The Impact of Deterrence Policies on Reckless Driving: The Case of Portugal

Running Head (Shortened Title): Impact of Deterrence Policies on Reckless Driving

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Abstract

In this paper, we test the effect of three different criminal deterrence theory policy tools: criminal certainty, severity, and celerity of punishment. Whereas most criminal deterrence studies in this field focus on the former two components of deterrence theory, this study also examines the potential deterrent effect of the latter component. Using a time-series design with monthly data, we estimate the effects of an increase in the threat of punishment for traffic offenses resulting from a general increase in fines for traffic offenses, an increase in the probability of getting caught with a blood-alcohol concentration (BAC) level outside the legal limits, and the enactment of an "on-the-spot" fine payment policy in Portugal. We find strong evidence to support a severity effect. An increase in the statutory severity of sentence maxima for traffic violations leads to a decrease in accident and injury rates—approximately an average 0.5 percent reduction in monthly accident and injury rates. Changes in the BAC levels and the mandatory swift payment policy did not produce any convincing deterrence impact.

Keywords: Blood-Alcohol Concentration (BAC) level, Deterrence Celerity, Deterrence Severity, On-the-Spot Payment, Reckless Driving

Introduction

When traffic statistics are published, Portugal usually tops the charts on accident and mortality figures. In 1995, Portugal ranked first among twenty five European Union countries in fatalities by population on motorways (CARE, 2006). Despite being comparatively high, accident and injury rates have very recently begun to decrease, both in absolute and relative terms. In 2000, Portugal trailed Latvia and Greece with the third highest traffic fatality rate per million inhabitants. Latest data confirm a downward trend, with Portugal occupying tenth place among the European Union countries in the ranking (CARE, 2006). During this period, fatalities per million inhabitants decreased from 271 in 1995 to 124 in 2004. Portuguese authorities have already proudly claimed credit for this decrease since stricter traffic legislation was enacted in the late 1990s. However, a more systemic analysis must be undertaken in order to test this political statement. Were Portuguese drivers deterred by the increase in the certainty, severity and celerity of punishment policies for traffic violations? Or, in other words, to what extent are these policy changes associated with a reduction in the accident rate resulting in death or injury?

The literature on deterrence is primarily concerned with the probability of detection and punishment for a specific category of traffic offenses—drunk-driving offenses. National governments, however, frequently employ deterrence policies that are not targeted specifically at alcohol-related incidents. These aim to reduce many different types of reckless behaviour at the wheel, including but not limited to, drunk-driving, aggressive driving, dangerous passing, and speeding. Furthermore, empirical work on drunk-driving systematically employs traffic fatalities or similar measures as dependent variables, even though only a relatively small proportion of accidents with victims occur as a result of drinking-and-driving behaviour (Deshapriya and Iwase, 1996). In Portugal, drunk-driving incidents represent about thirty percent of all traffic accidents,

while in the European Union only one in four traffic accidents are alcohol-related (European Commission, 2006).

The purpose of this study is to contribute to the large body of empirical studies by investigating the effects of deterrence-based traffic policies aimed at reducing reckless driving in general. We conduct this study in a setting that is usually understudied--Portugal. This is surprising for reasons mentioned above. Its outstanding record in traffic casualties demands a systemic investigation of the effects of governmental strategies in this policy area. An additional argument that makes this country an interesting site for investigation is the fact that the government has already claimed credit for a recent downward trend in accidents. This empirical observation is unsubstantiated scientifically and requires statistical testing. Given that the systematic collection of statistics on traffic accidents only began in the 1990s in this country, we are limited to traffic policies that have been implemented during and after that period.

Specifically, we examine the impact of a three-fold package of deterrence-based government interventions implemented in the latter half of the 1990s. These interventions raised the penalties for traffic offenses, and in this way increased the severity of punishment, and increased the likelihood of detection while driving under the influence by tightening the limits of blood-alcohol concentration (BAC). Finally, government intervention made punishment swifter by establishing the immediate mandatory payment of pecuniary sanctions for traffic offenses at the site of violation when stopped on the road. We test the hypothesis that by increasing the levels of severity, certainty, and celerity of traffic policies, the legislation enacted by the Portuguese government in the 1994-2004 period, resulted in a significant reduction in the number of traffic accidents, injuries, and fatalities. We test this hypothesis using multivariate autoregressive moving average models with monthly aggregate data, given that there is, as of yet, no systematic collection of individual-level data in Portugal.

The paper is organized as follows. Following a brief review of the literature on criminal deterrence policies to combat traffic accidents and mortality rates, we review the main policies implemented in Portugal since the restoration of the democratic regime in the mid-1970s and formulate our working hypotheses. Next, we present the results of our analysis and finish with a discussion of the results and their policy implications.

Deterrence Policies to Improve Road Safety

Although the beginnings of the literature on traffic safety date back to the late 1930s (Holcomb, 1938), it was not until the late 1970s and early 1980s that empirical studies became more commonplace. It has, since this time, remained an active subject in applied public policy studies. Most of the literature examines the effect of diverse government interventions aimed at deterring drivers from breaking the law, and, in this way, reducing traffic accidents and fatalities. In turn, most of the deterrence literature on traffic policy focuses on negative deterrence, both at the perceptual and aggregate levels. These studies investigate the threat of detection and punishment through legal and administrative sanctions and aim at increasing the expected cost of reckless driving.

