may affect the occurrence of accidents with dead or injured people (e.g. improvements in car safety). Common to most advanced economies, thanks to technological improvements and to a number of reforms to the road code, in Italy the number of accidents and victims has been steadily declining over the last years from the peak of 7.096 dead people in 2001 to the minimum of 3.283 in 2016 (see Figure 1). Similar trends are observed for the number of accidents and the number of injured people.

2.2 Reforms of the Road Code

In 1992 and 2010 the Road Code has been revised[1]. In 1992 there have been no big changes, but rather a unification of all the main laws into a unique code to help judges, lawyers and insurance companies. In 2010 a major intervention concerned the penalties in case of drunk driving that became more severe. Beside these revisions, the most important reforms implemented by the Italian Parliament over the last thirty years are the introduction of compulsory helmet (1986) and seat belt (1988), the Penalty Points System (2003), the "Tutor" average speed trap system (2006) and the Road Homicide (2016). See Figure 1 for the timeline.

In this research we focus on the third and fifth of these reforms. The Penalty Points System (PPS) has become effective on July 1, 2003 and provides to each driver a score with a virtual bonus of 20 points. Infractions to the road code imply – as before – a fine, plus a points penalty depending on the severity of the violation (see Table A1 in the Appendix for some examples). It is generally not possible to lose more than 15 points at a time, although there are exceptions, for example if a person is driving against the flow of traffic in the motorway or runs away from police, in which cases the license gets withdrawn immediately.

[1] Decreto Legislativo N. 285 del 30/04/1992, see http://www.mit.gov.it/mit/site.php?p=normativa&o=vd&id=1&id_cat=&id_dett=0 . Legge 29 luglio 2010 n. 120, Disposizioni in materia di sicurezza stradale, see https://www.gazzettaufficiale.it/gunewsletter/dettaglio.jsp?service=1&datagu=2010-07-29&task=dettaglio&numgu=175&redaz=010G0145&tmstp=1282037648530 .

Once points are exhausted, the license gets suspended for a number of months which depends upon several variables like the severity of the infraction, whether the driver caused an accident, whether he repeatedly violated the same law, etc. A driver who did not break any rules in the past earns two points every two years until the license reaches the maximum score of 30, while a driver who violated some rules in the past goes back to 20 points if he behaved for two years in a row. Drivers close to license suspension can recover 6 (for private driver) or 9 (for professional driver) points by attending driving courses. Finally, newly licensed drivers (i.e. those who have obtained their driving license in the last three years) lose twice the points for the same infraction compared to experienced drivers.

As to the Road Homicide (RH) reform, it became effective on March 25, 2016. This law was the answer to a growing awareness that many accidents are caused by alcohol, drugs and distracted driving (e.g. mobile phones, see Gariazzo et al., 2018), to the concern about the rising share of hit-and-run (from 0.4% in 2001 to 0.9% in 2016), and to the common belief that penalties were insufficient to discourage risky driving. With this reform, basic penalties for minor violations were left unchanged. However, the legislator increased the penalties for alcohol and drugs use, serious violations, hit-and-run, multiple deaths, and even for serious injuries. In fact, under the previous law having killed one or more people carried out the same penal consequences, while having injured somebody was relevant only for insurance purposes. Furthermore, with the new code, the driving license gets withdrawn for up

to 5 years in case of serious injuries and up to 15 years in case of road homicide, which can reach 30 years in case of hit-and-run.

More specifically, the new law considers three levels of damages: road homicide, very serious injuries and serious injuries. A public commission decides the seriousness of injuries according to the length of the inability to work and to the type and number of permanent disabilities. The number of years of jail is within a range specified in the law, which depends on the seriousness of the damage as defined above and on the type of infraction (see Table A2 for details). The same infraction with different damages carries on different legal consequences: being seriously drunk (more than 1.5 grams of alcohol per liter of blood) leads to 8-12 years of jail in case of homicide, to 4-7 years in case of very serious injuries, and to 3-5 in case of serious injuries. Similarly, the same damages caused by different infractions carry on different penal consequences: a road homicide where the driver was seriously drunk leads to 8-12 years of jail, while if he/she was drunk, but not seriously drunk (0.8-1.5 grams of alcohol per liter of blood), the penalty decreases to 5-10 years, and if he/she committed only minor infractions the penalty goes further down to 2-7 years. In case the driver is identified after a hit-and-run, the penalty is increased by a minimum of 1/3 and a maximum of 2/3 of the original penalty, with a minimum verdict of 5 years.

Jail was a possible penalty also before the Road Homicide law. However, it was such an unlikely event that the Ministry of Justice did not even collect and share data for this type of felony. In fact, every penal crime is subject to a minimum and a maximum penalty. For example, simple theft is punished with minimum 6 months and

maximum 3 years of jail. In case of persons without a criminal record, judges can apply the minimum penalty (e.g. six months in case of simple theft) and usually acknowledge the generic mitigating circumstance that may further reduce the severity of the charge. Therefore, the final judgment is usually so low that either the penalty is suspended (in case it is less than 3 years) or the accused can benefit from alternative punishments, like house arrest or social services. So, before the Road Homicide law, going to jail due to having caused a car accident was theoretically possible, but practically very unlikely, while afterwards, with much higher penalties, it is a concrete risk.

Since the Road Homicide reform has been introduced on March 25, 2016 and we have data until the end of the year, the maximum windows size is 282 days before and after the event, while for the Penalty Point System we use a slightly longer (300 days) window. Tables 1a and 1b report the daily values of the variables of interest in the 282 or 300 days before and after the two reforms, and the difference in mean. We can see that the number of daily accidents, dead and injured people declined significantly after the introduction of the PPS (Table 1a). On the opposite, from these descriptive statistics we do not observe any significant reduction after the introduction of the RH (Table 1b). These are of course just summary statistics and we now move to parametric and non-parametric analyses to account for other confounding variables and time trends.

