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Three Essays on Road Safety

Tres Ensayos sobre Seguridad Vial

D. Eduardo Martínez Gabaldón

2021

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FACULTAD DE ECONOMÍA Y EMPRESA

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Three Essays on Road Safety

Tres Ensayos sobre Seguridad vial

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Eduardo Martínez Gabaldón

Tutor

Ildefonso Méndez Martínez

Directores

Ildefonso Méndez Martínez

Jorge Eduardo Martínez Pérez

“Sin datos, sólo eres otra persona con una opinión.”

W. Edwards Deming

ASPECTOS FORMALES DE PRESENTACION

Esta tesis doctoral es presentada en la modalidad de compendio de publicaciones gracias a la autorización recibida por parte de la Comisión General de Doctorado de la Universidad de Murcia. Dicha autorización es adjuntada como parte de esta tesis doctoral. El artículo 20 del REGLAMENTO POR EL QUE SE REGULAN LAS ENSEÑANZAS OFICIALES DE DOCTORADO DE LA UNIVERSIDAD DE MURCIA exige tener publicados o aceptados un número mínimo de tres trabajos en revistas indizadas en bases de datos internacionales de reconocido prestigio o en revistas científicas o libros editados de importancia justificada, según los indicios de calidad establecidos por la Agencia Nacional de Evaluación de la Calidad y Acreditación (ANECA). A continuación, se muestran las referencias bibliográficas de los tres artículos publicadas en revistas incluidas en el Journal Citation Report (JCR) para la aceptación de la tesis doctoral por compendio de publicaciones:

Artículo 1. Martínez-Gabaldón, E., Méndez Martínez, I., & Martínez-Pérez, J. E. (2020). Estimating the impact of the Penalty Point System on road fatalities in Spain. Transport Policy, 86, 1–8. https://doi.org/10.1016/j.tranpol.2019.11.003

Artículo 2. Martínez-Gabaldón, E., Martínez-Peréz, J., & Méndez, I. (2019). An empirical characterization of high-risk drivers in Spain. The role of gender, age, marital status and education. Transportation Research Part F: Traffic Psychology and Behaviour, 66, 430–444. https://doi.org/10.1016/j.trf.2019.09.014

Artículo 3. Martínez Gabaldón, E., & Méndez Martínez, I. (2020). On the long-run association between personality traits and road crashes: Findings from the British cohort study. Personality and Individual Differences, 155(1), 109677. https://doi.org/10.1016/j.paid.2019.109677

Del mismo modo, esta tesis doctoral es redactada en inglés. El artículo 18 del REGLAMENTO POR EL QUE SE REGULAN LAS ENSEÑANZAS OFICIALES DE DOCTORADO DE LA UNIVERSIDAD DE MURCIA permite redactar la tesis doctoral en idioma inglés, sin necesidad de autorización previa por parte de la Comisión General de Doctorado de la Universidad de Murcia. Aunque la tesis doctoral sea redactada en idioma inglés, el citado artículo exige que el título de la tesis conste en el idioma original de su redacción, en este caso inglés, y en castellano, en la cubierta y en la portada. Asimismo, la tesis debe contener un resumen en castellano. Dicho resumen es adjuntado como parte de esta tesis doctoral.

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INTRODUCTION

1. INTRODUCTION.

1.1. Economics as a science of choice making.

A good way of starting a doctoral thesis in economics is obviously by defining what the word economy means. The word economy comes from the Greek term "oikonomos": "who manages the household", derived from the word "oikos": "household" and "nemein": "manage". From the term oikonomos was derived the term "oikonomia": "household manager"

Any individual who has managed a household will have faced the classic problem on which the economy is based: the allocation of scarce resources. People have infinite desires and wants, but only some limited amount of resources to satisfy them. For example, suppose an economy produces two goods: apples and guns. In a hypothetical world in which both resources were unlimited, it would be possible to obtain as many resources as possible. In other words, there would be no economy. However, we know that the real world does not work like that. The more money we spend on guns, the less money we have left to spend on apples.

This problem of allocating scarce resources[1] to make the best possible decision - known in economics as efficiency - affects all members of our society: individuals, families, businesses, and policymakers. An individual has to decide whether to study or go out with friends; a family has to decide whether to travel or save money; a company has to decide whether to invest in R&D or train its

[1] When referring to resources we do not only refer to the monetary resources, but also to the non-monetary ones: time, water, air, noise, etc

workers; a policymaker has to decide whether to invest in education to reduce the drop-out rate or in health care to reduce the prevalence of a disease.

Economists have faced this kind of dilemma since ancient[2] times and have contributed to the discussion on how to allocate scarce resources to infinite desires. As a result of this discussion, several research areas have emerged in economic depending on the good or service that want to satisfy. Health economics, education economics, labour economics, environmental economics, sports economics, transport economics are just a few examples.

This thesis is framed within the transport economic, but, before deepening into the subject of the thesis, itself, let us see what transport economics studies.

1.2. Transport Economics.

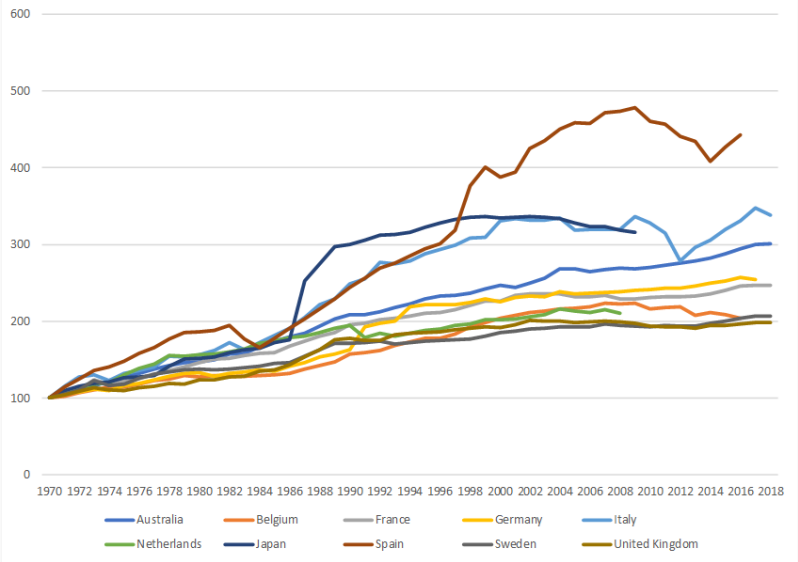
Humanity has always had the need to move from one place to another. It should not be forgotten that until the birth of agriculture and farming ("The Neolithic Revolution"), humanity was characterized by being a nomadic society (Scanes, 2018). Obviously, the reasons for which nomadic societies moved around – searching for daily food - are very different from those of present-day societies: working, shopping, health, religious, leisure, etc

This growing need for moving is reflected both at the macro and microeconomic level. Regarding macroeconomic level, according to Organisation-Economic-Cooperation-Development [OECD] (2020), the total volume of passengers per kilometre has doubled, tripled and even quadrupled in

[2] Nobel-winning economists Paul Samuelson said economics is the oldest of the arts, the newest of the sciences.

the world's highest-income countries from 1970 to the present (**Figure 1**). With regards to microeconomic level, 12.69% of the family budget in 2018 was allocated to transport-related activities (purchase of personal vehicles; purchase of accessories for personal vehicles; expenditure on fuel; maintenance and repair of personal vehicles; rail, road, air or sea transport services), only exceeded by the budget for housing (30.73%) and food (14.14%) (Instituto-Nacional-Estadística [INE], 2019)

Figure 1 Passenger road transport in some OECD countries 1970-2018. Base 1970=100.



Source: Own elaboration based on OECD (2020)

Formally, transport economics was founded in 1959 by American economist John R. Meyer and is defined as that branch of economics that deals with the efficient resource allocation within transport sector to meet the needs of a society (Wood, 2019).

Transport economics can be approached from both a macro and microeconomic perspective (Wood, 2019). From a macroeconomic perspective, transport economics looks at how the transport sector is an engine of economic

growth and employment generation. For example, the transport sector, in the broadest sense in Spain, accounts for almost 8.5% of value added and 7.6% of total employment (Aza & Escribano, 2019)

From the microeconomic point of view, transport economics studies the transport market through the law of supply and demand, competition between modes of transport (Gonzáles-Savignat, 2004; Jiménez & Betancor, 2012; Martín & Nombela, 2007), cost-benefit analysis of transport infrastructure investment (de Rus & Inglada, 1997), externalities derived from the transport sector (Parry et al., 2007; Santos et al., 2010; Stetjuha, 2017), pricing (Prud'homme & Bocarejo, 2005) among other topics. Our thesis is focused on externalities derived from the transport sector

1.3. Externalities in transport economics

As advanced above, 12.69% of the family budget is allocated to transport-related activities. These costs are considered internal, private or user costs since they are produced and perceived in a personal way by each individual and are considered when making individual transport decisions. However, other costs are imposed on others but are not supported by the road users when engaging in transport activities. These costs are known in economic as externalities or external costs. Table 1 displays the total social costs in the transport sector, differentiating between internal and external costs (European-Commission [EC], 1995).

Table 1. Classification of the costs of transports.

