CHARACTERISTICS OF LORRY AND BUS ACCIDENTS IN GREECE

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ABSTRACT

The objective of this research is the analysis of the effect of lorries and buses on the number of road accidents and related casualties in Greece. For this purpose, the NTUA database with disaggregate road accident data was exploited. In particular, a comparative analysis of all road accidents and related casualties with or without the involvement of lorries and buses was carried out, for different road network types, vehicle types, accident types and driver characteristics. Specific analysis techniques were implemented in order to deal with the lack of related exposure data (e.g. vehicle kilometres of travel), such as the calculation of accident severity rates and fatality distributions per accident type. The results revealed important involvement of lorries and buses in road accidents in Greece, rising up to more than 16% of all road accidents and more than 20% of all fatalities. As regards road accident severity, it was found that the number of fatalities per accidents in accidents with lorry or bus involvement is almost double than the related severity rate in accidents without lorry or bus involvement. However, the respective difference in accident severity for injured persons was not statistically significant. Moreover, lorries and buses are clearly over-represented in head-on or at-angle collisions. The results of this analysis may be useful for the planning and implementation of specific measures for the traffic management of lorries and buses, in order to decrease road accident involvement and severity of lorries in Greece, both in urban and interurban roads.

Keywords: Lorries; buses; road accidents; severity.

1. INTRODUCTION

Lorries and buses are vehicle groups with particular traffic and safety characteristics, since they have increased mass and weight, they are associated to different uses (e.g. commercial, recreational, transit), they present increased vehicle- and driver-kilometres traveled and they are often subject to particular traffic and operational rules. These vehicle groups are also associated with more severe accidents, mostly due to their increased dimensions that make the collision more severe for the opponent (Kockelman & Kweon, 2002; Broughton, 2008), especially for more vulnerable opponents (Lefler & Gambler, 2004; Dupont and Martensen, 2008). Other parameters that may or may not be common between lorries and buses accidents have been identified in the literature as determinants of these vehicles' accidents.

Most related studies are devoted to lorries' safety, aiming to identify risk and severity factors and to compare with those of other vehicle categories. In a longitudinal study (Loeb & Clarke, 2007), it was found that alcohol consumption, unemployment rate, and railroad activity have significant macroscopic effects on lorry accidents' trends, while deregulation of the lorrying industry in the U.S. had no statistically significant adverse effect on these accidents. Braver et al. (1997) found multiple-trailer lorries to be over-involved in multiple vehicle accidents compared to single-trailer lorries. Campbell (1991) found a dominant increasing effect of lorry driver's age on lorry accident involvement; in particular, young lorry drivers appeared to be more involved in accidents. In Miaou (1994) it is suggested that lorry accident involvement increases with horizontal road curvature, gradient and total traffic volumes but decreases with percentage of lorry traffic.

As regards accident severity, Blower et al. (1993) found that lorry-tractors' accident severity was higher in rural areas and during night-time and appeared to be more dependent on the road environment than the tractor configuration. Khorashadi et al. (2005) found that injury severity in large-lorry accidents increases with vehicle size and alcohol involvement, whereas different determinants are to be expected in rural and urban areas. Finally, Chang & Mannering (1999) compared lorry- and non-lorry-involved accident injuries and found several variables which significantly increase injury severity only for lorry-involved accidents, including high vehicle occupancy, high speed limits, turning manoeuvre accidents and rear-end collisions.

With respect to road safety characteristics of buses or coaches, the few studies available are more limited in their scope. Van Nooten et al. (1991) investigated time intervals between consecutive bus accidents but found no statistically significant pattern. Hamed et al. (1998) show that higher mini-bus accident rates are associated with less experienced drivers, rural areas and previous accident involvement. White & Dennis (1995) found no significant change in casualty rates for bus and coach occupants due to bus deregulation in Britain on 1986. Af Wåhlberg (2004) investigated urban bus accidents and identified a significant effect of junctions. No specific study on the severity of bus accidents was found.

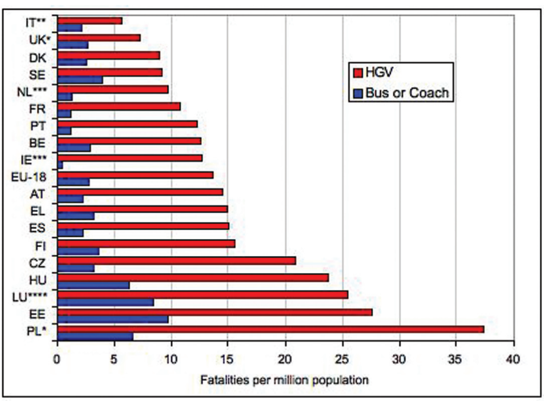
Within this framework, the objective of this paper is the analysis of lorries' and buses road accidents in Greece. In particular, the effect of lorry or bus involvement in road accidents is examined in terms of accident severity in relation to a number of key factors such as area type, vehicle type, accident type and driver age. Data from the database of the Department of Transportation Planning and Engineering of the National Technical University of Athens (NTUA/DTPE) are used on that purpose, including detailed disaggregate data of the National Statistics (NSSG) on road accidents and related casualties for the period 2002-2007. In order to deal with the lack of exposure data (i.e. vehicle kilometres of travel), only accident severity rates are examined (e.g. fatalities per accidents). Moreover, fatality distributions per accident type are estimated, under the assumption that exposure is constant across different accident types (Golias & Yannis, 2001).