3. Regression Discontinuity in Time (RDiT)

3.1 Parametric models

We start our econometric analysis with a parametric model. We rely on Ordinary Least Square (OLS) regressions with robust standard errors and use either the daily number of dead or that of injured people as dependent variable. Regressions include seasonal dummy variables (day of the week, month of the year, holiday), real oil price in constant 2016 Euros, an AR(1) component, and a cubic time trend. The autoregressive component has been included because, as pointed out by Hausman and Rapson (2017), estimates may be biased if the time-series properties of the data are ignored, for instance in presence of an autoregressive process. The inclusion of one lagged value of the dependent variable and the third degree of the polynomial have been selected according to Akaike and Schwarz information criteria (respectively, AIC and BIC).

Figure 2 represents the time dummies included in the regressions to measure the impact of the two reforms, PPS and RH. We include a dummy variable for the period going from January 1996 to N days before the cutoff and that following the N^{th} day after the cutoff until December 2016 (DV 1) and another dummy variable for the period from the cutoff to the N^{th} day after it (DV 2). The N days before the implementation of the policy is the reference base. We capture the effect of the reforms by comparing the N days before and after the policy, that is, the statistical and economic significance of DV 2. The maximum window length for the RH reform

is 282 days (until the 31st of December 2016), while for the PPS we use a 300 days window. In the non-parametric analysis, as a robustness check, we adopt for both reforms also 200- and 100-days symmetric windows and obtain similar results.

Table 2 reports the impact of the PPS and of the RH on the daily number of dead and injured people (robust standard errors in parentheses) and compares these values with the daily levels of the 300 days (282 for the RH reform) before the cutoff. It clearly emerges how the Penalty Points System was more effective than the Road Homicide on both the number of dead and, especially, that of injured people, which in the latter case is not significant. The magnitude of the effect of the Penalty Points System on road fatalities (-12%) is in line with that found in other studies mentioned in the introduction. Notice that results regarding control variables in this and the following parametric regressions are in line with the literature and confirm the cyclical effects of the weekend, summer, and holidays, which influence driving and alcohol and drug abuse, and that of real oil price, which affects the intensity of driving and speed. The autoregressive component is strongly significant, as well as the cubic time trend. Results are omitted for reasons of space but are available upon request.

The fact that the PPS is more effective than the RH may appear surprising, given the dramatic consequences the new law carries on in case of a fatal road accident. A possible explanation for this is that the probability to lose points is very high, while that of having an accident with dramatic consequences much lower. Indeed, most people drive cautiously and are never involved in a serious accident in their lifetime, therefore never experiencing the associated penalties. When the probability of an

event gets close to zero, people may (wrongly) consider it as impossible to happen. As described in Kahneman (2011), people may overestimate the probabilities of unlikely events, however, they may also underweight them, to the point of neglect, if they have never experienced their occurrence. This is indeed likely to be the case in this context, given that the Italian judicial system is very slow, as criminal trials take long time, usually from 3 to 6 years. Therefore, there is a long delay between the coming into force of the law and the experience (direct or through media) of people actually being jailed for their involvement in a serious car crash. On the opposite, the penalties in the PPS are experienced immediately. Given that between 2003 (law on the PPS) and 2016 (law on the RH) the number of dead people fell by around 50%, a further factor may be decreasing returns to enforcement of newer measures. In other words, when road accidents and mortality are relatively low it becomes more and more difficult to implement policies that can have a substantial impact. For the number of fatalities, the result for RH is similar to the one for PPS when considering the percentage change, while this is not the case for injured people.

To address heterogeneity of the effect, Tables 3a-3b and 4a-4b, look at the effects of the two policies on the gender and age groups separately. If we focus on the percentage change, it emerges how PPS is more effective on female (Table 3a) and young (Table 3b) drivers, while RH more on males (Table 4a) and young adults (Table 4b), at least regarding the number of deaths. Notice that most accidents involve more vehicles and, therefore, more drivers of potentially different gender and age groups. For this reason and taking into consideration that the majority of accidents involve

male drivers, we classified as "male" those accidents where all drivers were males, while, to have a sufficiently large sample size, "female" those where *at least* one driver was female. Similarly, we classified as "18-20" those accidents where at least one driver is in that age group, etc. While for gender there are only two categories and no double counting, for age there are four groups and the classification leads to double counting since an accident with three vehicles driven by three people belonging to different age groups is counted three times.

The stronger effect of the PPS on the young could be related to the stronger penalties (twice the points) on the newly licensed drivers, while that on women is unclear and might be due to higher risk aversion or other behavioral differences (Borghans et al., 2009). Contrary to the PPS, the RH contributes to a greater reduction in the number of dead people in accidents where only male drivers are involved. This might be due to the fact that males drink and drive more (WHO, 2007, p. 12); facing very severe penalties they may have either reduced alcohol consumption or the use of their own car after drinking.

Tables 5a and 5b report the reduction in dead and injured people for the two policies, divided by hour of the day, where "day" is from 5 AM to 8 PM and "night" the remaining hours. The percent decrease in the number of dead and injured following the PPS is identical by day and by night, while that following the RH is much larger by night. Again, this could be due to the heavy penalties introduced by the new laws in case of serious accidents caused by drunk behavior that could have discouraged either alcohol consumption or drunk driving. Even though we do not have data on the

BAC levels of drivers involved in the accidents, results seem to confirm that this reform was effective in reducing risky behaviors.

To summarize, we obtain three main results:

1) The PPS law is overall more effective than the RH;
2) The PPS is especially effective on young and female drivers, while the RH more on (young) adults and males;
3) For the PPS there is no time difference, while the RH is more effective by night.

3.2 Non-parametric models

To check the robustness of our results we rely on non-parametric methodologies and run local linear regressions over the whole 1996-2016 daily time series. Observations are replaced by their predicted values to create a smoothed graph of the relationship between Y and X. The 95% confidence intervals help us in the visual inspection of the significance of the discontinuity around the threshold (PPS or RH). We adopt a two-stage methodology. In the first stage, we run OLS regressions of the daily number of dead or injured people over the cyclical components (dummy variables for day of the week, month of the year, and national holiday) and real oil price. We then use the residuals as dependent variable in the second stage in a local-linear regression where the symmetric windows around the cutoff have N observations on each side, where N can be 300 (282 for the RH reform), 200 or 100.