Cost Categories	Social Costs	
	Internal/Private Costs	External Costs
Transport Expenditure	Fuel and vehicle costs; tickets/fares	Costs paid by others (e.g. free provision of parking spaces)
Infrastructures Costs	User charges, vehicle taxes and fuel excises	Uncovered infrastructure costs
Accident Costs	Costs covered by insurance, Own accident costs	Uncovered accident costs (e.g. pain and suffering imposed on others)
Environmental Costs	Own disbenefits	Uncovered environmental costs (e.g. noise disturbance to others)
Congestion Costs	Own-time costs	Delays/time costs imposed on others

Source: EC (1995)

Economic theory defines externalities as an action made by an economic agent that produces a negative or positive effect on a third party who is not directly involved in the action (Pigou, 1920). Specifically, in the transport sector, an externality is defined as follows:

> Transport externalities refer to a situation in which a transport user either does not pay for the full costs (e.g. including the environmental, congestion or accident costs) of his/her transport activity or does not receive the full benefits from it. (EC, 1995, p.4)

The transport sector generates both types of externalities. Positive externalities include productivity gains for companies due to the existence of a good network of infrastructure and supply of transport services; and time savings achieved by users of a regular service as the number of users increases ("Mohring effect") (de Rus et al., 2003). However, the literature has focused on negative externalities because of their greater magnitude. The list of externalities derived from the transport sector is extensive but the most obvious are

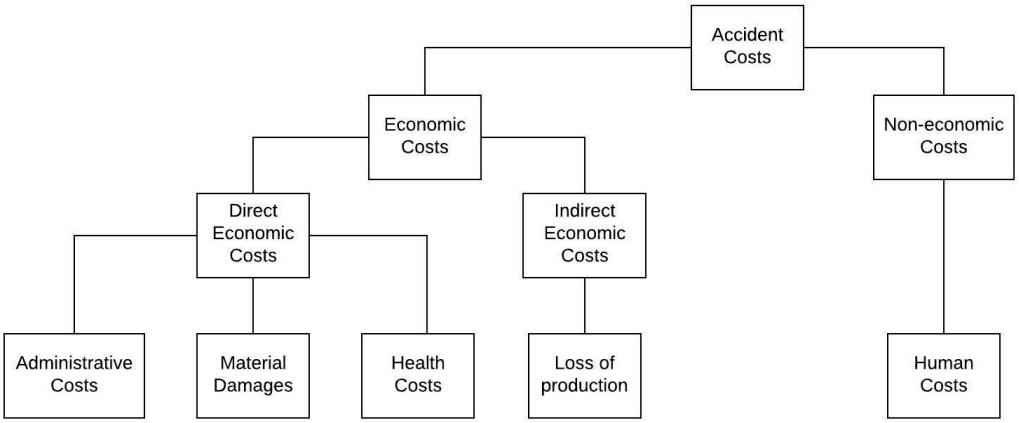
congestion[3], pollution, noise and road accidents (Parry et al., 2007; Santos et al., 2010). The magnitude of these external costs is not negligible. For example, the total external costs of the transport sector in the EU-28 were 987 billion euros in 2016, accounting for approximately 9% of the European Union's Gross Domestic Product. Road transport, especially passenger transport, is the main contributor to the external costs of the transport sector, accounting for 83% of the total (EC, 2019).

Focusing our analysis on road transport and specifically on road traffic accidents due to their greater relative importance[4], road accidents creates several costs (Bickel et al., 2005)., which are displayed below (Figure 2).

[3] it is argued that congestion is a transport externality because the road user only takes his time into account and not the extra time that he is imposing on other road users when deciding to use the vehicle (Ginés; de Rus et al., 2003). However, controversy has arisen over whether congestion costs should be considered a transport externality since these costs are supported by the same group of people who cause it (road users) (Fernández Fernández & Olmedillas Blanco, 2002)

[4] 37.82% of the external costs of road passenger transport are due to road accidents, followed by congestion costs (32.08%). The remaining costs are distributed as follows: climate change (9.52%), noise (6.83%), air pollution (6.28%) and other costs (7.47%) (EC, 2019)

Figure 2. Road accident costs



Source: own elaboration from Bickel et al. (2005).

(a) Economic costs

a. Direct economic costs

Administrative costs. They include the expenses derived from the work performed by police, firemen, judges, etc. for the administrative management of accidents: reports, forms, trials, etc.

Material damages. They include the costs of repairing damaged vehicles involved in accidents, as well as those damages caused in road infrastructure (safety barriers, public lighting, road signs, etc.)

Health costs. They cover the costs of health care from the time of the accident until the person completely recovers from his/her injury or the victim deceased.

b. Indirect economic costs

Loss of production. This includes loss of production due to temporary/permanent disability or death.

(b) Non-economic costs

Human cost. It reflects the sadness and pain experienced by family, friends and society. There are three methods for calculating it: the compensation method, the human capital method and the willingness to pay method.

In Spain, the cost of preventing a fatal accident is 1.4 million of euros. Regarding non-fatal serious and minor accidents, values are estimated at 219,000 and 6,100 euros, respectively (Martínez Pérez et al., 2015). Multiplying these figures by the number of deaths, serious and minor injuries, it is estimated that the costs associated with traffic accidents in Spain were 5,552 million of euros, that is, 0.5% of the Gross Domestic Product in 2016 according to police-reported data[5] (Dirección-General-Tráfico [DGT], 2017). This percentage ranges from 0.4% to 4,1% in several European countries; so, Spain is situated in the lowest part of distribution[6] (Wijnen et al., 2017)

The problem arises because road users do not take full cost into account when they decide to use their own vehicle. For example, material costs are already supported by road user through insurance premiums paid to insurance companies; whereas health or administrative costs are not, as they are borne by society[7]. In addition, human costs also have an external component as

[5] However, when the health system data are included, costs associated with traffic accidents rise to 10.3 billion euros (i.e. 1% of GDP) (DGT, 2017)

[6] However, the difference between countries is not only attributable to different levels of road safety, but also to differences in the methodology for calculating road accident costs, especially the human cost (Wijnen et al., 2017)

[7] There are large differences in the health insurance systems across countries in the EU. There are some countries where health costs can be claimed against the insurance company of the driver who caused the accident, whereas in other countries no claim can be possible against the insurance company (EC, 1995). Specifically, in Spain, Article 83 of the General Health Law states that: "Income from health care in cases of special compulsory insurance and in all cases, whether or not they are insured, in which a third party is obliged to pay, shall have the status of income of the corresponding Health Service. The expenses inherent in the provision of such services shall not be financed from the income of the Social Security. Under no circumstances may this income be used to pay for the services provided to these patients. For this purpose, the Public

road users assess their own risk when deciding to use their own vehicle (internal component[8]), but they do not assess the increased likelihood of having a road accident by other road users (external component). The external human costs will be higher as the causal relationship between increased traffic flow and increased accident risk is stronger[9]. In short, all these external costs must be considered by using the appropriate formula.

Internalising external costs is the formula for addressing the externalities associated with road accidents. Internalising means that users take external costs into account when making their own decisions. This internalisation can be achieved through market-based instruments (taxes, charges, tolls etc.) or "non-pricing" instruments (e.g. command-and-control measures) (EC, 1995). The former aim to make each road user pay the full social costs (private costs plus external costs) associated with their transport activity in order to try to reduce their demand; while the latter aim to change transport habits without influencing in the price (EC, 1995).

The selection of instruments to achieve a reduction in externalities is not arbitrary but it has to be based on a number of criteria: efficiency, cost-effectiveness, transparency, distributive equity, subsidiarity and indirect effects/secondary benefits (EC, 1995)

Administrations that have provided health care to users in such cases shall have the right to claim the cost of the services provided from the responsible third party" (Boletín-Oficial-Estado, 1986, p.33).

[8] However, it is argued that the risk of being involved in an accident is so tiny that an accurate perception of risk is very difficult if not impossible. Therefore, the human cost is fully considered external

[9] However, an extra vehicle could be considered as a positive externality as a crowded road will lead to less dangerous driving behaviour (e.g. lower average speed), thus decreasing the accident frequency and the severity of injuries in a given accident (Parry et al., 2007)

In line with classical economic theory, using market-based instruments is the most efficient way to address the objective of internalisation; however, there are different reasons for applying other types of instruments to address externalities: international dimension of some externalities, avoiding distortion of the internal market, better conditions for investing in technologies to reduce externalities, energy paradox, improving information to consumers/producers, responding to externalities that are not "targeted" by economic instruments and lack of political and social support for taxation (EC, 2019). Precisely, external accidents costs are not addressed by market-based instruments, mainly because it is not easy to internalise these costs through taxes or tolls. Therefore, other instruments (mainly command and control measures) are used to improve transport safety.

Regardless of the instrument used, economic or non-economic, state intervention is required to integrate the external costs on those agents causing negative externalities since internalisation cannot be reached by letting market forces play. Table 2 reflects the main instruments used by regulatory authorities to internalise external costs.

Figure 3. Review of the main instruments for internalising accident costs

OVERVIEW OF INTERNALISATION INSTRUMENTS			
	Type of instrument	Effectiveness	Cost-Effective-ness-ratio (ranking)
Accidents			
Education	Organisation/Institutional	Medium	1
Change of insurance/ liabil-ity(Bonus-Malus systems)	Economic	High	2
Limitation of alcohol limits	Command and Control	High	3
Speed limits	Command and Control	Very High	4
Courses for driving styles	Organisation/Institutional	High	5
Local measures	Infrastructure	Local High	6

Source: INFRAS/IWW (2004)

The most widely used economic[10] instrument for internalising the external costs of accidents is the insurance premiums paid by road users. Insurance companies offer differential premiums and road users choose the one that best meets their needs taking their perception of the risk into account. In addition, insurance companies differentiate insurance premiums taking account of those characteristics that affect the probability of being involved in a traffic accident (gender[11], age, length of driving licence, etc.), by penalising dangerous driving behaviour.

Regulatory authorities have little to say in the field of insurance companies, they can only encourage the existence of differential premiums. However, they do have a role to play in developing rules that affect the likelihood of having a road accident. Examples of such rules include speed limits;

[10] Other economic instruments used to internalise the road transport externalities are taxes or tolls. It is true that the existence of taxes or tolls influences the demand for transport and therefore the total volume of traffic. An increase in taxes or the introduction of a toll would mean a lower volume of traffic and, with the same accident risk, the number of accidents would be lower. However, this link appears to be indirect and it would be ideal to internalize accident cost using instruments that specifically target them (Santos, 2017)

[11] However, in March 2011 the European Court of Justice ruled against sex discrimination in insurance premium.

compulsory use of safety seat belts, helmets, and child restraint systems; banning the use of hand-held mobile phones, radio or GPS while driving; or driving under the influence of alcohol and/or drugs, etc. In the same vein, most European Union countries have adopted a driving license based on a point system to achieve a reduction in road accidents in Europe. **Chapter 2** of this thesis contributes to the existing literature on its causal effect. This is obtained by estimating the effect of this law on the number of deaths on Spanish roads using the methodology proposed in Abadie & Gardeazabal (2003) known as "Synthetic Control Method".

However, despite all these measures mentioned above, road user's behaviour (drivers, motorcyclists, cyclists and pedestrians) is far from being safe. Contributing factors to road accidents support this statement. Distracted driving appears as a contributing factor in 26% of total accidents, drunk driving in 12% and speeding in 9%. In addition, 11% of those killed on motorcycles on urban road did not wear helmets. This percentage was 4% on interurban road. 23% of those killed on interurban road did not use seat belts. Finally, 23% of the pedestrian who had been involved in a traffic accident on built-up areas had committed an offence (DGT, 2019b). For these reasons, public policies to decrease road accidents should be focused on reducing such risky driving behaviours as much as possible. In addition, it is widely known that the probability of participating in such risky driving behaviours is not homogeneously distributed across the population. **Chapter 3** of this thesis aims to identify the most prevalent risky behaviours in the Spanish drivers and to identify those groups of the

population that are highly dangerous while driving, with the aim of designing public policies on road safety targeted at these groups[12].

Finally, regulatory authorities can also ensure the internalisation of external costs by using institutional instruments giving safe driving style courses or educational policies that raise road safety awareness among road users. **Chapter 4** of this thesis contributes to the existing literature on education and road accidents. Specifically, it explores how fostering certain personality traits[13] in childhood can affect the likelihood of having a road traffic accident in adulthood.

