



A Review and Comparison of Road Safety in Greece in Recent Years

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Abstract

Greece ranks between the EU countries with the highest number of road fatalities per million inhabitants for the last two decades. Although the number of road fatalities has been significantly reduced over the last 15 years, it is still considerably higher than the EU average. This paper reviews the transport and economic status in Greece for the last 15 years and outlines the most significant changes in road safety levels for different categories. To support its aim, this paper is divided in three sections; a review, a comparison and a discussion. The review presents the economic and road safety status in Greece in recent years (2000-2014). An analysis of road safety data, which focuses on and compares periods “before” (2005-2009) and “after” (2010-2014) the economic recession, highlights trends with significant changes on road safety that coincide with the period of the economic recession. The results show that although there is a significant decrease of road fatalities during the period of the economic recession in Greece, these changes may not occur uniformly for all road users. A discussion summarizes findings, highlights cases that did not present significant changes in terms of safety levels and provides future research directions for formulating road safety policy.

Keywords: Roads and highways; road safety; health and safety; economic recession.

1. Introduction

In European Union (EU) 350,000 people died in road accidents and over 15 million were injured between 2005 and 2014 (EC, 2017). Towards strengthening efforts to improve road safety, the European Commission has set a goal to reduce road fatalities by 50% by 2020 starting in 2010 (EC, 2010). Development of effective measures and strategies to improve road safety in Greece and keep pace with the European goals has become a challenging task, due to economic restrictions and scarcity of resources since the commencement of the economic recession in 2009.

Greece has followed the EU trends and directions towards reducing road accidents and has adopted three Strategic Plans for road safety at national level. Following the 1st (2001 – 2005) and 2nd (2006 - 2010) Strategic Plan, the number of road fatalities reduced by 19% and 38%, respectively. The implementation of the 3rd Strategic Plan (2010) during the period of the Greek economic recession, was followed by a notable

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reduction of 37% in the number of road fatalities in just four years (2010-2014). This sharp reduction triggered research, and several studies from public and private sector focused on the evolution of road accidents over the last 10-15 years, and the exploration of the potential relationship that might exist between the number of road fatalities and several socioeconomic factors.

Prior to the Greek economic recession, several factors have found to contribute to fatal accidents in U.S., including demographic changes, economic conditions and unemployment, and transport modes (Smeed, 1968; Hedlund et al., 1984; Wagenaar, 1984). A study in the U.K. showed that the rate of road fatalities between 1979 and 2009 reduced significantly during periods of economic recession (e.g., 2007-2009) (U.K. DoT, 2011). Reinfurt et al. (1991) examined the effects of an economic recession within a broader context, associating unemployment rates with the number of fatal road accidents, suicides and homicides. The results showed that knowledge of unemployment rates does not improve the short-term predictions for fatal road accidents. Other recent studies (Yannis et al., 2014; French and Gumus, 2014; Chen, 2014; Antoniou and Yannis, 2013; Cotti and Tefft, 2011, Noland and Zhou, 2017) have also explored the relationship between economic conditions and traffic incidents and have developed long-term statistical models (Antoniou et al., 2016). For example, Yannis et al., (2014) found that there is a systematic relationship between the Gross Domestic Product (GDP) and the annual road fatality rate fluctuations.

The aim of this paper is to provide a thorough review of road safety levels in Greece in recent years in the light of the EU economic recession that started in 2009. Therefore, it is not our aim to provide a complete review of the literature in the field of economic conditions and their impact to road safety levels. To support its aim this paper is further divided in three sections; a review, a comparison and a discussion. Section 2 reviews the economic and road safety status in Greece in recent years (2000-2014). It highlights GDP and road fatality changes and presents fluctuations that occurred at the same period in transportation related indicators, including vehicle registrations, transport modes in operation and fuel consumption. Section 3 provides a comparison of road safety levels “before” (2005-2009) and “after” (2010-2014) the economic recession in Greece to highlight trends with significant changes on road safety that occurred during the period of the economic recession. Finally, Section 4 concludes the review by briefly discussing the position of Greece in terms of road safety levels in European Union, and presenting those cases for which safety indices did not present any significant change. Research directions based on paper findings are provided for improving road safety policy in Greece.

The study focuses on the last 10 years and especially in years before and after 2009, when significant changes in road safety coincide with the commencement of the economic recession. The study analyzes and presents available detailed data until the year 2014, when the interim report for the 3rd Strategic Plan 2011-2020 was prepared; year 2009 is used as the beginning year of the Greek government-debt crisis.

2. The economy and transport sector in Greece

2.1. The period before the economic recession

Greece entered the Euro area in 2001 and presented a remarkable economic transformation with an average GDP growth of 4% between 2001 and 2008 (Hellenic Statistical Authority, 2016). In addition, important transport infrastructure projects were

completed by 2004, including the El. Venizelos International Airport in Athens, the Athens bypass AttikiOdos motorway, the Athens metro system, and EgnatiaOdos – a 658 kilometers long motorway at northern Greece. At the same time, the organization of the Olympic Games in Athens, Greece in 2004 contributed in the technological advancement of road surveillance and intelligent transport systems, the operation of a new Traffic Management Center in Athens Metropolitan Area and the modernization of police techniques and procedures regarding enforcement in several municipalities. Finally, 2,500 kilometers of motorways upgraded, constructed and operated by 2008 through public private partnerships.

Greece has adopted three Strategic Plans for road safety since 2000 that led to an overall reduction of 61% in road fatalities between 2000 and 2014. More specifically, the 1st Strategic Plan for improving road safety in Greece (2001-2005) set a goal of reducing road fatalities by 20% between 2005 and 2000. The 1st Strategic Plan focused on four road safety dimensions: a) Safe road environment, b) Safe user and vehicles, c) Effective monitoring of road safety, and d) Effective treatment after the accident. The 2nd Strategic Plan for improving road safety in Greece (2006-2010) aligned with the European goal of 50% reduction in road fatalities by 2010 relatively to 2000 (i.e., 2,037 fatalities to be reduced to 1,018). The 2nd Strategic Plan focused on six road safety dimensions: a) Safe user and vehicles, b) Monitoring of road safety, c) Safe road environment, d) Treatment after the accident, e) Road safety education, and f) Road safety actions and governance. The 3rd Strategic Plan for improving road safety in Greece (2011-2020) adopted the European Commission's goal of reducing road fatalities by 50% by the year 2020 relatively to the base year 2010. More specifically, Greece set a goal of 640 fatalities by 2020 and the intermediate goal of less than 880 fatalities by 2015. Six programmes were set in the 3rd Safety Plan to support its goals: a) Road safety training, b) Road traffic monitoring, c) Safe road user, d) Safe road infrastructure, e) Safe vehicles, and f) Immediate response to road incidents (NTUA, 2011).

Meanwhile, a deep economic recession, which officially started in 2008, resulted in 2013 to a significant GDP decrease of about 25% and an overall increase of about 28% in the unemployment rate (Hellenic Statistical Authority, 2016). At the same time, traffic volumes and road accidents in urban and interurban roads decreased significantly.