Figures 3a-3b and 4a-4b report the scatterplot, fitted values and 95% confidence intervals of the number of dead and injured people in the 300 days (282 for the RH reform) before and after the policy implemented. Results for the 200+200 and

100+100 are similar and are omitted for reasons of space but are available upon request. Non-parametric regressions confirm the parametric results, the effects of the PPS being stronger than those of the RH. Furthermore, the fitted values of the dead and injured people after the introduction of the RH seem to go back to previous values, the effects of the reform vanishing or at least weakening after less than one year. As previously mentioned, since in Italy penal judgments take several years there could be a delay between the introduction of the RH reform and its effects, but the data do not seem to support this, at least for the time window considered here, pointing instead at a stronger effect of PPS.

4. Cost-Benefit analysis of the two policies

As mentioned, the two policies analyzed in this research are very different in the way they are conceived and implemented. The PPS introduces a softer penalty (loss of points and eventually driving license suspension) for a much larger number of people, the additional costs to implement the policy being virtually null. The RH, on the contrary, applies only to those accidents with dead or seriously injured people and carries on the hardest penalty (prison) which is very expensive. To improve our understanding of which policy is more efficient, here we analyze some of the costs and benefits associated with the two policies, using different scenarios and calculating the break-even point (see Tables 6a-6d).

First of all, to calculate the benefits, we consider the overall decrease in the number of daily dead and injured people after the introduction of the policy reported in Table

2. We multiply these numbers by 365 days to get the annual decline, and again multiply these numbers by the statistical value of a road victim. We use the Ministry of Transport's estimate, which takes into account all the costs for the society, that is: healthcare system, administrative and legal costs, lost income, compensation for permanent invalidity or for dead relatives, etc. The 2010 estimate for road victims was 1,503,000 € for a dead and 42,219 € for an injured person. These values have been increased by the cumulative inflation and expressed in 2017 terms.

The effect of the RH on the number of injured people is not significant with the parametric approach (Table 2), while the confidence intervals of the discontinuity do not overlap (Figure 4b). We opt for a cautious approach and decide to include in the calculations the benefits from a reduction in the number of injured people due to the RH, which anyway are not huge and amount to 63 million € per year.

As to the costs, those of the PPS are virtually null, the only additional expense being connected to the tribunal[2]. Data on the costs of judgments are not available, but in any case, they are minimal since the legal procedure is very fast, usually one judicial hearing to decide whether and for how long the license should be suspended. The costs of RH, on the contrary, are substantial and include those sustained by the State to imprison the guilty drivers and the income lost by the sentenced persons. As to the former, the Ministry of Justice's 2014 estimates of the costs of keeping a person in jail for one year amount to 45,610 €, which corresponds to 46,246 when expressed in

[2] An additional cost connected to the PPS is the decreased productivity of drivers whose license has been temporarily suspended. Unfortunately, we do not have data on the number of people and the average time lost to go to work by public transport versus private car, but these figures are most likely modest.

2017 terms. This annual cost has to be multiplied by the number of people and years sentenced because of the new RH laws.

For the lost income of the sentenced people, we rely on data from the Ministry of Industry and Transport (MIT)[3], whose estimates for the year 2008 of the lost income of a person dead in a road accident amount to 940,291 € for an average residual working life of 21.1 years, which makes 44,563 € per year. Drivers responsible for a serious accident are not observationally equivalent to their victims, for instance they are surely older than their victims (among which there are many minors), and this could overestimate their loss of income. On the other hand, the estimate includes only the loss of income *during* the imprisonment and excludes all problems and the missed opportunities *after* the convict is released from prison with a criminal record. We do not have such detailed information on the economic situation and problems after release and assume that the two effects cancel out. We express this amount in 2017 terms and multiply it by the average number of years people could stay in jail according to different possible scenarios.

How many people will actually go to jail and, net of penalty discounts, for how many years is still unknown. In 2016, there were 3,283 deaths due to accidents; if we focus on those with multiple vehicles, we are left with 1,793 victims. In the same year, there were 192,132 injured and seriously injured people involved in crashes with multiple vehicles[4]. As previously mentioned (see Table A2), the length of the penalty differs

[3] http://www.mit.gov.it/mit/mop_all.php?p_id=12919.

[4] Some accidents report simultaneously dead and injured people, but since the new law charges additional years in case of multiple victims they *must* be double counted.

according to the damage (injured, seriously injured or dead) and the severity of the road infraction (e.g. serious drunk, drunk or minor violations). Since Italian jails are overcrowded[5], judges tend to sentence the minimum number of years and to acknowledge the generic mitigating circumstances that may further reduce the severity of charges and even lead to the suspension of the penalty. For these reasons, we build three different scenarios where, in all cases, we exclude from the calculations the accidents where only one vehicle is involved because there are no damages to other people:

- In Table 6a we report the best scenario ("best" in the meaning of most favorable for the evaluation of the policy) and suppose that, in case of road homicide, on average drivers are sentenced to 1.5 years of jail (net of penalty discounts), while in case of injured people only 2.5% are actually sentenced, for only one year of prison (net of penalty discounts);
- In Table 6b we report the medium scenario and suppose that, in case of road homicide, on average drivers are sentenced to 3 years of prison (net of penalty discounts), while in case of injured people only 5% are actually sentenced to jail and for only one year (net of penalty discounts);
- In Table 6c we report the worst scenario and suppose that, in case of road homicide, on average drivers are sentenced to 5 years of jail (net of penalty

[5] In April 2018 in the Italian jails there were 58,285 prisoners against an official capacity of 50,619, see https://www.giustizia.it/giustizia/it/mg_1_14_1.page;jsessionid=U-JJ3cEfD2Z0isySRO1SWyQp?contentId=SST111146&previsiousPage=mg_1_14.

discounts), while in case of injured people 10% are actually sentenced, for only one year of prison (net of penalty discounts).