1.4. Road accidents

It is well known that road accidents remain a major economic and public health concern worldwide, and they have attracted many researchers' attention in several fields such as economics, psychology, clinical research, educational sciences, etc.

Every year, over 5 million people die from injuries worldwide. Road traffic injuries are the leading cause, accounting for 24% of injury deaths, almost 2.4 and 1.5 times the number of deaths from homicides and suicides, respectively. (World-Health-Organization [WHO] , 2014)

[12] In epidemiologic, two strategies are distinguished when limiting the incidence of a disease: the "high-risk" strategy and the "population" strategy. The former strategy identifies those individuals in a population more likely to develop certain diseases and concentrates resources on modifying their risk factors. The latter focuses on the entire population, regardless of whether they are at risk or not. For more details on the advantages and disadvantages of each of the strategies, see Spasoff (1999)

[13] There is little consensus on whether personality traits is the right way to describe those behaviours, personality characteristics, and attitudes other than cognitive skills. In this sense, character skills, competencies, non-cognitive skills, soft skills, life skills, and social and emotional skills are also widely used (Gutman & Shoon, 2013). Throughout this thesis we will not differentiate between them and use them interchangeably.

The word accident comes from the Latin "accidens: "an event; chance; misfortune". Because of this definition[14], an accident appears to be an event that occurs unexpectedly and unintentionally, sometimes causing injury, disability, or death However, most of them are predictable and preventable in real life, as over 90% are caused by the human factor. The remaining 10% are caused by environmental and vehicular factors (Singh, 2015).

The human factor includes those actions taken by road users, such as speeding, driving without a seat belt, and driving under the influence of alcohol and drugs. It also includes their personal characteristics: sex, age, marital status, risk perception, personality traits, etc. The environmental factor is associated with the design and condition of the roadway such as slick road, pothole, dangerous curve, etc. Finally, the vehicle factor includes vehicle failures such as defective brakes, tyres illegal, defective or under inflated, defective steering, defective or missing mirrors, etc. However, it is very unlikely that accidents are related to a single cause. For example, a driver driving at excessive speed has a flat tire and goes off the road in a dangerous curve. In this example, all three factors occur at the same time: human (speeding), vehicle (flat tyre) and environment (dangerous curve). For this reason, we speak of contributing factors, defined as those factors that have contributed to the occurrence of the accident or the worsening of its consequences. In Spain, the factors contributing to the accident is contained in

[14] There is a growing discussion about the meaning of "accidents" vs. "crashes" (DGT, 2013). The main idea is that the word accident describes the intention of the driver at the time of the event. If you deliberately drove your vehicle into something or someone, you caused a crash; whereas if you were driving and lost control of your vehicle and hit something or someone, and did not intend to do so, that was an accident. Throughout this thesis, we will not differentiate between the two terms and use them interchangeably.

Order INT/2223/2014, of October 27 (*Orden INT/2223/2014, de 27 de Octubre*), which must be filled by police officers.

Regardless of contributing factor, accidents are classified according to the severity of the traffic accident into only material damage; minor injuries; serious injuries; and deaths. Accordingly, there are several scales used for this purpose: the KABCO scale and the MAIS scale are two examples (Burdett, 2014).

The KABCO scale is used by police officers at the scene of an accident and rates injury severity in a descending manner, where K means fatality; A means disabling injuries, B means non-incapacitating injuries, C means possible injury accidents and O means property damage only.

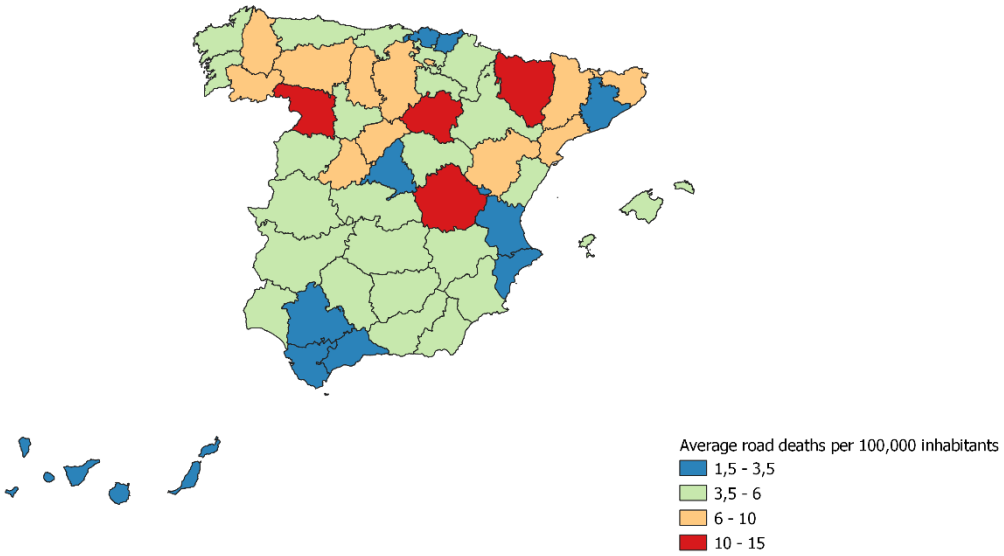
The MAIS scale is used by a medical professional in a hospital and rates injury severity in an increasing manner from 1 to 6, where 1 means minor injury, 2 means moderate injury, 3 means serious injury, 4 means severe injury, 5 means critical injury, and 6 means maximum injury.

In Spain, the scales mentioned above are not used, but casualties accidents are classified by police officers according to Annex III of Order INT/2223/2014, of October 27 (*Orden INT/2223/2014, de 27 de Octubre,*). Road dead is that person who dies immediately or within thirty days as a result of a traffic accident; road serious injured is that person who requires hospitalisation of more than twenty-four hours as result of a traffic accident; and, finally, road minor injured is that person who has not required hospitalisation of more than twenty-four hours as a result of a traffic accident (*Orden INT/2223/2014, de 27 de Octubre,*).

In 2016, road traffic accidents were the eighth leading cause of death worldwide and are expected to become the seventh leading cause of death by 2030. The number of road deaths worldwide is 1.35 million every year. Furthermore, road traffic accidents are not evenly distributed by age, sex and region. For example, road traffic crashes are the leading cause of death for people aged 15-29; they are three times more likely to happen among men than women; and the probability of dying in a road traffic crash is more than three times higher in developing countries than in developed ones (27.5 deaths per 100,000 population versus 8.3 deaths per 100,000 population) (WHO, 2018)

Spain is no exception to this economic and public health concern. In 2018, there were more than 100,000 traffic accidents, with 1,806 deaths, 8,935 serious injuries and 129,674 minor injuries (DGT, 2019a). As worldwide, road traffic injuries are not evenly distributed by age, sex and region. Specifically, road traffic injuries are the leading cause of death for people aged 15-29 and the fourth largest for those aged 30-49 (INE, 2019a). This implies that road traffic accidents are one of the main causes of premature death if we consider the average number of potential years of life lost, which is close to 30 years (DGT, 2017). Moreover, mortality from road accidents is particularly worrying for men. Specifically, 77.46% of those killed in Spanish road in 2018 were men, while 22.54% were women (DGT, 2019a). Finally, the average rate of road deaths per 100,000 inhabitants is higher in the north of Spain than in the south (Figure 4), especially in the provinces of Soria, Huesca, Zamora and Cuenca, where the average rate exceeded 10 deaths per 100,000 inhabitants in the period 2010-2018 (DGT, 2019a).

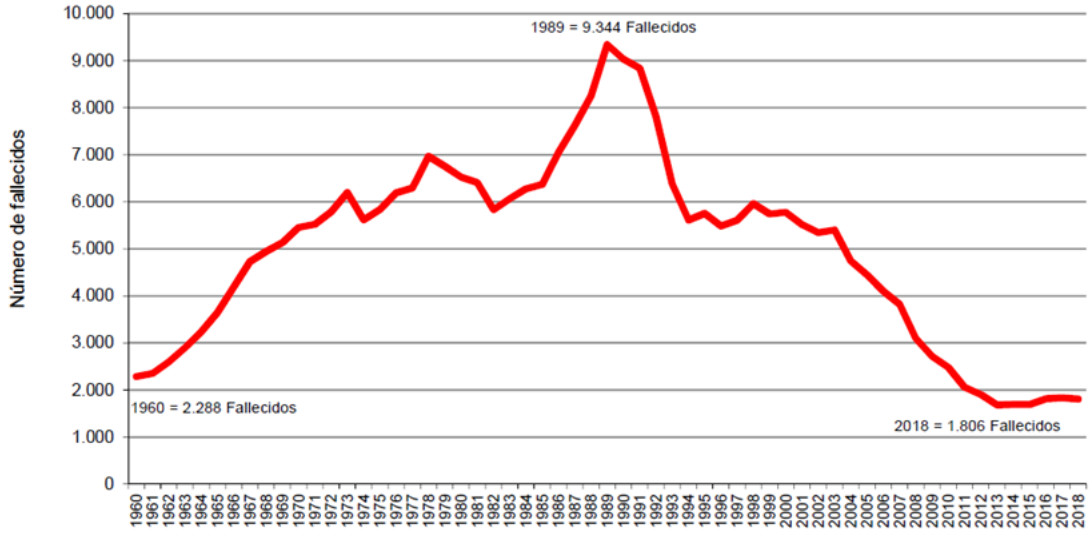
Figure 4 Average death rate on Spanish roads per 100,000 inhabitants by province. 2010-2018



Source: Own elaboration from DGT (2019a).

Once we have examined the current situation on Spanish roads deaths, it is also useful to analyse the previous situation (Figure 5). Traffic deaths on Spanish roads have experienced different cycles. Until 1989, mortality on Spanish roads continued to increase year after year, peaking at 9,344 in that year. From then on, the number of deaths fell by approximately 40% from 1989 to 1994, remaining stable from that year onwards (5,500 deaths per year). From 2004 onwards, road safety became a priority issue on the Spanish political agenda and a negative trend began in the number of deaths, reaching its lowest level in 2013. Since 2013, the trend for road deaths has changed tack and increased by 8% (DGT, 2019a).

Figure 5 Evolution of the number of deaths in traffic accidents in Spain. 1960-2018



Source: DGT (2019a).

1.5. Objectives

The global objective of this thesis was to explore non-economic instruments used by regulatory authorities to internalise external road accidents costs by developing rules that affect the likelihood of having a road accident or the worsening of its consequences. With this global purpose, three individual objectives were attempted to be addressed:

1. To estimate the causal effect of the introduction of Penalty Point System on the number of deaths on Spanish roads
2. To identify those groups of the population that are most likely to engage in risky behaviours while driving, with the aim of designing public policies on road safety targeted at them
3. To explore how fostering certain personality traits in childhood can affect the likelihood of having a road traffic accident in adulthood

CHAPTER 2

Estimating the impact of the Penalty Point System on road fatalities in Spain.