Given that reckless driving is a form criminal behaviour, governments encourage compliance with the law by adopting and enforcing a system of incentives, penalties, and controls so as to prevent criminal behaviour on the road. In doing so, they lay the foundation for an orderly transit system. Deterrence theory is a doctrine that makes that foundation possible by supplying a means with which to provide predictability in individual behaviour. It is based on the assumption that individuals are rational beings that balance private benefits and costs of undertaking a criminal activity in order to maximize their expected utility (Becker, 1968). As such, individuals in a society can be induced to comply with the law through their reactions to incentives and disincentives.

Deterrence operates at two distinctive levels. It dissuades those who experienced certain, swift, and/or severe punishment for traffic violations from committing the same infractions (specific deterrence), while simultaneously achieving a preventive effect by discouraging the general population from engaging in socially undesirable actions on the road (general deterrence) (Andenaes, 1975). Long-term effects of deterrence policies can be accomplished if a strict and persistent application of sanctions actually changes civic behaviour and habits behind the wheel (Deshapriya and Iwase, 1996).

Most deterrence policies in the literature on traffic safety fall into three groups: 1) enforcement policies; 2) punishment policies; 3) celerity policies. Enforcement policies are regulatory policies that set up mandatory actions or impose limits aimed at reducing the level of traffic accidents and the number of casualties resulting from these accidents. Because they seek to increase the probability of detection, prosecution, conviction, and punishment of drivers breaking the law, enforcement policies are concerned with the certainty of punishment. According to Becker (1968), the certainty and severity components are clearly identified as two equally relevant options available to reduce crime. Although deterrence theory does not specify which of its elements should have a greater effect on criminal reasoning, empirically speaking, of the three groups, enforcement policies are generally found to have the most relevance, consistently revealing statistically deterrent effects (Benson et al., 1999; Mendes, 2004). These policies include more visible law enforcement efforts (Benson et al., 1999), sobriety checkpoints (Fell et al., 2003; Kenkel, 1993), preliminary breath tests (Kenkel, 1993; Rhee and Zhang, 1993), and the establishment of a limit of blood alcohol concentration (BAC) above which it is illegal *per se* to drive. This latter policy tool is perhaps the most representative policy of this category (Dee, 2001; Eisenberg, 2003; Legge Jr. and Park, 1994; Mann et al., 2001). Dee (2001) studied 19 state laws establishing as illegal *per se* to drive with a BAC of 0.08 and concluded that these laws have been effective in reducing the number of traffic fatalities, especially among young adults.

Additional research by Eisenberg (2003) found that states lowering the illegal *per se* limit from 0.10 to 0.08 obtained a 3.1 percent reduction in fatal crash rates. However, this effect was somewhat delayed in time, indicating the need for public awareness campaigns to accomplish this policy effect.

Empirical research has also focused on regulatory policies that are less relevant for our study, such as policies that establish the minimum legal drinking age (Asch and Levy, 1990; Legge and Park, 1994), enforce mandatory seat belt laws (Houston and Richardson, 2002, 2006; Legge, 1990), mandatory vehicle inspections (Fuchs and Leveson, 1967; Loeb, 1990), and ignition interlock systems (Weinrath, 1997). All these studies have found some evidence that these policies are successful in decreasing accident, fatality, or injury rates.

With respect to the second category, punitive policy tools in the literature on traffic safety fall under the category of legal and/or administrative sanctions. These sanctions aim at increasing the severity of punishment under the assumption that harsher criminal penalties deter drivers from engaging in reckless behaviour at the wheel (Legge and Park, 1994). Several authors, having tested for the severity components of deterrence policies, found statistically significant effects for heavy pecuniary fines (Briscoe, 2004; Yu, 1994), jail terms for first offenders (Kenkel, 1993), mandatory license suspension/revocation (Kenkel, 1993; Legge and Park, 1994; Ross and Gonzales, 1988), and vehicle impoundment (DeYoung, 2000).

Celerity policies seek to reduce the time elapsed between a traffic violation and the administration of the sanction. Yu (1994) is an individual level study that examines the specific deterrent effect on drunk-driving by specifying the celerity and severity of punishment. He found that the probability of recidivism is greatly reduced with a combination of increased fines and mandatory license withdrawal, but no measurable effect was noted for celerity as an independent punishment factor.

Some authors argue that deterrent strategies also produce effects on a moral dimension of human behaviour, promoting a positive change in drivers' behaviour in the long run (Andenaes, 1971; Deshapriya and Iwase, 1996; Snortum and Berger, 1989). According to this argument, the goal of deterrence policies is not simply to discourage prospective reckless driving by upping the costs associated with it, but also to foster law-abiding driving by appealing to or instilling a sense of civility. Publicity and advertisement campaigns that stress certain, swift, and severe penalties to individuals engaging in reckless driving create a negative social construct surrounding undesired or offending acts (Ross, 1984; Tay, 1999, 2004, 2005) and produce a "threat of embarrassment" (Akers, 1990; Berger and Snortum, 1986; Grasmick et al., 1993; Green, 1989).

Traffic Policies in Portugal

The approval of the 1994 Driver's Code[1], replacing the previous 1954 Code, was the first organized and coherent effort to adopt comprehensive traffic policy legislation. The main purpose of the 1994 code was to update the legal rules and penalties for reckless driving and to compile the vast set of piecemeal legislation approved throughout that forty-year period. The 1994 code introduced a system of demerit points by which drivers lose their licenses if they accumulate more than a given number of points resulting from the degree of seriousness of the offense. Nevertheless, the seriousness of the traffic problem in Portugal prompted the national government to enact several laws beginning in the mid 1990s that reflect a strong inclination towards deterrence-based legislation.