Results of Tables 6a-6c show that the PPS carries large benefits for the society since it contributes to the decrease in dead and injured people and is almost costless. The calculations suggest that such a policy generated a net overall social *benefit* of 2.3 billion € per year. On the contrary, the calculations for the RH suggest a net overall social *cost* which ranges from 41 million € per year in the best scenario to 1.92 billion € in the worst one. The Road Homicide reform would reach the Break Even Point only with an unrealistic scenario made of extremely mild penalties (1 year of penalty in case of homicide and 6 months charged in case of serious injuries to 6.3% of drivers). In other words, the Road Homicide would carry on net social benefits only if the reform were *de facto* not implemented.

The Road Homicide reform seems not only economically inefficient, but also difficult to implement from the judicial point of view. In fact, in Italy the number of prisoners exceeds the capacity of jails. Over the last years the Government has actually issued a number of laws meant to reduce the number of prisoners, like the 2006 pardon which allowed three years of penalty discount for some selected crimes. Sending thousands of people per year to the jail because of the RH would exacerbate the overcrowding problem. Table 7 reports three simulations on the increase in the number of prisoners in the next decade due to RH, starting from the level of 58,285 of April 2018. We assume that after 4 years from the implementation of the RH law, thus in 2020, the tribunals will issue final judgments and the guilty will go to jail.

Scenario 1 reflects the assumptions of Table 6a, Scenario 2 those of Table 6b and Scenario 3 those of Table 6c. It thus appears that the RH reform would increase the number of prisoners from 3 to 21 thousand units according to the strictness of sentences.

A potential concern of this comparison is that the two policies (PPS and RH) have not been implemented at the same time. The law on the Road Homicide has been issued 13 years after that on the Penalty Points System, when – in line with most Western countries – the number of victims had dramatically fallen. This could bias the analysis, since, as mentioned earlier, reducing the number of road fatalities can be harder when you start from low levels. However, this may not be a major problem since it appears to be possible to reduce the number of dead people even when the initial level is very low, as shown in Table 3a where women – who start from much lower levels of dead and injured people – react to the introduction of the PPS with a stronger percent decrease.

5. Conclusions

The debate over the optimal magnitude and probability of penalties is long lasting. Using data on the universe of Italian road accidents from 1996 to 2016, we analyze and compare the effects of two reforms which are to some extent at the polar extreme of the policy space. The first, introduced in 2003, is the Penalty Points System (PPS) and implies additional but mild penalties, that is, loss of points and eventually temporary withdrawal of the driving license, for violations of the Traffic Code, an

event that happens relatively frequently. The second, implemented in 2016, increased the penalty in case of very infrequent events, accidents with dead or injured people, making incarceration very likely. Using parametric and non-parametric Regression Discontinuity in Time (RDiT) models we show that the PPS was more effective than the RH in terms of reducing the number of victims. Using these estimates, we then compare the monetary costs and benefits of these two reforms and find that the PPS carried significant gains (2.2 billion € per year) while the RH substantial losses (0.2-2.1 billion € per year depending to the scenarios on the probability and length of incarceration). Based on this evidence we conclude that, in the context of driving behavior, applying heavy penalties like incarceration to rare events is not an optimal policy from a social point of view.

References

- Becker, G.S. (1968), "Crime and Punishment: An Economic Approach", *The Journal of Political Economy*, Vol. 76, pp.169-217.
- Borghans, L., Golsteyn, B.H.H., Heckman, J.J. and Meijers, H. (2009), "Gender Differences in Risk Aversion and Ambiguity Aversion", *Journal of the European Economic Association*, Vol. 7, No. 2/3, pp. 649-658.
- Bourgeon, J.M. and Picard, P. (2007), "Point-Record Driving Licence and Road Safety: An Economic Approach", *Journal of Public Economics*, Vol. 91, pp. 235-258.
- Burke, P.J. and Nishitateno, S. (2015), "Gasoline Prices and Road Fatalities: International Evidence", *Economic Inquiry*, Vol. 53, No. 3, pp. 1437-1450.
- Castillo-Manzano J.I., Castro-Nuño, M. and Pedregal, D.J. (2010), "An Econometric Analysis of the Effects of the Penalty Points System Driver's License in Spain", *Accident Analysis & Prevention*, Vol. 42, No. 4, pp. 1310-1319.
- Castillo-Manzano J.I. and Castro-Nuño, M. (2012), "Driving Licenses Based on Points Systems: Efficient Road Safety Strategy or Latest Fashion in Global Transport Policy? A Worldwide Meta-Analysis", *Transport Policy*, Vol. 21, pp. 191-201.
- Chalfin, A. and McCrary, J. (2017), "Criminal Deterrence: A Review of the Literature", *Journal of Economic Literature*, Vol. 55, No. 1, pp. 5-48.
- Cheng, C. (2015), "Do cell phone bans change driver behavior?", *Economic Inquiry*, Vol. 53(3), pp. 1420-1436.
- Dobb, A.N. and Webster, C.M. (2003), "Sentence Severity and Crime: Accepting the Null Hypothesis", *Crime and Justice*, Vol. 30, pp. 143-195.
- Dohmen, T., Falk, A., Golsteyn, B., Huffman, D. and Sunde, U. (2017), "Risk Attitudes Across the Life Course", *Economic Journal*, Vol. 127, No. 605, pp. 95-116.

