DOCUMENTS DE TREBALL
DE LA FACULTAT DE CIÈNCIES
ECONÒMIQUES I EMPRESARIALS

Col·lecció d'Economia

Lowering blood alcohol content levels to save lives: A European case study

Daniel Albalate

University of Barcelona ψ

Adreça correspondència:
Departament de Política Econòmica i EEM
Facultat de Ciències Econòmiques i Empresarials
Universitat de Barcelona
Av. Diagonal 690,
08034 Barcelona. (Spain)
E-mail: albalate@ub.edu

ψ Research Unit of Public Policy and Economic Regulation (GPPRE-IREA) at Universitat de Barcelona. I wish to thank Marcos Vera-Hernández for his useful advice and support and to the rest of the Economics Department at University College London. I am also grateful for comments received from my colleagues in the Research Unit of Public Policy and Economic Regulation, in particular Germà Bel, Xavier Fageda and Laura Fernández. All errors are my own.

Abstract:

Road safety has become an increasing concern in developed countries due to the significant amount of fatalities and the associated economic losses. Only in 2005 these losses rose to 200,000 million euros, a considerable sum – approximately 2% of GDP – that easily justifies any public intervention. One measure taken by governments to address this issue is to enact stricter policies and regulations. Since drunk driving is one of the greatest concerns among public authorities in this field, several European countries have lowered their illegal Blood Alcohol Content (BAC) levels to 0.5 mg/ml during the last decade. This study is the first evaluation of the effectiveness of this transition using European panel-based data (CARE) for the period 1991-2003 with the differences-in-differences method in a fixed effects estimation that allows for any pattern of correlation (Cluster-Robust). The results reveal a positive impact on certain groups of road users and on the whole population when the policy is accompanied by enforcement interventions. Moreover, positive results appeared after a time lag of over two years. Finally, I state the importance of controlling for serial correlation in the evaluation of this type of policy.

Key words: Road Safety; Policy Evaluation; Differences-in-Differences; Drunk Driving; Illegal Blood Alcohol Content Levels (BAC)

JEL Code: I18; H73; K32; R41.

Resumen:

La seguridad vial se ha convertido en una creciente preocupación en el mundo desarrollado por el gran número de víctimas mortales sufridas y por las pérdidas económicas que se derivan de ella. En el año 2005 éstas ascendieron a 200.000 millones de euros, una cantidad que supone el 2% del PIB europeo y que justifica la existencia de intervención pública. Los gobiernos se enfrentan a este reto fijando leyes y normativas más estrictas, especialmente en la lucha contra la conducción bajo los efectos del alcohol. La mayoría de países europeos decidieron a lo largo de la última década rebajar el nivel de alcohol en sangre permitido hasta 0.5 mg/ml. Este trabajo evalúa por primera vez la eficacia de esta transición usando un panel de datos europeo (CARE) mediante el método de Diferencias en Diferencias y efectos fijos permitiendo cualquier patrón de correlación (Cluster-Robust).

Los resultados muestran la existencia de un impacto positivo sobre ciertos grupos, mientras que la efectividad sobre el conjunto de usuarios solo se consigue donde la reducción en el nivel de alcohol en sangre se acompaña de medidas que fuerzan su cumplimiento. Además, el trabajo encuentra un retardo superior a dos años en dicha eficacia. Finalmente, también se destaca la importancia de controlar por la autocorrelación, habitualmente olvidada en la evaluación de esta política.

1. Introduction.

In the 1997 programme to promote road safety the European Commission estimated annual losses associated with road accidents to be 45 billion euros.[1] This estimation increased following the expansion of the EU to 200 billion – approximately 2% of its GDP – in 2005.[2] Two thirds of this total are spent on medical care, police intervention and vehicle repair. The remainder represents the loss of economic production caused by deaths and injuries. Therefore, this estimation provides a strong argument for governments to consider the reduction of road accidents as an economic objective and justifies the implementation of costly measures.

It is already demonstrated and socially accepted that alcohol consumption has a dramatic impact on the individual's ability to drive. The European Commission considered in 2003 that at least 10,000 road users died every year in alcohol-related accidents, at a public cost of approximately 10 billion euros.[3] Consequently, governments try to discourage drunk driving by introducing specific regulations worldwide.

One common policy implemented in developed countries has been to establish of lower illegal limits of blood alcohol content.[4] This is a long-standing policy, particularly in Europe, where it has undergone an inconsistent

---

[1] COM (97) 131**.** Promotion of road safety in the European Union 1997-2001.

[2] More than 41,000 lives were lost and 1.9 million people were injured in that year, some of them severely, according to the EC Directorate-General for Energy and Transport.

[3] This estimation comes from the one million euros rule established in the European Road Safety Action Programme (1997), in which it was agreed that one life had a public value of one million euros.

[4] A BAC level is the number of grams of ethanol per litre of blood.

process of homogenisation since 1994.[5] As of 1994, most former EU15 countries lowered their illegal BAC limits, usually set at 0.8 mg/ml, to the level already established in other few countries: a BAC limit of 0.5 mg/ml. Since this process is almost complete, it is now time to evaluate its results. Therefore, the objective of this study is to evaluate the effectiveness of lowering illegal blood alcohol content limits to 0.5 mg/ml as a means to reduce road fatalities in Europe.

This study contributes to the literature in several ways. Firstly, to my knowledge, this is the first evaluation of BAC policies that uses international panel-based data for the former EU15 countries. Secondly, this research aims to fill another gap, since few studies evaluate the transition from higher BAC limits to the new level of 0.5 mg/ml.[6] Finally, the most recent and technically accurate studies which used differences-in-differences in panel-based data to evaluate BAC changes – Dee (2001) and Eisenberg (2003) – did not consider serial correlation problems. This absence can generate a downward bias in standard errors that could overestimate the effectiveness of lowering BAC levels. Therefore, the latest contribution is to solve the problem by taking into account not only the heterogeneity caused by dealing with different countries, but also the existence of serial correlation.

Our main results show how lowering illegal BAC limits to 0.5 mg/ml has been an effective policy in saving lives in particular road-user groups in Europe. A strong impact has been observed among male drivers, particularly in urban areas, and on all drivers aged between 20 and 49. However, the effect of illegal

[5] We call it an inconsistent process of homogenisation because some countries did not in fact lower the limit and still have an illegal BAC limit of 0.8 mg/ml.

[6] The literature was mainly focused in the American experience where several states lowered their illegal BAC levels to 0.8 mg/ml by the end of 1998. None of them established a lower limit.

BAC limits of 0.5 mg/ml are not found to be statistically significant for the whole population unless they are accompanied by specific enforcement activities such as random roadside checks. Moreover, the effectiveness of the policy is found to have a considerable time lag of over two years.

This study is organised as follows. In Section 2 I describe the evolution of the legislative process that led to the homogenisation of BAC limits and highlight the roles of national and European institutions. In Section 3 I introduce the related literature that has studied the effectiveness of setting and lowering BAC levels, focusing on the most recent and accurate studies that used panel-based data and differences-in-differences to evaluate results. In Sections 4 and 5 I explain the methods, data and variables employed. In Section 6 I provide the main results while in Section 7 I state the importance of controlling for serial correlation in the evaluation of this policy. Finally, Section 8 contains the concluding remarks to the study.

2. European and national legislation on BAC limits.

In Europe, the illegal blood alcohol content levels have always been established by national legislations. However, European institutions have not remained impassive and their concern was behind the 1988 EC Draft Directive to coordinate illegal BAC limits at 0.5 mg/ml in all member states.[7] At that point, the only countries that included this limit in their national legislation were Finland, the Netherlands, Portugal and Sweden. The EC proposal for a common limit across member countries was intended to send a clear and coherent message to the Community as a whole but did not succeed because

[7] COM (88) 707. The Commission explains that this level was chosen following several studies and took into account the public acceptance that the new limit would be effective in reducing the number of accidents.

several member states refused to observe the European legislation.[8] Although the directive did not prosper, many member states with higher BAC limits decided to bring them into line with the level recommended by the Commission during the following decade, as shown in **Table 1**. Despite this, it would be naive to think that their decision was taken purely because of this frustrated directive, especially if we take into account that the first reforms were not undertaken until 1994. However, it is fair to consider the EC proposal as the first important attempt to achieve a general reduction of BAC limits to 0.5 mg/ml across Europe.

Table 1. Changes adopted in illegal BAC limits. EU15 (1991-2003).

