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Comprehending these costs constitutes the first phase towards further analysis of the causes of traffic accidents, allowing for the implementation of policies that lead to their minimization, contributing thereof to the maximization of social welfare.

The empirical ascertainment of the social costs of accidents is an indicator of the magnitude of the social problem resulting therefrom, since it is virtually impossible, through any of the methods used herein, to accurately determine such a social cost.

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Arlindo Alegre Donário
Ricardo Borges dos Santos

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Preface

Road accidents represent a huge social problem. Many of these accidents are preventable and by preventing them, society increases the supply of scarce resources that can be used to increase income and improve welfare. The study presented in this book is the first comprehensive study of the costs of road accidents in Portugal. The study is unique by presenting estimates of road accident costs for a period of fifteen years. During this period, road safety has been greatly improved in Portugal and the costs of road accidents have therefore been reduced.

There are many ways of estimating road accident costs and no consensus exists regarding the best method. While the willingness-to-pay approach has many supporters, and from a theoretical point of view is the best approach, assessing willingness-to-pay empirically has turned out to be very difficult. Studies have been reported in many countries, but the results vary enormously. In view of this, there is a need for more research concerning how best to elicit willingness-to-pay for improved road safety.

The root of the difficulties may, however, run deeper than many researchers are willing to admit. If people do not have clear preferences regarding the provision of road safety, and are easily influenced by the way valuation tasks have been framed, any estimate of the willingness-to- pay for less road accidents is bound to be very imprecise.

This book has estimated the costs of road accidents by means of the human capital approach. The welfare effect, which many other studies try to estimate in terms of willingness-to-pay, is included by relying on court cases in which compensation has been paid for non-monetary damages.

The costs presented in this book should be viewed as minimum estimates.

The actual costs could be considerably higher, but are unlikely to be lower than estimated in this study. In addition to estimating the costs of accidents, the study includes an interesting analysis of factors that have influenced road safety in Portugal from 1988 to 2010. It is clear that some road safety initiatives taken in this period have been successful, others have not. It is important to systematically evaluate the effects of road safety measures in order to promote an optimal use of them. By studying historical experience both with respect to factors that have influenced road safety and changes in the cost of road accidents, an improved basis has been developed for a more effective road safety policy. It is to be hoped that policy makers will heed the lessons provided by this study.

Rune Elvik
Institute of Transport Economics, Oslo, Norway

Foreword

The National Road Safety Strategy, a structural and fundamental document of road safety policy in our country, has recognized the need to estimate the economic and social cost of road accidents in Portugal. It is our intent that this cost be considered in the decision-making process, namely in the transportation sector, land-use and territorial planning, internal affairs, education, health, taxation, among others. In doing so, we shall have more well-informed, fair and coordinated long-term decisions aimed at achieving a civilized road transport system founded on freedom of mobility and on an unconditional safeguard of human life of all those who make use of the road system.

Given the complexity and expertise needed to achieve such objectives we made no hesitation in contacting Prof. Arlindo Donário at the *Universidade Autónoma de Lisboa*, who has developed research in this field and has published several referential works, of which worth mentioning is his book entitled, "*Economic Analysis of Social Regulation, Causes, Consequences and Policy of Road Accidents*".

We congratulate him on his work which was conducted in co-authorship with Ricardo Borges dos Santos, for we are in mist of a highly regarded study that marks the beginning of a systematic data collecting process that will allow us to monitor and maintain updated the statistical data currently obtained.

Yet, the development of this study was not an isolated and secluded office process; on the contrary, it demanded innumerous meetings and countless hours of work between the co-authors and professionals at *ANSR*, regarding the discussion of methodology, collection of data from various government bodies and the discussion of results. It was a combined effort of which we are proud of since it has contributed to the acquisition and consolidation of knowledge in this field.

Finally, I can do no more but to conclude that the decision on choosing the "Human Capital" method to assess the costs of road accidents in Portugal proved to be the wisest. Indeed, in light of what we know today, it would have been foolish to have chosen an alternative methodology without having this study as a reference.

In regards to Prof. Arlindo Donário, Ricardo Borges dos Santos and his team I wish to thank them for their magnificent work, their open mind and their ability to search for the best solutions and I wish that other works with equal importance for road safety policies to be developed in the future.

Oeiras, July 2012

Paulo Marques Augusto
Presidente da Autoridade Nacional de Segurança Rodoviária
President of National Authority for Road Safety

Synopsis

The objective of the present study was to assess the economic and social costs of road accidents in Portugal.

It was conducted by the Center for Economic Analysis of Social Regulation (CARS) at the *Universidade Autónoma de Lisboa*, commissioned by the National Authority for Road Safety (*Autoridade Nacional de Segurança Rodoviária*), hereinafter ANSR, and is aimed at planning and coordinating the support of the Government's policy on road safety at the national level.

Comprehending these costs constitutes the first phase towards further analysis of the causes of traffic accidents, allowing for the implementation of policies that lead to their minimization, contributing thereof to the maximization of social welfare.

The empirical ascertainment of the social costs of accidents is an indicator of the magnitude of the social problem resulting therefrom, since it is virtually impossible, through any of the methods used herein, to accurately determine such a social cost.

Introduction

Throughout the ages mobility has been and will always be man's necessity. It allows people to interact with each other and to transact goods and services, increasing the level and quality of human life, an aspiration that reflects the very essence of man in his continuous struggle for permanent fulfillment of his objectives.

In the course of human history, inherent costs and resultant benefits have been associated to human mobility; however, it was during the twentieth century that road mobility – in addition to air transportation – advanced exponentially with the use of motor vehicles, decreasing the time spent on travel and increasing economic transactions worldwide.

Road mobility along with its diachronic increase has allowed Humanity to speed up its rate of development, rendering high benefits. Nonetheless, empirical evidence and theoretical studies have shown that costs and benefits arise from all choices, wherefore one of the main objectives is to minimize these costs, which is to say, to obtain benefits with the minimum of sacrifices so as to achieve efficiency, *i.e.*, to maximize social welfare (or utility).

Road transport allows for greater economic efficiency, reducing the time of travel while simultaneously having a negative impact on the environment and on safety, resulting therefore, in conflicting objectives that only through a costs-benefit analysis one can find equilibrium, which is demonstrated by the minimization of the social costs of accidents.

Even in theoretical terms, it can be said that when it comes to road transport it's unlikely (or even impossible) to reduce crashes to zero, since it is not humanly possible to eliminate risk, whether it is accident risk or any other risk-generating activity. Indeed, all aspects of human life and all choices involve risk and uncertainty, more or less, leaving it up to individuals and society as whole not to eliminate risk entirely – because it is futile – but rather to minimize it. Within the framework of road safety, it rests upon Government through its regulatory intervention, to enact and implement policies that contribute towards minimizing the social cost of road accidents, with the aim of maximizing social welfare.

When making decisions, individuals are driven to maximize self-interest, reducing the costs stemming from their choices while taking into account certain moral and ethical values (which compose his/her "personal equation"). Most often those choices adversely affect the interests of other groups of individuals.

In a cost-benefit analysis we most often observe that the choices made, bring about greater social costs than social benefits (although benefits outweigh the costs for certain individuals or groups) generating social inefficiency and consequently reducing collective welfare.

Road mobility entails high risk, which is *per se* one of the constituents of the social costs of accidents together with various sorts of monetary costs and non-monetary costs or moral costs, which aren't reflected in neither the national income nor product.

With regard to road mobility, in order to maximize social welfare, life in society implies that individuals agree to abide by a series of rules that enables social interaction at the most diverse levels. It also entails the valuation of a wide range of factors, so that safety – which can be considered a *primary* and *merit good* – can be maximized with an ensuing minimization of social costs of accidents in an efficient manner.

Within the theoretical framework developed in this study, we believe that when a person decides to take a trip – the means by which, at what time and for how long he travels – the expected costs and benefits are weighed, whereby the individual seeks to maximize the difference between expected private gain and cost.

In his choice, the individual marginally assesses the alternatives[1]. Usually, his decision fails to consider the external costs and benefits that result from such behavior. These external costs and benefits are respectively identified as negative and positive externalities.

Given that road transport generates widespread costs and benefits that affect not only the individual who decides on whether to adopt certain behavior when using a vehicle but also other individuals in society – granted that they seek to minimize costs and maximize utility brought about by their demeanor and actions – the (overall) social cost generally tends to be higher than the cost borne by individuals (referred to as private cost) who adopt certain behavior or actions.

Hence, the road safety market fails with respect to efficiency, justifying government intervention through various sorts of policies making individuals internalize their external costs. Only through this internalization will efficient behavior be obtained.

Regulation of road mobility is justified because the market fails to efficiently solve the problem of road safety. Individuals seek to maximize self-interest and may engage in behavior that affects road safety, for instance: driving without insurance or a driver's license, using a vehicle without passenger safety equipment, driving under the influence of alcohol or other substances and so on. Such reckless behavior increases the risk of

[1] The term "marginal" refers to the variance of the total cost or total benefit resulting from a new trip.

accidents along with the risk of fatality and injury. Risk, as stated earlier, is in itself one of the constituents of accident cost.

Government intervention through the enactment of rules is aimed at reducing reckless behavior with negative effects on society. Regulatory intervention is one of the methods that government uses to alter such conduct in order to increase efficiency along with direct intervention on roads. Road safety can be deemed a *merit good*, whose utility may not be adequately assessed by road users because they lack sufficient information, in particular, risk arising from road transport.

Since an accident is a rare event in the individual's driving career and, by the very definition of the word, an accident occurs through an unexpected combination of circumstances, people are unable to correctly assess the statistical probability of having an accident, since in general and on average, subjective probabilities differ from objective probabilities, and the greater the difference, the greater the error in assessing objective risk. For this reason, they will not take into account all the risks that may stem from their behavior, therefore leading to inefficiency with damages to themselves and to others in society.

State intervention is also justified by the compensatory function that is intended by the tort system through compulsory third-party liability insurance (with risk-differentiated premiums) mainly because of market failures relative to non-economic damages. Another reason is the existence of traffic accident externalities that can't be internalized, as is usually the case of personal injury whose full compensation is difficult or unfeasible as in the case of wrongful death[2].

Oftentimes, we witness violations of traffic rules – which allow for mobility at a minimal cost – as a result of existing market failures in the road mobility and safety market – generating motives for the State to intervene as a

[2] The victims who suffer the loss of a relative may only be partially and symbolically compensated. *Vide* Article 496 of the Portuguese Civil Code.

regulator through the enactment of rules and as an enforcer in the case of traffic offenses.

Government intervention is also justified by the existence of other market failures, among which we highlight: a) various types of externalities including monetary and non-monetary damages caused to third parties and environmental pollution; b) information failures c) the existence of goods with characteristics of public goods (roads); d) incomplete markets (represented by the absence of a market for certain non-monetary goods) and risk caused by automotive driving.

Considering that road accidents are caused by the interaction of multiple factors that form a complex and dynamic system, adequate policies that minimize social costs should be integrated, that is, the various sets of determinants of accidents should be taken into account and in many instances their interaction and potentiation of risk.

I
Regulation and Efficiency[3]

Road safety regulation[4] and liability in tort represent two very different approaches for controlling activities that create risks of harm to others.

Tort liability is private in nature and works indirectly since it influences the behavior of individuals through expected costs (i.e. deterrent effect of damage actions). It is employed *ex-post* in relation to damages[5].

Furthermore, the internalization of externalities is carried out by the initiative of private parties and most of the elements that compose external costs are assessed in accordance to market criteria. For tort rules to apply there must be an actual occurrence of harm to the victim. Victims corroborate in identifying tortfeasors because they expect to obtain compensation, and thus, contribute towards the efficacy of these rules.

On the other hand, road safety regulation imposes certain restrictions and establishes standard conduct. Consider for example, rules governing driv-

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[3] *Vide* Donário, (2010a). p. 338.

[4] The judicial system can be considered a *public good* that cannot be divided into units that can be sold in a market individually. It is referred to as an *indivisible good* that justifies government intervention to optimize the allocation of resources.

[5] For more on this subject see: Shavel, S. Liability for Harm versus Regulation of Safety. Working Paper No. 1218. National Bureau of Economic Research, 1983. Blomquist, C. G. The Regulation of Motor Vehicle and Traffic Safety. Kluwer Academic Publishers, 1988.

ing impairment, speed limits, seat belt use and the like. These standards are public in nature and usually modify driver behavior in an immediate way. They entail interdictions – interpreted as costs and loss of utility to individuals – and their purpose is to achieve road safety to minimize social costs. They set standard conduct and provide for sanctions that constitute a potential cost for offenders.

Most of these rules emanate from the *legislative branch* of government, whose task is to enact laws that govern road use. The *administrative branch* and the *judicial branch* of government intervene in the direct implementation of these rules through police authorities and the judicial system[6].

The effects of regulatory standards are *ex-ante* in relation to damages, *id est.;* the offense is associated to a penalty regardless of the actual occurrence of harm. Regulation is grounded in the tenet that the risk involved in automotive driving should be kept within certain limits for it to be socially acceptable, thereby contributing to minimize the social costs of accidents.

The burden of having to bear a certain level of risk foists a cost on road users and has an impact on accident risk because individual actors act in their own interests – with the amount of information available to them at each moment – and are likely to adopt behavior that maximizes the difference between expected costs and benefits. To control traffic accidents, it is imperative that the effort be focused on modifying the behavior of drivers and other road users, considering both the incentives created by regulation, by the probability of enforcement, and by other determinants of accidents among which we underline those related to the vehicle and road environment (roads and motorways) and the sociocultural and psychological aspects of the driver (set of moral values in a broad sense – including ethical, social and religious values).

[6] Caetano (1977) – *Princípios Fundamentais do Direito Administrativo*. Rio de Janeiro, Brazil: Forense, pp. 36-37.

As postulated by A.J. Bonni[7], the impact of regulation on the behavior of road users will depend on the distribution and intensity of individual preferences for various types of risky behavior and in their attitudes towards risk. Driving care demands that road users have adequate risk-perception. Road users must bear all the costs and benefits of their actions in order to fulfill the efficiency requirement. If the individual expects partial internalization of his externalities, his behavior will tend to be inefficient and the level of unlawful activity will increase, leading to behaviors such as speeding, more frequent use of vehicles, higher BAC levels, ingestion of illegal substances that impair risk perception and reduce reflexes and other traffic violations that tend to increase accident risk.

The sanctions provided for in road traffic rules combined with the probability of enforcement (expected sanction) constitute incentives that induce individuals to develop behavior that is conducive towards optimum care, thereby reducing the number of accidents and their consequences.[8] Collectively with the tort system, regulations are an aggregate of *behavioral modifiers* that, aside from their individual efficacy, acquire the synergetic effects of their joint application.

If drivers and other road users have incomplete information as to the objective probability of accidents it shall distort their risk-perception, either through risk-underestimation or risk-overestimation, producing inefficiency since individual behavior is based on subjective probability[9]. Incomplete information is a market failure that justifies social regulation

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[7] Bonni (1985) – The efficacy of law as paternalistic instrument. Accident Analysis and Prevention. In: *Nebraska Symposium on Motivation*, pp. 131-211.

[8] As mentioned, most accidents are not recorded by the authorities, in particular, those that only cause property damage, due to which their information could lead to increased insurance premiums. Moreover, the intervention of the law enforcement could result in a penalty for the causer if he had committed a violation.

[9] Kahneman; Tversky (1979) – *Prospect theory: An analysis of decision under risk*. *Econometrica*, Vol. 47, pp. 285 *et seq.*

of the road safety and mobility market through the enactment of road traffic regulations.

Increasing the objective probability of law enforcement tends to straighten the gap between objective and subjective probabilities, leading to increased efficiency of behavior. Herewith, a low objective probability of law enforcement will entail a wider gap in relation to subjective probability which determines driver demeanor, generating a higher level of inefficiency and reduced efficacy of road traffic rules.

Road traffic regulations establish standard driving conduct regardless of personal circumstances or extenuating conditions of vehicles and road environment due to the lack of complete information by the regulatory authority concerning the level of specific risk generated by each driver and road user. In short, regulation by generalization occurs because it is harder for the regulator to tailor the law to the specifics of each situation. Like any other individual, we assume that police officers seek to maximize their interests by weighing expected costs and benefits[10]. In Portugal, the Highway Code provides that police officers do not earn a percentage of the fines issued. Still, some agents may have to bear some of the costs of law enforcement including court appearances and perhaps some non-monetary costs. If expected costs outweigh expected benefits there will be incentives to avoid implementing the sanctions provided by law.

On the other hand, if the salaries of enforcers are relatively low and there is an absence of other positive incentives, and considering that if the structure of moral values is not eminent – with its set of *internal sanctions* (transposed as guilt) and *external penalties* (social reprimand) and its set of external and internal rewards – then incentives for corruption can arise, reducing the effectiveness of law enforcement.

[10] Becker; Stigler (1974) – Law Enforcement, Malfeasance, and Compensation of Enforcers. *The Journal of Legal Studies*, No. 3-1, pp. 1-18.

In economic terms, *target risk* of automotive driving is part of the decision-making process of people who act rationally within the confines of time, income and other goods. Suppose that safety is a normal or superior good subject to the law of diminishing marginal utility. Since road traffic regulations create incentives that alter the behavior of drivers and other road users – affecting the demand for *safety* – the risk that individuals decide to take at a given time shall be influenced. As pointed out by Alan Stone, regulation limits choice:

> *"Regulation has been defined as "a state imposed limitation on the discretion that may be exercised by individual's organizations, which is supported by the threat of sanction."*[11]

Effective enforcement of regulations raises the issue of the *compensation* or *substitution* effect. The imposition of a particular regulation, whose goal is to increase road safety, incites a positive behavioral change in individuals so that they may achieve their objectives in another way. Ultimately, if such behavioral change takes place the individual will seek "alternative goods" and the effectiveness of regulation will tend to decrease.

Among the existing theories regarding *risk compensation* we highlight the *risk-homeostasis* hypothesis postulated by Gerald J.S. Wilde[12]. This author seeks to integrate the heterogeneity of factors known to cause traffic accidents into a single concept of *target risk*. Changes resulting from incentives created by *ex-ante* regulation (vehicle safety and road environment regulation) and *ex-post* liability rules may have reduced efficacy because of possible substitution effects. According to this theory accident risk shall be reduced in the long term only if there is a change in the level of *target risk*.

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[11] Stone (1982) – *Regulations and Its Alternatives*. Washington, D.C.: Congressional Quarterly Press, p. 10. Cited by: Viscusi, W. Kip; Vermon, John M.; Harrington, Joseph E. *Economics of Regulation and Antitrust*. 2nd ed. Cambridge, Massachusetts: MIT Press, 1998. p. 307.

[12] Cf. Wilde (2001) – *Target Risk2*. Toronto-Ontario, Canada: PDE Publications.

Sam Peltzman, meanwhile, has also developed a theory regarding risk compensation. The crux of Peltzman's hypothesis is that *driving safety* is a *normal good* subject to the restrictions of income and time, and whose demand also depends on its *price* and the price of alternative goods. Thus, mandatory installation of safety devices in vehicles such as seat belts, airbags and other devices may cause substitution effects and offsetting behavior:

> "*The mandatory installation of safety devices does not by itself change the private demand for safety, but it may change some relevant prices, the response to which may mitigate some of the technological promises of these devices*".[13]

On one hand, the installation of passive safety devices in vehicles tends to reduce the risk of accidents and their effects but, on the other hand – considering the level of *target risk* – drivers tend to react to safety regulation by increasing risky behavior such as speeding and other risky maneuvers that offset some of the benefits of automobile safety equipment. On a final note, Peltzman roots his hypothesis on the concept of *wealth maximization* and relates *time-saving* to the origin of wealth.

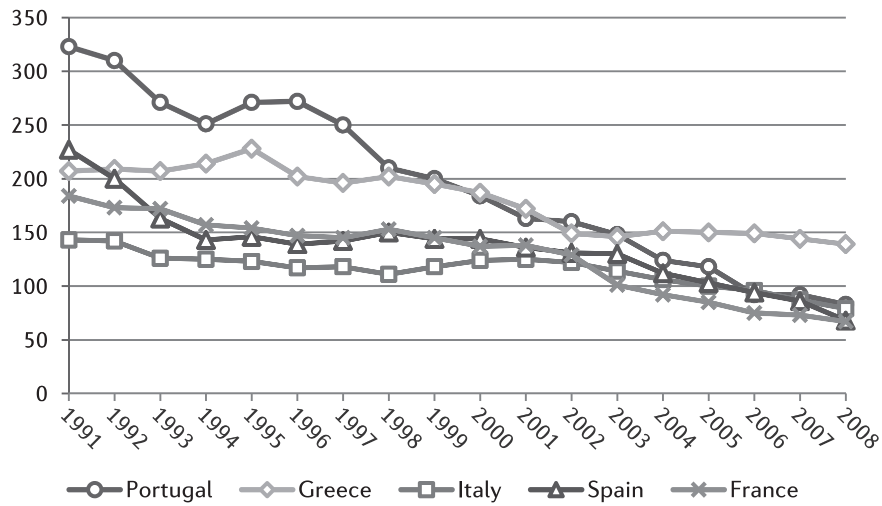
[13] Peltzman (1975) – The Effects of Automobile Safety Regulation. *Journal of Political Economy*, Vol. 83, No. 41, pp. 680-681.

II
European Comparison

For an overview of the magnitude of the problem in comparative terms, see the graph below pertaining to the number of road fatalities per million inhabitants in five southern European countries, during the period 1991-2008:

Graph 2.1

Trend in the number of road fatalities per million inhabitants in five countries: Portugal, Greece, Italy, Spain and France (1991-2008)



Source: Based on Eurostat data.

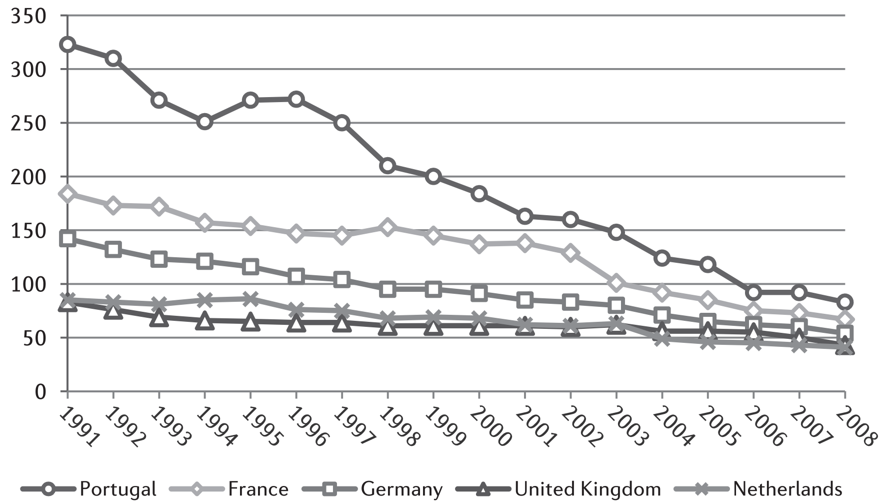
Among the five countries analyzed above, Portugal registered the highest road fatality rate per million inhabitants at the beginning of the period (323 deaths per million inhabitants) reaching a rate of 83 deaths per million inhabitants towards the end of the period (2008), drawing near Italy with a rate of 79, Spain with 68 and France with 67.

