ORIGINAL

Received: August 30th 2019
Accepted: October 31st 2019
Published: November 15th 2019

ANALYSIS OF THE DETERMINANTS OF COST SAVINGS IN TRAFFIC ACCIDENTS ON INTERURBAN ROADS IN SPAIN

María Pilar Sánchez González (1), Francisco Escribano Sotos (1) and Ángel Tejada Ponce (1)

(1) Faculty of Economic and Business Sciences. University of Castilla-La Mancha. Albacete. Spain.

Authors declare that there is no conflict of interest.

ABSTRACT

Background: The increase in traffic accidents depends on multiple factors; it generates an economic and public health problem that must be analyzed jointly by agents involved in road safety. The aim of the work was to quantify the effect of various factors in the cost savings due to traffic accidents on interurban roads in Spain.

Methods: It was analyzed, through a lineal regression with panel data model and in the period 2000-2017, how different factors affected cost savings due to the risk of mortality or injury avoided on Spanish interurban roads.

Results: A 1% increase in traffic volume led to a reduction in costs per MVKT (million vehicle-kilometres travelled) of €162.46 referring to the risk of mortality, €115.32 for serious injuries and €10.10 for mild injuries. This increase in unemployment caused a cost reduction of €31.43, €10.76 and €0.98, respectively. The same increase in the investment in replacement implied a reduction of these costs of €11 for any risk. A 1% increase in the ageing index led to an increase in costs of €276.83 in terms of mortality risk and €257.49 in terms of injury. Foreign tourism generated a higher cost of €40 for any risk. A 1% increase in Gross Domestic Product (GDP) per capita led to an increase in costs of €155.50, €138.09 and €8.21 for aforementioned risks. The points driving license led to an increase in costs of €785.50 per MVKR when referring to mortality risks.

Conclusions: Determining factors for cost savings: motorization rate, unemployment rate and investment in replacement interurban roads. Determining factors that increased costs: expiry of the effect of the penalty - points driving license, ageing index of the population, increase in GDP or proportion of foreign travelers.

Key words: Cost savings, Public health, Traffic accidents, Wounds and injuries, Linear models.

RESUMEN

Análisis de los factores determinantes del ahorro de costes en accidentes de tráfico en la red de carreteras de España

Fundamentos: El incremento de los accidentes de tráfico depende de múltiples factores, generando un problema económico y de salud pública que debe ser analizado conjuntamente por los agentes intervinientes en la seguridad vial. El objetivo del trabajo fue cuantificar el efecto de diversos factores determinantes en el ahorro de costes por accidentes de tráfico en vías interurbanas en España.

Métodos: Se analizó, a través de un análisis de regresión mediante datos de panel referidos al período 2000-2017, cómo afectaban diferentes factores al ahorro de costes por cada riesgo de mortalidad o lesividad evitado en las vías interurbanas españolas.

Resultados: El aumento del 1% del volumen de tráfico conllevó una reducción de costes por MVKR (millón de vehículos-kilómetros recorridos) de 162,46€ refiriéndonos al riesgo de mortalidad, 115,32€ para lesividad grave y 10,10€ para leve. El aumento en el desempleo supuso una reducción de costes de 31,43€, 10,76€ y 0,98€, respectivamente. Idéntico incremento de la inversión en la reposición implicó una reducción de estos costes de 11€ para cualquier riesgo. El aumento del 1% del índice de envejecimiento comportó un aumento de costes de 276,83€ hablando del riesgo de mortalidad y de 257,49€ si hablamos de lesividad. El turismo extranjero generó un coste superior a los 40€ para cualquier riesgo. El aumento del 1% del Producto Interior Bruto (PIB) per cápita conllevó un aumento de costes de 155,50€, 138,09€ y 8,21€ para los riesgos anteriormente definidos. El permiso de conducción por puntos condujo a un incremento de costes de 785,50€ por MVKR al referirnos a los riesgos de mortalidad.

Conclusiones: Los factores condicionantes del ahorro de costes son el volumen de tráfico, la tasa de paro y la inversión en reposición. Los factores condicionantes del incremento de costes son la caducidad del efecto del permiso de conducción por puntos, el índice de envejecimiento, el incremento del PIB y la proporción de conductores extranjeros.

Palabras clave: Ahorro de costo, Salud pública, Accidentes de tráfico, Heridas y traumatismos, Modelos lineales.

Correspondence:
Ángel Tejada Ponce
Facultad de Ciencias Económicas y Empresariales
Universidad de Castilla - La Mancha
Plaza de la Universidad, nº1
02071 Albacete, España
Angel.Tejada@uclm.es

Suggested citation: Sánchez González MP, Escribano Sotos F, Tejada Ponce A. Analysis of the determinants of cost savings in traffic accidents on interurban roads in Spain. Rev Esp Salud Pública. 2019;93: November 15th e201911111.

