

## Traffic accidents, deaths and alcohol consumption

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### TRAFFIC ACCIDENTS, DEATHS AND ALCOHOL CONSUMPTION

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## TRAFFIC ACCIDENTS, DEATHS AND ALCOHOL CONSUMPTION

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### Abstract

The main goal of this paper is to analyze the relationship existing among prices of alcoholic beverages, alcohol consumption and traffic fatalities for the Spanish Autonomous Communities during the time interval 1998-2002. Among the main results, we highlight a positive correlation between alcohol consumption and traffic mortality rate. Basically, governments implement two kinds of policies to reduce the traffic mortality rate. One is oriented to control the supply of alcohol by increasing alcohol taxes. The other is oriented to preserve traffic security, increasing the number of sanctions for traffic rule infraction. We find evidence that both policies exert a positive influence in the reduction of traffic fatalities. There is no empirical evidence to indicate that being a novice driver increases the tendency to be involved in a mortal traffic accident.

*Keywords:* Alcohol Consumption, Traffic Accidents, Fatalities, Traffic Measures, Alcohol Taxes.

*JEL Classification:* C3, H2, I1, R4.

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## 1. INTRODUCTION

Traffic accidents have become one of the most serious health problems of modern societies due to the number of deaths and handicaps that this kind of accident generates. Road fatalities are influenced by the quality and kind of vehicle used for transportation, so for instance, the repercussions of a traffic accident in which motorcycles are involved are usually more dangerous for the individual than those traffic accidents in which cars are implicated (Scuffham, 2003; Smith, 1999). The quality and coverage of the vehicle helps undoubtedly to reduce the impact of the accidents, however in traffic accidents in which excess speed and/or alcohol abuse are present, the security systems of the vehicles serve for little. In fact, these are the two most frequent reasons for traffic accidents (Spanish General Directorate of Traffic, 2004).

The Spanish General Directorate of Traffic (2005) estimates that in Spain there are around 3,000 mortal traffic accidents per year which cause the death of 5,000 people. With data provided from the Spanish General Directorate of Traffic, a Spanish newspaper highlights that: “more than 30% of traffic accidents during 2004 involved drivers who presented a Blood Alcohol Content (BAC) over the legal level” (see Spanish newspaper *El País*, December 07, 2005). The magnitude of this problem is so severe that for example drunk drivers are directly responsible for one in four deaths among young males aged from 15 to 29 (Spanish National Anti-Drug Campaign, 2001)<sup>1</sup>.

One of the main contributions accomplished by the economic analysis perspective in the research of alcohol consumption lies in the fact that if we only consider present monetary

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<sup>1</sup> In all these statistical numbers a distinction could not be made between traffic fatalities caused by the driver's own fault (e.g. death of drunk driver) or those caused by someone else's fault (e.g. drunk drivers kills other person). From the report of the Spanish General Directorate of Traffic (2005), we conclude that to analyse drunk driving, it is important to know the number of drivers who drove under the influence of alcohol, and the number of people who died as a consequence of having been involved in a traffic accident independently whether the person who died caused the traffic accident or not. So unless the contrary is said, the number of victims refers to

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3 prices of alcoholic beverages, we are undervaluing the real cost of alcohol consumption. Next  
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5 to the monetary dimension, problems derived from alcohol abuse should be valued (accidents,  
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7 health problems or social conflicts, among others). The costs that alcohol drinkers impose on  
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9 themselves and the people who surround them are the foremost reason why alcoholic  
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11 beverages, except wine<sup>2</sup>, are burdened with special indirect taxes. Indirect taxes are  
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13 transferred integrally to the final price of the product, so only consumers pay the tax. One of  
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15 the governmental justifications of a price increase is to make consumers aware of the real  
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17 costs related to alcohol consumption. This argument is particularly relevant to drinking where  
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19 there are serious short and long term dangers. Not everybody values these potential costs in  
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21 the same way; in fact, young people tend to give them less importance because they have less  
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23 money than adults (Grossman *et al.*, 1993). This differential sensibility means that if the final  
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25 price of alcoholic beverages increases, their consequences will be higher for youth. Thus  
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27 abusive alcohol consumption is promoted by the fact that the prices that consumers pay are  
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29 lower than marginal social costs of alcohol consumption; it is necessary to increase the taxes  
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31 on alcoholic beverages until the consumer realizes about the real cost of drinking alcohol  
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33 (Phelps, 1988). Cook (1988) supports this argument, if and only if abusive alcohol  
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35 consumption and its corresponding costs were sensitive to the price of alcoholic beverages.  
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45 Therefore, it is relevant to analyze the relationship between alcohol consumption and  
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47 its negative consequences, so policy makers can foresee how an increase in the taxation of  
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49 alcoholic beverages reduces alcohol consumption. In fact the scientific literature about the  
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51 effectiveness of alcohol taxation for the reduction of traffic fatalities has been increasing in  
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53 the last years (Cook and Tauchen, 1984; Dee, 1999; Dee *et al.*, 2005; Grossman *et al.*, 1993;  
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55 Mast *et al.*, 1999; Ruhm, 1995 and 1996; Saffer and Grossman, 1987; Young and Bielinska-

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60 the total number of people who died as a consequence of having been involved in a traffic accident in which the driver presented a BAC higher than that permitted.