Our period of analysis begins in January 1995 and ends December 2004. This decade is marked by three major modifications to the Code. Firstly, in January 1998, the Portuguese government approved legislation targeting both general and specific deterrence. The Portuguese parliament approved new legislation with a strong emphasis on the severity of penalties searching for a significant increase in the expected cost for committing traffic violations. This

legislation increased fines for serious and very serious driving offenses and introduced license suspension between one month and one year for serious offenses and between two months and two years for very serious offenses. Recidivism was also taken into consideration, with courts being allowed to remove, for a period of one to five years, the license of drivers with alcohol or drug addiction, with three very serious offenses or five serious offenses in a five-year period.

The second major change during this 10-year period was the introduction of a legal limit of 0.2 g/l (grams per litre) of blood alcohol level.[2] Drunk-driving offenses are one of the major causes of traffic accidents and fatalities, and this new, extremely stringent limit was considered to be a way to produce significant reductions in these statistics. However, this decision did not hold for a long period of time. In fact, only eleven months after its statutory adoption, the 0.2 g/l level was revoked and the 0.5 g/l level was restored as the legal limit,[3] as a result of pressures from the wine industry, one of the largest business interest groups in Portugal.

Finally, the third main change in traffic policy was the introduction of mandatory 'on-the-spot' payment of fines in October 2001.[4] Like other governmental authorities (Yu, 1994), Portuguese officials felt that the inefficacy of the fine-collecting system was undermining the deterrent impact of fines. They felt that something should be done to address this problem. In order to assure higher efficacy, or in other words, greater certainty in the application and collection of fines, the 'on-the-spot' policy makes it compulsory for drivers stopped for a specific offense, to immediately pay a fine for that offense, as well as any other outstanding fines he or she may have.

These policies enacted throughout the period clearly point to an emphasis on deterrence-based policies. Taken together, all three of these policy changes can be considered as a 'package' in order to improve the probability of success of these deterrent strategies (Mendes, 2004; Mendes and McDonald, 2002).

Hypotheses

As mentioned above, deterrence theory embodies three policy tools that are under the immediate control of government authorities. These tools affect the components that can alter the expected cost of punishment. These are the certainty of punishment (through the probability of arrest and/or the probability of convictions), the severity of punishment, and the celerity of punishment.

Authors often argue that merely raising the penalties without investing in the perception of a higher probability of detection and conviction is the easy, but ineffective way for legislators to attempt to raise the expected cost of punishment. To register a dissuasive effect in the potential criminal's mind, more offenses have to be detected and a greater proportion of the offenders have to be convicted. In other words, offenders have to perceive a 'certainty' that they will be caught and subsequently punished. Also, if criminals go unpunished, arresting loses much of its influence. If the severity of punishment for a given crime increases but potential offenders perceive that they are not going to get caught, the increase in severity loses its dissuasive effect. For deterrent strategies to have any chance for success, they need to address criminal behaviour as a 'package'. In other words, all elements operate in combination to affect the expected cost of punishment (Mendes, 2004; Mendes and McDonald, 2002).

Most aggregate level deterrence studies estimate potential deterrence effects of severity and certainty of punishment. Exceptions include policies that target the proximity of punishment (Yu, 1994). Very few studies at the aggregate level, as opposed to individual level, are able to incorporate a time element given the absence of aggregate statistics on the celerity of punishment. This is primarily due to the perceptual nature of the value that an individual places on the proximity or longevity of punishment in time.

In this study, we conduct an empirical analysis to test for deterrent impact of the imposition of heavier fines, the introduction of on-the-spot payment of fines, and the changes in

BAC levels. All three policies result in an increase of the expected cost of punishment in accordance with criminal deterrence theory.

Ideally, in keeping with deterrence theory, studies should test the effect of this expected cost of punishment on the traffic offense rate, given that it is the most adequate measure of reckless driving. Empirical studies on the deterrent effect of traffic policy generally, however, do not focus on traffic offenses. Rather, the dependent variable is usually measured as some form of accident rate. The present case is no different; monthly statistics on traffic offenses are not available, leaving us to infer any deterrent effect through changes observed in the rates of traffic accidents, fatalities, and injuries. These are our proxies for driving behaviour. Public authorities promoting deterrence-based policies anticipate a reduction in these rates. Our general hypothesis is as follows:

> H_1: An increase in the deterrent cost of punishment for traffic offenses decreases reckless driving.

We operationalize this hypothesis by breaking the deterrent expected cost into its deterrent components. In the present case, these components refer to the severity of punishment, as seen through an increase in fines, as well as the changes in the BAC level, and the increase in the celerity of punishment embodied in the mandatory prompt payment of fines. The deterrence literature generally employs the probability of detection and/or conviction to measure the certainty of punishment. However, as with the vast majority of empirical studies on the deterrent effect of traffic policy, no statistical measure of reckless driving arrests is available in Portugal. Legge and Park (1994) argue that illegal *per se* laws can be considered proxy measures of the certainty of punishment because they increase the probability of detection of illegal behaviour by defining a specific level of BAC as conclusive evidence of guilt (see also Benson et. al., 1999). This would allow the inclusion of BAC laws as proxies for the certainty of punishment. Thus:

> H_2: An increase in the severity of punishment for traffic offenses decreases reckless driving.