INTRODUCTION

Economic, social and cultural changes that have occurred in all countries have led to an increase in motorization that has resulted in an escalation of the accident rate worldwide in the last 20 years. In this context, in 2017 there were 102,233 traffic accidents with victims in Spain, resulting in 1,830 deaths, 9,546 people classified as seriously injured or hospitalized and 129,616 as slightly injured or non-hospitalized. While Spanish interurban roads accounted for the largest proportion of deaths and serious injuries (72% and 50% of the total for each type respectively), urban roads accounted for 60% of the minor injuries in traffic accidents[(1)]. These figures confirm that they continue to represent a real "public health" problem for Spain, whose burden on its national economy has been estimated at between 5,837 and 10,693 million euros in 2017[(2)].

The great repercussion of the consequences of traffic accidents causes Spanish society to demand road safety from the State, based on an improvement in interurban roads and greater attention to the high risk faced by the most vulnerable users (pedestrians, cyclists and motorcyclists) on urban and interurban roads. In recent years there has been a change in the consideration of traffic accidents: they are no longer fortuitous events, the product of chance and luck, but are controllable, avoidable and preventable public health problems, not only because of the injuries they cause, but also because they directly affect the overall health of individuals and societies.

This change in conception is due, in part, to the continuous effort made by scientific researchers, whose dedication over the last 20 years has focused on improving the knowledge associated with traffic accidents. A part of that literature has been focused on finding out the causes of traffic accidents, the conditioning factors of traffic accidents, concluding that traffic accidents are affected by factors such as the level of exposure[(3,4)], road policies aimed at controlling human behaviour[(5,6)], the economic environment[(7,8)], the level of economic development[(9)], sociodemographic factors[(10)], variables linked to road infrastructure[(4)] or the conditions of the vehicle fleet[(11)], among many others. Another part of the research has dealt with the economic assessment of the consequences of traffic accidents for society and national economies, quantifying through different methodologies the so-called "value of a statistical life", the main reference for calculating the cost of traffic accidents and evaluating road safety policies through cost-benefit analysis[(12,13,14,15,16)].

These lines of research linked to traffic accidents add an important volume of knowledge to the scientific literature, offering a set of information with great capacity to improve the road safety policy of all countries. Although it is essential to know the variables that affect the risk of death or injury in traffic accidents, it is also important to consider that the factors that affect a health problem need not be the same as those that affect the variation in its frequency[(17)]. Therefore, in economic terms and on the basis of this statement, it is likely that the determinants of the cost of traffic accidents caused in a given population may not be the same as those that cause victims to be saved or not, and therefore cost savings.

As we have pointed out, the determining factors of traffic accidents generate a socio-economic impact that causes a public health problem to which all countries devote a great economic effort with the implementation of different road safety plans.

In this sense, the quantification of the cost of traffic accidents on Spanish interurban roads makes it possible not only to determine their importance, but also to evaluate and quantify economically any measure or public policy aimed at eradicating them, managing to compare the cost of the policy with the economic saving achieved by the number of victims avoided.

In addition to this quantification, it is important to analyze which factors determine a cost saving linked to the risks of fatality, serious injury or slight injury caused by traffic accidents on Spanish roads, as this help us define where efforts to implement new road safety policies should be focused.

The quantification of costs and the identification of determining factors provides information for carrying out a cost-benefit analysis that must accompany any project or public action before taking a decision that compromises the scarce resources available to the Spanish Public Administration.

The objective of this work was to quantify, for the period 2000-2017, the effect of various determining factors on the cost saving from interurban traffic accidents in Spain caused by the risk of fatality or injury, serious or slight since we considered that accounting for economic effects of different public policies was key to directing and evaluating different road safety plans implemented.

MATERIAL & METHODS

Our objective was achieved using data from Spanish provinces for the period 1999-2017. For this purpose, the database constructed by Sánchez et al[18] was used, which describes a collection of data on various factors affecting interurban traffic accidents and which is used to analyze the risk of deaths and injuries resulting from such accidents on interurban roads in Spanish provinces since 1999. In this context, when referring to interurban roads, we include all those that are state-owned as well as those owned by different regions or provincial councils, that is, we add the kilometers of the entire State road system and the secondary road system of Spain.

The referenced database was extended with information until 2017 for all the variables contained therein. In addition, the following factors were incorporated for all provinces and years of the delimited period: degree of hotel occupancy, number of travelers by country of residence[19], ageing index[20] and Gross Domestic Product (GDP)[21]. The unavailability of information on this variable at provincial level for 2017 is supplemented by taking the growth rate of GDP per capita of the Region to which each province belongs.

Table 1 presents the definition of the variables used in the analysis[4]. All independent variables are expressed in terms of growth rates for each Spanish province.

The dependent variables, calculated equally for each province, being aware that the economic allocation to the human cost is not simple, were defined using the description of "victim avoided" delimited by Sánchez et al[22], applied to the variables "fatality risk", "serious injury risk" and "slight injury risk". We tried, with these dependent variables, to quantify the cost saving for each province and year of the period linked to these risks, obtained by means of the following expressions (in € per MVKT. In this sense, given that we are considering as interurban roads the entire road network of Spain, both the State and the secondary network, in the MVKT we aggregate all the kilometers of Spanish interurban roads, regardless of their ownership):

$$\text{Cost saving linked to avoided fatality risk} = (\text{Fatality risk}_t - \text{Fatality risk}_{t+1}) \times \text{Dead cost}_{t+1}$$

Cost saving linked to the risk of serious injury avoided =

Table 1
Variables used in the analysis.

