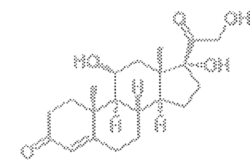
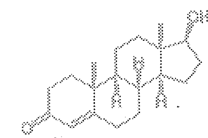
Arlindo Donário

Road Accidents, Risk and Biological Factors

The Portuguese Case





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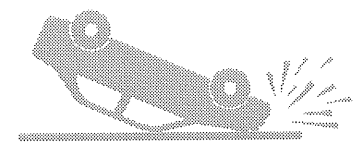

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Preface

A large number of factors influence the number and severity of road accidents. Some of these factors are very basic in their nature, such as biological factors. Analyses pointing to the role of biological factors in contributing to accidents have often been ridiculed. However, there is no reason to doubt the importance of these factors.

This study of risk factors associated with road accidents in Portugal confirms the influence of biological factors. Although these factors are not always measured directly, the pattern of accidents and variation in risk indirectly support their importance. There are, for example, more accidents during those times of the day when people are more likely to be fatigued, such as when they return home after a long working day or when they drive at night. The fragility of old people is shown by the fact that their chances of sustaining fatal injuries are greater than for younger road users.

Perhaps some of the traditional scepticism to assigning biological factors any role in contributing to accidents is that these factors are regarded as impossible to change and accidents related to them therefore regarded as impossible to prevent. It is true that there is very little an individual can do about his or her age and gender and the basic biology associated with age and gender. But it is not true that accidents that have been influenced by biological factors cannot be prevented.

Take fatigue for example. It is natural and normal for people to get tired as the day goes along; the dip in circadian rhythm after lunch is well-known and everybody has experienced it. The potential risk associated with it can be mitigated in many ways. One may postpone trips until the dip is over. Roads may be marked by rumble strips that alert drivers when they veer off course. Cars may be equipped with fatigue detection and warning systems. Training drivers to detect signs of fatigue may help them to pull over and have a short nap before continuing their trip. In short, the mere fact that something is related to our basic nature as animals does not, by itself, place it beyond the realm of accident prevention.

It has to be admitted, however, that some factors may be more difficult to influence than others. It seems clear that high levels of testosterone in young males make them take more risks than any other group of drivers. There is no doubt that this contributes to the very high risk of accident involvement of young male drivers. Despite this, it is probably a bad idea to try to suppress testosterone below its normal level in young males. There is evidence that sexual hormones are related to female accident involvement as well. Again, however, one should probably not try to tamper with nature.

What we need to do, is to better understand the role biological factors play in our lives and accept them as part of our normal human nature. Such an enriched understanding is likely to help in counteracting some of the unwanted effects of biological factors.

Oslo, September 18, 2013

Rune Elvik

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I
Road Accidents and Biological Factors

In Portugal like in many other countries, automotive accidents are the cause of thousands of casualties and the primary source of considerable moral and material damages. The dilemma goes beyond statistical data and numbers, which cannot quantify complex aspects such as pain and suffering and the disability and unanticipated death. As reported by Mohan et al:

"Any road traffic system is highly complex and can be hazardous to human health. Elements of the system include motor vehicles, roads, and road users along with their physical, social and economic environments. Making a road traffic system less hazardous requires a systems approach – understanding the system as a whole and the interaction between its elements, and identifying where there is potential for intervention" (Mohan et al, 2006:25).

1.1 – Automotive Accident Rate and Its Evolution

The main objective of road transport, especially highways, is to make travel and mobility easier. The betterment of road transport and the *technological revolution* of the information and communication sectors in particular the *Internet*, have made it easier and faster to communicate, increasing the number of transactions worldwide between individuals and groups of people, increasing competition and finally contributing towards a more effective global market. It is self-evident that without adequate means of communication the cost of transporting people and goods from place to place would be considerably much higher, affecting negatively those who live in regions that are not easily accessible due to under-development.

It is a fact that every day the number of registered vehicles circulating on Portuguese roads and highways increases, *ceteris paribus*, resulting in a proportional increase of accident risk and accident consequences (death and permanent disability) with high moral and material costs for society. On the other hand, these costs will provide a social benefit consisting in the utility that society as a whole gains from the use of a network of roads. Social regulation by government intervention in the traffic safety market is justifiable because of the existence of *market failures*. Government steps in to minimize social costs, moral costs included, with the intention of achieving *efficiency* in the traffic safety market.

Individuals tacitly agree to abide by statutes and regulations in order to make social life and interaction possible, valuing a wide range of factors. In relation to traffic safety, basic standards of conduct are set by legal statutes which generally attribute rights, set obligations and create sanctions for traffic offenses. These statutes are in great part acknowledged, comprehended and abided by both drivers and pedestrians. Statutes generate a certain level of trust[1] for those who drive and use road transport, even much so if statues are accepted and their legal content respected. Reverence for traffic norms will result from their ability to coincide with the standards and expectations set by society. If such con-

1 In fact using road transport namely highways and roads implies a certain level of trust and a belief that traffic will flow and that all drivers will contribute towards achieving this objective. Luhmann describes this as being basic trust: "*Trust, in the broadest sense of confidence in one's expectation, is a basic fact of life. In many situations, of course, man can choose in certain aspects whether or not to bestow trust. But a complete absence of trust would prevent him even from getting up in the morning.(...) He would not even be capable of formulating distrust and making that a basis for precautionary measures, since this would presuppose trust in other directions. Anything and everything would be possible.*" Luhmann, N. *Trust and Power*. NY: Willey, (1980). Reference to: Rothe, J. Peter. *Beyond Traffic Safety*. New Brunswick, NJ (USA): Transaction Publishers, 1994. P.12.

currence were not so, then there would be more tendency to violate traffic safety statutes, breeding social inefficiency translated as greater social costs in relation to social benefits which negatively affect social welfare.

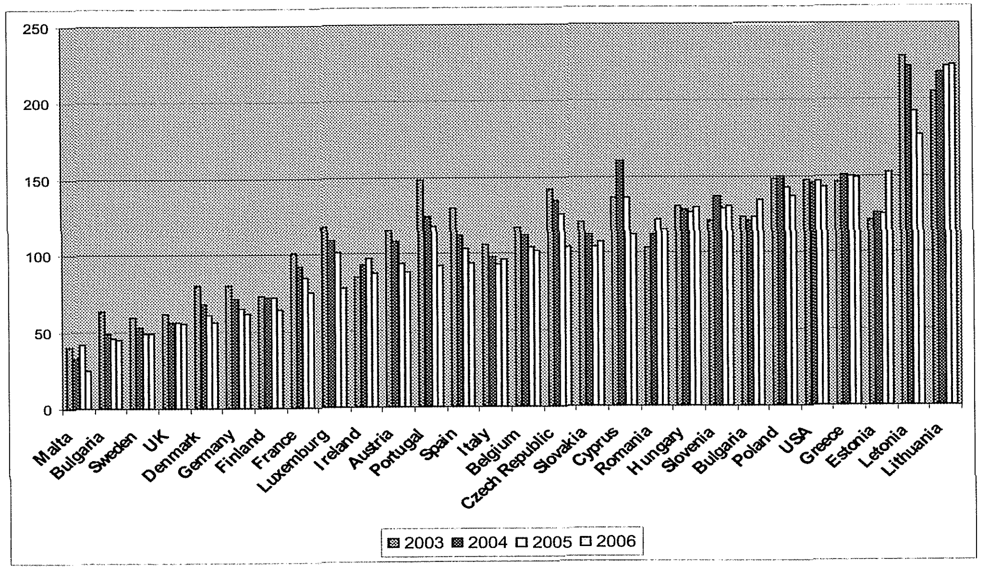
The inexistence of an efficient traffic safety market leads to the necessity of effective measures that will compel individuals who act in such a *market* to interiorize their externalities. Their purpose is to lead individuals to alter their behavior on the road so as to adopt an optimal level of care producing efficiency.

If these measures are applied effectively, driving conduct would be more predictable and traffic safety would tend to increase. On the other hand, if the disrespect for road safety statutes is considerably high, due to low sanction severity or because the probability of enforcement is minute (police law enforcement and courts) their fittingness to regulate the interaction of agents in this field of human activity will diminish and the rate of accidents will expand.

Of the 27 EU countries, Portugal was, about one decade ago, one of the leading members that registered more automotive accidents in relative terms. It is a problem that has been constantly debated due to the social costs that automotive accidents create for Portuguese society. In the following graph one can grasp the magnitude of the dilemma in relative terms, as we analyze the number of fatalities *per* one million inhabitants, registered during 2003-2006, in the 27 European Union countries and the United States of America (USA):

Graph 1.1.1

Fatality rate *per* one million inhabitants in 28 countries. (2003-2006)



Source: CARE: European Road Accident Database, for the European Union member states and NHTSA (U.S. Department of Transportation) 2007, for the USA.

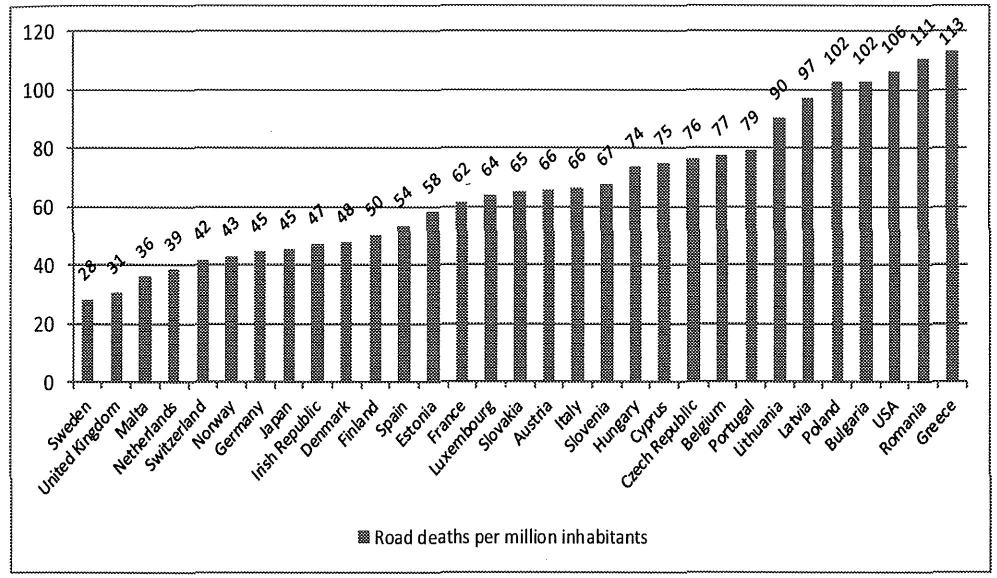
In 2003, USA and Portugal were among the countries with the worst fatality rates registered *per* one million inhabitants, with 148 fatalities. In 2006 the US came in 24th place registering 142 fatalities *per* one million inhabitants, recording a slight decrease, whereas Portugal came in 12th with 92 fatalities, reducing significantly its fatality rate. We therefore can conclude that the trend in the rate of fatalities *per* one million inhabitants in the U.S over the span of 4 years sluggishly decreased, having Portugal recorded a noticeable reduction. In the U.S., in 2010, the rate of deaths per million inhabitants was 106.3[2].

For the year 2010, we illustrate below road fatalities per one million inhabitants in 31 countries; 27 EU member states, Norway, Switzerland, USA and Japan:

[2] Source: NHTSA. Fatality Analysis Reporting System (FARS) Encyclopedia. (http://www.nhtsa.gov/FARS) Consulted in 28 July 2012.

Graph 1.1.2

Fatality rate *per* one million inhabitants in 31 countries. (2010)



Source: International Road Traffic and Accident Database (OECD), ETSC (European Transport Safety Council), EUROSTAT (Statistical Office of the European Union) and CARE (Community Road Accident Database).

In the ranking of 31 countries Portugal occupies the 24th position. By our estimates, in 2010, Portugal had a rate of 92 deaths per million inhabitants in traffic accidents within 30 days from the date of the accident (86 in 2011 and 88 according to data from the National Road Safety Authority), and 73 within the first 24 hours (69 in 2011). See chart 1.1.1.1-B in this section.

As we can observe, there is still potential for considerable improvement of highway safety in Portugal. As reported by Elvik:

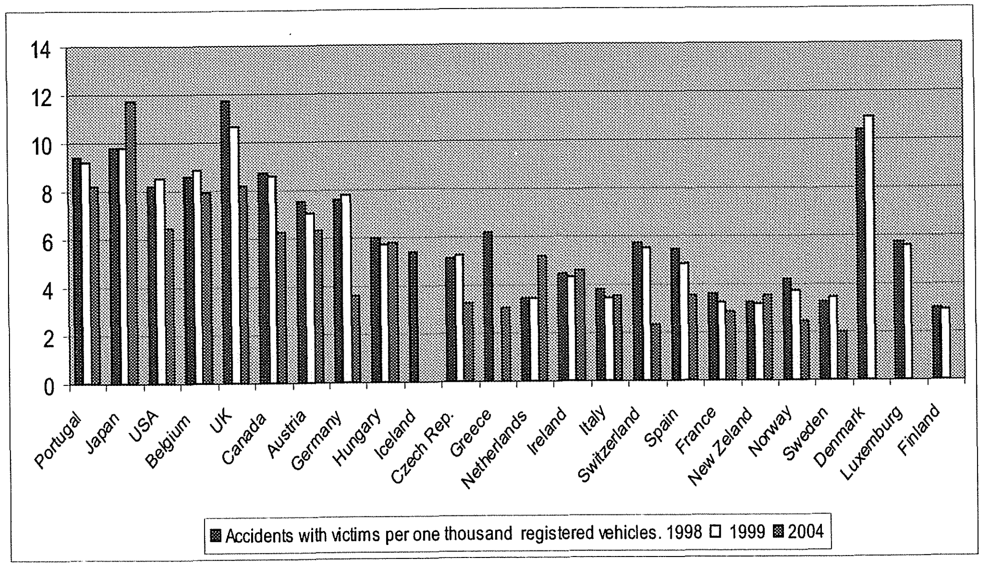
> *"A policy analysis for Norway (Elvik, 2007) indicated that the number of road accident fatalities could be reduced by more than 50% by 2020 if all cost-effective road safety measures are fully implemented. The term "cost-effective" denotes a road safety measure whose benefits,*

according to cost-benefit analysis, are greater than its costs." **(Elvik, Rune, 2011:476).**

We also comparatively analyzed the number of accidents *per* one thousand registered vehicles, in twenty four countries:

Graph 1.1.3

Accidents with victims per one thousand registered vehicles in various countries (1998, 1999, 2004)



Source: ANSR (National Authority for Road Safety)[3]. Adapted.

In 1998 Portugal was one of the leadings frontrunner when it came to accidents with victims *per* one thousand registered vehicles. In 1999 only Japan surpassed Portugal, having recorded more accidents with victims per one thousand registered vehicles. In 2004 Portugal came in 5^{th} trailing behind Japan, US, Austria and Canada.

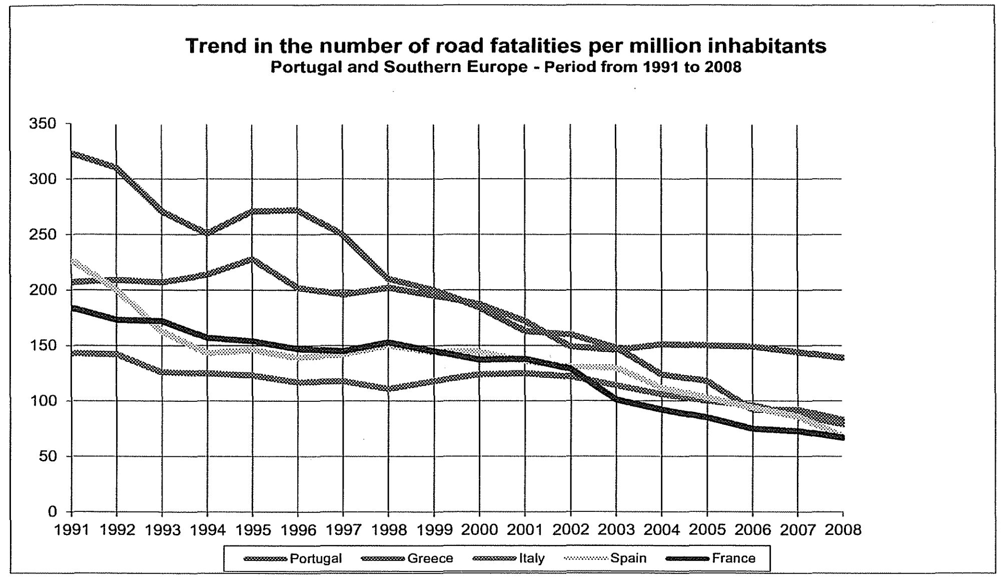
For a more recent overview of the magnitude of the problem in comparative terms (Donário; Arlindo; Santos, Ricardo Borges dos; 2012:15-17),

[3] Autoridade Nacional de Segurança Rodoviária (ANSR).

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 1.1.4

Road fatalities per million inhabitants in five countries: Portugal, Greece, Italy, Spain and France (1991-2008)



Source: Based on Eurostat data

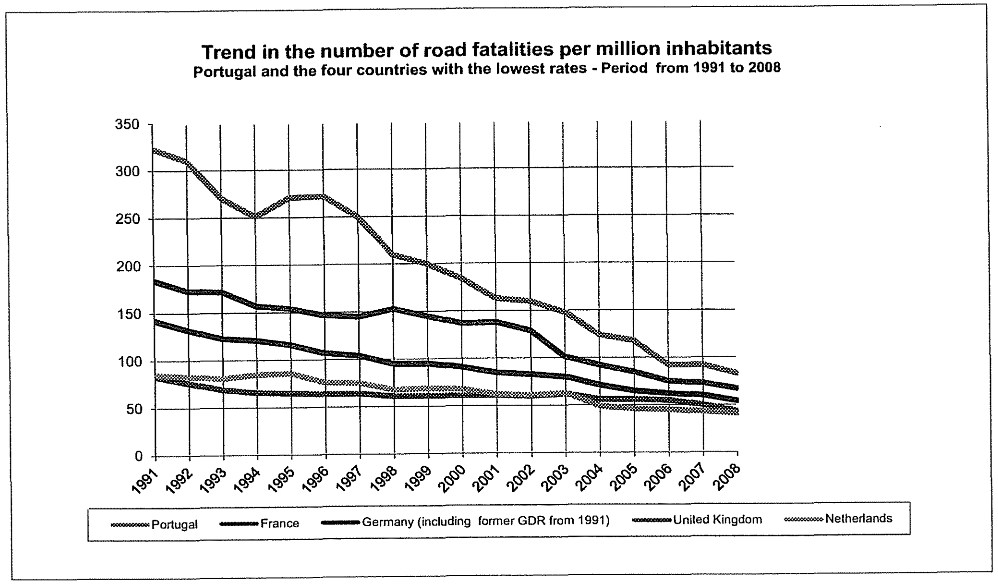
Among the five countries analyzed above, Portugal registered the highest road fatality rate per million inhabitants at the beginning of the period (323 deaths per million inhabitants) reaching a rate of 79 deaths per million inhabitants towards the end of the period (2008), drawing near Italy with a 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 to the four countries with the lowest rates of road fatality per million inhabitants, France, Germany, UK and the Netherlands:

Graph 1.1.5

Road Fatalities per million inhabitants.
Portugal compared to four countries with low rates (1991-2008)

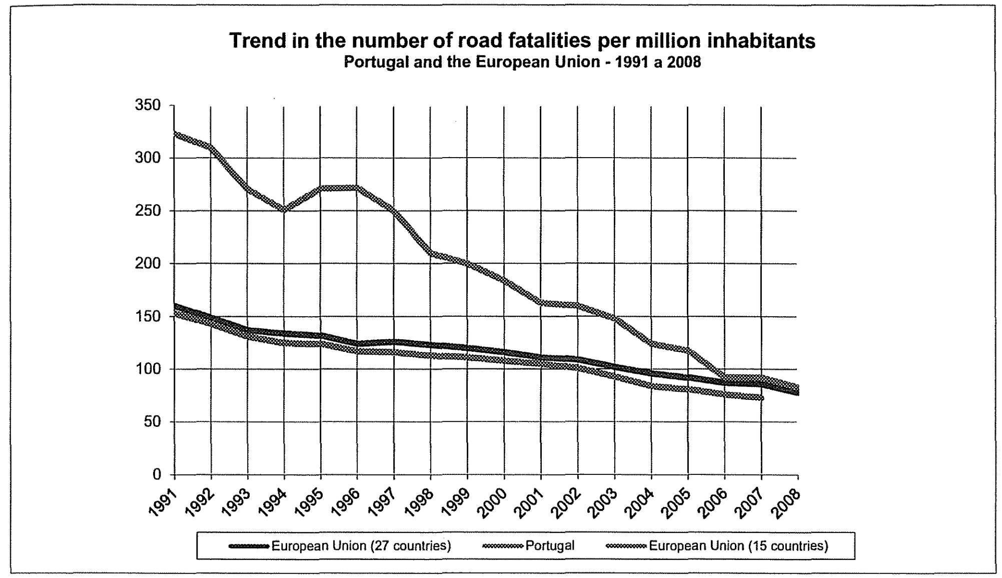


Source: Based on Eurostat data

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. 1.1.5

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.

1.1.1 – Automotive Accidents with Victims in Portugal (Fatalities and Injuries) and Other Data (1959-2011)

The subsequent subsections will break down the numbers into various categories bringing into light interesting findings. The chart and graph below illustrate the trend in the number of automotive accidents with victims (fatalities and injuries), making reference to the severity index[4].

Chart 1.1.1.1-A

Accidents with Victims, Fatalities, Injuries and the Severity Index (1959-2011).