2. Chapter 2. Estimating the impact of the Penalty Point System on road fatalities in Spain

3.1. Motivation

In 1989, the number of people who died on Spanish roads was 9,344; this figure fell to 1,806 in 2018, a decrease of 80% (DGT, 2019b).To reach this figure, much effort has been made to improve road safety. A non-exhaustive list of some main road safety measures to date: Traffic Law (1990) (Real Decreto Legislativo 339/1990, de 2 de marzo) repealed in RDL6/2015 (Real Decreto Legislativo 6/2015, de 30 de octubre), General Traffic Rules (1992) (*Real Decreto 13/1992, de 17 de Enero,*) modified in RD1428/2003 (*REAL DECRETO 1428/2003, de 21 de Noviembre*) , Creation of National Road Safety Observatory (2004), Road Safety Key Strategic Action Plan 2005-2008 (DGT, 2005), Penalty Point System (2006) (Ley 17/2005, de 19 de julio), Reform of the Penal Code (2007) (*LEY ORGÁNICA 15/2007, de 30 de Noviembre*), Spanish Road Safety Estrategy 2011-2020 (DGT, 2010)

Among the implemented several measures can be highlighted the point system because of its widely implementation in most European countries. Nowadays, 21 out of 27 EU countries have implemented this system (Klipp et al., 2011).

A point system assigns a certain number of points to every driver as they commit some traffic offences. When driver loses all her/his points or reaches a certain number of points depending on the system, her/his driving license is suspended for a period.

There is a consensus about the main aims of the point system. Firstly, this system prevent risky driving behaviour since drivers can lose their driving licence if they commit offences repeatedly; Secondly, point system allow the traffic authorities to find dangerous drivers and to withdraw them from road before causing an accident; Finally, this system may correct risky driving behaviour as road users can regain points by attending driver improvement course (SWOV, 2012)

Although most European countries punish drivers for similar offences such as exceeding speed limit, driving with a blood alcohol or under the influence of drugs; not obeying stop signs or traffic lights, driving without seat belt or helmet, etc; there is not a harmonization system across Europe (Klipp et al., 2011). The main differences among countries are: taxonomy[15] (Demerit Point System vs Penalty Point System), severity, amount of points until withdrawal; and withdrawal period (Klipp et al., 2011)

Finally, three big undesirable side-effects have appeared with point system: unlicensed driving - drivers may continue to drive although their licence is suspended-, points trafficking - added o subtracted points are transferred from the driver who commits the traffic offence to another driver who is not habitual

[15] Some countries like German, Greece, and Ireland have opted for a cumulative system (Demerit Point System) in which all drivers start without points. Whenever road users commit offences, they accumulate points. When drivers reach a certain number of points, they lose their driving licence. Other countries like France, Italy, and Spain have chosen a subtraction system (Penalty Point System). In this system, an initial number of points are assigned every driver. When they are caught committing a traffic violation, they lose points depending on the severity. If drivers lose all the points, their licence is suspended- Existing literature on which taxonomy is most effective is uncertain. However, from psychological decision-making theory proposed in Kahneman and Tversky (1979), it seems that a system where points are subtracted would be more effective because people are more likely to prevent loss than not to prevent gain "loss aversion principle" (van Schagen & Machata, 2012)

driver or have not driven for ages-, and hit-and-run crash – the tendency to drive on after causing an accident to avoid receiving extra points-. (SWOV, 2012)

The evaluation of causal effect[16] of point system has captured scholars' attention from several disciplines – economy, psychology, medicine, etc-. These researchers have focused their attention on two approaches: driving behaviour – using helmet or seat belt, speeding, driving after drinking alcohol, etc. and accident and health outcomes – accidents, traffic deaths or injuries, hospital admissions or emergency department visits because of road accidents. Existing literature has shown that point system have been important to modify risky driving behaviour (Gras et al., 2014; Montoro González et al., 2008; Zambon et al., 2008) and to reduce road accidents ant their consequences (Castillo-Manzano et al., 2010; De Paola et al., 2013; Donnelly et al., 2005; Farchi et al., 2007; Healy et al., 2004; Izquierdo et al., 2011; Novoa et al., 2010; Poli de Figueiredo et al., 2001; Zambon et al., 2007)

The objective of this chapter was to contribute to existing literature and to assess the causal effect of the Penalty Point System[17] on the number of people killed in road accidents in Spain. To do this, we used an methodology called Synthetic Control Method proposed in Abadie and Gardeazabal (2003), and expanded in Abadie et al. (2010) and Abadie et al. (2015). This method allows us to know what would have occurred to number of people killed in a road accident if the Penalty Point System had not come into force.

[16] As noted in van Schagen & Machata (2012), it is very complicated, if not impossible. to estimate the causal effect of point system since its implementation goes together enforcement increase, publicity and related factors.

[17] Throughout this thesis, we use the expression “effect of the Penalty Point System” to refer to the overall effect of Penalty Point System and related measures the went with it (enforcement, publicity campaigns, reform of the penal code, etc.)

3.2. Methodology

When evaluating the effects of a new program, policy, law, etc on some outcome of interest, the most difficult task is to estimate a suitable counterfactual. The counterfactual means what would have happened to treated unit if the intervention had not existed. The problem is that only is observed the actual outcome and not the counterfactual one. So, the first challenge is to create an appropriate counterfactual that best resemble what would have occurred to treated unit if the treatment had not been implemented.

There are several methodologies to address the key question of the counterfactual: randomized evaluations (Bloom et al., 1997), propensity score matching (Rosenbaum & Rubin, 1984), difference-in-differences (Card & Krueger, 1994; Montalvo, 2012), instrumental variable (Angrist, 1990), and regression discontinuity (De Paola et al., 2013). Each of these methods[18]. imposes certain assumptions on the control group. When these assumptions are reasonable, control group resemble counterfactual and our estimations will be unbiased. However, most of these assumptions are too restrictive and hard to accomplish and estimates may be biased.

To overcome the limitations, Abadie and Gardeazabal (2003) developed a methodology known as “Synthetic Control Method”. This methodology is based on the idea that, a weighted average of comparison units often provides a far better counterfactual than any comparison unit alone. Furthermore, contrary to Card (1990), who estimated the effect of the 1980 Mariel Boatlift on the Miami labour market by choosing subjectively four US cities

[18] A more detailed summary of the evidence of classical tools in the program evaluation can be seen in Abadie and Cattaneo (2018)

(Atlanta, Los Angeles, Houston, and Tampa-St. Petersburg) as comparison group, Synthetic Control Method forces researchers to show similar features between treated and control group reducing the arbitrariness when choosing the units for control group.

Synthetic Control Method has been widely used to evaluate the effects of events or interventions (Cavallo et al., 2013; Jimenez & Mercado, 2014; Kleven et al., 2013; Pinotti, 2015; Trandafir, 2014). It has been also used to identify the effects of road safety interventions such as prohibiting handheld cell phone use while driving (Sampaio, 2014) and liberalizing drinking bar hours (Green et al., 2014)

3.3. Data

Data are organized as country-level panel data for the period 1995-2010[19]. Penalty Point System came into force in July 2006 in Spain (Ley 17/2005, de 19 de julio), so we have eleven years of pre-intervention period and five years of post-intervention period.

Our synthetic Spain was formed by a weighted average of countries in the donor pool (UE-28). However, as displayed in Table 2 there are some member states that put in force this law during our sample period and other countries that had already implemented this law previously, so all of them were

[19] The period 1995-2010 is used for methodological reasons. Before 1993, road deaths are those who died within 24 h after the event. Between 1993-2010, road deaths are those who died at the scene of the crash or within 30 days following the crash using adjusting factor for those initially recorded as seriously injured. From 2011 onward, road deaths are those who died at the scene of the crash or within 30 days following the crash by linking the register of crashes reported by the police and the national death register

excluded. Thus, our donor pool consisted of the remaining member states: Belgium, Estonia, Lithuania, Portugal, Slovakia Republic, and Sweden.

Table 2 Countries with Point System

Country	Year	Country	Year
Germany	1974	Hungary	2001
United Kingdom	1972	Netherlands, Ireland, and Luxembourg	2002
Finland	1981	Italy	2003
France	1992	Latvia and Malta	2004
Croatia	1996	Austria and Denmark	2005
Poland and Slovenia	1998	Czech Republic and Spain	2006
Bulgaria, Cyprus, and Greece	2000	Romania	2007

Source: Adapted from.Klipp et al. (2011)

Road deaths per 100.000 inhabitants was our dependent variable. As regards independent variables, the diesel and gasoline consumption were employed as proxy of the rate of vehicle utilization; GDP per capita logged was included as proxy of the economic activity measure since road accidents are linked both to the rate of vehicle utilization and to the level of economic activity (García-Ferrer et al., 2007). Furthermore, considering that traffic crashes are the main cause of fatalities among young people aged 18-24 (INE, 2019a), it was included the percent aged 18-24 for both men and women. Finally, 23% and 27% of killed drivers on interurban and urban roads were tested positive for alcohol (International-Transport-Forum [ITF], 2019). Because of that, we included the alcohol consumption as a predictor variable.

3.4. Results

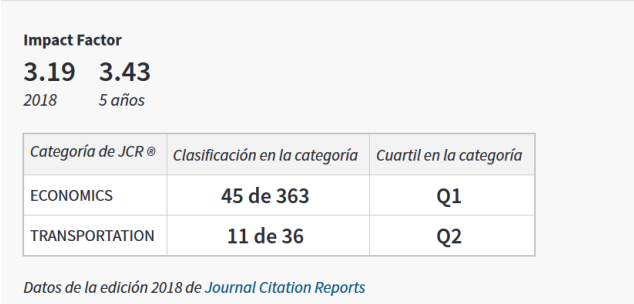
The results suggest that overall effect of the introduction of the Penalty Point System and related measures at the end of the year 2007 amounts to a reduction of fatality rates in Spain of 14.7% with respect to what would have been otherwise observed in the absence of those initiatives. Additionally, in the next two years, that is, in 2008 and 2009, the effect of the Penalty Point System and related initiatives amount to a 29.5% reduction in the fatality rate. The fatality rate in Spain in the absence of the Penalty Point System and related initiatives in 2010 would have been 2.2 points higher than the observed rate of 5.3 deaths per 100,000 inhabitants.