Variables	Description
Cost saving associated with fatality risk.	Cost saving in € per MVKT linked to the number of deaths avoided by MVKT.
Cost saving associated with the risk of serious injury.	Cost saving in € per MVKT linked to the number of serious injuries avoided by MVKT.
Cost saving associated with the risk of slight injury.	Cost saving in € per MVKT linked to the number of minor injuries avoided by MVKT.
Penalty - points driving license.	Variable dummy with a value of 1 in those periods in which the penalty - points driving licence has been introduced.
Traffic volume.	Growth rate of the number of vehicles travelling annually on interurban roads in each province.
Motorization rate.	Growth rate of the number of registered vehicles per 1,000 inhabitants.
Population density.	Growth rate of the number of inhabitants per square kilometer.
Unemployment rate.	Growth rate of the percentage of unemployed in relation to the working population.
GDP per capita.	Growth rate of economic output per inhabitant.
Precipitation.	Growth rate of total rainfall volume in millimeters.
Proportion of high-capacity roads.	Growth rate of the percentage of high-capacity roads in relation to the total number of kilometers of interurban roads.
Investment in replacement per kilometer of roads.	Growth rate of replacement investment in interurban roads per kilometer of roads.
Investment in construction per kilometer of roads.	Growth rate of construction investment in interurban roads per kilometer of roads.
Degree of hotel occupancy.	Growth rate of the proportion of the number of rooms occupied with respect to the total available in hotel establishments.
Proportion of foreign travelers.	Growth rate of the number of foreign travelers in relation to the total number of registered travelers in hotel establishments.
Ageing index of the population.	Growth rate of the proportion of the population over 64 years of age in relation to the population under 16 years of age.

Source: Own elaboration from database of Sánchez et al (2018a).

(Risk of serious injury$_t$ - risk of serious injury$_{t+1}$) x Cost of serious injury$_{t+1}$

Cost saving linked to the risk of slight injury avoided = (Slight injury risk$_t$ - Slight injury risk$_{t+1}$) x Slight injury cost$_{t+1}$

The choice of calculating this difference between consecutive years rather than obtaining it for a base year was intended to avoid an overestimation of cost savings. In addition, this definition could take into account the measures and actions carried out in road safety annually in each of Spanish provinces in defined periods.

The assessment of cost savings for each risk was based on the quantification of the cost of preventing a death or non-fatal victim (serious injury or slight injury). The costs were obtained from the studies carried out by Abellán et al[12,13], mainly because they are the official values used by the "Dirección General de Tráfico" to calculate the cost of traffic accidents and the methodology used to do so, the approach of willingness to pay. To some extent, we believe that this method reflects how much society is willing to pay from its taxes for the implementation of road safety policies.

With this concept we are collecting human costs plus productivity loss plus medical costs. Medical costs reflect the cost of ambulance and emergency services and, where appropriate, hospitalization cost. Medical costs are considered on the basis of the cost of restitution method[23]. This method consists of estimating the cost of restoration to a situation similar to that existing before the accident, through the application of market prices or administrative tariffs to the set of facts derived from the accident that can be valued. The degree of homogeneity with which these costs are calculated in the different countries is very high. The method used to estimate the value of these gross losses is the human capital method[23]. This methodology assumes that the present and future income of the victims is equivalent to the average of the population of the same age and sex. Thus, once the average income of each age group and sex is estimated, it is projected into the future taking into account variables such as the activity rates of each group, their life expectancy and the general growth of the economy.

At the beginning, these costs were quantified at €1,400,000 for the value of preventing a deceased, €219,000 for a non-fatal (serious) injury and €6,100 for a non-fatal (slight) injury, basing their valuation on the value of a statistical life through the method of willingness to pay, net output losses (gross for the injured) and medical costs. These figures are used for two reasons: first, because they are the official figures handled by DGT[24] and second, because the method used to obtain them, the method of willingness to pay, is the most used to value the cost of accidents in countries[14, 25]. Mishan[26] suggested that this method is the most suitable for the economic valuation of traffic accidents, since the individuals are who establish how much money they would be willing to pay to reduce the risk of suffering a traffic accident. In the present research, given that the last update of costs made by DGT was in 2011, in order to achieve more homogeneous and comparable costs, these costs are expressed in euros in 2017 by means of the Consumer Price Index (CPI)[27] and with the growth rate of real GDP per capita in Spain[28,29] they are updated for each year, achieving the intended homogeneity and comparability, changing slightly each year due to the variation in real income.