Country	Changes in illegal BAC limits during 1991-2003	BAC limit (mg/ml) in 2006
Austria	January 1998	0.5
Belgium	December 1994	0.5
Denmark	March 1998	0.5
France	July 1994 / August 1995	0.5
Finland	-	0.5
Germany	April 1998	0.5
Greece	March 1999	0.5
Luxembourg	-	0.8
Ireland	April 1994	0.8
Italy	July 2002	0.5
Netherlands	-	0.5
Portugal	-	0.5
Spain	May 1999	0.5
Sweden	-	0.2
United Kingdom	-	0.8

The first two countries that decided to reduce their BAC limits to the level proposed by the Commission were Belgium and France, in 1994 and 1995

[8] This proposal was rejected by the Council of Transport Ministers in 1989 since the member states that opposed the proposal (the United Kingdom, the Netherlands and Germany) claimed that the Community had no power to enforce the legislation and no sound justification.

respectively. In April 1997, the European Commission launched a new programme to promote road safety in the European Union which included the revival of the 1988 draft.[9] Again, the programme called for a reduction of the illegal BAC limits in those member states that still maintained levels above 0.5 mg/ml, but in this case the legislation would be passed at a national level.[10] This initiative was more successful than the 1988 draft because five countries (Austria, Denmark, Germany, Spain and Greece) decided to join to the 0.5 mg/ml group during the first two active years of the programme, which was clear evidence of a convergence towards a common illegal BAC level.

The most recent attempt was made in 2001 when, still in the last year of the above programme, the European Commission published a recommendation that pursued the same objectives and included the reduction of illegal BAC limits as one of the most important measures to promote road safety. In this recommendation the Commission set the recommended BAC limit for the European Union at 0.5 mg/ml.[11] Moreover, it pointed out that almost all members had already introduced the proposed limit. In these cases the Commission asked countries to continue the tendency and reduce the limit as much as possible. The remaining member states were invited to at least join the group at 0.5 mg/ml. Italy was the only remaining member that reduced its illegal BAC limit after the EC recommendation while Ireland, Luxemburg and the United Kingdom preferred to keep the limit at 0.8 mg/ml. Nevertheless, they are currently engaged in an ongoing public debate of the issue.[12]

---

[9] Promotion of road safety in the European Union 1997-2001. COM(97)131.

[10] The Commission was probably aware of the opposition of some members to passing a new Directive.

[11] EC Recommendation 2001. Official diary L 43, 14/02/2001.

[12] In Table 1 we can observe that a change was introduced in Ireland twelve years ago. Ireland had a higher illegal BAC level before 1994 and decided to lower it to 0.8 mg/ml. Although there is some debate in the country about the benefits of lowering it again, no decision has been taken as yet.

As a result of the above above, 12 member states of the former EU15 now have a permitted BAC level equal to or lower than 0.5 mg/ml.[13] Three countries had already met this condition before 1991 and eight introduced changes to their national legislation between 1991 and 2003 to enjoy the same situation.

Finally, it is worth noting that, in addition to the initiatives at EC and national level, a regional peer effect seems to have contributed to the expansion of the policy if we look at the chronology shown in **Table 1**. Limits were lowered to 0.5 mg/ml in Belgium and France between 1994 and 1996, while the Netherlands had already established this limit. Austria, Germany and Denmark also coordinated their limits during the same year. Finally, the Mediterranean countries – Greece, Spain and Italy – were the last group to reduce BAC limits and set the common BAC limit in 1999.[14] The United Kingdom and Ireland never reduced their limits to the recommended value, whereas Sweden and Finland had maintained a strict policy with regard to low BAC limits for a long time prior to 1991.

In conclusion, we have seen how European countries have individually decided to set their illegal BAC limits to 0.5 mg/ml as part of the national legislation but inspired by the work of the European Commission. A peer effect between neighbouring countries also seems to have had an influence. This

[13] The only country that established a lower BAC limit is Sweden which, having set a level of 0.5 mg/ml in 1957, decided to implement a further reduction to 0.2 mg/ml in 1990. Portugal also reduced the limit in 2001 to enforce zero consumption, although after one year the 0.5 mg/ml level was reinstated because of economic pressure and a lack of significant effectiveness.

[14] Spain and Greece also lowered their illegal BAC limits in 1999 to 0.5 mg/ml. Portugal and France already had this limit.

process, which began in the middle of the previous decade, has almost reached completion and only three countries have yet to join the initiative.

3. Related literature.

Road accidents and their repercussions have long been addressed in economic literature. Recent studies usually aim to evaluate the effectiveness of public policies and regulations in reducing road fatalities. Mandatory seat belt laws, vehicle safety inspections or speed limits are some recurrent examples. However, in this study we focus on those policies and regulations aimed at reducing alcohol-related road fatalities.

It is socially accepted that alcohol consumption is one of the main determinants of road accidents. The economic and medical literature also supports this theory. Levitt and Porter (1999), Moskowitz and Fiorentino (2000), Zador et al. (2000), Compton et al. (2002) and Keall et al. (2004) are just some of the recent examples of scientific studies and medical reviews that prove the negative effects of alcohol consumption on driving ability. As a result, policies designed to combat the problem of drunk driving have become increasingly important in the last two decades and are a favourite target for policy evaluators.

Some researchers analysed several alcohol-related laws and facts. Baughman et al. (2001) and McCarthy (2003), for example, studied the importance of alcohol availability and alcohol access laws on road safety output. Saffer (1997) studied the role of alcohol advertising as a contributing factor in road fatalities while alcohol taxes were also studied by Ruhm (1996) and Benson et al. (1999). Finally, Chaloupka and Saffer (1989) analysed the use of breath-testing as a deterrent against drunk driving.

In addition to the above considerations, the minimum legal drinking age (MLDA) laws and illegal BAC limits are the two types of regulation most commonly addressed in the literature. The concern caused by the huge amount of alcohol-related accidents involving young drivers and recent regulatory changes in the USA could explain the particular importance that is now afforded to this type of legislation.[15]

The literature on the effectiveness of BAC changes has shown mixed results. As Eisenberg (2003) points out, this is unsurprising if we consider the limitations and varying levels of accuracy in these studies.[16] **Table 2** shows some of the most relevant previous studies. Most of these suffered from weak research design, small samples, comparison problems and limited data, which made it impossible to draw solid conclusions. Others analyse post-policy periods that are too short or fail to control for simultaneous policies that can influence the real effectiveness of lowering illegal BAC levels. In addition, few studies attempted to control for unobserved characteristics that can vary from one state to another by using a wide set of explanatory variables. However, it is impossible to capture all of the heterogeneity by including a large number of covariates. Therefore, none of the studies manages to make a robust evaluation of the issue due to at least one of the above problems.

[15] Cook and Tauchen (1984), Asch and Levy (1990), DuMouchell et al. (1987), Saffer and Grossman (1987) and Wagenaar (1993) are just some of the interesting studies and reviews of the evaluation of changes to the MLDA in the USA. The results usually support the introduction of higher a MLDA.

[16] See Fell and Voas (2003) for a literature review on the evidence of lowering BAC laws.

In contrast, Dee (2001) and Eisenberg (2003) do not suffer from the same drawbacks and, to my knowledge, represent the most technically rigorous and accurate studies published to date. They use a large panel of annual state-level data covering the period 1982-2000 for US states and introduce fixed effects to capture the unobserved heterogeneity.[17] Moreover, several concurrent policies (minimum legal drinking age, seatbelt laws, license revocation, etc.) are introduced in the analyses to avoid other contributing factors that could bias the estimates. Other time varying covariates such as unemployment and vehicle-miles driven are also used. In both studies the results seem to bear out the effectiveness of lowering illegal BAC levels to 0.8 mg/ml in the USA.[18] Dee (2001), for example, finds that the new illegal BAC level causes a reduction of 7.2% in the total fatality rate, while Eisenberg (2003) observes a reduction of 3.1% in the total fatal crashes. The policy seems to be particularly effective in reducing fatalities among young drivers, at weekends and at night. The last contribution made by Eisenberg (2003) was the evaluation of the time taken for the effects of the policies to be observed. He found that the effectiveness of the measures was noted after a significant delay of six years, which does not strictly contradict the main result but introduces some doubts about how the policy works.