H_3: An increase in the certainty of punishment reduces reckless driving.

H_4: An increase in the celerity of punishment reduces reckless driving.

Data and Methods

Following prior empirical work by Briscoe (2004), we examine three measures of our dependent variable, reckless driving, that account for the level of road usage: (1) monthly accidents with victims per 100,000 registered vehicles (Accident Rate) (2) monthly fatalities per 100,000 registered vehicles (Fatality Rate), and (3) monthly injuries per 100,000 registered vehicles (Injury Rate) from January 1995 to December 2004.[5] All dependent variables appear in log form to allow for the interpretation of coefficients as growth rates.

Our variables of interest are policy interventions which take the form of dummy variables coded '0' before each intervention and coded '1' in the months following the intervention. The first policy came into effect in January 1998, the 37th month of these series. The second and third interventions occurred on October 2001, the 82nd month of our series, when on-the-spot payment of fines and the 0.02 BAC limit began. The third intervention, however, was short-lived, since new legislation enacted 11 months later reinstated the BAC level at 0.05. In this case, the BAC variable is coded '0' both before and after the 11-month period. Figures 1 to 3 show all policy interventions in the three non-differenced series. The first month of each series is January 1995 and the three series show a clear downward trend during the period of analysis, with no abrupt shifts.

[Figures 1-3 about here]

In extending our model specification to include control variables, we are limited to the data that are available on a monthly basis. These data include only vehicle inspections and the level of precipitation. In 1993, vehicle safety inspections became mandatory in Portugal. The number of automobile safety inspections increased significantly during our period of analysis.

This is thought to have had some impact in reducing the rate of road accidents because it removed older and/or structurally defective vehicles from the road.

Accidents, fatalities, and injuries are likely to be influenced by bad weather, but the direction of the change is uncertain *a priori*, either because drivers increase safety precautions and drive slower in rainy conditions or because poor driving conditions actually cause more accidents. The amount of precipitation in millilitres is employed to control for weather conditions.[6] Table 1 displays a short description and summary statistics for the dependent, intervention, and control variables.

[Table 1 about here]

Multivariate autoregressive-moving average models are used to explain the variation in our series. These models include both explanatory variables and error terms which are partially 'explained' by a time series model (Pindyck and Rubinfeld, 1998). The model assumes the following form:

$$y_t = a_0 + a_1 x_{1t} + a_2 x_{2t} + \Phi^{-1}(B)\theta(B)\eta_t$$

Where η_t is a normally distributed error term which may have a different variance from ε_t, the error term of the original regression equation. This model contains both a structural explanation of that part of the variance of y_t which can be explained structurally and a time-series "explanation" of that part of the variance of y_t which cannot be explained structurally (Pindyck and Rubinfeld, 1998: 590). As recommended by Pindick and Rubinfeld (1998), we arrive at the structural part of the model as a product of theoretical argument, whereas the time-series part of the model is the result of an analysis of the residuals of the structural model.

An ARIMA (1,1,1) process describes the noise component of the accidents rate series. A similar noise component characterizes the injury rate series. The fatality rate series has a more complex error structure characterized by an ARIMA (3,1,1). All series were differenced to remove non-stationarity and all models include monthly dummies to control for seasonal effects.

A battery of diagnostic tests was conducted to assess the ARIMA portion of the estimated equations. Tests confirm that the ARIMA terms are both stationary and invertible. All diagnostics conducted confirm that residuals are purely white noise, thus indicating the absence of serial correlation, heteroscedasticity, and autoregressive conditional heteroscedasticity. Table 2 reports the results of Least Squares estimates with ARMA components.

[Table 2 about here]

Findings

As we can see from Table 2, the results of our analysis strongly indicate that the legislative efforts to increase the severity of punishment for traffic violations have a strong deterrent effect. An increase in this form of severity of punishment leads to a decrease in two out of three measures of our dependent variable. That is, the 1998 legislation targeted at recidivist behaviour was successful in decreasing accidents and injuries. The legislative increase in penalties produces a significant average decrease in accident and injury rates of 0.5 percent and 0.4 percent, respectively, but not in fatality rates. Although the sign is in the same direction, the increase in severity in the latter model is not sufficient to produce any discernible effect on the number of deaths per 100,000 vehicles, at least as far as we can tell with our data. Notwithstanding the failure of statistical efficiency due to data limitations, the absence of an effect may be due to the fact that fatalities represent a small fraction of total accidents and injuries, a fraction that is most often associated with extreme recklessness behind the wheel. Individuals who engage in this type of behaviour are likely not affected by marginal changes in sentences, so it is not altogether surprising that this type of traffic incident is not responsive to sentence maxima.

The results of our certainty of punishment policy are not as conclusive. The changes in BAC levels are only significant only at the 90 percent confidence level in two of the three series, accident and fatality rates, and should, therefore, be read with caution. Although the efficiency of

the coefficients falls short of the conventional level of statistical significance of 95 percent, it may be worthwhile to at least mention these results, given the exploratory nature of the design and the limited model specification. If one can accept this argument as plausible, one could tentatively say that these results seem to indicate that the BAC legislation in Portugal, leads to an increase in accident and fatality rates—on average, 0.5 percent and 0.14 percent, respectively. This may indicate that the inconsistency in the BAC limit legislation could have sent mixed signals, inducing erratic, rather than predictable, behaviour.