With all the information indicated a database was constructed that has a panel data structure, so three panel data models are developed linked to each of the cost saving that we have defined linked to different risks with the following expression for province i during the t period:

$$y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots + \beta_K X_{kit} + \mu_i + \varepsilon_{it}$$

Where y_{it} is the cost saving linked to the risk of fatality or injury avoided for the province i in the year t, X_{kit} represent the independent variables, μ_i are the specific intercepts of each province and finally ε_{it} is the term of the error.

The fulfillment of Gauss-Markov's assumptions was checked to know if the Ordinary Least Squares is the best estimator. Therefore, in the first place, the Davidson-MacKinnon exogeneity test was applied in all models for each variable, instrumented by delay of order 1. This indicates that there were no endogeneity problems for the fatality risk and slight injury models. However, there were problems in the risk of serious injury model with respect to population density, unemployment rate and motorization rate. Harder to address this, these delayed variables were included for a period only in that model.

Hausman's test does not reject the random effects estimator as a suitable estimator, so the latter estimator was used because it is more efficient than the fixed effects estimator. There are no multicollinearity problems, with a combined IFV (inflation factor of the variance) of 1.37 and IFV much lower than 10 for all independent variables. Wooldridge test indicates the presence of autocorrelation only for the model linked to fatality risk; Levene and Forsythe-Browne tests indicate the presence of heterocedasticity in the most severe models (fatality and severe lesivity); both the variables individually and the models as a whole are cross-dependent. Pesaran and Fisher unit root tests were applied, showing that all variables used are stationary.

Non-compliance with the different assumptions leads to estimating the models using Panel Corrected Standard Errors (PCSE). Thus, the results are also presented applying the dynamic estimator (GMM) proposed by Arellano-Bond.

RESULTS

Figures presented in this section refer mainly to the estimates of the models obtained with PCSE, as it is the model that best fits the objective of the study.

Firstly, estimates of the cost saving associated with the fatality risk avoided on interurban roads revealed that, ceteris paribus, an increase of 1% in the motorization rate generates a cost saving of €359.15 per MVKT (table 2). The impact of a 1% increase in traffic volume or unemployment rate resulted in a cost saving for Spanish provinces of €162.46 and €31.43 per MVKT respectively. However, the introduction and validity of the penalty - points driving license led to an increase in costs of €785.50 per MVKT and the 1% increase in the ageing index of the population, or GDP per capita generated an increase in costs of €276.83 or €155.50 per MVKT respectively.

Arellano-Bond dynamic model warns that, although €1 increase in a cost saving from the previous year generated a higher cost of €0.23 per MVKT and the proportion of foreign travelers caused a cost of €49.54 per MVKT, the one-percentage point increase in investment in replacement per kilometer led to savings of €11.58 per MVKT in relation to avoided fatality risk.

With regard to cost savings in the risk of serious injury in traffic accidents on the Spanish roads, 1% increase in traffic volume, investment in replacement per kilometer or unemployment rate resulted in cost savings of €115.32, €11.69 or €10.76 per MVKT respectively (table 3). The effect of a change of one percentage unit on the ageing index of the population in Spanish provinces caused a cost of € 257.49 per MVKT. In addition, the level of economic development expressed by GDP per capita and foreign tourism (proportion of foreign travelers) generated a cost of €138.09 and €42 per MVKT.

Estimates using a dynamic panel data model (Arellano-Bond) show that an increase in fatality risk cost savings from the previous year by €1 had an effect of €0.27 in cost. In addition, the one percentage point growth in the proportion of high capacity roads was related to a higher cost of €29.30 per MVKT.

The direction of the impact of the selected factors on the cost saving of the risk of slight injury is similar to the two risks described above (table 4). The 1% increase in the motorization rate or traffic volume enabled Spanish

Table 2
Estimates of the cost saving associated with fatality risk.

Estimates	Panel data model with PCSE1(1)	Arellano-Bond Estimate
Cost saving from the risk of delayed fatality.	-	-0.2289608 (0.0001)
Penalty - points driving license.	-785.502 (0.006)	-427.9441 (0.646)
Traffic volume.	162.4604 (0.0001)	142.1936 (0.0001)
Motorization rate.	359.1456 (0.002)	702.1039 (0.0001)
Population density.	28.97465 (0.858)	-228.4098 (0.443)
Unemployment rate.	31.42831 (0.0001)	19.90173 (0.019)
GDP per capita.	-155.501 (0.002)	-278.6521 (0.0001)
Precipitation.	-4.521505 (0.263)	-5.293393 (0.273)
Proportion of high-capacity roads.	20.38312 (0.420)	-7.903359 (0.791)
Investment in replacement per kilometer of roads.	6.682285 (0.104)	11.57876 (0.001)
Investment in construction per kilometer of roads.	-0.0010565 (0.549)	-0.0000405 (0.960)
Degree of hotel occupancy.	-4.159972 (0.883)	-17.06973 (0.572)
Proportion of foreign travelers.	-19.24098 (0.489)	-49.54497 (0.0042)
Ageing index of the population.	-276.8274 (0.005)	-474.7179 (0.006)
Constant.	1,600.513 (0.001)	-
R^2.	0.1867	-
Joint significance test.	177.22(*)	6,659.39(*)
Number of observations.	772	715

(1) Panel Corrected Standard Errors; p-value in parentheses; (*) Significant at 5%; (**) Significant at 10%.

provinces to save €10.33 or €10.10 per MVKT respectively. While the effect of an increase in the unemployment rate or investment in replacement per kilometer was lower (€0.98-€0.53 per MVKT), a 1% growth in GDP per capita led to Spanish provinces at a cost of €8.21 per MVKT.