Despite being the most relevant studies published to date, Dee (2001) and Eisenberg (2003) did not take into account the possible serial correlation that can arise when using differences-in-differences methods with a large panel and a highly time-correlated dependent variable. As a result, their estimates could

[17] Cook and Tauschen (1984) and Evans and Graham (1988), to my knowledge, are probably the first studies to introduce fixed effects in the road safety literature. Ruhm (1996), for example, shows the goodness of this methodology in the evaluation of road safety measures.

[18] They also find the implementation of 1.0 BAC limits in places with no previous BAC legislation to be statistically effective. Eisenberg (2003) finds a higher effect associated with the 0.8 BAC level.

be downwardly biased – as is explained in Bertrand et al. (2004) – and overestimate the effectiveness of the policy. Later in this research I try to correct this problem by allowing for any pattern of correlation.

All of the above studies focus on the reduction of illegal BAC limits to the level of 0.8 mg/ml. This study attempts to evaluate the next step: the transition to 0.5 mg/ml. Unfortunately, there is far less literature available on 0.5 BAC limits. Essentially, a large proportion of these studies are simply national or regional reports that support the reduction of illegal BAC limits by comparing pre-post statistical data. Other scientific studies exhibit the same technical limitations as mentioned for the above studies of the 0.8 mg/ml limit. From this group of studies of the 0.5 mg/ml BAC limit, several should be mentioned, including Henstridge et al. (1997) for Australia, Bartl and Esberger (2000) for Austria, Bernhoft (2003) for Denmark, Mercier-Guyon (1998) for France, and finally Noordzij (1994) for the Netherlands. None of these works uses an international European panel to study this transition, which means that the present research can fill an important gap in the evaluation of such an interesting policy.

To conclude this section, I wish to highlight the main contributions of this study to the literature: firstly, this research is the first to estimate the effect of lowering illegal BAC limits in Europe by using panel-based data from former EU15 countries and fixed effects; secondly, it is the first study to take into account serial correlation in estimating the effect of changes to illegal BAC limits, which prevents the overestimation that commonly affected previous studies.[19]

[19] However, this is not the first study to control for serial correlation in the road safety literature. Dee and Sela (2003) was, to our knowledge, the first study that used this estimation strategy in evaluating speed limit changes in the USA.

Table 2. Previous literature evaluating the 0.8 mg/ml BAC limits.

Study	Location	Results
NHTSA (1991)	State of California (USA)	12% reduction in alcohol-related fatalities
NHTSA (1994)	Five States (USA)	Significant reductions in alcohol involvement
Johnson and Fell (1995)	Five States (USA)	Significant reductions in alcohol-related fatal crashes in 4 states
Rogers (1995)	State of California (USA)	Mixed Results
OTS (1995)	State of California (USA)	Mixed results
Hingson et al. (1996)	Five States (USA)	Reduction in alcohol involvement
Foss et al. (1998)	State of North Caroline (USA)	No clear effects
Apsler et al. (1999)	11 States (USA)	Significant reduction in alcohol involvement only in two states
Hingson et al. (2000)	Six States (USA)	6% reduction in alcohol-related fatal crashes
Voas et al. (2000)	50 States and District of Columbia (USA)	Reduction in alcohol involvement
Shults et al. (2001)	50 States (USA)	7% reduction in measures of alcohol-related fatal crashes
Dee (2001)	48 States (USA)	7.2% reduction in the total fatality rate
Eisenberg (2003)	50 States and District of Columbia (USA)	3.1% reduction in fatal crash rate

Source: Table adapted from Fell and Voas (2003). NHTSA: National Highway Traffic Safety Administration (USA).

4. Empirical strategy.

This study uses several fatality rates for the former EU15 members for the period 1991-2003 to evaluate the impact of reducing illegal BAC limits in some countries. The method chosen is a slight extension of the differences-in-differences estimation procedure specified as a two-way fixed effects model that takes the following form:

$$Y_{st} = X_{st}\beta + \delta Z_{st} + w_s + v_t + \varepsilon_{st} \qquad \textbf{(1)}$$

where $\boldsymbol{Y_{st}}$ is the chosen dependent variable (fatality rate), $\boldsymbol{X_{st}}$ contains the vector of time-varying control covariates and $\boldsymbol{Z_{st}}$ is the policy dummy variable being evaluated; $\boldsymbol{w_s}$ and $\boldsymbol{v_t}$ are state-specific and year-specific fixed effects and ε_{st} is a mean-zero random error. State fixed effects control for time-invariant state-specific omitted variables and year dummies control for national trends. The key element of this difference-in-difference model is the parameter **δ**, which measures the difference between the average change in the fatality rates of the treatment group (countries that have a BAC level of 0.5 mg/ml or lower at some point during the period studied) and the average change in the fatality rates of the control group (those countries that maintained a higher BAC level).

Specifically:

$$\delta = [\, E(Y_A / G = 1) - E(Y_B / G = 1)] - [\, E(Y_A / G = 0) - E(Y_B / G = 0)] \qquad \textbf{(2)}$$

where $\boldsymbol{Y_B}$ and $\boldsymbol{Y_A}$ denote the road fatality rate before and after the reform and $\boldsymbol{G = 1}$ and $\boldsymbol{G = 0}$ denote treatment and control group observations, respectively.

One of the most basic assumptions of differences-in-differences models is that the temporal effect in the two groups of states is the same in the absence of intervention. This is called the *fundamental identifying assumption* and is described as the equality between average changes in the two groups in the pre-treatment period. Like Galiani, Gertler and Schargrosdky (2005), this study tests for the equality between average changes in the two groups in the pre-treatment period to assess the plausibility of the fundamental identifying assumption. This type of test is notable for its absence from the literature in which differences-in-differences are used.

The strategy consists in considering only the pre-treatment years from each treated country, excluding observations from treated years. In addition, the observations from each control country for the whole period are added.[20] Once the observations of interest have been determined equation **(1)** is estimated, but now with two important changes. First, separate time dummies are used for treatment and control countries as they allow us to check whether the time trends in the pre-treatment period were the same; second, the policy dummy variable is omitted. Hence, the final estimated model is the following:

$$Y_{st} = X_{st}\beta + w_s + v_t^C + v_t^T + \varepsilon_{st} \qquad \textbf{(3)}$$

where $\boldsymbol{v}_t^C$ and $\boldsymbol{v}_t^T$ denote year-specific fixed effects for control and treated countries respectively. In this case, ***t*** covers the period from 1991 to the last pre-treatment year in the case of treatment countries **(*T*)** and to 2003 for control countries **(*C*)**. The results of the test tell us that we cannot statistically reject the hypothesis of having the same time trends in the pre-treatment period for

[20] The whole period can be used for the control countries because some countries that still maintain high BAC limits (United Kingdom, Ireland and Luxembourg) did not change the relevant legislation during the period considered.

control and treatment groups and, according to Heckman and Hotz (1989), this validates the main differences-in-differences identifying assumption. The results of this test can be found in the appendix (**A1**).

Another concern when using differences-in-differences to evaluate the impact of a given policy on heterogeneous individuals is to ensure that there is no endogeneity that may bias the policy effects. Bertrand et al. (2004) points out that differences-in-differences models can prevent many of these endogeneity problems but that they may still constitute an important limitation. As Besley and Case (2000) states, policy change is purposeful action and can rarely be treated as experimental data. Therefore, further research is needed to understand the motives behind the respective policies of each studied case.

In the present case it is not possible to test a policy equation, but we can attempt to determine whether there is any pattern in the evolution of fatality rates and the decision to lower illegal BAC levels. It would be reasonable to assume that those countries which adopted the policy may have recorded high fatality rates in their recent past.

The rates of variation constructed taking into account the last pre-treatment years for each country are shown in **Table 3** and indicate that we cannot clearly identify the pattern. In fact, only a few countries set new illegal BAC levels after recording positive rates of variation in the last pre-treatment years. However, it is true that the rate of change observed for the last pre-treatment year is slightly lower than the annual average change since 1991 in most of the countries studied. Nevertheless, all countries except Spain and Greece show good results for the last two years, which suggests that governments are unlikely to have considered what happened in the most recent period to be an important trend change. Moreover, only Austria and Spain recorded a dramatic rise in the fatality rate in the last pre-treatment year. Consequently, it seems to be an over-generalisation to believe that BAC limits were lowered because of major incidents in the period immediately prior to the change.

Table 3. Rates of change in the fatality rate before the introduction of the 0.5 mg/ml BAC limit (treated countries).