However, Portugal registered the highest rate of decreasing variance among these five countries, with an accumulated variance rate of - 147% at the end of the period, followed by Spain with a rate of - 131%, France with -108%, Italy with - 63% and lastly Greece with a rate of - 43%.

In the following graph we compare the Portuguese rate of road fatality per million inhabitants with the four countries with the lowest rates of road fatality per million inhabitants, France, Germany, UK and the Netherlands:

Graph 2.2

Trend in the number of road Fatalities per million inhabitants.
Portugal compared to four countries with low rates (1991-2008)



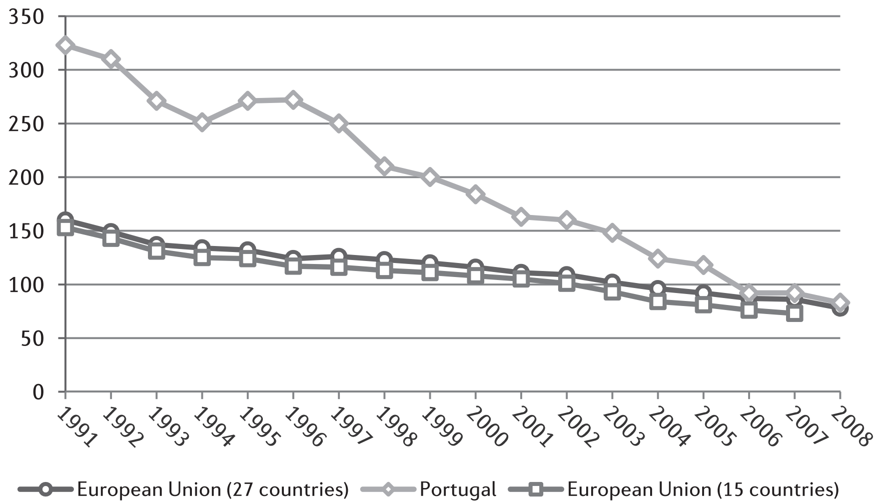
Source: Based on Eurostat data.

As seen above, there was a positive approximation all throughout the time frame, albeit, Portugal still had a higher rate than the four countries considered at the end of the period.

Finally we compare the road fatality rate per million inhabitants in Portugal to the European Union with 15 and 27 member states.

Graph 2.3

Trend in the number of road fatalities per million inhabitants.
Portugal compared to the European Union with 15 and 27 member states (1991-2008)



Source: Based on Eurostat data.

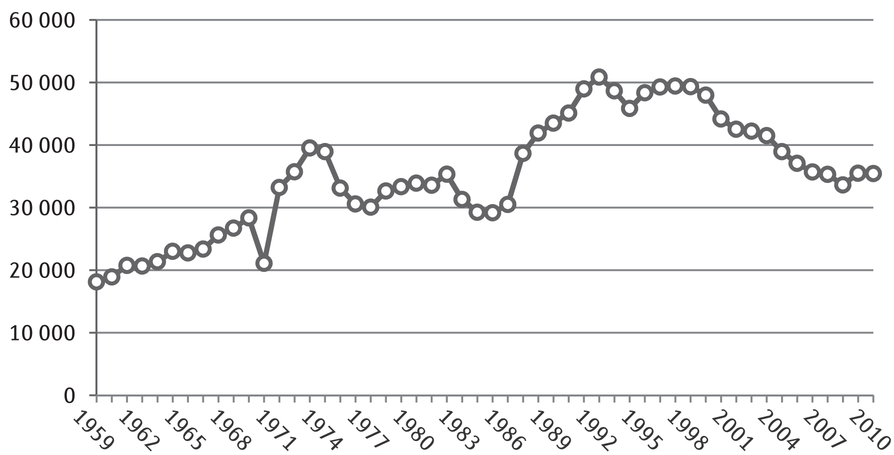
As illustrated, Portugal registered a positive trend all throughout the period, converging to the European Union averages with 27 and 15 member states. At the end of the period, the road fatality rate per million inhabitants was 78 in the European Union with 27 member states, having Portugal checked in with 83 deaths and the European Union with 15 member states registering a rate of 73 deaths per million inhabitants in 2007. In sum, a sharp decrease was verified in relation to Portugal whose rate drew close to the European Union rates.

III
Trend of Road Accidents with Casualties in Portugal (1959-2010)

As illustrated in the graph below, accidents[14] with casualties in Portugal have registered cyclical peaks and valleys between 1959 and 2010:

Graph 3.1

Trend in the number of accidents with victims in Portugal (1959-2010)



Source: Based on data obtained from the Portuguese Department of Motor Vehicles and the ANSR.

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[14] Unless otherwise, "accidents" are understood as accidents with victims.

Since the beginning of the period and during the years that led up to 1973 a constant slope was recorded – except for 1970 – giving way to a period of decline that began in 1974 and lasted until 1977. From that year onward and until 1982 the casualty toll grew again, reaching in this year 35,324 accidents with victims, a figure similar to that recorded 10 years earlier in 1972. From 1982 until 1985 the number of accidents declined once again coinciding with a slump in economic growth.

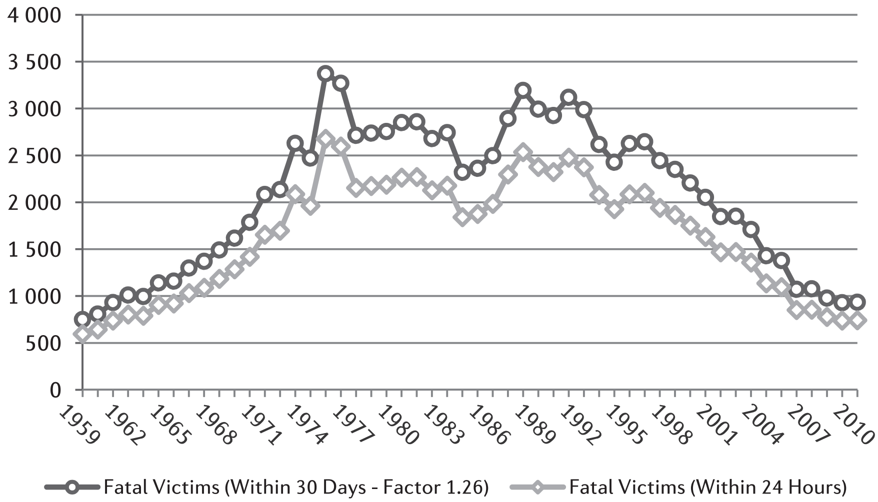
From 1985 to 1992 the number of accidents with victims soared, having reached an all-time high in 1992 with 50,851 accidents with casualties. There is evidence of a positive correlation with the level of economic development as a result of Portugal's entry into the European Community in 1986.

In the years that followed, 1993 and 1994, a decline in the number of accidents was reported. From 1994 to 1997, the accident toll ascended again and began to decrease in 1997 continuing steadily until 2008. In 2009 the number of accidents grew once again and during 2010, the toll slightly dropped (0.16%) in relation to 2009.

Trend in the Number of Road Accident Deaths in Portugal

As can be viewed in the graph below, road fatalities in Portugal during 1959 -2010 tend to increase and subsequently decline:

Graph 3.2
Trend in the number of road deaths in Portugal (1959-2010)



Source: Based on ANSR data.

In Portugal, the death toll was recorded in accordance with the number of victims who perished within the first 24 hours following an accident. This method led to a lower recorded death toll when confronted with that obtained using the method in practice in most European countries, along with other countries, and consisted in tallying – as fatal victims – those deaths that occurred within 30 days subsequent to a crash.

As it turned out, there was a discrepancy between criteria used for registering fatalities in Portugal and that used in remaining countries, whereupon it was decided that for international comparison purposes, the road accident death toll registered in Portugal in accordance with the 24 hour method should be multiplied by a factor of 1.14. Nonetheless, annual road fatality records continued to be conducted based on the “24 hour criterion”.

In this context and as a result of such discrepancy, the number of road fatalities began to be registered using the 30 day method, in order to unify the criterion used in Portugal with that used internationally.

The National Authority for Road Safety confirmed that, on average, the road death toll was in fact 26% higher than that recorded using the 24 hour method.

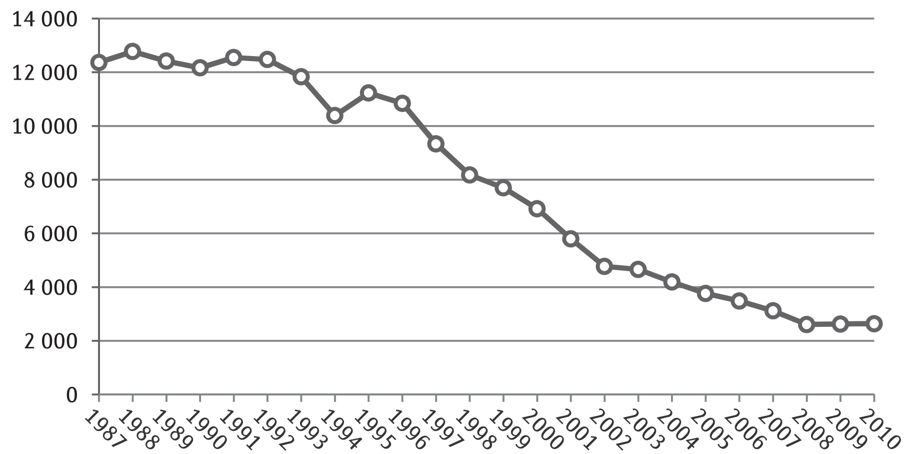
As shown in graph 3.2, the death toll grew – in general terms – until 1975 where it peaked an all-time high of 2,676 deaths (using the 24 hour criterion). During the period considered, 1975 was the year that marked the downward trend that lasted up until 1975, although not so pronounced, having increased again in 1988, year in which we witness a decreasing trend, reaching the death toll of 741 in 2010.

Trend in the Number of Seriously Injured Road Accident Victims in Portugal

In relation to the number of seriously injured road accident victims, the trend for the period 1987-2010 can be viewed in the following graph[15]:

Graph 3.3

Trend in the number of seriously injured road accident victims in Portugal (1987-2010)



Source: Based on data obtained from the Portuguese Department of Motor Vehicles and the ANSR.

[15] Data only available from 1987 onwards.

The trend of serious road injury decreased over the period illustrated. Between 1987 and the end of the period, the accumulated variance rate of seriously injured was - 144%. Over the time-span above, only in four years of the time series were rates of positive variance verified, namely, in 2009 with a positive variance rate of about 1%.

Apropos of the number of seriously injured, there is some discrepancy between data collected by police authorities and data recorded by hospitals, situation that exists in Portugal and in other countries as corroborated by several researchers[16]. It has been found that the number of serious injuries recorded by hospitals is in fact higher than the number recorded by police authorities[17].

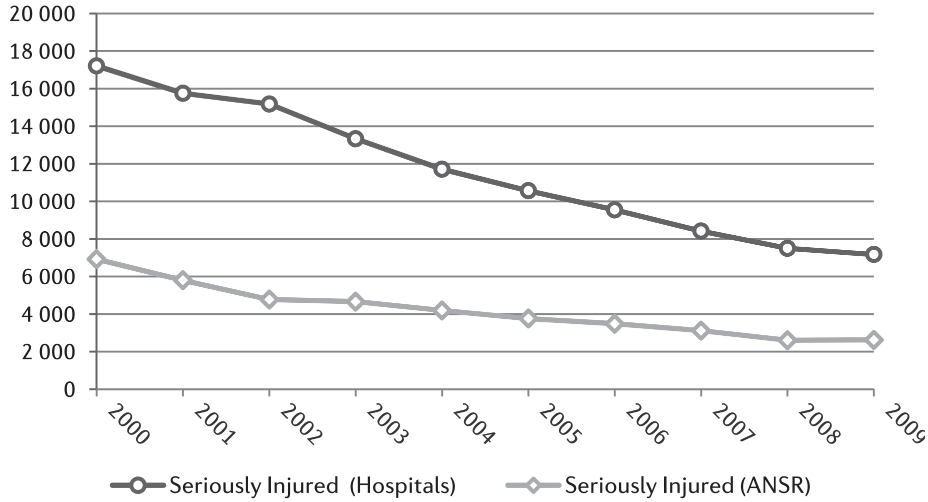
As for Portugal, in regards to seriously injured victims, the subsequent graph gives the reader a trend overview of the two time series pertaining to the data provided by the Ministry of Health[18] (hospital data) and by the ANSR (data recorded by police authorities).

[16] Cf. Amoros (2008); Elvik (2009); Derriks (2007); Chisvert, Ye Fan (2010); Ronan (2008).

[17] Police and Police Authorities refer to both the *Polícia de Segurança Pública (PSP)* and the *Guarda Nacional Republicana (GNR)*.

[18] Data was not provided for the period between 2000-2009.

Graph 3.4
Trend in the number of seriously injured road accident victims in Portugal recorded by hospitals and by Police Authorities (2000-2009)



Source: Based on data provided by the ANSR and the Ministry of Health.

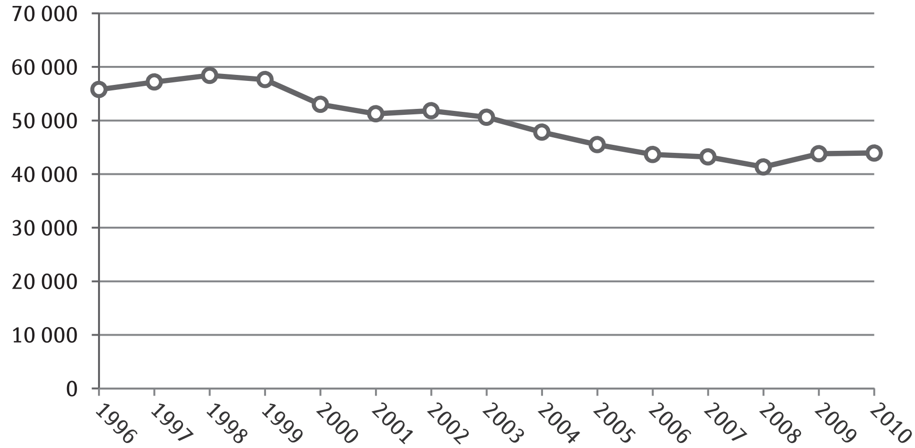
The difference between the two time series is high. As evidenced in various studies referred in footnote 16, one should be mindful that the classification found in records kept by police officials may be biased, where the same victim can be classified as slightly injured by police and seriously injured by hospital staff. The use of police records in assessing the social and economic costs of road accidents has led to biased results. Ultimately, the cost calculated for seriously injured victims is inferior to the cost that would have been obtained if the number recorded by hospitals had been used.

Trend in the Number of Slightly Injured Road Accident Victims in Portugal

In what concerns the number of minor road accident injuries, let's take a glance at the following graph[19]:

Graph 3.5

Trend in the number of slightly injured road accident victims (1996-2010)



Source: Based on ANSR data.

With regard to minor injuries, a steady decreasing trend is verified all throughout the period, although not as sharp as in the case of deaths and serious injuries, reaching nearly 56,000 minor injuries in 1996 dropping down to nearly 44,000 in 2010.

[19] Data only available from 1996 onwards.

IV
Methods Used in Estimating the Economic and Social Cost of Road Accidents

There are several methods among which we highlight the following:

a) Human Capital or GDP Method[20]

This method is based on the production potential of the fatal or disabled individual during his lifetime in the absence of a road accident. It consists in comprising the accident costs associated to the loss of future production, hospital costs, property damages, administrative and non-monetary costs;

b) Court Compensation Method

This method considers that society can assess accident costs through indemnity awarded by courts, a proxy measure of real costs;

c) Life insurance method[21]

This method is based on the use of the insurance premium that an individual would be willing to pay, coupled with the probability of being killed or injured in a road accident. One of the criticisms made to this approach

[20] Donário (2010a), pp. 101-112 and 649-660.

[21] Mishan (1976), pp. 300-303.

is that it only focuses on compensation provided to third parties and overlooks fatal victims, which – naturally – cannot be compensated;

d) Willingness-to-Pay Method

Such method considers the maximum amount that a person would be willing to pay to reduce the probability of having an accident and being killed or injured.

Withal, the two main approaches that have been used are: the Human Capital and the Willingness-to-Pay methods, which are analyzed below.

4.1 – Willingness-To-Pay Approach (WTP)

As an *ex-ante* approach[22] it is grounded on the principles of welfare economics, in line with the so-called principle of consumer sovereignty which tends to portray the interests and preferences of the individual, who is considered to be a rational maximizer of benefits and a minimizer of costs.

Specifically, willingness-to-pay[23] is defined as **the amount** a person would be willing to pay to reduce risk of having an accident[24] and therefore the risk of death or injury, which ultimately constitutes the individual's Stated Preferences (SA) which in turn may differ from Revealed Preferences (RP).

[22] Feldman (1997), p. 2. This author labels it as "*probabilistic willingness-to-pay*".

[23] *Willingness-to-pay* reflects what in economics is called a "*consumer surplus*" and consists in the utility that exceeds the market price or, to be more precise, it portrays the varying level of the individual's utility because of the reduction in accident risk and of death or injury.

[24] Risk reduction is not observable in the market but develops within the context of scarcity, through the choices, representing an opportunity cost.

This later set of preferences can be interpreted as the amount an individual currently spends on his/her road safety[25] through their actions.

This method[26] serves as a proxy used to estimate the potential value of non-market goods and combines the determinants of accident cost, namely costs resulting from decreased social utility, that is, it tends to coalesce all the social costs aside from those borne by accident victims (externalities). Here, we can allude to the costs associated with income, the cost with leisure, the cost of avoiding pain and suffering and the cost of relative risk aversion of a certain activity.

It should be noted that risk is both an individual and social cost and is present in virtually all aspects of life, making high accident risk a factor that should be taken into account whenever possible. Moreover, the attitude of individuals towards risk[27] should be contemplated in the policies and measures adopted to reduce accidents and their effects. Note, since the majority of individuals are risk-averse, high accident risk translates into a high additive factor of accident cost.

This method implies a trade-off between a given current "*state of the world*" with a certain level of welfare (utility) without road accidents and another potential "*state of the world*" with a lower level of welfare because of probable accidents. Such a trade-off determines, among other factors, the level of driving care observed on the road[28].

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[25] Frey (2004) – Valuing Public Goods: The Satisfaction Aproach, "*Due to the hypothetical nature of the questions asked and the unfamiliarity of the task, one cannot exclude that respondents fail to consider the effect of their budget constraints and substitutes.*", p. 7.

[26] Carthy *[et al]* On the Contigent Valuation of Safety... (1999) "*...collective WTP and WTA amounts can most effectively be estimated by asking a representative sample of people more or less directly about the sums that they would individually be willing to pay or to accept as compensation for pre-specified variations in safety—commonly referred to as the direct "contingent valuation" (CV) approach*", p. 188.

[27] Donário (2010a), pp.421-423 and Donário (2010b), pp. 15-22.

[28] Donário (2010a), pp. 165-178.

Since, life in itself is a *supreme good* and a requisite of one's ability to enjoy the utility of all other goods, death reduces the utility function of an individual to zero. Thus, the value of life, from an ontological point of view, is infinite and therefore immensurable. What is really sought out by many is the so-called *Value of a Statistical Life* (VSL) and not necessarily the value of a life of a particular person, because as said before, it is incalculable. The statistical value of life, as stated by Arianne Blaeij "... *is concerned with the valuation of changes in the level of risk exposure, rather than the valuation of life of a specific individual, and reported this as a 'normalized value*"[29].

Similarly, in a study conducted in the U.S. in 1976, Barbara Moyer Faigin adds:

> "...*the cost components and the total of these components are indicators of the significance of the motor vehicle accident problem.*"[30]

However, it is important that we point out that what is sought out by the willingness-to-pay approach is not the valuation of life *per se* of a particular individual, but rather the attainment of the probable *quantum* that the individual is willing to pay to reduce a percentage of the risk of death or injury or, as said earlier, the sovereignty of the consumer through his revealed preferences. Regarding the value of life we quote, José María Abellán Perpiñán:

> *"Since human loss cannot be directly valued, such can be assessed from the aggregate of individuals' willingness-to-pay for a small reduction in the risk of death in a crash. This aggregate consequently provides the monetary amount assigned by society to avoid the death of any person (a statistical life) resulting from a road accident"*[31].

[29] Blaeij (2003), p. 4.

[30] Faigin (1976), p. 1.

[31] Abellán *[et al]* (2010), p. 2. Our translation.

This method demands the consideration of the income and/or wealth effect (composite variables), or other goods (such as life and physical integrity) known in behavioral economic literature as the *endowment effect*[32] (reference point), which has effects on WTP *versus* the propensity to accept compensation (willingness-to-accept – WTA). The *endowment effect* reflects the difference between WTP and WTA.

This effect is reinforced by the *framing*[33] *effect*[34], evident when presenting the same question in different formats whereby a small change in the way the question is presented – framing – relative to stochastic matters, may have a high impact on the choice regarding the *quantum* an individual is willing pay to reduce the risk of death or injury in a road accident. However, individuals have a tendency to select inconsistent choices, depending on whether the question is framed to concentrate on losses or gains[35].

According to Thaler[36], the minimum compensation demanded for accepting a 0.001 risk of sudden death was higher by one or two orders of magnitude than the amount people are willing to pay (WTP) to eliminate an identical level of risk in the future. This discrepancy is a manifestation of loss aversion[37] when the good "life" is valued as a loss (instant endowment effect[38]) and as a gain, when it is perceived as decreased risk of death.

The endowment effect undermines the Coase theorem assertion, according to which, the allocation of resources will be independent of the assignment

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[32] Kahneman (1991), pp. 193-206.

[33] Cf. Tversky; Kahneman (1981).

[34] See: Kahneman (1979), p. 285.

[35] The development of these effects by Kahneman and Tversky refuted the independence axiom of the expected utility theory developed by John von Neumann and Oskar Morgenstern (1947).

[36] Cf. Thaler (1980).

[37] Kahneman; Tversky (1979), pp. 263-292.

[38] Kahneman *[et al]* (2003), p. 53.

of property rights when costless trades are possible, leading parties to seek an efficient outcome in spite of the initial allocation of rights[39].

4.2 – Human Capital Method

As an *ex-post* method, it places its attention on the potential production lost by an accident victim, killed or injured, and focuses on the negative effects for society leaving aside individual preferences which are considered in the willingness-to-pay method.

In this approach, one of the most important factors of the social cost of accidents is subsumed to potential production loss per dead or disabled accident victim, whose present value is calculated by a discount factor with reference to the base period (year) – in this case – the date of the accident.

Health costs (hospital costs and the like), damage to vehicles and other property damages are considered by this approach, in addition to, the estimated costs of diminishing utility represented by pain and suffering (physical or psychological) sustained by victims and their families, which we label moral or non-monetary damages.

Non-monetary damages should be assessed with recourse to whatever methods available. Such damages consist in intangible losses translated as a decrease in utility resulting from harm to personal or moral goods that comprise the utility function[40] (happiness function) of each person, affecting what is universally known as *joi de vivre*[41]. Non-monetary damages, as expected, do not depend on the ability to obtain income.

Since this method takes into account the gross domestic product (GDP) *per capita*, the social cost of accidents varies accordingly – where in spite

[39] Cf. Coase (1988).