Paper 1

Martínez-Gabaldón, E., Méndez Martínez, I., & Martínez-Pérez, J. E. (2020). Estimating the impact of the Penalty Point System on road fatalities in Spain. *Transport Policy*, *86*, 1–8. https://doi.org/10.1016/j.tranpol.2019.11.003

Journal

Transport Policy



Impact Factor

3.19 **3.43**

2018 *5 años*

Categoría de JCR ®	*Clasificación en la categoría*	*Cuartil en la categoría*
ECONOMICS	45 de 363	Q1
TRANSPORTATION	11 de 36	Q2

Datos de la edición 2018 de Journal Citation Reports

Abstract

Traffic accidents are a major public health concern since they are the leading cause of death for those aged 15–29 years and the ninth cause of death worldwide. In this paper, we estimate the overall effect on traffic fatalities of the introduction of the Penalty Point System (PPS) in Spain in 2006, jointly with those of the publicity campaigns that went with it and the reform of the Penal Code to toughen the consequences of traffic offenses in 2007. We use a synthetic-control method that controls for differences in the distribution of control variables, changing business cycles conditions, the effect of unexpected policies or events that happen between the pre- and the post-PPS periods and the arbitrariness in the selection of the control group. We find that the introduction of the PPS and related initiatives lead to a reduction of almost 15% in traffic fatality rates in Spain during the first two years. The magnitude of the estimated effect monotonically increased over time until reaching a 40% reduction in fatality rates in 2009 and 2010

Url

https://www.sciencedirect.com/science/article/abs/pii/S0967070X18307091

Chapter 3

An empirical characterization of high-risk drivers in Spain. The role of gender, age, marital status and education.

3. Chapter 3- An empirical characterization of high-risk drivers in Spain. The role of gender, age, marital status and education.

3.1. Motivation

> According to the Spanish general traffic regulations, article 3.1:
>
> Driving must be done with the diligence and precaution necessary to avoid any damage, personal or external, taking care not to endanger both the driver himself and the other occupants of the vehicle and the other road users. Careless or reckless driving is strictly prohibited (REAL DECRETO 1428/2003, de 21 de Noviembre, 2003, p. 45689)

However, the scientific literature on road safety compliance have shown that people drive dangerously disregarding and failing to comply with road safety rules. For example, Bautista Ortuño & Miró Llinares (2015) found that 33.9% of drivers surveyed use mobile phones while driving, 31.6% exceed the speed limit and 11.5% drive after drinking alcohol. In contrast, more than 90% of drivers surveyed always wear seat belts. These risky driving behaviours are closely related to fatal and injury accidents. Specifically, speeding was contributing factor in 22% of fatal accidents and 9% of injury accidents in Spain in 2018. In the same line, 23% and 27% of killed drivers on interurban and urban roads were tested positive for alcohol, and distraction while driving such as the use of mobile phones, radios, DVDs, witnessing a previous crash, etc. was reported as a contributing factor in 32% of fatal accidents and 26% of injury accidents. Finally, 23% of car fatalities aged 12 and over were not wearing seat belts on interurban roads (ITF, 2019).

The aim of this chapter was to identify the most prevalent dangerous driving behaviours and which groups of people are most likely to engage in

dangerous driving behaviour to improve and prevent such behaviour through the implementation and evaluation of public policies targeted at them. For example, the intervention program “Alcohol-free on the road” (Dutch: “Alcoholvrij op weg”) aims to enhance young people’s awareness of the effects of driving after drinking alcohol. This program achieved that only 0.4% of male participants were registered in the Office of the Public Prosecutor for driving under the influence of alcohol compared to 4,2% of those in the control group (Brookhuis et al., 2011)

3.2. Methodology

Several analyses were conducted. First, when there were only two groups (for example, gender), an independent t-test was conducted to investigate if there was a statistically significant difference between them. In addition, when the assumption of equal variances was not met (p-value of Bartlett's test was below 0.1), Welch's formula was used. Second, when the number of groups was greater than two, a one-way ANOVA was conducted to analyse if there was a statistically significant difference between them. Besides, multiple-comparisons tests were computed using either Bonferroni test when the assumption of equal variances was met (p-value of Bartlett's test was above 0.1) or Games-Howell test when the assumption of equal variances was not met.

In addition, to resolve the problem for potential confounding factors, multivariate analysis was carried out by using a logit model to estimate the relationship between several demographic variables (gender, age, marital status and education level) and each of the seven risky driving behaviours analysed.

Finally, a linear regression was computed to examine the relationship between global risky driving behaviour and our independent variables of interest, controlling for a full set of potential confounding factors. The new dependent

variable was created by aggregating each of the seven risky driving behaviours into a single scored called risky driving total score.

3.3. Data

The data used are extracted from the May 2016 barometer elaborated by the Spanish Sociological Research Centre. This barometer consists of a nationwide personal survey conducted to people over 18 years old and it is divided into two blocks. The first block are questions from which the ‘‘poll indicators are drawn up” and the second block are questions, which focus on a particular political or social issue on each occasion. Because of the 10th anniversary in Spain of the Penalty Point System, the second block of May 2016 barometer included questions related to driving such as risky driving behaviour, driving experience, habits, exposure, offences, etc. To be more precise, seven risky driving behaviours were included: speeding in built-up areas, using mobile phone while driving, passing through a yellow light, speeding in motorway, handling GPS or radio while driving, driving after drinking alcohol, and driving without fastening the seat belt. These questions were answered by participants using a five-point Likert scale. Individuals had to mark their opinion on each question ranging always (1) to never (5).

The sample consisted of 1,628 individuals who regularly drove. 58.95% were males and 41.05% females. 230 (14.09%) were 18-29 years old; 741 (45.40%) were 30-49 years old; 440 (26.96%) were 50-64 years old; 221 (13.54%) were 65 years old and over. In addition, more than half of participants (55.47%) were married and 26.92% had completed higher education.

3.4. Results

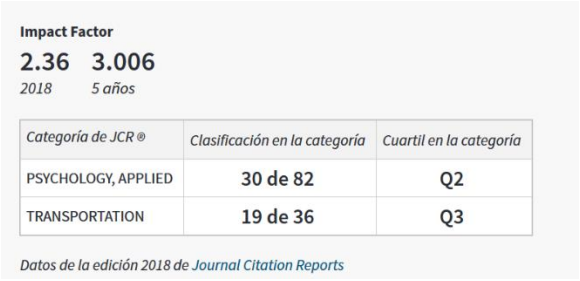
Our results suggest that men, young, single, and people with secondary or higher education are more likely to engage in dangerous driving behaviour. However, analysis by risk behaviour reveals differences by group. For example, men are more likely than women to exceed the speed limit or drive after drinking alcohol, but there is no difference between them when using a mobile phone while driving. Older people are less likely to use a mobile phone, GPS or radio and to exceed the speed limit on motorways than younger, while there are no differences in the remaining behaviours. Third, single people are also more likely to drive after drinking alcohol than married people. Finally, people with secondary or higher education are more likely to engage in dangerous driving behaviour, except for speeding

Paper 2

Martínez-Gabaldón, E., Martínez-Peréz, J., & Méndez, I. (2019). An empirical characterization of high-risk drivers in Spain. The role of gender, age, marital status and education. *Transportation Research Part F: Traffic Psychology and Behaviour*, *66*, 430–444. https://doi.org/10.1016/j.trf.2019.09.014

Journal

Transportation Research Part F: Traffic Psychology and Behaviour



Impact Factor

2.36 *2018* **3.006** *5 años*

Categoría de JCR ®	*Clasificación en la categoría*	*Cuartil en la categoría*
PSYCHOLOGY, APPLIED	30 de 82	Q2
TRANSPORTATION	19 de 36	Q3

Datos de la edición 2018 de Journal Citation Reports

Abstract

Traffic accidents are both a major economic and public health problem worldwide. We use data from the May 2016 Spanish barometer (n = 1632) to analyse the characteristics of drivers who declare different types of risky driving behaviours. Our estimates suggest that the likelihood of being a high-risk driver in Spain increases with educational attainment and decreases with age. Moreover, it is higher for those with previous sanctions and for men, particularly so regarding speeding and driving after drinking alcohol. These results suggest that prevention policies in Spain should be targeted to different collectives of drivers depending on the particular risky behaviour considered.

Url

https://www.sciencedirect.com/science/article/abs/pii/S1369847818305266?via%3Dihub

Chapter 4

On the long-run association between personality traits and road crashes: Findings from the British cohort study

4. Chapter 4. On the long-run association between personality traits and road crashes: Findings from the British cohort study

4.1. Motivation

There is considerable correlational research indicating the importance of personality traits as predictors of road safety outcomes (Arthur et al., 2001, 2005; Arthur & Day, 2009; Arthur & Doverspike, 1992, 2001; Arthur & Graziano, 1996; Guastello & Guastello, 1986; Iversen & Rundmo, 2002; Montag & Comrey, 1987). However, most of them show the relationship between personality traits and road accidents by using cross-sectional data and less attention has been paid on the long-run association between personality traits and road accidents using prospective cohort design. To the best of our knowledge, only Batty et al. (2007) studied the long-term importance of cognitive and non-cognitive ability in predicting a range of self-reported causes of non-fatal, unintentional accidents, including road accidents.

This chapter fills this gap in the literature by analysing the predictive importance of childhood personality traits on traffic accidents in adulthood. In addition, this chapter has also contributed to existing literature on personality measures in childhood and later socioeconomic, health and labour outcomes.

4.2. Data

The database used in this chapter was constructed from 1970 British Cohort Study (BCS70). The BCS70 is an ongoing, multidisciplinary, longitudinal study that follows the lives of more than 17,000 children born in England, Scotland and Wales between 5th and 11th April 1970 (Brown, 2014). Since the birth survey in 1970, other surveys have been conducted at: 5 years (1975), 10

years (1980), 16 years (1986), 26 years (1996), 30 years (2000), 42 years (2012), 46 years (2016) and, most recently, at 50 years (2020). These surveys were conducted in order to monitor their health, education, social development and economic circumstances, among other factors. In particular, data from three waves were used: at birth (1970), at age 10 (1980) and at age 30 (2000).

The birth survey consists of a form completed by the midwife. The 1980 survey included a parental interview, a parental self-completion questionnaire, a medical examination, education assessments, a pupil self-completion questionnaire, and an educational questionnaire which was completed by teachers and head-teachers. The 2000 survey included questions related to several topics such as housing, social and personal relationships children, employment, lifelong learning, health, citizenship and values, among others.

Our dependent variable is obtained using the 2000 survey. In this survey, respondents were asked to indicate whether they had/had not received medical assistance as a result of an accident since they were 16 years old. A positive answer to this question was followed by another question about the type of accident, including road accident as pedestrian, driver or passenger.