Finally, the incorporation of a cost saving from the previous year (Arellano-Bond) provided some different results: cost saving of €31.15 per MVKT generated by an increase in population density was offset by a cost of €70.52 caused by the entry into force and validity of the penalty - points driving license.

Table 3
Estimates of the cost saving associated with the risk of serious injury.

Estimates	Panel data model with PCSE1(1)	Arellano-Bond Estimate
Cost saving from the risk of delayed fatality.	-	-0.2727965 (0.000)
Penalty - points driving license.	-64.00849 (0.888)	26.55733 (0.937)
Traffic volume.	115.3251 (0.0001)	93.11195 (0.0001)
Motorization rate.	153.1258 (0.103)	93.15558 (0.210)
Population density.	-118.751 (0.421)	184.3097 (0.161)
Unemployment rate.	10.76333 (0.092)	16.85616 (0.008)
GDP per capita.	-138.0957 (0.004)	-100.1753 (0.011)
Precipitation.	-2.491138 (0.447)	-2.98573 (0.222)
Proportion of high-capacity roads.	2.071826 (0.911)	-29.29693 (0.059)
Investment in replacement per kilometer of roads.	11.69146 (0.0001)	9.283676 (0.002)
Investment in construction per kilometer of roads.	-0.0037991 (0.014)	-0.0025616 (0.290)
Degree of hotel occupancy.	-15.5729 (0.537)	-7.046622 (0.742)
Proportion of foreign travelers.	-41.99033 (0.032)	-45.31087 (0.001)
Ageing index of the population.	-257.4858 (0.010)	-361.1614 (0.0001)
Constant.	1,019.981 (0.028)	1,362.887 (0.0001)
R^2.	0.1534	-
Joint significance test.	132.53(*)	219.77(*)
Number of observations.	724	715

(1) Panel Corrected Standard Errors; p-value in parentheses; (*) Significant at 5%; (**) Significant at 10%.

Table 4
Estimates of the cost saving model associated with the risk of slight injury.

Estimates	Panel data model with PCSE1(1)	Arellano-Bond Estimate
Cost saving from the risk of delayed fatality.	-	-0.0249705 (0.488)
Penalty - points driving license.	-34.06392 (0.152)	-70.5215 (0.078)
Traffic volume.	10.10276 (0.0001)	10.52063 (0.001)
Motorization rate.	10.32928 (0.057)	3.094709 (0.723)
Population density.	-8.285363 (0.294)	31.15107 (0.029)
Unemployment rate.	0.9806741 (0.039)	1.553031 (0.008)
GDP per capita.	-8.212474 (0.011)	-7.142107 (0.098)
Precipitation.	-0.2578542 (0.211)	-0.4547016 (0.001)
Proportion of high-capacity roads.	-0.1854173 (0.874)	1.883943 (0.349)
Investment in replacement per kilometer of roads.	0.5260233 (0.033)	0.1742361 (0.115)
Investment in construction per kilometer of roads.	-0.0003079 (0.130)	-0.0002432 (0.0001)
Degree of hotel occupancy.	-0.4399131 (0.782)	0.4686531 (0.896)
Proportion of foreign travelers.	-0.5395821 (0.631)	-1.721385 (0.545)
Ageing index of the population.	-3.375334 (0.537)	7.435437 (0.552)
Constant.	39.81733 (0.108)	-
R^2.	0.1160	-
Joint significance test.	101.30(*)	192.66(*)
Number of observations.	772	715

(1) Panel Corrected Standard Errors; p-value in parentheses; (*) Significant at 5%; (**) Significant at 10%.

DISCUSSION

The results found with respect to the estimates of the determinants of cost saving due to traffic accidents in Spain represent a novelty for the scientific literature, not only because of the significance of the factors considered for the scientific community and political decision-makers, but also because of the definition of the risk of fatality or injury based on avoided victim employed by Sánchez et al (in press).

The positive coefficients of the motorization rate reveal the importance of this factor to achieve cost savings in the risks of fatality and slight injury, in line with the relationship found by other scientific research[10,30]. This finding indicates that the effect of higher level of development of the provinces predominates: higher rates of motorization are associated with better infrastructure, vehicles and social attitudes of road safety.