Our results also fail to show any strong indication of an impact of the celerity policy on reckless driving. In the case of the injury rate, the enactment of the on-the-spot payment policy actually points to an increase in reckless driving, although this effect is also only significant at the 90 percent confidence level.

Discussion

What are the policy implications of these results? Taken together, they suggest that the deterrent impact is not as effective as it could be. In other words, the current package of Portuguese traffic policies is very likely not maximizing the threat of punishment. The fact that the increase in fines may likely decrease reckless driving does not mean that the magnitude of this decrease is as large as it could be. As argued above, the severity of punishment does not work independently of the certainty and celerity components. Together, they determine the expected cost of punishment that, in the end, should affect drivers´ reasoning while behind the wheel. The ambiguity with respect to the certainty and celerity components of deterrence theory thus compromises the overall impact of expected cost of punishment on drivers' behaviour.

Government strategies need to focus on the certainty of punishment first. Generally speaking, Portuguese drivers are risk takers. Hidden police surveillance videos often reveal

shocking and aggressive manoeuvres. This may be due to a low enforcement level, and, consequently, a low perception of the probability of getting caught driving recklessly. The Portuguese government could stand to gain in rethinking its budget for criminal deterrence. Increasing the upper limit in fines for traffic violations is not a policy tool that puts any strain on the deterrence budget; on the contrary, it actually increases government resources at the same time that it decreases traffic violations. This extra cash flow could be reinvested in the police budget. By investing more resources toward increasing the enforcement level of the BAC policy and police patrol and detection in general, the combined deterrence efforts of the severity, certainty and celerity factors could yield a more efficacious threat of punishment.

Conclusion

In this paper, we test deterrence theory as it applies to traffic policy in Portugal. Following a brief review of the literature and a description of this Portuguese traffic legislation, we test for an effect of the certainty, severity, and celerity of punishment through three different policies enacted by the Portuguese government since the mid 1990s. One policy intervention increased the severity of punishment by raising penalties for traffic offenses. Another policy intervention tightened the limits of blood-alcohol concentration (BAC), only to loosen them a few months later. Finally, we also examine a celerity policy that called for the immediate mandatory payment of pecuniary sanctions for traffic offenses when stopped on the road.

Using a multivariate autoregressive moving average design and a dataset assembled for the purpose of this study, we find strong evidence of a deterrent effect of the increase in fines in the case of accident and injury rates. This increase in sentence maxima leads to an approximate average reduction of 0.5 percent in monthly accident and injury rates. There is no clear evidence of any discernible effect of the changes in the BAC levels and the enactment of "on-the-spot" fine payment policy does not produce any convincing effects on these rates.

The policy implications of this study are straightforward. Our results suggest that Portuguese efforts to reduce reckless driving need to focus on the police end of the deterrence package. A greater perception of the enforcement of the BAC policy, and consequently, of the on-the-spot payment policy could generate more conclusive deterrent effects. Although the increase in fines may very likely reduce traffic violations, the increase in the expected cost of punishment from the severity component could be greater if policies were also designed to increase the likelihood of punishment. Not only that, but additional deterrent effects resulting from more efficacious certainty and celerity policies would further increase the expected threat of punishment and decrease reckless driving.

Notes

1. Law-Decree 114/94, May 3.

2. Law-Decree 162/2001, May 22 and Law-Decree 265-A/2001, September 28. The actual change in BAC levels came into effect on October 1.

3. Law 20/2002, August 21. A 0.5 g/l level is a 0.05 BAC (Blood Alcohol Concentration) or 0.05 of alcohol by volume.

4. Law-Decree 265-A/2001, September 28.

5. Data were provided by the *Direcção Geral de Viação* (Department of Motor Vehicles) and the *Associação Portuguesa de Comércio de Automóveis* (Portuguese Automobile Trade Association).

6. Vehicle inspection data are available from the Department of Motor Vehicles and rainfall amounts are collected and made available by the Portuguese Institute of Meteorology.

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References

Akers, R. L. (1990). Rational Choice, Deterrence, and Social Learning Theory: The Path Not Taken. Journal of Criminal Law and Criminology, 81(3), 653-676.

Andenaes, J. (1971). The Role of Law: The Socializer - The Moral or Educative Influence of Criminal Law. Journal of Social Issues, 27(2), 17-31.

Andenaes, J. (1975). General Prevention Revisited: Research and Policy Implications. Journal of Crime, Law and Criminology, 66(3), 338-365.

Asch, P. and Levy, D.T. (1990). Young Driver Fatalities: The Roles of Drinking Age and Drinking Experience. Southern Economic Journal, 57(2), 512-520.

Benson, B.L., Rasmussen, D.W., and Mast, B.D. (1999). Deterring Drunk Driving Fatalities: An Economics of Crime Perspective. International Review of Law and Economics, 19(2), 205-225.

Berger, D.E. and Snortum, J.R. (1986). A Structural Model of Drinking and Driving: Alcohol Consumption, Social Norms, and Moral Commitments. Criminology, 24(1), 139-153.

Briscoe, S. (2004). Raising the Bar: Can Increased Statutory Penalties Deter Drink-Drivers? Accident Analysis and Prevention, 36(5), 919-929.

CARE (EU Road Accidents Database). (2006). Road Safety Evolution in the European Union. Brussels: European Commission/Directorate General Energy and Transport.

Chaloupka, F. J., Saffer, H., and Grossman, M. (1993). Alcohol-Control Policies and Motor Vehicle Fatalities. Journal of Legal Studies, 22(1), 161-186.