- Durlauf, S.N. and Nagin, D.S. (2011), "Imprisonment and Crime", *Criminology & Public Policy*, Vol. 10, No. 1, pp. 13-54.
- Elvik, R. and Christensen, P. (2007), "The Deterrent Effect of Increasing Fixed Penalties for Traffic Offences: The Norwegian Experience", *Journal of Safety Research*, Vol. 38, No. 6, pp. 689-695.
- ERSO-EU (2016), "Traffic Safety Basic Facts 2016", https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/statistics/dacota/bfs2016_seasonality.pdf.
- Gariazzo, C., Stafoggia, M., Bruzzone, S., Pelliccioni, A. and Forastiere, F. (2018), "Association Between Mobile Phone Traffic Volume and Road Crash Fatalities: A Population-Based Case-Crossover Study", *Accident Analysis & Prevention*, Vol. 115, pp. 25-33.
- Garoupa, N. (2001), "Optimal Magnitude and Probability of Fines", *European Economic Review*, Vol. 45, No. 9, pp. 1765-1771.
- Grant, D. (2010), "Dead on arrival: Zero tolerance laws don't work", *Economic Inquiry*, Vol. 48(3), pp. 756-770.
- Hausman, C. and Rapson, D.S. (2017), "Regression Discontinuity in Time: Considerations for Empirical Applications", NBER Working Paper No. 23602.
- IRTAD, (2018), "Alcohol-Related Road Casualties in Official Crash Statistics", available at https://www.itf-oecd.org/sites/default/files/docs/alcohol-related-road-casualties-official-crash-statistics.pdf.
- Kahneman, D. (2011), Thinking, fast and slow. Allen Lane.
- Mäkinen, T., Zaidel, D.M. et al. (2003), "Traffic Enforcement in Europe: Effects, Measures, Needs and Future", The "Escape" Project, Contract Nº: RO-98-RS.3047, available at http://virtual.vtt.fi/virtual/proj6/escape/escape_d10.pdf.

- Novoa, A.M., Pérez, K., Santamariña-Rubio, E., Marí-Dell'Olmo, M. and Borrell, C. (2010), "Impact of the Penalty Points System on Road Traffic Injuries in Spain: A Time–Series Study", *American Journal of Public Health*, Vol. 11, pp. 2220-2227.
- WHO (2007), "Drinking and Driving: A Road Safety Manual", https://www.grsproadsafety.org/wp-content/uploads/DrinkingDriving_English.pdf.
- WHO (2018), "Global status report on road safety 2018", https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/.
- Wijnen, W. and Stipdonk, H. (2016), "Social Costs of Road Crashes: An International Analysis", *Accident Analysis & Prevention*, Vol. 94, pp. 97-106.

Table 1a: Summary statistics and difference in mean, PPS

Variable	Before PPS	After PPS	Diff. in mean	Std. Err.	Sign. Level
Dead					
All	19.12	16.32	-2.79	0.50	1%
Night	6.80	5.83	-0.97	0.31	1%
Day	12.33	10.50	-1.82	0.36	1%
Injured					
All	1,038	915	-123	10.55	1%
Night	272	243	-29	7.43	1%
Day	766	672	-94	10.21	1%
Accidents					
All	728	647	-81	8.69	1%
Night	173	157	-17	3.73	1%
Day	555	491	-64	9.25	1%

Note: The table reports means before/after the PPS, difference in mean, standard errors and significance level of the difference in mean.

Table 1b: Summary statistics and difference in mean, RH

Variable	Before RH	After RH	Diff. in mean	Std. Err.	Sign. Level
Dead					
All	9.43	9.36	-0.07	0.32	No
Night	3.00	2.94	-0.06	0.18	No
Day	6.44	6.42	-0.01	0.25	No
Injured					
All	677	700	24	8.30	1%
Night	163	159	-3	3.60	No
Day	514	541	27	8.40	1%
Accidents					
All	476	494	18	7.34	5%
Night	106	104	-3	1.93	No
Day	370	390	21	7.36	1%

Note: The table reports means before/after the RH, difference in mean, standard errors and significance level of the difference in mean.

Table 2: Number of dead and injured people, PPS and RH

Parametric model				
	PPS		RH	
VARIABLES	Dead	Injured	Dead	Injured
Policy (PPS or RH)	-2.260***	-58.23***	-1.046***	-8.123
	(0.434)	(8.294)	(0.317)	(6.427)
Before	19.12	1,038	9.43	677
% change	-11.8	-5.6	-11.1	-0.6

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3a: Number of dead and injured people by gender, PPS

Parametric model				
	Dead		Injured	
VARIABLES	Male	Female	Male	Female
PPS	-1.975***	-0.608***	-53.25***	-27.94***
	(0.423)	(0.167)	(7.624)	(4.149)
Pre-PPS	18.0	3.7	951	395
% change	-11.0	-16.5	-5.6	-7.1

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3b: Number of dead and injured people by age, PPS

Parametric model

	Dead				Injured			
VARIABLES	18-20	21-29	30-65	65+	18-20	21-29	30-65	65+
PPS	-0.299**	-0.778***	-1.553***	-1.839***	-13.96***	-27.84***	-44.49***	-49.31***
	(0.122)	(0.256)	(0.320)	(0.417)	(1.819)	(4.358)	(6.653)	(6.975)
Pre-PPS	1.8	7.0	12.7	17.2	126	440	771	904
% change	-16.6	-11.1	-12.3	-10.7	-11.1	-6.3	-5.8	-5.5

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4a: Number of dead and injured people by gender, RH

Parametric model

	Dead		Injured	
VARIABLES	Male	Female	Male	Female
RH	-0.921***	-0.0944	-6.124	-4.863
	(0.304)	(0.134)	(5.771)	(3.428)
Pre-RH	8.8	1.8	596	287
% change	-10.5	-5.1	-1.0	-1.7

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 4b: Number of dead and injured people by age, RH

Parametric model

	Dead				Injured			
VARIABLES	18-20	21-29	30-65	65+	18-20	21-29	30-65	65+
RH	-0.0848	-0.384**	-0.643**	-0.849***	2.731*	-7.984***	-1.546	-6.795
	(0.0831)	(0.170)	(0.251)	(0.302)	(1.462)	(2.871)	(5.166)	(5.554)
Pre-RH	0.7	2.1	6.8	8.7	59	209	540	605
% change	-12.4	-18.3	-9.4	-9.7	-4.6	-3.8	-0.3	-1.1

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5a: Number of dead and injured people by hour, PPS