The cost saving related to the three avoided risks defined are favoured by the increase in traffic volume or the worsening economic environment. Firstly, the statistically significant positive coefficient of traffic volume shows a positive effect on road safety caused by increased congestion, leading to lower speeds, reducing the risk of death or injury in traffic accidents and, therefore, cost saving[31,32]. Secondly, an unfavourable economic situation leads to a lower risk of fatality and injury in Spanish provinces, in line with the results of research by Elvik[14] and Sánchez et al[4]. In times of economic recession, the number of kilometers travelled by heavy traffic, lower speeds and more moderate driving due to higher fuel prices or a lower proportion of less risky driving behaviour may be reduced[33].

The increase in investment effort materialized through investment in replacement per kilometer has repercussions on the country's economic growth: the statistically significant positive coefficient in injury and fatality models (the latter only in the Arellano-Bond model) shows that the growth in investment in improving and maintaining interurban roads in Spain results in a cost saving due to the risk of dying or suffering some type of injury on them, a result in line with that found by Albalate et al[34] and Sánchez et al[4] in their work.

The estimate of some of the selected determining factors reveal their negative impact on the capacity to reduce the risk of accidents and, therefore, the cost saving due to traffic accidents on interurban roads in Spanish provinces. The statistically significant negative coefficient of GDP per capita in the three estimated models warns of the negative effect of economic growth, causing a cost of the risk of fatality or injury higher than expected[35,36].

The statistically significant positive coefficient of the " proportion of foreign travelers " factor reveals the effect that tourism has on traffic accidents[37], generating an increase in costs linked to the risk of serious injury. The lack of knowledge of the environment of these foreign drivers and the difficulty of cross-border exchange of information in the field of road safety in relation to sanctions against foreign offenders could justify this finding, acquiring a certain relevance for the scientific community and political decision-makers. However, in reference to the difficulty of exchanging information, although it is true that Directive 2015/413 of the European Parliament and of the Council of 11 March 2015 facilitating the cross-border exchange of information on traffic offences in the field of road safety, and which has its national transposition in Royal Legislative Decree 6/2015 of 30 October, which approves the revised text of the Law on Traffic, Motor Vehicle Circulation and Road Safety, its application only affects two years of our period of study.

The changes in the structure of the population of the provinces measured by the ageing index of the population have a negative impact on the economy of Spanish provinces, with a higher cost for fatality and injury risks, which is in line with other studies[10,38] whose results demonstrate the higher accident risk of the elderly population.

The effectiveness of the penalty - points driving license in improving road safety on interurban roads in Spain is questioned by the results obtained in models linked to the risk of fatality and slight injury (Arellano-Bond). The statistically significant coefficient in these models indicates that their validity generates a higher cost than expected, which reinforces the idea of exhaustion of their capacity to improve road safety[39,40].

This finding represents a novelty for the scientific literature for its evidence of the impact on road safety in Spain contrary to that expected and found by other research whose methodology and period of study are similar to those used in this research[4]. In addition, it is important to highlight the relevance of this result for the definition of road safety policy in the near future, and a reconfiguration of this legislative measure is necessary to prevent its effect on road safety from becoming a brake on the country's economic growth.

Finally, results of the delayed dependent variable in the models associated with the risk of fatality and serious injury indicate a slight negative impact on the economic growth of Spanish provinces due to the higher cost, which is not supported by the reviewed scientific research.

Talking about conclusions, this paper analyses how different conditioning factors associated with traffic accidents affect the cost saving due to the risk of fatality or injury avoided on interurban roads in Spain during the period 2000-2017. Our findings found in the different regressions through panel data models constitute a novelty for the scientific community and the political community in charge of planning road safety policy in Spain.

The level of development of Spanish provinces, as measured by the motorization rate, is an important conditioning factor for reducing the economic impact of the most direct consequences of traffic accidents. Linking motorization rates to better transport systems, vehicles or social attitudes confirms the importance for road safety of allocating resources to research for better transport systems, safer vehicles and a population educated in the value of road safety. In addition, investment in the replacement and improvement of interurban roads should support these improvements to the transport system in order to achieve the best results in reducing the risk of death or injury in traffic accidents in Spain.

More congested roads slow down the assumed speeds, which represents a lower risk of accident. For this reason, factors of attraction of population and, therefore, of trips of the Spanish cities and provinces suppose a determinant of the road safety. This, together with differences in the economic situation of each province, can act as an agent characterizing the economic growth of Spanish provinces considering its effect on a cost saving due to the risk of fatality or injury avoided.

Those responsible for designing road safety policy must consider, on the one hand, the effect that economic growth has on traffic accidents and, on the other hand, the future forecasts of the increasingly ageing population structure, in order to achieve an optimal configuration with available resources. It is precisely those responsible who are obliged to carry out a review and reconfiguration of the penalty - points driving license, the effectiveness of which has been called into question in recent years.

The work done is not without limitations, among which we can highlight:

– The use of the statistical life values provided by Abellán et al[12,13] implies presupposing that citizens' preferences regarding road safety have not changed during the period analyzed, which is a restrictive assumption with respect to reality. Even so, the effect this may have on the valuation of the three dependent variables can be assumed. Secondly, the presence of cross-sectional dependence in independent variables induces us to take with caution the results of

Arellano - Bond dynamic model, whose estimates of cross-sectional dependency are not as efficient as those obtained under the assumption of cross-sectional independence.