Chaloupka, F. J. and Wechsler H. (1996). Binge Drinking in College: The Impact of Price, Availability, and Alcohol Control Policies. Contemporary Economic Policy, 14(4), 112-124.

Coate, D., and Grossman, M. (1988). Effects of Alcoholic Beverage Prices and Legal Drinking Ages on Youth Alcohol Use. Journal of Law and Economics, 31(1), 145-171.

Dee, T. S. (2001). Does Setting Limits Save Lives? The Case of 0.08 BAC Laws. Journal of Policy Analysis and Management, 20(1), 111-128.

Deshapriya, E. and Iwase, N. (1996). Are Lower Legal Blood Alcohol Limits and a Combination of Sanctions Desirable in Reducing Drunken Driver-Involved Traffic Fatalities and Traffic Accidents? Accident Analysis and Prevention, 28(6), 721-731.

DeYoung, D. J. (2000). An Evaluation of the General Deterrent Effect of Vehicle Impoundment on Suspended and Revoked Drivers in California. Journal of Safety Research, 31(2), 51-59.

Ehrlich, I. (1973). Participation in Illegitimate Activities: A Theoretical and Empirical Investigation. Journal of Political Economy, 81(3), 521-565.

Eisenberg, D. (2003). Evaluating the Effectiveness of Policies Related to Drunk Driving. Journal of Policy Analysis and Management, 22(2), 249-274.

European Commission. (2006). An EU Strategy to Support Member States in Reducing Alcohol Related Harm. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of Regions. Brussels: European Commission.

Fell, J. C., Ferguson, S.A., Williams, A.F., and Fields, M. (2003). Why are Sobriety Checkpoints not widely adopted as an Enforcement Strategy in the United States? Accident Analysis and Prevention, 35(6), 897-902.

Fuchs, V.R. and Leveson, I. (1967). Motor Accident Mortality and Compulsory Inspection of Vehicles. Journal of the American Medical Association, 201(9), 657-661.

Grasmick, H.G. and Bryjak, G. (1980). The Deterrent Effect of Perceived Severity of Punishment. Social Forces, 59(2), 471-491.

Grasmick, H.G., Bursik, R.J., and Arneklev, B.J. (1993). Reduction in Drunk Driving as a Response to Increased Threats of Shame, Embarrassment, and Legal Sanctions. Criminology, 31(1), 41-67.

Green, D.E. (1989). Past Behavior as a Measure of Actual Future Behavior: An Unresolved Issue in Perceptual Deterrence Research. Journal of Criminal Law and Criminology, 80(3), 781-804.

Holcomb, R.L. (1938). Alcohol in Relation to Traffic Accidents. Journal of American Medical Association, 111, 1076-1085.

Houston, D.J. and Richardson Jr., L.E. (2002). Traffic Safety and the Switch to a Primary Seat Belt Law: the California Experience. Accident Analysis and Prevention, 34(6), 743-751.

Houston, D.J. and Richardson Jr., L.E. (2004). Drinking-and-Driving in America: A Test of Behavioral Assumptions Underlying Public Policy. Political Research Quarterly, 57(1), 53-64.

Houston, D.J. and Richardson Jr., L.E. (2006). Reducing Traffic Fatalities in the American States by Upgrading Seat Belt Use Laws to Primary Enforcement. Journal of Policy Analysis and Management, 25(3), 645-659.

Kenkel, D.S. (1993). Drinking, Driving, and Deterrence: The Effectiveness and Social Costs of Alternative Policies. Journal of Law and Economics, 36(2), 877-913.

Kenkel, D.S. (1996). New Estimates of the Optimal Tax on Alcohol. Economy Inquiry, 34(2), 296-319.

Legge Jr., J.S. (1990). Reforming Highway Safety in New York State: An Evaluation of Alternative Policy Interventions. Social Science Quarterly, 71(2), 373-382.

Legge Jr., J.S. and Park, J. (1994). Policies to Reduce Alcohol-Impaired Driving: Evaluation Elements of Deterrence. Social Science Quarterly, 75(3), 594-606.

Loeb, P.D. (1990). Automobile Safety Inspection: Further Econometric Evidence. Applied Economics, 22(12), 1697-1704.

Mann, R.E., Macdonald, S., Stoduto, G., Bondy, S., Jonah, B., and Shaikn, A. (2001). The Effects of Introducing or Lowering Legal per se Blood Alcohol Limits for Driving: an International Review. Accident Analysis and Prevention, 33(5), 569-583.

Mendes, S.M. (2004). Certainty, Severity, and their Relative Deterrent Effects: Questioning the Role of Risk. Policy Studies Journal, 32(1), 59-74.

Mendes, S.M. and McDonald, M.D. (2002). Putting Severity of Punishment Back in the Deterrence Package. Policy Studies Journal, 29(4), 588-610.

Page, Y. (2001). A Statistical Model to Compare Road Mortality in OCDE Countries. Accident Analysis Prevention, 33(3), 371-385.

Paternoster, R. (1987). The Deterrent Effect of the Perceived Certainty and Severity of Punishment. Justice Quarterly, 4(2), 173-217.

Pindyck, R.S. and Rubinfeld, D.L. (1998). Econometric Models and Economic Forecasts. 4th Edition. Boston, MA: McGraw-Hill.