[40] Or, in legal terms, they comprise the legal domain of a natural person.

[41] Cf. Gerondeau (1979).

of identical methodology – the cost is greater in countries with a higher GDP *per capita*.

The use of this method often leads to lower values in relation to those obtained through the willingness-to-pay approach, thereby setting a benchmark for accident prevention policies.

Considering what was said apropos of the WTP approach, the high discrepancies witnessed regarding the statistical value of life – estimated in various studies – are explained in part by the different formats in which questions are presented to respondents, mainly because of the *endowment* and *framing effects*. This results in very different answers with regard to the *quantum* an individual is willing pay to reduce the risk of death or injury in a road accident.

For these reasons, we believe that the Human Capital method used to estimate the social cost of road accidents tends to be more trustworthy than the WTP method.

4.3 – The Method Used

Regardless of the implementation of the willingness-to-pay method in several studies, we chose to employ the Human Capital (HC) approach. Although it is an *ex-post* method, it allows us to use data from several institutions, particularly public institutions, for a period of 15 years, displaying the trend in the cost of accidents in Portugal and revealing the effectiveness of policies all throughout their implementation.

This method renders estimated costs inferior to those obtained using the willingness-to-pay method and is chiefly based on historical data, allowing us to estimate a benchmark for policies based on a cost-benefit analysis.

For its part, the WTP method would have to be based on national surveys, where it would only be possible to assess the cost of accidents for the period (year) in which the surveys were conducted. Hence, we believe that the method chosen (CH) will render us an adequate estimate of the social costs of road accidents in Portugal allowing us to analyze the trend of these costs over a period of 15 years.

V
Data

The data used in this study is referent to:

a) Annual number of accidents with victims;
b) Annual number of fatal accidents;
c) Annual number of accidents with seriously injured victims;
d) Annual number of accidents with minor injuries;
e) Number of accidents with injuries in general.

We aimed to estimate the average cost that each fatal and seriously injured victim represents to society in order to determine the social cost of fatal accidents and the social cost of accidents with seriously injured victims in mainland Portugal.

The social cost of road accidents comprises monetary and non-monetary damages sustained in a crash. It is inevitable that negative effects emanate from road accidents, whether it is financial, personal, etc... It entails a cost not only for the individual but for society as a whole, that is to say, there are always negative externalities.

The data used in this study was provided by the following organizations:

- Health Care System Administration (*ACSS*);
- National Authority for Road Safety (*ANSR*);

- Ministry of Health;
- European Central Bank;
- Francisco Manuel dos Santos Foundation (*FFMS*) (*PORDATA*, *FFMS* public statistical information service);
- National Police Authority (*PSP*);
- Portuguese National Guard (*GNR*);
- Institute for Justice Financial Management and Infrastructure (*IGFIJ*);
- Portuguese Insurance Institute (*ISP*);
- Institute of Judicial Technologies and Computerization (*ITIJ*);
- National Statistics Institute (*INE*).

With regard to the data of the remaining components of the social cost of road accidents, we were unable to attain such information from the competent authorities, albeit, we did rely on a study conducted in 1987 by the Portuguese Road Safety Association (*Prevenção Rodoviária Portuguesa*) in order to estimate these values. In doing so, we used the yearly number of registered deaths and injuries as a guideline and considered the existing research category layout although without available data (mainly in regards to Justice).

VI
Components of the Economic and Social Cost of Road Accidents

The economic and social costs of accidents can be categorized into:

– Monetary
– Non-monetary or moral.

In turn, monetary costs are classified as:

– Direct
– Indirect.

Direct monetary costs of road accidents include:

– Damage to vehicles and other public and private property;
– Hospital costs related to victims;
– Cost resulting from time expended on hospital visits;
– Ambulance fees and victim transport costs;
– Loss adjustment costs;
– Direct intervention of law enforcement;
– Funeral expenses of victims.

Indirect monetary costs of road accidents consist in:

- Value of lost potential production of fatal and injured victims;
- Insurer administrative costs;
- Value of court fees;
- Attorney fees;
- Costs of preventing accidents or road safety;
- Operating costs of courts;
- Cost of accident risk;
- Cost associated with negative externalities that affect the environment, which will not be considered in this study because of the lack of available data.

Non-monetary damages include pain and suffering endured by victims and third parties. Such costs will be discussed further on in our study.

6.1 – Value of lost production

With regard to the value of production loss[42], such is obtained through the sum of:

- Fatal victims;
- Seriously injured;
- Slightly injured.

6.1.1 – Loss of production relative to fatalities

When calculating the value of lost production capacity of fatal accident victims – in the market – we thought it would be best to go with the GDP method and not exclude consumption, since it is believed that even when individuals withdraw from the labor market, they continue to "consume"

[42] To calculate the value of lost production follow closely the method contained in Donário (2010a), pp. 655-657.

contributing thereof to the growth of domestic expenditure consequently increasing the domestic product (fundamental identity between expenditure, product and income).

Costs pertaining to fatalities should also take into account potential production loss outside the market (which consists in unpaid work) related to home, family and the community[43]. These are opportunity costs reflected as losses outside the 40-hour work-week. Although they are difficult to estimate[44], there are studies that have estimated these costs at approximately 30% of formal employment income (obtained in the market). Thus, losses resulting from road accidents reduce the social utility function and are not usually absorbed by the national product's estimate.

In calculating the value of production loss, Portuguese GDP per capita was used along with the number of work years lost per fatal victim, the fatality toll[45] per annum with an added 26%[46] and the update rate of production loss. This rate is the function of the average net interest rate for financial investments and the annual growth rate of production

As for the Portuguese GDP per capita, we decided to use the gross domestic product per capita at constant prices (2006)[47], eliminating therefore the impact of inflation. Concurrently, a relatively current base-year was used so as to minimize probable misinterpretation of general price level variability. Since the national product per capita differs from country to country, production loss will also be different. This makes international comparisons very difficult.

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[43] Faigin (1976), p. 1.

[44] Atkins (1981), p. 47.

[45] Statistics only considered as fatal victims those who perished at the scene of the accident or within the following 24 hours. For international comparison 14% was added on.

[46] The ANSR estimated that on average the official number of fatalities is higher by about 26%.

[47] See: *Francisco Manuel dos Santos Foundation.*

Regarding the loss in productive working life per fatal victim we made use of the data provided by the National Authority for Road Safety (ANSR)[48] referent to the number of deaths per age group which allowed us to obtain an estimate of the median age of a fatal victim.

Considering that estimated life expectancy in Portugal is on average 80 years of age, we were able to obtain the number of lost productive working years per road fatality by subtracting the median age of a fatal victim from average life expectancy. It is worth mentioning that the estimated cost measures the value of person's activity, regardless of whether or not the fatal victim is employed.

The annual road fatality death toll used to calculate the overall value of lost production per fatality was that contained in the National Authority for Road Safety 2010 Report, with a correction of 26%, which resulted from the ANSR's conclusion that the annual fatality toll should be adjusted so as to provide a more accurate perception of reality.

Update Rate Used

The update rate[49] of the value of lost production is a composite rate of the average net interest rate for financial investments and the annual growth rate of production. In what concerns the average net interest rate for financial investments, we decided to use the average *Euribor* benchmark rate[50] with a maturity period of 6 months during 1996 - 2010, since this period is the time interval under analysis. The *Euribor* was also chosen because it is the interest rate that depicts the change in money supply and demand in the European interbank market and, therefore, represents the capacity that the banking system has to finance itself efficiently and at the same time provide for its needs of liquidity. In this manner, the *Euribor* is

[48] *Autoridade Nacional de Segurança Rodoviária* (2010) – National Authority for Road Safety.

[49] This rate is also known as the *time preference rate*.

[50] *Vide* European Central Bank.

an adequate *proxy* for measuring the average net interest rate for financial investments.

Our choice of a longer maturity period of 6 months instead of 3 months was due to the fact that the former period portrays the change in the *Euribor* rate more reliantly. On the other hand – compared with an even longer maturity period of 12 months – the 6 month period is more flexible when it comes to the adjustment capacity of financial markets.

The annual growth rate of production used to calculate the update rate of the value of lost production is the result of the average annual growth rate of the Portuguese gross domestic product at constant prices (2006)[51] during the period between 1996 and 2010. Note, that the impact of inflation was excluded since it was decided that the value of lost production should be assessed in accordance to the effective wealth created and not the volatility of the economy's overall price level which would skew the intended analysis.

We also decided that it would be best to use the median age of fatal victims rather than the average age.

6.1.2 – Seriously injured victims

The cost related with seriously injured victims can be divided into five components:

- Hospital costs, including medication;
- Costs arising from the total loss of potential production in relation to seriously injured victims with 100% permanent disability;
- Loss of production resulting from reduced productivity due to permanent partial disability;
- Loss of production resulting from temporary disability;

[51] *Vide Francisco Manuel dos Santos Foundation.*

- Costs related to the *risk premium*.

6.1.2.1 – Hospital costs with seriously injured victims

Such costs represent the expenses that society incurs in the treatment of seriously injured road accident victims (stabilization and recovery) whatever their level of severity. These costs are recorded by hospitals and the records are kept with the Ministry of Health.

6.1.2.2 – Costs pertaining to the total loss of potential production with seriously injured victims

a) Seriously injured victims with 100% permanent disability

The costs that represent the loss of production of seriously injured victims with 100% permanent disability entail loss of production – in and out – of the market. Individuals with a 100% permanent disability are not only unable to engage in any activity but their special condition requires that other social resources be allocated to satisfy their needs, in particular, specialized human capital, which constitutes an opportunity cost.

b) Seriously injured victims with permanent partial disability

A fraction of seriously injured road accident victims are left with some degree of permanent partial disability. These cases, in general, entail lifetime effects which are reflected in the disabled person's production capacity.

The various degrees of permanent disability, which are clinically assessed, affect future production in and out of the market. The percentage of permanent clinical impairment is a *proxy* measure for assessing the cost of the decrease in expected production that could have been obtained in the absence of disability.

c) Seriously injured victims with temporary disability

Another fraction of seriously injured victims sustain temporary disability – total or partial – during a more or less extended period beyond the time of hospitalization and recovery, whose effects also constitute a portion of the cost of road accidents.

d) Seriously injured victims and the risk premium

In the case of risk-averse individuals, we can define the *risk premium* as the maximum amount an individual is willing to pay (or not receive) to avoid a certain level of risk which determines the *certainty equivalent* and in turn is associated to *threshold probability*.

Whenever an indemnity or compensation dispute arises there are two main ways of settling it, aside from an amicable agreement between the parties:

i) Out-of-court settlements with insurers, and
ii) Lawsuits.

Bearing in mind that most accident victims are risk-averse and considering that the degree of risk-aversion varies inversely with the level of income and wealth; the greater the degree of risk aversion the higher the *risk premium*. Furthermore, as long as individuals remain risk-averse, the lower their income and wealth the higher the *risk premium*.

In Portugal's case, high variability (variance) of court awards for comparable cases and high judicial delay make judicial protection a risky prospect. On the other hand, greater predictability, lower variance of the compensation set by insurers and expeditious indemnity payments lead to a higher degree of certainty.

Thus, risk-averse individuals (seriously injured victims) are likely to prefer a certain method rather than an uncertain method of dispute resolution, meaning that they choose compensation set by insurers in spite of it being lower than the average indemnity award set by courts[52] for similar cases.

The difference between the expected value of damages awarded by courts and the amount set by insurers for comparable cases, can be regarded as the *risk premium* which in itself is a social cost and should integrate the social cost of road accidents.

Therefore, aside from individual utility, the social utility function is negatively affected, in the long term, due to permanent disability of seriously injured victims. In cases where a high degree of permanent disability exists, material and human resources (human capital) are diverted from other productive functions (market and non-market) and are allocated to cater to the special needs of accident victims with permanent disability.

e) Effects of permanent disability

Injury contemplated in permanent disability mainly generates two types of effects:

i) *Monetary damages*, which include property damage to vehicles, medical and pharmaceutical expenses and personal injury that precludes full or partial performance of ordinary day-to-day activities (whether it is market or non-market), and

ii) *Non-monetary damages*, which may be permanent and don't necessarily imply an economic loss in a narrow sense. They epitomize social cost. They also bring about pain and suffering which is not only sustained by the victim but by family and friends[53].

[52] Donário (2010a), pp. 236-238 and 325-328.

[53] Cf. Sá (1992).

6.1.3 – Slightly injured victims

With regard to the assessment of production loss of slightly injured victims we considered – with an excess margin of error – those individuals who sustain minor injuries following a road accident and are, on average, inactive for a period of 24 hours. In many of these cases, we found that hospitalization and recovery – and therefore consequent production loss – was inferior to 24 hours.

6.2 – Administrative costs of insurers

Characterized as indirect costs they consist in insurer administrative costs namely operating costs, employee wages, advertising, administration and taxes associated with road accident injured victims.

In this section we used data provided by the Portuguese Insurance Institute (*ISP*). Despite the difficulties in obtaining data for the period under review, i.e. 1996-2010, the *ISP* was able to provide data pertaining to the period 2000-2009. In this context, we chose to consider the years between 1996 and 1999 as having the same value of insurer administrative costs as in the year 2000, and the year of 2010 as having the same administrative costs as the year of 2009.

6.3 – Indirect costs with public road safety institutions

There are public entities whose main objective is road safety. They represent government intervention as a result of market failures in the road mobility and safety market.

Indeed, the majority of road users have imperfect information, not only in relation to effective probabilities of crashes but also in regards to the negative externalities their road behavior may cause.

Subjective probabilities – based on heuristic mechanisms (trial-and-error) – are influenced by various biases, to be more precise, individuals tend to make judgments about the likelihood of future events based on the ease of imagining such events, which translates into "*availability heuristic*" that leads to another bias known as *hindsight bias* which is the knowledge and understanding that a person has about an event only after it occurs, and thus, can easily imagine similar events, consequently overestimating probabilities.

Another bias in the assessment of probabilities is known as "*representativeness heuristic*" which consists in judging conditional probabilities in accordance to how the data represents a hypothesis or an example in which people rely on. Sometimes, this heuristic way judging probabilities is erroneous.

Further, another bias identified as the "*law of small numbers*" leads individuals to think that the characteristics of a sample population can be estimated from a small number of observations or data points, leading them into error.

Such justifies the need for institutions like the National Authority for Road Safety, who seeks to minimize the economic and social costs of road accidents through the implementation of various strategies and whose operating costs should be considered as economic and social costs of accidents.

Having been established in 2007, the ANSR's budget is only available from 2008 onward. Therefore, we made the assumption that the expenditure on road safety in previous years (from 1996 to 2007) is similar to the amount spent in 2008.

However, ANSR expenditures are not the only costs involved in this category. In this context, we draw on a study carried out by the Portuguese Road Safety Association in 1987[54] in order to estimate the remaining costs

[54] Donário (2010a), p. 106 *et seq*.

of road safety. In consequence, we add the estimated amounts based on this study to the ANSR's budget for the period under review.

6.4 – Operating costs of courts

Part of the operating costs of courts should be attributed to the economic and social cost of accidents as indirect costs, since human and material resources are allocated to satisfy the demand for judicial protection in settling disputes emerging from road accidents, namely in cases involving fatalities and seriously injured victims. Such emergent disputes also entail other indirect costs which can be construed as contributing towards judicial delay and court congestion.

Since we were unable to obtain the necessary data from the competent judicial authorities, we estimated these costs based on the study conducted by the Portuguese Road Safety Association in 1987, aforementioned, taking into account the number of road accident fatalities and injuries while maintaining the same research category layout.

6.5 – Hospital costs associated with fatal and seriously injured victims

In this section we used the data provided by the Health Care System Administration (*ACSS*) of the Portuguese Ministry of Health. Despite the difficulties in obtaining the data for the period under review, the ACSS was able to provide data for the period 2000-2009. In this context, we decided that that the years ranging from 1996 to 1999 would have the same value of hospital costs relative to fatalities and seriously injured than those recorded in 2000 and that for the year 2010 hospital costs would be same as those registered in 2009.

6.6 – Ambulance fees and victim transport costs

Costs and fees for transporting road accident fatal and seriously injured victims to hospitals were provided by the National Institute for Medical Emergencies (*INEM)* for the period 2004 - 2009. Since the period under review ranges from 1996 to 2010, it was decided that the transport costs for the years between 1996 and 2003 would be the same as those recorded in 2004 while the costs pertaining to 2010 would be similar to those in 2009.

6.7 – Cost of law enforcement

In this section we used the data provided by the National Police Authority (*PSP*) and the Portuguese National Guard *(GNR)*. There was some difficulty in obtaining data for the period under review, albeit, the National Police Authority did release data pertaining to the period 2000 - 2010. On the other hand, we were able to obtain data from the Portuguese National Guard referent to the period 2001 - 2010. In this context, we were able to combine both sets of available data by extrapolating information from the data obtained from the Portuguese National Guard for the year 2000. Once this was done, we decided that the costs of law enforcement for the years 1996-1999, as in the previous categories, would be the same as those recorded in 2000.

6.8 – Cost of property damage to vehicles

Monetary damages to property can be differentiated from personal injury. In the case of monetary damages to property we witness a loss of utility of economic goods. The valuation of reproducible goods damaged in a road accident demands that the cost of replacement or repair be taken into account – whenever possible – and that the choice should rest upon whichever is lower so as to minimize social costs, i.e. maximize efficiency.

In this section we made use of the data provided by the Portuguese Insurance Institute (*ISP*). Despite the problems in obtaining data for the period under review, the *ISP* was able to provide data for the period 2000-2009. In this context, we chose to attribute the same value of insurer administrative costs recorded in 2000 for the years 1996 -1999 while the costs pertaining to 2010 would be similar to those in 2009.

6.9 – Accident loss adjustment costs

The competent authorities could not provide the necessary data. In this sense, we drew on the study conducted by the Portuguese Road Safety Association in 1987 and estimated the values for the period under analysis.

6.10 – Attorney Fees

The competent judicial authorities were also unable to provide the necessary data. Once again, we resorted to the study carried out by the Portuguese Road Safety Association in 1987 and estimated the values for the period under review.

6.11 – Court Fees

Court fees portray the value, price or expense with a lawsuit until its final outcome – expressed as a certain factual situation or the declaration of a right -, which is from the outset, a factor to take into account when assessing the economic and social cost of road accidents. Although we had some information on court fees pertaining to road accident lawsuits, it was insufficient in quantitative terms for an accurate estimation. In this sense, it was decided, once again, to resort to the study carried out by the

Portuguese Road Safety Association in 1987 and estimate the values for the period under review.

6.12 – Funeral Expenses

Although funeral expenses are somewhat irrelevant when assessing the economic and social cost of road accidents, they remain an important category due to their religious and customary nature and, therefore, must be taken into account. However, it was not possible to obtain updated information from the competent authorities because of the inexistence of such records. In this sense, it was decided, once again, to resort to the study carried out by the Portuguese Road Safety Association in 1987 and estimate the values for the period under review.

6.13 – Non-monetary or moral costs

Such costs are unquantifiable market costs that emerge from road accidents. Moreover, they reduce the utility function of individuals – as in the case of injured victims – because they deprive the injured and their loved ones of the normal pleasures of living, and in the case of death, the effects of this cost are transferred to family members. Pain and suffering represent costs to society and are defined as personal moral costs. They are non-market costs that can only be estimated through the use of *proxies*.

Indeed, the absence of a price set by the market in relation to non-monetary costs results in a market failure, justifying government intervention in the assignment of a price. However, government doesn't assign a value of compensation, because such is impossible in cases of wrongful death (since the utility function of the deceased no longer exists) but it also intervenes to assign a price in certain cases of permanent disability.

There are also negative effects on third parties, since the capacity to consume or enjoy certain goods is eliminated or reduced, which ultimately leads to a decrease in the utility function (or welfare). Surely, in order to remove utility (pleasure) though the use or consumption of certain goods, it is necessary that certain capabilities exist, that when eliminated or reduced, cause certain goods to become useless. For instance, loss of sight, hearing, mobility and so on. In these cases, and the like, two types of effects emerge[55]:

1 – Decreased capability to obtain income in the market and its *proxy* translated as the decrease of services rendered outside the market, that is, services rendered at home, for the family and for the community (which are opportunity costs), imposing other probable costs that arise from the use of services provided by others and the use of alternative goods that would not have used in the absence of disability;

2 – Decrease of the utility function as a result of the elimination or reduction of certain vital functions of the victim, bearing in mind the principle of diminishing marginal utility. For example, in the case of blindness (or another vital function essential to welfare), high compensation awarded to the victim – no matter how high it is – it cannot be spent on goods whose utility can only be attained through eyesight or the vital function affected as a result of the accident. In this manner, the victim's options of consumption are limited, therefore reducing his utility function (translating into cost or disutility). In other words, no matter how much available income he may have at his disposal, it would be difficult and in some cases virtually impossible to attain a level of satisfaction equal to what would exist in absence of disability.

The appliance of income on alternative goods shall constitute diminishing marginal utility, as a result of limited choices, reflecting a decrease in the marginal value of each monetary unit (euro). One of the ways in which

[55] Pintos Ager (2000) and Friedman (1982).

we can estimate these non-monetary costs is by using the *proxy* of court awards.

In effect, the quantitative valuation (monetary assessment) carried out by the courts regarding non-monetary damages sustained by fatal or disabled victims can be used as a proxy for the said cost to society, as shall be explained further on in this study.

As provided by Portuguese law, in Article 496 § 1 of the Portuguese Civil Code "*In setting compensation, serious non-pecuniary losses deserving legal protection should be considered*. Therefore, when courts assess non-monetary damages, translated into pain, suffering and anguish, they act on society's behalf as a sovereign competent power, assigning – *as a proxy* – a monetary value of compensation to such damages, in view of the existing social and moral values in that given society. This valuation will diachronically vary with the change in social and moral values over time.

Given the high subjectivity in the assessment of non-monetary damages by courts, which leads to large variance, we shall use the average of a large sample in the attempt to obtain a non-biased estimate of these costs.

In this context, the estimation of non-monetary damages was based on the information[56] contained in nearly 260 judgments from different Portuguese Courts of Appeal, pertaining to traffic accident claims in which non-monetary damages were awarded.

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[56] *Vide* Portuguese Ministry of Justice, Institute of Judicial Technologies and Computerization (*ITIJ*).

VII
Empirical Study

The purpose of this chapter is to reveal the values obtained regarding the components of the economic and social cost of road accidents. This is done according to the general-to-specific approach.