ACCIDENTS WITH VICTIMS , FATALITIES, INJURIES AND THE SEVERITY INDEX 1959-2011

Year	Accidents with victims	Fatalities within the first 24 hours	Fatalities within the first 30 Days	Total Injuries	Seriously Injured (From ANSR)	Slightly Injured	Victims	Severity Index	Fatal drivers	Fatal Pedestrians	Fatal Passengers
1959	18,112	594	748	25,657	na	na	26,251	3.28	163	254	177
1960	18,900	641	808	28,849	na	na	29,490	3.39	177	274	190
1961	20,756	738	930	31,203	na	na	31,941	3.56	205	315	218
1962	20,644	802	1,011	34,355	na	na	35,157	3.88	226	342	233
1963	21,335	789	994	32,557	na	na	33,346	3.70	249	337	203
1964	22,990	904	1,139	30,557	na	na	31,461	3.93	285	386	233
1965	22,735	920	1,159	40,576	na	na	41,496	4.05	279	405	236
1966	23,372	1,030	1,298	36,264	na	na	37,294	4.41	331	438	261
1967	25,600	1,087	1,370	35,047	na	na	36,134	4.25	350	464	273
1968	26,704	1,183	1,491	35,957	na	na	37,140	4.43	385	502	296
1969	28,353	1,284	1,618	37,837	na	na	39,121	4.53	451	493	340
1970	21,082	1,417	1,785	41,101	na	na	42,518	6.72	501	536	380
1971	33,211	1,653	2,083	44,574	na	na	46,227	4.98	597	611	445
1972	35,715	1,695	2,136	47,116	na	na	48,811	4.75	681	644	370
1973	39,521	2,086	2,628	39,545	na	na	41,631	5.28	772	755	559
1974	38,942	1,961	2,471	39,365	na	na	41,326	5.04	735	692	534
1975	33,109	2,676	3,372	40,576	na	na	43,252	8.08	1,030	921	725
1976	30,568	2,594	3,268	36,264	na	na	38,858	8.49	1,016	869	709
1977	30,062	2,153	2,713	35,047	na	na	37,200	7.16	997	702	454
1978	32,637	2,173	2,738	35,957	na	na	38,130	6.66	1,012	689	472
1979	33,331	2,186	2,754	37,837	na	na	40,023	6.56	901	685	600
1980	33,886	2,262	2,850	41,101	na	na	43,363	6.68	1,031	569	662
1981	33,560	2,269	2,859	44,574	na	na	46,843	6.76	1,001	650	618
1982	35,324	2,126	2,679	47,116	na	na	49,242	6.02	1,045	440	641
1983	31,285	2,177	2,743	39,545	na	na	41,722	6.96	1,017	560	600
1984	29,255	1,841	2,320	39,365	na	na	41,206	6.29	823	537	481
1985	29,156	1,875	2,363	39,560	na	na	41,435	6.43	1,052	645	178
1986	30,485	1,982	2,497	41,100	na	na	43,082	6.50	1,212	641	129
1987	38,656	2,296	2,893	54,517	12,364	42,153	56,813	5.94	1,155	601	540
1988	41,915	2,534	3,193	59,532	12,771	46,761	62,066	6.05	1,255	612	667
1989	43,499	2,375	2,993	61,519	12,414	49,105	63,894	5.46	1,224	589	562
1990	45,110	2,321	2,924	63,329	12,165	51,164	65,560	5.15	1,237	613	471
1991	48,953	2,475	3,119	69,535	12,548	56,987	72,010	5.06	1,277	534	664
1992	50,851	2,372	2,989	70,986	12,475	58,511	73,358	4.66	1,309	538	525
1993	48,645	2,077	2,617	66,710	11,830	54,880	68,787	4.27	1,063	434	580
1994	45,830	1,926	2,427	62,163	10,387	51,776	64,089	4.20	1,036	480	410
1995	48,339	2,085	2,627	65,827	11,229	54,598	67,912	4.31	1,139	422	524
1996	49,265	2,100	2,646	66,627	10,842	55,785	68,727	4.26	1,145	356	599
1997	49,417	1,939	2,443	66,516	9,335	57,181	68,455	3.92	1,104	422	413
1998	49,319	1,865	2,350	66,603	8,177	58,426	68,468	3.78	1,070	356	439
1999	47,966	1,750	2,205	65,327	7,697	57,630	67,077	3.65	1,022	348	380
2000	44,159	1,629	2,053	59,924	6,918	53,006	61,553	3.69	916	337	376
2001	42,521	1,466	1,847	57,044	5,797	51,247	58,510	3.45	838	296	332
2002	42,219	1,469	1,851	56,585	4,770	51,815	58,054	3.48	832	297	340
2003	41,495	1,356	1,709	55,258	4,659	50,599	56,614	3.27	836	246	274
2004	38,930	1,135	1,430	52,009	4,190	47,819	53,144	2.90	677	204	254
2005	37,066	1,094	1,378	49,249	3,762	45,487	50,343	2.90	674	188	232
2006	35,680	850	1,071	47,137	3,483	43,654	47,987	2.40	551	137	162
2007	35,311	854	1,076	46,318	3,116	43,202	47,172	2.40	531	137	186
2008	33,613	776	978	43,933	2,606	41,327	44,709	2.40	492	136	148
2009	35,484	737	929	46,414	2624	43790	47,151	2.10	450	130	157
2010	35,426	741	934	46,561	2,637	43,924	47,302	2.10	479	109	153
2011	32,541	689	868	42,162	2436	39726	42,851	2.10	440	117	132

Source: ANSR (National Authority for Road Safety). Adapted.

4 Severity Index is the number of fatalites per one hundred automotive accidents with victims.

Chart 1.1.1.1-B

Accidents per inhabitants, Accident per vehicle, Deaths per one million inhabitants[5]

Year	Population (Country)	Population (Mainland)	Registered Vehicles	Accidents per one hundred thousand inhabitants	Accidents per one thousand registered vehicles	Deaths per one million inhabitants (within the first 24 hours)	Deaths per one milion inhabitants (within the first 30 Days)
1959	8,870,000	8,426,500	259,245	215	70	70	89
1960	8,889,392	8,444,922	280,859	224	67	76	96
1961	8,889,392	8,444,922	305,534	246	68	87	110
1962	8,800,000	8,360,000	329,821	247	63	96	121
1963	8,800,000	8,360,000	354,522	255	60	94	119
1964	8,700,000	8,265,000	379,791	278	61	109	138
1965	8,700,000	8,265,000	422,348	275	54	111	140
1966	8,690,000	8,255,500	468,831	283	50	125	157
1967	8,690,000	8,255,500	517,421	310	49	132	166
1968	8,630,000	8,198,500	572,644	326	47	144	182
1969	8,620,000	8,189,000	699,500	346	41	157	198
1970	8,611,125	8,180,569	555,000	258	38	173	218
1971	8,726,751	8,290,414	619,000	401	54	199	251
1972	8,842,378	8,400,259	690,500	425	52	202	254
1973	8,958,004	8,510,104	757,000	464	52	245	309
1974	9,073,630	8,619,949	843,500	452	46	227	287
1975	9,189,256	8,729,794	911,000	379	36	307	386
1976	9,304,883	8,839,639	993,000	346	31	293	370
1977	9,420,509	8,949,483	1,060,500	336	28	241	303
1978	9,536,135	9,059,328	1,102,500	360	30	240	302
1979	9,651,761	9,169,173	1,145,000	364	29	238	300
1980	9,767,388	9,279,018	1,205,000	365	28	244	307
1981	9,833,014	9,388,863	1,288,000	357	26	242	305
1982	9,881,427	9,387,356	1,371,000	376	26	226	285
1983	9,879,841	9,385,849	1,433,000	333	22	232	292
1984	9,878,254	9,384,341	1,482,000	312	20	196	247
1985	9,876,667	9,382,834	1,541,000	311	19	200	252
1986	9,875,081	9,381,326	1,605,000	325	19	211	266
1987	9,873,494	9,379,819	1,683,000	412	23	245	308
1988	9,871,907	9,378,312	1,849,000	447	23	270	340
1989	9,870,320	9,376,804	1,908,000	464	23	253	319
1990	9,868,734	9,375,297	2,198,000	481	21	248	312
1991	9,867,147	9,471,980	2,444,100	517	20	261	329
1992	9,916,044	9,482,261	2,707,300	536	19	250	315
1993	9,964,941	9,499,263	2,965,000	512	16	219	275
1994	10,013,838	9,528,599	3,236,900	481	14	202	255
1995	10,062,735	9,556,916	3,434,400	506	14	218	275
1996	10,111,632	9,589,006	3,675,900	514	13	219	276
1997	10,160,529	9,628,374	3,944,300	513	13	201	254
1998	10,209,426	9,669,603	4,236,000	510	12	193	243
1999	10,258,323	9,717,347	4,535,000	494	11	180	227
2000	10,307,220	9,779,845	4,750,000	452	9	167	210
2001	10,356,117	9,851,424	4,957,000	432	9	149	188
2002	10,376,667	9,927,441	5,138,000	425	8	148	186
2003	10,397,216	9,991,654	5,241,100	415	8	136	171
2004	10,417,766	10,043,763	5,405,700	388	7	113	142
2005	10,438,316	10,082,154	5,523,270	368	7	109	137
2006	10,458,866	10,110,271	5,625,000	353	6	84	106
2007	10,479,415	10,126,880	5,727,100	349	6	84	106
2008	10,499,965	10,135,309	5,757,400	332	6	77	96
2009	10,520,515	10,144,940	5,809,500	350	6	73	92
2010	10,541,064	10,143,600	5,832,600	349	6	73	92
2011	10,561,614	10,047,083		324		69	86

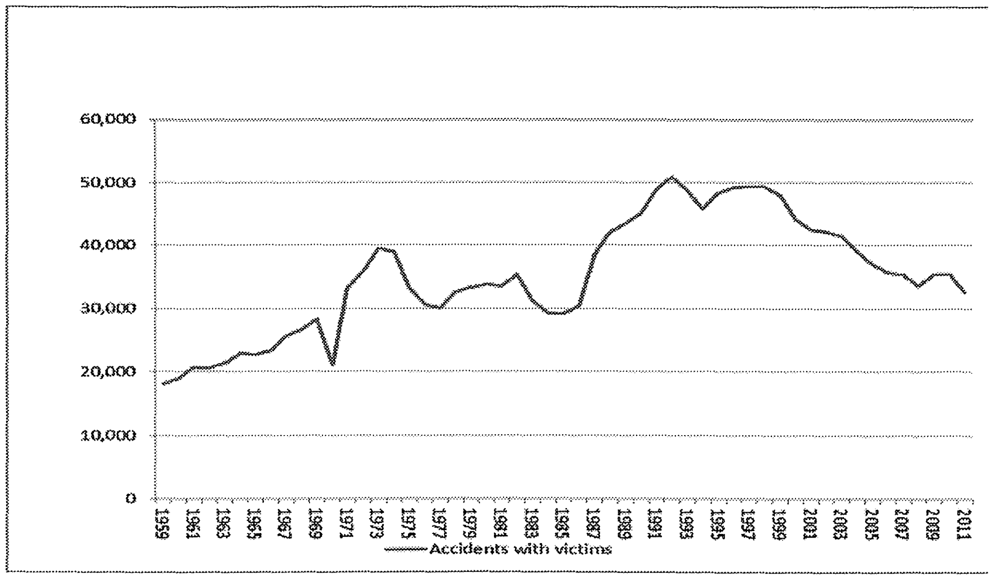
Source: ANSR (National Authority for Road Safety). Adapted.

5 We use the population of mainland Portugal, since the number of accidents used refers to the continental Portugal without considering the Azores and the Madeira islands.

It is important to note that the statistical data used in our chart regarding automotive crashes draws specific attention to registered accidents with victims. Many accidents, especially those resulting in material damages, are left unregistered by law enforcement officials and never make it to the records. These accidents are not accounted for because parties choose not to involve police officials, resolving their conflicts on their own. In these cases, a private transaction between both parties is verified because the *expected utility* obtained from cordial agreements is much greater than that provided by other alternatives. Preference for this form of conflict resolution in cases where traffic *offenses* are much *severe*[6] will depend on the expected benefit that the parties involved gain from such amicable agreements. Graph 1.1.1.1 below displays the progression of accidents with victims from 1959 to 2011:

Graph 1.1.1.1

Evolution of the number of accidents with victims (1959-2011)



Source: Chart 1.1.1.1 – A

6 Traffic offenses are classified in more detail in the Portuguese Transportation Code of Rules and Regulations (PTCRR).

The number of accidents with victims during the time period considered in our graph grew with some fluctuations having decreased from 1998 onward[7]. To be more precise, a constant upward slope was evident until 1969. The 1969 Oil Crisis sparked a drastic drop in accident toll in the early 70´s mostly due to restrictions on oil supply. During the following years the number of accidents began once more to increase reaching an all time high in 1973. Between 1959 and 2011, the highest accident toll was reached in 1992 checking in with a total of 50,851.

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[8] and in 2011 decreased again. (Donário; Borges dos Santos, 2012:18-19).

Trend in the Number of Road Accident Deaths in Portugal[9]

As can be viewed in the graph below, road fatalities in Portugal during 1959 -2011 tend to increase and subsequently decline:

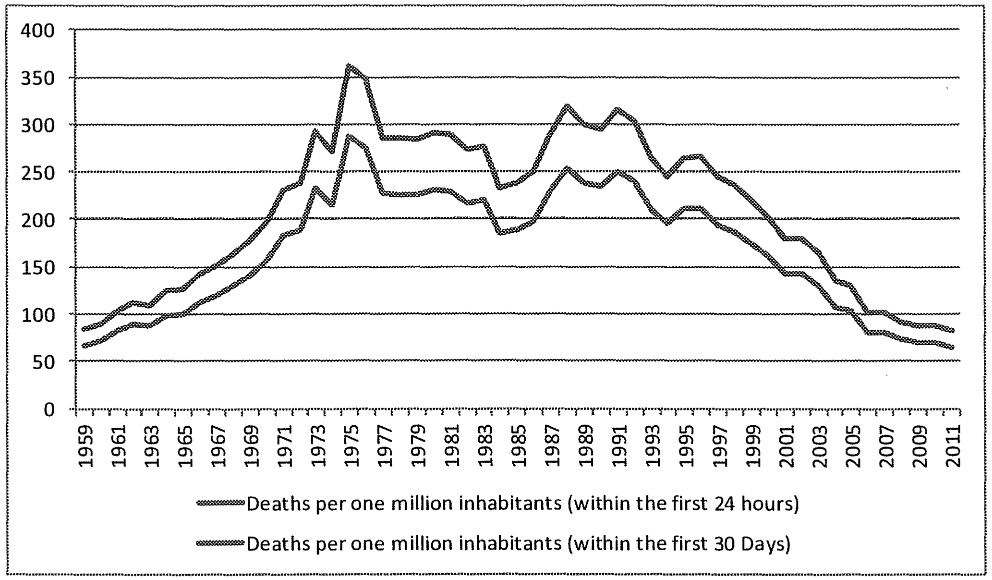
7 Economic factors are also one of the probable causes for this drastic decline as we will have a chance to see in Chapter III.

8 We thank Ricardo Borges dos Santos, co-author of the study "The Economic and Social Cost of Road Accidents. The Portuguese Case", his permission to reproduce here, largely this study.

9 Idem.P.19

Graph 1.1.1.2

Trend in the number of road deaths in Portugal.1959-2010



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.

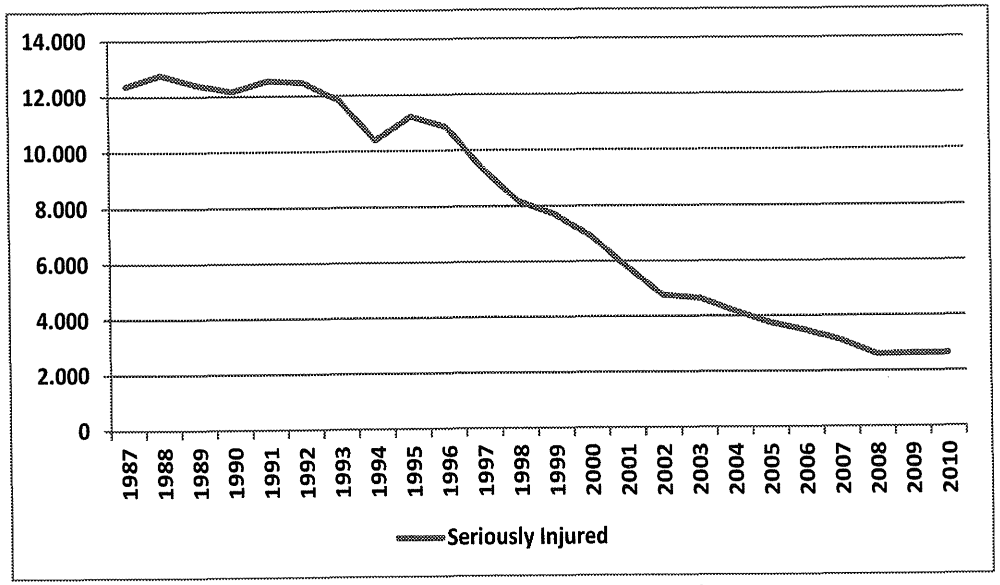
Trend in the Number of Seriously Injured Road Accident Victims in Portugal

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[10]:

[10] Data only available from 1987 onwards.

Graph. 1.1.1.3

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



Source: Based on data obtained from ANSR

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[11](. It has been found that the number of serious injuries

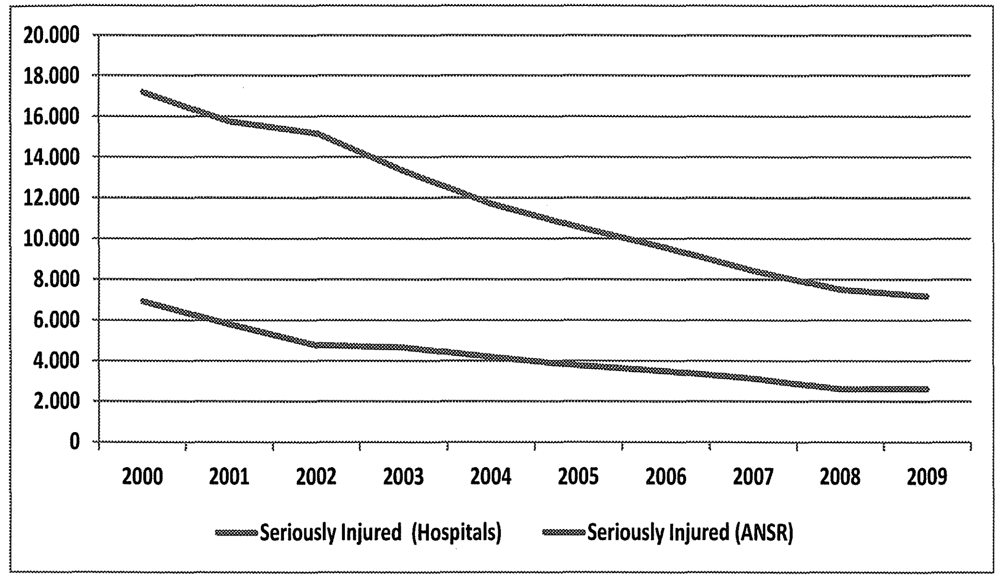
[11] Amoros (2008); Elvik (2009); Derriks, (2007); Chisvert, Ye Fan (2010); Ronan (2008)

recorded by hospitals is in fact higher than the number recorded by police authorities[12].

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[13] (hospital data) and by the ANSR (data recorded by police authorities).

Graph. 1.1.1.4

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 National Authority for Road Safety (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

[12] Police and Police Authorities refer to both the *Polícia de Segurança Pública (PSP –* Public Security Police) and the *Guarda Nacional Republicana* – GNR (National Republican Guard)

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

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.

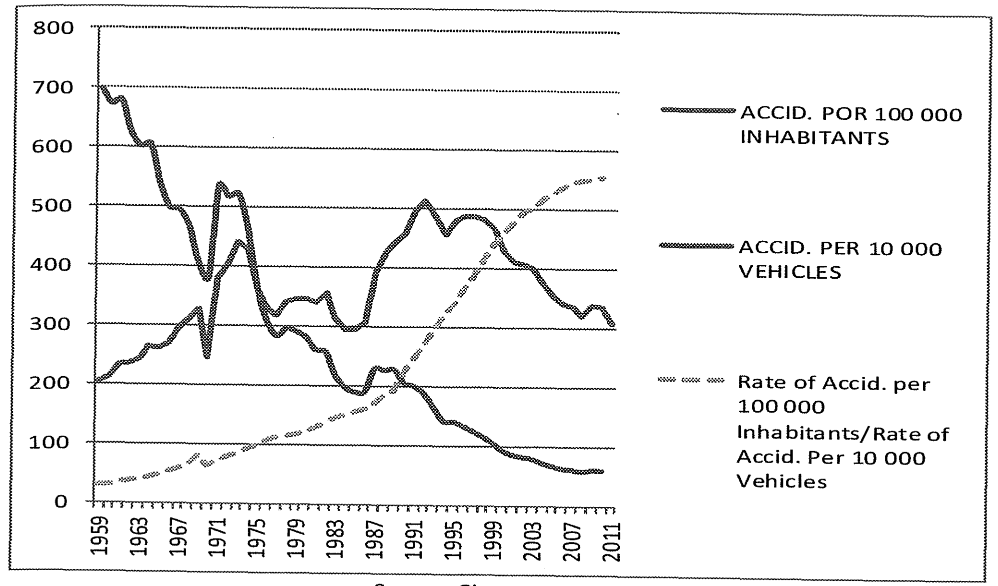
1.1.2 – Automotive Accidents with Victims *Per* Ten Thousand Registered Vehicles and *Per* One Hundred Thousand Inhabitants

Using statistical data from 1959-2011 we were able to trace the growth rate of the number of accidents with victims *per* ten thousand registered vehicles[14] and the rate of accidents *per* one hundred thousand inhabitants. We then took the rate of accidents *per* one hundred thousand inhabitants and weighed it to the rate of accidents *per* ten thousand vehicles in road circulation.

[14] Source: Portuguese Department of Motor Vehicles *(Direcção Geral de Viação)* and the Portuguese Automobile Industry Association (Associação *do Comércio Automóvel de Portugal).*

Graph 1.1.2.1

Accidents *per* inhabitant and per vehicle (1959-2011)



Source: Chart 1.1.1.1 – B

Graph 1.1.2.1 depicts a progressive decline with insignificant fluctuations in the toll pertaining to automotive accidents *per* ten thousand vehicles. As shown above, a steady drop was verified from 1959 until 1970, year in which a startling increase was recorded lasting until 1974. However, it was short lived for the toll began once more to plummet towards the end of the period with slight fluctuations. Many factors can be summoned to explain this drastic decline namely behavioral change in driving conduct, safety enhancements to vehicles, the construction of safer roads and highways with center guard-rails and the construction of circles in urban areas.

The number of accidents *per* one hundred thousands inhabitants tended to increase with some flux registering an abrupt drop in 1971. A similar slump was recorded towards the end of the period shown in our graph.

Lastly, the number of accidents *per* one hundred thousand inhabitants pondered by the rate of accidents *per* ten thousand vehicles in circulation increased at a steady rate. Constant growth of this rate is interpreted as being the result of an extended period of high accident risk among total population. Our interpretation remains valid in spite of a decline verified after 1988 and regardless of the constant decrease in the rate pertaining to the number of accidents *per* ten thousand vehicles on the road.

Many of these factors are indeed relevant although we tend to focus our attention more on factors of economic nature namely the unemployment rate[15] and GDP. In times of economic depression or in times of high unemployment it is evident that the marginal utility of "time" for individuals who find themselves unemployed is relatively low. Consequently, these individuals will attribute a higher marginal value to their income. How does this affect the accident toll? Well, if the majority of unemployed individuals have more time on their hands then they will tend to drive at lower speeds and will tend to drive less, lowering their spatial and temporal mobility. These drivers will be affected in such a way that over time the income spent on automotive driving will gradually loose its utility.

Soaring inflation and high taxes can also play an active role in reducing accident risk exposure (i.e. fewer km driven *per* unit of time) due to the negative affect on the amount of available income of drivers especially the unemployed. It will also cause a decrease in the marginal utility of vehicles generating thereafter a decrease in accident toll and a decrease in accident consequences. Basically, individuals will drive less because driving is an expensive activity.