Richardson Jr., L.E. and Houston, D.J. (2005). Deterring Drinking-and-Driving: State DWI Laws and Perceptions of Punishment Costs. Unpublished manuscript.

Rhee, L. and Zhang, J. (1993). Breath Testing in Canada: Deterrence or Detection? Applied Economics, 25(6), 765-775.

Ross, H. L. (1984). Social Control through Deterrence: Drinking-and-Driving Laws. Annual Review of Sociology, 10, 21-35.

Ross, H. L. and Gonzales, P. (1988). The Effect of License Revocation on Drunk-Driving Offenders. Accident Analysis and Prevention, 20(5), 379-391.

Snortum, J.R. and Berger, D.E. (1989). Drinking-Driving Compliance in the United States: Perception and Behavior in 1983 and 1986. Journal of Studies in Alcohol, 50, 306-319.

Tay, R. (1999). The Effectiveness of the Anti-Drink Driving Advertisement Campaign in New Zealand. Road Transport Research, 8(4), 3-15.

Tay, R. (2004). The Relationship between Public Education and Enforcement Campaigns and their Effectiveness in Reducing Speed Related Serious Crashes. International Journal of Transport Economics, 31(2): 251-255.

Tay, R. (2005). Drink Driving Enforcement and Publicity Campaigns: Are the Policy Recommendations Sensitive to Model Specification? Accident Analysis Prevention, 37(2), 259-266.

Tonry, M. (2005). Why are Europe's Crime Rates Falling? ESC Criminology in Europe Newsletter, 4(2), 1, 8-11.

Von Hirsch, A., Bottoms, A.E., Burney, E. and Wickstrom, P-O. (1999). Criminal Deterrence and Sentence Severity. Oxford: Hart.

Weinrath, M. (1997). The Ignition Interlock Program for Drunk Drivers: A Multivariate Test. Crime and Delinquency, 43(1), 42-59.

Table 1 – Descriptive Statistics

Variables	Description	Mean	Std. Dev.	Minimum	Maximum
Dependent Variables					
Accident Rate Series	Accidents with Victims per 100,000 registered vehicles	88.69	22.33	53.43	144.52
Fatality Rate Series	Deaths per 100,000 registered vehicles	3.34	1.22	1.40	6.83
Injury Rate Series	Injuries per 100,000 registered vehicles	119.68	31.58	70.77	206.06
Independent Variables					
Fines (0-1)	Dummy Variable	0.70	0.46	0	1
On the Spot Payment (0-1)	Dummy Variable	0.33	0.47	0	1
Blood Alcohol Concentration	Dummy Variable	0.092	0.29	0	1
Control Variables					
Vehicle Inspections	Inspections per 100,000 registered vehicles	62668	15571	26782	108377
Precipitation	Milliliters	74.99	73.53	0.2	321.3

Table 2 – Least-squares estimates, semi-log models for traffic accident, injury and fatality rates

	Accident Rate	Injury Rate	Fatality Rate
Intervention Parameters			
Fines	-.0048***	-.0043***	-.0023
	(.0012)	(.0012)	(.0022)
	-4.02	-3.58	-1.05
On-Spot-Payment	.0027	.0033*	.0013
	(.0018)	(.0018)	(.0039)
	1.51	1.84	0.34
BAC	.0050*	.0035	.0138*
	(.0028)	(.0027)	(.0072)
	1.82	1.29	1.93
Control Parameters			
Precipitation	5.16E-06	-1.37E-05	-3.77E-05
	(2.89E-05)	(3.17E-05)	(5.78E-05)
	0.18	-0.43	-0.65
Vehicle Inspections	2.53E-08	-1.57E-08	-2.93E-07
	(1.09E-07)	(1.10E-07)	(1.99E07)
	0.23	-0.14	-1.47
Noise Parameters			
AR (1)	.1151	.1125	.1045
	(.1003)	(.1040)	(.0983)
	1.15	1.08	1.06
AR (2)			-.1750**
			(.0845)
			-2.07
AR (3)			.0039
			(.1321)
			.0297
MA (1)	-.9905***	-.9973***	-.9824***
	(.0128)	(.0488)	(.0086)
	-77.34	-20.43	-114.8
R^2	0.81	0.85	0.68
Adjusted R^2	0.77	0.82	0.61
Jarque–Bera	.508	2.154	5.754
Breusch-Godfrey LM test	1.054	0.628	0.379
ARCH test	0.328	0.205	1.060
N	118	118	116

Standard Errors in parentheses; Errors of the Fatality Rate Series are calculated using the Newey-West HAC Consistent Covariance estimator; t-statistics below standard errors; Monthly dummies are omitted
* P<0.10 level; ** P<0.05 level; *** P<0.01 level.