7.1 – Total value of lost production

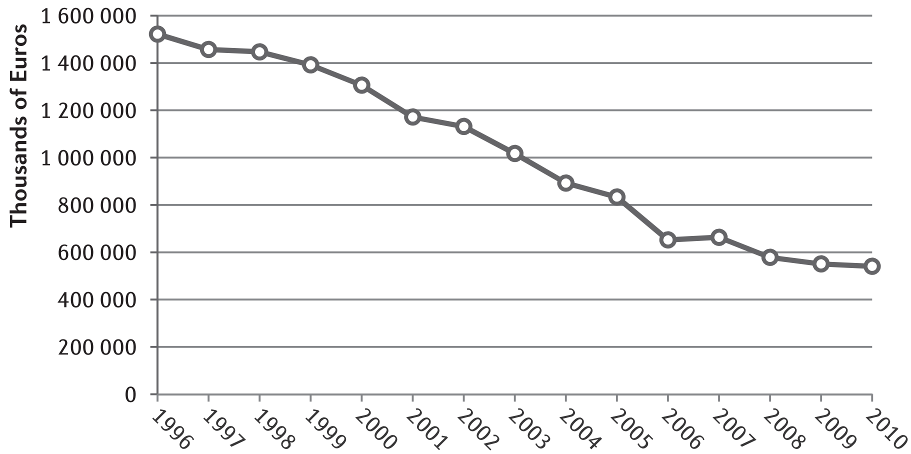
The total value of lost production, obtained through the ex-post human capital method, includes the potential loss of productivity or production capacity of all road accident casualties (fatalities and injured victims). The cost of potential output lost by victims as a result of premature death or disability has been corrected to present day value by using the update rate.

7.1.1 – Value of lost production of total victims

The following graph illustrates the trend in the value of total production loss of total casualties in the period 1996 -2010:

Graph 7.1.1.1

Value of production loss of total victims



Elaborated by the author (See Appendix 6).

In fact, with the exception of 2006 to 2007, all other years consistently exhibited a decrease from year to year. In this context, the year 1996 displayed the highest absolute value of lost production, nearly 1.522 billion euros, whereas the lowest absolute value was recorded in 2010 representing a loss in nearly 540 million euros.

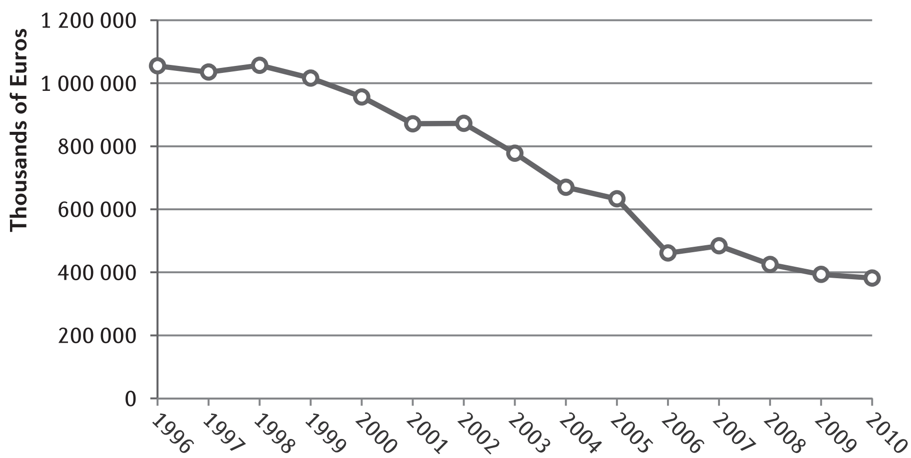
If the total value of lost production was substantial in 1996, about 1.2% of GDP, this figure represented about 0.3% of GDP in 2010. Nevertheless, the total amount of production that society lost, over the period considered, amounted to approximately 15. 153 billion euros. If we take into account the total wealth produced during this period (gross domestic product from 1996 to 2010 – at constant prices 2006), the value that society lost with the total number of road accident victims is about 1% of the total wealth created.

Note that this value would have been higher if it were not for the downward trend of total victims and therefore the value of lost production, since there was an absolute cumulative gain (no-loss) of about 982 million euros for society during the period considered.

7.1.2 – Value of lost production of fatal victims

The following chart illustrates the trend in the value of lost production of fatal victims from 1996 to 2010:

Graph 7.1.1.2
Value of lost production of fatalities



Elaborated by the author (See Appendix 3).

With the exception of 1997 to 1998, 2001 to 2002 and 2006 to 2007, all other years revealed a decrease from year to year.

In this context, the year that checked in with highest absolute value of lost production was 1996 with about 1.055 billion euros, contrariwise, the lowest absolute value was recorded in 2010 representing nearly 382 million euros. If the value of loss of production were to be weighed in 1996, it would represent approximately 1% of GDP and about 0.2% in 2010.

Nevertheless, the total amount of production lost by society, over the time span reviewed, amounted to approximately 11.088 billion euros. If we were to take into account the sum of the gross domestic product from 1996 to 2010 (at constant prices of 2006), the value that society lost due to road accident fatalities is about 0.5% of the total wealth generated during this period.

It is worth mentioning that this value would have been higher if it were not for the downward trend of fatalities and therefore the value of lost production, since there was an absolute cumulative gain (no-loss) of about 673 million euros for society during the period considered.

In estimating the potential loss of production of fatal victims, we assessed the median age of fatal road accident victims, using both the data provided by the *ANSR* regarding fatalities per age group and the average life expectancy in Portugal.

Fatalities weigh the most when it comes to the total cost of accidents in each year of the time-series analyzed (1996-2010). The variance rate in the number of fatalities throughout the period was constantly negative, except for 2002, 2007 and 2010. The cumulative variance rate in the period reviewed was - 97%, indicating a positive trend.

Similarly, the variance rate of costs related to the estimated lost production with fatalities was continuously negative, except for 1998, 2002 (which was zero) and 2007. The cumulative variance rate was - 93%.

The similarity between the two sets of variance rates indicates that there is high correlation between them, whereby the reduction of road fatalities has an almost equal and proportional effect on the reduction of the costs of lost production.

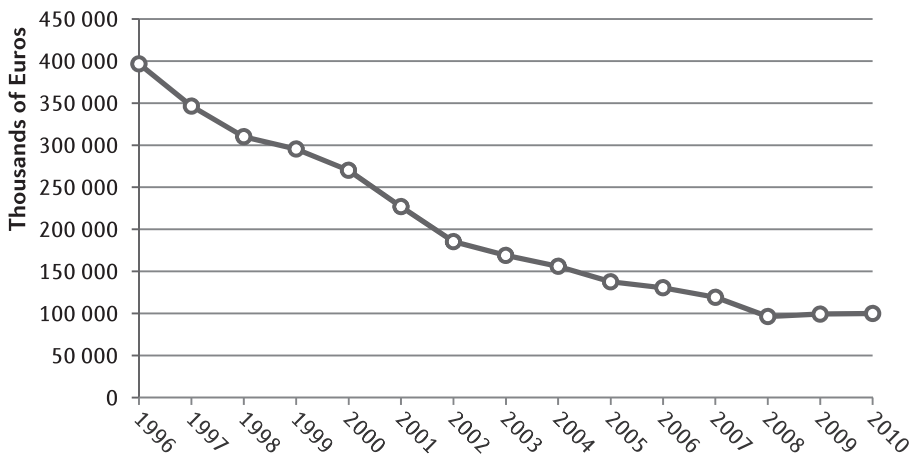
In 1996, the estimated value of lost production relative to road fatalities was about 1.055 billion euros at 2006 constant prices, whereas at the end of the period this estimated value was nearly 381.8 million euros, i.e., 2.76 times lower. Over the span of 15 years, the total estimated value of production loss referent to fatal road accident victims was about 11.088 million euros.

7.1.3 – Value of lost production of seriously injured victims

The value of lost production of seriously injured victims is illustrated in the following graph and allows the reader to visualize the trend of this cost in the period analyzed herein:

Graph 7.1.1.3

Value of lost production of seriously injured victims



Elaborated by the author (See Appendix 4).

Except for the period between 2008 and 2010, all other years presented a decrease from year to year. The highest absolute value of lost production resulting from seriously injured victims was verified in 1996, nearly 397 million euros, while on the other hand the lowest absolute value was recorded in 2008 representing a loss of about 96 million euros.

The value of lost production resulting from seriously injured victims, in 1996, represented about 0.3% of GDP and in 2010 it represented about 0.1% of GDP, reflecting a steady decline all throughout the period.

Nevertheless, the total amount of production lost by society in respect to seriously injured victims, over the time span reviewed, amounted to approximately 3.039 billion euros. If we were to take into account the sum of the gross domestic product from 1996 to 2010 (at constant prices of 2006), the value that society lost due to seriously injured road accident victims is about 0.13% of the total wealth generated during this period.

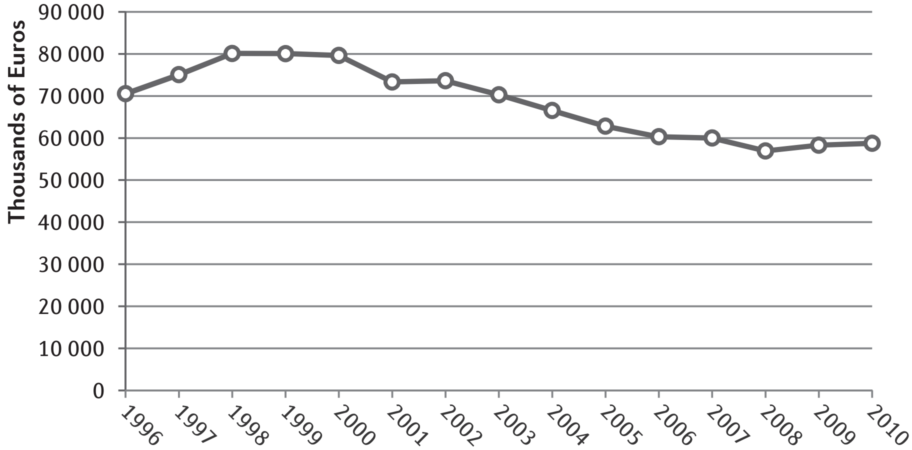
We also draw attention to the fact that this value would have been higher if it were not for the downward trend of seriously injured victims and therefore the value of lost production, since there was an absolute cumulative gain (no-loss) of about 297 million euros for society during the period considered.

7.1.4 – Value of lost production of slightly injured victims

Regarding the value of production loss of slightly injured victims, its progression is depicted in the graph below for the period 1996 - 2010:

Graph 7.1.1.4

Value of lost production of slightly injured victims



Elaborated by the author (See Appendix 5).

The decreasing slope was not as pronounced although it did reveal a downward trend. In this context, 1998 was the year with the highest absolute value of lost production checking in with cost of nearly 80.1 million euros, whereas the lowest absolute value was recorded in 2008, representing roughly 57 million euros.

If in 1996 the value of lost production associated to road accident minor injury represented about 0.06% of GDP, it was about 0.04% in 2010. Still, the total amount of production lost by society, over the time span reviewed, amounted to approximately 1.026 billion euros. If we were to take into account the sum of the gross domestic product from 1996 to 2010 (at constant prices of 2006), the value that society lost due to slightly injured road accident victims is about 0.04% of the total wealth generated during this period.

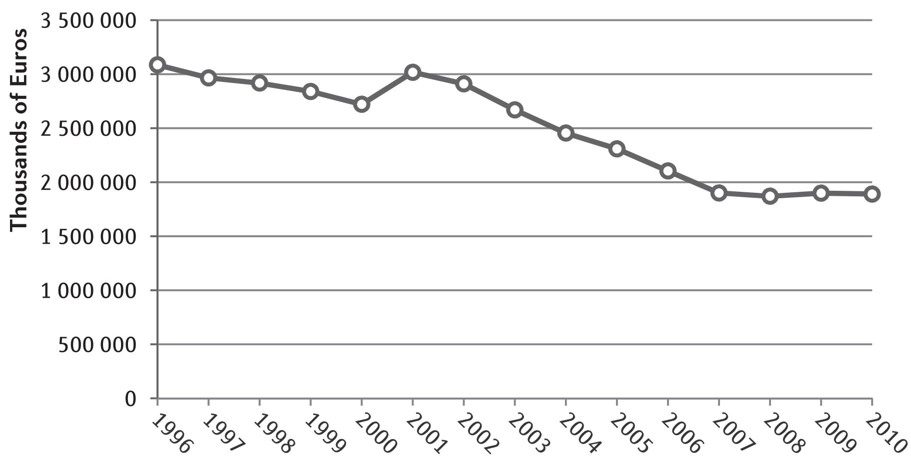
Despite of the moderate decreasing slope in relation to other types of victims, this value would have been higher if it were not for the downward trend of slightly injured victims and therefore the value of lost production, since there was an absolute cumulative gain (no-loss) of about 12 million euros for society during the period considered.

7.2 – Economic and social cost of road accidents

Since accidents with victims originate costs of various kinds, it is important to analyze the evolution of the total cost of accidents over the period considered. As noted earlier, the value of lost production caused by fatal, seriously and slightly injured accident victims revealed a downward trend, which was reflected in the total cost of accidents due to the importance that these categories represent in such total cost.

Graph 7.2.1

Evolution of the economic and social cost of road accidents



Elaborated by the author (See Appendix 8).

The graph above allows us to take a glance at the trend of the economic and social cost of road accidents in Portugal during the period 1996 - 2010.

Cost evolution displayed a decreasing trend although there were some years where the cost increased, in particular, from 2000 to 2001 and from 2008 until 2009.

In this context, 1996 was the year with the highest absolute value, nearly 3.086 billion euros, whereas the lowest absolute value was recorded in 2008, representing roughly 1.870 billion euros.

In 1996 the amount of the economic and social cost of road accidents was nearly 2.41% of GDP and in 2010 it was about 1.17%. Nevertheless, the total cost for society, over the time span considered, amounted to approximately 37.549 billion euros. If we were to take into account the sum of the gross domestic product from 1996 to 2010 (at constant prices of 2006), it would suggest that the value lost by society as a result of fatal victims was about 1.64% of the total wealth generated during this period.

The annual value of the economic and social cost in the period considered would have been higher if it were not for the downward trend, since there was an absolute cumulative gain (no-loss) of about 1.196 billion euros for society.

Upon analysis of the time frame spanning from 1996 to 2010, we estimated that the annual average economic and social cost of road accidents in Portugal (including road fatality, serious and minor injury) was about 2.503 billion euros.

Since we are studying the cost associated to road accidents in Portugal, it is imperative that we evaluate the different factors and elements that contribute to the value of the economic and social cost attained. Actually, the ontological aspect has a fundamental role in this matter. Despite of the assessment of monetary and non-monetary costs of road accidents being the core purpose of our present study, it should be pointed out, that it is upon people that accidents inflict more pain, suffering and often irreparable damage. Therefore, it becomes evident of how important it is to know how these three types of accident victims contribute towards the economic and social cost borne by society.

In the chart below we can verify the evolution of the economic and social cost of road accidents with fatalities:

Chart 7.2.1

Evolution of the economic and social cost of road accidents with fatalities during the period 1996- 2010

Year	Average Annual Social Cost of Road Accidents with Fatal Victims (In Euros)
1996	1 250 197 239
1997	1 217 203 441
1998	1 233 072 090
1999	1 182 844 325
2000	1 114 833 343
2001	1 028 231 232
2002	1 030 999 221
2003	921 983 307
2004	791 785 522
2005	749 321 662
2006	553 188 798
2007	573 938 956
2008	509 705 841
2009	473 667 213
2010	462 951 908

Elaborated by the author (See Appendix 17).

In reviewing the chart above, we found that the annual social cost of road accidents with fatalities plummeted in the period under review, except in 2007, implying a reduced impact of road fatality cost on the overall economic and social cost, which fell from roughly 41% in 1996 to about 24% in 2010.

Considering the time interval afore, the average annual economic and social cost of fatal road accidents in Portugal was about 873 million euros, which was strongly affected by the initial annual values of the period. In relative terms, the average cost of fatal accidents had an impact of about 35% on the average overall economic and social cost.

Regarding the trend in economic and social cost of accidents with seriously injured victims, we present the illustrative chart below:

Chart 7.2.2

Evolution of the economic and social cost of road accidents with seriously injured victims during the period 1996- 2010

Year	Average Annual Social Cost of Road Accidents with Seriously Injured Victims (In Euros)
1996	921 518 835
1997	805 448 157
1998	717 551 494
1999	684 104 314
2000	632 885 172
2001	587 877 957
2002	485 916 347
2003	454 334 263
2004	416 032 370
2005	370 129 330
2006	352 794 520
2007	307 528 248
2008	262 474 940
2009	266 758 689
2010	268 060 232

Elaborated by the author (See Appendix 18).

Based on the detailed information provided in the chart above, we verified that the annual social cost of road accidents with seriously injured victims fell all throughout the period, except during the last two years, suggesting a reduced impact of minor injury cost on overall economic and social cost, which fell from roughly 30% in 1996 to about 14% in 2010.

During this time interval, the average annual economic and social cost of road accidents with seriously injured victims was approximately 502.2 million euros. In relative terms, the average cost of road accidents involving serious injury had an impact of about 20% on the average overall economic and social cost.

In what pertains to minor injury accidents, the following chart gives an idea of its cost evolution:

Chart 7.2.3

Evolution of the economic and social cost of road accidents with slightly injured victims during the period 1996- 2010

Year	Average Annual Social Cost of Road Accidents with Slightly Injured Victims (In Euros)
1996	913 830 989
1997	942 829 823
1998	966 600 723
1999	972 265 583
2000	972 470 139
2001	1 400 638 069
2002	1 393 606 287
2003	1 293 475 203
2004	1 246 503 663
2005	1 188 900 916
2006	1 197 378 473
2007	1 018 774 998
2008	1 097 586 503
2009	1 157 998 863
2010	1 158 812 509

Elaborated by the author (See Appendix 19).

Contrary to what was verified in the case of fatal and serious injury accident cost we detected an infrequent and increasing trend in the cost of minor road accident injury during the period considered. Nevertheless, we found that its impact on overall economic and social cost, increased from about 30% in 1996 to about 61% in 2010, suggesting an increased impact of the said victims on overall accident cost in Portugal.

From 1996 to 2010, the average annual economic and social cost of road accidents with slightly injured victims was about 1.128 billion euros. In relative terms, the average cost of road accidents involving minor injury had an impact of about 45% on the average overall economic and social cost.

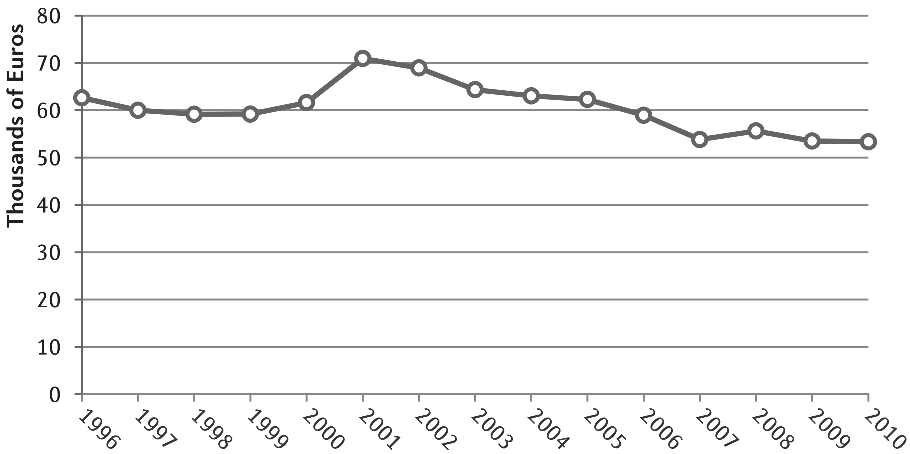
Thus, it appears that the average impact of the cost of accidents with minor injury is – *per se* – almost as high as the average impact of the cost of accidents with fatalities and serious injury combined.

7.2.1 – Average cost per accident with victims

The trend in the average cost per accident with victims can be seen in the following graph:

Graph 7.2.1.1

Trend in the average economic and social cost per accident with victims



Elaborated by the author (See Appendix 16).

We observe a decreasing trend from 1996 up until 1999 (except for a slight increase of about 40 euros during 1998 and 1999) rising from 1999 to 2001, then falling again until 2007, increasing once more until 2008 and finally decreasing by the end of the period. There is evidence of a slight downward trend in the average value of cost per accident with victims in the period under review, in spite of the two recorded increases.

In this context, 2001 was the year with the highest absolute value, nearly 71 thousand euros, whereas the lowest absolute value was recorded in 2010, roughly 53.3 thousand euros. At the beginning of the period, the average cost per accident with victims was about 62.6 thousand euros and by the end of that same period it was about 53.3 thousand euros, precisely the lowest absolute value.

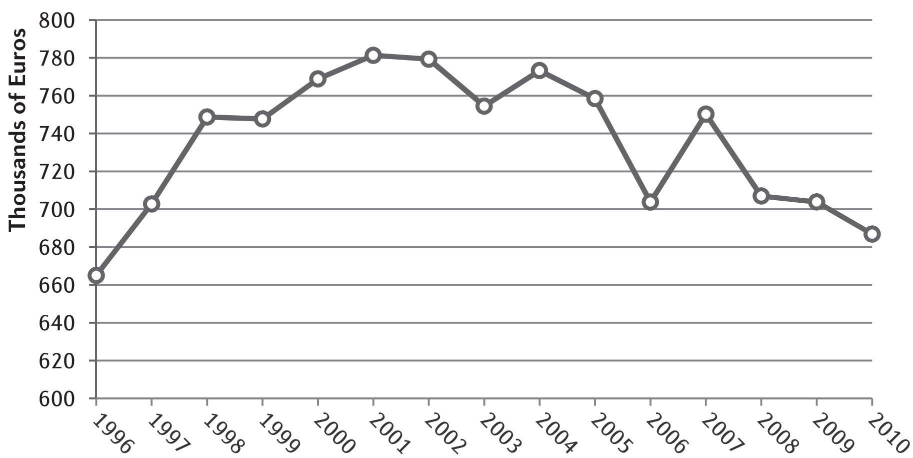
The balance between gains and losses throughout the period, allowed us to conclude that the average value of cost per accident with victims had decreased by about 9.3 thousand euros, suggesting a downward trend in the unit value of economic and social cost per accident with victims.

Furthermore, if we were to conduct a variance analysis we would we find that during the period considered, the cumulative rate was negative and that it was approximately 14%, translating into an average of about 60.5 thousand euros per accident with victims.

7.2.2 – Average cost per accident with fatalities

Let's take a look at the trend illustrated in the graph below pertaining to the average cost per accident with fatalities for the period 1996-2010:

Graph 7.2.2.1
Trend in the average economic and social cost per accident with fatalities



Elaborated by the author (See Appendix 12).

This cost registered an increasing trend until 2001 having decreased from this year onward with some fluctuation, namely from 2003 to 2004 and from 2006 to 2007.

In this context, 1996 was the year with the lowest absolute value, nearly 665 thousand euros, whereas the highest absolute value was recorded in 2001, roughly 781.3 thousand euros. At the beginning of the period, the average cost per accident with fatalities was about 665 thousand euros and by the end of that same period it was about 687 thousand euros.

The balance between gains and losses in the period reviewed, allowed us to conclude that the cost value of each accident with fatalities had increased by about 21.9 thousand euros, suggesting an upward trend in the unit value of economic and social cost per accident with fatalities.