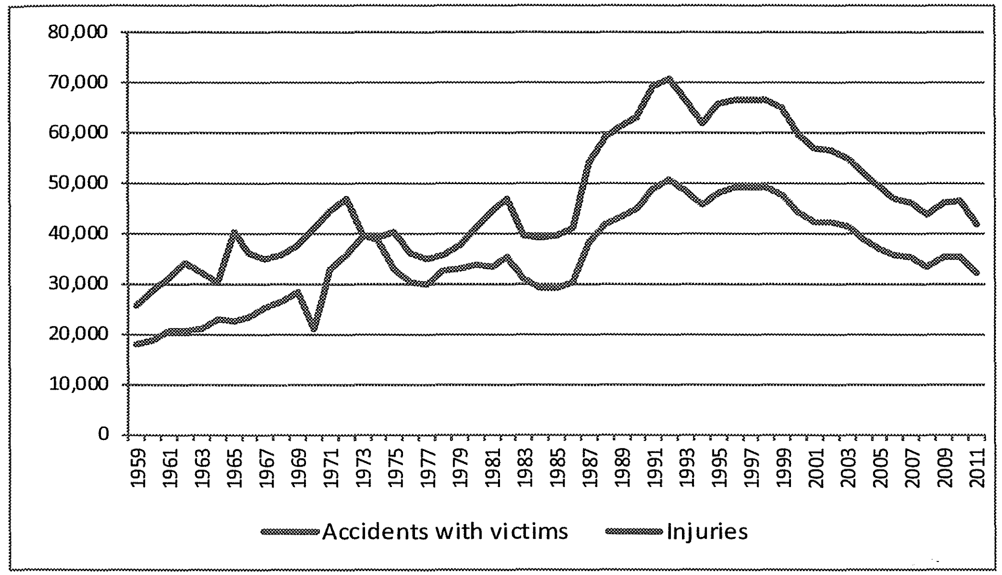
[15] Theoretically there is a chance that the unemployment rate may continue to grow in spite of the growth of the Gross National Product but at a rate no greater than 2% to 2.5%. See: Okun Law.

1.1.3 – Trend in the Number of Accident Fatalities and Injuries

Personal damages resulting from automotive accidents are first and foremost death or injury[16]. Graph 1.1.3.1 illustrates the growth of the injury toll and the number of accidents with victims between 1959 and 2011:

Graph 1.1.3.1

Evolution of the Injury Toll and the number of Accidents with Victims (1959-2011)



Source: Chart 1.1.1.1 – A

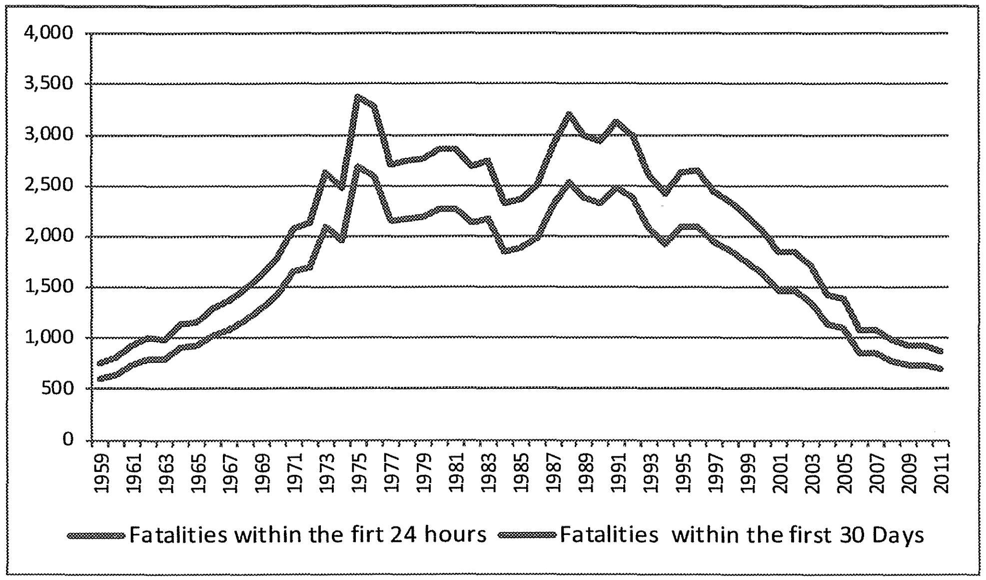
[16] Due to unavailable data we were unable to investigate the probability of death or injury in function of vehicle seats. However, we do know that drivers and front row passengers are more exposed to accident risk. We also know that passengers usually choose their seats in accordance to their age and sex/gender, implying that each seat and their respective occupant are subject to different levels of exposure to the risk of death or serious injury. Since there are different sets of risks at hand, the law has made it mandatory that certain age groups travel in back seats of vehicles. This occurs in Portugal and in other countries of the European Union along with the U.S. Failure to comply will lead to probable sanctions and fines.

From the statistical data above we verify that the injury toll increased at a higher rate than that of the total number of accidents with victims.

As observed in graph 1.1.3.2 below, accident fatalites skyrocketed during 1959 and 1976[17] reaching a maximum of 2,594 deaths in 1976. This year marked the beginning of a downward slope lasting until 1985 which was later followed by another increase that reached its highest value in 1988. Subsequently, a decline was verified lasting until 2011 registering little or no fluctuation.

Graph 1.1.3.2

Accident Fatalities within the first 24 hours and within the first 30 days(1959-20011)



Source: Chart 1.1.1.1-B

Various factors could have contributed towards reducing the death toll over the last couple of years, to be more precise, legally mandated safety enhancements to vehicles (i.e. airbags and anti-lock brakes) the compliance of seat belt laws by front row passengers and drivers, legislative

[17] With exception to 1974.

measures punishing drunk driving, the betterment of medical assistance to accident victims and the construction of new and safer highways.

"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.

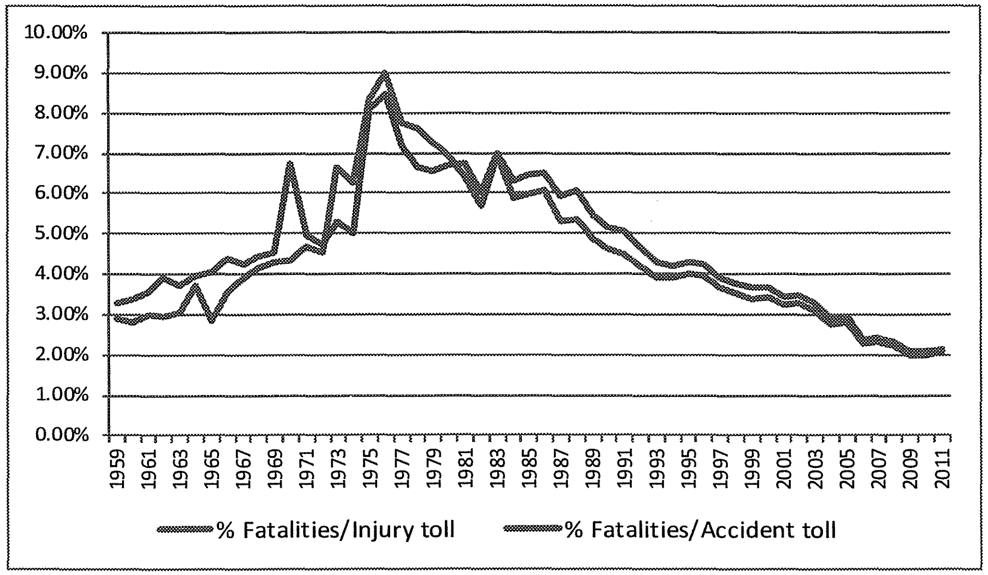
The National Authority for Road Safety confirmed that, on average, the road death toll was in fact 26% higher than that recorded using the 24 hour method.

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 2011.*[18]

Graph 1.1.3.3 traces the development of the fatality rate, comparing it to the injury and accident tolls. We can divide the graph into two different time periods; one prior to 1976 and another post 1976. From 1959-1976 we witness that both percentages increased at similar rates. In 1976, 7.15% of total injuries were fatal and 8.49% of total accidents resulted in fatal victims.

Graph 1.1.3.3

Percentage of Fatalities in Relation to Injuries and Accidents (1959-2011)



Source: Chart 1.1.1.1 – A

During the second period (1976-2011) both percentages registered the same downward slope showing little or no sings of fluctuation. Investment in infrastructure, mainly the construction of new highways and

[18] Donário, Arlindo; Borges dos Santos, Ricardo (2012) – The Economic and Social Cost of Road Accidents. The Portuguese Case – EDIUAL – *Universidade Autónoma de Lisboa.*

safer roads, conjugated with safety enhancements made to vehicles had a profound effect over both percentages.

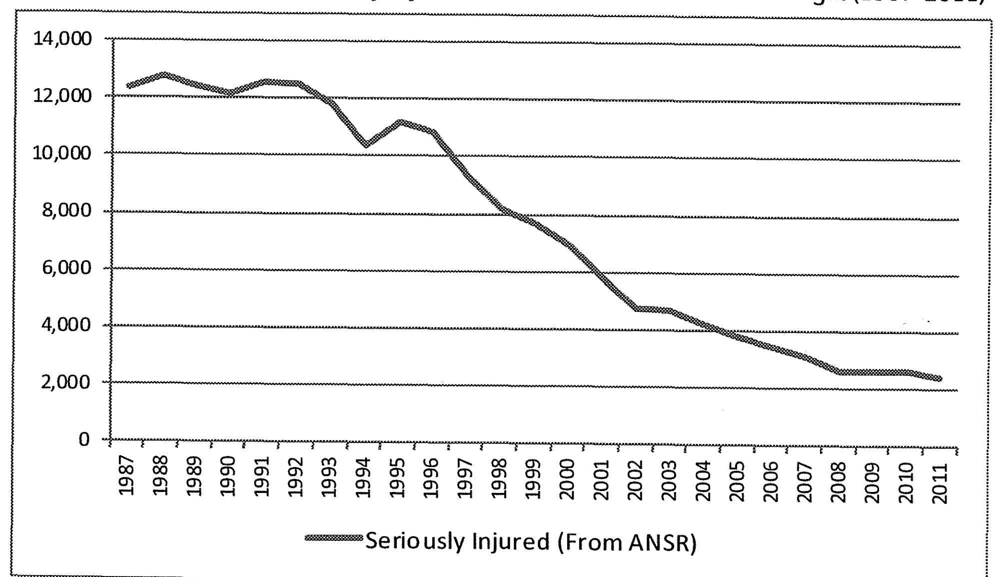
Further in our study we will look into the intricacies of spatial and temporal mobility as well as the driving frequency of drivers aiming towards a rigorous analysis of the factors behind the number of accidents and the accident fatality toll.

1.1.4 – 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 1987-2011 can be viewed in the following graph[19]:

Graph. 1.1.4.1

Trend in the number of seriously injured road accident victims in Portugal (1987-2011)



Source: Based on data obtained from the National Authority for Road Safety *(ANSR)*

[19] 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[20]. It has been found that the number of serious injuries recorded by hospitals is in fact higher than the number recorded by police authorities[21].

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[22] (hospital data) and by the ANSR (data recorded by police authorities).

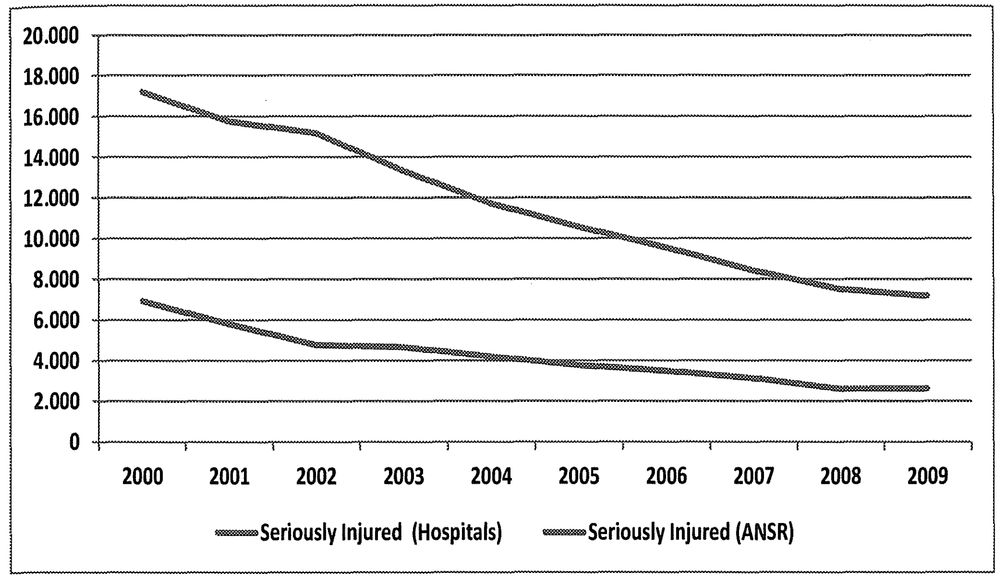
20 Amoroso (2008), Elvik (2009), Derriks, (2007) Chisvert, Ye Fan (2010) e Ronan (2008)

21 Police and Police Authorities refer to both the Polícia de Segurança Pública (PSP) and the Guarda Nacional Republicana (GNR).

22 Data was not provided for the period between 2000-2009.

Graph. 1.1.4.2

Trend in the number of seriously injured road accident victims in Portugal recorded by hospitals and by Police Authorities (2000-2009)[23]



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.[24]

23 Donário; Borges dos Santos –(2012) The Economic and Social Cost of Road Accidents. The Portuguese case. (UA L) Universidade Autónoma de Lisboa.

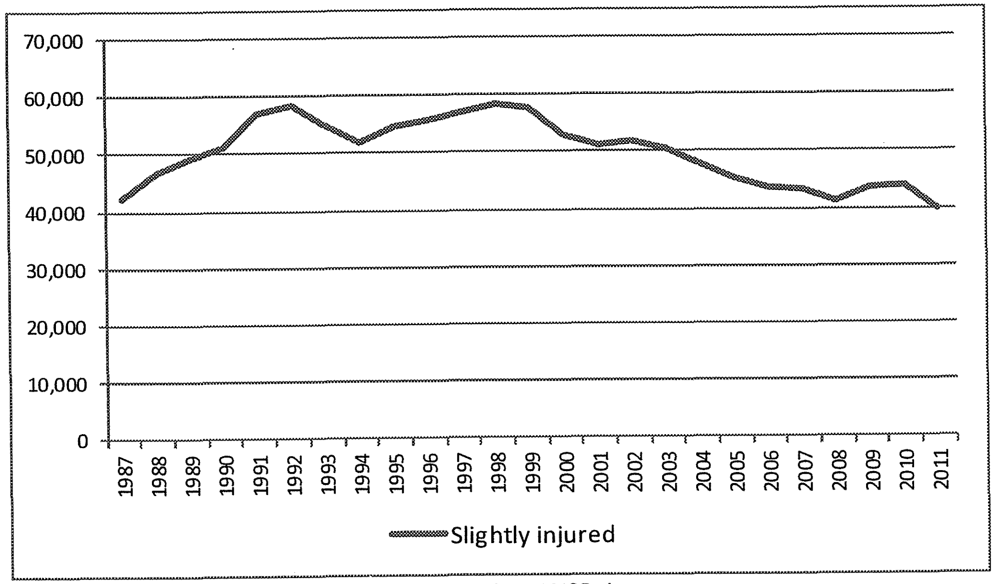
24 Donário; Borges dos Santos –(2012) The Economic and Social Cost of Road Accidents. The Portuguese case. UAL.

1.1.5 – 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[25]:

Graph. 1.1.5.1

Trend in the number of slightly injured road accident victims (1996-2011)



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[26].

25 Data only available from 1996 onwards.

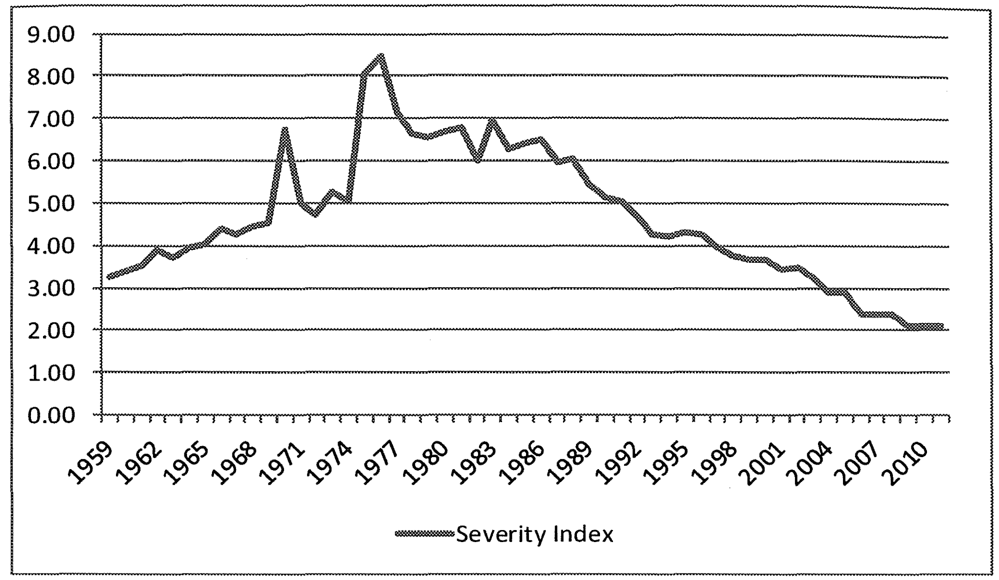
26 Donário; Borges dos Santos –(2012) The Economic and Social Cost of Road Accidents. The Portuguese case. -UAL.

1.1.6 – Severity Index

The severity index measures the number of fatalities for every 100 registered accidents with victims. In the graph below we find the stats pertaining to the period between 1959 and 2011:

Graph 1.1.6.1

Severity Index (1959-2011)



Source: Chart 1.1.1.1-A

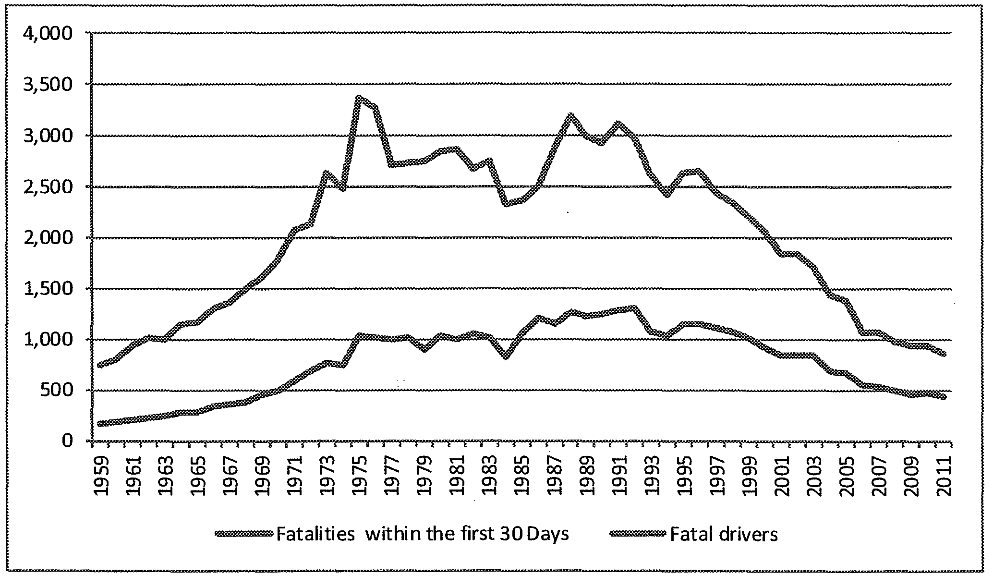
In 1975 the severity index measured 8.08, having reached the maximum of 8.49 in 1976. The index points towards a decrease in the level of care adopted by drivers, a factor known to increase the risk of accidents. When analyzing the data registered between 1974 and 1976 we should bear in mind that Portugal withstood massive political and social change during this period. Once stability was restored in 1977 the index value soared showing us that political a social change *(Structural Shocks)* can influence traffic safety. As evidenced the severity index has steadily decreased until the end of the period, as shown in graph above.

1.1.7 – Driver Fatality Rate

The data provided in the subsequent graph provides us a visual of the trend in the driver fatality rate along with the total number of accident fatal victims:

Graph 1.1.7.1

Fatal Drivers and Accident Fatalities (1959-2011)

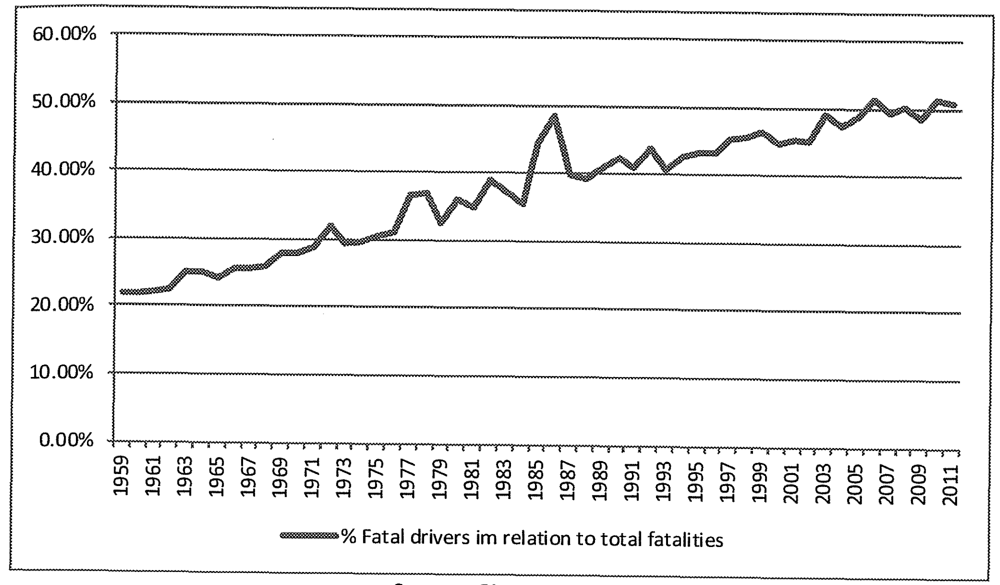


Source: Chart 1.1.1.1-A

As denoted in the graph above, we verify that the fatality rate increased at a constant rate until 1975 having "flat-lined" during the following years. However, slumps were recorded in 1979 and 1984. In 1984 the curve representing the fatality rate dropped to below the 1,000 mark. The period between 1984 and 1992 was characterized by yet another upward slope and by a subsequent valley in the fatality rate that would last untill 2011. The information provided in the previous chart is complemented by graph 1.1.7.2 which illustrates the percentage of fatal drivers in relation to the total number of accident fatal victims:

Graph 1.1.7.2

Percentage of Fatal Drivers in relation to Total Fatalities (1959-2011)



Source: Chart 1.1.1.1

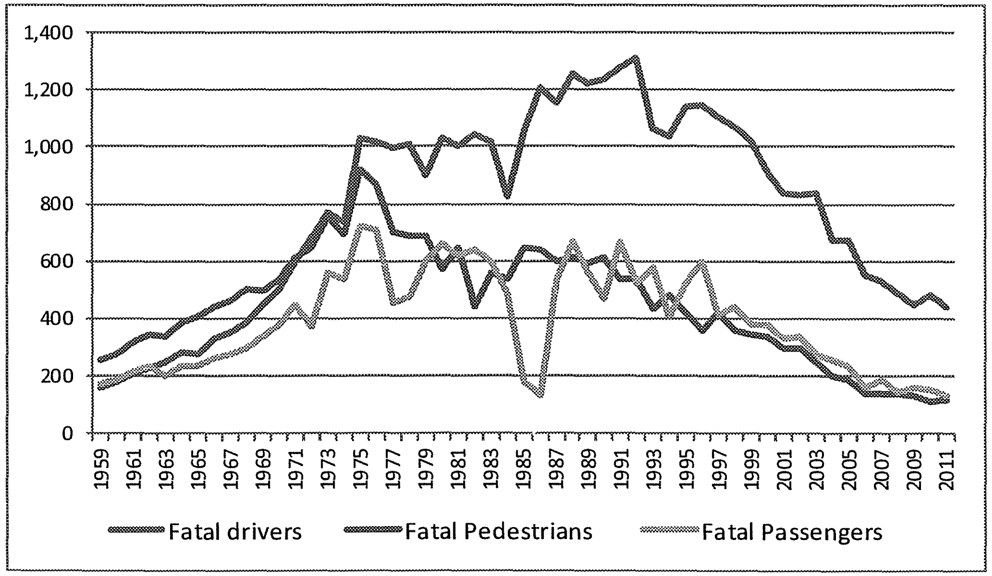
We have seen from graph 1.1.7.2 that the percentage values have increased over the time span considered. We can partially explain this phenomenon by underlining the fact that everyday there are fewer passengers that travel in vehicles and that the rate of vehicles *per* one thousand inhabitants keeps rising.