2.2. Transport facts and trends in years of the economic recession

Socioeconomic changes in recent years have resulted in a significant change in transport patterns and trends. According to published data by the Greek Government and private road operation authorities, traffic volumes dropped on average by 5-15% on main arterial roads in the Metropolitan Area of Athens (i.e., capital of Greece), while the reduction in many cases reached up to 50% between 2009 and 2012 (Kopelias et al., 2016). Although, average reduction of traffic volumes may not be significant in urban areas, it appears to be higher for interurban and long haul trips. More specifically, the traffic volumes in EgnatiaOdos dropped by roughly 35% between 2010 and 2013 (EgnatiaOdos, 2014). In AttikiOdos, a privately owned toll motorway that bypasses the Greater Metropolitan Area of Athens, the average daily entries dropped from 307,300 to 196,960 vehicles (-36%), between 2009 and 2014 (Attica Tollway, 2015).

Additionally, a reduction of new vehicle registrations (Figure 1), total number of vehicles in operation (Table 1) and fuel consumption (Table 2), is recorded since 2009. Figure 1 shows the number of new and second-hand passenger cars and motorcycles that were registered in Greece for first time (1991-2014) and the dramatic decrease (-70%) since 2008 (Hellenic Statistical Authority, 2016).

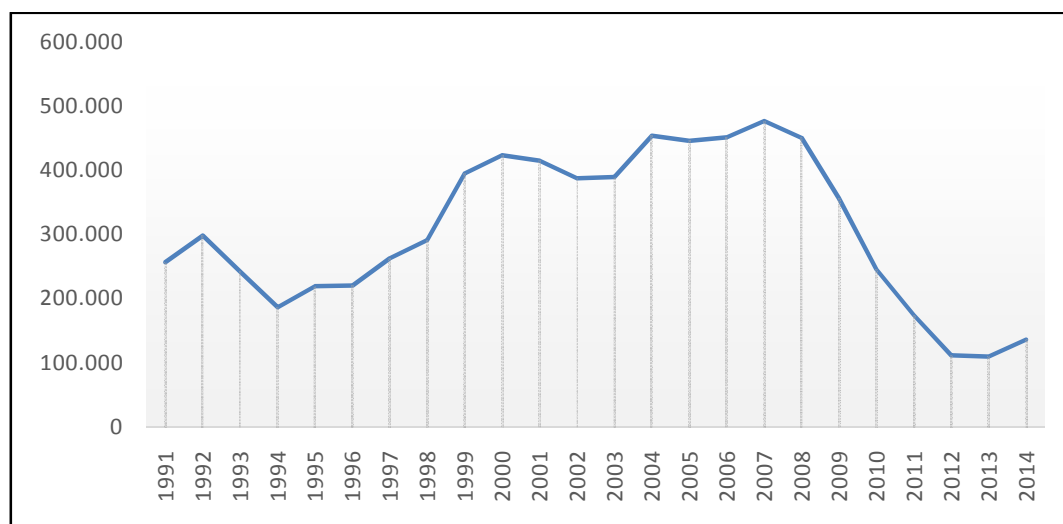


Figure 1: Annual registrations of cars and motorcycles (new and second hand) in Greece, 1991-2014.

The total number of passenger cars in operation increased from 1991 to 2009; however, the number of cars started decreasing slightly after 2010 as shown in Table 1. While the number of passenger cars decreases after 2010, the number of motorbikes in operation kept increasing with lower intensity compared to the prerecession period, showing that road users turned to cheaper modes of private transport. The number of trucks in operation, which is an index of the economic activity in the country, started being almost stable after the year 2009 (Table 1). Third party logistics (3PL) services in Greece increased between 1998 and 2008, with an average annual growth rate of 19.7%; however, during the years of economic recession and until 2016 the sector demonstrated a decline of about 24% (ICAP, 2017).

Table 1: Number of motor vehicles in operation and annual change, 2005-2014.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Passenger cars	4,303,129	4,543,016	4,798,530	5,023,944	5,131,960	5,216,873	5,203,591	5,167,557	5,124,208	5,110,873
Annual change (%)	-	5.6%	5.6%	4.7%	2.2%	1.7%	-0.3%	-0.7%	-0.8%	-0.3%
Buses	26,829	26,938	27,102	27,186	27,324	27,311	27,121	26,962	26,783	26,691
Annual change (%)	-	0.4%	0.6%	0.3%	0.5%	0.0%	-0.7%	-0.6%	-0.7%	-0.3%
Trucks	1,186,483	1,219,889	1,255,945	1,289,525	1,302,430	1,318,768	1,321,296	1,318,918	1,315,836	1,317,945
Annual change (%)	-	2.8%	3.0%	2.7%	1.0%	1.3%	0.2%	-0.2%	-0.2%	0.2%
Motorbikes	1,124,172	1,205,816	1,298,688	1,388,607	1,448,851	1,499,133	1,534,902	1,556,435	1,568,596	1,592,929
Annual change (%)	-	7.3%	7.7%	6.9%	4.3%	3.5%	2.4%	1.4%	0.8%	1.6%

Total	6,640,613	6,995,659	7,380,265	7,729,262	7,910,565	8,062,085	8,086,910	8,069,872	8,035,423	8,048,438
Annual change (%)	-	5.3%	5.5%	4.7%	2.3%	1.9%	0.3%	-0.2%	-0.4%	0.2%

Reduction of passenger cars in operation is also supported by the return of license plates to Greek authorities, which is not reflected in Table 1. In 2010, 170,000 license plates were returned back to Greek authorities mainly due to inability of vehicle owners to update the annual registration and pay the annual vehicle taxes; in 2011 the number soared to 204,000, in 2012 to 365,000, while in 2013 the number of returned license plates was limited to 135,000. Reports from the Hellenic Association of Insurance Companies (Hellenic Association of Insurance Companies, 2014) show that while in 2009 revenues from vehicle insurance companies were estimated to be €5.5 billion, in 2013 revenues fell to €3.5 billion (-36%); the number of uninsured vehicles is estimated to be around 730,000 of the total 8 million registered vehicles.

Reduction of mobility in Greece was followed by an overall reduction in fuel consumption. Motor and heating fuels sales recorded a decrease of 20.2% and 34.1%, respectively (Kopelias et al., 2016). Unleaded and diesel sales decreased by 31% and 14%, respectively, between 2009 and 2014, (Table 2). It should be noted that sales for year 2014 for unleaded and diesel fuels approximate those for years 2001 and 2002, respectively. Diesel sales start increasing after 2012, mainly due to the lower price of diesel that turned consumers to diesel engine vehicles (i.e., 31,004 diesel versus 23,293 gasoline passenger cars were sold in 2013 in Greece).

Table 2: Annual consumption (tons) and change of unleaded and diesel fuel consumption, 2005-2014.

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Unleaded	3,415,208	3,597,084	3,496,340	3,512,936	3,604,538	3,422,408	3,119,072	2,829,437	2,580,832	2,495,741
Annual change (%)	-	5.3%	-2.8%	0.5%	2.6%	-5.1%	-8.9%	-9.3%	-8.8%	-3.3%
Diesel	2,537,546	2,714,656	2,838,156	3,065,418	2,838,406	2,488,048	2,188,854	2,185,909	2,298,541	2,441,950
Annual change (%)	-	7.0%	4.5%	8.0%	-7.4%	-12.3%	-12.0%	-0.1%	5.2%	6.2%

The reduction of mobility for Greek households in the years of the economic recession is also highlighted by findings of the Household Budget Survey that was conducted in 2013 (Hellenic Statistical Authority, 2016). The survey showed that the average monthly household expenditure, decreased from €2,203 in 2009 to €1,509 in 2013, which corresponds to a 32% reduction (in 2013€). Expenditure for “Transportation activities” dropped by 30% in 4 years, while other categories including “Recreation/culture” and “Hotels, cafes and restaurants”, which traditionally generate vehicle trips, recorded a reduction of 34% and 37%, respectively.