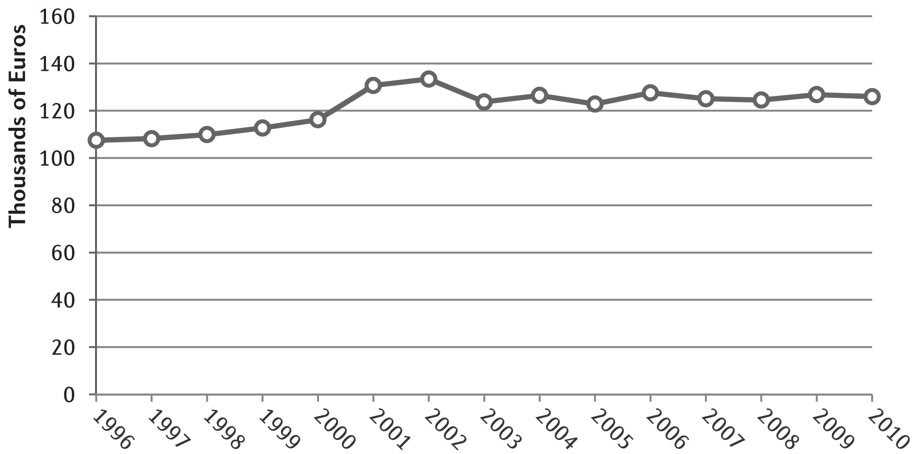
From the variance analysis, we obtained confirmation of an increasing cost per accident with fatalities in the period considered, having verified that the cumulative growth rate was positive and that it was approximately 4%, translating into an average of about 735 thousand euros per accident with fatalities.

7.2.3 – Average cost per accident with seriously injured victims

The average cost per accident with seriously injured victims is portrayed in the following graph which allows us to visualize the evolution of this cost in the period analyzed herein:

Graph 7.2.3.1

Trend in the average economic and social cost per accident with seriously injured victims



Elaborated by the author (See Appendix 13).

The average cost to society of each accident with seriously injured victims during the period considered, reveals an overall growing trend, with a more accentuated growth period between 2000 and 2002, maintaining itself constant through the remainder of the period.

The growing trend of this cost did however register some fluctuation namely, from 2002 to 2003, from 2004 to 2005, from 2006 to 2008 and from 2009 to 2010, periods in which we witnessed a decline in the cost per accident with seriously injured victims, having presented – in all other years – an increase from year to year.

In this context, 1996 was the year with the lowest absolute value, nearly 107.5 thousand euros, whereas the highest absolute value was recorded in 2002, roughly 133.4 thousand euros. At the beginning of the period, the cost per accident with seriously injured victims was about 107.5 thousand euros and by the end of that same period it was about 126 thousand euros.

When we contemplate the balance between gains and losses in the time period viewed, the cost value of each accident with seriously injured victims had increased by about 18.5 thousand euros, suggesting an upward trend in the unit value of economic and social cost per accident with seriously injured victims.

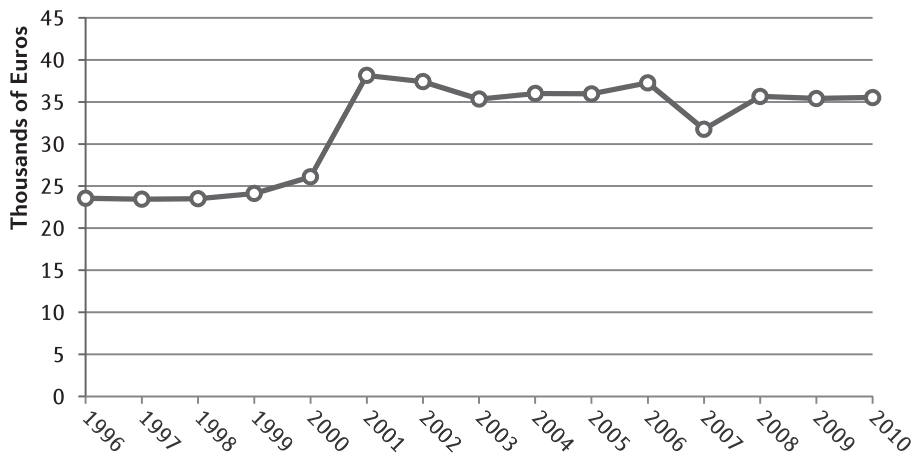
From the variance analysis, we verified that the cumulative rate was positive and that it was approximately 17%, translating into an average of about 121.4 thousand euros per accident with seriously injured victims.

7.2.4 – Average cost per accident with slightly injured victims

The following graph provides the reader with an overview of the trend in the cost per accident with minor injuries during the period 1996 - 2010:

Graph 7.2.4.1

Trend in the average economic and social cost per accident with slightly injured victims



Elaborated by the author (See Appendix 14).

The average cost to society of each accident with slightly injured victims during the period considered, presented an overall growing trend, with a sharp growth period between 2000 and 2001[57], maintaining itself constant through the remainder of the period, except for 2006-2007, year in which it converged towards a value of nearly 35 thousand euros.

In this context, 1997 was the year with the lowest absolute value, nearly 23.4 thousand euros, whereas the highest absolute value was recorded in 2000, roughly 38 thousand euros. At the beginning of the period, the cost per accident with slightly injured victims was about 23.5 thousand euros and by the end of that same period it was about 35.5 thousand euros.

By conducting a balance between gains and losses in the period considered, we verified that the cost value of each accident with slightly injured victims had increased by about 12 thousand euros, suggesting an upward trend in the unit value of economic and social cost per accident with slightly injured victims.

From the variance analysis, we verified that the cumulative rate was positive and that it was approximately 52%, translating into an average of about 32 thousand euros per accident with slightly injured victims, strongly driven by growth verified between 2000 and 2001, whose variance rate was about 46%[58].

[57] Due to a strong growth in the value of costs relating to property damage to vehicles. Data provided by the Portuguese Insurance Institute *(ISP)*.

[58] *Idem*.

7.3 – Average cost per fatal, seriously and slightly injured victim

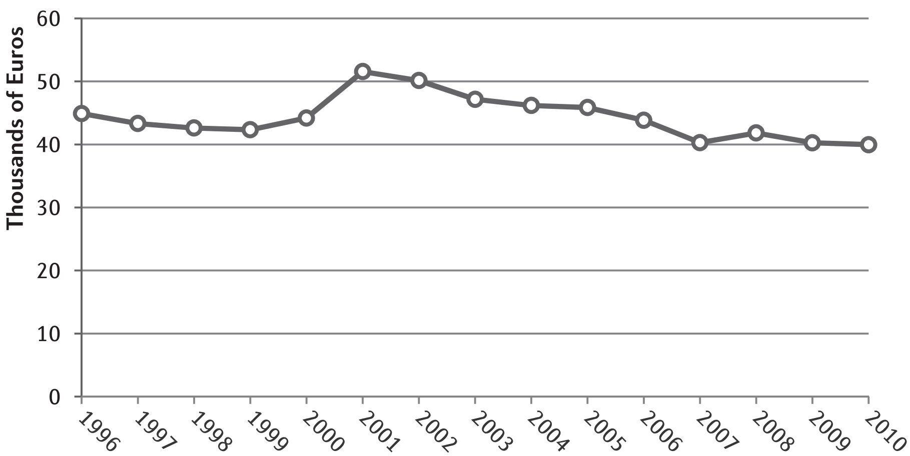
The subsequent analysis estimates the average cost per victim by dividing the total cost of accidents by the number of total victims (which comprises fatal and injured victims) or by the average cost per fatality, per seriously injured victim and per slightly injured victim.

7.3.1 – Average cost per victim

The average cost per victim includes the cost of fatalities and the cost of seriously injured victims. The following graph allows the reader to view its evolution over the period 1996 - 2010.

Graph 7.3.1.1

Trend of the average cost per victim



Elaborated by the author (See Appendix 15).

The average cost per victim declined from 1996 until 1999, rising from 1999 to 2001, falling again until 2007 recording a subsequent increase until 2008, only to fall again at the end of the time period. Such evidence reveals a downward trend in the average cost per victim, except for two instances in the time series where the opposite was verified.

In this context, 2001 was the year with the highest absolute value, nearly 51.5 thousand euros, whereas the lowest absolute value was recorded in 2010, roughly 40 thousand euros.

At the beginning of the period, the average cost per victim was about 44.9 thousand euros and by the end of that same period it was about 40 thousand euros.

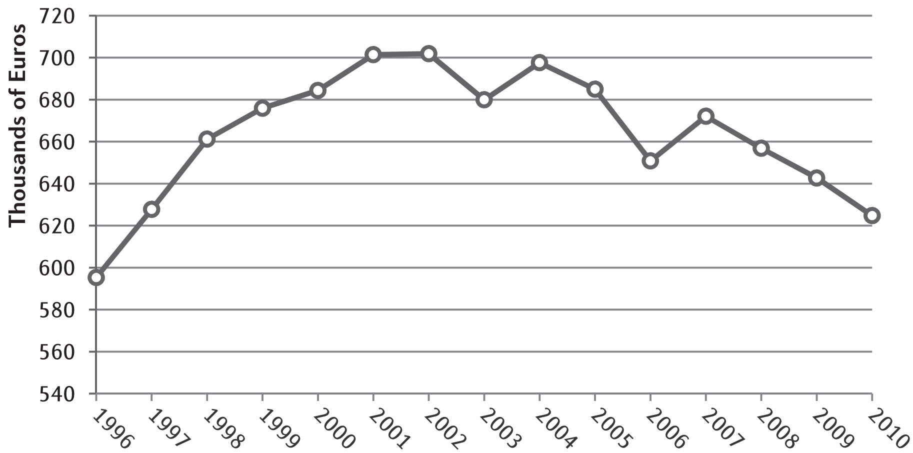
By conducting a balance between gains and losses in the period considered, we verified that the average cost per victim had decreased by about 5 thousand euros, suggesting a downward trend in the unit value of the average economic and social cost per victim.

Furthermore, if we were to conduct a variance analysis we would we find that during the period above, the cumulative rate was negative and that it was approximately 9%, translating into an average of about 44.3 thousand euros per victim.

7.3.2 – Average cost per fatality

The graph below depicts the evolution of the average cost per fatality during the period 1996 - 2010:

Graph 7.3.2.1
Trend of the average cost per fatality



Elaborated by the author (See Appendix 9).

The average cost per fatality grew from 1996 up until 2002, year in which it began to display a downward trend, namely from 2002 to 2003, from 2004 to 2006 and from 2007 until the end of the period, having only checked in with a slight increase during 2003 and 2004 and from 2006 to 2007[59]. In this context, 1996 was the year with the lowest absolute value, nearly 595.3 thousand euros, whereas the highest absolute value was recorded in 2002, roughly 702 thousand euros.

At the beginning of the period, the average cost per fatality was about 595.3 thousand euros and by the end of that same period it was about 624.8 thousand euros. By conducting a balance between gains and losses

[59] This increase was the result of growth in the Portuguese GDP *per capita*.

in the period considered, we verified that the average cost per fatality had increased by about 29.4 thousand euros, suggesting an upward trend in the unit value of the economic and social cost of accidents per fatality.

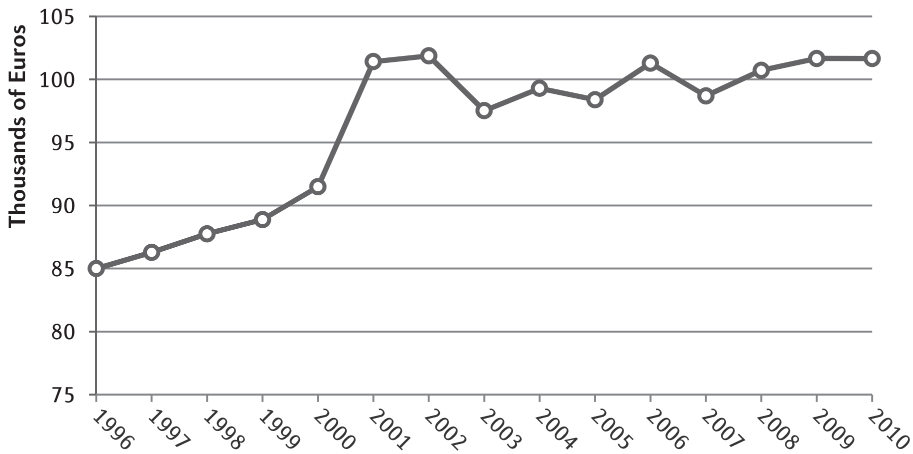
Furthermore, if we were to conduct a variance analysis we would we find that during the period above, the cumulative rate was positive and that it was approximately 6%, translating into an average of about 663.8 thousand euros per fatality.

7.3.3 – Average cost per seriously injured victim

The following graph shows the evolution in the cost per seriously injured victim during the period 1996 - 2010.

Graph 7.3.3.1

Trend of the average cost per seriously injured victim



Elaborated by the author (See Appendix 10).

According to official data provided by the Portuguese Insurance Institute (*ISP*); there was a noticeable "leap" from period between 2000 and 2001.

In spite of drops recorded from 2002 to 2003, from 2004 to 2005, from 2006 to 2007 and from 2009 to 2010 (in about 8 euros), the overall increasing trend was evident. The lowest absolute value was witnessed in 1996, nearly 85 thousand euros, whereas the highest absolute value was recorded in 2002, roughly 101.9 thousand euros.

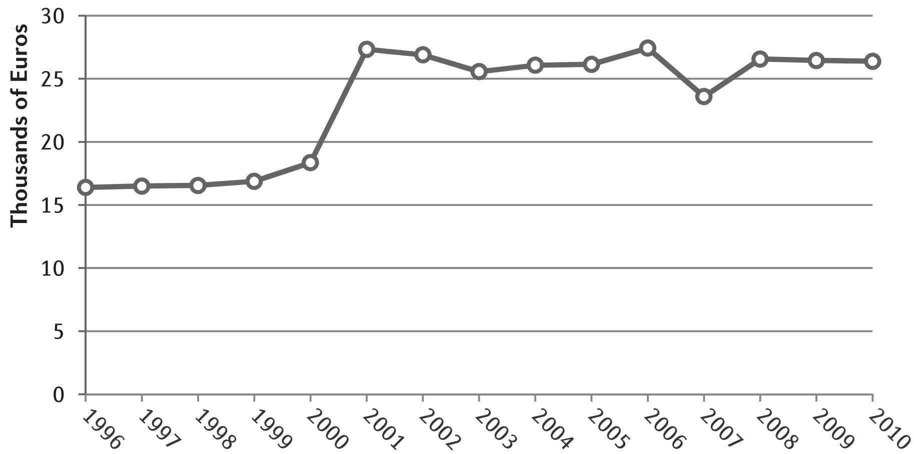
At the beginning of the period, the average cost per seriously injured victim was about 85 thousand euros and by the end of that same period it was about 101.6 thousand euros. By the assessment of gains and losses in the period considered, we verified that the average cost per seriously injured victim had increased by about 16.6 thousand euros, suggesting an upward trend in the unit value of the average economic and social cost of accidents per seriously injured victim.

Further, if we were to conduct a variance analysis we would we find that during the period above, the cumulative rate was positive and that it was approximately 19%, translating into an average of about 96.1 thousand euros per seriously injured victim.

7.3.4 – Average cost per slightly injured victim

Cost per slightly injured victim during the period between 1996 and 2010 has been summarized in the line graph below.

Graph 7.3.4.1
Trend of the average cost per slightly injured victim



Elaborated by the author (See Appendix 11).

As seen above there was a “leap” from 2000 to 2001. Although with some fluctuation, the value of the average cost of accidents per slightly injured victim remained relatively stable at around the threshold of 25 thousand euros, registering some lows between the periods from 2001 to 2003, from 2006 to 2007, and from 2008 until the end of the time frame. In this context, 1996 was the year with the lowest absolute value, nearly 16.4 thousand euros, whereas the highest absolute value was recorded in 2006, roughly 27.4 thousand euros.

At the beginning of the period, the average cost per slightly injured victim was about 16.4 thousand euros and by the end of that same period it was about 26.4 thousand euros. In the assessment of gains and losses in the period considered, we verified that the average cost per slightly injured victim had increased by about 10 thousand euros, suggesting an upward trend in the unit value of the economic and social cost of accidents per slightly injured victim.

From the variance analysis, we verified that the cumulative rate was positive and that it was approximately 59%, translating into an average of about 23.1 thousand euros per slightly injured victim.

7.4 – Econometric Analysis

The purpose of this section is to analyze some of the determinants of the total number of road accident casualties – deaths, serious and minor injuries – and to assess not only the efficacy of these explicative variables but also the effectiveness of road regulation reforms in Portugal over the period between 1988 and 2010.

7.4.1 – Data and explicative variables

In each econometric model the dependent variable shall be the total number of casualties – deaths, serious and minor injuries – whereas the corresponding realizations of the time-series shall contain 270 monthly observations.

The explanatory variables[60] shall be:

a) Time-series realizations (with 270 monthly observations):

- **GAS** – road transport fuel consumption as a proxy of the time of exposure to risk;

[60] The data relative to these time-series were provided by the ANSR.

- **Y_{-1} –** lagged dependent variable;
- **X_{-1} – LnGAS –** lagged;
- **HWY –** number of motorway kilometers (SHWY) as structural change relative to physical driving environment[61]. Roads and highways are variables that relate to the physical driving environment and are one of the factors leading to accidents, combined with human factors, vehicle factors and economic variables.

b) Dummy variables pertaining to the reforms made to the Highway Code (HC) which translate into incentives aimed at the behavior of drivers and other road users so as to increase driving care and minimize social costs. These qualitative variables (found in the models) are as follows:

- **CRIMEALC (D_1) –** dummy variable that represents rules of criminal law referent to the criminal offense of DWI (driving while intoxicated), whose impact is verified prior to an accident (*ex-ante*). It has a value of 1 starting from the second quarter of 1991 onwards and has the value of 0 for all other periods;
- **SL50Km (D_2) –** dummy variable that stands for reforms made to the Highway Code HC, namely, those that enforced a reduction in the speed limit within urban areas (50 kph), with a value of 1 starting from June 1994 onwards and a value of 0 for all other periods;
- **CHILDDEV (D_3) –** dummy variable representing reforms made to the Highway Code HC regarding the mandatory use

[61] We did not consider the number of kilometers of roads in the models due to unavailable data.

of child safety vehicle restraints, with a value of 1 starting from July 1995 onwards and a value of 0 for all other periods;

- **INCRSANCTIP (D_4)** – dummy variable that symbolizes reforms made to the Highway Code HC regarding increased monetary sanctions and mandatory immediate payment of traffic offenses;
- **ZT (D_5)** – "Zero Tolerance"; dummy variable which stands for the strict law enforcement on certain stretches of roads, with a value of 1 starting from the third quarter of 1998 onwards and with a value of 0 for all other periods.

c) The models also contain a dummy variable that represents the structural change referent to the current economic and social crisis verified in Portugal:

- **CRISIS (D_6)** – dummy variable (structural change) representing the economic and social crisis witnessed in Portugal since 2007, with a value of 1 starting from January 2007 onwards and with a value of 0 for all other periods.

7.4.2 – Time-series tests performed

To obtain the functional form of our econometric modeling, we used the J. MacKinnon, H. White and R. Davidson test (MWD), having concluded that the *log-linear* functional form is the most adequate form of linear regression because it is the best at portraying the relationships between the dependent variable and the explanatory variables, reason for which we used the log-linear form in our econometric analyses.

To verify trend and seasonality in time-series we used the Ljung-Box tests. Our findings pointed towards seasonality in the time-series. We conducted a seasonal-trend decomposition of the time-series through the Census II method which gave us adjusted time-series. The seasonal adjustment of the time-series indicated that the first differences remove non-stationarity of the adjusted series, which are integrals of order (1).

The time-series of first differences are apparently stationary, I (0). For this purpose we performed the Dickey-Fuller[62] tests which corroborated our finding. We also carried out the co-integration Engle-Granger tests whose results indicated that the series were co-integrated.

Since non-equilibrium is present in many economic processes, dynamic models – with some metric variable lags – allow for the adjustment of non-equilibrium. Introducing lagged variables is statistically correct because it assists in avoiding omitted variable bias which results from the incorrect exclusion of dynamic processes of adjustment and from the dismissal of individual behavior outside equilibrium. Therefore, dynamic autoregressive distributed lag models (ADL) were estimated.

[62] Cf. Dickey (1979).

7.4.3 – Econometric models pertaining to the total number of road accident victims (Fatal, Seriously and Slightly Injured)

The purpose of this section is to analyze which factors influence the total number of victims – deaths, serious and minor injuries.

7.4.3.1 – Total victims

The following chart displays two econometric models estimated for the total number of victims involved in road accidents:

Chart 7.4.3.1.1

Dynamic ADL models (1,1). Regression results.

Dependent Variable/Regressand: Ln TOTAL VICTIMS$_t$

LnTOTAL VICTIMS		(Constant)	LagLn-TVICT	LnGAS (X_1)	LAG-(lnGAS (X_{-1})	LnHWY (X_2)	CRIME-ALC (D_1)	SL50Km (D_2)	CHILD-DEV (D_3)	INCR-SANCIP (D_4)	TZ (D_5)	CRISIS (D_6)
MODEL A	Coef	-1.152	0.612	0.772	-0.257	-1.159	0.109	-0.014	-0.021	-0.045	-0.067	0.016
Log-linear	se	0.976	0.047	0.074	0.085	0.315	0.037	0.032	0.029	0.022	0.026	0.020
N=276	Beta		0.611	0.985	-0.331	-0.642	0.159	-0.034	-0.053	-0.114	-0.175	0.032
	t	-1.180	12.931	10.429	-3.015	-3.685	2.954	-0.441	-0.729	-2.066	-2.548	0.822
	pv	0.239	0.000	0.000	0.003	0.000	0.003	0.659	0.467	0.040	0.011	0.412
MODEL B	Coef	-0.231	0.614	0.738	-0.294	-1.192	0.114			-0.033	-0.060	
Log-linear	se	0.667	0.047	0.070	0.081	0.246	0.033			0.019	0.024	
N=276	Beta		0.614	0.942	-0.378	-0.660	0.166			-0.082	-0.156	
	t	-0.346	13.101	10.601	-3.631	-4.852	3.493			-1.824	-2.521	
	pv	0.729	0.000	0.000	0.000	0.000	0.001			0.086	0.012	
	R^2	R^{2a}	RSS	F	SE	DW						
MODEL A	0.821	0.815	1.775	121.488	0.08199	2.047						
MODEL B	0.820	0.815	1.788	174.005	0.08182	2.047						

Source: Based on ANSR data.

Overall, Model B is the best specified model in view of the *F* statistic's value.

The results of the dynamic models indicate that the variable representing road transport fuel consumption is significant and that its coefficient of linear regression is positive, indicating that, as a proxy for risk exposure, it contributes towards explaining the variation in the number of accidents.

We also found that highways **(HWY)** contribute towards reducing the total victim toll – given that it (variable) was also significant and its partial regression coefficient was negative. Highways are deemed as safer roads because they reduce the risk of accidents and their effects.

As for the variable that represents the criminal offense of DWI (driving while intoxicated), there is evidence that the change in the corresponding legal sanction had no effect on driver behavior. This variable is significant. Nonetheless its linear regression coefficient is positive, contrary, to what would been expected. This is an indication of a rigid demand for these types of traffic offenses by drivers who usually drive with BAC levels greater than or equal to 1.2 g/l.

Studies in the field of behavioral economics[63] and *neuroeconomics* have shown that drugs – namely alcohol – reduce risk perception[64] and consequently make individuals more risk-seeking[65] when compared to the average person[66], resulting in more accidents.

Increased risk as a result of driving impairment may be compensated with a higher probability of law enforcement – so that effective probability is greater than threshold probability – which may occur with a higher level of enforcement and apprehension.