Country	Change Last Year[1]	Change Last Two Years[2]	Annual Average Change since 1991[3]
Austria	7%	-9%	-6%
Belgium	-1%	-12%	-6%
Denmark	-5%	-17%	-4%
Germany	-3%	-10%	-5%
Greece	3%	1%	0%
Spain	6%	8%	-5%
France	-2%	-10%	-5%
Italy	0%	5%	-2%

1. Change in the fatality rate observed in the last year before setting the 0.5 BAC limit.
2. Change in the fatality rate observed in the last two years before setting the 0.5 BAC limit.
3. Average rate of variation in the fatality rate from 1991 until the year in which the limit was introduced.

Two other possible explanations are the peer effect expansion and the role of the European Union and its campaign against road fatalities. The detailed description of the legal chronology given in the previous section shows a probable regional influence on the decision to set new illegal BAC limits. However, we cannot overlook the involvement of the European Commission and its programme to promote road safety launched in 1997, which proposed the 0.5 BAC limit and was followed by several countries. The two explanations do not represent an endogeneity problem and cannot lead to misleading conclusions.

In the last effort to overcome the problem of endogeneity, I follow the strategy of Eisenberg (2003) and check the time pattern with which the effects of the policy were noted with respect to the date of adoption. This is intended to address unobserved factors like attitude shifts that can be partly responsible for the enactment of stricter policies. This test consists of the same basic model **(1)** introduced above but which now considers binary variables related to the length of time from the year in which the policy was adopted instead of the policy dummy. The results of the test can be found in the appendix **(A2)** and show that no significant time patterns can be observed before the enactment of the new policy.

Finally, Bertrand et al. (2004) find that most studies that employ differences-in-differences estimation ignore serial correlation problems even when they use data from a large number of years and dependent variables that are likely to be serially correlated.[21] We cannot forget that the estimated effect of the policy is the common OLS estimate. This generates standard errors that severely underestimate the standard deviation of the differences-in-differences estimator in the presence of serial correlation. In order to correct this bias Bertrand et al. (2004) propose different solutions that are applied according to the characteristics of the sample. Given the number of states in this study, the method that performs better according to their Monte Carlo simulations is to allow for an arbitrary variance-covariance matrix.[22] Therefore, the results shown below take into account not only heteroskedasticity but also serial correlation within states, and this represents a significant difference between this study and the most advanced literature focused on the evaluation of BAC

[21] Three contributing factors can be found in Bertrand et al. (2004): long time series, serial correlated dependent variables and a treatment variable that changes very little within a state over time.

[22] See Bertrand et al. (2004) for a summary of their Monte Carlo simulations for different numbers of states.

laws.[23] As is well known, this method is based on the estimation of the variance-covariance matrix allowing for all arbitrary of correlation. This estimator takes the following form:

$$V = (X'X)^{-1} \left(\sum_{i=1}^{N} u_i' u_i\right) (X`X)^{-1} \qquad \textbf{(4)}$$

$$u_i = \sum_{t=1}^{T} e_{it}\, x_{it}$$

where V is the variance-covariance estimator, X is the matrix of independent variables, N is the number of groups (states), e_{it} is the state-year specific residual and x_{it} is the vector of independent variables.[24, 25]

Having carried out all of these checks to prevent possible obstacles and problems, in the following section I shall explain the data and variables used to estimate the model presented.

5. Data and variables employed.

This research is based on the European database CARE (*Community database on Accidents on the Roads in Europe*), which started collecting data in 1993 and provides information on annual road casualties reported by the countries that make up the EU25.[26] The EC created this Community database on road safety outputs (fatality Rates, total Fatalities, total Injuries, etc.) in order to

[23] The same strategy is used by Dee and Sela (2003) in the evaluation of changes in speed limits, as mentioned in note 15.

[24] In fact, this is known as the White-like formula to compute standard errors (White, 1984). Also see Arellano (1987) for a more in-depth understanding.

[25] Since this method is only valid asymptotically, we apply the finite sample adjustment used by STATA: N-1/(N-k) * M/(M-1), where N is the number of observations, k the number of regressors including the constant and M the number of clusters.

[26] This database can be consulted on-line at: http://ec.europa.eu/transport/roadsafety

identify and quantify road safety problems in Europe.[27] Therefore, CARE contains state-level data for the period from 1991 to 2004 for the EU25 countries. However, we are interested here in the homogenisation of illegal BAC limits which occurred during the last decade, just before the enlargement of the European Union. For this reason I use only data related to the former EU15 countries. In addition, I only use data up for the period until 2003 because the rest of the variables are not always available for that final year. As a result, the sample in this study is based on 15 countries over a period of 13 years for the total fatality rates (195 observations).

The most useful characteristic of the CARE database is its high level of disaggregation, which makes it possible to use different fatality rates taken from several victim groups. The available groups are divided according to gender, age, area and type of road user (driver, passenger or pedestrian). Unfortunately, CARE does not contain disaggregated data for Germany. Therefore, 14 countries are used in the analysis of disaggregated dependent variables (182 observations).

The rest of the variables are found in international databases such as Eurostat, WHO Europe, World Bank Development Indicators and the World Road Statistics. The policy variables used are found in national and European reports. **Table 4** shows the explanatory variables used in this research and their descriptive statistics for the whole sample.

Several dependent variables are used depending on the age group and gender of the victims and the areas where they were killed. These dependent variables are simply the fatality rates per 100,000 inhabitants in each population

[27] Council Decision 93/704/EC.

group or the fatality rate per 100,000 km driven.[28] Unfortunately, CARE does not contain the latter type. To compensate for this absence and compare the two rates – at least for the aggregated rates – I use data that are available in the WHO database for Europe.[29]

Before considering the control variables it is worth noting that the inclusion of a large number of socioeconomic covariates removes the confounding factors that can bias the impact of the policy by keeping them constant and can also provide a better understanding of which factors may influence the number of road fatalities in Europe.

In Ruhm (1996) we saw that macroeconomic variables can help to improve the present estimation, since road fatalities and alcohol consumption are usually procyclical.[30] To account for the economic cycle I include unemployment and economic growth rates.

In addition to macroeconomic variables, I include more covariates that are related to transport and the use of vehicles. These variables are motorisation and vehicle-km. I also include infrastructure variables to account for the possible effect of road quality and characteristics on driving. These variables are motorways and national roads (% of the total road network) and are not usually included in the literature. The educational background of the population between 15 and 64 years old is also taken into account as an additional socioeconomic covariate.

---

[28] According to Eisenberg (2003), the literature traditionally uses these fatality rates as output measures because of their accuracy and importance for policy makers.
[29] World Health Organization Regional Office for Europe (HFA-DB Database).
[30] See Evans and Graham (1988) and Ruhm (1995) for a more in-depth discussion of these relationships.

The last group of covariates is made up of the binary regulatory variables. Ruhm (1996), Dee (2001) and Eisenberg (2003) show that it is important to introduce different laws related to road fatalities in order to prevent the confounding effects that may arise in the evaluation of a particular policy if other legal reforms were undertaken simultaneously. The minimum legal drinking age (MLDA) and the points license are therefore introduced as potentially simultaneous policies. The first takes a value of 1 for states in years when there is a clear minimum legal drinking age for purpose and non-purpose drinking for all alcoholic beverages, and 0 otherwise. The second covariate takes a value of 1 in state-years in which the system of points-based driving licenses is in effect, and 0 otherwise. Although other potentially relevant policies could be included, it is important to maintain a degree of freedom. The choice of these two policies is arbitrary but follows the general criteria of being comparable across states, manageable given the differences in national legislations, and affected by within-group variation in some countries for the period studied. Additionally, policies that were uniformly identified in the literature as having no impact on road fatalities or present mixed results were discarded. The use of the points license as a simultaneous policy variable is particularly interesting because it is essentially a European policy that has been introduced recently in some countries and which has not been studied in depth as yet.