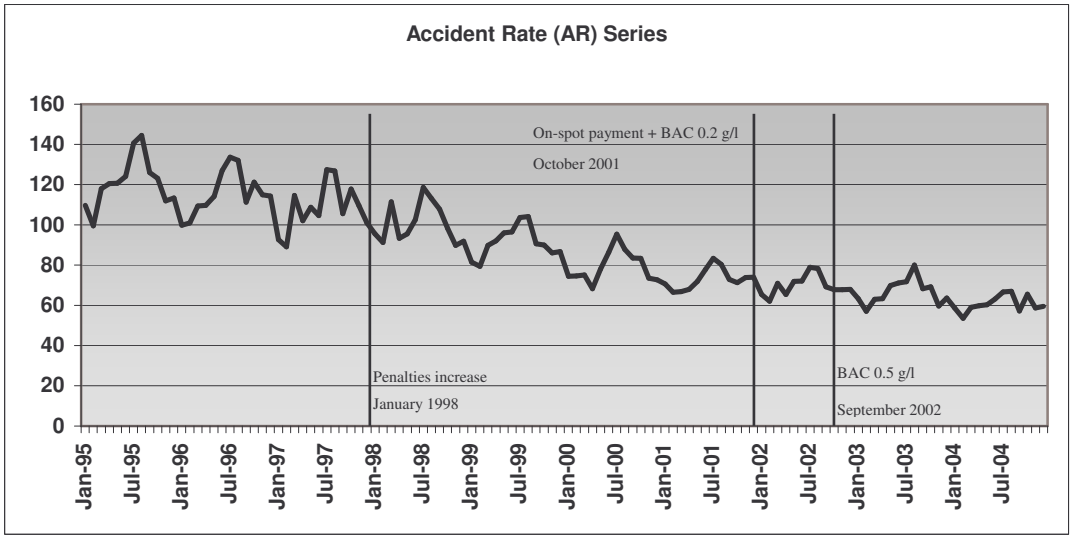

Fig. 1. Monthly traffic accidents per 100 000 vehicles in Portugal, 1995-2004

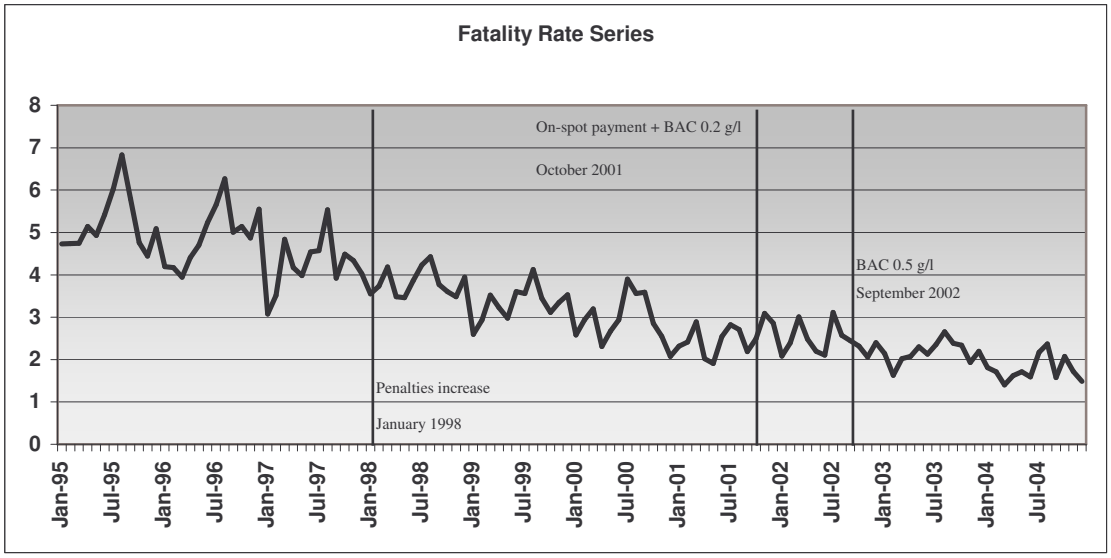

Fig. 2. Monthly traffic fatalities per 100 000 vehicles in Portugal, 1995-2004

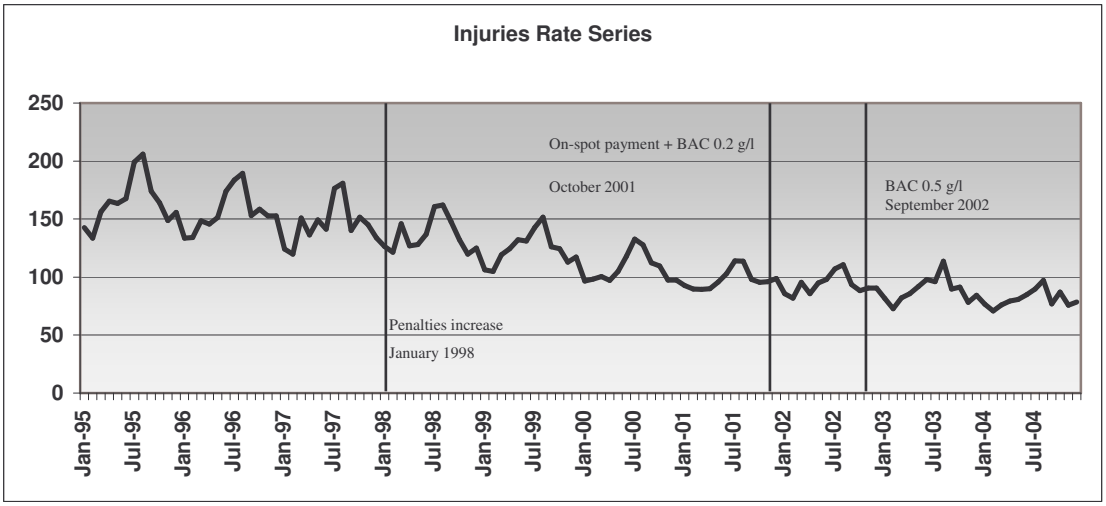

Fig. 3. Monthly traffic injuries per 100 000 vehicles in Portugal, 1995-2004