– Although the analysis is carried out using information disaggregated by provinces and considering the MVKT, the effects on the cost saving have been quantified on an aggregate basis for the entire national territory. It would be interesting to know what the specific effects are on each type of road, depending on whether it is owned by the State, regions or provincial councils, a fact that is not disaggregated in this work.

– We can also consider as a limitation the lack of consideration of the impact of both emergency and out-of-hospital health care conditions and, in general, the possible ecological fallacy present in the work.

– We cannot forget that there is an interrelationship between the defined dependent variables and different variables associated or linked to urban, local or regional factors that are not incorporated in our models.

REFERENCES

1. Dirección General de Tráfico. Anuario estadístico de accidentes 2017. Madrid: Dirección General de Tráfico, 2018.

2. Dirección General de Tráfico. Las principales cifras de la Siniestralidad Vial España 2017. Madrid: Dirección General de Tráfico, 2018.

3. Abdel-Aty MA, Radwan AE. Modeling traffic accident occurence and involvement. Accid Anal Prev 2000; 32(5), 633-642. doi: http://dx.doi.org/10.1016/S0001-4575(99)00094-9.

4. Sánchez MP, Escribano F, Tejada, A. Impact of provincial characteristics on the number of traffic accidents victims on interurban roads in Spain. Accid Anal Prev 2018; 118, 178-189. doi: http://dx.doi.org/10.1016/j.aap.2018.02.015.

5. Albalate D. Lowering blood alcohol content levels to save lives: The European Experience. J Policy Anal Manage 2008; 27(1), 20-39. doi: http://dx.doi.org/10.1002/pam.20305.

6. Pulido J, Lardelli P, De la Fuente L, Flores VM, Vallejo F, Regidor E. Impact of the demerit point system on road traffic accident mortality in Spain. J Epidemiol Community Health 2010; 64, 274-276. doi: http://dx.doi.org/10.1136/jech.2008.082461.

7. Gerdtham U, Ruhm C. Death rises in good economic times: Evidence from the OECD. Econ Human Biol 2006; 4(3), 298-316. doi: http://dx.doi.org/10.1016/j.ehb.2006.04.001.

8. Kweon YJ. What affects annual changes in traffic safety? A macroscopic perspective in Virginia. J Safety Res 2015; 53, 17-21. doi: http://dx.doi.org/10.1016/j.jsr.2015.03.003.

9. Bishai D, Quresh A, James P, Ghaffar A. National road casualties and economic development. Health Econ Rev 2006; 15, 65-81. doi: http://dx.doi.org/10.1002/hec.1020.

10. Castillo-Manzano JI, Castro-Nuño,M, Fageda X. Can cars and trucks coexist peacefully on highways? Analyzing the effectiveness of road safety policies in Europe. Accid Anal Prev 2015; 77, 120-126. doi: http://dx.doi.org/10.1016/j.aap.2015.01.010.

11. Blows S, Ivers R, Woodward M, Connor J, Ameratunga S, Norton R. Vehicle year and the risk of car crash injury. Inj Prev 2003; 9(4), 353-356. doi: http://dx.doi.org/10.1136/ip.9.4.35.3.

12. Abellán JM, Martínez JE, Méndez I, Pinto JL, Sánchez MF. El valor monetario de una vida estadística en España. Madrid: Dirección General de Tráfico, 2011. Disponible en: https://www.mscbs.gob.es/profesionales/saludPublica/prevPromocion/Lesiones/JornadaDecenioAccionSeguridadVial/docs/InformeVVEJorgeMartinez.pdf.

13. Abellán JM, Martínez JE, Méndez I, Sánchez FI, Pinto JL, Robles JA. El valor monetario de una víctima

no mortal y del año de vida ajustado por la calidad en España. Madrid: Dirección General de Tráfico, 2011. Disponible en: http://www.dgt.es/Galerias/seguridad-vial/investigacion/estudios-e-informes/2011/SPAD1A_-.-ESTIMACION-EN-EL-CONTEXTO-DE-LOS-ACCIDENTES-DE-TRAFICO_INFORME-PARA-WEB.pdf.

14. Elvik R. An analysis of official economic valuations of traffic accident fatalities in 20 motorized countries. Accid Anal Prev 1995; 27, 237-247. doi: http://dx.doi.org/10.1016/0001-4575(94)00060-Y.

15. Wijnen W, Stipdonk H. Social costs of road crashes: An international analysis. Accid Anal Prev 2016; 94, 97-106. doi: http://dx.doi.org/10.1016/j.aap.2016.05.005.

16. Wijnen W, Weijemars W, Schoeters A, Van den Berghe W, Bauer R, Carnis L, Martensen H. An analysis of official road crash cost estimates in European countries. Saf Sci 2019; 113, 318-327. doi: http://dx.doi.org/10.1016/j.ssci.2018.12.004.