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[63] Cf. Nestler (2004); Paulus (2007); Shermer (2008).

[64] Peterson (2007), p. 67.

[65] Cf. Lane (2004); Elder (2004).

[66] Cf. Camerer (1989).

If the probability of law enforcement would increase, (provided that exceeds the threshold probability) self compliance is likely to be internalized in the individual, reducing the risk of accidents.

Further, the dummy variable that represents zero tolerance enforcement was also significant and had a negative linear regression coefficient, pointing to the assumption that the increased probability of law enforcement had a decisive impact on reducing accidents.

The dummy variable that represents reforms made to the Highway Code HC regarding increased monetary sanctions and mandatory immediate payment of traffic offenses was also significant and checked in with a negative linear regression coefficient. This means that immediate payment of traffic offenses generates higher probability of law enforcement, making it an effective policy measure.

In contrast, the dummy variable pertaining to the reform made to the Highway Code regarding the reduction of the speed limit in urban areas to 50 kph, was insignificant, suggesting that law enforcement in regards to this variable revealed a low expected sanction.

The dummy variable referent to mandatory use of child vehicle restraints was also not significant.

We also verified that the economic crisis, portrayed by the dummy variable **CRISIS (D_6)** – which is a structural change endured since 2007 – was not statistically significant. Apparently, this is evidence that this structural change does not explain the trend in the total number of accident victims during the period in question.

7.4.3.2 – Econometric models concerning fatalities

The following chart presents two econometric models with regard to fatalities:

Chart 7.4.3.2.1

Dynamic ADL models (1,1). Regression results.

Dependent Variable/Regressand: Ln $FATALITIES_t$

LnFATALITIES		(Constant)	LagLn-FATALITIES (Y_{-1})	LnGAS (X_1)	LAG-(lnGAS (X_{-1})	LnHWY (X_2)	CRIME-ALC (D_1)	SL50Km (D_2)	CHILD-DEV (D_3)	INCR-SANCIP (D_4)	TZ (D_5)	CRISIS (D_6)
MODEL A	Coef	0.023	0.002	0.744	0.095	-3.324	0.230	0.052	-0.026	-0.179	-0.111	-0.163
Log-linear	se	1.774	0.000	0.134	0.145	0.599	0.066	0.058	0.054	0.039	0.047	0.036
N=276	Beta		0.286	0.410	0.053	-0.795	0.144	0.053	-0.027	-0.194	-0.125	-0.141
	t	0.013	5.485	5.536	0.653	-5.548	3.469	0.899	-0.478	-4.592	-2.364	-4.585
	pv	0.990	0.000	0.000	0.514	0.000	0.001	0.369	0.633	0.000	0.019	0.000
MODEL B	Coef	0.024	0.002	0.782		-2.926	0.200			-0.192	-0.121	-0.173
Log-linear	se	1.115	0.000	0.122		0.430	0.057			0.035	0.042	0.034
N=276	Beta		0.297	0.431		-0.700	0.126			-0.208	-0.136	-0.149
	t	0.021	6.170	6.427		-6.811	3.536			-5.553	-2.905	-5.020
	pv	0.983	0.000	0.000		0.000	0.000			0.000	0.004	0.000

	R^2	R^{2a}	RSS	F	SE	DW
MODEL A	0.890	0.886	5.847	214.254	0.14882	1.895
MODEL B	0.890	0.887	5.876	307.828	0.14835	1.895

Source: Based on ANSR data.

The models display global significance. Model B continues to be the better specified model.

As in the previous subsection, the variable representing the number of motorway kilometers was significant and its partial regression coefficient was negative, indicating that these roads contribute towards reducing the number of fatalities.

As for the variable that represents the criminal offense of DWI (driving while intoxicated), it did reveal significance, however its linear regression coefficient[67] was positive, contrary, to what would have been expected. This is an indication of a rigid demand for these types of traffic offenses by drivers who usually drive with BAC levels greater than or equal to 1.2 g/l. For further explanation, see what was said regarding the models on total victims.

The dummy variables pertaining to the mandatory use of child vehicle restraints and the reduction of the speed limit in urban areas to 50 kph, are insignificant in explaining variation in the number of fatalities.

The dummy variable that represents reforms made to the Highway Code HC regarding increased monetary sanctions and mandatory immediate payment of traffic offenses was also significant and checked in with a negative linear regression coefficient. This means that the immediate payment of traffic offenses, when identified by police authorities, is an effective policy measure that increases the probability of law enforcement and contributes towards reducing the road fatality toll.

Similarly, the dummy variable that represents zero tolerance enforcement was also significant and had a negative linear regression coefficient, pointing to the assumption that the increased probability of law enforcement had a decisive impact on reducing accidents.

As for the dummy variable that represents the economic and social crisis endured in recent years (structural change), it did reveal significance and its coefficient of linear regression was negative, indicating that it may have had some effects and can help in explaining the decrease in the number of fatalities.

[67] Standardized linear regression coefficients can be observed, interpreted and rescaled.

7.4.3.3 – Econometric models concerning serious injury

The estimated results regarding seriously injured victims are presented below:

Chart 7.4.3.3.1

Dynamic ADL models (1,1). Regression results.

Dependent Variable/Regressand: Ln SERIOUSLY INJURED$_t$

LnSERIOUSLY INJURED		(Constant)	LagLn-SERIN-JVIC	LnGAS (X_1)	LAG-(lnGAS (X_{-1})	LnHWY (X_2)	CRIME-ALC (D_1)	SL50Km (D_2)	CHILD-DEV (D_3)	INCR-SANCIP (D_4)	TZ (D_5)	CRISIS (D_6)
MODEL A	Coef	3.206	0.643	0.726	-0.484	-2.180	0.185	0.091	-0.019	-0.104	-0.056	-0.116
Log-linear	se	1.434	0.046	0.107	0.112	0.474	0.052	0.044	0.042	0.033	0.027	0.036
N=276	Beta		0.641	0.299	-0.201	-0.390	0.087	0.069	-0.015	-0.084	-0.045	-0.075
	t	2.236	14.041	6.781	-4.332	-4.604	3.544	2.049	-0.454	-3.103	-2.044	-3.190
	pv	0.026	0.000	0.000	0.000	0.000	0.000	0.041	0.650	0.002	0.042	0.002
MODEL B	Coef	3.455	0.643	0.718	-0.492	-2.202	0.188	0.084		-0.102	-0.056	-0.117
Log-linear	se	1.323	0.046	0.105	0.110	0.470	0.052	0.041		0.033	0.027	0.036
N=276	Beta		0.641	0.296	-0.204	-0.394	0.089	0.064		-0.082	-0.045	-0.075
	t	2.611	14.059	6.810	-4.480	-4.681	3.658	2.023		-3.076	-2.061	-3.223
	pv	0.010	0.000	0.000	0.000	0.000	0.000	0.044		0.002	0.040	0.001
	R^2	R^{2a}	RSS	F	SE	DW						
MODEL A	0.962	0.961	3.596	673.795	0.11672	2.272						
MODEL B	0.962	0.961	3.599	750.888	0.11654	2.272						

Source: Based on ANSR data.

The models display global significance. Model B remains the best specified model.

As in previous models, the variable representing the number of motorway kilometers was significant and its partial regression coefficient was negative, indicating that these roads contribute towards reducing the number of seriously injured victims, in the same fashion as fatalities.

As for the variable that represents the criminal offense of DWI (driving while intoxicated), it did reveal significance, however its linear regression coefficient was positive, contrary, to what would have been expected. This is an indication of a rigid demand for these types of traffic offenses by drivers who usually drive with BAC levels greater than or equal to 1.2 g/l. For further explanation, see what was said regarding the models on total victims.

Despite being significant, the dummy variables pertaining to the mandatory use of child vehicle restraints and the reduction of the speed limit in urban areas to 50 kph, checked in with positive linear regression coefficients, suggesting that they are not effective policy measures and do not determine the number of seriously injured victims.

Just as in the models pertaining to fatalities, the dummy variable that represents reforms made to the Highway Code HC regarding increased monetary sanctions and mandatory immediate payment of traffic offenses together with the *dummies* that embody zero tolerance enforcement and the economic and social crisis (structural change), were all significant and their partial regression coefficients were all negative. This implies that road policy measures that increase the probability of law enforcement are all effective.

7.4.3.4 – Econometric models concerning minor injury

The following chart depicts the two estimated econometric models with regard to slightly injured victims:

Chart 7.4.3.4.1

Dynamic ADL models (1,1). Regression results.

Dependent Variable/Regressand: Ln SLIGHTLY INJURED$_t$

LnSLIGHTLY INJURED		(Con-stant)	LagLn-SLIGH-INVIC	LnGAS (X_1)	LAG-(lnGAS (X_{-1})	LnHWY (X_2)	CRIME-ALC (D_1)	SL50Km (D_2)	CHILD-DEV (D_3)	INCR-SANCIP (D_4)	TZ (D_5)	CRISIS (D_6)
MODEL A	Coef	-2.003	0.602	0.794	-0.231	-1.039	0.110	-0.027	-0.021	-0.041	-0.062	0.025
Log-linear	se	0.998	0.048	0.076	0.088	0.316	0.038	0.033	0.030	0.022	0.027	0.020
N=276	Beta		0.604	1.221	-0.357	-0.693	0.193	-0.077	-0.063	-0.125	-0.194	0.061
	t	-2.008	12.679	10.503	-2.625	-3.291	2.926	-0.818	-0.704	-1.854	-2.317	1.270
	pv	0.046	0.000	0.000	0.009	0.001	0.004	0.414	0.482	0.065	0.021	0.205
MODEL B	Coef	-0.871	0.626	0.763	-0.282	-1.203	0.127				-0.049	
Log-linear	se	0.665	0.046	0.070	0.083	0.211	0.031				0.024	
N=276	Beta		0.627	1.174	-0.437	-0.803	0.224				-0.153	
	t	-1.310	13.745	10.936	-3.414	-5.691	4.100				-2.030	
	pv	0.191	0.000	0.000	0.001	0.000	0.000				0.043	
	R^2	R^{2a}	RSS	F	SE	DW						
MODEL A	0.730	0.720	1.849	71.283	0.08369	2.048						
MODEL B	0.725	0.718	1.885	117.505	0.08386	2.048						

Source: Based on ANSR data.

The models display global significance. Model B remains the best specified model.

In this model, the variable representing the number of motorway kilometers was significant – as in all other models analyzed – and continues to be an important factor in reducing the number of minor injury and accidents.

Likewise, the dummy variable *zero tolerance* was significant, with a negative linear regression coefficient, suggesting, as in all other models, that increased probability of law enforcement is effective.

In contrast, the variables that represent reforms made to the Highway Code HC regarding increased fines and mandatory immediate payment of traffic offenses, mandatory use of child vehicle restraints, the reduction of the speed limit in urban areas to 50 kph and the economic and social crisis, were all insignificant.

7.4.4 – Analysis of covariance for independent sets of variables

Covariance analysis aims to assess the strength or degree of each independent variable (IV) or sets of variables, in explaining the variance of the dependent variable / regressand (DV) and represented as Y in each model.

In this analysis we considered two Sets/Groups of explanatory variables, A and B, and we partialled out (i.e. kept constant or statistically controlled) the effects of the variables contained in Set A upon the variance of the regressand – in each model – in order to determine which part of the dependent variable's variance is only explained by Set B's independent variables. Set B is a *research factor* whose variance in the dependent variable is assumed to be zero because of the *null hypothesis*.

7.4.4.1 – Covariance analysis of the total number of victims

Let's take an in-depth look into the covariance analysis of the explained variable (total number of victims):

Chart 7.4.4.1.1

Covariance analysis of independent sets of variables – Total number of Victims

(a)	(b)	(c)	(d)	(e)	(f)	(g)
TESTS	SET B	K_B	SET A	K_A	$R^2_{.AB}$	$R^2_{.A}$
1	X_2, D_4, D_5, D_6	4	$Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3$	6	0.830	0.78
2	D_4, D_5, D_6	3	$Y_{-1}, X_1, X_{-1}, X_2, D_1, D_2, D_3$	7	0.830	0.82
TESTS	SET B	$R^2_{(AB-A)}$	ERROR	Source of error		F Test
			$1-R^2_{AB}$	gl (k_B)	df ($n-k_A-k_B-1$)	
1	X_2, D_4, D_5, D_6	0.05	0.17	4	265	168.149
2	D_4, D_5, D_6	0.02	0.17	3	265	168.149
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Partial Correlation (pR^2_B)		
				$pR^2_B = (R^2_{AB} - R^2_A)/(1-R^2_{AB})$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.29		
2	D_4, D_5, D_6	2.64	3.85	0.09		
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Semi Partial Correlation (sR^2_B)		
				$sR^2_B = R^2_{AB} - R^2_A$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.05		
2	D_4, D_5, D_6	2.64	3.85	0.02		

Source: Based on ANSR data.

KEY (applied in all models):

- **Y** – dependent variable (regressand) in each model;
- **Y_{-1}** – lagged dependent variable;
- **X_1 – LnGAS** – road transport fuel consumption as a proxy of the time of exposure to risk (in logs);
- **X_{-1} – LnGAS** – lagged;
- **X_2 – LnHWY** – number of motorway kilometers (in logs);
- **D_1 – CRIMEALC** – dummy variable that represents rules of criminal law referent to the criminal offense of DWI (driving while intoxicated);
- **D_2 – SL50Km** – dummy variable that stands for reforms made to the Highway Code HC, namely, those that enforced a reduction in the speed limit within urban areas (50 kph);
- **D_3 – CHILDDEV** – dummy variable representing reforms made to the Highway Code HC regarding the mandatory use of child safety vehicle restraints,;
- **D_4 – INCRSANCTIP** – dummy variable that symbolizes reforms made to the Highway Code HC regarding increased monetary sanctions and mandatory immediate payment of traffic offenses;
- **D_5 – ZT** – "Zero Tolerance"; dummy variable which stands for the strict law enforcement on certain stretches of roads,
- **D_6 – CRISIS** – dummy variable (structural change) representing the economic and social crisis witnessed in Portugal since 2007.

Is it should be pointed out that each of the independent variable Sets, A and B, co-vary with Y but also between themselves.

The decision to include the explanatory variables, X_2, D_4, D_5, in Set B, was based on our belief that such factors have a positive impact in reducing the number of accident victims. The two dummy variables, D_4 and D_5, are summed up as policies that result in increased probability of law enforcement which, according to recent studies[68], have been proven to be effective and are consistent with the theory of threshold probability.

Just as the econometric models pointed out, the variables referent to the maximum speed limit of 50 kph in urban areas (D_2), the mandatory use of child vehicle restraints (D_3) and the variable that represents the economic crisis (D_6) do not display significance and do not provide any explanation of variance in the number of total accident victims[69] (explained variable, Y).

As observed in test 1, Set A (partialled) comprised of six independent variables – predictors (**Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3,**) is responsible for 78% of the variance in the number of total accident victims.

The further increment in explained variance caused by the independent variables (predictors) – X_2, D_4, D_5, D_6 contained in Set B is 5%, as shown in the chart above (square of semi partial correlation. The variance that exists between the variables of Set B and Set A was removed, maintaining the explained variable constant. Only Set B is residualized. The square of the semi partial correlation can be interpreted as the proportion or percentage of the criterion variance – dependent variable (total victims) associated uniquely with Set B (predictor).

However, Set B with its explanatory variables, is responsible for 29% of the variance in the total number of accident victims, unexplained by the other variables in the models, as shown in the chart above (square of partial correlation). The portion of variance associated between Set B and Set A and/or between Y and Set A, was removed, contrary to semi partial

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[68] Cf. Donário (2010a).

[69] Some of the tests conducted are not explained in the text.

correlation. With this, we are able to explain part of the variance in total victims that is not explained by the variables of Set A.

In test 2 we included only three dummy variables in Set B, D_4, D_5 and D_6. The square of the semi partial correlation is 2% and the square of partial correlation is 9%, revealing the importance of law enforcement.

7.4.4.2 – Covariance analysis of the number of fatalities

In the following chart we can observe the results of the covariance analysis with respect to fatalities:

Chart 7.4.4.2.1

Covariance analysis of independent sets of variables – Fatalities

(a)	(b)	(c)	(d)	(e)	(f)	(g)
TESTS	SET B	K_B	SET A	K_A	$R^2_{.AB}$	$R^2_{.A}$
1	X_2, D_4, D_5, D_6	4	$Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3$	6	0.890	0.800
2	D_4, D_5, D_6	3	$Y_{-1}, X_1, X_{-1}, X_2, D_1, D_2, D_3$	7	0.890	0.870
TESTS	SET B	$R^2_{(AB-A)}$	ERROR	Source of error		F Test
			$1-R^2_{AB}$	gl (k_B)	df ($n-k_A-k_B-1$)	
1	X_2, D_4, D_5, D_6	0.090	0.110	4	265	384.24
2	D_4, D_5, D_6	0.020	0.110	3	265	447.00
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Partial Correlation (pR^2_B)		
				$pR^2_B = (R^2_{AB} - R^2_A)/(1-R^2_{AB})$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.82		
2	D_4, D_5, D_6	2.64	3.85	0.18		
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Semi Partial Correlation (sR^2_B)		
				$sR^2_B = R^2_{AB} - R^2_A$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.090		
2	D_4, D_5, D_6	2.64	3.85	0.020		

Source: Based on ANSR data.

In the models relative to road accident fatalities, we included three dummy variables in Set B and in tests 1 and 2. Note, the variable that represents CRISIS (D_6) is significant in explaining the variation in the number of fatalities.

Just as the econometric models pointed out, road safety policy measures such as those pertaining to the maximum speed limit of 50 kph in urban areas (D_2) and the mandatory use of child vehicle restraints (D_3) did not prove to be significant and do not provide any explanation of variance in the number of fatalities.

As observed in test 1, Set A (partialled) comprised of six independent variables – predictors (**Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3**) is responsible for 80% of the variance in the number of fatalities. The further increment of the variance uniquely explained by the independent variables (predictors) – X_2, D_4, D_5, D_6 contained in Set B is 9%, as shown in the chart above (square of semi partial correlation). In turn, the square of partial correlation is 82% of the variance in the number of fatalities which is not explained by other the variables of the models.

7.4.4.3 – Covariance analysis of the number of seriously injured victims

In the following chart we can observe the results of the covariance analysis with respect to seriously injured victims:

Chart 7.4.4.3.1

Covariance analysis of independent sets of variables – Seriously Injured

(a)	(b)	(c)	(d)	(e)	(f)	(g)
TESTS	SET B	K_B	SET A	K_A	$R^2_{.AB}$	$R^2_{.A}$
1	X_2, D_4, D_5, D_6	4	$Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3$	6	0.963	0.950
2	D_4, D_5, D_6	3	$Y_{-1}, X_1, X_{-1}, X_2, D_1, D_2, D_3$	7	0.963	0.960
TESTS	SET B	$R^2_{(AB-A)}$	ERROR	Source of error		F Test
			$1-R^2_{AB}$	gl (k_B)	df ($n-k_A-k_B-1$)	
1	X_2, D_4, D_5, D_6	0.013	0.037	4	265	869.238
2	D_4, D_5, D_6	0.003	0.037	3	265	971.372
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Partial Correlation (pR^2_B)		
				$pR^2_B = (R^2_{AB} - R^2_A)/(1-R^2_{AB})$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.351		
2	D_4, D_5, D_6	2.64	3.85	0.081		
TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Semi Partial Correlation (sR^2_B)		
				$sR^2_B = R^2_{AB} - R^2_A$		
1	X_2, D_4, D_5, D_6	2.4	3.38	0.013		
2	D_4, D_5, D_6	2.64	3.85	0.003		

Source: Based on ANSR data.

As observed in test 1, Set A (partialled) comprised of six independent variables – predictors (**Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3**) is responsible for 95% of the variance in the number of seriously injured victims. The further increment of the variance uniquely explained by the independent variables (predictors) – X_2, D_4, D_5 and D_6 contained in Set B is 1.3%, as shown in the chart above (square of semi partial correlation). In turn, the square of partial correlation is 35.1% of the variance in the number of seriously injured victims which is not explained by other the variables of the models.

In test 2, the results reveal that the square of semi partial correlation is 0.3% and the square of partial correlation is 8.1%, suggesting that the variables related to higher monetary fines and mandatory immediate payment of traffic offenses (D_4), "Zero Tolerance" (D_5) and CRISIS (D_6), have contributed towards reducing the number of seriously injured victims.

7.4.4.4 – Covariance analysis of the number of slightly injured victims

In the following chart we can observe the results of the covariance analysis with respect to slightly injured victims:

Chart 7.4.4.4.1
Covariance analysis of independent sets of variables – Slightly Injured

(a)	(b)	(c)	(d)	(e)	(f)	(g)
TESTS	SET B	K_B	SET A	K_A	$R^2_{.AB}$	$R^2_{.A}$
1	X_2, D_4, D_5, D_6	4	$Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3$	6	0.730	0.683
2	D_4, D_5, D_6	3	$Y_{-1}, X_1, X_{-1}, X_2, D_1, D_2, D_3$	7	0.730	0.720

TESTS	SET B	$R^2_{(AB-A)}$	ERROR	Source of error		F Test
			$1-R^2_{AB}$	gl (k_B)	df ($n-k_A-k_B-1$)	
1	X_2, D_4, D_5, D_6	0.047	0.270	4	265	37.349
2	D_4, D_5, D_6	0.010	0.27	3	265	41.575

TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Partial Correlation (pR^2_B)
				$pR^2_B = (R^2_{AB} - R^2_A)/(1-R^2_{AB})$
1	X_2, D_4, D_5, D_6	2.4	3.38	0.174
2	D_4, D_5, D_6	2.64	3.85	0.037

TESTS	SET B	$F_{0,05}$-critical value	$F_{0,01}$-critical value	Square of Semi Partial Correlation (sR^2_B)
				$sR^2_B = R^2_{AB} - R^2_A$
1	X_2, D_4, D_5, D_6	2.4	3.38	0.047
2	D_4, D_5, D_6	2.64	3.85	0.010

Source: Based on ANSR data.

As observed in test 1, Set A (partialled) comprised of six independent variables – predictors (**Y_{-1}, X_1, X_{-1}, D_1, D_2, D_3**) is responsible for 68.3% of the variance in the number of slightly injured victims. The further increment of the variance uniquely explained by the independent variables (predictors) – X_2, D_4, D_5 and D_6 contained in Set B is 4.7%, as shown in the chart above (square of semi partial correlation). In turn, the square of partial correlation is 17.4% of the variance in the number of slightly injured victims which is not explained by other the variables of the models.

In test 2, the results reveal that the square of semi partial correlation is 1 % and the square of partial correlation is 3.7%, suggesting that the variables related to higher monetary fines and mandatory immediate payment of traffic offenses (D_4), "Zero Tolerance" (D_5) and CRISIS (D_6), have contributed towards reducing the number of slightly injured victims.

VIII
Conclusions

It is estimated that from 1996 to 2010 there was an average annual loss of production in respect to all road accident victims of about 1.010 billion euros, adding up to approximately 15.153 billion euros which represents nearly 40 % of the economic and social cost of road accidents in Portugal in the period analyzed.