Parametric model

	Dead		Injured	
VARIABLES	Night	Day	Night	Day
PPS	-0.832***	-1.520***	-17.64***	-50.09***
	(0.246)	(0.341)	(3.853)	(6.684)
Pre-PPS	6.80	12.32667	271.7733	765.74
% change	-12.2	-12.3	-6.5	-6.5

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5b: Number of dead and injured people by hour, RH

Parametric model

	Dead		Injured	
VARIABLES	Night	Day	Night	Day
RH	-0.515***	-0.577**	-13.38***	2.376
	(0.181)	(0.246)	(3.196)	(5.254)
Pre-RH	3.0	6.4	163	514
% change	-17.2	-9.0	-8.2	-0.5

Note: Regressions include seasonal DVs (day of the week, month, holiday), real oil price, an AR(1) component, and a cubic time trend. Results for these control variables are omitted for reasons of space but are available upon request. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 6a: Cost-benefit analysis, best scenario

Variable	**PPS**		**RH**	
	dead	**injured**	**dead**	**injured ***
A. Decrease in nr of dead/injured	825	21,254	382	2,965
B. Unit value of dead/injured	1,622,546	45,577	1,622,546	45,577
Total benefit (A×B)	1,338,438,049	968,691,718	619,471,769	135,131,081
Total costs **	-	-	-255,989,740	-457,183,683
Net benefit	1,338,438,049	968,691,718	363,482,030	-322,052,603
Overall (dead+injured)	**2,307,129,767**		**41,429,427**	

* The effect of RH on injured people is not significant with parametric and significant with non-parametric regressions. We adopt a conservative approach and include these benefits in the estimates of the overall effect.

** Hypotheses: in case of RH, on average drivers are sentenced to 1.5 years of jail (net of penalty discounts), while in case of injured people only 2.5% are actually sentenced, for only one year of prison (net of penalty discounts).

Table 6b: Cost-benefit analysis, medium scenario

Variable	PPS		RH	
	dead	injured	dead	injured *
A. Decrease in nr of dead/injured	825	21,254	382	2,965
B. Unit value of dead/injured	1,622,546	45,577	1,622,546	45,577
Total benefit (A×B)	1,338,438,049	968,691,718	619,471,769	135,131,081
Total costs **	-	-	-511,979,479	-914,367,366
Net benefit	1,338,438,049	968,691,718	107,492,290	-779,236,286
Overall (dead+injured)	**2,307,129,767**			

* The effect of RH on injured people is not significant with parametric and significant with non-parametric regressions. We adopt a conservative approach and include these benefits in the estimates of the overall effect.

** Hypotheses: in case of RH, on average drivers are sentenced to 3 years of jail (net of penalty discounts), while in case of injured people only 5% are actually sentenced, for only one year of prison (net of penalty discounts).

Table 6c: Cost-benefit analysis, worst scenario

Variable	PPS		RH	
	dead	injured	dead	injured *
A. Decrease in nr of dead/injured	825	21,254	382	2,965
B. Unit value of dead/injured	1,622,546	45,577	1,622,546	45,577
Total benefit (A×B)	1,338,438,049	968,691,718	619,471,769	135,131,081
Total costs **	-	-	-853,299,132	-1,828,734,733
Net benefit	1,338,438,049	968,691,718	-233,827,362	-1,693,603,652
Overall (dead+injured)	**2,307,129,767**			

* The effect of RH on injured people is not significant with parametric and significant with non-parametric regressions. We adopt a conservative approach and include these benefits in the estimates of the overall effect.

** Hypotheses: in case of RH, on average drivers are sentenced to 5 years of jail (net of penalty discounts), while in case of injured people 10% are actually sentenced, for only one year of prison (net of penalty discounts).

Table 6d: Cost-benefit analysis, Break Even Point

Variable	PPS		RH	
	dead	injured	dead	injured *
A. Decrease in nr of dead/injured	825	21,254	382	2,965
B. Unit value of dead/injured	1,622,546	45,577	1,622,546	45,577
Total benefit (A×B)	1,338,438,049	968,691,718	619,471,769	135,131,081
Total costs **	-	-	-170,659,826	-576,051,441
Net benefit	1,338,438,049	968,691,718	448,811,943	-440,920,360
Overall (dead+injured)	**2,307,129,767**			

* The effect of RH on injured people is not significant with parametric and significant with non-parametric regressions. We adopt a conservative approach and include these benefits in the estimates of the overall effect.

** Hypotheses: in case of RH, on average drivers are sentenced to 1 year of jail (net of penalty discounts), while in case of injured people 6.3% are actually sentenced, for only six months of prison (net of penalty discounts).

Table 7: Forecasted number of prisoners with the RH, three scenarios

Year	Scenario 1	Scenario 2	Scenario 3
2018	58,285	58,285	58,285
2019	58,285	58,285	58,285
2020	60,251	66,203	72,469
2021	61,078	67,856	74,122
2022	61,078	69,509	75,775
2023	61,078	69,509	77,428
2024	61,078	69,509	79,081
2025	61,078	69,509	79,081
2026	61,078	69,509	79,081
2027	61,078	69,509	79,081
2028	61,078	69,509	79,081

Note: The simulations use the number of prisoners of April 2018 as a starting point which is assumed constant over the next years, and adds the number of people/year sentenced because of dead or injured people according to the three scenarios explained in Chapter 4.