1.1.8 – Comparision Between the Pedestrian, Driver and Passenger Fatality Tolls

From the data plotted in graph 1.1.8.1 we deduce that until 1971 more pedestrians were killed than drivers and passengers. Nevertheless, pedestrian fatalites decreased in absolute terms from 1975 onward when compared to the fatality rate of drivers, indicating that drivers tended to increase their level of driving care in relation to pedestrians. This change in driving behavior can be attributed to many factors especially the increase of pedestrian walkways in urban areas.

Graph 1.1.8.1

Fatal Pedestrians, Fatal Drivers and Fatal Passengers (1959-2011)



Source: Chart 1.1.1.1-A

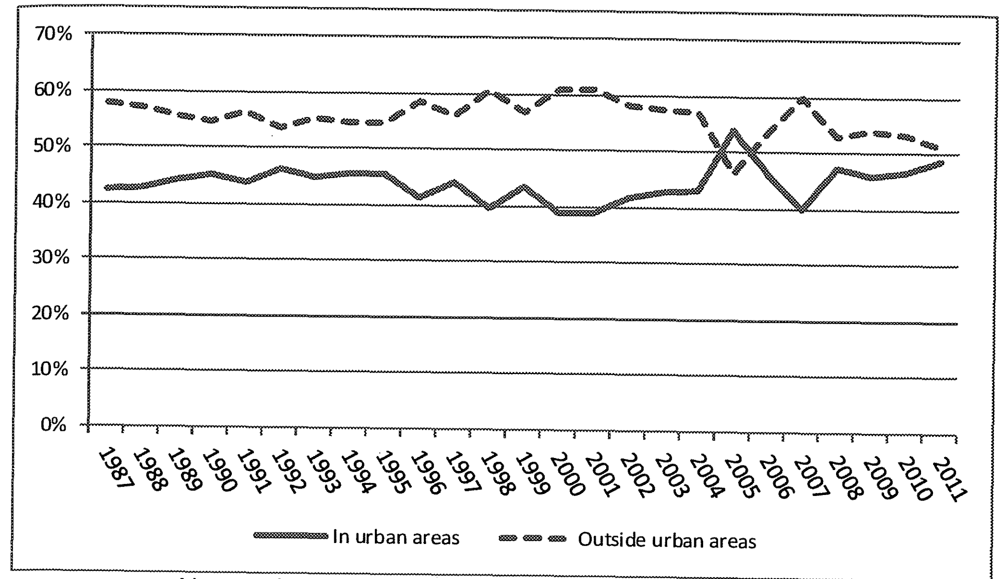
It is obvious that the drastic increase in the driver fatality rate when compared to the rate of fatal pedestrians and passengers is due to the fact that every day vehicles merely transport the driver and/or a limited number of passengers. As previously mentioned we infer that a logical explanation for this attitude is the increase of the number of vehicles *per* inhabitant.

1.1.9 – Relationship Between the Fatality Rate and the Location of Accidents

Statistical data concerning accident deaths both in and outside urban areas (See: appendix 3-A) between 1987 and 2011 are displayed below:

Graph 1.1.9.1

Fatalities in and out of Urban Areas (1987-2011)



Source: National Authority for Road Safety. Statistics: 1987-2011. Lisbon

The pattern followed by both rates is very similar during much of the time period considered above although the number accident fatalites outside urban areas is relatively higher, albeit it has been declining. This situation poses a problem since the deaths within the urban areas have been increasing, being 49% of all deaths in 2011(deaths within the first 24 hours from the accident).

In order to provide further and more easily interpretable information on the relationship between accident fatalites and their location we turn to the following chart which summarizes the number of automotive fatalities in accordance to the types of roads and highways that compose the Portuguese network during 2004 and 2011:

Table 1.1.9.1

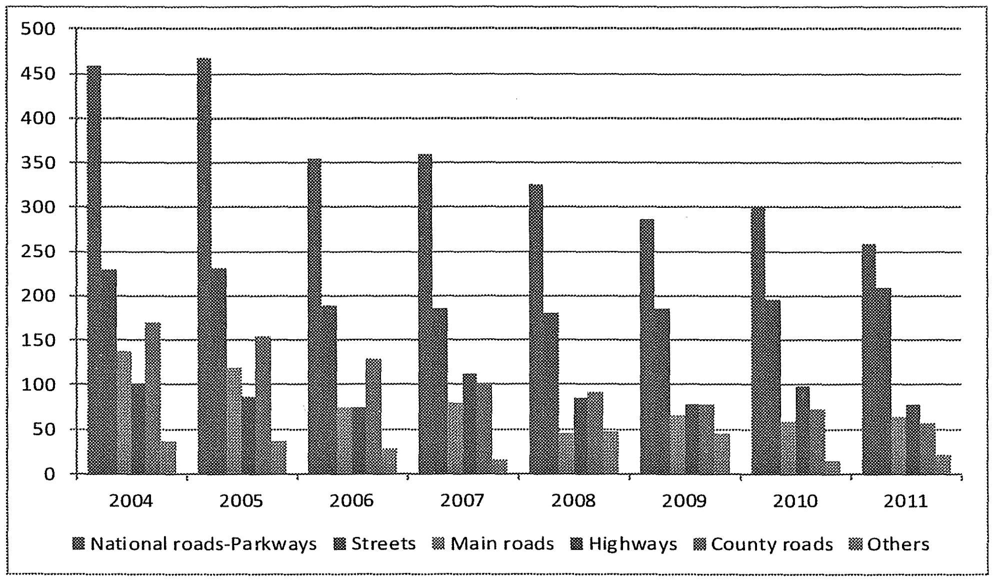
Location of Automotive Fatalities

Year	National roads-Parkways		Streets		County roads		Highways		Main roads		Others		Total
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%	
2004	459	40.44%	229	20.18%	170	14.98%	102	8.99%	138	12.16%	37	3.26%	1135
2005	467	42.69%	232	21.21%	154	14.08%	86	7.86%	118	10.79%	37	3.38%	1094
2006	354	41.65%	189	22.24%	129	15.18%	74	8.71%	75	8.82%	29	3.41%	850
2007	360	42.15%	185	21.66%	102	11.94%	112	13.11%	79	9.25%	16	1.87%	854
2008	326	42.01%	181	23.32%	92	11.86%	84	10.82%	46	5.93%	47	6.06%	776
2009	286	38.81%	185	25.10%	77	10.45%	78	10.58%	65	8.82%	46	6.24%	737
2010	302	40.76%	195	26.32%	72	9.72%	98	13.23%	59	7.96%	15	2.02%	741
2011	259	37.59%	210	30.48%	58	8.42%	77	11.18%	64	9.29%	21	3.05%	689
Total	2813	40.91%	1606	23.36%	854	12.42%	711	10.34%	644	9.37%	248	3.61%	6876

Source: ANSR. Observatório de *Segurança Rodoviária*

Graph 1.1.9.1

Location of Automotive Fatalities



Source: ANSR

The stats above provided by the National Highway and Road Safety Authority reveal different percentage values for the different roads considered. In effect, the highest number of fatalities occurred on national roads/parkways reaching 42.69% in 2005 and 37.59% in 2011. The national roads/parkways are the most dangerous roads due to the high number of registered accidents. Urban streets record the second highest

rates, reaching a total value of 20% in 2004 and 30% in 2011; therefore they are deemed the second most dangerous types of roads.

Notice how the numbers reveal that highways are much safer when compared to national roads/parkways[27], where the fatality percentages registered were 8.99% in 2004 and 11.18% in 2011. But how can this be? Isn't it true that on highways vehicles travel at greater speeds? Well indeed they do travel at higher velocities but road conditions may affect the probability of crashes as we shall explain in more detail in section 3.12. This takes us to a remarkable inference: more highways will tend to decrease the number of accident fatalities[28]. This because, pedestrians, cyclists and slow-moving motor vehicles are not permitted on highways and the driving conditions are maintained at a high standard, where the probability of frontal collisions between vehicles is very low and can only occur when a driver drives in the wrong direction.

We also point out that mainly in the surrounding area of major cities increased traffic causes congestion, which reduces average speeds and therefore also reduces the likelihood of accident fatalities since driving at lower speed lessens the probability of serious injury.

1.1.10 – The Influence of Hormones, Weather Conditions and Feelings on the Level of Risk Taking in Driving

> "*Virtually all current theories of choice under risk or uncertainty are cognitive and consequencialist.*"[29]. (Loewenstein, F. George; Hsee, K. Christopher, 2001:267)

Herbert Simon developed the concept of bounded rationality, given that there are systematic situations (in real life) that deviate from the neo-

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27 Elvik, R., Vaa, T., (2004). – The Handbook of Road Safety Measures – Elsevier Amsterdam, p. 183.

28 We will analyze this subject in more detail in Chapter III.

29 Loewenstein, F. George; Hsee, K. Christopher – (2001) Risk as Feelings, p.267. – Psychology Bulletin.200. Vol. 127. Nº 2, pp. 267-287

classical model of *homo economicus* who is supposed to act rationally, with perfect information, without regard to feelings and emotions either by intersubjective relations.

As stated by Amartya Sen:

> "*Rational Choice Theory characterizes rationality of choice simply as smart maximization of self-interest. It is somehow taken for granted in this approach that people would fail to be rational if they did not intelligently pursue only their own self-interest, without taking note of anything else (except to the extent that 'the something else' might – directly or indirectly – facilitate the promotion of their self-interest)*"[30](Sen, Amartya, 2009:179).

Driving is a high-risk activity. Loewenstein and Hsee consider, contrary to neoclassical theory, that risk can be understood as feelings that *highlight the role of affect experienced at the moment of decision making.*[31] These authors propose a hypothesis considering risk as feelings, inserting affect and emotions as factors explaining the variation in the number of accidents, fatalities and injuries, replacing what was considered as *homo economicus* acting rationally without considering emotions[32] (Bechara, Antoine; Antonio R. Damásio 2005) and feelings, which is based on the Cartesian dichotomy and the Newtonian mechanics, considering the individual insensitive to the social and intersubjective relations.

30 Sen, Amartya (2009) – The Idea of Justice – The Belknap Press of Harvard University Press Cambridge, Massachusetts. p. 179.

31 idem

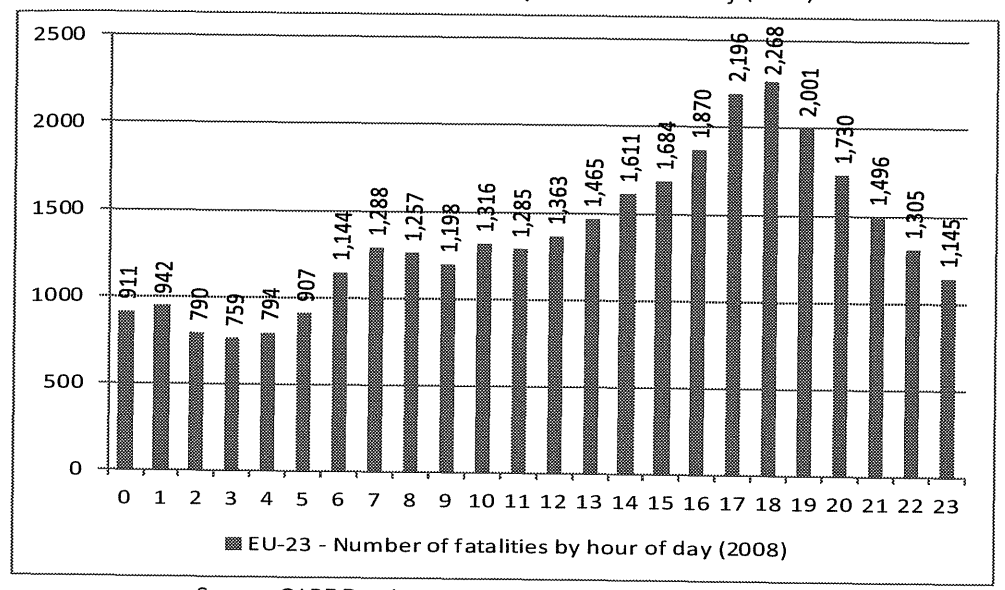
32 Bechara, Antoine; Antonio R. Damásio (2005) – The somatic marker hypothesis: A neural theory of economic decision – Games and Economic Behavior 52 (2005) 336–372. Available online 23 September 2004.

A) Deaths Per Hour of Day

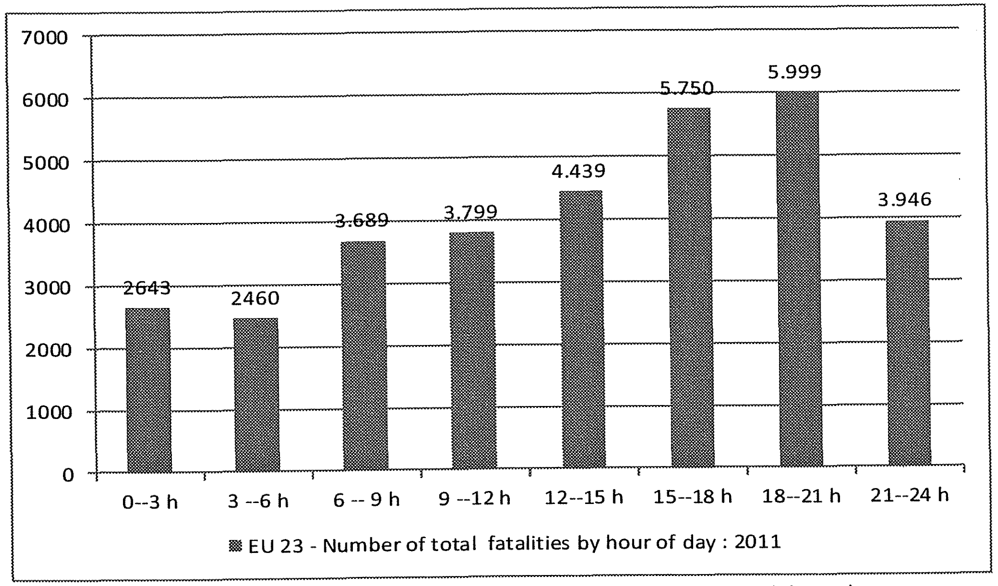
The number of road fatalities varies in accordance to the hours of the day. In the following chart we show the trend in fatalities over 24 hours of the day for 23 European Union member states during 2008:

Graph. 1.1.10.1

EU-23 – Number of fatalities per hour of the day (2008)



Source: CARE Database / EC. Date of query: November 2010

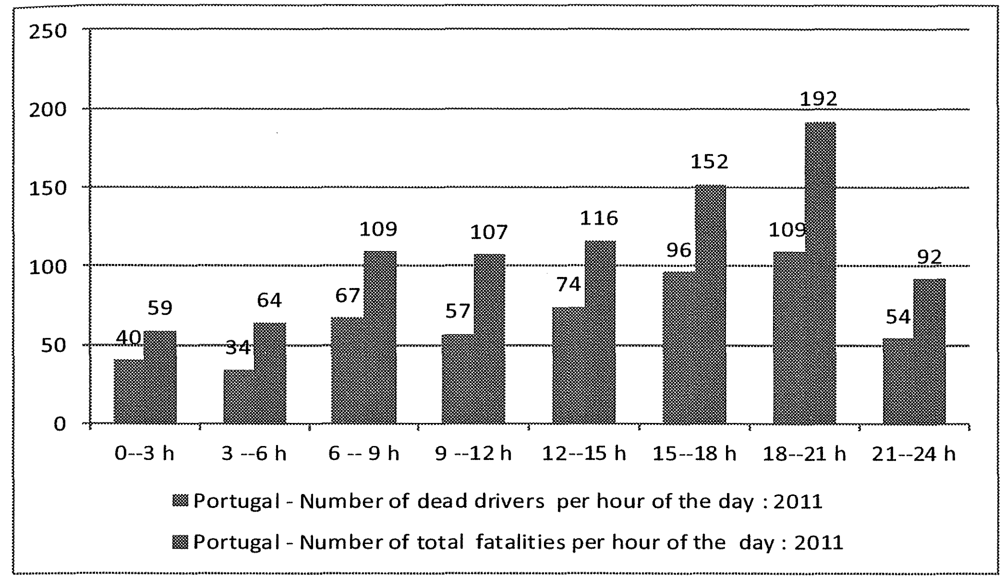


Source: CARE Database / EC. Date of query: November 2010.Adapted

In the Portuguese case, the following graph shows the total number of fatalities (within the first 30 days) and dead drivers per hour of the day in 2011:

Graph. 1.1.10.2

Portugal – Number of total fatalities and dead drivers per hour of the day (2011)



Source: ANSR. Adapted

There are studies which consider that the level of risk aversion or risk proclivity varies by the daytime hours, which may partly explain the variation in the number of deaths during the daytime hours. In certain contextual circumstances individuals reveal diverse attitudes towards risk during the different times of the day, leading them to consider the consequences of their behavior in a different way, namely hazardous driving[33].

Another explanation for these phenomena is based on neuroeconomics studies which relate testosterone level[34] (Elvik, Rune, 2004:18) with the

[33] Kobbeltvedt, Therese ;Katharina Wolff – (2009) The Risk-as-feelings hypothesis in a Theory-of-planned-behaviour perspective.-Judgment and Decision Making, vol. 4, no. 7, December 2009,.p.568.

[34] Elvik, Rune (2004) – Why some road safety problems are more difficult to solve than others – Institute of Transport Economics. Oslo, Norway, p. 18.

amount of risk taken by individuals[35] (Stanton, Angela A., 2010). Usually, testosterone level is high at around 5 and 7 p.m., in most EU countries analyzed, and in Portugal it is the highest between 6 and 9 p.m., coinciding with the time of the day in which most people are leaving work and have more free time.

Among others, a study conducted by Mehta and Josephs(2010) [36] revealed that the combination of testosterone level and cortisol level (not just the level of each of these hormones) influence human behavior with regard to decisions about risk; which can be applied to automotive driving. According to this study, the testosterone effect in relation to aggressiveness, dominance and the maintenance or seeking of a higher *status* and therefore a higher level of risk depends on the level of cortisol. Thus, when individuals are under stress, the cortisol level is high, blocking the effects of testosterone even if level of testosterone is high.

Since for most people going to work is something unpleasant (Camus, Albert (1942 [1955]:74) [37], their mood tends to be bad, but once work is finished people tend to get better. "Bad moods" have been found to be linked to more cautious behavior (Krivelyova, Anna; Cesare Robotti,

[35] Stanton, Angela A. (2010) – Hormonal influence on male decision-making: implications for organizational management *in* Neuroeconomics and the Firm (2010), pp. 131-150 – Edward Elgar.

[36] Mehta, Pranjal H.; Robert A. Josephs (2010) – Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone Hypothesis – Hormones and Behavior. Available online 15 September 2010

[37] Camus, Albert (1942 [1955]) – The Myth Of Sisyphus And Other Essays – Translated from the French by Justin O'Brien 1955. "*The gods had condemned Sisyphus to ceaselessly rolling a rock to the top of a mountain, whence the stone would fall back of its own weight. They had thought with some reason that there is no more dreadful punishment than futile and hopeless labor.*", p. 74.
——————— LE MYTHE DE SISYPHE. Essai sur l'absurde. – Paris, Les Éditions Gallimard, 1942, 189 pp. Collection : Les essais, XII. Édition augmentée, 69[e] édition, 1942.

2003:2)[38] so, with better mood, usually after leaving work perhaps there will be a decrease in risk aversion. This leads to a level of care below optimal adopted by the driver, consequently producing more accidents, deaths and injuries.

On the other hand, for most people leaving work results in a reduction of stress and, in consequence, in a reduction of cortisol and an increase of testosterone leading to an increase in risk loving behavior when driving, raising the probability of accidents, deaths, injuries and material damages.

The data analyzed above fits the hypotheses found in these studies, allowing us to conclude that during the later hours of the day when people leave work they become less risk averse, thus explaining the higher number of deaths between 6 and 9 p.m..

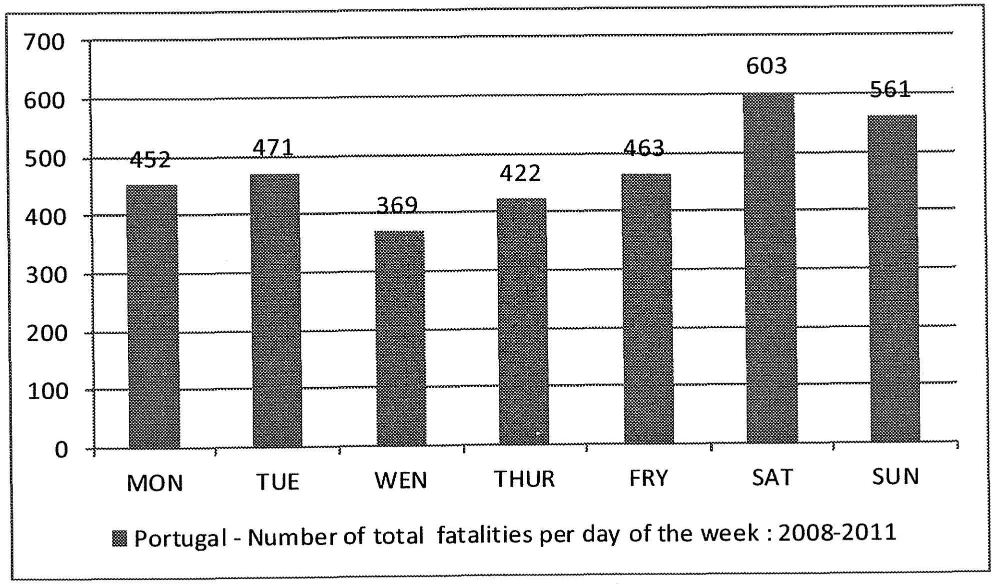
B) Deaths by Weekdays

Using the previous method we shall now analyze the number of accident deaths per weekday for the years 2008-2011. In the following graph we can observe the trend in total fatalities by day of the week, for the years 2008-2011:

[38] Krivelyova, Anna; Cesare Robotti (2003) – Playing the Field: Geomagnetic Storms and the Stock Market, p.2 – Federal Reserve Bank of Atlanta, Working Paper 2003-5b

Graph. 1.1.10.3

Number of total fatalities per day of the week (2008-2011)



Source: ANSR. Adapted

By analyzing the data in relation to road accidents by day of the week, we can see that the day with fewer accident deaths is Wednesday and the day with more deaths recorded is Saturday. The weekend is the period of the week with most deaths. We can also observe that there is an expressive drop in the number of deaths from Saturday to Sunday. Then how can we explain this phenomenon?