Finally, the key policy variable that is expected to be essential in evaluating the effectiveness of lowering legal limits of blood alcohol content is called BAC0.5. This variable takes a value of 1 in states and years when a country has an illegal BAC limit of 0.5 mg/ml or lower, and 0 when this limit is

Table 4. Explanatory variables. Definitions and descriptive statistics

Explanatory variables	Description	Mean	S.D.
Unemployment Rate	Unemployment rate in %.	8.748	4.296
Growth Rate	Rate of change (%) of the real GDP, PPP$ per capita.	2.750	2.617
Motorization	Number of passenger cars per 1000 inhabitants.	418.536	93.768
Vehicle-km driven	Annual number of passenger cars-km expressed in billion km and weighted by the national population.	9.146	2.452
Upper Secondary Education	% population between 16-64 years old with upper secondary education.	55.911	18.270
Motorways	Proportion in % of motorways (km) in the total road network.	1.312	0.935
National Roads	Proportion in % of national roads (km) in the total road network.	8.942	5.105
Minimum Legal Drinking Age	Binary variable: **1** for purpose and non-purpose minimum legal drinking age for all beverages. **0** Otherwise.	0.592	0.491
Points License	Binary variable: **1** for countries with a driving license governed by a points system. **0** Otherwise.	0.174	0.377
Random Checks	Binary variable: **1** for countries that allow random breath or blood tests on the road. **0** Otherwise.	0.779	0.416
BAC05	Binary variable: **1** countries with an illegal BAC limit of 0.5 mg/ml or lower. **0** for higher illegal BAC limits.	0.504	0.495
BAC05 + Random Checks	Binary variable: **1** for countries that allow random checks and maintain an illegal BAC level of 0.5 mg/ml. **0** Otherwise.	0.496	0.497

higher.[31] A fractional correction is applied for cases in which the policy was implemented at some point during the same year. Dee (2001) explains that it is not only important to control for the policy of evaluation, but also for the level

[31] It is important to point out that Sweden, for example, has a BAC limit of 0.2 mg/ml for the whole time series and Portugal has the same BAC limit in 2001. These facts justify the decision to control for BAC levels of 0.5 mg/ml or lower.

of enforcement that exists. The variable Random Checks is therefore used to control for the enforcement of this policy. Random Checks identifies countries that authorise and carry out random breath tests on the road. In addition, I also create a new binary explanatory variable that is formed by the interaction between lowered BAC limits and random checks to record whether the policy has a different impact when accompanied by a reasonable level of enforcement activity.

It is interesting to note that alcohol consumption is not included in this part of the study, despite its obviously strong impact on road fatalities, because it is directly affected by the regulation under evaluation. It is suggested later in the paper that the success of lowering BAC levels may be due mainly to the effect of this change on alcohol consumption in the studied countries.

6. Main results.

The estimation results for the total fatality rates are shown in **Table 5**. Specifications **(1)** and **(2)** show that the coefficients associated with the 0.5 mg/ml BAC limit are not significant for either the total fatality rate per unit population or the total fatality rate per km driven. In contrast, when the key policy variable is the interaction between BAC limits and Random Checks in models **(3)** and **(4)**, there is a significant negative impact, even at a 5% significance level in the latter model. This suggests that lowering BAC levels does not have a global impact unless the regulation is enforced in practice by random road checks. Therefore, when these two regulatory measures are combined both fatality rates seem to decrease considerably. The fatality rate per unit population decreases by 4.3%, while the fatality rate per km driven falls 6.1%.

Macroeconomic variables do not seem to have a strong influence on road fatalities in Europe. Only growth rates seem to have an impact on fatality rates with specifications **(1)** and **(3)**, but their significance decreases when the dependent variable is the fatality rate per km driven, as shown in models **(2)** and **(4)**. Unemployment rates also seem to have no significant impact. Therefore, while the procyclical effect of road fatalities cannot be ruled out, it does seem to be weaker than expected.

In contrast, the coefficient associated with the level of motorisation in the respective countries is highly significant in all specifications. It is worth noting that its negative sign can be explained by the level of transport development in the country. There is a significant negative correlation between development and number of accidents, since more developed countries usually have better infrastructures, safer cars, clearer regulations and a greater frequency of police intervention. Therefore, the number of cars per 1000 inhabitants may be considered as a proxy for the level of transport development.

Interesting results are obtained regarding the road infrastructure variables. The coefficient associated with motorways – the best type of road and therefore the safest – is always strongly significant across all specifications and has a negative sign. Moreover, national roads – roads of lesser quality than motorways but on which drivers still travel at high speeds – have a positive sign and a significant coefficient in models **(2)** and **(4)**. This result suggests that the quality and characteristics of the road system also influence the success of BAC policies.

Table 5. Least-squares estimates for semi-log models. Total fatality rates.

Independent variables	TFR per 100,000 population (1)	TFR per 100,000 km driven (2)	TFR per 100,000 population (3)	TFR per 100,000 km driven (4)
BAC0.5	-0.0339 (0.0271)	-0.0429 (0.0338)	-	-
Random Checks	-0.0040 (0.0758)	0.0861 (0.0731)	-	-
BAC0.5 + Random Checks	-	-	-0.0426* (0.0228)	-0.0612** (0.0220)
Points License	0.00556 (0.0411)	-0.0618 (0.0533)	0.0072 (0.0402)	-0.0612 (0.0503)
MLDA	-0.0121 (0.0215)	0.0059 (0.0235)	-0.0102 (0.0197)	0.0064 (0.0197)
Unemployment rate	-0.0032 (0.0030)	0.0009 (0.0039)	-0.0032 (0.0032)	0.0009 (0.0044)
Growth rate	0.0091* (0.0049)	0.0064 (0.0059)	0.0093* (0.0046)	0.0057 (0.0054)
Motorization	-0.0019** (0.0006)	-0.0040*** (0.0003)	-0.0019*** (0.0006)	-0.0041*** (0.0003)
Vehicle-km	0.0381 (0.0436)	-	0.0381 (0.0433)	-
Upper Sec. Education	0.0046 (0.0030)	0.0065* (0.0036)	0.0045* (0.0024)	0.0072** (0.0032)
Motorways	-0.0478*** (0.0103)	-0.0464*** (0.0124)	-0.0455*** (0.0099)	-0.0372*** (0.0109)
National Roads	0.0033 (0.0023)	0.0040* (0.0021)	0.0032 (0.0022)	0.0032* (0.0017)
R-sq	0.81	0.93	0.80	0.93

Standard errors are given in parenthesis to allow for clustering by country. Each model also includes time and state fixed effects and a constant term.* Statistically significant at 10% level; ** at 5% level and *** at 1% level.

Finally, the upper secondary education variable is significant in all models except specification **(1)** and has a positive impact. One possible explanation is that more educated people tend to travel more often and have more leisure time. This would act as a proxy for income, which, in the literature, is generally found to be positively related to accidents because of the positive correlation between income and both alcohol consumption and vehicle use.

Recent studies on road fatalities such as Eisenberg (2003), Dee and Sela (2003) and Grabowsky and Morrisey (2004), have analysed the impact of road safety measures on different victim groups. I also follow this strategy by dividing victims into groups according to age and gender. With the CARE database it is also possible to include the difference between urban and non-urban fatalities to establish in which type of area the policy has been most effective. **Table 6** shows the results of applying specifications **(1)** and **(3)** to each age group. Lowering BAC limits seems to be effective for people aged between 20 and 49. A reduction of approximately 10.5% is found in the number of victims aged between 20 and 40 and a reduction of 8% is found for the 40-50-year-old age group. Older groups do not seem to be affected by the change in the policy.

Table 7 shows the results for gender groups and areas.[32] Men seem to be affected by the policy, which causes a decrease of 5.7% in the corresponding fatality rate for this gender group. In contrast, the policy seems to have no impact on the number of female fatalities, possibly because this group already showed a higher level of compliance with existing laws.

---

[32] Models **(1)** and **(3)** are also applied here but Motorways and national roads are dropped out when we study urban fatalities.

Table 6. Least-squares estimates for semi-log models. Age group fatality rates (selected results).

Independent variables	Age Group 20-29 (5)	Age Group 30-39 (6)	Age Group 40-49 (7)	Age Group 50-59 (8)
BAC0.5	-0.1050* (0.0515)	-0.1043** (0.0400)	-0.0819* (0.0422)	-0.0965 (0.0656)
BAC0.5 + Random Checks	-0.0992* (0.052)	-0.1077** (0.0396)	-0.0823* (0.0417)	-0.0862 (0.0620)

Independent variables	Age Group 60-69 (9)	Age Group 70-79 (10)	Age Group +70 (11)	Age Group + 80 (12)
BAC0.5	0.0153 (0.0638)	0.0378 (0.035)	-0.0767 (0.0968)	-0.0068 (0.0842)
BAC0.5 + Random Checks	0.0170 (0.0651)	0.0424 (0.0332)	-0.0680 (0.0829)	0.0075 (0.0877)

Each model include the rest of the explanatory variables, time and state dummy variables and a constant term. Standard errors allowing for clustering by country are given in parenthesis.