8.1 – General Findings

In what pertains to monetary costs (insurer administrative costs, road safety costs, court operating costs, hospital costs, victim transport costs, law enforcement costs, property damages to vehicles, loss adjustment costs, attorney fees, court costs, funeral expenses – direct and indirect) relative to road accidents, it is estimated that the average annual cost was approximately 1.245 billion euros.

The overall value of this cost in the period examined, amounts to approximately 18.683 billion euros, which stands for nearly 50% of the economic and social cost of road accidents in the period analyzed.

As for non-monetary costs (moral damages) relating to road accidents in the period reviewed, we estimate that the average annual value was about

247.5 million euros. The overall value of this cost in the period analyzed, amounts to about 3.712 billion which represents about 10% of the economic and social cost of road accidents in Portugal from 1996 to 2010.

Given that the economic and social cost of road accidents is an aggregate of the components aforementioned, its total value was roughly 37.549 billion euros between 1996 and 2010, representing nearly 1.64% of total production in Portugal over the fifteen years considered. In this context, we estimate an average annual economic and social cost of road accidents in Portugal of about 2.503 billion euros.

Of these 2.503 billion euros, nearly 35% was attributable to fatal road accidents, 20% to serious injury road accidents and the remaining 45% to minor injury road accidents.

Considering the average value of the economic and social cost of road accidents in Portugal for the period under review and bearing in mind; 1) that in 2010 the Portuguese gross domestic product at constant prices of 2006 was approximately 162.033 billion euros and 2) that the average economic and social cost of road accidents estimated in 2010 was about 1.890 billion euros, we conjecture that in 2010, the average economic and social cost ranges from about 1.17% to 1.54% of the Portuguese gross domestic product at constant prices of 2006.

In addition to the value of the average economic and social cost of road accidents in Portugal – considered as a whole – we depicted the average individual cost according to the different categories of victims:

Chart 8.1.1

Average individual cost according to the different categories of victims

	Period 1996 - 2010 (Values in Euros)
Annual Average Economic and Social Cost of Road Accidents in Portugal	**2 503 267 447**
Annual Average Economic and Social Cost per Casualties (Deaths and Injuries)	**44 292**
Annual Average Economic and Social Cost per Fatality	**663 826**
Annual Average Economic and Social Cost per Seriously Injured Victims	**96 126**
Annual Average Economic and Social Cost per Slightly Injured Victims	**23 135**

Our estimates are based on the records provided by ANSR, ECB PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

As stated above, the average economic and social cost of road accidents in Portugal was about 2.503 billion euros, at constant prices of 2006.

By analyzing the average economic and social cost per casualty (deaths and injuries) we verified that it is approximately 44.3 thousand euros in the period under consideration.

When we compare the different categories of victims the values are quite different, namely, the average economic and social cost per fatality ascended to around 663.8 thousand euros in the period under review.

For serious injuries, the average economic and social cost for each seriously injured victim was roughly 96.1 thousand euros.

With respect to minor injuries, the average economic and social cost for each slightly injured victim is about 23.1 thousand euros.

The following chart depicts the values for the different average individual costs for accidents with victims:

Chart 8.1.2

Average individual cost *per accident* with casualties

	Period 1996 - 2010 (Values in Euros)
Annual Average Economic and Social Cost of Road Accidents in Portugal	**2 503 267 447**
Annual Average Economic and Social Cost per Accident with Casualties (Deaths and Injuries)	**60 491**
Annual Average Economic and Social Cost per Accident with Fatalities)	**735 428**
Annual Average Economic and Social Cost per Accident with Seriously Injured Victims)	**121 429**
Annual Average Economic and Social Cost per Accident with Slightly Injured Victims)	**31 944**

Our estimates are based on the records provided by ANSR, ECB PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

As seen above, the average economic and social cost per accident with casualties (again, including all types of victims), amounted to approximately 60.5 thousand euros in the period considered.

When we take a look at the individual differences between fatalities, seriously and slightly injured victims with respect to accidents with casualties, we verify that the values are disparate in relation to the cost per accident with victims, in particular, the average economic and social cost per accident with fatalities ascended to about 735.4 thousand euros in the period under review.

With regard to serious injuries, the average economic and social cost per accident was about 121.4 thousand euros.

As for minor injuries, the average economic and social cost per accident was about 31.9 thousand euros.

8.2 – Specific findings

This study was aimed at estimating the economic and social cost of road accidents in Portugal for a period of fifteen years, having done so through the use of the *ex-post* Human Capital method.

We consider that the estimated costs of road accidents act as limitations upon society keeping it from reaping the gains that result from the reduction in road accidents and their direct and indirect consequences.

An estimated assessment of the economic and social cost of road accidents is necessary – although insufficient – for the enactment of policy measures in the road safety and mobility market so as to minimize these social costs within the limited resources available in society. What is at hand is not the total elimination of accident risk – for it an impossible task – but its minimization.

The greatest difficulty encountered in our study was the process of obtaining data from various sources which often led to delay and the non-disclosure of certain data, chiefly, within the Ministry of Justice.

Despite the limitations on the availability of data referent to the various components that comprise road accident cost, the assessment of such costs was achieved through the use of previous studies, namely, the Portuguese Road Safety Association's (PRP) 1987 Report and the study contained in *Economic Analysis of Social Regulation, Causes, Consequences and Policies of Automotive Accidents* – Donário (2007). The cost components for which data was unavailable are as follows:

- Court administrative costs;
- Attorney Fees;
- Court fees, and
- Funeral Expenses.

Thus, the estimated costs of these components should be deemed as preliminary and ought to be further investigated and researched using data recorded by the various competent institutions.

In effect, to better estimate the economic and social costs of accidents (both monetary and non-monetary) it is necessary that we have more viable information as well as other data that was not made available to us in this study. It is imperative that there be more coordination and organization regarding statistical records of all information pertaining to road accidents.

8.2.1 Evolution of the costs implied in the loss of potential production of total accident victims

When we consider the value of lost potential production generated by each of the three categories of accident victims in the period between 1996 and 2010, we obtain the overall value of potential production loss generated by the total number of casualties in the period under review.

The overall value of potential production loss with the total number of victims represents about 40% of the total value of the economic and social cost of road accidents in Portugal during the period covered by the time-series (1996-2010).

The variance rate of the total number of accident victims throughout the period from 1998 until 2008 was always negative, except in 1998, 2009 and 2010, having checked in with an accumulated variance rate of nearly - 36%. This indicates a positive trend in the sense of a fewer accident victims and lower social cost.

The variance rate of costs pertaining to the estimated lost production with of the total number of victims was always negative, having checked in with an accumulated rate of variance of - 97%.

Since this rubric is an aggregate of the three components mentioned below, once again we verified that there is a high correlation between the two sets of variance rates thus indicating colinearity between them, whereby the reduction in the total number of accident victims tends to have a proportional effect on the cost reduction of lost production.

In 1996, the estimated value of lost production was about 1.522 billion euros (at constant prices of 2006) whereas by the end of that same period it was about 540 million euros, that is, nearly 2.82 times less than the value recorded at the beginning of the period. Over the fifteen years considered, the total value of estimated lost production with total number of accident victims was about 15.153 billion euros (see Appendix 6).

8.2.2 – Evolution of the costs implied in the loss of potential production of fatalities

Regarding the assessment of lost potential production with fatalities, we estimated the median age of such victims by taking into account the data provided by ANSR per age group and the average life expectancy in Portugal.

These costs are the bulk of the total value of lost production in each year of the time-series analyzed (1996-2010). The variance rate of the number of fatalities throughout the period was always negative, except in 2002, 2007 and 2010, having registered an accumulated variance rate of about - 97%. This indicates a positive trend in the sense of fewer fatalities and lower social cost.

The variance rate of costs pertaining to the estimated lost production with fatal victims was negative, except in 1998, 2002 and 2007, having checked in with an accumulated rate of variance of 93%.

Similarity between the two sets of variance rates reveals high correlation between them, whereby the reduction in the number of road accident fatalities tends to have a proportional effect on the cost reduction of lost production.

In 1996, the estimated value of lost production was about 1.055 billion euros (at constant prices of 2006) whereas by the end of that same period it was about 382 million euros, i.e., nearly 2.76 times less than the value recorded at the beginning of the period. Over the fifteen years considered, the total value of estimated lost production with road accident fatalities was about 11.088 billion euros (see Appendix 3).

8.2.3 – Evolution of the costs implied in the loss of potential production of seriously injured victims

Regarding the assessment of lost potential production with seriously injured victims, we estimated the median age of such victims by taking into account the data provided by ANSR per age group and the average life expectancy in Portugal.

These costs represent about one-fifth of the total value of lost production in each year of the time-series analyzed (1996-2010). The variance rate of the number of serious accident injuries throughout the period was always negative, except in 2009 and 2010, having registered an accumulated variance rate of about -132%. This indicates a positive trend in the sense of fewer seriously injured victims and lower social cost.

The variance rate of costs pertaining to the estimated lost production with seriously injured victims was negative, except in 2009 and 2010, having checked in with an accumulated rate of variance of about - 128%.

Similarity between the two sets of variance rates reveals high correlation between them, whereby the reduction in the number of seriously injured road accident victims tends to have a proportional effect on the cost reduction of lost production.

In 1996, the estimated value of lost production was about 397 million euros (at constant prices of 2006) whereas by the end of that same period it was about 100 million euros, i.e., nearly 3.97 times less than the value recorded at the beginning of the period. Over the fifteen years considered, the total value of estimated lost production with seriously injured road accident victims was about 3.039 billion euros (see Appendix 4).

8.2.4 – Evolution of the costs implied in the loss of potential production of slightly injured victims

In assessing the loss of potential production with slightly injured victims, we estimated the median age of such victims by taking into account the data provided by ANSR per age group and the average life expectancy in Portugal, just as was done for other categories of victims.

These costs represent about 7% of the total value of lost production in each year of the time-series analyzed (1996-2010). The variance rate of the number of minor accident injuries throughout the period was negative from 1998 to 2008 (except from 1997 to 1998 and from 2009 to 2010), having registered an accumulated variance rate of about - 23%. This indicates a positive trend in the sense of fewer slightly injured victims and lower social cost, albeit, this decrease was not as sharp as that seen in relation to fatalities and serious injury.

The variance rate of costs pertaining to the estimated lost production with slightly injured victims fluctuated although with a negative trend, having checked in with an accumulated rate of variance of about - 17%.

Again there is similarity between the two sets of variance rates, thus revealing high correlation between them, whereby the reduction in the number of slightly injured road accident victims tends to have a proportional effect on the cost reduction of lost production.

In 1996, the estimated value of lost production was about 70.5 million euros (at constant prices of 2006) whereas by the end of that same period it was about 58.7 million euros, that is, nearly 1.2 times less than the value recorded at the beginning of the period.

Over the fifteen years considered, the total value of estimated lost production with slightly injured road accident victims was about 1.026 billion euros (see Appendix 5).

8.2.5 – Evolution of the economic and social cost of road accidents

The economic and social cost of road accidents in Portugal reflects the sum of several cost components in the period ranging from 1996 to 2010, which include the overall value of lost potential production of total victims, insurer administrative costs, road safety costs, court operating costs, hospital costs, victim transport costs, law enforcement costs, property damages to vehicles, loss adjustment costs, attorney fees, court costs, funeral expenses and non-monetary costs or moral damages to road crash victims (and their families).

The value of the economic and social cost of road accidents in Portugal represents about 1.64% of the Portuguese gross domestic product at constant prices of 2006, during the period covered by the time-series (1996-2010).

The variance rate of the total number of accidents with victims throughout the period was negative (except for 1997 and 2009) and the accumulated rate of variance was -32%, indicating a positive trend in the sense of fewer accident victims and lower social cost.

The variance rate of the economic and social cost of road accidents in Portugal in the period considered tended to be negative (except for 2001 and 2009), having checked in with an accumulated rate of variance of about - 46%.

Since this rubric is an aggregate of the various components aforementioned, we verified that there is a correlation between the two sets of variance rates thus indicating colinearity between them, whereby the reduction in the number of accidents with victims tends to have a proportional effect on the reduction of economic and social costs of road accidents.

In 1996, the estimated value of economic and social cost of road accidents was approximately 3.085 billion euros (at constant prices of 2006) whereas by the end of that same period it was about 1.890 billion euros, that is, nearly 1.63 times greater than the value recorded at the beginning of the period. Over the fifteen years considered, the total value of the average economic and social cost of road accidents in Portugal was nearly 37.549 billion euros (see Appendix 8).

During this period, the accumulated total value of annual economic and social cost of road accidents in Portugal was about 37.549 billion, in which 35% was attributable to fatal road accidents, 20% to serious injury road accidents and the remaining 45% to minor injury road accidents.

8.2.6 – Evolution of the average total cost per accident with victims

The value of the average cost *per accident* with victims is nearly 1.37 times greater than the average cost per victim, indicating that, on average, there is more than victim per crash during the period covered by the time-series (1996-2010).

The variance rate of the average cost per accident with victims in the period reviewed was almost always negative (except in 1999, 2000, 2001 and 2008), having checked in with a cumulative rate of about - 14 %.

In 1996, the estimated average cost per accident with victims was about 62.6 thousand euros (at constant prices of 2006) whereas by the end of that same period it was about 53.3 thousand euros, i.e., nearly 1.17 times greater than the value recorded at the beginning of the period (see Appendix 16).

8.2.7 – Evolution of the average cost per accident with fatalities

The value of the average cost *per accident* with fatalities is nearly 1.11 times greater than the average cost per fatality, signifying that, on average, there is slightly more than one person killed per fatal car crash during the period covered by the time-series (1996-2010).

The variance rate of the average cost per accident with fatalities in the period under review was always positive – though with a downward slope – until 2002, year in which it began to fluctuate between positive and negative values, having checked in with a positive cumulative rate of about 4 % at the end of the period.

At the beginning of the period, the average cost per accident with fatalities was about 655 thousand euros (at constant prices of 2006) and by the end of that same period it was about 686.9 thousand euros, to be exact, nearly 1.03 times greater than the value recorded at the beginning of the period (see Appendix 12).

8.2.8 – Evolution of the average cost per accident with seriously injured victims

The value of the average cost *per accident* with seriously injured victims is roughly 1.26 times greater than the average cost per seriously injured victim, meaning that, on average, there is more than one person seriously injured in motor vehicle accidents of this category during the period covered by the time-series (1996-2010).

The variance rate of the average cost per accident with seriously injured victims in the time frame considered was always positive until 2002, year in which it began to fluctuate between positive and negative values, having checked in with a positive cumulative rate of about 17 % at the end of the period.

At the beginning of the period, the average cost per accident with seriously injured victims was about 107.5 thousand euros (at constant prices of 2006) and by the end of that same period it was about 126 thousand euros, that is to say, nearly 1.17 times greater than the value recorded at the beginning of the period (see Appendix 13).

8.2.9 – Evolution of the average cost per accident with slightly injured victims

The value of the average cost *per accident* with slightly injured victims is about 1.38 times greater than the average cost per slightly injured victim, reflecting a higher toll in relation to the other categories of accident victims. This is consistent with observed reality since minor injuries represent, on average, about 88% of all road accident victims in period analyzed.

The variance rate of the average cost per accident with slightly injured victims in the period considered was always fluctuating between positive and negative values, except for 2001 (year in which the variance rate grew by about 46%) and in the years 2007 and 2008 in which it decreased by about 15% and grew by 12% respectively, having checked in with a positive cumulative rate of about 52 % at the end of the period.

At the beginning of the period, the average cost per accident with slightly injured victims was about 23.5 thousand euros (at constant prices of 2006) and by the end of that same period it was about 35.5 thousand euros, that is, approximately 1.51 times greater than the value recorded at the beginning of the period (see Appendix 14).

8.2.10 – Evolution of the average cost per victim

At the beginning of the period, the average cost per victim was about 44.9 thousand euros (at constant prices of 2006) and by the end of that same period it was about 40 thousand euros, *id est*, roughly 1.12 times less than the value recorded at the beginning of the period.

The variance rate of the average cost per victim in the period under review was almost always negative, except for the years 2000, 2001 (years in which the variance rate grew by about 4% and 17%, respectively) and in 2008 year in which it grew by about 4%, having checked in with a negative cumulative rate of about 9% at the end of the period (see Appendix 15).

8.2.11 – Evolution of the average cost per fatality

At the beginning of the period, the average cost per fatality was about 595.3 thousand euros (at constant prices of 2006) and by the end of that same period it was about 624.8 thousand euros, in other words, 1.05 times greater than the value recorded at the beginning of the period.

The variance rate of the average cost per fatality in the period under analysis was always positive until 2002, year in which it began to fluctuate between positive and negative values, having checked in with a positive cumulative rate of about 6% at the end of the period (See Appendix 9).

8.2.12 – Evolution of the average cost per seriously injured victim

At the beginning of the period, the average cost per seriously injured victim was about 85 thousand euros (at constant 2006 prices) and by the end of that same period it was about 101.7 thousand euros, i.e. nearly 1.2 times greater than the value recorded at the beginning of the period.

The variance rate of the average cost per seriously injured victim during the period reviewed, was always positive until 2002, year in which it began to fluctuate between positive and negative values, having checked in with a positive cumulative rate of about 19% at the end of the period (See Appendix 10).

8.2.13 – Evolution of the average cost per slightly injured victim

At the beginning of the period, the average cost per slightly injured victim was about 16.4 thousand euros (at constant 2006 prices) and by the end of that same period it was about 26.4 thousand euros, that is, approximately 1.61 times greater that the value recorded at the beginning of the period.

The variance rate of the average cost per slightly injured victim in the period considered grew from 1997 to 2001, year in which it began to fluctuate between positive and negative values, having checked in with a positive cumulative rate of about 59% at the end of the period (See Appendix 11).

8.2.14 – Econometric Analysis Findings

Econometric models and covariance analysis showed that the increase in sanction severity, *per se*, in most cases, is not an effective policy in reducing road accidents and their effects – death and injury.

A legal sanction does not constitute in and by itself a behavioral incentive for drivers and other road users. For this we have the *Expected Sanction* – which is the product of the legal sanction weighed by its probability of enforcement and involves police action. The manner in which justice is administered, namely, judicial delay, is also important.

When it comes to road transport, the attitude of individuals towards risk has a great impact on their demeanor. Attitude towards risk can be divided into risk-adversity, risk-seeking and risk-neutrality. Such attitude is taken into account for road safety policy purpose serving as a guideline when choosing on whether to increase sanctions or to increase the probability of enforcement.

Raising the severity of legal sanctions, *per se*, may have deterrent effects on risk-neutral and risk-averse individuals even if the probability of law enforcement is low. Such does not occur in relation to risk-seeking individuals because, to them, the increase in sanction severity with a low probability of law enforcement shall increase traffic law offenses and consequently increase the number of accidents – bearing in mind moral and ethical values.

Moreover, regardless of the severity of legal sanctions and the attitude towards risk, if the effective probability of law enforcement is less than threshold probability *(considering the axiological standards as given)* there will be a tendency to violate road traffic laws.

The econometric model results and the covariance analysis show evidence, that aside from the number of motorway kilometers – which has an impact on reducing the number of road accidents through the substitution effect and its consequences – policy measures that have increased the probability of law enforcement have been proven to be effective in reducing the effects of accidents. Example of these policies, are the reforms made to the Highway Code increasing fines, mandatory immediate payment of traffic offenses and the "Zero Tolerance" policy on certain stretches of roads.

On the other hand, there is evidence that the economic crisis that has affected the country in recent years (at least since 2007) is significant when it comes to explaining the positive evolution of fatalities and seriously injured victims (i.e., the reduction in the death and seriously injured toll). However, the econometric analysis performed eliminates this structural variable in reference to minor injury, apparently suggesting that the variable "economic crisis" did not influence the evolution of minor accident injuries in Portugal in the period under review. In the case of total number of victims, the variable Crisis also does not interfere in the evolution of accident victims when considered conjointly.

However, to fully capture the explanation of an event through models construed for that said purpose, it is necessary to bear in mind the indirect effects that a variable which may not directly appear to contribute to the demarcation of a certain event, but when considered in a composite manner with another variable (or other variables) can increase the explanatory robustness of the model.

In this context, if we were to conjointly consider the variables 1) Crisis; 2) immediate payment of traffic offenses and 3) "zero tolerance" policy, it appears that this Set of variables is significant and explains the evolution of the total number of victims as well as the different categories of road accident victims in Portugal.

IX
Recommendation

Knowing that:

- Mobility is an intrinsic necessity of the individual which is mainly carried out by the means of road transport;
- Road transport allows for greater economic efficiency although it has a negative impact on the environment and on safety;
- Driver behavior can trigger social costs and benefits that affect not only themselves but other citizens;
- A driver seeks to minimize costs and maximize his utility therefore the cost borne by society tends to be, by and large, greater than the cost borne by the individual;
- Since the road safety and mobility market fail to attain efficiency, there is a need for government intervention;
- The enactment and adoption of policy measures requires knowledge of the economic and social magnitude of road accidents;
- A good proxy for this magnitude is the economic and social cost of road accidents;
- This cost can be monetary and non-monetary or moral;

– Monetary costs are categorized as Direct and Indirect;
– Direct monetary costs of road accidents include property damages to vehicles and other public and private property; hospital-related costs with victims; time spent on hospital visits; transport of victims; loss adjustment costs; direct intervention of law enforcement; funeral expenses of victims etc…;
– Indirect monetary costs of road accidents includes the value of lost potential production of fatalities and injured victims; insurer administrative costs; court fees; road safety or deterrence costs; attorney fees; court operating costs, cost of accident risk;
– There are costs associated with negative externalities that affect the environment and should be considered when assessing the economic and social cost of road accidents;
– In pursuance of this study some difficult was encountered during the process of gathering data from various sources which often led to delay and the non-disclosure of certain data, mainly, within the Ministry of Justice.

We recommend:

– **The formation of a permanent inter-ministerial body that will incorporate the existing support structure for mid-term review of the National Road Safety Strategy, supported by the ANSR, to coordinate, organize, obtain and provide – on a regular basis – the necessary data for the assessment of the economic and social cost of road accidents in Portugal.**

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Appendix

Appendix 1

Year	Number of Accidents with Victims	Variance Rate of Accidents with Victims	Number of Accidents with Fatalities	Number of Accidents with Fatalities and/or Injured Victims	Number of Accidents with Seri-ously Injured Victims	Number of Accidents with Slightly Injured Victims	Number of Accidents with Total Injured
1996	49 265	0.019	1 880	10 456	8 576	38 809	47 385
1997	49 417	0.003	1 732	9 178	7 446	40 239	47 685
1998	49 319	-0.002	1 647	8 176	6 529	41 143	47 672
1999	47 966	-0.027	1 582	7 652	6 070	40 314	46 384
2000	44 159	-0.079	1 450	6 898	5 448	37 261	42 709
2001	42 521	-0.037	1 316	5 814	4 498	36 707	41 205
2002	42 219	-0.007	1 323	4 966	3 643	37 253	40 896
2003	41 495	-0.017	1 222	4 894	3 672	36 601	40 273
2004	38 930	-0.062	1 024	4 314	3 290	34 616	37 906
2005	37 066	-0.048	988	4 001	3 013	33 065	36 078
2006	35680	-0.037	786	3 551	2 765	32 129	34 894
2007	35311	-0.010	765	3 224	2 459	32 087	34 546
2008	33613	-0.048	721	2 829	2 108	30 784	32 892
2009	35484	0.056	673	2 777	2 104	32 707	34 811
2010	35426	-0.002	674	2 802	2 128	32 624	34 752

Source: Elaborated by the author with data from ANSR.