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3 Kwapisz, 2006; Young and Likens, 2000). Nevertheless we fail to notice empirical evidence  
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5 under a European context, so our main contribution lies in providing the first empirical  
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7 estimations for Spain.  
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11 As a starting point we study some basic statistics that provide us with a preliminary  
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13 glimpse of the problem. In Table 1, we show the numbers and percentage of traffic fatalities  
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15 (and deaths) with respect to population for Spanish Autonomous Communities for the time  
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17 period 1996-2002. From Table 1, we appreciate that there are around 5,000 traffic fatalities  
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19 per year. In relative terms, we appreciate that between one and two deaths in 100 are derived  
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21 from traffic accidents and one person from 10,000 citizens dies because of traffic accidents.  
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23 The communities with a higher percentage of traffic fatalities with respect to population and  
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25 total number of deaths are Aragon, Castilla-León, Galicia, Murcia, Rioja and Navarra. In  
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27 contrast, Cantabria and Madrid are the regions with the lowest percentages. With regard to the  
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29 temporal evolution, we observe that the number of traffic fatalities with respect to the total  
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31 number of deaths increases in all Autonomous Communities during the time interval  
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33 considered, being specially high up to the year 2000. This increase of traffic fatalities is a  
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35 problem that worries the Spanish Society and Public Institutions.  
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*(Insert Table 1)*

47 The main goal of this paper is to analyze the relationship existing among alcohol  
48 consumption, prices of alcoholic beverages and traffic accidents in Spain. In particular, we  
49 focus on investigating the effectiveness of diverse economic policies (alcohol taxes) and  
50 traffic policies (sanctions) that are applied with the purpose of reducing the number of traffic  
51 fatalities. The most important contribution of this paper lies in its being the first economical  
52 analysis that goes deeply into the relationship between drinking and driving for the Spanish  
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<sup>2</sup> Wine products have been exempt from special indirect taxes to protect the competitiveness of European wine

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3 case. Economic theory states that alcohol consumption is negatively correlated with the price  
4 of alcoholic beverages, so an increase in these prices, *ceteris paribus*, reduces alcohol  
5 consumption, and consequently, the number of traffic fatalities. Therefore, the hypothesis we  
6 want to verify is:  
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14 Alcohol Prices → Alcohol Consumption → Traffic Fatalities.  
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17 To that end, we define a theoretical model that combines theories of addiction and  
18 crime. For the empirical analysis, we have drawn data from Consumption Household Survey  
19 (Spanish Ministry of Food, Agriculture and Fishing); Survey of Deaths by Cause and  
20 Harmonized Consumption Index (Spanish National Institute of Statistics); Statistic Yearbook  
21 about Labor Issues (Spanish Labor Ministry) and Statistic Yearbook (General Directorate of  
22 Traffic).  
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32 The rest of the paper is structured as follows. In Section 2 we present the previous  
33 theoretical and empirical researches. Section 3 is devoted to the theoretical model. In Section  
34 4 we detail the empirical framework and database. In Section 5 we explain the results of the  
35 estimations. Finally, in Section 6, we summarize the main conclusions and we suggest  
36 corresponding policy implications.  
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## 45 **2. THEORETICAL AND EMPIRICAL LITERATURE REVIEW**

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49 In previous papers, authors analyze the determinants of traffic accidents, paying  
50 special attention to the effects of traffic sanctions, alcohol consumption and alcohol taxes. The  
51 main argumentation line establishes that offences committed by individuals are negatively  
52 correlated with their costs. So offences can be defined as a function of the probability of being  
53 arrested and punished, as well as the severity of the punishment. Several empirical studies  
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industry. However the European Commission has been debating the adequacy of this exemption.

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3 have demonstrated that harder traffic sanctions contribute to increasing the cost of the offence  
4 of driving under the influence of alcohol, so this kind of traffic offence will experience a  
5 reduction, and therefore, traffic fatalities will be reduced too (Young and Likens, 2000). Other  
6 empirical studies question the effectiveness of harder sanctions because of two main reasons:  
7 an incorrect transmission of new penalties so that a population group remains unaware of the  
8 latest sanctions, and the laxness of present penalties. For that reason, it is necessary to  
9 increase the penalties until they reach their real social costs (Kenkel, 1993a; Kenkel and  
10 Koch, 2001). Next to penalization, the probability of being arrested plays an outstanding role  
11 in the reduction of drinking and driving (Benson *et al.*, 1999).  
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26 Although drunk driving may seem irrational, it is not wrong to model the co-joint  
27 decision of drinking and then driving under the structure of rational theories. The models in  
28 which individuals maximize their utilities are applicable to criminal behaviour, which  
29 includes driving under the influence of alcoholic beverages (Becker, 1968). In fact, there is  
30 strong empirical evidence about the positive link between alcohol consumption and the  
31 number of traffic accidents. Among priority measures that should be implemented, we  
32 underline the reduction of alcohol abuse. In fact, most governments frequently recur to  
33 increasing alcohol taxes which raises the final price of alcoholic beverages, and consequently,  
34 reduces alcohol demand as the acquisition capacity is restrained (Young and Bielinska-  
35 Kwapisz, 2006). Nevertheless, the effectiveness of policies centred on tax increases is under  
36 debate. Whereas it is an efficient policy for some authors (Benson *et al.*, 2000; Ruhm, 1995  
37 and 1996; Young and Bielinska-Kwapisz, 2002), for others, tax effects are limited due to the  
38 existence of fixed spatial effects<sup>3</sup> (Dee, 1999; Mast *et al.*, 1999) or due to the occurrence of  
39 measurement errors at the time of calculating alcohol prices (Young and Bielinska-Kwapisz,  
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<sup>3</sup> These papers have analyzed the traffic accidents in USA where the fixed spatial effects are related to the different States.



2003), or even due to the presence of alcohol consumption in early stages of life (Sloan *et al.*, 1994).

With the goal of postponing the age at which young people start their experience with alcoholic beverages, the minimum legal age for buying alcoholic beverages has been frequently raised. Making access to alcoholic beverages more difficult for youth will reduce the tendency of drunk driving for at least this population group (Cook and Tauchen, 1984). However, this idea is questioned by Asch and Levy (1987), who concede greater importance to the experiences of driving and drinking than to the minimum legal age for buying alcoholic beverages.

Lastly, there are authors who, although they recognize the impact of alcoholic consumption over the number of traffic accidents, also suggest improving vehicle security to reduce traffic mortality rates, such as for example, controlling the use of seat belts or helmets (Sen, 2001).

### 3. THEORETICAL MODEL

To define the theoretical model we take as a starting point the article of Mast *et al.* (1999), in which the number of deaths by traffic accidents<sup>4</sup> ( $R$ ) depends on drunk driving offences ( $D$ ) and a vector that includes measures of traffic such as new expedited driving licenses, that is, the number of people with newly acquired driving licenses ( $T$ ):

$$R_t = R(D_t, T_t) \quad (1)$$

The main problem with equation (1) is that  $D$  is not observable, so there is no data available for drunk driving. To solve the maximization problem, we focus on the pattern that

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<sup>4</sup> The number of deaths by traffic accidents reflects the total number of people who died as a consequence of having been involved in a traffic accident independent of whether they provoked it or not.