2.3. Macroscopic accident data in recent years

Accident datasets were collected from the Hellenic Statistical Authority (2016) and used in this section together with datasets from the Hellenic Police (2014) to review disaggregated road accident characteristics in Greece. According to the Hellenic Statistical Authority, the number of road accidents decreased by 49% and 21% in the period 2000-2014 and 2009-2014, respectively. Road fatalities reduced by 45% between 2009 and 2014, while injuries also reduced by 22% in the same period (Table 3).

Table 3: Road accident data, Greece 2000-2014.

	2000	2001	2003	2004	2009	2010	2011	2012	2013	2014	% Change 2000-2014	% Change 2009-2014
Road accidents*	23,001	19,671	15,751	15,509	14,789	15,032	13,849	12,398	12,109	11,690	-49%	-22%
Fatalities	2,037	1,880	1,605	1,670	1,456	1,258	1,141	988	879	795	-61%	-37%
Total injuries**	30,763	26,336	20,737	20,179	18,641	19,108	17,259	15,640	15,175	14,564	-53%	-24%

Note (*): Road accidents with at least one injury

Note (**): Total injuries include slightly and seriously injured

According to the 3rd Strategic Plan 2011-2020, Greece aims to decrease road fatalities by 50% by 2020, which equals to 640 road fatalities, while the mid-term milestone for 2015 was aiming to achieve less than 880 road fatalities (relatively to base year 2010). Between the period 2010 and 2014, Greece achieved to reduce road fatalities by 37% (795 fatalities in 2014), road accidents by 22% and total injuries by 24%.

Accounting for the number of vehicles in operation, the fatality rate in Greece decreased rapidly from 1997 to 2003 with an annual average rate of roughly 10% and continued to decrease gradually from 2004 onwards to 2014 with an annual average rate of 8.6% as shown in Figure 2. Vehicles in operation include all vehicles types (Table 1).

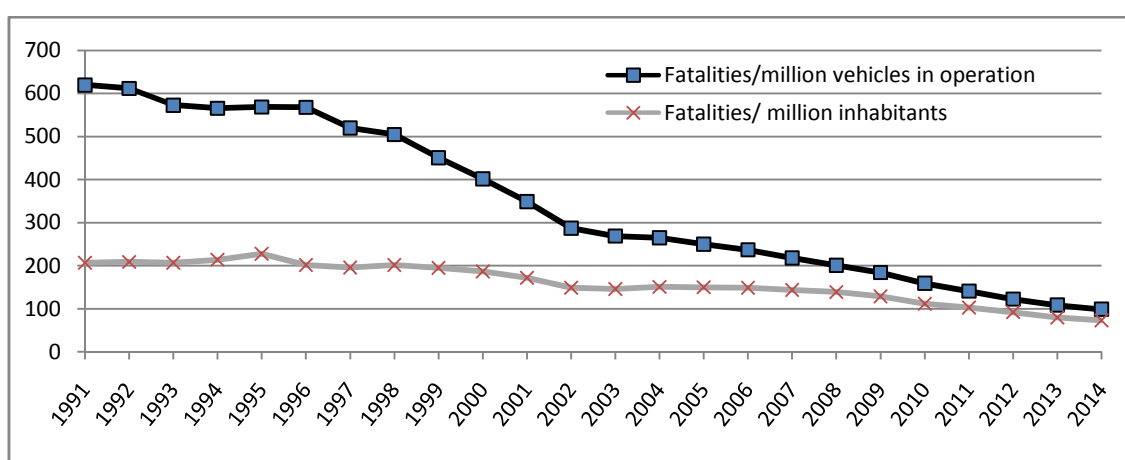


Figure 2: Fatalities per million of vehicles and inhabitants, 1991-2014.

The annual fatality rate per million inhabitants between 1991 and 2014 decreased on average by 4.8% (i.e., 207 to 73 fatalities per million inhabitants). Although, a significant decrease in the number of fatalities per million vehicles in operation is shown over a period of 25 years (1991-2014), it should be noted that the highest reduction was estimated for the period 2001-2002 (-21.5%), which followed the introduction of Euro currency (Figure 2). The second highest reduction is noted for the period 2009-2010 (-15.8%), during the first year of the economic recession. The difference in the reduction rate is more apparent when comparing “before” and “after” periods of the economic recession. The average annual reduction rate is estimated to be

7.6% for “before” (2005-2009) and 13.2% for “after” (2009-2014) the economic recession period.

A macroscopic view in the number of road fatalities and GDP data for Greece between 2000 and 2015 (Figure 3) shows the potential impact of the economic recession to road fatalities. Figure 3 shows the annual number of road fatalities in Greece during the three periods of the Strategic Plans for road safety. During the 1st Strategic Plan (2001 – 2005) an average annual reduction of road fatalities of 4.4% is recorded (grey solid line). During the 2nd Strategic Plan (2006 – 2009) the average annual reduction of road fatalities reduced slightly to 3.3% (black solid line), while after 2009 the average annual reduction of road fatalities increased to 12.9% (dashed grey line). The grey dotted line shows how road fatalities would have been reduced if these had followed linearly the fatality reduction rate of the 2nd Strategic Plan. The black dotted line presents linearly the reduction rate of road fatalities after the beginning of the economic recession in 2009. Thus, the distance between the dotted black and grey lines illustrates the difference between the actual and expected number of annual fatalities, between 2009 and 2015. In the period of the Greek economic boom (2002-2008), a moderate decrease of road fatalities was recorded. However, after the introduction of the economic recession, while the GDP decreased by almost 32% (2008-2014) and the average Greek public deficit reached to 179% of the Greek GDP (2014), the number of road fatalities presented a significant reduction.