Personality traits were constructed using the third wave (1980) of the BCS70. This wave included the responses of the child's teacher to a questionnaire with 52 items describing the child's social behaviour. A total of 30 out of the 52 items were selected to construct our measures of personality traits[20]. A principal-component factor analysis was conducted to resume the information

[20] The remaining 22 items were discarded since they are not related to personality traits.

provided by the items and four factors with eigenvalues greater than one were obtained. These factors jointly explained over 60 per cent of the variance in the original data. Factors 1, 2, 3 and 4 corresponded to neuroticism, conscientiousness, extraversion and agreeableness, respectively. Similar to Prevoo & ter Weel (2015) and Macmillan (2013) openness was not retained as no item captured this measure of personality trait. Factors presented a good internal consistency, except for factor 4. More specifically, the corresponding alphas of the factors were 0.93, 0.93, 0.83, and 0.66, respectively

Finally, control variables were incorporated to our database using at birth (1970), and at age 30 (2000) survey.

4.3. Methodology

The association between early personality traits at age of 10 and the probability of being involved in a traffic accident at the age of 30 was explored, by estimating a probit model where dependent variable equals to one if respondent has been involved in one or more accidents as a driver, a passenger, or a pedestrian and equal to zero if respondent has never been involved in any type of road accident.

Three specifications were considered. Firstly, the raw association only included personality variables. Secondly, the raw specification was expanded to control for the respondent's sex, their parent's educational attainment and the mother's age when she had her first child (control variables at birth). Finally, the full specification controlled for information obtained when the respondent was 30 years old such as region of residence, main activity, marital status, highest qualification among other factors (control variables at birth and 30 years).

We analyse heterogeneity in the association between childhood personality traits and road safety outcome in adulthood by estimating model separately for men and women.

4.4. Results

Our results suggest that early personality traits are associated with the probability of having a traffic accident in adulthood. Specifically, both conscientiousness and neuroticism at the age of 10 are associated with the probability of having a traffic accident in adulthood. Children who had a 1 standard deviation above average conscientiousness (neuroticism) at age 10 were 1,72 (1,43) percentage points less (more) likely to be involved in a traffic accident at the age of 30. However, only conscientiousness[21] remained statistically significant after controlling for a large set of confounding variables. In particular, children who rated an above-average standard deviation of conscientiousness at age 10 were associated with a 1.42 percentage point decrease in the likelihood of having a traffic accident at age of 30.

The estimated effects differed significantly by sex. In particular, there was no statistically significant evidence supporting the hypothesis that early measures of personality traits affect the probability of having a road traffic accident for women at the age of 30, whereas the estimated effect for men is very significant, implying that boys who had a 1 standard deviation above average conscientiousness at the age of 10 were 3 percentage points less likely to be involved in a traffic accident at age of 30.

[21] Neuroticism remained marginally significant at the 10% level in the full specification

Paper 3

Martínez Gabaldón, E., & Méndez Martínez, I. (2020). On the long-run association between personality traits and road crashes: Findings from the British cohort study. *Personality and Individual Differences*, *155*(1), 109677. https://doi.org/10.1016/j.paid.2019.109677

Journal

Personality and Individual Differences

Impact Factor

1.997 *2018* **2.419** *5 años*

Categoría de JCR ®	*Clasificación en la categoría*	*Cuartil en la categoría*
PSYCHOLOGY, SOCIAL	**24 de 63**	**Q2**

Datos de la edición 2018 de Journal Citation Reports

Abstract

Traffic crashes are the leading cause of death for those aged 15–29 years and the ninth cause of death worldwide. Personality traits play an important role in explaining traffic crashes. We use data from the British Cohort Study 1970 to analyse the effect of the respondent's personality traits at age 10 on the probability of having had at least one injurious traffic crash at age 30. Our results support the hypothesis on the long-run associations between personality traits in childhood and injurious road crashes in adulthood, but only for men. Specifically, a one standard deviation increase in the level of conscientiousness at age 10 would lower men's likelihood of having at least one injurious traffic crash by approximately 3 percentage points. The association found in this paper may suggest that improving personality traits through educational programs could lower traffic crashes and risky driving behaviours

Url:

https://www.sciencedirect.com/science/article/abs/pii/S0191886919306099

CONCLUSIONS

5. Conclusions

Despite the significant progress made in road safety in Spain over the last two decades, road accidents remain a major economic and public health concern in our country. The long-term negative trend that started at the beginning of the 21st century was broken in 2013 when annual road deaths reach its lower level. Since then, It has produced stagnation in the number of road deaths (DGT, 2019b). This problem is particularly worrying for young people and men. Specifically, road traffic injuries are the leading cause of death among young adults aged 15-29 years (INE, 2019a), and 77.46% of those killed in Spain were men (DGT, 2019b)

Traffic accidents include several costs: administrative, material, health, loss of productivity and human costs (Bickel et al., 2005). In Spain, these costs amounted to 5,552 million euros, that is, 0.5% of the Gross National Product in 2016, of which 47.13% were due to road deaths, 38.6% to serious injuries and 14.18% to minor injuries (DGT, 2017).

The problem arises because road users do not take the full cost of using their own vehicle into account. This is known in economics as an externality. Regulatory authorities have two types of instruments, economic and non-economic, so that road users internalise such external costs. This thesis has focused on non-economic instruments as they have been shown to be more effective in reducing the likelihood of being involved in a road accident, while economic ones are more effective in reducing other external costs associated with transport sector: congestion, pollution, climate change or noise.

The term accident makes us think as a purely random event that occurs unexpectedly and unintentionally; however, the empirical evidence has identified three contributing factors to traffic accidents: environment, vehicle and human. The latter factor is precisely which causes approximately 95% of road accidents (Singh, 2015).

The human factor includes, among other things, the driving behaviour. Research literature has shown the correlation between such behaviours and mortality on Spanish roads. For example, Sánchez-Mangas et al. (2010) found a positive and statistically significant association between driving under the influence of alcohol or not using safety restraints, such as seat belts; and the mortality rate in Spain. In this same line, García-Ferrer et al. (2007) showed that mandatory seat belt use led to a permanent drop in the road death rate in Spain. However, it is well known that these dangerous behaviours are not evenly distributed across population. The third chapter of this thesis aimed to identify those driving behaviours with the highest prevalence in the Spanish drivers and to identify those groups of drivers who are highly dangerous at the wheel.

In this sense, the introduction of effective interventions in road safety field could reduce the probability of having a road accident and engaging in risky driving behaviour. The existing research literature on road safety has used Haddon Matrix (Haddon, 1968) as a tool of classifying road safety interventions (Novoa et al., 2009). This two-dimensional matrix classifies road safety interventions based on two criteria. The first criterion refers to at the time of the event: pre-crash, crash and post-crash. The second criterion includes the contributing factor: human, vehicle and environment (Haddon, 1972).

Firstly, pre-crash interventions aim to reduce the probability of being involved in an accident and/or reduce exposure to risk. Secondly, those focused on the time of the accident aim to reduce the severity of the accident. Finally, those focused on post-crash aim to ensure that victims are only injured and do not die (Novoa et al., 2009)

This thesis has focused their attention on pre-accident interventions aimed at improving the human factor. Therefore, our policy recommendations will be focused on this factor.

Chapter 2 has contributed to exiting literature on causal effect of Penalty Point System because of its importance in road safety as it has been implemented in most European Union countries. (Klipp et al., 2011) . Our results suggest that it was an effective measure in reduce the number of road deaths. Specifically, we estimate the causal effect of such measure on road fatality rate per 100,000 inhabitants in Spain. Our estimates suggest that the introduction of the Penalty Point System and related initiatives lead to a reduction of almost 15% in traffic mortality in Spain during the first two years. Furthermore, in the following two years, 2008 and 2009, the effect of the Penalty Point System and related initiatives was a 30% reduction in the mortality rate. The mortality rate that would have been observed in Spain in the absence of the Penalty Point System and related initiatives in 2010 would have been 2.2 points higher than the observed rate of 5.3 deaths per 100,000 inhabitants. This result is in line with those found in the preceding literature (Márquez, 2016). However, despite the undoubtedly success, a growing discussion has arisen in recent years on the need to be updated so that it remains effective. In this sense, two new systems are proposed below.

Firstly, results found in chapter 3 has shown that road users usually participate in more than one risky behaviour. More specifically, over 60% of sample claimed to have participated in two or more risky driving behaviour. A widely recognized tool for recidivists is **progressive penalty system**. This system consists of penalizing more severely, i.e. losing more points, as road users commit more offences. The justification for this policy lies in the association between the probability of having a traffic accident and the frequency of traffic offences committed (Goldenbeld et al., 2013). Currently, the number of points subtracted from the points-based system is identical, regardless of whether a previous offence has been committed. Our proposal would be to penalise with a higher loss of points if the driver has been previously sanctioned for the same or another traffic offence. For example, driving between 150-170 kilometres per hour on motorways means a loss of 2 points regardless of the number of offences committed previously. With our proposal, 2 points would be lost if it is the first time that a traffic offence is committed, 4 points if it is the second time, 6 points if it is the third time and so on. In short, it would consist of multiplying the number of points deducted under the current point system by the number of offences committed on his/her driving record.

Secondly, most countries apply their point system in the same way to all drivers. However, Chapter 3 has shown that the probability of engaging in risky driving behaviour does not evenly distributed across the population. For example, men are more likely to exceed the speed limit or drive after drinking alcohol than women, but there is not different between them when using a mobile phone while driving. In this same line, older people are less likely to use a mobile phone, GPS or radio and to exceed the speed limit on motorways than younger age groups,

while there are no differences in other behaviours. As regards marital status, the only significant difference was found in driving after drinking alcohol, with married people being less likely to engage in such behaviour. Finally, people with secondary or higher education are more likely to engage in dangerous driving behaviour, except for speeding, than people with primary education. These results seem to support the development of a **more differentiated system based on high-risky drivers**. Nowadays, it is only applied to novice and professional drivers, but it could be extended to all drivers of motorised vehicles. Those groups of drivers who scientific evidence has shown to be more likely to engage in risky driving behaviours should be assigned more points for the same offences than those groups of drivers who are less likely to participate in that same behaviour. The differential of points assigned would be proportional to the higher probability of committing such an offence by that risk group. For example, our results suggest that the probability of using a mobile phone while driving is 70% lower for people over 65 than for the rest of the age group; therefore, in our system, the points assigned for using the mobile phone while driving should be 70% higher for those under 65 compared to those over 65. To our knowledge, no country has implemented a point system like the one proposed and Spain could be a pioneer in implementing this system.