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3 defines drunk driving. The function that explains driving under the influence of alcohol ( $D$ )  
4 includes alcohol consumption ( $C$ ), and expected punishment for drunk driving. The  
5 punishment is determined by the probabilities of being arrested and fined ( $F$ ), and by the  
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10 punishment severity ( $S$ ):

$$11 \quad D_t = D(C_t, F_t, S_t) \quad (2)$$

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17 We just substitute the  $D$  expression in (1)

$$18 \quad R_t = R(C_t, F_t, S_t, T_t) \quad (3)$$

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21 where  $C$  is determined by a Marshallian demand function which takes into account the  
22 additive characteristics of tolerance and reinforcement (Becker and Murphy 1988)<sup>5</sup>:  
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$$30 \quad C_t = C(P_{t-1}, P_t, P_{t+1}, I) \quad (4)$$

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34  $I$  represents initial wealth and total life incomes valued at the initial moment and  $P_t$  is the  
35 price of alcoholic beverages for the moment of time  $t$ . If alcohol consumption depends on the  
36 present, past and future prices of alcoholic beverages, then the individual takes decisions  
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39 *rationally* because at the moment of deciding how much to drink, past alcohol consumption  
40 determines present demand and present consumption affects future demand. If alcohol  
41 consumption depends exclusively on the present and past prices of alcoholic beverages, then  
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60 the individual takes decisions *myopically*, because current consumption is independent of

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<sup>5</sup> The modelling of traffic accidents as a function of alcohol consumption, equation (3), is not exempt of weaknesses. For instance, whether alcohol consumption increases the probability of a traffic accident depends on: when the alcohol is consumed (just before driving); where the alcohol is consumed (e.g. at home or away from home, with dinner); and how much alcohol is consumed in a short period of time. So two people, or two regions or two countries, can have the same amount of alcohol consumption, but very different levels of traffic risk. Regularly drinking a glass of wine with dinner may not be a problem; drinking 7 glasses of beer on a Friday night could cause a drunk driving accident.

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3 future consumption and/or future events. The main difference between rational and myopic  
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5 points of view is that the latter is entirely backward-looking (Becker *et al.*, 1994).  
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9 Models of drunk driving characterized by an economic perspective tend to emphasize  
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11 the impact of alcohol taxes on the crime prevalence versus police efforts to combat drunk  
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13 driving. Benson *et al.* (2000) show that police can indeed deter drunk-driving by using  
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15 aggregated data that includes variables such as drug arrests, property arrest and violent arrest.  
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17 To measure the probability of being arrested, we will introduce the annual number of traffic  
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19 sanctions registered by the policy.  
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24 For the North-American society, there are more complex models that consider the  
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26 influence of other variables, for instance legislative, in the process of utility maximization.  
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28 This complexity is derived from the fact that the diverse States are self-ruling to implement  
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30 health and traffic public policies (Benson *et al.*, 2000; Dee *et al.*, 2005; Kenkel *et al.*, 2001;  
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32 Morrissey and Grabowski, 2005; Pacula 1998). Kenkel and Koch (2001) highlight that new  
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34 state laws will be effective in the deterrence of drunk driving, only if people know about  
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36 them. In fact, although new state laws have been implemented and their efficiency is under  
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38 question, there is evidence of rational behaviour given the lack of knowledge of these laws  
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40 among citizens.  
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For the empirical application of the Spanish case (1998-2002), there have not been  
substantial legislative changes. Concerning alcohol issues, the minimum legal age for buying  
alcoholic beverages has been increased from 16 to 18 years in most of the Autonomous  
Communities. The Spanish Autonomous Communities are self-governing to determine the  
minimum legal age for the purchase of alcoholic beverages, so the rise of this legal age has  
taken place in different communities at different times. For example, Catalonia and Navarre  
were the first communities to adopt this policy in 1991, whereas Aragon and Rioja were some

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3 of the last ones to adopt the policy in 2001. Nevertheless, we do not introduce this policy  
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5 measure in our model, because it is necessary to be at least 18 years old to have access to a  
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7 driver's license. Concerning traffic measures in Spain, one of the main legal changes has been  
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9 to reduce the allowed BAC from 0.8 grams per litre in 1992 (Royal Decree 13/1.992, of  
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11 January 17) to 0.5 grams per litre in 2003 (Royal Decree 1428/2003, of November 21). So  
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13 only when we have available data of traffic accidents for the year 2003 and after, will it be  
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15 possible to analyze the effectiveness of this policy. Concerning traffic sanctions, there are four  
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17 legislative documents (Legislative Royal Decree 339/1.990, of March 2; Law 5/1997, of  
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19 March 24; Law 19/2001, of December 19; Law 17/2005, of July 19) in which the character of  
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21 driving is established with higher levels of the legal BAC (serious infraction and very serious  
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23 infraction since 2001) and the monetary and non monetary penalties (maximum 600 Euros).  
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25 We observe that the infraction of drunk driving is redefined from serious to very serious, but  
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27 the monetary penalty is scarcely raised by 2 Euros from the Legislative Royal Decree of 1990  
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29 and the Law of 2001, thus we consider that the offender faces the same sanction along the  
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31 studied period of time. According to this argumentation line the variable  $S$  keeps constant  
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33 along the period 1998-2002, so we will introduce it under the constant term to avoid problems  
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35 of multicollineality. Once we have obtained the optimal consumption of alcoholic beverages,  
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37 we will translate the result into the following function to obtain the rate of traffic fatalities:  
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$$R_t = R(C_t, P_t, T_t) \quad (5)$$

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50 from which we will analyze the impact of alcohol consumption, traffic sanctions and the rest  
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52 of traffic measures in the formation of the rate related to traffic fatalities. The empirical results  
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54 will confirm if a lower demand of alcoholic beverages reduces the mortality rate by traffic  
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56 accidents.  
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#### 4. EMPIRICAL MODEL AND VARIABLES