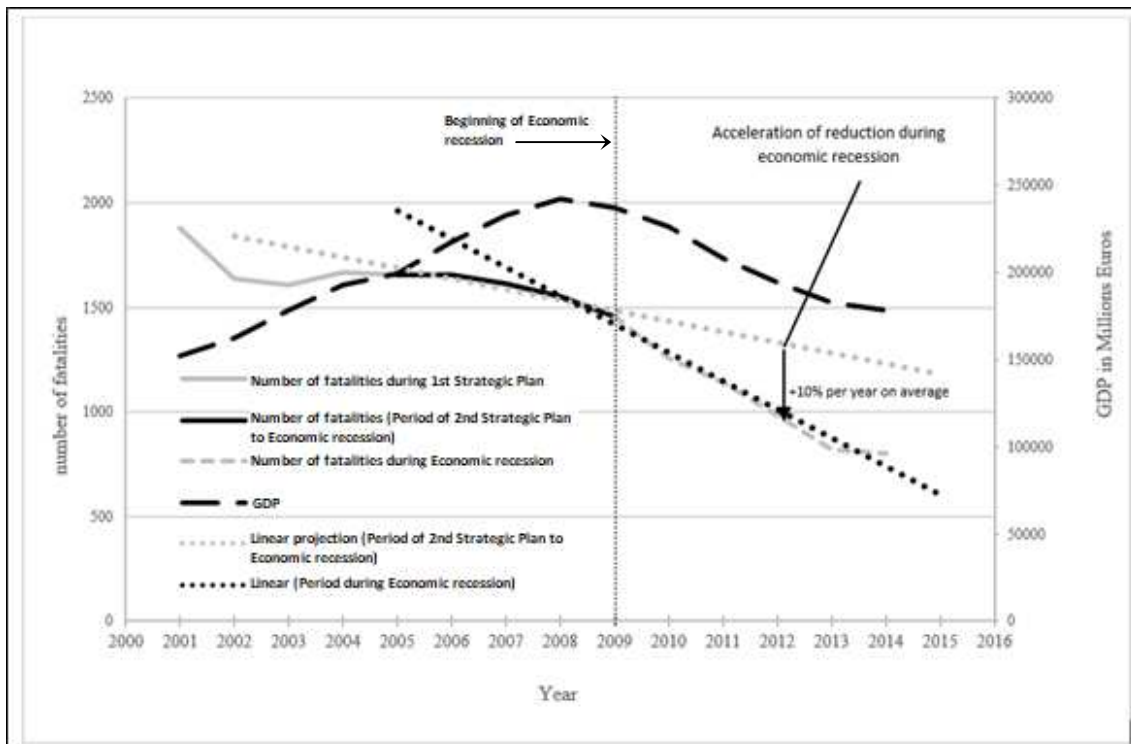


Figure 3: Annual road fatalities and GDP trend since 2001, Greece.

The relationship between road fatalities and GDP has been explored in several studies. Chen (2014) analyzed data from 32 organization for the Economic Co-operation and Development (OECD) countries and concluded that for a GDP growth of 1.0% road accident fatalities increased by 1.1% and vice versa. In the case of Greece (Figure 3),

between 2009 and 2014 the GDP decreased by 30.5% while the number of road fatalities dropped by 45.4%. In addition to GDP, a U.S. based study concluded that the unemployment rate and the consumer price index are correlated with changes in road safety levels (Kweon, 2011). A large drop in fatalities in 2008-2009 as well as in 1990-1991 and 1981-1982 in the U.S. has coincided with a recession in the U.S. economy and an increase of the unemployment rate (NHTSA, 2010). Using road safety data for EU countries, Yannis et al. (2014) suggested that a relationship exists between annual GDP and fatality rate changes. Their research showed that GDP increase leads to annual fatality rate increase, and vice versa, for three groups of countries (Northern/Western, Central/ Eastern and Southern European countries).

3. Road accident disparities before and after the economic recession

Despite significant changes in road safety levels a before-after analysis shows that the overall decrease in the number of road fatalities/accidents did not occur uniformly among all categories in Greece. The following sections present the results of the road accident data analysis for different categories and highlight the most important findings. Data are analyzed for two periods; “before” (2005-2009) and “after”(2010-2014) the economic recession period.

3.1. Road user group, age and sex

Disaggregated data for road accidents in Greece show that their distribution varies for different groups of road users. Table 4 presents an overview of the distribution of the number of fatalities by user group, age group and sex for year 2014. The analysis shows that the fatalities for male and female account for 82% and 18% of total fatalities, respectively, while 94% of killed drivers are male. This distribution is almost stable from 2000 to 2014 with an average of 15 years of 93.5% for male drivers and 6.5% for women drivers.

The highest share (24%) of fatalities including all road users (i.e., drivers, passengers and pedestrians) is attributed to the 65+ age group, with 80% of them being male and 48% being drivers. These figures highlight the necessity to reconsider the Greek driving legislation that assess drivers over 65 years old every three years to enforce a more strict health control (CONSOL, 2013). Further data analysis for the period 2009-2014 shows that the number of elderly women drivers (65+ age group) who died in road accidents is very small compared to the corresponding number of men (26 vs 658).

The second highest group in terms of total fatalities in 2014 is found to be the age group of 15-24, which accounts for 17% of total fatalities, with 76% of them being male, 71% being drivers, and 64% being male drivers; the high number of dead male drivers is attributed to higher driving speeds among men and less attention to traffic laws (Norris et al., 2000). It should be noted that the age group 15-24 was ranked third between all age groups in terms of total fatalities before 2014. On the other hand, young driver fatalities (15-24 age group) present a reduction of about 52% since 2009, following the overall reduction rate in recent years.

Table 4: Number of fatalities by age group, sex and road user group, 2014.

Age (years)	Drivers		Passengers		Pedestrians		Drivers	Passenger	Pedestrian	M	F	Total	%
	M	F	M	F	M	F							
0-5	0	0	1	1	1	1	0	2	2	2	2	4	0.5%
6-14	1	1	3	0	1	0	2	3	1	5	1	6	0.8%
15-24	85	10	14	18	3	3	95	32	6	102	31	133	16.7%
25-34	88	6	9	6	5	3	94	15	8	102	15	117	14.7%
35-44	85	8	5	8	8	4	93	13	12	98	20	118	14.8%
45-54	81	4	5	17	14	2	85	22	16	100	23	123	15.5%
55-64	73	3	5	9	8	4	76	14	12	86	16	102	12.8%
65+	90	3	12	17	48	17	93	29	65	150	37	187	23.5%
Unknown	2	0	0	0	2	1	2	0	3	4	1	5	0.6%
Total	505	35	54	76	90	35	540	130	125	649	146	795	100%
%	94%	6%	42%	58%	72%	28%	68%	16%	16%	82%	18%		

The pedestrian fatalities for the age group of 65+ account for more than half (52%) of total pedestrian fatalities; among them male and female account for 74% and 26%, respectively. Total pedestrian fatalities for the age group of +65 is roughly fourfold compared to the second ranked age group of 45-54, which highlights the necessity for implementing safety measures to protect elderly pedestrians, which are usually characterized by lower perception-reaction time, lower crossing speeds and higher vulnerability in crashes (EC, 2016).

The overall number of road fatalities (i.e., drivers, passengers and pedestrians) that involved a passenger vehicle reduced by 43% between “before” and “after” periods. Specifically, the age group of 15-34 presented a reduction of 56%; whereas for the age group of 55+, road fatalities reduced by only 28%. The number of road fatalities that involved a passenger between 2009 and 2014, for the age group of 25-34 reduced by 67%; whereas for the age group of 45-54 increased by 22% for the same period.

By comparing 2014 and (2009) data, the number of driver, passenger and pedestrian fatalities for all age groups account for 68% (66%), 16% (20%) and 16% (14%) of total fatalities, respectively, showing a stable share per user category. Although, the share of driver fatalities has slightly increased between 2009 and 2014 compared to the share of passenger and pedestrian fatalities, these statistics give an overall overview of the number of fatalities in Greece and their characteristics and do not take into account exposure to lead to safe conclusions through cross-comparisons.