Following the idea of high-risky drivers, chapter 3 has found that people aged 15-29 years are most likely to engage in risky driving behaviours. Existing literature suggests that the most likely factors contributing are driving inexperience and immaturity (Williams, 1997). In this sense, a widely recognized tool of controlling the risks and reducing crash rates among young drivers is the **Graduated Driver Licensing**. Graduated driving licence aims to enable road

users to start driving in safe environments and to be gradually introduced to higher risk driving situations. This type of licence is usually divided into three stages. The first stage, the initial stage, requires driving in the presence of an adult with a valid license. The intermediate stage allows inexperience driver to drive without adult but under certain restrictions (no driving at night or limitation of passengers, restrictions on blood alcohol concentration). The final stage does not impose any restrictions by driving with total independence (Russell et al., 2011). The effectiveness of this licence in reducing young driver crashes has been widely demonstrated in the systematic review in Russell et al. (2011). However, a note of caution should be mentioned since some authors have shown that lower crashes are due to a reduction in exposure rather than a change in dangerous driving behaviour (Karaca-Mandic & Ridgeway, 2010).

However, despite the significant progress made in road safety in Spain over the last two decades, chapter 3 suggests that Spanish drivers remain driving dangerously disregarding and failing to comply with road safety rules Understanding and predicting why some people take such major risks to their lives is a key element to change the behaviour of road users towards safer behaviours.

Chapter 3 revealed differences in the compliance with traffic rules[22]. Our results suggest that the least frequently obeyed rules were handling GPS or radio while driving. It is not surprising since more than 50% of drivers think that manipulating a GPS while driving is legal (Prat et al., 2017). Especially worrying is speeding on a motorway or in built-up areas since they were the second and

[22] Passing the yellow traffic light is not illegal, but it does constitute a risky driving behaviour.

the third least frequently obeyed rules. Next, driving after drinking alcohol and using a mobile phone while driving were the following non-obeyed rules. Finally, seat belt wearing was the most frequently obeyed rule. These results are in line with scientific literature on road safety compliance. For example, Bautista Ortuño & Miró Llinares (2015) found that 33.9% of drivers surveyed use mobile phones while driving, 31.6% exceed the speed limit and 11.5% drive after drinking alcohol. In contrast, more than 90% of drivers surveyed always wear seat belts.

The compliance with traffic rules is determined by two factors: objective risk -the actual probability of getting caught by police officers for traffic violations - and subjective risk – road users' perception of getting caught by police officers for traffic violations. In this sense, **increase enforcement** play a key role to change both types of risks aimed at modifying risky driving behaviours, especially those most prevalent reported.

In this sense, Traffic Police have police check as tool available for enforcing road traffic rules. In Spain, Traffic Police conducted speed controls on 13.6 million vehicles in 2018; however, this is far from the 35 million controls conducted in 2013. With respect to alcohol checks, Traffic Police carried out more than 5 million alcohol checks in 2018, 6% more than in 2017. It is worth noting the drug tests, which increased by 56% in 2018 to 139,703 (DGT, 2019b). The effectiveness of enforcing in reducing road accidents on Spanish roads is supported by a report conducted by the MAPFRE Foundation and the University of Seville. This study concludes that a 10% increase in radar speed controls leads to a 4% decrease in the number of fatalities. This percentage is 0.74% for alcohol control (Fundación-MAPFRE, 2017). Therefore, an increase in the human and material resources allocated to Traffic Police could reduce the number of deaths.

In fact, the previous study concludes that police capacity is at a suboptimal level and a 10% increase could reduce the number of deaths by 5.3% (Fundación-MAPFRE, 2017).

Moreover, the compliance with traffic law can also come from social norms, which has their roots in the behavioural economics, a research field in economics that uses psychological principles to understand the human behaviour. In this line, preceding literature has been much influenced by neoclassical economics. According neoclassical economics theory, people will engage in risky behaviours if expected gains are higher than losses (Ben-Ari, 2004) However, the emerging field of behaviour economics has shown that individuals' choices deviate from the predictions of rational behaviour and points out that many decisions are made on the basis of conjecture, feeling and intuitions. One of the instruments proposed to change the behaviour of people is the concept of "nudge". This concept seeks to alter people's behaviour in a predictable way towards more favourable options for their own well-being but without modifying or prohibiting other alternative options (Thaler & Sunstein, 2008). There are numerous examples of "nudges" to encourage road safety behaviour, including the "Most of Us Wears a Seat Belt Campaign" and the "Most of Us Prevents Drinking and Driving Campaign" (social norms); "Default Activation of Intelligent Speed Adaptation" (Default); "Speed Reduction Marks" (Priming Effect) among others[23]. Countries such as the United States of America and the United Kingdom have incorporated this phenomenon into their political agenda by creating "nudge units" (Patel et al., 2018). The **creation of nudge units** to design and implement "nudges" in Spain would be useful to help mitigate

[23] For more details, see Avineri (2014)

both road safety problems and other behavioural problems: smoking, alcohol consumption, low exercise and being overweight or obese

Finally, literature investigating personality traits has shown to be associated with risky driving behaviour (Ehsani et al., 2015; Hubicka et al., 2010; Schwebel et al., 2006) and, consequently, with traffic accidents (Arthur et al., 2001, 2005; Arthur & Day, 2009; Arthur & Doverspike, 1992, 2001; Arthur & Graziano, 1996; Guastello & Guastello, 1986; Iversen & Rundmo, 2002; Montag & Comrey, 1987). Results found in chapter 4 are in line with preceding literature, supporting the hypothesis that personality traits are correlated with traffic accidents. Specifically, we found that early measures of consciousness predict traffic crashes even after controlling for a large set of control variables. Children who have an above-average standard deviation of consciousness at age 10 are associated with a 1.42 percentage point decrease in the likelihood of having a traffic crash at age 30. These results seem to open up the possibility of **new educational policies**[24] since substantial benefits can be obtained on road safety if effective interventions are implemented to **improve such personality traits in childhood**. In this sense, Senserrick et al. (2009) found that high school students who participated in a program to boost resilience reduced their risk relative for crash by 44% compared to those who did not participate. Likewise, Griffin et al. (2004) found that those students who participated in a drug abuse prevention program known as Life Skills Training were less likely to have violations and points on their driving records compared to those students who did not participate in the same program. Finally, Murcia University is implementing a social and

[24] Existing literature on the effectiveness of driving educational programs for improving road safety does not appear to be effective in reducing crashes and injuries (Ker et al., 2003; Novoa et al., 2009)

emotional learning program aimed at improving the personality traits in childhood. This program has shown to be successful at increasing children´s inhibitory control, cognitive flexibility, working memory and planning. These dimensions have been shown to be linked to dangerous driving behaviour. For example, inhibition control is related to using a mobile phone while driving, driving after drinking alcohol and speeding. Likewise, planning is correlated with driving without a seat belt (Hayashi et al., 2018)

Having said that, future research into interventions designed to improve road safety is extremely necessary. In this sense, as suggested in Novoa et al. (2009)., road safety intervention should show its effectiveness based on scientific evidence. Implementing interventions that are not effective can be costly to society in terms of both wasted monetary resources and lost lives. For this reason, the **creation of an interdisciplinary office to conduct evidence-based policy evaluations** is extremely urgent. Furthermore, by its own interdisciplinary nature, it would not be limited exclusively to road safety interventions, but it would be extrapolated to labour, health, education interventions.

SUMMARY IN SPANISH

6. Summary in Spanish (Resumen en Español)

Los accidentes de tráfico siguen siendo un importante problema económico y de salud pública en todo el mundo. Cada año, alrededor de 1,35 millones de personas mueren como resultado de un accidente de tráfico en todo el mundo y muchas más resultan heridas, algunas de ellas con lesiones incapacitantes permanentes (World-Health-Organization [WHO], 2018).

España no es una excepción este enorme problema. Poniendo cifras, en 2018, hubieron más de 100.000 accidentes de tráficos en las carreteras españolas, con un balance de 1.806 fallecidos, 8.935 heridos de gravedad y 129.674 heridos leves (Dirección-General-Tráfico [DGT], 2019a). Además, es ampliamente conocido que los accidentes de tráfico no se distribuyen de forma homogénea entre la población, sino que varía en función de características socioeconómicas como el sexo, la edad o la región de residencia. Concretamente, los accidentes de tráfico son la principal causa de muerte para aquellas personas entre 15-29 años y la quinta causa de muerte para los de 30-49 años. Esta circunstancia implica que los accidentes de tráfico son una de las principales causas de muerte prematura en España, suponiendo, de media, 30 años de vida potencialmente perdidos (DGT, 2017). Además, los accidentes de tráfico son especialmente preocupante en los hombres, ya que más del 75% de los fallecidos en España en 2018 como resultado de un accidente de tráfico en España fueron hombres, frente al 22,54% de mujeres (DGT, 2019a). Finalmente, la tasa media de fallecidos por cada 100.000 habitantes es mayor en el norte de España que la zona sur, especialmente en provincias como Soria, Huesca, Zamora y Cuenca donde la tasa media en el periodo 2010-2018, excedió los 10 fallecidos por cada 100.000 habitantes.

Esta tesis aborda la problemática de los accidentes de tráfico desde un punto de vista económico, considerando a los accidentes de tráfico como una externalidad o costes externos asociada al sector del transporte.

Una externalidad en el sector de transporte se define como aquella acción realizada por un usuario del sector del transporte quien ni paga el coste total de su acción (externalidad negativa) ni recibe el beneficio completo de su acción (externalidad positiva) (European-Commission [EC], 1995)

Aunque el sector de transporte lleva consigo aparejado una serie de externalidades positivas (ganancia de productividad de las empresas al aprovecharse de la existencia de una buena red de transporte, efecto “Mohring” (de Rus et al., 2003)), la literatura se ha centrado especialmente en las externalidades negativas debido a su mayor magnitud. La lista de externalidades derivadas del sector del transporte es extensa, pero las más obvias son la congestión, la contaminación atmosférica y/o acústica y los accidentes de tráfico (Parry et al., 2007). La magnitud de estos costes externos no son nada despreciables. Por ejemplo, los costes externos totales en el sector de transporte en la Unión Europea-28 fueron de 987 miles de millones en 2016, siendo el transporte por carretera, especialmente el de pasajeros, el principal contribuidor, aglutinando el 83% del total (EC, 2019).

Dentro del transporte por carretera, destaca especialmente los accidentes de tráfico ya que el 37,82% de los costes externos del transporte por carretera de pasajeros son debidos a los accidentes de tráfico, seguido por los costes de congestión (32,08%). El resto de los costes externos se distribuyen de la siguiente forma: cambio climático (9,52%), contaminación acústica (6,83%), contaminación atmosférica (6,28%) y otros costes (7,47%) (EC, 2019).