Figure 1: Road accidents, dead and injured people in Italy

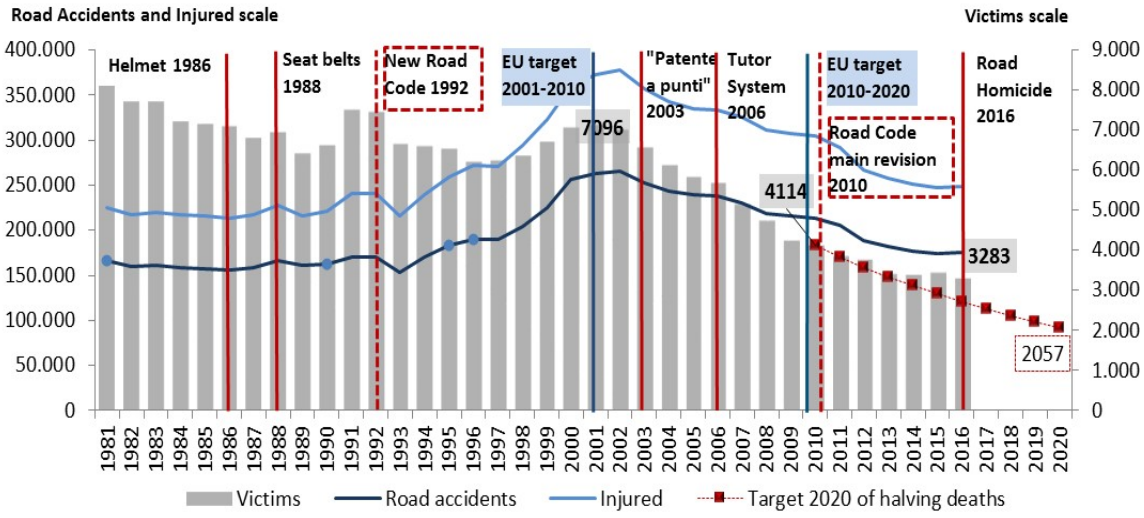


Figure 2: Dummy Variables to compute the effect of

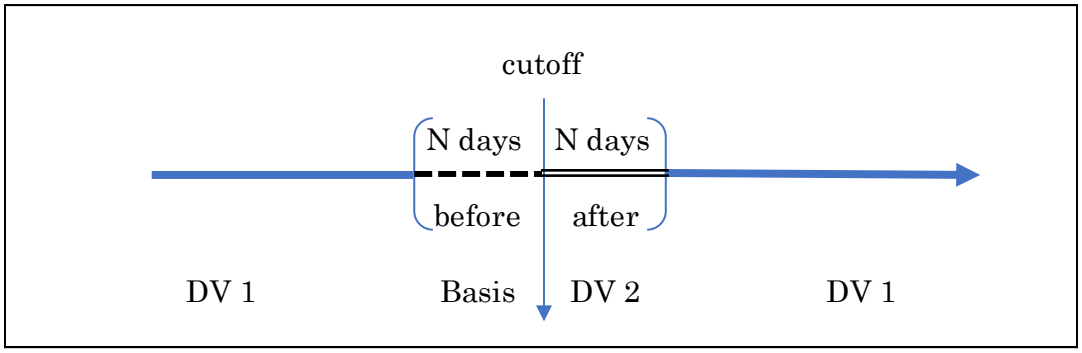


Figure 3: Non-parametric regressions, PPS

Fig. 3a: Number of dead people

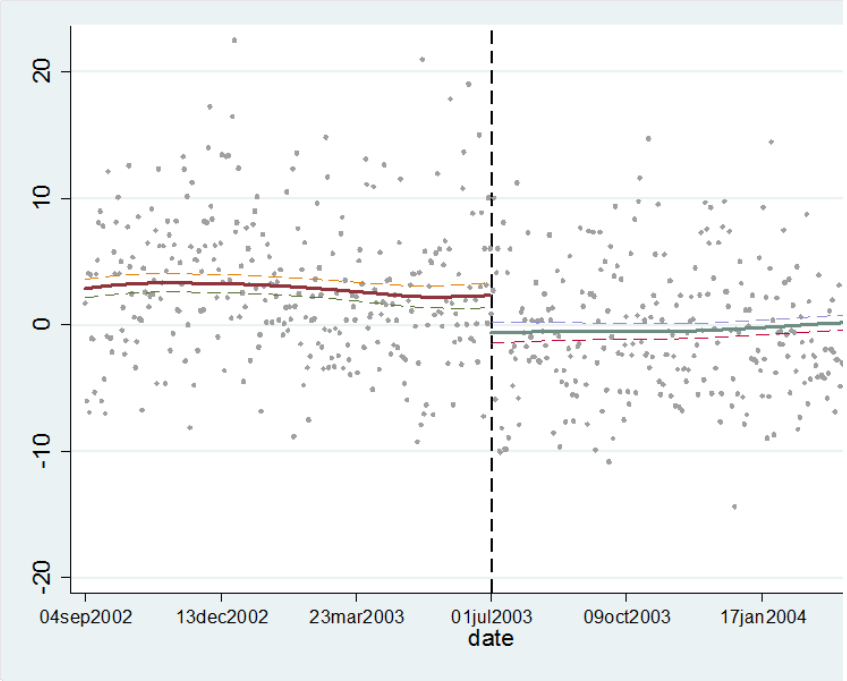
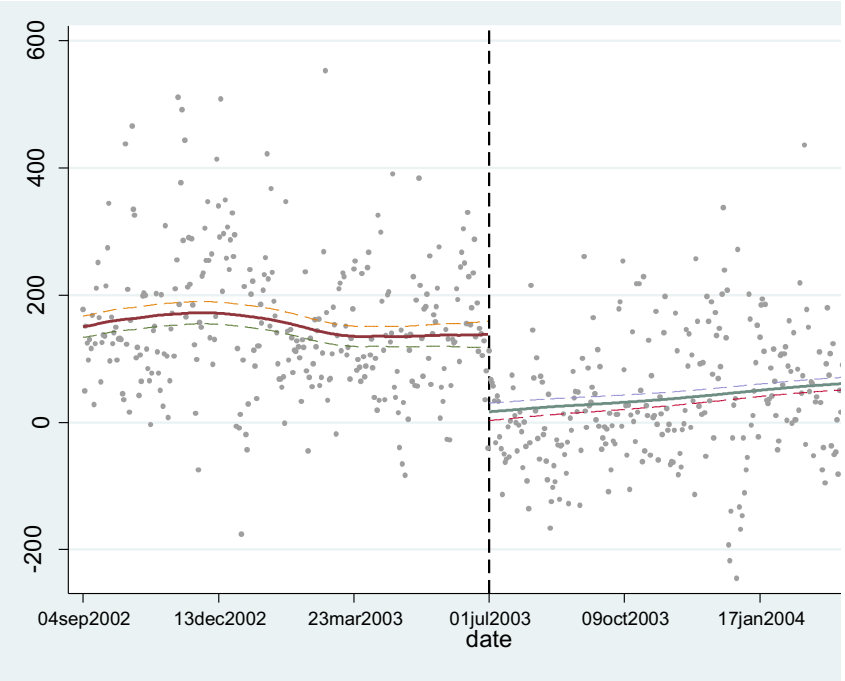


Fig. 3b: Number of injured people



Note: The dependent variable is the predicted residual of the first stage regression where the number of victims was regressed over DVs for day of the week, month and national holyday, and the real oil price in €. The symmetric window includes 300 days before and 300 days after the cutoff.