Regarding to the empirical model, we will structure the estimations in two stages. In the first stage, we will think about the determinants of alcohol consumption per capita. Among these determinants we draw attention to the price of alcoholic beverages for the present, past and future time periods, individual incomes and dummy variables that summarize fixed temporal and spatial effects. In a second stage, we will define the rate of traffic fatalities as a function of alcohol consumption, the number of traffic sanctions (proxy variable of sanctions and traffic measures) and the attainment of a new driving license. In addition, we introduce dummy variables to introduce fixed effects related to the different Autonomous Communities and time periods<sup>6</sup> in both stages. So equations (4) and (5) will adopt the following formulations:

$$C_{it} = Z_{it}\phi + w_{it} \quad i=1,2,\dots,18; t=1998,\dots,2002. \quad (6)$$

$$R_{it} = C_{it}\alpha + X_{it}\beta + v_{it} \quad i=1,2,\dots,18; t=1998,\dots,2002 \quad (7)$$

where  $C_{it}$  represents the consumption of alcohol per capita for the Autonomous Community  $i$  for the year  $t$ ;  $R_{it}$  is the rate of traffic fatalities;  $X_{it}$  and  $Z_{it}$  are matrices of explicative variables;  $\beta, \alpha$  and  $\phi$  are vectors of parameters;  $w_{it}$ , and  $v_{it}$  are residuals which summarize the unobserved aspects that influence both alcohol consumption and traffic fatalities. For instance, the residual of the equation of traffic fatalities will include human failure or weather conditions, among others.

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<sup>6</sup> The mortality rate of traffic fatalities is the best empirical approximation to analyze the relationship between alcohol consumption and traffic fatalities (Young and Likens, 2000; Young and Bielinska-Kwapisz, 2006). Although all traffic accidents are not the result of drunk driving, there is a strong correlation between both variables.

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3 The most common specification<sup>7</sup> of the dependent variable  $R_{it}$  in the equation of the  
4 mortality rate (7) consists in a logistic transformation of this variable. That is, if  $r_{it}$  is obtained  
5 for the Autonomous Community  $i$  as the number of deaths in traffic accidents divided by the  
6 Community population for each year  $t$ , then the dependent variable in the regression is  
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12  $R_{it} = (r_{it} / (1 - r_{it}))$ . One advantage of this transformation lies in that it restrains the foresee  
13 values of the mortality rate to 0 and 1.  
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19 We also assume that unobservable components that influence traffic fatalities may be  
20 unique for each Autonomous Community and constant over time. Additionally, there may  
21 also be specific unobservable aspects for each year<sup>8</sup>. Thus the residual in equation (7) should  
22 be transcribed as  $v_{it} = \varphi_i + \lambda_t + \varepsilon_{it}$ ; where  $\varphi_i$  represents the unobservable fixed effects for each  
23 Autonomous Community,  $\lambda_t$  the fixed effect for each year and  $\varepsilon_{it}$  the error term whose  
24 variance is constant and uncorrelated with observable and unobservable characteristics for the  
25 Autonomous Communities through time. The same argumentation line may be translated to  
26 the unobservable aspects that influence the alcohol consumption, so the residual in equation  
27 (6) should be transcribed as  $w_{it} = \pi_i + \theta_t + \rho_{it}$ , where  $\pi_i$  is the specific unobservable component for  
28 each Autonomous Community,  $\theta_t$  the fixed effect for each year and  $\rho_{it}$  the error term whose  
29 variance is constant and uncorrelated with observable and unobservable characteristics  
30 through time. The specific unobservable fixed effects for each Community and year are  
31 summarized under dummy variables for each Community and year.  
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50 Concerning the estimation method, we will take into account the following  
51 distinctions. We estimate equation (6) applying OLS, thus the right hand of the equation only  
52 contains exogenous variables ( $Z$ ) and additionally these variables are not correlated with the  
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59 <sup>7</sup> Other useful specification lies in the Linear Regression Models. Young and Likens (2000) compare the results  
60 of both specifications (linear and logistic) finding just small differences. We have also carried out estimations  
from both specifications concluding that the results are very similar. Results are available on request.

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3 residual  $w_{it}$ , so all assumptions of the classic OLS are satisfied. Regarding equation (7), we  
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5 highlight that the endogenous variable C is introduced as an explicative variable next to the  
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7 rest of the independent variables that configure X. Under these circumstances, OLS can also  
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9 be implemented, only if, C were not correlated with the residual  $v_{it}$ . To find out whether there  
10  
11 is correlation or not, we carry out two tests: the endogeneity, or simultaneity, test of Hausman  
12  
13 (1978) and the Augmented Test Regression, also known as Durbin-Wu-Hausman (DWH) of  
14  
15 Davidson and Mackinnon (1993) also based on the asymptotic requirement of the Hausman  
16  
17 test<sup>9</sup>. The results of both tests are presented in Table 2, in which the first column is devoted to  
18  
19 the Hausman test and the second, to the DWH test. Both tests fail to reject the null hypothesis  
20  
21 of exogeneity, thus alcohol consumption is an exogenous variable in equation (7). In the way  
22  
23 that the alcohol consumption variable is not correlated with the residual, the OLS estimators  
24  
25 are consistent and asymptotically efficient. In summary, the two-equation-system is recursive,  
26  
27 so we will estimate two independent equations by OLS because it is not necessary to apply the  
28  
29 methodology of simultaneous equations (Greene, 2003, section 15.5.1).  
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3 of Deaths by Cause and Harmonized Consumption Indexes (Spanish National Institute of  
4 Statistics); Statistic Yearbook about Labor Issues (Spanish Labor Ministry) and the Statistic  
5 Yearbook (General Directorate of Traffic).  
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12 *(Insert Table 3)*  
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15 Table 3, contains the mean and standard deviation of each variable, which have been  
16 classified by sources. The period of time considered is from 1998 to 2002. Regarding the  
17 variables related to consumption and acquisition capacity, we observe that on average an  
18 individual demands 53.56 Kg. of alcoholic beverages per year, and the labour cost per capita  
19 is 1,313.932 Euros per month. The Price Index of Consumption (CPI) is, with an index of  
20 108.580, superior to the corresponding past CPI (105.205) and lower than the corresponding  
21 future CPI (109.001). Concerning traffic conditions, there were 133 traffic sanctions for every  
22 1000 citizens, and on the other hand, a new driving license A or A1 was expedited for every  
23 1000 citizens. Regarding geographical distribution, 27.8% of the observations are for  
24 Autonomous Communities that reside in the North, 22.2% for Communities allocated in the  
25 Center, 16.7% for Communities placed in the South and East, 11.1% for the Islands and the  
26 remaining 5.6% for Madrid.  
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43 One of the peculiarities of the model is that we focus on the previous number of  
44 sanctions instead of the present number of traffic sanctions, so the variable is retarded one  
45 period<sup>11</sup>.  
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56 <sup>10</sup> To check the presence of heteroskedasticity we carry out the test of White and the test of Breuch-Pagan/Cook-  
57 Weisburg which are also available in the software package *Stata 9.0*. Both test results are algebraically identical  
58 and are available from the authors upon request.