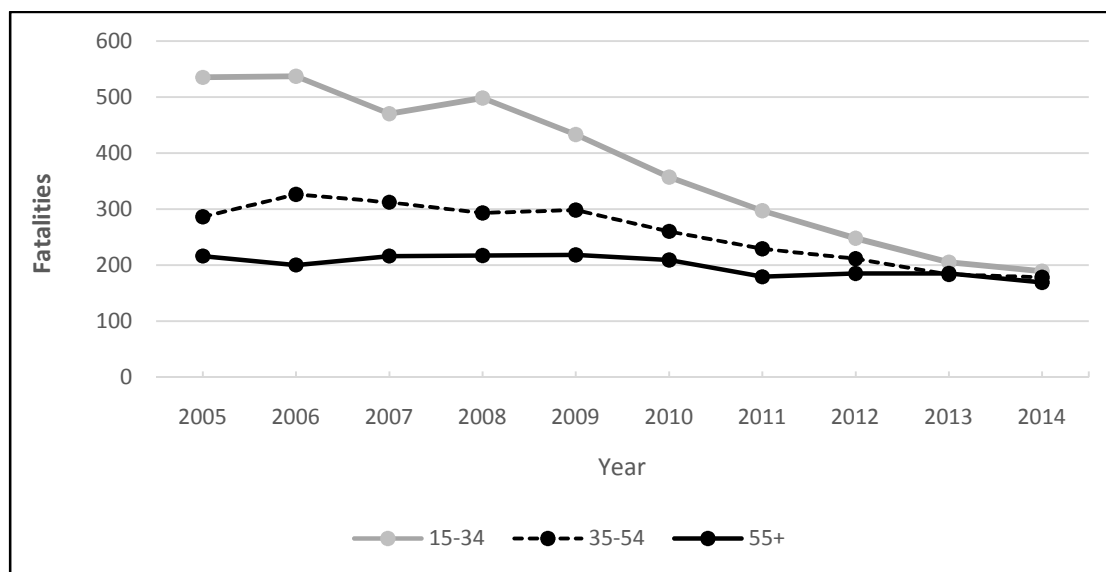


Figure 5: Driver road fatalities per age group “before” (2005-2009) and “after” (2010-2014) the economic recession.

Younger drivers – especially for the age group 15-34 – present a significant reduction of road fatalities of 57% between 2009 and 2014, whereas for the same period the age groups of 35-54 and 55+ present a reduction of 40% and 23%, respectively (Figure 5). This could be partially explained by the fact that young groups experienced a high rate of unemployment in the recent years of economic recession and they generally have less disposable income, which means they are more vulnerable to changing fuel prices and vehicle maintenance costs. Wolff (2014) found that for an increase of \$1.00 in gasoline prices, speed decreases by 0.25-0.29 miles per hour or that a 1.0% increase in gasoline prices is associated with a 0.1% decrease of monthly road accidents per inhabitant within 9 months or 0.16% within 12 months, while the effects of gasoline price reductions have a direct impact on the reduction of injuries for younger population (Guangqing et al., 2013).

3.2. Area type

Road accidents in residential areas accounted for approximately 84% of total road accidents in 2014. Fatal road accidents in non-residential and residential areas decreased by 41% and 31%, respectively between “before” and “after” periods of the economic recession. Early evidence suggests that the economic recession - and high fuel costs - substantially reduced fatalities in non-residential areas. This trend might be attributed to exposure; during the economic recession period there are fewer vehicles on the road (less traveling and higher vehicle occupancy) and therefore fewer opportunities for accidents. Table 5 compiles road fatalities data for residential areas for before and after periods of the economic recession. Similarly to earlier findings, the average number of road fatalities for male users account for 80% of total road fatalities for “before” and “after” periods; however the percentage reduction for both male and female users is roughly equal (-30%). Although the road fatality share per user group is roughly equal for drivers, passengers and pedestrians between “before” and “after” periods, the passengers fatalities recorded the highest reduction (-38%), and pedestrian fatalities the

lowest one (-27%). It is worth noting that for residential areas one in four road fatalities involves a pedestrian for both “before” and “after” periods.

Table 5: Road fatalities in residential areas “before” (2005-2009) and “after” (2010-2014) the economic recession.

<i>Category</i>		<i>Before (2005-2009)</i>		<i>After(2010-2014)</i>		<i>Change(%) Before-After</i>
		<i>Fatalities</i>	<i>(%)</i>	<i>Fatalities</i>	<i>(%)</i>	
Sex	Male	581	79.7%	403	80.1%	-30.6%
	Female	144	19.7%	100	19.9%	-30.4%
	Unknown	4	0.6%	0	0%	0%
User	Driver	448	61.4%	309	61.4%	-31.0%
	Passenger	101	13.9%	63	12.5%	-38.1%
	Pedestrian	180	24.7%	132	26.2%	-26.9%

3.3. Time of day

The distribution of the number of fatalities for drivers, passengers and pedestrians per hour of the day was also estimated for the period 2005-2014 for both male and female. The results revealed that road accidents occurred during the daytime (5:00 – 21:00) with an average rate of 72%. Male drivers account for 75% of total fatalities while female drivers account for only 20% of total fatalities and female passengers for 50% of total fatalities. Comparing “before” and “after” periods, the highest reduction of road fatalities is noted during night-time between 0:00 and 4:59(-42%), whereas the second highest reduction is noted during noon between 13:00 and 16:59 (-40%) (Table 6). The high reduction of road fatalities over the night-time may attributed to improved transport conditions as low luminance plays a major role in road injuries (Plainis et al., 2006), reduced consumption of alcohol and increased police surveillance (Hellenic Police, 2014).

Table 6: Average number of road fatalities and change “before” (2005-2009) and “after” (2010-2014) the economic recession.

<i>Time</i>	<i>Before (2005-2009)</i>		<i>After (2010-2014)</i>		<i>Change(%) Before-After</i>
	<i>Average</i>	<i>(%)</i>	<i>Average</i>	<i>(%)</i>	
0:00-4:59	270.8	17.1%	157.2	15.5%	-41.9%
5:00-8:59	252.4	16.0%	165.0	16.3%	-34.6%
9:00-12:59	231.6	14.6%	169.2	16.7%	-26.9%
13:00-16:59	305.6	19.3%	183.0	18.1%	-40.1%
17:00-20:59	328.4	20.8%	206.8	20.4%	-37.0%
21:00-23:59	192.6	12.2%	131	12.9%	-32.0%
Total	1,581	100.0%	1,012	100.0%	-36.0%

Road fatalities for male road users reduced by 41% (highest) and 30% (lowest) for the time periods of 0:00-4:59 and 9:00-12:59, respectively; whereas the highest average number of male fatalities occurred during afternoon times (17:00-20:59) (i.e., 192 versus 126 fatalities for “before” and “after” period, respectively).

3.4. Transport mode

The number of fatalities per transport mode between “before” and “after” periods fluctuates from -43% for passenger cars to +5% for buses, as shown in Table 7. As the number of fatalities for passenger cars and motorbikes accounts roughly each year for 85% of total fatalities, the comparison focuses on these two transport modes.

Table 7: Number of fatalities per transport mode and change “before” (2005-2009) and “after” (2010-2014) the economic recession.

	<i>Before</i>					<i>After</i>					<i>Change (%) Before-After</i>
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	
Passenger car	949	874	925	839	797	643	591	482	429	358	-43%
Truck	151	163	124	143	129	118	102	94	78	72	-35%
Bus	11	10	7	11	1	6	13	10	7	6	5%
Bike	18	21	16	22	15	23	13	21	15	19	-1%
Mopeds	60	60	46	44	29	38	36	36	26	20	-35%
Motorcycles	436	476	449	437	443	397	352	316	296	301	-26%

While the number of fatalities for car drivers reduced by 66% (514 to 198) between 2005 and 2014, for the same period the number of fatalities for motorcycle drivers reduced by only 33% (374 to 249) (Figure 6). The number of fatalities for motorcycle drivers accounted in 2014 for 46% of all driver fatalities and vehicle types (i.e., 249 of total 540). If the number of driver fatalities by bicycles and mopeds is added, then the percentage share increases to 53%. It is worth mentioning that during the years of the economic recession in Greece the difference between the number of driver fatalities by car and motorcycle changed more rapidly because the number of driver fatalities by car was affected more compared to the number of motorcycle drivers (Figure 6).