Figure 4: Non-parametric regressions, RH

4a: Number of dead people

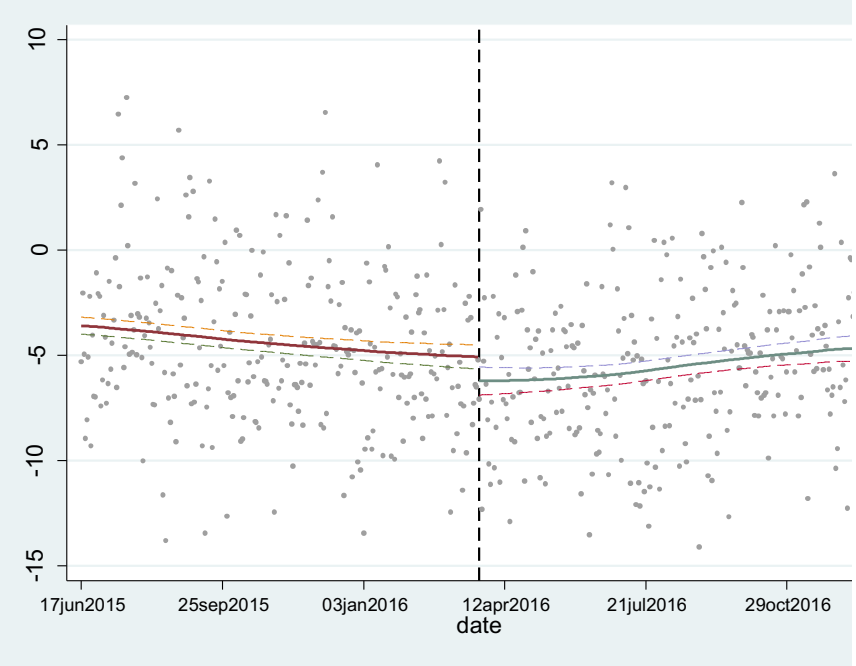
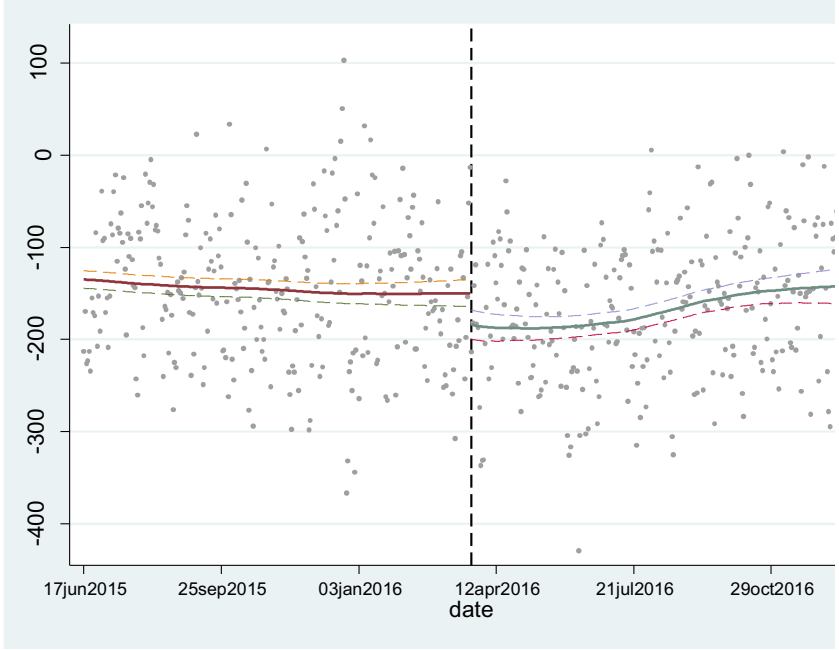


Figure 4b: Number of injured people



Note: The dependent variable is the predicted residual of the first stage regression where the number of victims was regressed over DVs for day of the week, month and national holyday, and the real oil price in €. The symmetric window includes 282 days before and 282 days after the cutoff.

Table A1: Example of points withdrawn with the PPS

Points	Violation
1	Incorrect use of lights
2	Parking close to a bus station
3	Excess speed between 10 and 40 kph
4	Driving in the wrong direction
5	No helmet
	No seatbelts
6	Excess speed between 40 and 60 kph
	Crossing the street on a red light
8	U-turn close to a cross, curve or hill
10	Race
	Excess speed above 60 kph
	Reversing on a Motorway

Table A2: New law on the Road Homicide, penalties for the crimes

A. Seriousness of road code violations	B. Penalties
Very serious responsibility	**Road Homicide**
BAC > 1.5 gr/liter	From 8 to 12 years
Drugs	From 5 to 10 years
	From 2 to 7 years
Serious responsibility	
0.8 < BAC < 1.5 gr/liter	**Very serious injuries**
Excess speeding	From 4 to 7 years
Red traffic light	From 2 to 4 years
Driving the wrong way	From 1 to 3 years
U-turn close to curves or bumps	
Overtaking on a road with continuous dividing line	**Serious injuries**
	From 3 to 5 years
Minor responsibility	From 1.5 to 3 years
Other violations of the road code	From 3 months to 1 year