59 <sup>11</sup> The temporal interdependency of alcohol consumption derived from the Addiction Theory (Becker and  
60 Murphy, 1988) postpones the effect of public policies, thus the individual requires a period of time to adjust to  
the new changes in the parameters that define alcohol consumption (McKenzie, 1991).



## 5. RESULTS.

We will keep the sequence defined in the theoretical framework for the presentation of the results. Thus, we start with the estimation of alcohol consumption under rational and myopic addition. Both equations differ from each other only in the introduction of the future price of alcoholic beverages. To that end, we have repeated the estimations by OLS twice, in order to know if the pattern of alcohol consumption is defined as rational or myopic. Then we will continue with the estimation of traffic mortality rate.

Table 4, contains estimation results for alcohol consumption according to the theories of rational addiction and myopic addiction. In this table, we observe that the lagged price of alcoholic beverages is negatively correlated to the present alcohol consumptions. Thus, an increase of 1% in the lagged price of alcohol reduces alcohol consumption by 0.61%. This value is within the range of price elasticities for aggregate alcohol consumption estimated in previous work (Young and Bielinska-Kwapisz, 2003, 2006). Furthermore, if for instance the individual foresees a 1% increase in the future price of alcoholic beverages, he/she will tend to increase his/her present alcohol consumption in a 0.17%, but we have to be cautious with this affirmation because the estimated parameter is not statistically significant. In addition to the lack of significance of future alcohol price, we observe that although the adjusted coefficient of determination is slightly higher for the myopic model (and the Akaike info criterion slightly lower), we can not strongly affirm that the pattern of alcohol consumption for the Spanish society behaves myopically rather than rationally.

*(Insert Table 4)*

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3 Concerning other monetary variables, we observe that higher available budgets  
4 promote higher demand for alcoholic beverages. So, for instance, an increase of a 1% increase  
5 in the monthly income<sup>12</sup> raises the demand for alcohol by 0.53%. per year.  
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11 In relation to spatial and temporal effects, we observe that alcohol consumption per  
12 capita is higher in all areas in relation to Madrid, with the higher marginal effect for those  
13 regions allocated in the South followed by the North and East. On the other hand, alcohol  
14 consumption experienced the highest marginal effect increase in 1999 in relation to 2001,  
15 while during 2000 and 2002, alcohol consumption experienced a reduction. Nevertheless, the  
16 effects of these last two dummy variables are not statistically significant.  
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26 Once having analyzed the demand of alcoholic beverages, we proceed with the  
27 presentation of the results related to traffic fatalities in Table 5 using two different  
28 specifications for equation (7). Model 1, includes alcohol consumption as regressor and  
29 Model 2 repeats again the estimation of traffic mortality rate but this time, including as a  
30 regressor, the price of beer. In Model 1 we appreciate that higher traffic control, measured by  
31 the lagged number of traffic sanctions registered by police, is negatively correlated with the  
32 rate of traffic fatalities, so for example an increase in traffic sanctions<sup>13</sup> by 10% reduces the  
33 rate of traffic fatalities by 0.34%. So, a higher public expenditure allocated in stronger traffic  
34 control will have a positive effect in the reduction of traffic fatalities.  
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*(Insert Table 5)*

Another determinant, cited recurrently as a source of traffic accidents, is the lack of driving experience; therefore we introduce a variable that informs us about the number of new drivers in each Autonomous Community. Contrary to what we would have expected, this

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<sup>12</sup> We have recurred also to the Gross National Product (GNP) with which we have obtained similar estimations to that described in the present paper.

<sup>13</sup> The variable related to traffic sanctions informs us of the number of sanctions expedited by the Policy as a consequence of traffic controls.

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3 population group does not increase the tendency to suffer a traffic accident, which we analyze  
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5 as deriving from two facts. Novice drivers have lower speed limits during the first year, and  
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7 lower legal BAC for the first two years<sup>14</sup>. In fact, an increase of 10% new drivers reduces the  
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9 rate of traffic fatalities by 0.23%.

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12 By region, we observe that coherent with the alcohol consumption levels, the rate of  
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14 traffic fatalities is higher for all areas with respect to Madrid. Nevertheless, the Communities  
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16 allocated in the South and the Islands have the highest mortality rate.

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19 But undoubtedly, the most interesting result is the one that confirms that higher  
20  
21 alcohol consumption per capita increases the rate of traffic fatalities. So an increase of alcohol  
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23 demand by 1% provokes an increase of 0.305% in the number of traffic fatalities. This result,  
24  
25 next to the fact that an increase in the lagged price of alcoholic beverages reduces the present  
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27 demand of alcohol, allows us to affirm that an increase in the price of alcoholic beverages  
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29 reduces the rate of traffic fatalities. By definition, the elasticity fatalities with respect to the  
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31 price of alcohol,  $E_{fp}$ , is equal to the product of the price-consumption elasticity,  $E_{cp}$ , and the  
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33 consumption-fatality elasticity,  $E_{fc}$ . This implies that the price-fatality elasticity is  
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35  $E_{fp}=0.615*0.305=0.187\cong 0.19$ . So an increase of the lagged alcohol price in 1% reduces the  
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37 number of traffic fatalities by 0.19%. This is the first paper that calculates the price-fatality  
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39 elasticity for the particular case of a European country; however this magnitude has already  
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41 been obtained for the North-American society. Thus, the relationship between alcohol price  
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43 and number of traffic fatalities is also negative and the absolute value of the price-fatality  
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45 elasticity falls in a range of 0.5 to 1.0 in USA (Kenkel, 1993; Young and Bielinska-Kwapisz  
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47 2006).