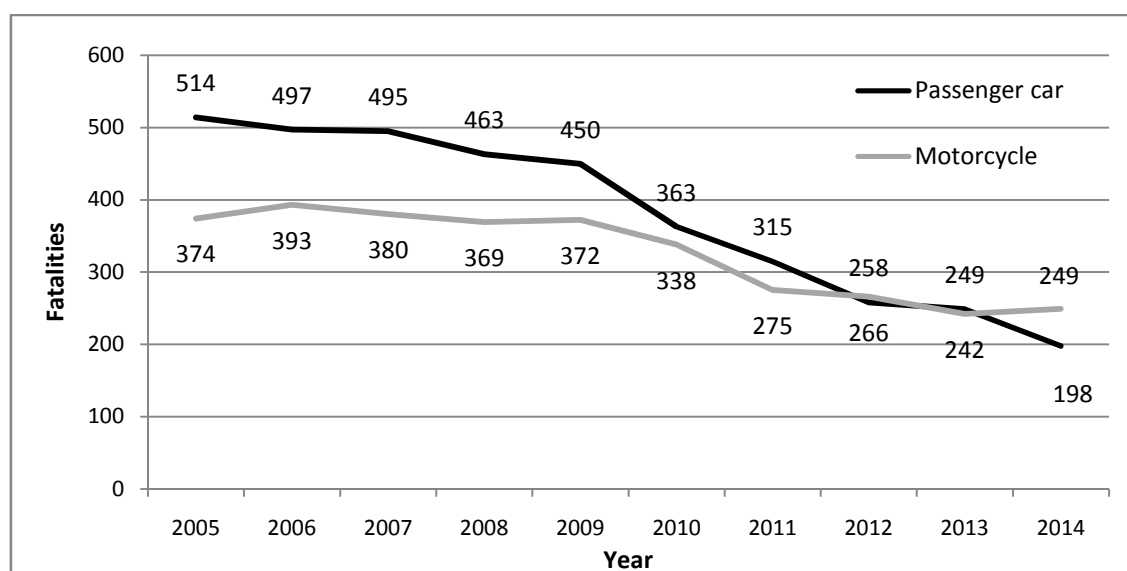


Figure 6: Driver road fatalities by passenger car and motorcycle, 2005-2014.

Similarly, road fatalities (i.e., drivers, passengers and pedestrians) that involved a motorcycle reduced by 26% between “before” and “after” periods. Focusing on the age groups and motorcycle accidents it is found that the number of fatalities between “before” and “after” periods for the age group 15-34 reduced by 38%, while for the age group 55+ fatalities increased by 9%. The number of road fatalities that involved a motorcycle between 2009 and 2014 for the age group 15-34 reduced by 45%, while for the age group 55+ fatalities increased by 3% for the same period. These numbers indicate that although weather conditions in Greece favor the use of two-wheelers, customization of policies per user group is necessary to protect vulnerable users. Similarly to earlier findings (section 3.1), young motorcycle users are likely affected more by economic recession impacts, including unemployment and less disposable income, and thus are more vulnerable to vehicle operation and maintenance costs.

4. Discussion

The economic recession commenced in European Union the same year for all countries, but the effects and the end of the recession period vary greatly among them. For countries, including the Belgium, Germany, Italy, Finland, Sweden and the U.K., the economy started recovering after 2009, and similarly the number of fatalities started increasing. On contrary, countries for which the GDP kept decreasing after 2009, including Greece, Ireland, Spain and Portugal, fatalities continued decreasing in 2011 (OECD, 2015). Nevertheless, there are other EU countries (i.e., Austria, the Netherlands, Hungary and the Czech Republic) that although their GDP recovered, the number of fatalities continued decreasing.

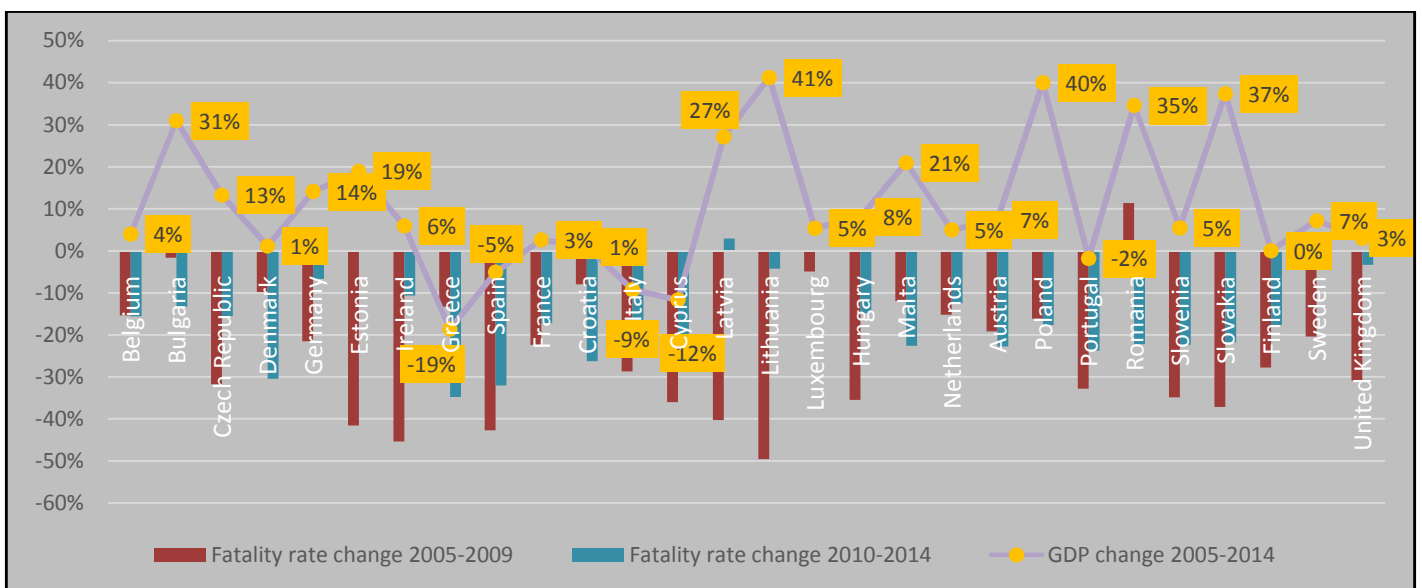


Figure 7: Percentage change of fatalities by population “before” (2005-2009) and “after” (2010-2014) the economic recession and GDP change (2005-2014).

As the latest economic recession had varying effects in different countries globally and in the European Union, the case of Greece might be considered unique at EU level. Figure 7 presents the percentage change of the fatality rate (i.e., number of fatalities permillion inhabitants) per EU country for “before” (2005-2009) (red bar) and “after”

(2010-2014) (blue bar) recession periods and the percentage change in GDP per capita per EU country between 2005 and 2014 (i.e., yellow label). While the reduction rate of fatalities per million inhabitants improved for many EU countries between “before” and “after” periods of the economic recession, five countries demonstrated significant improvement: Greece (+161%), Denmark (+209%), Croatia (+229%), Malta (+90%) and Romania (+295%); however, among these countries only Greece recorded a GDP per capita reduction (-19%) between 2005 and 2014. It should be noted that Denmark has one of the lowest fatality rates in EU (fifth best for 2014).