Appendix 2

Year	Number of Fatalities	Influence of Fatalities on the Total Injured Victim Toll	Number of Seriously Injured Victims	Influence of Seriously Injured Victims on the Total Injured Victim Toll	Number of Slightly Injured Victims	Influence of Slightly Injured Victims on the Total Injured Victim Toll	Total Number of Injured Victims	Total Number of Accident Victims
1996	2 100	0.031	10 842	0.158	55 785	0.812	66 627	68 727
1997	1 939	0.028	9 335	0.136	57 181	0.835	66 516	68 455
1998	1 865	0.027	8 177	0.119	58 426	0.853	66 603	68 468
1999	1 750	0.026	7 697	0.115	57 630	0.859	65 327	67 077
2000	1 629	0.026	6 918	0.112	53 006	0.861	59 924	61 553
2001	1 466	0.025	5 797	0.099	51 247	0.876	57 044	58 510
2002	1 469	0.025	4 770	0.082	51 815	0.893	56 585	58 054
2003	1 356	0.024	4 659	0.082	50 599	0.894	55 258	56 614
2004	1 135	0.021	4 190	0.079	47 819	0.900	52 009	53 144
2005	1 094	0.022	3 762	0.075	45 487	0.904	49 249	50 343
2006	850	0.018	3 483	0.073	43 654	0.910	47137	47 987
2007	854	0.018	3 116	0.066	43 202	0.916	46318	47 172
2008	776	0.017	2 606	0.058	41 327	0.924	43933	44 709
2009	737	0.016	2624	0.056	43790	0.929	46414	47 151
2010	741	0.016	2 637	0.056	43 924	0.929	46561	47 302

Source: Elaborated by the author with data from ANSR.

Appendix 3

Year	Value of Lost Production of Fatalities (in Euros)	Absolute Losses and Gains of the Value of Lost Production of Fatalities (in Euros)	Variance Rate of the Value of Lost Production of Fatalities	Trend in the Lost Production of Fatalities in % of GDP	Relative Losses and Gains of Lost Production of Fatalities in % of GDP
1996	1 054 911 249	NA	NA	0.0082	NA
1997	1 035 271 775	-19 639 475	-0.019	0.0078	-0.0005
1998	1 056 770 424	21 498 650	0.021	0.0075	-0.0002
1999	1 016 118 775	-40 651 650	-0.038	0.0070	-0.0006
2000	956 333 379	-59 785 396	-0.059	0.0063	-0.0007
2001	871 009 651	-85 323 727	-0.089	0.0056	-0.0007
2002	872 363 727	1 354 076	0.002	0.0056	0.0000
2003	777 798 439	-94 565 288	-0.108	0.0050	-0.0006
2004	669 829 831	-107 968 608	-0.139	0.0043	-0.0008
2005	632 971 243	-36 858 588	-0.055	0.0040	-0.0003
2006	461 224 479	-171 746 764	-0.271	0.0029	-0.0011
2007	483 982 133	22 757 654	0.049	0.0029	0.0001
2008	424 937 740	-59 044 393	-0.122	0.0026	-0.0003
2009	393 040 186	-31 897 554	-0.075	0.0024	-0.0001
2010	381 835 255	-11 204 931	-0.029	0.0024	-0.0001

Source: Elaborated by the author with data from ANSR, ACSS, ECB and PORDATA.

Appendix 4

Year	Value of Lost Production of Seriously Injured Victims (in Euros)	Absolute Losses and Gains of the Value of Lost Production of Seriously Injured Victims (in Euros)	Variance Rate of the Value of Lost Production of Seriously Injured Victims	Trend in the Lost Production of Seriously Injured Victims in % of GDP
1996	396 617 564	NA	NA	0.003
1997	346 458 073	-50 159 491	-0.126	0.003
1998	310 076 712	-36 381 361	-0.105	0.002
1999	295 392 026	-14 684 686	-0.047	0.002
2000	270 059 149	-25 332 876	-0.086	0.002
2001	226 969 062	-43 090 088	-0.160	0.001
2002	185 385 189	-41 583 873	-0.183	0.001
2003	169 045 856	-16 339 333	-0.088	0.001
2004	155 970 935	-13 074 920	-0.077	0.001
2005	137 608 336	-18 362 599	-0.118	0.001
2006	130 472 627	-7 135 709	-0.052	0.001
2007	119 165 718	-11 306 909	-0.087	0.001
2008	96 321 307	-22 844 412	-0.192	0.001
2009	99 184 638	2 863 331	0.030	0.001
2010	99 896 190	711 552	0.007	0.001

Source: Elaborated by the author with data from ANSR, ACSS, ECB and PORDATA.

Appendix 5

Year	Value of Lost Production of Slightly Injured Victims (in Euros)	Absolute Losses and Gains of the Value of Lost Production of Slightly Injured Victims (in Euros)	Variance Rate of the Value of Lost Production of Slightly Injured Victims	Trend in the Lost Production of Slightly Injured Victims in % of GDP
1996	70 517 643	NA	NA	0.0006
1997	75 049 605	4 531 962	0.064	0.0006
1998	80 093 379	5 043 774	0.067	0.0006
1999	80 059 696	-33 683	0.000	0.0005
2000	79 617 731	-441 965	-0.006	0.0005
2001	73 329 631	-6 288 099	-0.079	0.0005
2002	73 607 955	278 323	0.004	0.0005
2003	70 280 695	-3 327 260	-0.045	0.0005
2004	66 535 532	-3 745 163	-0.053	0.0004
2005	62 803 299	-3 732 233	-0.056	0.0004
2006	60 286 102	-2 517 197	-0.040	0.0004
2007	59 990 110	-295 992	-0.005	0.0004
2008	56 923 725	-3 066 385	-0.051	0.0003
2009	58 288 946	1 365 221	0.024	0.0004
2010	58 735 243	446 297	0.008	0.0004

Source: Elaborated by the author with data from ANSR, ACSS, ECB and PORDATA.

Appendix 6

Year	Total Value of Lost Production (Fatalities and Injured Victims) – in Euros	Absolute Losses and Gains of the Value of Lost Production (Fatalities and Injured Victims) – in Euros	Variance Rate of the Value of Lost Production (Fatalities and Injured Victims)	Trend in the Lost Production (Fatalities and Injured Victims) in % of GDP
1996	1 522 046 456	NA	NA	0.012
1997	1 456 779 453	-65 267 003	-0.043	0.011
1998	1 446 940 515	-9 838 938	-0.007	0.010
1999	1 391 570 497	-55 370 019	-0.038	0.010
2000	1 306 010 259	-85 560 238	-0.061	0.009
2001	1 171 308 345	-134 701 914	-0.103	0.008
2002	1 131 356 871	-39 951 474	-0.034	0.007
2003	1 017 124 990	-114 231 881	-0.101	0.007
2004	892 336 298	-124 788 692	-0.123	0.006
2005	833 382 878	-58 953 420	-0.066	0.005
2006	651 983 208	-181 399 670	-0.218	0.004
2007	663 137 961	11 154 752	0.017	0.004
2008	578 182 771	-84 955 190	-0.128	0.004
2009	550 513 770	-27 669 001	-0.048	0.003
2010	540 466 689	-10 047 081	-0.018	0.003

Source: Elaborated by the author with data from ANSR, ACSS, BCE and PORDATA.

Appendix 7 – A

Year	Administrative Costs of Insurers (in Euros)	Road Safety Costs (in Euros)	Court Operating Costs (in Euros)	Hospital Costs with Fatalities and Seriously Injured Victims (in Euros)	Ambulance Fees and Transport Costs of Fatalities (in Euros)	Ambulance Fees and Transport Costs of Total Injured (in Euros)	Total Costs with Law Enforcement (in Euros)
1996	176 326 589	46 481 993	877 525	50 854 318	2 004 614	2 004 614	90 625 429
1997	176 326 589	46 436 150	874 052	50 854 318	2 004 614	2 004 614	90 625 429
1998	176 326 589	46 438 341	874 218	50 854 318	2 004 614	2 004 614	90 625 429
1999	176 326 589	46 203 903	856 457	50 854 318	2 004 614	2 004 614	90 625 429
2000	176 326 589	45 272 891	785 925	50 854 318	2 004 614	2 004 614	90 625 429
2001	182 012 906	44 760 025	747 071	47 765 034	2 004 614	2 004 614	90 888 651
2002	151 781 754	44 683 171	741 249	47 164 702	2 004 614	2 004 614	89 018 041
2003	215 887 976	44 440 475	722 863	42 549 078	2 004 614	2 004 614	88 089 126
2004	201 456 750	43 855 643	678 557	38 979 387	2 004 614	2 004 614	92 209 330
2005	206 368 692	43 383 564	642 793	34 680 537	1 554 880	1 554 880	92 580 414
2006	208 378 205	42 986 485	612 711	33 906 206	1 318 659	1 318 659	94 824 465
2007	217 835 513	42 849 125	602 305	31 576 589	1 387 411	1 387 411	93 912 216
2008	175 932 761	42 434 012	570 857	27 261 606	1 624 810	1 624 810	91 257 889
2009	187 768 155	40 455 985	602 037	27 331 977	1 578 490	1 578 490	87 193 493
2010	187 768 155	31 033 356	603 965	27 331 977	1 578 490	1 578 490	97 160 399

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 7 – B

Year	Costs with property damage to vehicles (in Euros)	Accident Loss Adjust-ment Costs (in Euros)	Attorney Fees (in Euros)	Court Fees (in Euros)	Funeral Expenses (in Euros)	Non-Monetary Damages of Fatalities (in Euros)	Non-Monetary Damages of Seriously Injured Victims (in Euros)	Social and Economic Cost of Automotive Accidents in Portugal (in Euros)
1996	714 632 915	8 825 506	5 977 899	3 510 073	1 361 520	150 303 232	309 714 382	3 085 547 064
1997	714 632 915	8 790 577	5 954 240	3 496 181	1 257 137	138 779 984	266 665 168	2 965 481 422
1998	714 632 915	8 792 247	5 955 371	3 496 845	1 209 159	133 483 584	233 585 547	2 917 224 307
1999	714 632 915	8 613 623	5 834 381	3 425 803	1 134 600	125 252 693	219 873 787	2 839 214 223
2000	714 632 915	7 904 264	5 353 902	3 143 678	1 056 150	116 592 364	197 620 743	2 720 188 654
2001	1 188 190 501	7 513 500	5 089 221	2 988 263	950 471	104 925 970	165 598 070	3 016 747 258
2002	1 183 943 641	7 454 944	5 049 558	2 964 974	952 416	105 140 689	136 260 616	2 910 521 855
2003	1 010 861 405	7 270 028	4 924 306	2 891 430	879 153	97 052 944	133 089 772	2 669 792 773
2004	964 971 812	6 824 431	4 622 484	2 714 207	735 869	81 235 318	119 692 239	2 454 321 555
2005	895 928 210	6 464 744	4 378 852	2 571 153	709 287	77 513 524	106 637 501	2 308 351 907
2006	896 263 866	6 162 200	4 173 926	2 450 825	551 091	59 906 574	98 524 710	2 103 361 790
2007	684 823 975	6 057 543	4 103 037	2 409 201	553 685	60 765 449	88 840 779	1 900 242 202
2008	808 806 110	5 741 259	3 888 805	2 283 409	503 114	55 325 904	74 329 166	1 869 767 284
2009	861 039 570	6 054 846	4 101 211	2 408 129	477 829	52 534 558	74 786 225	1 898 424 764
2010	861 039 570	6 074 237	4 114 345	2 415 841	480 422	52 963 996	75 214 717	1 889 824 649

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 8

Year	Social and Economic Cost of Automotive Accidents in Portugal (in Euros)	Absolute Losses and Gains of the Value of Social and Economic Cost of Automotive Accidents in Portugal (in Euros)	Variance Rate of the Value of Social and Economic Cost of Automotive Accidents in Portugal	Total Social and Economic Cost of Accidents with Victims in Relation to GDP
1996	3 085 547 064	NA	NA	2.41%
1997	2 965 481 422	-120 065 642	-0.039	2.22%
1998	2 917 224 307	-48 257 115	-0.016	2.08%
1999	2 839 214 223	-78 010 084	-0.027	1.94%
2000	2 720 188 654	-119 025 568	-0.042	1.79%
2001	3 016 747 258	296 558 604	0.109	1.95%
2002	2 910 521 855	-106 225 403	-0.035	1.87%
2003	2 669 792 773	-240 729 083	-0.083	1.73%
2004	2 454 321 555	-215 471 218	-0.081	1.57%
2005	2 308 351 907	-145 969 648	-0.059	1.46%
2006	2 103 361 790	-204 990 117	-0.089	1.31%
2007	1 900 242 202	-203 119 588	-0.097	1.15%
2008	1 869 767 284	-30 474 918	-0.016	1.14%
2009	1 898 424 764	28 657 480	0.015	1.18%
2010	1 889 824 649	-8 600 115	-0.005	1.17%

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 9

Year	Average Value of Social and Economic Cost per Fatality (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Fatality (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Fatality
1996	595 332	NA	NA
1997	627 748	32 416	0.054
1998	661 165	33 417	0.053
1999	675 911	14 746	0.022
2000	684 367	8 456	0.013
2001	701 386	17 019	0.025
2002	701 837	452	0.001
2003	679 929	-21 909	-0.031
2004	697 608	17 680	0.026
2005	684 938	-12 671	-0.018
2006	650 810	-34 127	-0.050
2007	672 060	21 249	0.033
2008	656 837	-15 222	-0.023
2009	642 696	-14 141	-0.022
2010	624 766	-17 930	-0.028

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 10

Year	Average Value of Social and Economic Cost per Seriously Injured Victim (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Seriously Injured Victim (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Seriously Injured Victim
1996	84 995	NA	NA
1997	86 283	1 287	0.015
1998	87 752	1 470	0.017
1999	88 879	1 127	0.013
2000	91 484	2 604	0.029
2001	101 411	9 927	0.109
2002	101 869	459	0.005
2003	97 518	-4 352	-0.043
2004	99 292	1 774	0.018
2005	98 386	-905	-0.009
2006	101 290	2 904	0.030
2007	98 693	-2 597	-0.026
2008	100 719	2 026	0.021
2009	101 661	942	0.009
2010	101 653	-8	-0.0001

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 11

Year	Average Value of Social and Economic Cost per Slightly Injured Victim (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Slightly Injured Victim (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Slightly Injured Victim
1996	16 381	NA	NA
1997	16 489	107	0.007
1998	16 544	56	0.003
1999	16 871	327	0.020
2000	18 346	1 476	0.087
2001	27 331	8 985	0.490
2002	26 896	-435	-0.016
2003	25 563	-1 333	-0.050
2004	26 067	504	0.020
2005	26 137	70	0.003
2006	27 429	1 292	0.049
2007	23 582	-3 847	-0.140
2008	26 559	2 977	0.126
2009	26 444	-114	-0.004
2010	26 382	-62	-0.002

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 12

Year	Average number of Fatalities per Accident with Fatalities	Average Social and Economic Cost per Accident with Fatalities (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Accident with Fatalities (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Accident with Fatalities
1996	1.12	664 999	NA	NA
1997	1.12	702 773	37 775	0.057
1998	1.13	748 678	45 904	0.065
1999	1.11	747 689	-988	-0.001
2000	1.12	768 851	21 161	0.028
2001	1.11	781 331	12 480	0.016
2002	1.11	779 289	-2 042	-0.003
2003	1.11	754 487	-24 802	-0.032
2004	1.11	773 228	18 741	0.025
2005	1.11	758 423	-14 805	-0.019
2006	1.08	703 803	-54 620	-0.072
2007	1.12	750 247	46 444	0.066
2008	1.08	706 943	-43 304	-0.058
2009	1.10	703 815	-3 128	-0.004
2010	1.10	686 872	-16 942	-0.024

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 13

Year	Average number of Seriously Injured Victims per Accident with Serious Injury	Average Social and Economic Cost per Accident with Serious Injury (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Accident with Serious Injury (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Accident with Serious Injury
1996	1.26	107 453	NA	NA
1997	1.25	108 172	719	0.007
1998	1.25	109 902	1 730	0.016
1999	1.27	112 703	2 800	0.025
2000	1.27	116 168	3 466	0.031
2001	1.29	130 698	14 529	0.125
2002	1.31	133 384	2 686	0.021
2003	1.27	123 729	-9 654	-0.072
2004	1.27	126 454	2 724	0.022
2005	1.25	122 844	-3 609	-0.029
2006	1.26	127 593	4 749	0.039
2007	1.27	125 062	-2 531	-0.020
2008	1.24	124 514	-549	-0.004
2009	1.25	126 786	2 273	0.018
2010	1.24	125 968	-818	-0.006

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 14

Year	Average number of Slightly Injured Victims per Accident with Minor Injury	Average Social and Economic Cost per Accident with Minor Injury (in Euros)	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Accident with Minor Injury (in Euros)	Variance Rate of the Average Value of Social and Economic Cost per Accident with Minor Injury
1996	1.44	23 547	NA	NA
1997	1.42	23 431	-116	-0.005
1998	1.42	23 494	63	0.003
1999	1.43	24 117	624	0.027
2000	1.42	26 099	1 982	0.082
2001	1.40	38 157	12 058	0.462
2002	1.39	37 409	-748	-0.020
2003	1.38	35 340	-2 069	-0.055
2004	1.38	36 009	670	0.019
2005	1.38	35 956	-53	-0.001
2006	1.36	37 268	1 311	0.036
2007	1.35	31 750	-5 517	-0.148
2008	1.34	35 654	3 904	0.123
2009	1.34	35 405	-249	-0.007
2010	1.35	35 520	115	0.003

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 15

Year	Average Social and Economic Cost per Victim (Fatalities and Injured) – in Euros	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Victim (Fatalities and Injured)- in Euros	Variance Rate of the Average Value of Social and Economic Cost per Victim (Fatalities and Injured)
1996	44 896	NA	NA
1997	43 320	-1 576	-0.035
1998	42 607	-713	-0.016
1999	42 328	-279	-0.007
2000	44 193	1 865	0.044
2001	51 560	7 367	0.167
2002	50 135	-1 425	-0.028
2003	47 158	-2 977	-0.059
2004	46 182	-975	-0.021
2005	45 852	-330	-0.007
2006	43 832	-2 021	-0.044
2007	40 283	-3 549	-0.081
2008	41 821	1 538	0.038
2009	40 263	-1 558	-0.037
2010	39 952	-310	-0.008

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 16

Year	Average Number of Victims (Fatalities and Injured) per Accident with Victims	Average Social and Economic Cost per Accident with Victims (Fatalities and Injured) – in Euros	Absolute Losses and Gains of the Average Value of Social and Economic Cost per Accident with Victims (Fatalities and Injured) – in Euros	Variance Rate of the Average Value of Social and Economic Cost per Accidents with Victims (Fatalities and Injured)
1996	1.40	62 632	NA	NA
1997	1.39	60 009	-2 622	-0.042
1998	1.39	59 150	-859	-0.014
1999	1.40	59 192	42	0.001
2000	1.39	61 600	2 408	0.041
2001	1.38	70 947	9 347	0.152
2002	1.38	68 939	-2 009	-0.028
2003	1.36	64 340	-4 599	-0.067
2004	1.37	63 044	-1 296	-0.020
2005	1.36	62 277	-768	-0.012
2006	1.34	58 951	-3 326	-0.053
2007	1.34	53 814	-5 136	-0.087
2008	1.33	55 626	1 812	0.034
2009	1.33	53 501	-2 125	-0.038
2010	1.34	53 346	-155	-0.003

Source: Elaborated by the author with data from ANSR, ECB, PORDATA, PRP, ISP, ACSS, INEM, GNR, PSP and ITIJ.

Appendix 17

Year	Average Annual Social Cost of Road Accidents with Fatal Victims (In Euros)	Annual Weight of Social Cost of Road Accidents with Fatal Victims
1996	1 250 197 239	41%
1997	1 217 203 441	41%
1998	1 233 072 090	42%
1999	1 182 844 325	42%
2000	1 114 833 343	41%
2001	1 028 231 232	34%
2002	1 030 999 221	35%
2003	921 983 307	35%
2004	791 785 522	32%
2005	749 321 662	32%
2006	553 188 798	26%
2007	573 938 956	30%
2008	509 705 841	27%
2009	473 667 213	25%
2010	462 951 908	24%
Value of the Period 1996-2010	**13 093 924 098**	**35%**
Annual Average	**872 928 273**	**35%**

Source: Elaborated by the author with data from ANSR.

Appendix 18

Year	Average Annual Social Cost of Road Accidents with Seriously Injured Victims (In Euros)	Annual Weight of Social Cost of Road Accidents with Seriously Injured Victims
1996	921 518 835	30%
1997	805 448 157	27%
1998	717 551 494	25%
1999	684 104 314	24%
2000	632 885 172	23%
2001	587 877 957	19%
2002	485 916 347	17%
2003	454 334 263	17%
2004	416 032 370	17%
2005	370 129 330	16%
2006	352 794 520	17%
2007	307 528 248	16%
2008	262 474 940	14%
2009	266 758 689	14%
2010	268 060 232	14%
Value of the Period 1996-2010	**7 533 414 867**	**20%**
Annual Average	**502 227 658**	**20%**

Source: Elaborated by the author with data from ANSR.

Appendix 19

Year	Average Annual Social Cost of Road Accidents with Slightly Injured Victims (In Euros)	Annual Weight of Social Cost of Road Accidents with Slightly Injured Victims
1996	913 830 989	30%
1997	942 829 823	32%
1998	966 600 723	33%
1999	972 265 583	34%
2000	972 470 139	36%
2001	1 400 638 069	46%
2002	1 393 606 287	48%
2003	1 293 475 203	48%
2004	1 246 503 663	51%
2005	1 188 900 916	52%
2006	1 197 378 473	57%
2007	1 018 774 998	54%
2008	1 097 586 503	59%
2009	1 157 998 863	61%
2010	1 158 812 509	61%
Value of the Period 1996-2010	**16 921 672 742**	**45%**
Annual Average	**1 128 111 516**	**45%**

Source: Elaborated by the author with data from ANSR.

Appendix 20

Year	Portuguese GDP at constant prices of 2006 in Euros	Portuguese GDP per capita at constant prices of 2006 in Euros	Portuguese Population
1996	127 964 841 100	12 723	10 057 836
1997	133 573 304 200	13 237	10 091 133
1998	140 318 361 100	13 853	10 129 315
1999	146 039 009 900	14 357	10 171 973
2000	151 773 012 300	14 842	10 225 845
2001	154 758 286 100	15 035	10 292 996
2002	155 857 518 300	15 032	10 368 382
2003	154 406 195 000	14 788	10 441 105
2004	156 811 857 100	14 932	10 501 943
2005	157 998 642 300	14 977	10 549 419
2006	160 273 457 000	15 143	10 584 346
2007	164 663 844 800	15 522	10 608 348
2008	164 090 143 900	15 448	10 622 440
2009	160 577 505 000	15 103	10 632 512
2010	162 032 546 100	15 232	10 637 300

Source: Elaborated by the author with data from Pordata.