When we introduce the area in which the accident occurred, no difference is observed until this information is combined with gender, which in turn indicates that only one group is affected by the policy: men in urban areas. The estimated decrease in fatalities is 9.5 or 10.9%, depending on the BAC variable used, as shown in **Table 7**. However, no impact is observed in non-urban areas. This could be explained by the fact that non-urban fatalities can be caused by other problems that are more closely related to speed, tiredness and road characteristics. These factors are more likely to influence non-urban driving, since in urban areas vehicles generally travel at lower speeds and the characteristics of the roads are more homogeneous.

Table 7. Least-squares estimates for semi-log models.

Gender and area fatality rates (selected results).

Independent Variables	**Male Total Fatalities (13)**	**Female Total Fatalities (14)**	**Non-Urban Total Fatalities (15)**	**Urban Total Fatalities (16)**
BAC0.5	-0.0573* (0.0317)	-0.0250 (0.0407)	-0.0362 (0.0573)	-0.0470 (0.0413)
BAC0.5 + Random Checks	-.0574* (0.0313)	-0.0232 (0.0394)	-0.0310 (0.0425)	-0.0678 (0.0405)
Independent Variables	**Male Non-Urban Fatalities (17)**	**Male Urban Fatalities (18)**	**Female Non-Urban Fatalities (19)**	**Female Urban Fatalities (20)**
BAC0.5	-0.0470 (0.0361)	-.0959** (0.0419)	-0.0362 (0.0573)	-0.0205 (0.0603)
BAC0.5 + Random Checks	-0.0351 (0.0402)	-0.1094** (0.0463)	-0.0240 (0.0601)	-0.0240 (0.0601)

Each model includes the rest of the explanatory variables, time and state dummy variables and a constant term. Standard errors allowing for clustering by country are given in parenthesis. The variable Motorways is excluded from the models that treat urban road fatalities.

Finally, I evaluated a new combination of age groups and area but, as shown in the Appendix **(A3** and **A4)**, no stable results are found, with the exception of young groups in urban areas, where the policy is seen to have a strong impact. **Table 8** shows the results for the young age group by area.

After identifying the affected groups, the next interesting aspect is the time-scale in which the effects of the policy are produced. Eisenberg (2003) introduced this analysis in the literature and found a significant lag of at least six years. In the present study I replicate the strategy by using binary time

Table 8. Least-squares estimates for semi-log models. Age group 20-29 and area fatality rates (selected results).

Independent Variables	Non-Urban Age 20-29 (25)	Urban Age 20-29 (21)
BAC0.5	-0.0341 (0.0561)	-0.2830** (0.0972)
BAC0.5 + Random Checks	-0.0341 (0.0561)	-0.2947** (0.1031)

Two-way fixed effects estimation. The model includes a constant term and the rest of the covariates used in previous specifications, with the exception of infrastructure variables in the case of urban fatality rate. Cluster-robust standard errors in parenthesis.

variables instead of the 0.5 BAC policy. These new dummies are constructed as time intervals that account for the time elapsed after the new legislation was adopted. Because of data constraints I define two periods. The first, which takes value one in state-years from 0 to 2 years after the enactment and zero otherwise, is thought to identify short-term effects. The second, which takes value one from the third year after policy introduction and zero otherwise, captures the long-term effects. Therefore, the procedure is only applied to those models in which the 0.5 BAC policy was observed to be effective in the previous estimations.

The results shown in **Table 9** seem to suggest that lowering BAC levels is not generally effective in the short term. It seems that a period of more than two years is required before the effects of the policy are observed. A short-term effect can be observed among mal drivers in urban areas, but the coefficient for the long-term period is also significantly higher. Although a significant delay is observed, the results of this study are less surprising than the 6-year delay obtained by Eisenberg (2003). However, it must be recognised that these results only imply that the policy can start to have an effect in the third year, and it is impossible to be certain that the effects are not produced later due to the time intervals I have used.

In summary, we have seen that lowering illegal BAC limits has proved to be an effective policy for the whole population when it is accompanied by random road checks. Moreover, in disaggregated cases, we have determined that male and young drivers, particularly in urban areas, are clearly affected by the policy. The remaining drivers, aged between 30 and 49, also indicate a positive impact of the lower BAC levels. However, the effectiveness of the policy is not usually apparent in the short term. The other victim groups do not seem to benefit from the policy.

Table 9. Time delay in the effectiveness of lowering illegal BAC levels (selected results).

Independent variables	**Total Fatalities (21)**	**Males (22)**	**Males in Urban Areas (23)**
After 0-2 years	0.0059 (0.0234)	-0.0141 (0.0287)	-0.0730** (0.0327)
After +3 years	-0.0455* (0.0256)	-0.0683** (0.0299)	-0.1013* (0.0485)
Independent variables	**Age Group 20-29 (24)**	**Age Group 30-39 (25)**	**Age Group 40-49 (26)**
After 0-2 years	-0.0543 (0.0469)	-0.0288 (0.0250)	-0.0149 (0.0506)
After +3 years	-0.1322** (0.0505)	-0.1568*** (0.0515)	-0.0923** (0.0413)

The same previous models are applied substituting the BAC policy variables with time interval dummies. Cluster-robust standard errors are shown in parenthesis. * Statistically significant at the 10% level; ** at the 5% level and *** at the 1% level.

7. Serial correlation treatment.

In Section 5 I argued that disregarding the effect of serial correlation can sometimes lead to overly optimistic estimates of the effectiveness of the policy using differences-in-differences methods. Consequently, I provide some evidence of this here by determining the results I would have obtained if ignoring serial correlation and basing the estimation only on heteroskedastic-consistent standard errors, as was the case in previous studies.

Table 10 shows the results of this estimation serves as a comparison with **Table 5**. In the hypothetical, the reduction of BAC levels would have appeared to be effective even in countries without random road checks, while we have seen that the policy is only effective when accompanied by random checks. In addition, the coefficient associated with the low BAC policy becomes more significant in those estimations that include an interaction variable that identifies policy and enforcement simultaneously (BAC05+Random Checks). The remaining variables do not change significantly.

When the same strategy is applied to the rest of the fatality rates, those that were shown to be affected in Section 6 now have even more statistically significant coefficients associated with the BAC policy. However, the only fatality rate to change that was not previously affected is that of urban fatalities, while it has been demonstrated the benefits of the policy in these areas are observed only in male drivers. The remaining fatality rates do not change and lead to the same interpretations as in Section 6.

These examples highlight the importance of controlling for serial correlation in order to avoid misleading interpretations when evaluating public policies using differences-in-differences in large panels. In the case studied here, few errors would be created by disregarding serial correlation but they would be sufficient to confound some effects.

Table 10. Least-squares estimates for semi-log models for total fatality rates. White-robust estimation (selected results).

Independent variables	TFR per 100,000 Population (27)	TFR per 100,000 km driven (28)	TFR per 100,000 Population (29)	TFR per 100,000 km driven (30)
BAC0.5	-0.0339* (0.0271)	-0.0429* (0.0338)	-	-
Random Checks	-0.0040 (0.0758)	0.0861 (0.0731)	-	-
BAC0.5 + Random Checks	-	-	-0.0426** (0.0228)	-0.0612*** (0.0220)
R-sq	0.81	0.93	0.81	0.93

Heteroskedastic-consistent standard errors are given in parenthesis. Each model also includes time and state fixed effects, the rest of the covariates and the constant term.

8. Concluding remarks.

The lowering of illegal BAC levels to 0.5 mg/ml has proved to be an effective policy in Europe. However, some further discussion is required. As has been demonstrated in this paper, the policy is not found to be effective for all road users in a country unless it is actively enforced, which is highlighted as an important procedure in any policy or regulatory change. Moreover, the effectiveness of the policy is heterogeneous depending on the age, gender and area of the victim group. Therefore, this can be used by policy-makers as an indication of which groups are more likely to be affected by this and other policies related to drunk driving. However, we have seen that there is usually a delay of more than two years before the positive influence of the policy can be observed, which rules out a short-term effect. Further research is needed to understand this time lag.[33]

It is also important to point out that although the enactment of the policy was found to have positive effects, a cost-benefit analysis is essential in order to determine whether this policy is economically viable. We cannot forget that changing the behaviour of the public in this case can generate a negative impact on several sectors (alcoholic beverages industry, bars and restaurants, nightclubs, etc.).[34] Therefore, we should make sure that predicted costs do not exceed the economic benefits obtained by the policy before recommending this policy to those European countries that still maintain higher illegal BAC limits. This analysis is left for future research.