In addition to other factors that contribute to the variation in the number of deaths per day of the week, we can also apply what was referred above in relation to deaths per hour of day.

On the weekend, especially on Saturday, individuals tend to do what they enjoy in their free time, increasing good mood and optimism, leading to higher testosterone levels thereby reducing risk aversion when driving.

From the analysis we can conclude that road safety measures should take into consideration the hour of the day and the day of the week in which individuals are more prone to accidents with deaths and injuries.

As we will see in sections 3.6 and 3.7, increasing the probability of law enforcement has an effect in changing the behavior of drivers and other road users, being a more effective measure than increasing the severity of penalties. Indeed, if the probability of law enforcement (effective probability) is less than *threshold* probability, there will be a tendency for the breach of rules, even if they are increased, bearing in mind the internal and external sanctions related to axiological systems embodied in moral, ethical, social and religious values.

1.1.11 – Conclusions

- The Portuguese accident rate was one of the highest in Europe, but, in the last decade, that rate has declined greatly. In 2007, the road fatality rate per million inhabitants was 78 in the European Union with 27 member states, having Portugal checked in with 83 deaths.
- In the U.S., in 2010, the rate of deaths per million inhabitants was 106.3
- In Portugal, according to our calculations, the death rate per million inhabitants was 87 with the deaths within 30 days and 69 with the deaths within 24 hours from the accident.
- During the period (1959-2011) the number of accidents with victims showed signs of an upward cyclical pattern, reaching the maximum in 1992, with 50,851. From this year ahead the trend was decreasing up until 2011 with 32,541 accidents with victims
- During the period, 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, and 3,372 deaths with the deaths within 30 days from the accident.

- 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 from 1988 up until 1988. This year was the beginning of a decreasing trend, more or less continuous, in road fatalities, up until the end of the period,
- The trend of serious road injury decreased over the period of 1987-201. Between 1987 and the end of the period, the accumulated variance rate of seriously injured was -144%.
- In relation to 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. It has been found that the number of serious injuries recorded by hospitals is in fact higher than the number recorded by police authorities
- Severity index, used to measure the number of accident fatalites *per* one hundred accidents with victims grew until 1976. From this year onward the number began to dwindle as motor-vehicle manufacturing safety standards were introduced, medical assistance to accident victims was improved and the Portuguese road network (highways with guard-rails) was expanded and improved;
- The percentage of fatal drivers in comparison to the total number of automotive accident fatal victims increased, leading us to believe that there are fewer passengers and car-pooling is less frequent;
- Pedestrian death toll also increased until 1975 decreasing in the years thereafter;
- The number of fatal drivers in relation to that of pedestrians and passengers increased. This is a direct consequence of a growing rate of vehicles *per inhabitant* and a decrease in passengers per vehicle;

- The hour of the day and the day of the week influence the behavior of drivers which translates into more accidents at certain times of the day and day of the week. For this variation, several studies point to the existence of biological factors that explain, at least in part, these variations in the number of accidents, deaths and injuries.

II
Accident Injury and Fatality Rates by Age Group

The key objective of this section is to investigate the eventual relation between the automotive accident toll and the age of accident victims using the data provided by the PTSA, ETSC (CARE) and the NHTSA as the backbone for our analysis. Indeed, if such relation exists, we cannot afford to ignore it for its understanding will facilitate the adoption of measures aimed towards reducing accident risk levels of age groups whose likelihood of accident involvement is high.

Many investigations conducted in the U.S. [39] have uncovered impelling evidence that the age of accident victims is an underlying element in explaining the automotive accident severity rate[40].

With the objective of discerning the incidence of age over the accident fatality rate[41], proponents of such tenet elaborated a study based on an

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39 – Backer, S.P; O'Neil, B.; Karph, R.S. (1984) – *The Injury Fact Book.* Lexington: Lexington Books, 1984. Partika, S.C. Restraint use and fatality risk for infants and toddlers. Washington, DC: National Highway Traffic Safety Administration.
– Evans, Leonard (1991) – Traffic Safety and the Driver – New York: Van Nostrand Reinhold.
– Lewis, I., Watson, B., & Tay, R. (2007). Examining the effectiveness of physical threats in road safety advertising: The role of the third person effect, gender, and age. – Transportation Research Part F: Traffic Psychology and Behavior, 10, 48 and 60.

40 Severity rate is the number of victims, dead and injured, *per* one hundred registered automotive accidents.

41 Evans, L. (1988) – Risk of fatality from physical trauma versus sex and age. – *Jornal of Trauma*, 1988, No. 28, pp. 368-378.

ordinary twenty year-old male driver accompanied by a passenger of the same age and gender. The idea was to determine the corresponding fatality rates *per* accident for drivers and passengers belonging to this particular age group. Subsequently, the fatality risk for 25 year-old drivers was compared to the risk of 20 year-olds then the risk for 30 year-olds to that of 25 year-olds and so on. Logically, the fatality risk for thirty year-old drivers in relation to the risk of twenty year-old drivers was arithmetically obtained by multiplying the rates of both age groups. This procedure was repeated once and again for all other age groups. In this manner, the accident fatality risk of all ages in comparison to twenty year-old drivers was attained without having to resort to individual age comparisons, merely considering large age intervals[42].

By applying the previous method to the purposes aforementioned it was possible to empirically analyze data and elaborate a series of graphs that substantiate the belief that the accident fatality rate increases with age and varies in function of vehicle passenger seats (front and back row seats)[43]. The study made particular reference to front row passengers who either refuse to buckle-up or wish to wear seat belts. Conclusively, the investigation rendered results that indicate the fatality rate increases with age although it decreases with seat belt use. A similar experiment was carried out in relation to the female gender bringing forth an analogous trend in function of age.

– Evans, Leonard (2004) -Gender And Age Influence On Fatality Risk From The Same Physical Impact Determined Using Two-Car Crashes. – Paper Number 011174. – Peter H. Gerrish Nesa and Associates, Inc.

42 The margin of error in relation to each age is the reflection of the various steps of the process which uses a certain age as reference, this margin of error increases as we move further away from the age of reference.

43 We do not have any knowledge of similar data in Portugal that can give us an idea of the accident fatality toll in function of vehicle passenger seats.

2.1 – Estimated Probabilities: Dead and Injured

Before considering further developments in regards to this subject, we present the reader with the estimated probabilities pertaining to accident fatality and injury *per* age group during the period spanning from 1992 to 2011:

A) Estimated Probability of Fatal Victims

Drawing on data made available to us as the tool for our empirical explanation, we were able to obtain estimated probabilities of accident fatality for an individual belonging to a given age group *(i.e. relative re-occurrence rates of accident fatality for a given age group in relation to the total number of causalities)*. Chart 1.2.1.1 below illustrates the yearly percentage rate of accident fatality for an individual of a given age group in relation to total deaths:

Chart 2.1.1

Percentage of Accident Fatality for an Individual of a Given Age Group in relation to total deaths (1992-2011)

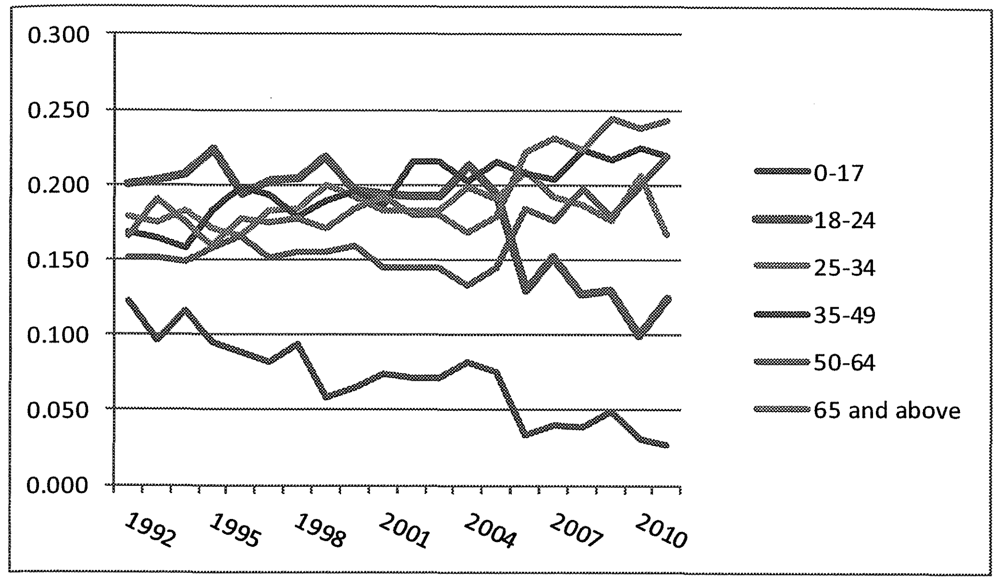
Year	Age Group					
	0-17	18-24	25-34	35-49	50-64	65 and above
1992	0.123	0.201	0.178	0.168	0.152	0.166
1993	0.097	0.203	0.175	0.164	0.151	0.191
1994	0.115	0.207	0.183	0.158	0.149	0.174
1995	0.094	0.224	0.171	0.183	0.158	0.159
1996	0.089	0.194	0.166	0.199	0.165	0.178
1997	0.082	0.203	0.183	0.193	0.152	0.175
1998	0.094	0.204	0.183	0.179	0.155	0.178
1999	0.058	0.218	0.200	0.189	0.155	0.171
2000	0.065	0.196	0.192	0.195	0.159	0.184
2001	0.074	0.194	0.182	0.187	0.145	0.192
2002	0.071	0.192	0.182	0.216	0.144	0.180
2003	0.071	0.192	0.182	0.216	0.144	0.180
2004	0.081	0.214	0.199	0.202	0.132	0.168
2005	0.075	0.192	0.190	0.216	0.144	0.178
2006	0.033	0.129	0.209	0.207	0.184	0.222
2007	0.040	0.152	0.192	0.204	0.176	0.231
2008	0.039	0.128	0.187	0.223	0.197	0.223
2009	0.049	0.130	0.176	0.217	0.179	0.244
2010	0.031	0.100	0.206	0.224	0.200	0.238
2011	0.028	0.125	0.167	0.219	0.219	0.242

Source: Portuguese Department of Motor Vehicles (*Autoridade Nacional de Segurança Rodoviária* –ANSR) Death Toll 1992-2011. Our estimates.

In 20 years it was found that the percentage of fatalities in relation to the total number of deaths in the age group 18-24 began to decline from the year 2005 until 2011. The reason for this is the dwindling birth rate in Portugal particularly from 2005 onwards which has its effects on the 18-24 age group since there are fewer drivers in this age bracket. Let´s not forget that Portugal is currently embroiled in what is arguably the biggest financial crisis in its history, situation that has heavily influenced its natality rate. Thus, as drivers of this age group grow older the lower the percentage of deaths in this age group, as can be seen in the following graph:

Graph 2.1.1

Percentage of Accident Fatality for an Individual of a Given Age Group in relation to total deaths (1992-2011)



As illustrated in the figure above, the demographic and population structure has great influence on traffic safety. As the population structure of Portugal changes with fewer youngsters belonging to the general population and considering that the probability of accident fatality for young drivers is much higher than that of older drivers – as we shall see – we begin to witness a decreasing trend in both the accident fatality and injury tolls in the country, *ceteris paribus*.

We proceed to review the probabilities of accident fatality according to age group population. To accomplish such task we considered the census data provided in the following chart which summarizes mainland Portuguese population broken down by age group[44]:

[44] Only mainland Portuguese population was considered since the data pertaining to automotive accident casualties and injuries in the autonomous regions (Azores and Madeira) was excluded from the statistical data obtained.

Chart 2.1.2

Portuguese Population (Mainland) per Age Group

Year	Age Group						
	0-17	18-24	25-34	35-49	50-64	65 and above	Total
1992	2,218,670	1,072,280	1,366,730	1,830,490	1,564,140	1,285,150	9,337,460
1993	2,162,240	1,093,420	1,380,850	1,852,430	1,561,470	1,347,230	9,397,640
1994	2,113,310	1,107,700	1,395,100	1,871,430	1,564,940	1,362,530	9,415,010
1995	2,051,650	1,108,170	1,410,140	1,885,590	1,570,100	1,396,330	9,421,980
1996	2,012,790	1,096,520	1,430,170	1,904,770	1,570,080	1,419,120	9,433,450
1997	1,980,450	1,078,880	1,454,190	1,924,100	1,576,640	1,439,980	9,454,240
1998	1,952,220	1,059,100	1,475,750	1,935,470	1,593,560	1,457,970	9,474,070
1999	1,955,503	1,060,881	1,478,231	1,938,724	1,596,239	1,460,421	9,489,999
2000	1,955,509	1,060,884	1,478,236	1,938,730	1,596,245	1,460,426	9,490,030
2001	1,898,000	1,043,900	1,518,400	1,992,900	1,613,300	1,423,500	9,490,000
2002	1,987,558	1,093,157	1,590,046	2,086,936	1,689,424	1,490,669	9,937,790
2003	1,985,488	1,092,019	1,588,391	2,084,763	1,687,665	1,489,116	9,927,442
2004	1,985,488	1,092,019	1,588,391	2,084,763	1,687,665	1,489,116	9,927,442
2005	2,008,753	1,104,814	1,607,002	2,109,190	1,707,440	1,506,564	10,043,763
2006	1,874,456	863,571	1,557,919	2,216,897	1,830,985	1,766,145	10,109,973
2007	1,864,456	837,474	1,545,920	2,233,846	1,857,840	1,787,344	10,126,880
2008	1,853,503	815,848	1,525,802	2,249,052	1,879,453	1,811,651	10,135,309
2009	1,840,029	799,746	1,496,383	2,270,634	1,899,821	1,838,327	10,144,940
2010	1,801,315	766,994	1,360,863	2,245,227	1,941,015	1,941,966	10,057,380
2011	1,782,452	760,642	1,306,173	2,250,841	1,953,023	1,975,103	10,028,234

Source: Portuguese Institute of Statistics (*INE*). Lisbon. Annual Stats 1992-2011. Adapted.

The subsequent chart presents us with the results gathered in reference to the estimated probabilities:

Chart 2.1.3

Estimated Probability of Accident Fatality for an Individual of a Given Age Group In Relation to the Corresponding Total Population of that Same Age Group

Year	Age Group					
	0-17	18-24	25-34	35-49	50-64	65 and above
1992	0.00013	0.00045	0.00031	0.00022	0.00023	0.00031
1993	0.00009	0.00039	0.00026	0.00018	0.00020	0.00029
1994	0.00011	0.00036	0.00025	0.00016	0.00018	0.00025
1995	0.00010	0.00042	0.00025	0.00020	0.00021	0.00024
1996	0.00009	0.00037	0.00024	0.00022	0.00022	0.00026
1997	0.00008	0.00037	0.00024	0.00019	0.00019	0.00024
1998	0.00009	0.00036	0.00023	0.00017	0.00018	0.00023
1999	0.00005	0.00036	0.00024	0.00017	0.00017	0.00021
2000	0.00005	0.00030	0.00021	0.00016	0.00016	0.00020
2001	0.00006	0.00027	0.00018	0.00014	0.00013	0.00020
2002	0.00005	0.00026	0.00017	0.00015	0.00013	0.00018
2003	0.00005	0.00024	0.00016	0.00014	0.00012	0.00016
2004	0.00005	0.00023	0.00015	0.00012	0.00009	0.00013
2005	0.00004	0.00019	0.00013	0.00011	0.00009	0.00013
2006	0.00002	0.00016	0.00014	0.00010	0.00011	0.00013
2007	0.00002	0.00020	0.00013	0.00010	0.00010	0.00014
2008	0.00002	0.00015	0.00012	0.00010	0.00010	0.00012
2009	0.00002	0.00015	0.00011	0.00009	0.00009	0.00012
2010	0.00002	0.00012	0.00014	0.00009	0.00010	0.00011
2011	0.00001	0.00014	0.00011	0.00008	0.00010	0.00011

Source: Portuguese Department of Motor Vehicles (*Autoridade Nacional de Segurança Rodoviária* – ANSR) 1992-2011. Our estimates.

The highest annual estimated probability of accident fatality for an individual of a given age group in relation to its corresponding total population prominently belongs to the 18-24 age group. However, the results point towards a slight decrease in trend from 1995 onward. To a lesser extent the 65 and above age group has sporadically swapped places with the 25-34 age bracket for the second highest rate.

The fatality rate per million inhabitants between the ages of 20 and 24 was 135 in 2011[45], while the remaining 88 deaths registered in that year belonged to other age groups. If we consider that the probability of a

45 Source: ANSR, Report (2011).

male person dying in road accidents is much higher than that of women then we can assume that the fatality rate per million inhabitants for men between the ages of 20 and 24 will be much higher.

Studies in neuroscience explain the reduced risk-averse behavior in relation to young drivers, as pointed out by Glendon and Ian:

> "*Young drivers are much more likely than older drivers to be influenced by their peers (Gardner & Steinberg, 2005; Simons-Morton, & Singer, 2005; Steinberg, 2008b). Gardner and Steinberg found higher levels of risk taking, greater focus on benefits than potential costs of risk taking, and riskier decisions by adolescents when in peer groups than when alone. Steinberg reported FMRI data indicating that although brain regions activated in a driving task associated with cognitive control and reasoning (e.g., prefrontal and parietal association cortices) were active irrespective of driving condition, additional brain regions were activated (medial frontal cortex and left ventral striatum – primarily the accumbens, left superior temporal sulcus, and left medial temporal structures) when peers were present. This socioemotional network led to more risky driving behavior, indicating that peer presence enhanced rewards from potentially risky driving behavior.*" (Glendon, A. Ian, 2011:118)"[46]

Young people seek to express their behavior through identity, norms and social categories, seeking an ideal of who they should be and how they should act while their peers, perhaps some of them, are regarded as the people they wish to follow (Akerlof, George A.; Kranton, Rachel E., 2010:118)[47]. We know that driving, especially for young people, is a *good* that provides pleasure by itself and that it is a means to reveal their

[46] Glendon, A. Ian – (2011) Neuroscience and Young Drivers *in* Handbook of Traffic Psychology, p. 118. – Elsevier, San Diego, USA.

[47] Akerlof, George A.; Kranton, Rachel E. (2010) – Identity Economics how our identities shape our work, wages, and well-being, p. 11. Princeton University Press, Princeton and Oxford.

identity, especially for young men. According to prospect theory behaviors are situation-dependent, meaning that changes in states of reference alter behavior. Samuel Bowels states:

> "*Thus, the value individuals place on states depends on the relationship of the state to the status quo (or possibly some other reference state, such as an aspiration level or the states enjoyed by peers).*" (Bowles, Samuel, 2004) [48]

As for the 0-17 age group their probabilities are diminutive since this age cluster is mostly constituted by young children and adolescents who usually travel in back seats of vehicles under the care and vigilance of adults.

Comparatively the U.S. registers similar estimated accident fatality probabilities in spite of different age intervals and a higher population[49]:

[48] Bowles, Samuel (2004) – Microeconomics behavior, institutions, and evolution *Samuel Bowles*. – Russell Sage Foundation, Princeton University Press.

[49] Note: U.S population is nearly 30 times higher than that of Portugal. Legal driving age in the U.S. is 16 whereas in Portugal the legal licensing age is 18 and only exceptionally 16 years of age (e.g. emancipated minors).

Chart 2.1.4

Estimated Probability of Accident Fatality for an Individual of a Given Age Group in Relation to the Corresponding Total Population of that Same Age Group (U.S.A.)

Year	0-15	16-24	25-34	35-54	55-64	Over 65
1994	0.000056	0.000308	0.000183	0.000139	0.000131	0.000209
1995	0.000054	0.000309	0.000193	0.000144	0.000139	0.000208
1996	0.000053	0.000305	0.000189	0.000144	0.000141	0.000209
1997	0.000051	0.000292	0.000186	0.000143	0.000144	0.000215
1998	0.000048	0.000285	0.000179	0.000145	0.000141	0.000211
1999	0.000047	0.000289	0.000180	0.000144	0.000138	0.000205
2000	0.000045	0.000291	0.000183	0.000146	0.000137	0.000191
2001	0.000040	0.000292	0.000171	0.000148	0.000135	0.000192
2002	0.000039	0.000293	0.000172	0.000146	0.000132	0.000186
2003	0.000040	0.000279	0.000168	0.000147	0.000134	0.000185
2004	0.000040	0.000276	0.000171	0.000144	0.000131	0.000179
2005	0.000036	0.000274	0.000176	0.000148	0.000138	0.000177
2006	0.000033	0.000272	0.000177	0.000145	0.000132	0.000161
2007	0.000031	0.000258	0.000167	0.000140	0.000125	0.000157

Source: NHTSA (Traffic Safety Facts Final Reports 1994-2007), FARS (Fatality Analysis Reporting System), GES (General Estimates System) and U.S. Census Bureau. Adapted

B) Estimated Probability of Injured Victims

Just as in the previous subsection we carried out a similar analysis in regards to injured victims. Chart 1.2.1.5 sets the milieu for our investigation as it traces the trend of accident injury *per* age group in relation to total number of accident injured victims:

Chart 2.1.5

Percentage of Accident Fatality for an Individual of a Given Age Group in relation to total injured (1992-2011)

Year	Age Group					
	0-17	18-24	25-34	35-49	50-64	65 and above
1992	0.167	0.274	0.202	0.168	0.115	0.073
1993	0.166	0.274	0.199	0.164	0.118	0.079
1994	0.164	0.274	0.195	0.166	0.117	0.083
1995	0.153	0.270	0.198	0.174	0.122	0.083
1996	0.141	0.260	0.206	0.182	0.124	0.087
1997	0.142	0.258	0.203	0.184	0.124	0.088
1998	0.146	0.249	0.202	0.185	0.126	0.091
1999	0.106	0.248	0.221	0.199	0.128	0.097
2000	0.109	0.257	0.214	0.199	0.127	0.095
2001	0.111	0.235	0.223	0.202	0.128	0.101
2002	0.103	0.232	0.229	0.207	0.130	0.100
2003	0.103	0.232	0.229	0.207	0.130	0.100
2004	0.103	0.232	0.229	0.207	0.130	0.100
2005	0.103	0.232	0.229	0.207	0.129	0.100
2006	0.101	0.172	0.218	0.224	0.144	0.118
2007	0.104	0.164	0.214	0.229	0.149	0.125
2008	0.098	0.164	0.216	0.231	0.153	0.124
2009	0.095	0.162	0.206	0.236	0.159	0.129
2010	0.090	0.158	0.207	0.238	0.164	0.130
2011	0.091	0.152	0.197	0.246	0.165	0.138

Source: ANSR. Annual Stats 1992-2011. Adapted.