Moreover, between all EU countries, only five countries recorded a GDP per capita reduction between 2005 and 2014, including Greece (-19%), Spain (-5%), Italy (-9%), Cyprus (-12%) and Portugal (-2%) (Figure 7); and among these five countries only Greece presented an improvement in the percentage change of the fatality rate (number of fatalities per million inhabitants) between “before” and “after” periods.

The economic recession had varying effects in different countries as well as to different users and accident categories. Road safety levels have been improved in Greece within the last years of the economic recession likely due to actions of the 3rd Strategic Plan, new transportation infrastructure projects, modernization of intelligent transport systems and police’s surveillance systems, and road safety campaigns. While overall statistics show that the road safety has been improved and Greece has succeeded to achieve the mid-term goal of less than 880 road fatalities before 2015, based on the 3rd Strategic Plan, in some cases there was no significant changes in safety indices.

A recent study about road safety in Greece (Kopelias et al., 2016) indicated that the rate of fatal accidents is 2.1 to 3.2 times less than the change of the absolute number of fatal accidents, for before and after periods of economic recession when considering risk factors such as the degree of exposure, sales/consumption of motor fuels, GDP and household expenditure. This could be attributed to the fact that a negative economic growth leads to a reduction of commuting car trips, and to a reduction of fuel sales, which is an indicator of private car utilization. This conclusion is supported by the OECD report (2015) that states that during periods of economic recession three factors come into play: 1) Lower traffic growth rates, 2) Disproportionate reductions in the exposure of high-risk groups, and 3) Reductions in more risky behavior (for instance, people might drive more slowly to save fuel, or drink and drive less).

Similarly, Greek police data indicate that while road accidents have been reduced other potential risk factors remain, and thus may lead to an increase of road accidents when traffic volumes grow back again to prerecession levels (Hellenic Police, 2014). Based on police surveillance data, 1.8 million drivers were tested for alcohol impairment and 2.1% were found positive in 2010, while 2.7% and 1.6% were found positive in 2013 and 2014, respectively. Speed limit violations accounted for 48% and 45% of all road violations in 2010 and 2015, respectively; additionally, usage of mobile phones while driving accounted for 3.5% and 5.1% of total violations in 2010 and 2015, respectively.

Another critical issue is the number of incidents or situations (i.e. debris and obstacles on the road, non-authorized users on the motorway and overloaded vehicles) that may cause a road accident. Incident data in Greece are recorded only for major motorways where Operations and Maintenance companies are responsible for traffic operations. For example, traffic and incident data for AttikiOdos (the bypass for the Metropolitan Area of Athens) show that traffic volume levels compared to year 2009 dropped by 8.5%, 11.0%, 13.9%, 7.0% and 1.8% in 2010, 2011, 2012, 2013 and 2014, respectively. At the

same period, the number of road incidents reduced by only 1.5% in 2011 and increased by 6.7% in 2012 compared to year 2009, showing that while reduction of traffic volumes coincide with decreased road accidents, road incidents with a significant level of risk were not decreased proportionally.

As mentioned earlier, reduction of road accidents may attributed to exposure (fewer vehicles on the road and therefore fewer opportunities for accidents); however, increase of road incidents with a significant level of risk during the years of the economic recession shows that road user behavior may change only when it is related to economic impacts, such as driving slower thus consuming less fuel. Instead, if direct economic drivers are absent, road user behavior may remain the same or becomes worse in terms of using the road responsible and safe. Behavior based research to explore the relationship between users' behavior and specific factors during the period of the economic recession in Greece is necessary to provide important insights towards improving road safety strategies in the future.

Following the “before-after” analysis, young road users appeared to experience the highest reduction in fatalities during the years of the economic recession. As it was seen, young drivers presented a fatality reduction of 57% between 2009 and 2014 and overall fatalities of young road users reduced by 43% between “before” and “after” periods. Similarly, fatalities of young drivers by motorbike for the age group 15-34 reduced by 38% while for the age group 55+ fatalities increased by 9% between “before” and “after” periods. Further research is necessary to explore the relationship that might exist between young users, road accidents and fatality numbers, especially with respect to the patterns in the latest economic recession. Data exploration may focus on potential factors that are related to exposure of young road users. Therefore, in addition to factors that mentioned earlier in this paper, including unemployment, reduced income, etc., other factors may be considered. Such factors may include the change in the number of young people willing to take the driving test due to the cost of lessons, the average distance driven by young drivers, the average trip speed and mode shift “before” and “after” the economic recession.

Additionally, analysis results for “before” and “after” periods of the economic recession suggested that the highest fatality reduction occurred during the night-time between 0:00 and 4:59 (-42%), and for car drivers (-43%). These figures may be the result of changes in users' behavior in terms of transport mode choice, during the years of the economic recession. Public transit services have been improved significantly in Athens, the capital of Greece, due to the utilization of telematics, introduction of new buses, and opening of new metro stations within the last 15 years, which resulted to an extended network coverage, reliability and increased public transit ridership. It should be noted that the Athens metro system since 2011 has extended its operation during Friday and Saturday, and operates from 5:30am to 2:00am. Increased public transit ridership might be affected also by the fact that many vehicle owners preferred to take of the road their vehicles than paying the high annual costs of insurance, taxes and maintenance. At the moment there is not an active replacement car program in Greece, which results to an average car age of 13.5 years, and thus to higher maintenance costs for car owners.

Finally, further research will be necessary to understand the underlying noise between periods of economic recession and road safety levels, as the latest accident data show that road fatality trends have started to rebound following Greece's macroeconomic stability. Provisional data for 2015 and 2016 show that road fatalities in Greece follow

the economy stabilization and demonstrate a short increase. In 2016 the Greek GDP dropped by 0.15% compared to 2015 and road fatalities increased by 1% (804 fatal accidents in 2016 compared to 796 in 2015).

5. Conclusion

Road safety and socioeconomic data were used in this paper to present changes during the economic recession in Greece; however, other macroscopic variables may also be used, including urban sprawl, oil prices and utilization of public transit or cheaper transport modes. In addition to changes in macroscopic variables that contribute to changes in road safety, although findings are not always consistent (Wegman et al., 2017), other variables have been studied in literature. Microscopic or seasonal changes in economic and social factors have been associated with changes of road safety levels, as well as regional policies also contribute to road safety changes over time; however, smaller compared to economic effects (Noland and Zhou, 2017).

Although, a clear relationship between changes in road fatalities and socioeconomic indices cannot be established here, the “before-after” analysis showed that significant changes of road safety levels occurred after the beginning of the economic recession in Greece that cannot be omitted by policy makers. Policy makers should consider carefully these results when setting road safety goals and forming Strategic Plans for the future.

Maintaining a safe road environment from now on for all users relies on the study and implementation of measures that focus on regional characteristics rather on national characteristics of road network and users. Vulnerable user groups, including elderly drivers, passengers and pedestrians, user group at the age cohort of 15-24 as well as pedestrians and motorcycle drivers, are considered ‘at risk’ compared to other user groups, and thus more effort is required to improve their fatality rates.

While the economic recession has passed for many countries in the EU, Greece appears to face socioeconomic issues for the last ten years. Countries such as Austria, the Netherlands, Hungary and the Czech Republic, for which the GDP has recovered but fatalities continue decreasing should provide further insight on their processes. As Greece’s GDP for year 2017 appears to increase for the first time since 2009, policy makers should prepare for the effects on the transportation sector. Supporting efforts should be focused on: a) Studying users’ behavior, b) Exploring the relationship between potential factors that might have contributed in the improvement of safety levels in recent years, and c) Collecting and analyzing experiences from places that gained in terms of fatality reduction while recovering from the recession, to develop the pathway for planning for a safe future on roads.