We have seen the importance of allowing for any pattern of correlation in this kind of estimation in order to avoid misleading interpretations that could affect the degree of effectiveness derived from the analysis. Consequently, I give strong arguments and evidence in favour of reviewing the estimates made in previous literature on BAC policies.[35] By overcoming the problem this research makes a new and useful contribution to the literature.

Finally, I consider that a preliminary debate on the various effects of the policy against drunk driving needs to be launched. This research was motivated by the assumption that by lowering BAC levels it would be possible to reduce

[33] See Eisenberg (2003).
[34] This negative impact can be translated into lower alcohol consumption and, therefore, lower income and probable employment losses.
[35] To my knowledge, Dee and Sela (2003) were the first authors to use differences-in-differences to consider serial correlation in their evaluation of the effectiveness of speed limit changes in the USA.

drunk driving through discouraging alcohol consumption.[36] However, this might not be the only possible effects of the policy. Another feasible consequence could be a reduction in km travelled. This could be caused by increased use of public transport or by changing leisure habits (fewer journeys, more home meetings, walking longer distances, etc.). In the Appendix (**A5**) I present a preliminary test which suggests that people reduce their alcohol consumption when this policy comes into force. However, these preliminary results are not conclusive and, consequently, more robust analyses are needed for them to be confirmed.

References

Apsler, R., A.R.Char, W.M. Harding, and T.M. Klein (1999) "The effects of 0.08 BAC laws", Washington DC, National Highway Traffic Safety Administration.

Arellano, M. (1987) "Computing Robust Standard Errors for Within-Groups Estimators", Oxford Bulletin of Economics and Statistics, XLIX, pp. 431-434.

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

Bartl, G. and R. Esberger (2000) Effects of lowering the legal BAC limit in Austria. In H. Laurell & F. Schlyter (Eds.), "Proceedings of the 15th International Conference on Alcohol, Drugs and Traffic Safety", May 22-26, 2000.

Baughman, R., M. Conlin, C., S. Dickert-Conlin and J. Pepper (2001) "Slippery when wet: The effects of local alcohol access laws on highways safety", Journal of Health Economics 20, pp. 1089-1096.

Benson, B.L., B.D Mast and D. Rasmussen (1999) "Beer taxation and alcohol-related traffic fatalities", Southern Economic Journal, Vol. 66, No. 2, pp. 214–249.

Bernhoft, I.M. (2003) "Effect of lowering the alcohol limit in Denmark", Accident analysis and Prevention, Vol. 35, No. 4, pp. 515-25.

[36] This explains why we did not include alcohol consumption as an explanatory variable in the basic model used to evaluate the effectiveness of BAC policies.

Bertrand, M., E. Duflo and S. Mullainathan (2004) "How much should we trust differences-in-differences estimates", The Quarterly Journal of Economics MIT press, Vol. 119, No. 1, pp. 249-275.

Besley, T. and A. Case (2000) "Unnatural experiments: Estimating the incidence of Endogenous Policies", The Economic Journal, Vol. 110, pp. 672-694.

Chaloupka, F. and H. Saffer (1989) "Breath testing and Highway fatality rates", Applied Economics, Vol. 21, pp. 901-912.

Compton, R.P., R.D. Blomberg, H. Moskowitz, M. Burns, R.C. Peck and D. Fiorentiono (2002) "Paper presented at the Proceedings of Alcohol, Drugs & Traffic Safety – T 2002: 16th International Conference on Alcohol, Drugs & Traffic Safety", August 4-9, 2002, Montreal, Canada.

Cook, P.J and G. Tauchen (1984) "The effect of minimum drinking age legislation on youthful auto fatalities, 1970-1979", Journal of Legal Studies, Vol. 13, pp. 169-190.

Dee, T. S. (2001) "Does setting limits save lives? The case of 0.08 BAC laws" Journal of Policy Analysis and Management, Vol. 20, No. 1, pp. 111-118.

Dee, T.S. and R.J. Sela (2003) "The fatality effects of highway speed limits by gender and age", Economic letters, Vol. 79, pp. 401-408.

DuMouchel, W., A.F. Williams and P. Zador (1987) "Raising the alcohol purchase age: Its effects on fatal motor vehicle crashes in twenty-six states", Journal of Legal Studies, Vol. 26, pp. 249-266.

Eisenberg, D. (2003) "Evaluating the effectiveness of policies related to drunk driving", Journal of Policy Analysis and Management, Vol. 22, No.2, pp. 249-274.

Evans, W.N and J.D. Graham (1988) "Traffic safety and the business cycle", Alcohol, Drugs and Driving, Vol. 4, pp. 31-38.

Fell, J., and R. Voas (2003) "The effectiveness of reducing illegal blood alcohol concentration (BAC) Limits for Driving: Evidence for Lowering the Limit to .05 BAC in Canada", Calverton, Md.: Pacific Institute for Research & Evaluation.

Foss, R.D., J.R. Stewart, and D.W. Reinfurt (1998) "Evaluation of the effects of North Carolina's 0.08% BAC law", Washington, DC: National Highway Traffic Safety Administration.

Galiani, S., P. Gertler, and E. Schargrodsky (2005) "Water for Life: The Impact of the Privatization of Water Services on Child Mortality", Journal of Political Economy, Vol. 113, pp. 83-120.

Grabowsky, D.C, and M.A.Morrisey (2004) "Gasoline price and motor vehicle fatalities", Journal of Policy Analysis and Management, Vol. 23, No. 3, pp. 575-593.

Heckman, J. and V.J. Hotz (1989) "Choosing among Alternatives Nonexperimental Methods for Estimating the Impact of Social programmes", Journal of the American Statistical Association, Vol. 84, pp. 862-874.

Henstridge, J., R. Homel, and P. Mackay (1997) "The long-term effects of random breath testing in four Australian states: A time series analysis", Canberra: Federal Office of Road Safety.

Hingson, R., T. Heeren, and M. Winter (1996) "Lowering state legal blood alcohol limits to 0.08%: The effect on fatal motor vehicle crashes", American Journal of Public Health, Vol. 86, No. 9, pp. 1297-1299.

Hingson, R., T. Heeren, and M. Winter (2000) "Effects of recent 0.08% legal blood alcohol limits on fatal crash involvement", Injury Prevention, Vol. 6, pp. 109–114.

Johnson, D., and J.C. Fell (1995) "The impact of lowering the illegal BAC limit to .08 in five states in the U.S., 39th Annual Proceedings for the Association for the Advancement of Automotive Medicine", October 16-18, Chicago, IL: Association for the Advancement of Automotive Medicine.

Levitt, S.D. and J. Porter (1999) "Estimating the effect of alcohol on driver risk using only fatal accident statistics", Working Paper 6944. Cambridge, MA: National Bureau of Economic Research.

Keall, M., W. Frith, and T. Patterson (2004) "The influence of alcohol, age and number of passengers on the night-time risk of driver fatal injury in New Zealand", Accident Analysis and Prevention Vol. 36, pp. 49-61.

McCarthy, P. (2003) "Alcohol-related crashes and alcohol availability in grass roots communities", Applied Economics, Vol. 35, pp. 1331-1338.

Mercier-Guyon, C. (1998) "Lowering the BAC limit to 0.05: Results of the French experience. Paper presented at the Transportation Research Board 77th Annual Meeting", January 11-15, Washington, DC.

Moskowitz, H. and D. Fiorentino (2000) "A review of the scientific literature regarding the effects of alcohol on driving-related behavior at blood alcohol concentrations of 0.08 grams per deciliter and lower", Washington, DC: National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (NHTSA) (1991) "Alcohol Limits for Drivers: A Report on the Effects of Alcohol and Expected Institutional Responses to New Limits" (DOT HS 807 692), National Highway Traffic Safety Administration.

National Highway Traffic Safety Administration (NHTSA) (1994) "Computing a BAC estimate", Washington, DC: National Highway Traffic Safety Administration.

Noordzij, P.C. (1994) "Decline in drinking and driving in the Netherlands. Transportation Research Circular, Vol. 422, pp. 44-49.