The results obtained reveal that individuals between the ages of 18 and 24 are more likely to get injured in a car crash. However, a sharp percentage decline has been verified over the last couple of years specifically from 2000 onward in relation to these individuals. The probability rates of the 25-34 age group also stand out due to constant percentage increases from 2000 until 2005. Another age group recording high percentage increases since 2005 and until 2011 has been the 35-49 age group mostly because of the low birth rate and the aging of younger drivers. The 65 and above age group comes in last with low injury probability albeit some signs of percentage increase are clearly visible.

We estimated the probability of accident injury per age group in relation to its corresponding population. The following chart illustrates such probabilities:

Chart 2.1.7

Estimated Accident Injury Probability in relation to Age Group Population

Year	Age Group					
	0-17	18-24	25-34	35-49	50-64	65 and above
1992	0.00544	0.01844	0.01064	0.00660	0.00531	0.00412
1993	0.00522	0.01704	0.00979	0.00602	0.00512	0.00399
1994	0.00491	0.01568	0.00882	0.00563	0.00474	0.00387
1995	0.00499	0.01630	0.00940	0.00619	0.00523	0.00399
1996	0.00475	0.01616	0.00981	0.00648	0.00536	0.00419
1997	0.00488	0.01626	0.00947	0.00648	0.00535	0.00417
1998	0.00494	0.01556	0.00906	0.00630	0.00523	0.00414
1999	0.00341	0.01475	0.00942	0.00646	0.00507	0.00418
2000	0.00329	0.01435	0.00860	0.00608	0.00471	0.00385
2001	0.00328	0.01265	0.00827	0.00570	0.00446	0.00397
2002	0.00276	0.01124	0.00763	0.00526	0.00407	0.00354
2003	0.00285	0.01159	0.00787	0.00542	0.00420	0.00365
2004	0.00268	0.01091	0.00741	0.00510	0.00395	0.00344
2005	0.00251	0.01022	0.00693	0.00478	0.00369	0.00322
2006	0.00255	0.00941	0.00659	0.00477	0.00372	0.00316
2007	0.00258	0.00909	0.00642	0.00474	0.00373	0.00323
2008	0.00233	0.00885	0.00621	0.00450	0.00358	0.00302
2009	0.00239	0.00942	0.00638	0.00483	0.00389	0.00326
2010	0.00233	0.00959	0.00709	0.00495	0.00393	0.00311
2011	0.00216	0.00842	0.00635	0.00461	0.00355	0.00294

Source: ANSR. Annual Stats 1992-2011. Adapted.

Using the data provided in the previous chart several conclusions can be drawn. Individuals between the ages of 18 and 24 have a greater probability of automotive accident injury when compared to other age groups which in turn has severe implications on society. In fact, if we keep in mind the average life expectancy, permanent disability resulting from serious accident injury will affect the quality of life during a much longer period of time, inflicting higher social costs.

In addition, this situation leads us to place a broad array of inquiries concerning the lifestyle and day-to-day habits of individuals who belong to the 18-24 age cluster. For example: Do 18 year olds portray identical behavior as 24 year olds? How do social factors affect the driving conduct of 18-24 year olds especially those related with family, community, employment, schooling, dropout rate, relationships with friends, self-esteem, the need of transportation, peer pressure, fitting in a social group *(i.e. ownership of a car as a social symbol)*?

On this logic, although the influence of social factors may not seem apparent we still consider these youngsters to be a part of a generation whose maturity, interests, values and priorities vary significantly in function of age and life experience. Further, they are individuals whose behavior reflects personal concepts of sociability, independence and social responsibility. They choose to accept rules of conduct that denote their preferences, concerns and quotidian circumstances. In this perspective and bearing these considerations in mind, road safety research should specifically focus on young adult drivers because they are more likely to suffer the consequences of automotive accidents. Yet other questions arise: Should the severity of sanctions be bolstered or should there be more restrictions based on driver age (e.g. graduated licensing programs)? Should alternative strategies be adopted for instance the betterment of driver education, rehabilitative courses and post licensing control for young drivers in local high schools? Graph 1.2.1.1 compares the accident fatality rate to that of accident injured victims *per* age group:

We estimated the probability of accident injury per age group in relation to its corresponding population. The following chart illustrates such probabilities:

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2010	0.00233	0.00959	0.00709	0.00495	0.00393	0.00311
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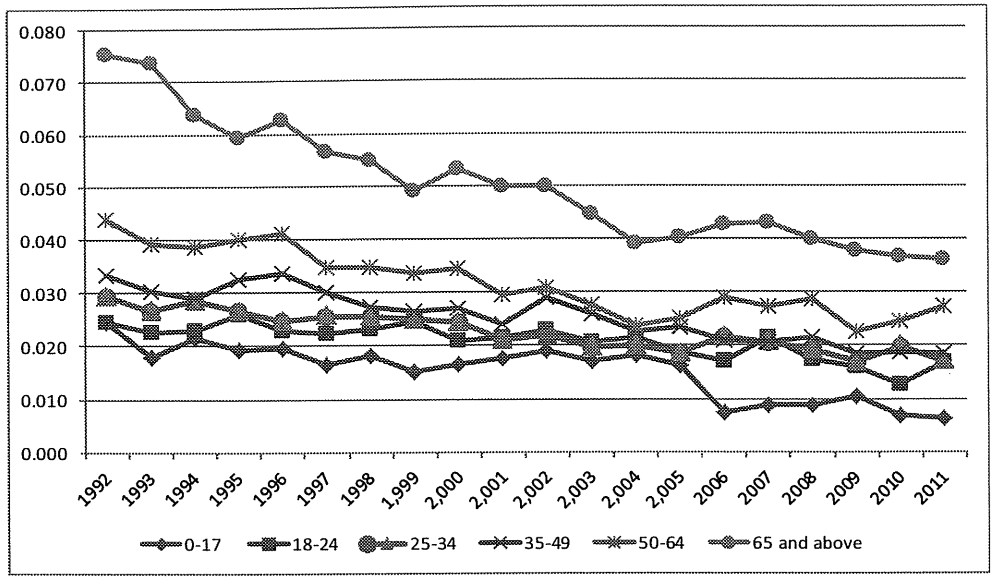
Graph 2.1.1

Fatal Victims in Relation to Injured Victims *per* Age Group



Source: ANSR. Annual Stats 1992-2011. Adapted

From the graph above we see that 65 and above age group registers a relatively high percentage perhaps due to causes of physical and psychological nature inherent to its members. In what concerns other age groups, individuals between the ages of 50 and 64 occupy the second position while the ensuing age intervals follow and inverse order in relation to age.

2.2 – Injury Resulting in Permanent Disability *Per* Age Group

For the purpose of investigating the influence of age over the seriousness of automotive accident injuries resulting in permanent disability (PD) we comprised a sample of 1,113 injury cases between 1997 and 1999:

Chart.2.2.1

Permanently Disabled Victims *per* Age Group (Sample 1,113 Cases)							
	0-17	18-24	25-34	35-49	50-64	65 and Above	Total
PD up to 50%	79	372	306	57	100	80	994
PD 51%-100% or PFD	2	18	18	23	32	26	119
Total	81	390	324	80	132	106	1.113

Source: Portuguese Insurance Companies

Data above alludes to the fact that 89.31% of accident injury cases resulting in (PD) fit into the first group *(i.e. disability inferior to 50%)* while the remaining 10.69% incorporate the second group, disability greater than 50%. Once again the 18-24 age cluster recorded the highest numbers succeeded by the 25-35 age group when it came to injuries that result in permanent disability inferior to 50%. At the other end of the spectrum, the 18-24 and the 25-34 age groups register identical values in respect to (PD) greater than 50% although inferior to those verified in other age intervals. Empirical evidence suggests that accident injury resulting from car crashes with identical impact tends to be more severe with age.

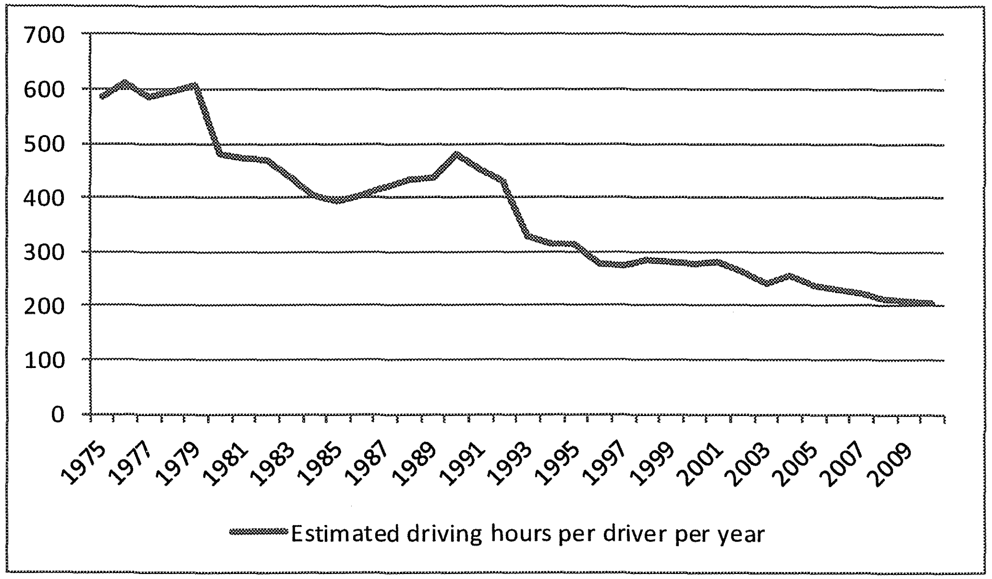
2.3 – Fatal Drivers and the Time of Exposure to Accident Risk

As with all risky activities automotive driving naturally involves risk even if exercised with optimal care. Such risk varies in function of a myriad of factors, for instance; driver and vehicle characteristics, road environment, age of drivers and so on. However, the time of exposure to accident risk *(i.e. time spent driving and the intensity of the activity)* is truly a determinant factor when assessing accident probability. Using the available statistical data, we set out to study the trend in driver fatality toll *per* unit of time spent driving or in more technical terms, the *temporal -accident risk exposure rate.*

Albeit, average speeds differ considerably in accordance to location (urban or suburban areas) we considered mean velocity to be 60km/hr since available stats made such differentiation unfeasible. However, such hindrance does not affect our findings which we found to be very accurate in relative terms. The following graph conveys the trend in time spent driving per driver:

Graph 2.3.1

Estimated Time of Exposure to Accident Risk (Hours) *per* Driver (1975-2010)



Source data: ANSR (Fuel Consumption).

Let's suppose that the quantum of total driving time represents exposure to accident risk and that as more time is allocated towards the practice of this risky activity the greater total accident risk will be, *ceteris paribus*. In the figure above, we observe that average estimated driving mobility (per driver) diminished over the duration of the period under examination which consequently brings about a decrease in accident risk per driver and a reduction in the accident fatality toll thereof.

An explanation for the decreasing trend in the temporal-accident risk exposure rate per driver resides in a profound change in the structure of licensed drivers witnessed over the past couple decades. As more women and younger drivers gain access to the activity along with an increase in the number of vehicles per household, shorter routes will be travelled resulting in a reduction in accident risk exposure per driver. Statistical data has also pointed out the female drivers, on average, use more caution when driving.

2.4 – Some Comments on the Probability of Accident Fatality and Injury and the Behavior of Young People – in Particular Males.

New scientific findings are altering our perspective on how we perceive adolescent and young adult behavior. Today, research performed on the adolescent and young adult brain suggests that the human brain is still developing during adolescent years, with changes that continue into the early 20´s. (Giedd. J. N. (2004). [50].

Maturation of the prefrontal cortex in the brain (PFC) is not complete until near the age of 25. This brain region gives an individual the capacity to exercise "good judgment" when presented with difficult life situations since it is the part of the brain that governs the control mechanisms[51]. The PFC prompts a more careful deliberative analysis that triggers secondary emotional responses (secondary induction) that help guide advantageous decision-making (Levin, Irwin P. *et al*,2012)[52]. Thus, in accordance to these studies – inter alia (Denson, Thomas F.*et al*,

[50] Giedd. J. N. (2004). Structural magnetic resonance imaging of the adolescent brain. *Annals of the New York Academy of Sciences*, 1021, pp. 77-85.

[51] Idem.

[52] Levin, Irwin P. *et al* (2012) – A Neuropsychological Approach to Understanding Risk-Taking for Potential Gains and Losses.

2012)[53] – young people will have lesser ability to control their impulses causing them to be more risk-lovers or takers, especially when driving a vehicle. This behavior is known as *myopia* in terms of time preference, where individuals exhibit positive time preference (Loewenstein, George, 1987) [54] in relation to pleasure in the present (short-term) rather than in the future (long-term). When coupled with the development of part of the brain that commands self-control, it can explain much of the behavior of male young drivers on the road.

In economics this behavior is known as "'*bounded willpower' or 'insufficient self-command*'" (Sen, Amartya (2009:176)[55], what is sometimes called the "weakness of will", that Aristotle called *akrasia*[56 57] that occurs when we do wrong knowingly, typically as a result of some passion such as anger or pleasure.

As reported by Thaler and Sustein, people's state of arousal varies over time and the degree of arousal influences decision-making. The authors consider two extreme points: hot and cold. The decisions in a cold state are different from those in a hot state. The cold state is more related

[53] Denson, Thomas F.; Richard Ronay; William von Hippel;, Mark M. Schira1 (2012) – Endogenous testosterone and cortisol modulate neural responses during induced anger control. – Psychology Press, an imprint of the Taylor & Francis Group, an Informa business (Australia).

[54] Loewenstein, George (1987) – Anticipation and the Valuation of Delayed Consumption – The Economic Journal, 97: 666–684, reproduced *in* Exotic Preferences Behavioral. Economics and Human Motivation, by Loewenstein , pp. 385-410, Oxford University Press (2007).

[55] Sen , Amartya (2009) – The Idea of Justice – The Belknap Press of Harvard University Press, p.176.

[56] Aristotle – Rhetoric, *in* "*The Complete Aristotle*", *p. 2309.* – *//ebooks.adelaide.edu.au/a/Aristotle ."You may get your pleasure on the spot and the pain later, or the gain on the spot and the loss later. That is what appeals to weak-willed persons—and weakness of will may be shown with regard to all the objects of desire.".*

[57] Aristotle – Nicomachean Ethics, Book VII, 3.

with the reflexive system of thinking and the hot state is more associated with the automatic system of thinking.

The context influences the level of arousal and, consequently, the cold and hot states determine decision-making. The desires and behaviors of individuals will be altered when they are under the influence of arousal. Related with these states – cold and hot – are the classical case of Ulysses and the sirens. The songs of the sirens, as a metaphor, can be understood as the influence that emotions and feelings have in the decisions of individuals, which vary with the context in which they are, according to the state of arousal, hot or cold. As reported by Loewenstein:

> "*Affect has the capacity to transform us, as human beings, profoundly; in different affective states, it is almost as if we are different people. Affect influences virtually every aspect of human functioning: perception, attention, inference, learning, memory, goal choice, physiology, reflexes, self-concept, and so on….People who are in "hot" states tend to underappreciate the extent to which their preferences and behavioral inclinations are influenced by their affective state; they typically believe that they are behaving more dispassionately than they actually are*" (Loewenstein, George, 2005:S49) [58]

Understanding the internal mechanics and the hot-cold states of individuals, namely young people, allow us to develop processes in all areas, including automotive driving, in order to reduce the number of deaths and injuries on the road by applying measures that lead to changes in the behavior of young people, particularly young males.

The young in certain contexts, tend to act on their own short-term affect-driven preferences. Young drivers perceive risk differently than

[58] Loewenstein, George (2005) – Hot-Cold Empathy Gaps and Medical Decision Making – Health Psychology, 2005. Vol. 24, No.4 (Suppl.) S49-S56, p.S49.

adults (Glendon, A. Ian,2011:112)[59], their subjective level of risk (perceived risk) is usually lower than objective risk. The greater the gap between subjective risk and objective risk the greater the deviation from optimal care and, in consequence, the outcome (and the process) will be inefficient and the economic and social costs of accidents will not be minimized.

We can also integrate the *time discount rate* into this analysis and apply it to young drivers, mainly males. This *time discount rate* is not constant but hyperbolic (Shane, Frederick, *et al*, 2004); [60]. It is often used to convey the idea that a person has a declining rate of time preference. In this sense, internal factors associated with the development of a young person can lead to a high positive *hyperbolic discount rate*, producing a preference in young individuals for short-term pleasure (*time preference*[61]), thereby inducing them to take on high risk when driving with the negative consequences that our study has shown as well as other research conducted on this subject.

Such conduct by young drivers (displaying high risk proclivity) which may appear to violate the rationality axioms of neoclassical economics, constituting *anomalies* (Loewenstein, George; Richard Thaler, 1989)[62] for this theory, in reality should be understood as a normal pattern of human behavior. In fact, these anomalies must be considered as *regularities (Frey, Bruno S.; Alois Stutzer, 2007:4)*[63] *and as part of normal human behavior in accordance to biological, cultural and external factors.*

Bearing in mind that the "anomalies" considered by neoclassical theory are indeed normal behaviors – as behavioral economics, psychology and neuroeconomics have shown – one should not regard these anomalies as violations of rationality (Elvik, Rune, 2004:15)[64], but rather try to comprehend what factors – biological, cultural and others – determine these behaviors in order to develop the means that lead to the minimization of negative results, including high risk driving. The traditional theory of rational choice considers that a great part of the behavior of young drivers violates rational choice as advocated for over a century by economic neoclassical theory which is the underpinning of rational choice theory.

Many of the problems associated with the view of neoclassical economics results from Cartesian dualism (Descartes, René, 1637)[65] and Newtonian physics, which compares individuals to Newtonian atoms and, moreover, perceives rationality as devoid of feelings and emotions.

The vision of *homo economicus* (Thaler, Richard H.,2000)[66] limits the understanding of the complex system of motivations of the individual, where emotions and feelings are factors that determine the decisions under risk (all decisions are associated with some level of risk (Wilde,

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59 Glendon, A. Ian (2011) – Neuroscience and Young Drivers, *in* Handbook of Traffic Psychology -. ELSEVIER. "*Hence, although young drivers can "see" the same things (including obvious hazards) as adults, they cannot always perceive risks appropriately because they have yet to fully develop higher level cognitive interpretive functions*". p.112.

60 Shane, Frederick; George Loewenstein; Ted O` Donoghue (2002 [2004]) -Time Discounting and Time Preference: A Critical Review." *Journal of Economic Literature* 40 (June): 351–401, republished *in* Advances in Behavioral Economics, pp. 162-222 – Princeton University Press-2004.

61 *Idem*, p. 64.

62 Loewenstein, George; Richard Thaler (1989) – Anomalies Intertemporal Choice – Journal of Economic Perspectives –Vol. 3, No. 4 – pp. 181-193.

63 Frey, Bruno S.; Alois Stutzer (2007) – The Economics and Psychology: Developments and Issues. *in Economics and Psychology*, p. 4 – CESifo Seminar Series.

64 Elvik, Rune (2004) – Why some road safety problems are more difficult to solve than others, p.15. – Institute of Transport Economics. Oslo, Norway,

65 Descartes, René (1637) – *Discourse on the Method of Rightly Conducting the Reason, and Seeking Truth in the Sciences*: – This Electronic Book Is a Publication of the Pennsylvania State University's Electronic Classics Series, Jim Manis Faculty Editor, pp. 22-23.

66 Thaler, Richard H. (2000) – From Homo Economicus to Homo Sapiens – Journal of Economic Perspectives—Volume 14, Number 1—Winter 2000—Pages 133–141.

Gerald J.S.,2001:1)[67]). It is not only reason that determines the behavior, as has been understood by neoclassical theories. Economic theory was largely derived from rational, consequentialist assumptions about decision-making. Standard economic theory assumes that people choose between alternative courses of action based on the desirability or "utility" of their consequences. (Loewenstein, George; Scott Rick,2004) [68]

The "status quo bias" (Kahneman, Daniel; Jack L. Knetsch; Richard H Thaler,1991:193-206) [69] suggests that individuals have preference for present rather than future situations, and because the level of cognitive interpretative functions is less developed in younger individuals there is a natural tendency for young people to prefer the present to the future when obtaining satisfaction from driving.

To understand the behavior of young people it is also necessary to take into account peer pressure as well as all intersubjectivity **(Davis, John,2002)[70]** comprising relations of alterity that are external factors that influence their behavior.

Rune Elvik (2004:15)[71] poses the question that some road safety problems are harder to solve than others, explaining that biological factors

[67] Wilde, Gerald J.S. (2001) – *Target Risk2*. Toronto-Ontario: PDE Publications, 2001, p. 1.

[68] Loewenstein, George; Scott Rick (2004) – Emotion in economics (The challenge of emotions for economic theory) – *Letters Proceedings: Biological Sciences*, 4, 177-179. (Proc. R. Soc. Lond. B; Suppl., DOI 10.1098/.

[69] Kahneman, Daniel; Jack L. Knetsch; Richard H Thaler (1991) – Anomalies The Endowment Effect, Loss Aversion, and Status Quo Bias – *Journal of Economic Perspectives* – Volume 5, No. 1 – Winter 1991 – pp. 193-206.

[70] Davis, John (2002) – Collective intentionality and individual behavior *in* "Intersubjectivity in Economics", pp.11-27 – Rutledge.

[71] Elvik, Rune (2004) – Why some road safety problems are more difficult to solve than others, p.15. – Institute of Transport Economics. Oslo, Norway, referring Evans, L. (2006) *in* "Innate sex differences supported by untypical traffic fatalities. Chance", 19 (1), 10-15.

contribute towards young drivers being more risk-loving, namely because the level of testosterone influences the level of risk taking.

Rona and Von Hippel reported that physical risk taking by young men increases in the presence of an attractive female, and "*that this increase in risk taking is caused in part by elevated testosterone levels of men who performed in front of the attractive female.*" (Ronay, Richard; William von Hippel,2009) [72] The increase in the level of testosterone combined with a low level of cortisol reduces fear – increasing the level of risk – reduces focus attention on rewards and reduces sensitivity to losses (Van Honk, Jack *et al*, 2005) [73] which is associated with decreased aversion to risk (Carney, Dana R.; Mason, Malia F.) [74].