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<sup>14</sup> Novice drivers are not allowed to drive with BAC higher than 0.3 for the first two years (Royal Decree 1428/2003, of November 21).

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Lastly, we repeat again the estimation of traffic mortality rate but this time including as a regressor the price of beer (Model 2). The reason why we introduce the beer price is to observe the influence of an increase in the price of a particular alcoholic beverage on the number of traffic fatalities (Young and Likens, 2000; Young and Bielinska-Kwapisz, 2006). At the same time, as we failed to reject the null hypothesis of exogeneity of alcohol consumption (previously mentioned in page 13), so to confirm this hypothesis is important to consider the statistical power of the test. If the instrumental variables are not very strong, the Hausman test is weak and will fail to reject exogeneity. In order to carry out a robustness test, we estimate the reduced form, Model 2, where consequently the potentially endogenous variable (alcohol consumption) has been replaced with an exogenous determinant of alcohol consumption, that is, the price of beer. According to the price-fatality elasticity, we conclude that if the tax applied to beer increases in 10%, the rate of traffic fatalities will drop by 6.9%, which is the result of multiplying the increase in the price of the beer as a consequence of the tax increase<sup>15</sup> by the price elasticity of Model 2 in Table 5. Furthermore, we observe that the parameter of the beer price is strongly accepted under a significance level of 5%, so we do not have any signal that the Hausman test is weak.

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Once our theoretical model has been validated for both general price of alcoholic beverages and the price of a particular alcoholic beverage, it is reasonable to support the strategy of incrementing alcohol taxes in order to reduce their negative externalities.

## 50 51 52 53

## 6. CONCLUSIONS AND POLICY IMPLICATIONS

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Although the consumption of legal drugs, such as alcoholic beverages, is not considered as pernicious as the consumption of illegal ones, the real situation is that alcohol

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<sup>15</sup> Alcohol taxes are fully passed through to final prices (Kenkel, 2005). Taking into account that the Spanish tax rate applied to beer is around 16.75% of the final price (including all indirect taxes, that is VAT and special tax),

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3 consumption promotes serious health problems. One of the main contributions of this paper  
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5 lies in being the first economic analysis that demonstrates the positive relationship between  
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7 alcohol consumption and the number of traffic fatalities for the Spanish case. Drug control  
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9 and prevention has become mainly a responsibility of governments which usually restrain  
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11 their policies to market regularization (Reuter, 1988). Due to the fact that taxes are the most  
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13 applied public policy instrument for reducing alcohol abuse, we have analyzed the  
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15 effectiveness of a price increase. Next to economic policies, we have also introduced traffic  
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17 measures such as a higher traffic control through an increase in the number of traffic  
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19 sanctions. The empirical evidence validates our main hypotheses: an increase in alcohol prices  
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21 reduces alcohol consumption, and consequently, the number of traffic fatalities. On the other  
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23 hand, a higher number of traffic sanctions reduces the rate of deaths by traffic accidents. In  
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25 the way that a higher number of traffic sanctions has a positive influence, it is surprising that  
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27 economical sanctions have been kept constant since their introduction (max. 600 Euros), and  
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29 considering the serious magnitude of the negative externalities of drunk driving, this monetary  
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31 penalty can even be considered quite indulgent.  
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40 Although governments can rarely hope to reduce risks to zero, they can aim to lower  
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42 them to a more acceptable level, and to explain, through open communication with the public,  
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44 why and how they are doing so. On the one hand, there is a global tendency towards  
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46 increasing taxes in order to limit alcohol consumption, while on the other hand some domestic  
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48 production is being protected. For example, the tax harmonization process of the European  
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50 Union reveals that Mediterranean countries tend to apply lower tax rates to wine as opposed to  
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52 alcoholic beverages, and furthermore, wine producers receive subsidies from the European  
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54 Commission to help them compete with countries outside the European Union. There is a  
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56 debate about the justification for these policies. In particular, Eastern-European countries,  
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an increase by 10% of the beer taxes will increase the final price of the beer by more or less 9.4% (Law 37/1992

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3 which have recently joined the European Union, are requesting the same privileges for their  
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5 beer industry that is currently granted to the wine sector. In order to avoid domestic subsidies,  
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7 an alternative approach is to impose import taxes. For example, this is the way the USA has  
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9 protected their local wine industry.  
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14 On the other hand, one of the main sources of public income is tax collection. Because  
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16 the demand for alcoholic beverages tends to behave as inelastic, an increase in the  
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18 corresponding taxes might be more beneficial in terms of increasing public revenue than in  
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20 terms of reducing alcohol abuse.  
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24 In addition, these economic and traffic measures are not the only ones that promote  
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26 welfare, the policy makers have a wide range of possibilities, such as promoting healthy  
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28 leisure activities as an alternative to alcohol consumption. So although decisive steps have  
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30 been implemented in the fight against alcohol abuse and drunk driving, the magnitude of these  
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32 policies is still uncertain, such as for example a decrease in the BAC. It is also worthy to draw  
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34 attention to alternative actions such as the removal of driving licenses in the case of risky  
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36 driving.  
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of December 29 and Law 38/1992 of December 28). (See Table 6)

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**Table 1. Deaths and traffic fatalities in Spain.**