La literatura científica ha identificado diversos costes asociados a los accidentes de tráfico (Bickel et al., 2005). Los costes administrativos incluye los gastos derivados del trabajo realizado por la policía, bomberos y/o jueces como consecuencia de un accidente de tráfico (informes de periciales; gastos de abogados y jueces, etc); los daños materiales incluye el coste de reparación de los vehículos implicados en el accidente así como cualquier daño ocasionado a la infraestructura vial (barreras protectoras, señales de tráfico, alumbrado público, etc); los costes sanitarios incluye todos los gastos del sistema sanitario de salud desde el momento en que se produce el accidente hasta el final del proceso de seguimiento del paciente accidentado, ya sea por muerte o recuperación; la pérdida de producción incluye la pérdida de producción debido a la discapacidad temporal o permanente así como a la muerte prematura como consecuencia de sufrir un accidente de tráfico; finalmente, el coste humano incluye la tristeza y dolor experimentado por la familia, amigos y sociedad cuando se produce un accidente de tráfico.

En España, los costes asociados a los accidentes de tráfico no son nada desdeñables. Concretamente, el coste de prevenir un accidente fatal se estima en 1,4 millones de euros, un accidente grave en 219.000 euros y un accidente leve en 6.100 euros (Martínez Pérez et al., 2015). Para poner estas cifras en contexto, si las multiplicamos por el número de fallecidos, heridos graves y heridos leves, se estima que los costes asociados a los accidentes de tráfico en España fueron de 5.552 millones de euros, es decir, un 0,5% del Producto Interior Bruto en 2016 (DGT, 2017).Comparando este porcentaje con nuestros socios europeos, España se sitúa en la parte baja de la distribución ya

que este porcentaje oscila entre el 0,4-4,1% en otros países europeos (Wijnen et al., 2017)

La externalidad asociada a los accidentes de tráfico en el transporte de pasajeros por carretera surge porque el usuario no tiene en cuenta el coste completo cuando decide usar su propio vehículo. Algunos costes, por ejemplo, los daños materiales al vehículo, sí son tenidos en cuenta por el usuario a través de la prima de seguro pagadas a las compañías de seguros, mientras que otros costes (sanitarios, administrativos o daños materiales a las infraestructuras) no son tenidas en cuenta, ya que ellos son soportados por la sociedad. Además, el coste humano también tiene un componente externo ya que los usuarios sí evalúan su propio riesgo de sufrir un accidente cuando deciden usar su propio vehículo (componente interno), pero no evalúan el riesgo incrementado de sufrir un accidente de tráfico por otros usuarios de la carretera (componente externo) cuando un vehículo extra entra en la carretera.

La fórmula para solucionar lo mencionado en el párrafo anterior es que el usuario internalice dichos costes, esto es, los tenga en cuenta a la hora de tomar su decisión cuando utiliza su propio vehículo. Dicha internalización puede lograrse a través de instrumentos económicos (impuestos, peajes, etc) o instrumentos no económicos (medidas de command-and-control) (EC, 1995).

Independientemente del instrumento utilizado, la intervención estatal es requerida para integrar los costes externos sobre aquellos agentes causantes de la externalidad negativa ya que esta no puede ser alcanzada mediante la libre fuerza de mercado.

Las autoridades reguladoras tienen poco que decir en el campo de las compañías de seguros, ellas solo pueden alentar al establecimiento de primas de seguros diferenciales en función del riesgo del asegurado. Sin embargo, sí tienen un papel muy activo en el desarrollo de reglas que afecten a la probabilidad de sufrir un accidente de tráfico y al grado de severidad de este. Ejemplo de tales reglas incluyen el establecimiento de límites de velocidad; el uso obligatorio de cascos, cinturones de seguridad, sistemas de retención infantil; prohibición del uso del móvil, radio o GPS mientras se conduce; prohibición de conducir bajo la influencia de alcohol y drogas, etc.

En esta línea de normas establecidas para reducir la siniestralidad vial, la mayoría de los países de UE han adoptado una licencia de conducción por puntos. El **capítulo 2** de esta tesis doctoral contribuye a la literatura sobre su efecto causal. Esto es obtenido utilizando una metodología puntera en el campo de las estimaciones causales desarrolladas en Abadie & Gardeazabal (2003) conocido como método de control sintético.

El método de control sintético permite estimar cual hubiera sido la evolución del número fallecidos en las carreteras españolas si no se hubiera introducido el permiso por puntos en España (Contrafactual) usando una muestra de países de similares características a España que no hayan implementado el permiso por puntos en sus respectivos países.

Nuestras estimaciones sugieren que la introducción del permiso por puntos y las iniciativas relacionadas con el mismo supusieron una reducción de casi el 15% de las tasas de mortalidad de tráfico en España durante los dos primeros años de implantación. Además, en los dos años siguientes, es decir, en 2008 y 2009, el efecto del permiso por puntos y las iniciativas relacionadas

supuso una reducción del 30% de la tasa de mortalidad. La tasa de mortalidad que se habría observado en España de no existir el permiso por puntos y las iniciativas relacionadas en 2010 hubiera sido 2,2 puntos más alta que la tasa observada de 5,3 muertes por cada 100.000 habitantes.

No obstante, a pesar de los logros obtenidos en materia de seguridad vial, el comportamiento al volante todavía está lejos de ser el idóneo. La literatura científica ha mostrado la correlación existente entre dichos comportamientos y la mortalidad en las carreteras españolas, Por ejemplo, Sánchez-Mangas et al. (2010) encontró una asociación positiva y estadísticamente significativa entre conducir bajos los efectos del alcohol o sin los medios de protección adecuados, como el cinturón de seguridad, y la tasa de mortalidad en España. Asimismo, García-Ferrer et al. (2007) mostró que la obligatoriedad en el uso del cinturón provocó una caída permanente en la tasa de mortalidad en España. Ahora bien, estos comportamientos peligrosos no están distribuidos de forma homogénea en la población. El **capítulo 3** de esta tesis doctoral ha tenido como objetivo identificar aquellos comportamientos con mayor prevalencia en la población española e identificar aquellos grupos de población altamente peligrosos al volante.

Nuestra especificación logística multivariante preferida sugiere la existencia de cuatro grupos de conductores peligrosos al volante: hombres, jóvenes, solteros, y estudios secundarios o superiores. Sin embargo, un análisis desglosado por comportamientos peligrosos nos revela diferencias por grupos. Por ejemplo, los hombres son más probables en exceder el límite de velocidad o conducir después de haber bebido alcohol que las mujeres, pero no existen diferencias por sexo a la hora usar el móvil al volante. En esta misma línea, las

personas mayores son menos probables a usar el móvil, GPS o radio y exceder el límite de velocidad en autovías que los grupos de menor edad, mientras que no existen diferencias en los demás comportamientos. Respecto al estado civil, la única diferencia significativa la encontramos en conducir después de haber consumido alcohol, siendo las personas casadas menos probables en participar en dicho comportamiento. Finalmente, las personas con educación secundaria o superior son más probables a participar en comportamientos peligrosos al volante, excepto para el exceso de velocidad, que las personas con estudios primarios.

Finalmente, los rasgos de personalidad es un componente claramente asociado al comportamiento peligroso al volante (Ehsani et al., 2015; Hubicka et al., 2010; Schwebel et al., 2006) y, por consiguiente, a los accidentes de tráfico (Arthur et al., 2001, 2005; Arthur & Day, 2009; Arthur & Doverspike, 1992, 2001; Arthur & Graziano, 1996; Guastello & Guastello, 1986; Iversen & Rundmo, 2002; Montag & Comrey, 1987). El capítulo 4 de esta tesis doctoral ha contribuido a esta literatura mediante la exploración de la relación existente entre las medidas tempranas de rasgos de personalidad y los accidentes de tráfico a los 30 años. Utilizando una regresión probit, se obtiene que los rasgos de personalidad a edades tempranas están correlacionados con los accidentes de tráfico en la edad adulta. Siendo concretos, se encuentran que las medidas tempranas de responsabilidad predicen los accidentes de tráfico incluso después de controlar un gran conjunto de variables de control. Los niños que puntúan una desviación estándar por encima de la media de responsabilidad a la edad de 10 años se asocian con una disminución de 1,42 puntos porcentuales en la probabilidad de tener un accidente de tráfico a la edad de 30 años.

Los efectos estimados difieren notablemente según el sexo. En particular, aunque no encontramos pruebas de que las medidas tempranas de los rasgos de personalidad afecten a los accidentes de tráfico para las mujeres, el efecto estimado para los hombres es muy significativo, lo que implica que una puntuación de una desviación estándar por encima de la responsabilidad media a la edad de 10 años se asocia con una disminución de 3 puntos porcentuales en la probabilidad de tener un accidente de tráfico a los 30 años.

Finalmente, esta tesis doctoral concluye con una serie de recomendaciones políticas para la mejora de la seguridad vial. La literatura ha utilizado la Matriz de Haddon (Haddon, 1968) como referente para clasificar las intervenciones en materia de seguridad vial (Novoa et al., 2009). Esta matriz bidimensional clasifica las intervenciones basadas en dos criterios. El primero hace referencia al momento temporal: antes, durante y después del accidente. El segundo criterio recoge al factor causante del accidente: humano, vehículo y entorno.

Las intervenciones centradas en el momento previo al accidente tienen como objetivo reducir la probabilidad de estar involucrado en un accidente y/o reducir la exposición al riesgo; aquellas centradas en el momento del accidente persiguen reducir la severidad del accidente; finalmente, aquellas enfocadas en el momento posterior al accidente se centran en lograr que las víctimas sean solo heridos y no lleguen a fallecer (Novoa et al., 2009).

Los tres capítulos de nuestra tesis doctoral han centrado su atención en intervenciones previas al accidente dirigidas al factor humano con el objetivo de reducir la siniestralidad vial. Por lo tanto, nuestras recomendaciones han ido orientadas a este factor: modificación del permiso por puntos actual mediante un

sistema de penalización progresiva o por grupo de riesgo; permiso de conducción gradual; programas educativos orientados a mejorar los rasgos de personalidad y funcionamiento ejecutivo de los niños a edades tempranas; políticas de nudges en materia de seguridad vial; y, finalmente, incrementar la aplicación práctica (“enforcement”) en materia legislativa de seguridad vial.

No obstante, se requiere un análisis más profundo de todas estas intervenciones ya que, como es sugerido en Novoa et al. (2009), cualquier intervención en materia de seguridad vial debe demostrar su efectividad en base a la evidencia científica, independientemente del factor causante en la que esté centrado. Implementar intervenciones que no son efectivas para mitigar este problema puede ser costoso para la sociedad tanto en recursos monetarios malgastados como en vidas perdidas y daños ocasionados. Por este motivo, resulta urgente la creación de una oficina para llevar a cabo evaluaciones de políticas públicas basadas en la evidencia empírica. Esta oficina sería transversal a diferentes disciplinas -laborales, sanitarias, educativas, entre otras- y no limitarse exclusivamente a intervenciones en materia de seguridad vial

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