Substantial policy planning will likely attract more investments for implementing new safety measures, maintaining old road infrastructure and customizing actions per location and user group. The end of the economic recession period and the return to a sustainable growth should be combined with the utilization of appropriate mechanisms for the collection, processing and publication of reliable road safety data to support suggested efforts and to ensure the stabilization of improvement of road safety levels in Greece.

References

- Antoniou, C., Yannis, G., Papadimitriou, E., Lassarre, S. (2016) “Relating Traffic Fatalities to GDP in Europe on the Long Term”, *Accident Analysis and Prevention* 92, pp. 89-96.
- Antoniou, C., Yannis, G. (2013) “Assessment of Exposure Proxies for Macroscopic Road Safety Prediction”, *Transportation Research Record* 2386, pp. 81-94.
- Attica Tollway. (2015) *Company Reports, Athens, Greece*. Retrieved from <http://www.aodos.gr>.
- Chen G. (2014) “Association between Economic Fluctuations and Road Mortality in OECD Countries” *European Journal of Public Health* 24(4), pp.612-614.
- CONSOL. (2013) CONCerns and SOLutions – *Road Safety in the Ageing Societies*. EU funded project.
- Cotti, C., Tefft, N. (2011) “Decomposing the Relationship between Macroeconomic Conditions and Fatal Car Crashes during the Great Recession: Alcohol-and non-Alcohol-related Accidents”, *The B.E. Journal of Economic Analysis and Policy, De Gruyter* 11(1), pp. 1-24.
- EC – European Commission. (2017) *Mobility and Transport - Road Safety*. Retrieved from http://ec.europa.eu/transport/road_safety/specialist/statistics/index_en.htm
- EC – European Commission. (2016) *Road Safety: New Statistics Call for Fresh Efforts to Save Lives on EU Roads*. Retrieved from http://europa.eu/rapid/press-release_IP-16-863_en.htm Press release. Accessed March 2016.
- EC – European Commission. (2010) *Road Safety Programme 2011-2020: Detailed Measures. European Commission, MEMO/10/343, Brussels*. Retrieved from http://europa.eu/rapid/press-release_MEMO-10-343_en.htm.
- EgnatiaOdos. (2014) *Observatory, Indicator TRA07 Vehicles Kilometers Travelled*. Retrieved from <http://observatory.egnatia.gr>.
- French, M.T., Gumus, G. (2014) “Macroeconomic Fluctuations and Motorcycle Fatalities in the U.S.”, *Social science and Medicine* 104(C), pp.187-193.
- Guangqing, C., Porter, R.J., Cosby, G.A., Levinson, D. (2013) “The Impact of Gasoline Price Changes on Traffic Safety: A Time Geography Explanation”, *Journal of Transport Geography* 28, pp. 1–11.
- Hellenic Association of Insurance Companies. (2014) *Uninsured Vehicles*. Retrieved from <http://www.asfalisinet.gr>.
- Hellenic Police. (2014) *Annual Reports*. Retrieved from <http://www.astynomia.gr>
- Hedlund, J., Arnold, R., Cerrelli, E., Partyka, S., Hoxie, P., Skinner, D. (1984) “An Assessment of the 1982 Traffic Fatality Decrease”, *Accident Analysis and Prevention* 16(4), pp. 217–261.
- Hellenic Statistical Authority - EL.STAT. (2016) *Social Statistics Division. Justice and Public Order Statistics Section Road Traffic Accidents*. Retrieved from <http://www.statistics.gr>.
- ICAP. (2017) *Third Party Logistics Providers*, ICAP Group: Athens, Greece.
- Kweon, Y.J. (2011) “What Affects Annual Changes in Traffic Safety Measures in Virginia? Macroscopic Perspective”, *Transportation Research Board 90th Annual Meeting*, Compendium of Papers DVD, January 23-27, 2011, Washington D.C.
- Kopelias, P., Misokefalou, E., Tsantsanoglou, A. (2016) “Evaluation of Road Safety Level during a Recession Period: A Comparison using Safety and Economic

- Factors”, *Advances in Transportation Studies an International Journal* 38, pp. 121-134.
- NHTSA - U.S. Department of Transportation. (2010) *An Analysis of the Significant Decline in Motor Vehicle Traffic Fatalities in 2008*. Retrieved from <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811346>.
- Noland, B., Zhou, Y. (2017) “Has the Great Recession and its Aftermath Reduced Traffic Fatalities?” *Accident analysis and Prevention* 98, pp. 130–138.
- Norris, F.H., Matthews, B.A., Riad, J.K. (2000) “Characterological, Situational, and Behavioural Risk Factors for Motor Vehicle Accidents: A Prospective Examination”, *Accident Analysis and Prevention* 32, pp. 505 - 515.
- NTUA – National Technical University of Athens. (2011) *Strategic Plan for Improving Road Safety in Greece, 2011-2020*. Retrieved from <https://www.nrso.ntua.gr/wp-content/uploads/ntua-rss3-rn54sgr.pdf>.
- OECD - Organisation for Economic Co-operation and Development. (2015) *Why does Road Safety Improve When Economic Times are Hard?* Retrieved from <https://www.itf-oecd.org/why-does-road-safety-improve-when-economic-times-are-hard>.
- Planis, S., Murray, I.J., Pallikaris, I.G. (2006) “Road Traffic Casualties: Understanding the Night-time Death Toll”, *Injury Prevention* 12 (2), pp. 125–128.
- Reinfurt, D.W., Stewart, J.R., Weaver, N.L. (1991) “Economy as a Factor in Motor Vehicle Fatalities, Suicides, and Homicides” *Accident Analysis and Prevention* 23(5), pp. 453–462.
- Smeed, R.J. (1968) “Variations in the Pattern of Accident Rates in Different Countries and their Causes”, *Traffic Engineering and Control* 10(7), pp. 364–371.
- Stuckler, D. Basu, S., Suhrcke, M., Coutts, McKee, M. (2009) The Public Health Effect of Economic Crises and Alternative Policy Responses in Europe: An Empirical Analysis. *The Lancet*, 374 (9686), pp. 315–323.
- UK DoT – UK Department of Transport. (2011) *Strategic Framework for Road Safety*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/8146/strategicframework.pdf.
- Wagenaar, A.C. (1984) “Effects of Macroeconomic Conditions on the Incidence of Motor Vehicle Accidents”, *Accident Analysis and Prevention*, 16(3), pp. 191–205.
- Wegman, F., Allsop, R., Antoniou, C., Bergel-Hayat, R., Elvik, R., Lassarre, S., Lloyd, D., Wijnen, W. (2017) “How did the Economic Recession (2008–2010) Influence Traffic Fatalities in OECD-Countries?” *Accident Analysis and Prevention* 102 (1), pp. 51-59.
- Wolff, H. (2014) “Value of Time: Speeding Behavior and Gasoline Prices”, *Journal of Environmental Economics and Management* 67, pp. 71-88.
- Yannis, G., Papadimitriou, E., Folla, K. (2014) “Effect of GDP Changes on Road Traffic Fatalities”, *Safety Science* 63, pp. 42–49.
- Yannis, G., Antoniou, C., Papadimitriou E., Katsochis, D. (2014) “When May Road Fatalities Start to Decrease?” *Journal of Safety Research* 42, pp. 17–25.