	Number of deaths and percentage with respect to population								Number of traffic fatalities and percentage with respect to population								Percentage of traffic fatalities with respect to total number of deaths			
	1996		1998		2000		2002		1996		1998		2000		2002		1996	1998	2000	2002
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	%	%	%	%
Andalusia	59,562	0.82	61,619	0.84	32,520	0.44	62,697	0.83	920	0.01	1005	0.01	856	0.01	858	0.01	1.54	1.63	2.63	1.37
Aragon	12,480	1.04	13,002	1.09	6,740	0.56	12,985	1.06	156	0.01	213	0.02	219	0.02	190	0.02	1.25	1.64	3.25	1.46
Asturias	12,156	1.11	12,259	1.12	6,359	0.59	12,424	1.14	166	0.02	159	0.01	177	0.02	134	0.01	1.37	1.3	2.78	1.08
Balers	6,789	0.88	7,079	0.88	3,839	4.34	7,114	0.77	117	0.02	114	0.01	137	0.01	108	0.01	1.72	1.61	3.57	1.52
Canaries	11,046	0.68	11,724	0.71	6,663	0.39	11,863	0.64	183	0.01	212	0.01	212	0.01	136	0.01	1.66	1.81	3.18	1.15
Cantabria	5,189	0.97	5,167	0.97	2,761	0.52	5,278	0.96	52	0.01	74	0.01	62	0.01	53	0.01	1	1.43	2.25	1
Castilla-Leon	25,118	0.99	25,970	1.03	13,649	0.55	26,349	1.05	469	0.02	421	0.02	444	0.02	435	0.02	1.87	1.62	3.25	1.65
Castilla-Mancha	16,832	0.97	17,141	0.99	8,624	0.49	17,577	0.98	234	0.01	244	0.01	272	0.02	248	0.01	1.39	1.42	3.15	1.41
Catalonia	54,036	0.88	56,052	0.9	29,235	0.46	57,862	0.88	756	0.01	881	0.01	925	0.01	811	0.01	1.4	1.57	3.16	1.4
Valencia	35,928	0.89	36,383	0.9	19,320	0.47	38,023	0.87	579	0.01	640	0.02	595	0.01	569	0.01	1.61	1.76	3.08	1.5
Extremadura	10,508	0.97	10,623	0.98	5,405	0.5	10,549	0.97	144	0.01	148	0.01	156	0.01	132	0.01	1.37	1.39	2.89	1.25
Galicia	28,879	1.04	28,103	1.02	14,716	0.54	28,353	1.03	610	0.02	641	0.02	563	0.02	495	0.02	2.11	2.28	3.83	1.75
Madrid	36,804	0.73	37,711	0.74	19,615	0.38	39,281	0.71	446	0.01	461	0.01	452	0.01	417	0.01	1.21	1.22	2.3	1.06
Murcia	8,581	0.78	9,060	0.81	4,860	0.42	9,441	0.76	153	0.01	201	0.02	212	0.02	194	0.02	1.78	2.22	4.36	2.05
Navarre	4,690	0.89	4,816	0.9	2,589	0.47	4,989	0.87	84	0.02	100	0.02	102	0.02	76	0.01	1.79	2.08	3.94	1.52
Basque Country	18,035	0.85	18,153	0.86	9,802	0.46	18,627	0.88	271	0.01	314	0.01	304	0.01	269	0.01	1.5	1.73	3.1	1.44
Rioja	2,549	0.95	2,588	0.97	1,388	0.52	2,634	0.93	39	0.01	61	0.02	49	0.02	59	0.02	1.53	2.36	3.53	2.24
Total	349,182	0.88	357,450	0.89	160,257	0.4	366,046	0.87	5,379	0.01	5,889	0.01	5,688	0.01	5,183	0.01	1.54	1.65	3.55	1.42

**Table 2. Endogeneity test for the variable alcohol consumption in the equation (7)**

<b>Index of Mortality</b>	<b>Hausman Test</b>	<b>DWH Test</b>
	$\chi^2$ (1 degree of freedom) (significance level)	F-snedecor value (1,48) (significance level)
<i>Whole Survey:</i>	1.28	1,29
<i>Rational addiction</i>	(0.257)	(0,261)
<i>Whole Survey:</i>	0.76	0,76
<i>Myopic addiction</i>	(0.383)	(0,388)

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**Table 3. Variables and descriptive statistics (1998-2002).**

Variables	Description	Mean (S. Deviation)
<b>Survey of Deaths by Cause, Spanish National Institute of Statistics</b>		
$Y_{it}=RFT$	Rate of traffic fatalities (logistic transformation) by Autonomous Communities.	0.016 (0.03)
<b>Statistic Yearbook about Labor Issues, Spanish Labor Ministry</b>		
<i>INCOMEDF</i>	Labor cost per worker by Autonomous Communities. (in Euros deflated to 2001)	1313.932 (157.777)
<b>Consumption Household Survey, Spanish Ministry of Food, Agriculture and Fishing</b>		
<i>CA</i>	Annual alcohol consumption per capita (Kg.) by Autonomous Communities. The quantities have been corrected by ethanol content (by 1 beer; 2 wine/champagne/cider; 8 strong liquors).	53.560 (14.910)
BEERPRICE	Average price of beer in Euros per kg. by Autonomous Communities.	1.155 (0.097)
<b>Statistic Yearbook, General Directorate of Traffic</b>		
<i>SANCTION(t-1)</i>	Number of traffic sanctions by Autonomous Communities for the period t-1 (numbers in thousand).	133.650 (179.099)
<i>NDA</i>	Number of novice drivers type A and A1 (every 1000 citizens) by Autonomous Communities for the period t.	0.927 (1.656)
<b>CPI, Spanish National Institute of Statistics</b>		
<i>CPIA</i>	Present harmonized CPI of alcoholic beverages by Autonomous Communities.	108.580 (19.539)
<i>CPIA(t-1)</i>	Lagged harmonized CPI of alcoholic beverages by Autonomous Communities.	105.205 (19.903)
<i>CPIA(t+1)</i>	Future harmonized CPI of alcoholic beverages by Autonomous Communities.	109.001 (15.366)
<b>SPATIAL DUMMY VARIABLES</b>		
<i>NORTH</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the North (Asturias, Cantabria, Galicia, Navarre and Basque Country), 0 otherwise.	0.278 (0.450)
<i>SOUTH</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the South (Andalucia, Murcia, Ceuta and Melilla), 0 otherwise.	0.167 (0.375)
<i>EAST</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the East (Aragon, Catalonia and Valencia), 0 otherwise.	0.167 (0.375)
<i>CENTER</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the Center (C. Mancha, C. Leon, Extremadura and Rioja), 0 otherwise.	0.222 (0.418)
<i>ISLANDS</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the Islands (Balers and Canaries), 0 otherwise.	0.111 (0.316)
<i>MADRID</i>	Dummy variable that takes the value 1 if the observation is related to an Autonomous Community placed in the Madrid, 0 otherwise.	0.056 (0.230)