17. Rose G. Sick individuals and sick populations. Int J Epidemiol 1985; 14(1), 32-38. doi: http://dx.doi.org/10.1093/ije/14.1.32.

18. Sánchez MP, Escribano F, Tejada A. Data on the determinants of the risk of fatalities, serious injuries and light injuries in traffic accidents on interurban roads in Spain. Data Brief 2018; 18, 1941-1944. doi: http://dx.doi.org/10.1016/j.dib.2018.04.117.

19. Instituto Nacional de Estadística. Hoteles: encuesta de ocupación, índice de precios e indicadores de rentabilidad. 2019 Disponible en INEbase: http://ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736177015&menu=resultados&secc=1254736195376&idp=1254735576863.

20. Instituto Nacional de Estadística. Indicadores de estructura de la población 2019. Disponible en INEbase: http://ine.es/dynt3/inebase/es/index.htm?padre=2077&capsel=2083.

21. Instituto Nacional de Estadística. Contabilidad regional de España. Base 2010. Serie homogénea 2000-2016. Disponible en INEbase: http://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736167628&menu=resultados&idp=1254735576581.

22. Sánchez MP, Escribano F, Tejada A. Ahorros de costes provinciales en los accidentes viales en España (2000-2014). Gac San. (en prensa).

23. Alfaro JL, Chapuis M, Fabre F. Socio-economic cost of road accidents: final report of action COST 313. Brussels: Comission of European Community,1994.

24. Dirección General de Tráfico. Las principales cifras de siniestralidad. España 2012. Madrid, 2013.

25. Mohamed HA. Estimation of Socio-Economic Cost of Road Accidents in Saudi Arabia: Willingness-To-Pay Approach (WTP). Advances in Management and Applied Economics 2015; 5, 43-61.

26. Mishan EJ. Evaluation of Life and Limb: A Theoretical Approach. J of Polit Econ 1971; 79, 687-705.

27. Instituto Nacional de Estadística. Variaciones del índice de precios al consumo. 2015. Disponible en http://www.ine.es/varipc/index.do.

28. Instituto Nacional de Estadística. Tasa de crecimiento del PIB per cápita de España. 2015. Disponible en https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736167628&menu=resultados&idp=1254735576581.

29. Instituto Nacional de Estadística. Tasa de crecimiento del PIB per cápita de España. 2016. Disponible en https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736167628&menu=resultados&idp=1254735576581.

30. Albalate D, Bel G. Motorways, tolls and road safety: evidence from Europe. SERIEs 2012; 3(4), 457- 473. doi: https://doi.org/10.1007/s13209-011-0071-6.

31. Zeng Q, Wen H, Huang H, Abdel-Aty M. A Bayesian spatial random parameters Tobit model for analyzing crash rates on roadway segments. Accid Anal Prev 2017; 100, 37-43. doi:10.1016/j.aap.2016.12.023.

32. Zeng Q, Wen H, Huang H, Pei X, Wong S. A multivariate random-parameters Tobit model for analyzing highway crash rates by injury severity. Accid Anal Prev 2017; 99, 184-191. doi:10.1016/j.aap.2016.11.018.

33. Yannis G, Papadimitriou E, Folla K. Effect of GDP changes on road traffic fatalities. Saf Sci 2014; 63, 42-49. doi:https://doi.org/10.1016/j.ssci.2013.10.017.

34. Albalate D, Fernández L, Yarygina A. The road against fatalities: Infrastructure spending vs. regulation?? Accid Anal Prev 2013; 59, 227-239. doi:https://doi.org/10.1016/j.aap.2013.06.00.8.

35. Noland RB. Traffic fatalities and injuries: the effect of changes in infrastructure and other trends. Accid Anal Prev 2003; 35, 599-611. doi:10.1016/S0001-4575(02)00040-4.

36. Noland RB, Zhou Y. Has the great recession and its aftermath reduced traffic fatalities? Accid Anal Prev 2017; 98, 130-138. doi:10.1016/j.aap.2016.09.011.

37. Roselló J, Saenz de Miera O. Road accidents and tourism: the case of the Balearic Islands (Spain). Accid Anal Prev 2011; 43, 675-683. doi:10.1016/j.aap.2010.10.011.

38. Yee M, Cameron PA, Bailey M. Road traffic injuries in the elderly. Emerg Med J 2006; 23(1), 42-46. doi: http://dx.doi.org/10.1136/emj.2005.023754.

39. Castillo-Manzano JI, Castro-Nuño M. Driving licenses based on point systems: Efficient road safety strategy or latest fashion in global transport policy? A worldwide meta-analysis. Transp Policy 2012; 21, 191-201. doi: https://doi.org/10.1016/j.tranpol.2012.02.003.

40. Castillo-Manzano JI, Castro-Nuño M, Fageda X. Can health public expenditure reduce the tragic consequences of road traffic accidents? The EU-27 experience. Eur J Health Econ 2014; 15(6), 645-652. doi: https://doi.org/10.1007/s10198-013-0512-1.