Other studies[75] (Mehta, Pranjal H.; Robert A. Josephs,2010; Josephs, Robert A.*et al*,2006) [76] show that threats to status cause more testosterone production and thus increase risk propensity. So, when young people, especially males, are with their peers or driving with their girlfriends they tend to reveal their status. When such status is threatened they are led to reveal dominance and risk taking. This is one of the physiological and behavioral factors that can help explain higher accident fatality and injury rates among young males.

[72] Ronay, Richard; William von Hippel, (2009) – Power, Testosterone, and Risk-Taking -Journal of Behavioral Decision Making, J. Behav. Dec. Making, (2009)

[73] Van Honk, Jack *et al* (2005) – Testosterone Reduces Unconscious Fear but Not Consciously Experienced Anxiety: Implications for the Disorders of Fear and Anxiety – BIOL PSYCHIATRY. 2005;58:218–225. 2005 Society of Biological Psychiatry.

[74] Carney, Dana R.; Mason, Malia F. (-) – Moral Decisions and Testosterone – Columbia University.

[75] Mehta, Pranjal H.; Robert A. Josephs (2010) – Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone hypothesis – journal homepage: www.elsevier.com/ locate/yhbeh.

[76] Josephs, Robert A.; Jennifer Guinn Sellers; Matthew L. Newman; Pranjal H. Mehta (2006) – The Mismatch Effect: When Testosterone and Status Are at Odds – Journal of Personality and Social Psychology Copyright 2006 by the American Psychological Association 2006, Vol. 90, No. 6, 999–1013.

Given that the capacity for reflection and self-control in young people is not fully developed until about the age of 25, *visceral factors* should also be considered as playing an important role in their behavior. Visceral factors influence behavior more directly, as stated by Loewenstein:

"*virtually all visceral factors can influence behavior without conscious cognitive mediation* (Loewenstein, Georg, 2004)"[77]. In the same vein, Peterson: "*because the reward and loss systems influence thought and lie beneath awareness, they often direct behavior automatically through subtle emotional influences on judgment, thinking, and behavior*[78]*... the emotion of excitement indicates that one has identified an opportunity. Excitement propels increased risk seeking and exploratory behavior*". (Peterson, Richard L. , 2007:26 and 37) [79].

We can also refer that the way of life of young people, the alteration of sleep, mainly on weekends, will affect the level of risk. (Groeger, J. A., 2006) [80].

In order to understand the behavior of young drivers we should also consider what is known in behavioral economics as *procedural utility*. It has been convincingly demonstrated that people do not only value outcomes but also the way by which they are reached.(Frey, Bruno F.; Alois Stutzer,2007:7)[81] Therefore, young drivers can often lead to high risk levels since driving pleasure devalues the results of their behavior.

77 Loewenstein, Georg (2004) – Out of Control: Visceral Influences on Behavior, *in* Advances in Behavioral Economics (2004), p. 694. – Princeton University Press.

78 Peterson, Richard L. (2007) – Inside the Investor's Brain – John Wiley & Sons, p. 26.

79 Idem, p. 37.

80 Groeger, J. A. (2006) – Youthfulness, inexperience and sleep loss: The problems young drivers face and those they pose for us – Injury Prevention, 12, i19 – i 24

81 Frey, Bruno F.; Alois Stutzer (2007) – Economics and Psychology: Developments and Issues., *in* Economics and Psychology A Promising New Cross – Disciplinary Field, p. 7 – The MIT Press.

According to several studies (Thaler, Richard H.; Cass R. Sunstein, 2007)[82] there are two systems (Camerer, Colin; George Loewenstein; Drazen Prelec, 2005:16)[83] of thinking, one that is intuitive and automatic (Automatic System) and the other reflective and rational (Reflective System), and whose characteristics are summarized in the following chart:

Chart 2.4.1

Cognitive systems

Two cognitive systems	
Automatic System	Reflective System
Uncontrolled	Controlled
Effortless	Effortful
Associative	Deductive
Fast	Slow
Unconscious	Self-aware
Skilled	Rule-following

Source: Thaler, Richard H.; Cass R. Sunstein (2007) – Nudge Improving Decisions About Health, Wealth, and Happiness[84] – Yale University Press, p. 20.

Reflective or analytical system judgment is primarily logic based, while the intuitive or automatic system is rapid and feeling based. If we consider that some functions of the human brain related to self-control and reflection, are only complete at around 25 years old, we can deduce that young drivers mainly use the functions related to the automatic system, which can be potentiated by visceral factors, as mentioned earlier, developing high risk proclivity on young people, explaining, at least in part, the high number of deaths and injuries of young male drivers in

82 Thaler, Richard H.; Cass R. Sunstein (2007) – Nudge. Improving Decisions About Health, Wealth, and Happiness – Yale University Press.

83 Camerer, Colin; George Loewenstein; Drazen Prelec (2005) – Neuroeconomics: How Neuroscience Can Inform Economics, p. 16 – *Journal of Economic Literature Vol. XLIII (March 2005), pp. 9–64*

84 See also: Kahneman, Daniel (2011) – Thinking Fast and Slow – Farrar, Straus and Giroux. (Kahneman calls system I (Fast) and system II) (Slower)), pp. 20-21.

road accidents. According to Zweig (2007)[85] cited by Donald T. Wargo[86] *et al*, the size of the reward is processed by the automatic system, unconsciously, while the probabilities must be processed in the rational brain, the reflective system, which may mean that young male drivers tend to make their decisions underpinned in their emotions and feelings without the control that is developed by the reflection system.

Consequently, in view of the advances in scientific knowledge about human behavior, road safety policy should take into account greater risk propensity among young males, which is evidenced by the analysis on the probabilities of dying or getting injured in road traffic accidents, leading to the need for greater oversight and intervention in road safety.

> "*Therefore, interventions to reduce road traffic injuries among the young must take into account the evolving complexity of brain – behavior – social context interactions from birth to young adulthood.*" (Huang, Patty; Flaura Koplin Winston, 2011:315)[87]

Since the consequences of traffic accidents in relation to young people are very austere for society, seeing that individuals aged 18 to 24 are more likely to die or get injured in road accidents, we quote Rune Elvik on the importance of adopting systemic measures by society – including policy makers,

[85] Zweig, J. (2007) -Your Money and Your Brain: How the New Science of Neuroeconomics Can Help Make You Rich – New York: Simon and Schuster.

[86] Wargo, Donald T.; Norman A. Baglini; Katherine A. Nelson (2010) – Dopamine, expected utility and decision-making in the firm, *in* Neuroeconomics and the Firm, p.166. – Edward Elgar Publishing, Inc..

[87] Huang, Patty; Flaura Koplin Winston (2011) – Young Drivers, *in Handbook of Traffic Psychology*. – ELSEVIER, p. 315.

> "*The greater its magnitude, since a major problem may require major investments or major changes in road user behaviour in order to be solved,*" (Elvik, Rune, 2004:12)[88].

According to what was analyzed we can conclude that change can be brought about by interventions that effectively alter young people´s perception values of risk, namely increasing the probability of law enforcement and at a more general and profound level, investing in cultural, ethical and moral values, which alter the internal sanctions for violations of rules, increasing the global sanction and, consequently changing the behavior of individuals. For safety, behavioral change in relation to automotive driving shall be more important than technological measures and policies. In this vein we cite Dieter Klebelsberg,

> "*a dangerous road does not imply that certain constructional – i. e. , non-individual – properties of the road are dangerous in themselves, but that on this road an unusual amount of dangerous behavior is to be observed; thus, the road only becomes dangerous or safe through behavior.*" (Klebelsberg, Dieter, 1994:51) [89]

Considering the interaction of multiple factors as determinants of accidents, which form a complex and dynamic system, we must act in an integrated manner in order to obtain effective results and, thus, minimize the social cost of accidents. We must consider not only the underlying factors but also the role played by the different players and the efforts of institutions in increasing accident prevention since crashes along with their consequences are a multidimensional problem that requires a broad view and understanding of the causes, consequences and solutions. On this subject, we provide the reader with the following fig-

[88] Elvik, Rune (2004) – Why some road safety problems are more difficult to solve than others – Institute of Transport Economics. Oslo, Norway, p. 12.

[89] Klebelsberg, Dieter (1994) – Is Risk Compensation a Personality Trait, and Attitude or a Behavior?, *In* "Challenges to Accident Prevention. The Issue of Risk Compensation Behavior", p. 51. – STYX Publications, Groningen, The Netherlands.

ure which portrays an integrated view on accidents and outlines the named theory "Risk – Motivation Theory", proposed by Rudiger Trimpop (Trimpop,1994)[90]:

Chart 2.4.1

Risk Motivation Theory

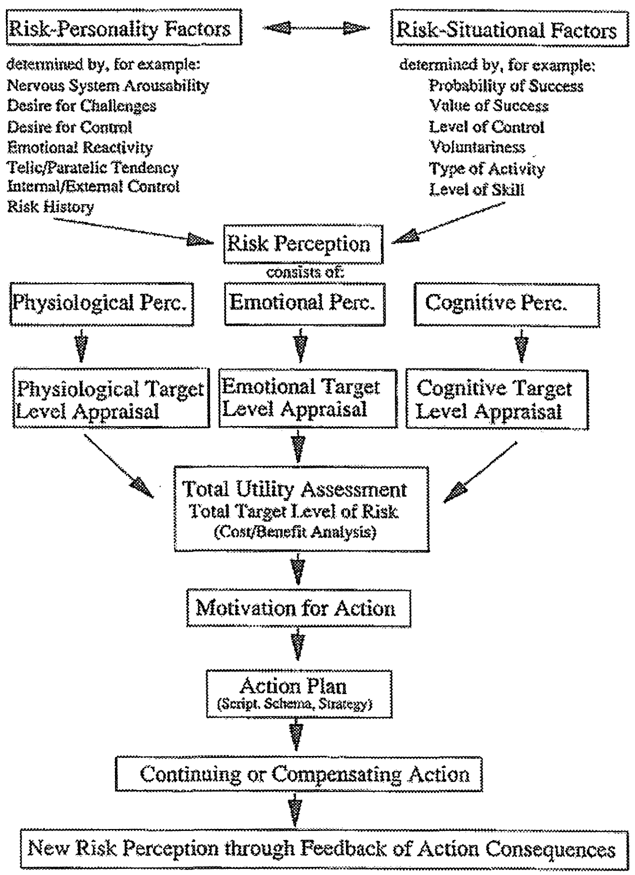

Figure 1: Risk Motivation Theory (RMT)
(Perception-Appraisal-Motivation-Compensating Action-Feedback Model)

[90] Trimpop, Rudiger (1994) – Risk Compensation and the Interaction of Personality and Situational Variables, *in* "Challenges to Accident Prevention. The Issue of Risk Compensation Behavior" – STYX Publications, Groningen, The Netherlands.

Source: Rudiger Trimpop – Risk Compensation and the Interaction of Personality and Situational Variables, *in* "Challenges to Accident Prevention. The Issue of Risk Compensation Behavior", p.142. – STYX Publications, Groningen, The Netherlands.

This theory encompasses the cognitive, emotional and psychological dimensions and can be related to what we analyzed above in relation to the diverse factors that tend to explain the behavior of young people when driving.

On a final note, the demographic structure of population has a great impact on traffic safety. As young road users represent high accident risk basically worldwide, and considering that the proportion of young people on the general population has decreased, especially in Portugal due to a low birth rate, there should be fewer casualties in the near future in relation to younger drivers.

2.5 – Conclusions

The analyses conducted above allow us to extract the following conclusions:

- Age is one of the risk factors of road traffic deaths and injuries;
- In what concerns accident fatality, the probability of death for an individual belonging to 18-24 age interval in relation to the total number of accident deaths is usually the highest amongst all other ages;
- Further, estimated accident fatality probability for the contemporaries of the 18-24 age cluster in relation to its total corresponding age group population drew attention since it recorded the highest percentage values amongst all other ages;
- With respect to the accident injury toll, results were conclusive in suggesting that individuals between the ages of 18 and 24 are susceptible to a higher probability of accident injury when compared to total number of crash injuries.

- The probability rates of the 25-34 age group was also prominent due to constant percentage increases from 2000 until 2005;
- Another age group recording high percentage increases since 2005 and until 2011 was the 35-49 age group mostly because of the low birth rate and the aging of younger drivers.
- Evidence from the rate comparison of fatalities to injuries shows that the 65 and above age group cataloged the highest percentage values mostly due to reasons of physiological and physical nature. Moreover, since this particular age group constitutes the bulk of registered run-down pedestrians it becomes obvious why it has registered the highest percentage ratios of accident fatalities to accident injuries. Thus, in order to abate such causalities more investment on strategies that persuade divers to adopt optimal levels of driving care should be adopted – especially in urban and high density areas.
- Among the myriad of feasible measures more *speed bumps* are required in certain inner-city streets and roads impelling drivers to reduce speed even if their level of *desired risk (target risk)* [91] is greater than objective risk. Perhaps, consequential damages caused by speed bumps to vehicles when driving at inadequate speeds may serve as stimuli for drivers, thus demanding higher levels of driving care.
- Other strategies can also encourage efficiency and therefore reduce personal damages such as increasing the *expected sanction*[92] which can be achieved by the dint of effective radars on roads and highways. As further analyzed in section 3.6 of chapter III, the most effective policy destined towards behavioral changes in risk –loving drivers is to increase the probability of law enforcement.

[91] Level of *desired risk (target risk)* is the optimal level of risk that the individual is willing to incur where expected costs and benefits are maximized in accordance to the person's perception. Vide: Section 1.4 of Chapter I.

[92] See: Section 3.6 of Chapter III.

- From extensive empirical study above we also conclude that individuals comprehended between the ages of 18 and 24 followed by the 25-34 age group are more vulnerable to automotive accident death and injury. Evidence supporting once more the need to develop road safety measures aimed specifically towards this portion of the population inculcating valuable information and moral values that ultimately induce drivers to control risk factors, to alter levels of desired risk and to modify automotive driving behavior.
- A long term policy would be to investment on driver education and information dissemination regarding objective risk inherent to automotive driving. In fact, individuals who belong to this particular age bracket are in great part risk-takers suggesting that an increase of law enforcement, carried out by numerous methods of intervention, is an adequate measure towards reducing the harm caused by reckless driving and low levels of driving care.
- Along with other risky behaviors, excessive speed is a form of arousal for young and old drivers alike who seek pleasure and the approval of their peers. If more social activities and beneficial programs were to be accessible to youngsters coinciding with their personal interests then reckless risky driving behavior would dissipate ultimately contributing towards a reduction in automotive accident fatality and injury;
- Usually, the majority of drivers especially those between the ages of 18-24 are *risk-under-estimators* with levels of *subjective risk (perceived risk)* much inferior to the *real and objective probability* of accident involvement. As a result, drivers generate a level of *objective risk* superior to optimal which consequently originates greater accident risk;

- Concerns must be raised by policy-makers regarding the risk-taking behavior of young people, namely males, where the results obtained herein have strongly stressed the need to take a more broad-based, systematic and social-determinant approach to the behavior of young drivers.
- We also analyzed certain factors related to young male drivers and their propensity towards risk. Biological factors must be taken into account when implementing policy measures. Among these biological factors we highlighted the incompleteness of the prefrontal cortex in the brain (PFC) which fully develops at about the age of 25[93]. As previously stated the PFC is the part of the brain that governs the control mechanisms and integrates the reflexive system.
- Young people are on average risk-takers especially in activities that provide them with immediate pleasure. Their hyperbolic time preference discount rate is higher and they are also more influenced by visceral factors – whose effects are less controlled due to their cerebral maturation – leading them to frequently use their automatic system of thinking rather than their reflective one.

93 Idem.

III
Automotive Accidents and Gender of Drivers

The aim of this section is to study the relation between gender of drivers and automotive accidents. Using available data we were able to estimate the probabilities of automotive accident fatality according to the respective gender of drivers.

Similar to driver age, driver gender is a factor that indirectly affects both automotive driving behavior and the level of driving care (Evans, 1991:23)[94]. In spite of progress made by society in relation to equality among men and women, there are still differences. Society still sets different standards of conduct, assigning different characteristics for men and women. Audacity and competiveness which are traditionally associated to masculinity, contribute to the underlying assumption that men are more prone to risk than women and hence are more vulnerable to automotive accidents. The same idea can be illustrated in following chart where one can observe the trend in the driver death toll in accordance to corresponding gender:

94 Evans, Leonard.-(1991) *Traffic Saftey and the Driver*. New York: Van Nostrand Reinhold, 1991, p. 23. Studies conducted in the U.S have shown that the effects of accidents vary between males and females with similar ages.

Chart 3.1

Fatal Drivers According to Gender (1987-2011)

Year	Dead drivers				
	Total	Male		Female	
		N.º	%	N.º	%
1987	1,155	1,110	96.10%	45	3.90%
1988	1,255	1,205	96.02%	50	3.98%
1989	1,224	1,171	95.67%	53	4.33%
1990	1,237	1,171	94.66%	66	5.34%
1991	1,277	1,203	94.21%	74	5.79%
1992	1,309	1,243	94.96%	66	5.04%
1993	1,063	998	93.89%	65	6.11%
1994	1,036	973	93.92%	63	6.08%
1995	1,139	1,080	94.82%	59	5.18%
1996	1,145	1,085	94.76%	60	5.24%
1997	1,104	1,048	94.93%	56	5.07%
1998	1,070	1,015	94.86%	55	5.14%
1999	1022	942	92.13%	80	7.87%
2000	916	844	92.13%	72	7.87%
2001	838	776	92.60%	61	7.28%
2002	832	759	91.23%	73	8.77%
2003	836	775	92.70%	61	7.30%
2004	677	627	92.61%	49	7.24%
2005	667	608	90.21%	59	8.85%
2006	526	487	92.01%	39	7.41%
2007	527	487	91.71%	40	7.59%
2008	490	435	88.78%	55	11.22%
2009	449	409	91.09%	40	8.91%
2010	479	441	92.07%	38	7.93%
2011	440	392	89.09%	48	10.91%

Source: ANSR. Adapted. . Annual data 1987-2011

Indeed, we verify that the number of dead female drivers is much lower than that of male drivers. In 2011 the ratio of total male fatal drivers to total of fatal drivers, was about 89%.

To make further assessment easier in regards to this phenomenon we elaborated the following chart illustrating the total number of drivers according to their gender and their corresponding ratios from 1990 to 2007:

Chart 3.2

Number of Drivers *per* Gender

Year	Sex		Total	%	
	Male	Female		Male	Female
1990	1,126,853	272,182	1,399,035	80.55%	19.45%
1991	1,239,289	355,878	1,595,167	77.69%	22.31%
1992	1,369,990	457,516	1,827,506	74.97%	25.03%
1993	1,841,225	679,962	2,521,187	73.03%	26.97%
1994	1,960,049	793,295	2,753,344	71.19%	28.81%
1995	2,071,064	900,071	2,971,135	69.71%	30.29%
1996	2,177,743	1,002,009	3,179,752	68.49%	31.51%
1997	2,272,246	1,098,198	3,370,444	67.42%	32.58%
1998	2,361,682	1,189,018	3,550,700	66.51%	33.49%
1999	2,539,881	1,308,117	3,847,998	66.01%	33.99%
2000	2,718,597	1,438,338	4,156,935	65.40%	34.60%
2001	2,847,056	1,543,675	4,390,731	64.84%	35.16%
2002	2,987,562	1,653,515	4,641,077	64.37%	35.63%
2003	3,104,894	1,755,093	4,859,987	63.89%	36.11%
2004	3,219,213	1,853,683	5,072,896	63.46%	36.54%
2005	3,299,386	1,928,235	5,227,621	63.11%	36.89%
2006	3,387,129	2,009,518	5,396,647	62.76%	37.24%
2007	3474872	2,090,801	5,565,673	62.43%	37.57%

Source: Adapted. ANSR. Annual data 1990-2007

In absolute terms the number of drivers (male and female) prominently increased over the prolonged period in consideration although the corresponding percentage of female drivers increased at a higher rate checking in with percentage ratios in relation to total drivers of 19.45% in 1990 and 37.57% in 2007. More important, however, is the fact that the gap between both percentage ratios has narrowed since 1990 mostly due to an extreme increase of female drivers. Before proceeding, we can easily infer that according to the data displayed above the number of registered female drivers is still inferior to that of male drivers not only in absolute terms but also in relative terms.

Surely, the escalating number of female drivers rendered a percentage augmentation in the female driver fatality toll recording a minimum percentage of 3.9% in 1987, a maximum of 8.75% in 2005 and recently 7.53% in 2007 (*Vide*: chart 1.3.1).

Running through the list of various reasons that may acutely explain the statistical data above we dare to mention that inevitably women tend to adopt higher levels of driving care than men, especially when it comes to controlling speed. It is also most likely that the average temporal and spatial mobility rates of women drivers are inferior[95] to those of male drivers[96] implying lower exposure to accident risk and consequently a lower probability of accident involvement.

3.1 – Estimated Probabilites of Death for Drivers According to Gender[97]

In view of the information provided in charts 1.3.1 and 1.3.2 we calculated the estimated automotive accident fatality probabilities of drivers according to gender, using the following equation:

$$p\,(D|dv) = p\,(D|Fdv) \times p\,(Fdv) + p\,(D|Mdv) \times p\,(Mdv)$$

where:

p: Probability

D: Accident Death;

dv: Drivers;

p(D|dv): Probability of death in an accident given that the victim is a driver;

Tdv: Total number of drivers;

[95] However, we do not have proper and sufficient data that allows us to prove the validity of this statement.

[96] In this sense, the fact that male professions usually involve more total driving time plays an important role when comparing male and female driver temporal mobilities.

[97] I am grateful to Professor Bento Murteira and Professor João Faria for the clarification they gave me in this part of the study.

Fdv: Total number of female drivers;

Mdv: Total number of male drivers;

TDdv: Total number of dead drivers;

DFdv: Total number of dead female drivers

DMdv: Total number of dead male drivers

p(Fdv): Probability of a driver being female (Fdv/Tdv);

p(Mdv): Probability of the driver being male (Mdv/Tdv);

p(D|Fdv): Probability of death in an accident given that the driver is female (DFdv/Fdv);

p(D|Mdv): Probability of death in an accident given that the driver is male (DMdv/Mdv).