**Table 4. Estimation of alcohol consumption.**

	RATIONAL ADDICTION				MYOPIC ADDICTION			
	Coefficient	S. Deviation	Sign.	Elasticity	Coefficient	S. Deviation	Sign.	Elasticity
<i>CPIA</i>	0.0153	0.0124		0.3097	0.0214	0.0096	**	0.4311
<i>CPIA(t-1)</i>	-0.0312	0.0092	***	-0.6096	-0.0315	0.0092	***	-0.6150
<i>CPIA(t+1)</i>	0.0082	0.0105		0.1667	-	-	-	
<i>INCOMEDF</i>	0.0021	0.0008	***	0.5255	0.0022	0.0008	***	0.5317
<i>NORTH</i>	1.3181	0.4598	***	0.0724	1.3323	0.4582	***	0.0732
<i>SOUTH</i>	1.4784	0.5781	***	0.0325	1.4871	0.5765	***	0.0327
<i>EAST</i>	1.3146	0.4929	***	0.0433	1.3205	0.4915	***	0.0435
<i>CENTER</i>	0.8601	0.5471		0.0378	0.8765	0.5452		0.0385
<i>ISLANDS</i>	0.9267	0.5663	*	0.0204	0.9359	0.5647	*	0.0206
<i>MADRID</i> <sup>a)</sup>	-	-	-		-	-	-	
<i>YEAR 2002</i>	0.5053	0.4141		0.0189	0.6355	0.378	*	0.0237
<i>YEAR 2001</i> <sup>d)</sup>	-	-	-		-	-	-	
<i>YEAR 2000</i>	-0.0152	0.3594		-0.0006	0.1724	0.2666		0.0064
<i>YEAR 1999</i>	2.8487	0.3445	***	0.1064	3.0124	0.2726	***	0.1125
<i>YEAR 1998</i>	0.1384	0.3626		0.0052	0.3048	0.2925		0.0114
<i>INTERCEPT</i>	1.455	1.4523			1.552	1.443		
<i>F-Snedecor (Prob)</i>	18.78 (0.00)				20.41 (0.00)			
<i>R<sup>2</sup> (corrected)</i>	0.7335				0.7349			
<i>R<sup>2</sup></i>	0.7747				0.7728			
<i>Akaike info criterion</i>	2.4639				2.4490			

Note: \*\*\* indicates individual significance at the 1% level; \*\* 5% level; \* 10% level.

- Reference variable in a)
- The dependent variable Alcohol Consumption has been divided by 10.
- The elasticity terms have been calculated from the marginal effect using the routine in STATA9.0 named "mfx". The elasticity terms have been evaluated at the mean of the independent variables.

**Table 5. Estimation of the rate of traffic fatalities.**

	Model 1				Model 2			
	Coefficient	S. Deviation	Sign.	Elasticity	Coefficient	S. Deviation	Sign.	Elasticity
<i>ALCOHOL CONSUMPTION</i>	0.0009	0.0004	**	0.3052	-	-		
<i>BEER PRICE</i>	-	-			-0.0109	0.0054	**	-0.7488
<i>SANCTION(t-1)</i>	-0.0004	0.0002	*	-0.0342	-0.0005	0.0002	**	-0.0411
<i>NDA</i>	-0.0005	0.0002	**	-0.0234	-0.0004	0.0002	*	-0.0207
<i>NORTH</i>	0.0043	0.0016	***	0.0711	0.0054	0.0016	***	0.0881
<i>SOUTH</i>	0.0076	0.0017	***	0.0511	0.0068	0.0018	***	0.0459
<i>EAST</i>	0.0046	0.0016	***	0.0533	0.0047	0.0016	***	0.0540
<i>CENTER</i>	0.0043	0.0016	***	0.0619	0.0032	0.0016	**	0.0464
<i>ISLANDS</i>	0.0056	0.0017	***	0.0375	0.0059	0.0017	***	0.0397
<i>MADRID</i> <sup>a)</sup>	-	-	-		-	-	-	
<i>CONSTANTE</i>	0.0093	0.0023	***		0.0259	0.0064	***	

Note: See Table 4. The estimation also includes dummy year variables. The SANCTION (t-1) variable has been divided by 100.

**Table 6. Prices and taxes of beer.**

<i>Region</i>	<i>Price before taxes (Euros)</i>	<i>Taxes (%)</i>	<i>Price after taxes (Euros)</i>	<i>Tax increase (10%)</i>		
				<i>Taxes (%)</i>	<i>Price after taxes (Euros)</i>	<i>Price increase (%)</i>
Andalucia	0.12	16.81	2.27	18.49	2.48	9.44
Aragon	0.14	16.70	2.61	18.37	2.86	9.43
Asturias	0.14	16.69	2.63	18.35	2.88	9.43
The Balearic Islands	0.14	16.72	2.53	18.39	2.77	9.43
The Canary Islands	0.15	16.68	2.67	18.34	2.92	9.43
Cantabria	0.15	16.68	2.65	18.34	2.90	9.43
C. Mancha	0.12	16.80	2.28	18.48	2.50	9.44
C. Leon	0.13	16.78	2.35	18.45	2.57	9.44
Catalonia	0.14	16.72	2.54	18.39	2.78	9.43
Valencia	0.12	16.81	2.25	18.49	2.46	9.44
Extremadura	0.14	16.72	2.53	18.39	2.77	9.43
Galicia	0.14	16.71	2.56	18.38	2.80	9.43
Madrid	0.14	16.72	2.51	18.39	2.74	9.43
Murcia	0.13	16.78	2.33	18.45	2.55	9.44
Navarra	0.14	16.71	2.57	18.38	2.82	9.43
The Basque Country	0.15	16.67	2.72	18.33	2.98	9.43
Rioja	0.12	16.81	2.25	18.49	2.46	9.44

Source: Consumption Household Survey, Spanish Ministry of Food, Agriculture and Fishing (2000).

Average price of a beer (33 cc.) acquired in a supermarket.

Law 37/1992 of December 29 and Law 38/1992 of December 28.