Office of Traffic Safety (OTS) (1995) "The general deterrent impact of California's 0.08% blood alcohol concentration limit and administrative per se license suspension laws", Office of Traffic Safety, State of California.
Rogers, P. (1995) "The general deterrent impact of California's 0.08% blood alcohol concentration limit and administrative per se license suspension laws", Sacramento, CA: California Department of Motor Vehicles.
Ruhm, C.J. (1995) "Economic conditions and alcohol problems" Journal of Health Economics, Vol. 14, pp. 583-603.
Ruhm, C.J. (1996) "Alcohol policies and highway vehicle fatalities", Journal of Health Economics, Vol. 15, pp 435-454.
Saffer, H. and M. Grossman (1987) "Drinking Age Laws and Highway Mortality Rates: Cause and Effect", Economic Inquiry, Vol. 25, No.3, pp. 403-417.
Saffer, H. (1997) "Alcohol advertising and motor vehicle fatalites" The Review of Economics and Statistics. Vol. 79, No. 3, pp. 431-442.
Shults, R. A., R.W. Elder, D.A. Sleet, J.L. Nichols, M.O. Alao, V.G. Carande-Kulis, S. Zaza, D.M. Sosin, R.S. Thompson and Task Force on Community Preventive Services (2001) "Reviews of evidence regarding interventions to reduce alcohol- impaired driving", American Journal of Preventive Medicine, Vol. 21, No. 4, pp. 66-88.
Voas, R.B., E. Taylor, T. Kelley Baker and A.S. Tippetts (2000) "Effectiveness of the Illinois .08 law", (DOT HS 809 186). Washington, DC: Department of Transportation, National Highway Traffic Safety Administration.
Wagenaar, A.C. (1993) "Minimum drinking age and alcohol availability to youth: Issues and research needs", in M. Hilton and G. Bloss, eds., Economics and the prevention of alcohol-related problems, US Department of Health and Human Services. Rockville, MD, 175-200.
White, H. (1984) "Asymptotic Theory for Econometricians", Academic Press, San Diego CA.
Zador, P., S. Krawchuk and R. Voas, (2000) "Alcohol related relative risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: An update using 1996 data", Journal of Studies of Alcohol, Vol. 61, No. 3, pp. 387-395.

APPENDIX

A1.a. Identifying assumption test. Estimation results.

Robust ln Rate fat.	Coef.	Std. Err.	t	P>|t|
Random checks	0.0143	.0888	0.16	0.874
MLDA	0.0126	.0332	-0.38	0.709
Points License	0.0159	.04312	0.37	0.717
Unemployment	-0.0045	.0034	-1.35	0.199
Growth rate	0.0090	.0062	1.44	0.172
Motorization	0.0021	.0008	-2.70	0.017
Vehicle-km	0.0341	.0437	0.78	0.447
Education	0.0066	.0029	2.26	0.040
Motorways	-0.0521	.0129	-4.03	0.001
National Roads	0.0046	.0030	1.53	0.148
yeartreated~1991	**0.3544**	**.0632**	**5.61**	**0.000**
yearcontrol~1991	**0.1585**	**.1783**	**0.89**	**0.389**
yeartreated~1992	**0.2957**	**.0496**	**5.97**	**0.000**
yearcontrol~1992	**0.1847**	**.1563**	**1.18**	**0.257**
yeartreated~1993	**0.2662**	**.0598**	**4.45**	**0.001**
yearcontrol~1993	**0.1229**	**.1372**	**0.90**	**0.386**
yeartreated~1994	**0.1853**	**.0482**	**3.84**	**0.002**
yearcontrol~1994	**0.0522**	**.1159**	**0.45**	**0.659**
yeartreated~1995	**0.1868**	**.0637**	**2.93**	**0.011**
yearcontrol~1995	**0.0891**	**.0755**	**1.18**	**0.258**
yeartreated~1996	**0.1473**	**.0590**	**2.50**	**0.026**
yearcontrol~1996	**0.0960**	**.0523**	**1.84**	**0.087**
yeartreated~1997	**0.1221**	**.0461**	**2.65**	**0.019**
yearcontrol~1997	**0.0834**	**.0464**	**1.80**	**0.094**
yeartreated~1998	**0.1275**	**.0433**	**2.94**	**0.011**
yearcontrol~1998	**0.0158**	**.0435**	**0.36**	**0.723**
yeartreated~1999	**0.1060**	**.0345**	**3.07**	**0.008**
yearcontrol~1999	**0.0698**	**.0435**	**1.61**	**0.131**
yeartreated~2000	**0.1047**	**.0447**	**2.34**	**0.035**
yearcontrol~2000	**0.0449**	**.0449**	**1.00**	**0.334**
yeartreated~2001	**0.0999**	**.0359**	**2.78**	**0.015**
yearcontrol~2001	**0.0260**	**.0556**	**0.47**	**0.646**
yeartreated~2002	**0.0561**	**.0203**	**2.75**	**0.016**
yearcontrol~2002	**0.0262**	**.0325**	**0.81**	**0.434**
constant	4.9012	.3542	13.84	0.000

A1.b. Identifying assumption test. Testing hypothesis.

H_0 : yeartreated *i* + yearcontrol *i* = 0

H_1 : yeartreated *i* + yearcontrol *i* ≠ 0

Year	F-Stat. (1, 14)	Prob > F. Stat	H_0 vs. H_1
1991	**1.58**	**0.2299**	**H_0**
1992	**0.73**	**04066**	**H_0**
1993	**1.82**	**0.1993**	**H_0**
1994	**2.24**	**0.1569**	**H_0**
1995	**3.06**	**0.1021**	**H_0**
1996	**1.04**	**0.3255**	**H_0**
1997	**0.66**	**0.4286**	**H_0**
1998	**4.74**	**0.0471**	**H_1**
1999	**0.53**	**0.4775**	**H_0**
2000	**1.12**	**0.3070**	**H_0**
2001	**1.12**	**0.3079**	**H_0**
2002	**0.59**	**0.4538**	**H_0**

A2. Pre-treatment time pattern test results.

ln Rate fat.	Coef.	Robust Std. Err.	t	P>|t|
Unemployment	-0.0032	0.0027	-1.16	0.266
Growth rate	0.0089	0.0051	1.73	0.105
Motorization	-0.0018	0.0007	-2.57	0.022
Vehicle-km	0.0377	0.0452	0.83	0.418
Education	0.0049	0.0030	1.64	0.123
Motorways	-0.0508	0.0110	-4.63	0.000
National Roads	0.0036	0.0023	1.59	0.134
MLDA	-0.0117	0.0253	-0.46	0.650
Points License	-0.0002	0.0384	-0.01	0.996
Random	-0.0034	0.0758	-0.05	0.965
Before02	**0.0145**	**0.0240**	**0.61**	**0.554**
Before+3	**0.0159**	**0.0362**	**0.44**	**0.667**

This model also uses year-specific national fixed effects and state-specific fixed effects. Cluster-robust standard errors are given.

A3. Least-squares estimates for semi-log models. Age group and urban fatality rates (selected results).

Independent Variables	Urban Age 20-29 (21)	Urban Age 30-39 (22)	Urban Age 40-49 (23)	Urban Age 50-59 (24)
BAC0.5	-0.2830**	-0.0370	-0.1074	-0.1319
	(0.0972)	(0.1196)	(0.0724)	(0.0763)
BAC0.5 + Random Checks	-0.2947**	-0.0531	-0.1246*	-0.1310
	(0.1031)	(0.1167)	(0.0677)	(0.0750)

The same two-way fixed effects model is applied to these groups of victims. Cluster-robust standard errors in parenthesis.

A4. Least-squares estimates for semi-log models. Age group and non-urban fatality rates (selected results).

Independent Variables	Non-Urban Age 20-29 (25)	Non-Urban Age 30-39 (26)	Non-Urban Age 40-49 (27)	Non-Urban Age 50-59 (28)
BAC0.5	-0.0341	-0.1200*	-0.0124	-0.0883
	(0.0561)	(0.0635)	(0.0467)	(0.0908)
BAC0.5 + Random Checks	-0.0341	-0.1014	0.0007	-0.0883
	(0.0561)	(0.0584)	(0.0511)	(0.0908)

The same two-way fixed effects model is applied to these groups of victims. Cluster-robust standard errors in parenthesis.

A5. Least-squares estimates, semi-log model. Alcohol consumption.

Independent variables	**Alcohol Consumption (29)**
BAC0.5	-0.0656** (0.0297)
Points License	0.0338* (0.0174)
MLDA	-0.0687 (0.0615)
Unemployment rate	-0.0164*** (0.0038)
Growth rate	0.0033 (0.0023)
R-sq	0.50

Two-way fixed effects model for alcohol consumption. Standard errors allowing clustering by country are given in parenthesis.