In spirit of compromise with what was established in the equation above, the estimated probabilities are as follows:

Chart 3.1.1

Estimated Probabilities

Year	P{D}	P{Fdv/ Tdv}	P{Mdv/ Tdv}	P{DFdv| TDdv}	P{DMdv/ TDdv}	(DFdv/ Fdv)	(DMdv/ Mdv)
1990	0.0009	0.195	0.805	0.053	0.947	0.00024	0.00104
1991	0.0008	0.223	0.777	0.058	0.942	0.00021	0.00097
1992	0.0007	0.250	0.750	0.050	0.950	0.00014	0.00091
1993	0.0004	0.270	0.730	0.061	0.939	0.00010	0.00054
1994	0.0004	0.288	0.712	0.061	0.939	0.00008	0.00050
1995	0.0004	0.303	0.697	0.052	0.948	0.00007	0.00052
1996	0.0004	0.315	0.685	0.052	0.948	0.00006	0.00050
1997	0.0003	0.326	0.674	0.051	0.949	0.00005	0.00046
1998	0.0003	0.335	0.665	0.051	0.949	0.00005	0.00043
1999	0.0003	0.340	0.660	0.079	0.921	0.00006	0.00037
2000	0.0002	0.346	0.654	0.079	0.921	0.00005	0.00031
2001	0.0002	0.352	0.648	0.073	0.926	0.00004	0.00027
2002	0.0002	0.356	0.644	0.088	0.912	0.00004	0.00025
2003	0.0002	0.361	0.639	0.073	0.927	0.00003	0.00025
2004	0.0001	0.365	0.635	0.072	0.926	0.00003	0.00019
2005	0.0001	0.369	0.631	0.088	0.902	0.00003	0.00018
2006	0.0001	0.372	0.628	0.071	0.920	0.00002	0.00015
2007	0.0001	0.376	0.624	0.075	0.917	0.00002	0.00014

Source: Adapted. ANSR. Annual data 1990-2007

In resort to the *conditional probability* concept, we were able to obtain the equations below and the corresponding automotive accident fatality probabilities for a female and/or male driver:

p (D|Fdv) = p (D) x p (Fdv|D) / p (Fdv)

p (D|Md)= p (D) x p (Md|D) / p (Md)

Chart 3.1.1

Estimated Automotive Accident Fatality Probabilities for a female and/or male driver

Year	P(D| Fdv)	P(D| Mdv)	{P(D| Mdv) / P(D| Fdv)}
1990	0.00024	0.00104	4.29
1991	0.00021	0.00097	4.67
1992	0.00014	0.00091	6.29
1993	0.00010	0.00054	5.67
1994	0.00008	0.00050	6.25
1995	0.00007	0.00052	7.96
1996	0.00006	0.00050	8.32
1997	0.00005	0.00046	9.04
1998	0.00005	0.00043	9.29
1999	0.00006	0.00037	6.03
2000	0.00005	0.00031	6.20
2001	0.00004	0.00027	6.90
2002	0.00004	0.00025	5.75
2003	0.00003	0.00025	7.18
2004	0.00003	0.00019	7.37
2005	0.00003	0.00018	6.02
2006	0.00002	0.00015	7.71
2007	0.00002	0.00014	7.33

Source: Adapted. ANSR. Annual data 1990-2007

Essentially, the data shown above illustrates that in 1998 for every 100,000 female drivers 5 died from automotive accidents whereas in every 100,000 male drivers 43 died from the same cause. Stated differently, in 1998 the estimated probability of death for male drivers is 9.3 times higher than that of female drivers having since decrease to 7.3 times in 2007. These results indicate that the majority of men underestimate the risk of accident fatality when compared to women.

3.2 – Fatality Rate of Drivers in Contrast to the Total Number of Drivers and in Accordance to Gender

The following chart specifics the fatality rate of drivers according to gender contrasting it to the total number of drivers:

Chart 3.2.1

Fatality Rate of Drivers Compared to the Total Number of Drivers According to Gender

Year	Sex/ gender	
	Male	Female
1990	0.104%	0.024%
1991	0.097%	0.021%
1992	0.091%	0.014%
1993	0.054%	0.010%
1994	0.050%	0.008%
1995	0.052%	0.007%
1996	0.050%	0.006%
1997	0.046%	0.005%
1998	0.043%	0.005%
1999	0.037%	0.006%
2000	0.031%	0.005%
2001	0.027%	0.004%
2002	0.025%	0.004%
2003	0.025%	0.003%
2004	0.019%	0.003%
2005	0.018%	0.003%
2006	0.015%	0.002%
2007	0.014%	0.002%

Source: Adapted. ANSR. Annual data 1990-2007

Not surprising, however, is the fact that the male driver fatality rate overshadows the corresponding rate of female drivers. Beyond this preliminary observation we see that the rate concerning male drivers has decreased from 0.104% in 1990 to 0.014% in 2007. In addition, the same occurred in the case of female drivers having registered a continuous percentage drop roughly from 0.024% in 1990 to 0.002% in 2007.

Taking into account the results gathered we reason that the accident fatality rate of women drivers is proportionally lower than that of male drivers. Coherent reasons that may explain such dissimilarity reside in the fabric of gender behavioral characteristics, that is, different attitudes towards driving risk, different vehicle purposes, different driving habits, and most importantly of all different spatial mobility rates translated into accident risk exposure.

3.3 – Comments on the Results of the Propabilities of Death and Injury Among Male and Female Drivers

Studies in the field of neuroscience on the level of risk taken when driving, in relation to gender, show that women are more influenced by context and culture than for biological reasons. Further, statistical data indicates that female drivers, on average, adopt higher levels of driving care. As reported by Ray Fuller :

> "*The acceptable level of risk feeling and task difficulty may vary as a function of factors such as journey goals and emotional state, and there appear to be individual differences in preferred levels related to age, experience, gender, and personality.*" (Fuller, Ray, 2011:24)[98].

We must consider that, although the probability of dying or being injured in road accidents is lower for females, as shown by Evans:

"*Fatality risk from the same impact is found to be (22 ± 9)% greater for females than for males, and to increase annually after age 20 by (2.86 ± 0.32)% for males and (2.66 ± 0.37)% for females.*".(Evans; Gerrish, 2004)[99]

98 Fuller, Ray (2011) – Driver Control Theory. From Task Difficulty Homeostasis to Risk Allostasis . *in* Handbook of Traffic Psychology, p.24 – Bryan E. Porter. ELSEVIER.

99 Evans, Leonard; Gerrish, Peter H. (2004) – Gender And Age Influence On Fatality Risk From The Same Physical Impact Determined Using Two-Car Crashes.

Other studies reveal that women are more risk averse (Croson; Gneezy, 2009)[100] than men (Sapienza, et al, 2009)[101] due to biocharacteristics and because testosterone is more abundant in men as several studies (van Honk, 2010, 2005;Carney; Mason, 2010; Ronay; von Hippel, William, 2010);Ronay; von Hippel, William, 2009; Mazur, Allan; Booth, Alan, 1998; Denson, Thomas F. et al, 2012; Mehta, Pranjal H. et al, 2010; Josephs, Robert A., 2006;Apicella, C. L., Dreber,2008) [102 103 104] have shown.

100 Croson, R., and Gneezy, U. (2009) – Gender differences in preferences, *Journal of Economic Literature*, **47**, 448–74.

101 Sapienza, Paola; Zingales, Luigi; Maestripieri, Dario (2009) – Gender differences in financial risk aversion and career choices are affected by testosterone – University of Chicago, Chicago, IL, July 1, 2009.

102 van Honk, Jack et al (2010) – Socially Explosive Minds: The Triple Imbalance Hypothesis of Reactive Aggression – Journal of Personality 78:1, February 2010.
– van Honk, Jack*et al* (2005) – Testosterone Reduces Unconscious Fear but Not Consciously Experienced Anxiety: Implications for the Disorders of Fear and Anxiety – BIOL PSYCHIATRY 2005;58:218–225. 5.
– Carney, Dana R.; Mason, Malia F.(2010) – Decision making and testosterone: When the ends justify the means – Elsevier.
– Ronay, Richard; von Hippel, William (2010) – The Presence of an Attractive Woman Elevates Testosterone and Physical Risk Taking in Young Men – Social Psychological and Personality Science
– 1(1) 57-64. SAGE.
– Ronay, Richard; von Hippel, William (2009) – Power, Testosterone, and Risk-Taking – Journal of Behavioral Decision Making J. Behav. Dec. Making, (2009).
– Mazur,Allan; Booth, Alan (1998) – Testosterone and dominance in men – BEHAVIORAL AND BRAIN SCIENCES (1998) **21**, 353–397.
– Denson, Thomas F. *et al* (2012) – Endogenous testosterone and cortisol modulate neural responses during induced anger control – Psychology Press, an imprint of the Taylor & Francis Group, an Informa business (Australia).
– Mehta, Pranjal H. *et al* (2010) – Genetic, Hormonal, and Neural Underpinnings of Human Aggressive Behavior – Handbook of Neurosociology, Handbooks of Sociology and Social Research. Springer Science+Business Media B.V. 2012.

103 Josephs, Robert A. (2006) – The Mismatch Effect: When Testosterone and Status Are at Odds. – Journal of Personality and Social Psychology 2006, Vol. 90, No. 6, 999–1013.

The higher the level of testosterone the higher the risk propensity, since men are more overconfident (Barber, B. M.; Odean, T., 2001)[105]. Hence, we can conclude that there are biological factors that predispose men to be more risk lovers than women, In effect, there is a tendency towards a higher level of driving risk in relation to men than that of women. (Andersson, Henrik; Petter Lundborg, 2006)[106].

3.4 – Conclusions

Our study brings into light that indeed there is an important linkage between the sex/gender of drivers and automotive accident risk:

- The female driver fatality toll is lower than that of male drivers, both in absolute and relative terms;
- When considering the total female driver fatality toll, the probability of a female driver dying in an automotive accident is much seldom when compared to a male driver. As evidence we submitted the different percentages registered for both genders showing that female drivers recorded a percentage of 0.053 in 1990 and 0.075 in 2007 and male drivers 0.95 and 0.92 respectively.
- Of equal significance is the upsetting fact that during 1998 in every 100,000 female drivers nearly 5 died as a result of automotive accidents whereas in every 100,000 male drivers 43 died from the same cause. These numbers indicate that the probability of death of a male driver was 10 times higher than that of a women driver. Laudable progress has been recorded ever since. In 2007 the probability of male drivers had decreased, however it was still 7 times greater than the probability of the opposite sex.
- Generally speaking, one can infer that women tend to adopt higher levels of driving care when compared to men. This is why the probability of accident fatality for male drivers is substantially higher than that of female drivers. This fact could some what be a direct result of the values embodied in Portuguese society where *risk* is a prominent behavioral characteristic of masculinity and due to biological factors.

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[104] Apicella, C. L., Dreber, A., Campbell, B., Gray, P. B., Hoffman, M.; Little, A. C. (2008) – Testosterone and financial risk preferences, *Evolution and Human Behavior*, **29**, 38490.

[105] Barber, B. M.; Odean, T. (2001) – Boys will be boys: gender, overconfidence, and common stock investment, *Quarterly Journal of Economics*, 116, 261–92, pp. 264-266.

[106] See also: Andersson, Henrik; Petter Lundborg (2006) – *Perception of Own Death Risk An analysis of Road-Traffic and Overall Mortality Risks* – VTI notat 12A-2006, Stockholm, Sweden.

Bibliography

Akerlof, George A.; Kranton, Rachel E. (2010) – Identity Economics how our identities shape our work, wages, and well-being, p. 11. Princeton University Press, Princeton and Oxford.

Amoros, Emmanuelle [et al.] (2008)–Actual incidences of road casualties, and their injury severity, modelled from police and hospital data – France.European Journal of Public Health. Oxford: Oxford University Press. Vol. 18, No. 4, p. 360-5.

Andersson, Henrik; Petter Lundborg (2006) – *Perception of Own Death Risk An analysis of Road-Traffic and Overall Mortality Risks* – VTI notat 12A-2006, Stockholm, Sweden.

Apicella, C. L., Dreber, A. Campbell, B., Gray, P. B., Hoffman, M.; Little, A. C. (2008) – Testosterone and financial risk preferences, *Evolution and Human Behavior*, **29**, 38490.

Aristotle – Nicomachean Ethics, Book VII, 3.

Aristotle – Rhetoric, *in "The Complete Aristotle", p. 2309.* – *//ebooks.adelaide.edu.au/a/Aristotle.*

Barber, B. M.; Odean, T. (2001) – Boys will be boys: gender, overconfidence, and common stock investment, *Quarterly Journal of Economics*, **116**, 261–92, pp. 264-266.

Backer, S.P; O'Neil, B.; Karph, R.S. (1984) – *The Injury Fact Book*. Lexington: Lexington Books, 1984. Partika, S.C. Restraint use and fatality risk for infants and toddlers. Washington, DC: National Highway Traffic Safety Administration.

Bechara, Antoine; Antonio R. Damásio (2005) – The somatic marker hypothesis: A neural theory of economic decision – Games and Economic Behavior 52 (2005) 336–372. Available online 23 September 2004.

Bowles, Samuel (2004) – Microeconomics behavior, institutions, and evolution *Samuel Bowles*. – Russell Sage Foundation, Princeton University Press.

Camerer, Colin; George Loewenstein; Drazen Prelec (2005) – Neuroeconomics: How Neuroscience Can Inform Economics, p. 16 – *Journal of Economic Literature Vol. XLIII (March 2005), pp. 9–64*

Carney, Dana R.; Mason, Malia F. (-) – Moral Decisions and Testosterone – Columbia University.

Carney, Dana R.; Mason, Malia F.(2010) – Decision making and testosterone: When the ends justify the means – Elsevier.

Chisvert, Mauricio [et al.] – Quality and representativity of the traffic accident data in urban areas State of the Art. –Instituto de Tráfico y Seguridad Vial. [Valencia: Universidad de Valencia; s.d].

Croson, R., and Gneezy, U. (2009) – Gender differences in preferences, *Journal of Economic Literature*, **47**, 448–74.

Davis, John (2002) – Collective intentionality and individual behavior *in* "Intersubjectivity in Economics", pp.11-27 – Rutledge.

Denson, Thomas F.; Richard Ronay; William von Hippel;, Mark M. Schira1 (2012) – Endogenous testosterone and cortisol modulate neural responses during induced anger control. – Psychology Press, an imprint of the Taylor & Francis Group, an Informa business (Australia).

Derriks, Harry M.; MAK, Peter M. (2007) – IRTAD: Special Report Underreporting of Road Traffic Casualties. [s.n]: Ministry of Transport, Public Works and Water management.

Descartes, René (1637) – *Discourse on the Method of Rightly Conducting the Reason, and Seeking Truth in the Sciences*: – This Electronic Book Is a Publication of the Pennsylvania State University's Electronic Classics Series, Jim Manis Faculty Editor.

Donário; Arlindo; Borges dos Santos, Ricardo (2012) – The Economic and Social Cost of Road Accidents in Portugal – EDIUAL.

Elvik, Rune (2011) – Public Policy *in* Handbook of Traffic Psychology – Bryan E. Porter. ELSEVIER.

Elvik, Rune [et al.] (2009) – The Handbook of Road Safety Measures – Bingley: Emerald Group Publishing Limited.

Elvik, Rune (2004) – Why some road safety problems are more difficult to solve than others, p.15. – Institute of Transport Economics. Oslo, Norway.

Evans, Leonard (2004) -Gender And Age Influence On Fatality Risk From The Same Physical Impact Determined Using Two-Car Crashes. – Paper Number 011174. – Peter H. Gerrish Nesa and Associates, Inc..

Evans, Leonard (1991) – *Traffic Safety and the Driver* – New York: Van Nostrand Reinhold.

Evans, L. (1988) – Risk of fatality from physical trauma versus sex and age. – *Jornal of Trauma*, 1988, No. 28, pp. 368-378.

Frey, Bruno S.; Alois Stutzer (2007) – The Economics and Psychology: Developments and Issues. *in Economics and Psychology* – CESifo Seminar Series.

Fuller, Ray (2011) – Driver Control Theory. From Task Difficulty Homeostasis to Risk Allostasis. *in* "Handbook of Traffic Psychology" – Bryan E. Porter. ELSEVIER.

Giedd. J. N. (2004) – Structural magnetic resonance imaging of the adolescent brain. *Annals of the New York Academy of Sciences*, 1021.

Glendon, A. Ian (2011) – Neuroscience and Young Drivers *in* Handbook of Traffic Psychology – Elsevier, San Diego, USA.

Groeger, J. A. (2006) – Youthfulness, inexperience and sleep loss: The problems young drivers face and those they pose for us – Injury Prevention, 12, i19 – i 24.

Huang, Patty; Flaura Koplin Winston (2011) – Young Drivers, *in Handbook of Traffic Psychology*. – ELSEVIER.

Josephs, Robert A. (2006) – The Mismatch Effect: When Testosterone and Status Are at Odds. – Journal of Personality and Social Psychology 2006, Vol. 90, No. 6, 999–1013.

Josephs, Robert A.; Jennifer Guinn Sellers; Matthew L. Newman; Pranjal H. Mehta (2006) – The Mismatch Effect: When Testosterone and Status Are at Odds – Journal of Personality and Social Psychology Copyright 2006 by the American Psychological Association 2006, Vol. 90, No. 6, 999–1013.

Kahneman, Daniel (2011) – Thinking Fast and Slow – Farrar, Straus and Giroux.

Kahneman, Daniel; Jack L. Knetsch; Richard H Thaler (1991) – Anomalies The Endowment Effect, Loss Aversion, and Status Quo Bias – *Journal of Economic Perspectives* – Volume 5, No. 1 – Winter 1991 – pp. 193-206.

Klebelsberg, Dieter (1994) – Is Risk Compensation a Personality Trait, and Attitude or a Behavior?, *In* "Challenges to Accident Prevention. The Issue of Risk Compensation Behavior", p. 51. – STYX Publications, Groningen, The Netherlands.

Krivelyova, Anna; Cesare Robotti (2003) – Playing the Field: Geomagnetic Storms and the Stock Market, p.2 – Federal Reserve Bank of Atlanta, Working Paper 2003-5b

Kobbeltvedt, Therese ;Katharina Wolff (2009) – The Risk-as-feelings hypothesis *in* "A Theory-of-planned-behaviour perspective.-Judgment and Decision Making", vol. 4, no. 7, December 2009.

Levin, Irwin P. *et al* (2012) – A Neuropsychological Approach to Understanding Risk-Taking for Potential Gains and Losses.

Lewis, I.; Watson, B.; & Tay, R. (2007) – Examining the effectiveness of physical threats in road safety advertising: The role of the third person effect, gender, and age – Transportation Research Part F: Traffic Psychology and Behavior, 10.

Loewenstein, George (2005) – Hot-Cold Empathy Gaps and Medical Decision Making – Health Psychology, 2005. Vol. 24, No.4 (Suppl.) S49-S56, p.S49.

Loewenstein, Georg (2004) – Out of Control: Visceral Influences on Behavior, *in* "Advances in Behavioral Economics" (2004), p. 694. – Princeton University Press.

Loewenstein, George; Scott Rick (2004) – Emotion in economics (The challenge of emotions for economic theory) – *Letters Proceedings: Biological Sciences*, 4, 177-179. (Proc. R. Soc. Lond. B; Suppl., DOI 10.1098/.

Loewenstein, G., and J. S. Lerner (2003). – The Role of Affect in Decision Making *in "Handbook of Affective Science"*, ed. R. Davidson, *Notes* **339** H. Goldsmith, and K. Scherer. Oxford: Oxford University Press, pp.619–664.

Loewenstein, F. George; Hsee, K. Christopher (2001) – Risk as Feelings – Psychology Bulletin.200. Vol. 127. N° 2, pp. 267-287.

Loewenstein, George; Richard Thaler (1989) – Anomalies Intertemporal Choice – Journal of Economic Perspectives – Vol. 3, No. 4 – pp. 181-193.

Loewenstein, George (1987) – Anticipation and the Valuation of Delayed Consumption – The Economic Journal, 97: 666–684, reproduced *in* Exotic Preferences Behavioral. Economics and Human Motivation, by Loewenstein , pp. 385-410, Oxford University Press (2007).

Luhmann, N. *Trust and Power*. NY: Willey, (1980). Reference to: Rothe, J. Peter. *Beyond Traffic Safety*. New Brunswick, NJ (USA): Transaction Publishers, 1994. P.12.

Mazur, Allan; Booth, Alan (1998) – Testosterone and dominance in men – BEHAVIORAL AND BRAIN SCIENCES (1998) 21, 353–397.

Mehta, Pranjal H. *et al* (2010) – Genetic, Hormonal, and Neural Underpinnings of Human Aggressive Behavior – Handbook of Neurosociology, Handbooks of Sociology and Social Research. Springer Science+Business Media B.V. 2012.

Mehta, Pranjal H.; Robert A. Josephs (2010) – Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone hypothesis – journal homepage: www.elsevier.com/ locate/yhbeh.

Mohan et al (2006) – Road Traffic Injury Prevention Training Manual – World Health Organization 2006. Indian Institute of Technology Delhi.

Peterson, Richard L. (2007) – Inside the Investor's Brain – John Wiley & Sons.

Ronan, A. Lyons [et al] (2008) – Using multiple datasets to understand trends in serious road traffic casualties. In Accident analysis and prevention. Dunedin: University of Otago Medical School. Vol.40 nº4 (Jul 2008).

Ronay, Richard; von Hippel, William (2010) – The Presence of an Attractive Woman Elevates Testosterone and Physical Risk Taking in Young Men – Social Psychological and Personality Science 1(1) 57-64. SAGE.

Ronay, Richard; William von Hippel, (2009) – Power, Testosterone, and Risk-Taking -Journal of Behavioral Decision Making, J. Behav. Dec. Making, (2009).

Sapienza, Paola; Zingales, Luigi; Maestripieri, Dario (2009) – Gender differences in financial risk aversion and career choices are affected by testosterone – University of Chicago, Chicago, IL, July 1, 2009.

Sen, Amartya (2009) – The Idea of Justice – The Belknap Press of Harvard University Press Cambridge, Massachusetts.

Shane, Frederick; George Loewenstein; Ted O` Donoghue (2002 [2004]) -Time Discounting and Time Preference: A Critical Review." *Journal of Economic Literature* 40 (June): 351–401, republished *in* Advances in Behavioral Economics, pp. 162-222 – Princeton University Press-2004.

Stanton, Angela A. (2010) – Hormonal influence on male decision – making: implications for organizational management *in* Neuroeconomics and the Firm (2010), pp. 131-150 – Edward Elgar.

Thaler, Richard H.; Cass R. Sunstein (2007) – Nudge. Improving Decisions About Health, Wealth, and Happiness – Yale University Press.

Thaler, Richard H. (2000) – From Homo Economicus to Homo Sapiens – *Journal of Economic Perspectives—Volume 14, Number 1—Winter 2000—Pages 133–141.*

Trimpop, Rudiger (1994) – Risk Compensation and the Interaction of Personality and Situational Variábles, in "Challenges to Accident Prevention. The Issue of Risk Compensation Behavior" – STYX Publications, Groningen, The Netherlands.

van Honk, Jack et al (2010) – Socially Explosive Minds: The Triple Imbalance Hypothesis of Reactive Aggression – Journal of Personality 78:1, February 2010.

van Honk, Jack et al (2005) – Testosterone Reduces Unconscious Fear but Not Consciously Experienced Anxiety: Implications for the Disorders of Fear and Anxiety – BIOL PSYCHIATRY. 2005; 58:218–225. 2005 Society of Biological Psychiatry.

Wargo, Donald T.; Norman A. Baglini; Katherine A. Nelson (2010) – Dopamine, expected utility and decision-making in the firm, *in* Neuroeconomics and the Firm, p.166. – Edward Elgar Publishing, Inc..

Wilde, Gerald J.S. (2001) – *Target Risk2*. Toronto-Ontario: PDE Publications, 2001.

Zweig, J. (2007) – Your Money and Your Brain: How the New Science of Neuroeconomics Can Help Make You Rich – New York: Simon and Schuster.