The analysis starts with an overview of basic trends and figures of lorries and buses accidents in Europe and in Greece, allowing for an overall picture of the current road safety level associated with these vehicles. Then, the global severity rates of accidents with or without lorry or bus involvement are calculated. These are further disaggregated per driver age, vehicle type (lorry or bus), area type (inside or outside urban area), lighting conditions and accident type (head-on, at-angle, side or rear-end collision, run-off road, collision with fixed object, pedestrian involvement etc.). Combined effects of these parameters are also examined both for lorries and buses accidents. Finally, the results are discussed in terms of traffic management and general policy implications, in the light of related policies and measures that are recommended internationally for the improvement of lorries and buses road safety.

2. BASIC FIGURES

Fatalities in accidents involving heavy lorries (i.e. >3,5 tons) and buses present a decreasing trend of more than 30% during the last decade in Europe (1997-2006), while in Greece the respective decrease was of more than 35%. Nevertheless, in 2006, more than 6.000 fatalities were recorded in road accidents involving heavy lorries or buses in Europe (the EU-14 -not including Germany- plus the Czech Republic, Estonia, Hungary Malta and Poland), out of which 5.000 fatalities in accidents involving heavy lorries and 1.000 fatalities in accidents involving buses or coaches (ERSO, 2008). Figure 1 presents the fatality rates (fatalities per million inhabitants) from accidents involving heavy lorries (HGVs) or buses on 2006 in the eighteen European countries mentioned above. It is noted that the related fatality rates in Greece are higher than the average and the highest among the EU-14 countries, although the new Member States present significantly higher fatality rates.

Figure 1. Fatality rates in accidents involving Lorries (HGVs) and Buses, 2006 (Source: ERSO, 2008)



* Data from 2005 (UK = GB 2006 + NI 2005)
** Data from 2004
*** Data from 2003
**** Data from 2002

Source: CARE Database / EC
Date of query: July 2008
Source of population data: EUROSTAT

In particular, in Greece there were 151 fatalities in accidents involving light lorries, 167 fatalities in accidents involving heavy lorries and 36 fatalities in accidents involving buses on 2006; the sum of these fatalities corresponds to more than 20% of all fatalities in Greece on 2006. The related proportion of road accident with lorry or bus involvement was more than 15% of all road accidents in Greece.

The use of the database of NTUA/DTPE allows for detailed analysis of lorry and bus accident severity in Greece. Accident severity rates, defined as the number of casualties per accidents, were calculated separately for bus- or lorry-involved accidents and non-bus- or non-lorry-involved accidents. These are presented in Table 1. It can be seen that the severity rate for fatalities in lorry-involved accidents is by 70% higher than the average (all accidents) and almost double than the respective severity rate in non-lorry-involved accidents. On the other hand, no significant differences between lorry-involved and non-lorry-involved accidents are observed with respect to serious or slight injuries. Another interesting effect identified concerns uninjured drivers, whose rate is by 19% higher in lorry-involved accidents than in non-lorry-involved accidents; this may be attributed to the better protection offered by the vehicle to the lorry drivers, indicating that the increased fatality rate of lorry-involved accidents mainly concerns the opponent vehicles.

As regards bus accidents, the severity rate for fatalities in bus-involved accidents is by only 20% higher than both the average and the respective rate of non-bus-involved accidents (and by 40% lower than the respective rate of lorry-involved accidents). However, a difference is observed as regards slight injuries, which are by 10% higher in bus-involved accidents compared to both the average and the respective rate of non-bus-involved accidents. It is possible that the increased slight injury rate of bus-involved accidents is due to the higher occupancy of buses. It is further noted that the rate of uninjured drivers in bus-involved accidents in around 35% higher than the average, suggesting that bus drivers may be even more protected than lorry drivers, and also more protected than the bus passengers.

Table 1. Number of casualties per accident in Greece 2002-2006, with and without lorry or bus involvement (Source: NSSG, Processing: NTUA/DTPE)

Severity rates	**Lorry-involved accidents**	**Non-lorry-involved accidents**	**All accidents**
Uninjured drivers	1.01	0.85	**0.87**
Fatalities	0.17	0.09	**0.10**
Serious injuries	0.17	0.14	**0.14**
Slight injuries	1.17	1.17	**1.17**
Severity rates	**Bus-involved accidents**	**Non-bus-involved accidents**	**All accidents**
Uninjured drivers	1.18	0.86	**0.87**
Fatalities	0.12	0.10	**0.10**
Serious injuries	0.14	0.14	**0.14**
Slight injuries	1.28	1.16	**1.17**

These results indicate that both lorry-involved and bus-involved accidents results in increased severity, mostly as regards their collision opponents. However, they also suggest that the two vehicle types present significantly different patterns as regards accident severity. A more disaggregate analysis, taking into account road network, accident and driver characteristics, may therefore reveal additional effects. This analysis is presented in the following section.

3. DETAILLED ANALYSIS

Table 2 presents a disaggregation of lorry- and bus-involved accident severity rates per driver age, aiming to identify age groups of lorry and bus drivers associated with increased lorry or bus accident severity. These rates were calculated as the number of casualties per lorry- or bus-involved accident per age of the lorry or bus driver. Given that more than one buses or lorries may be involved in one accident, some of the related casualties are double-counted (e.g. in case there are two lorry drivers of different age group in a multi-vehicle accident, the fatalities of that accident are associated with both drivers resulting in double-counting of these fatalities). Consequently the average severity rates are slightly different than those presented in the first column of Table 1. It is also noted that lorry and bus drivers of <25 and >65 years old are not considered, due to insufficient sample of related fatalities that would results in limited accuracy of the respective accident rates.

It is interesting to note that lorry driver age does not appear to significantly affect the severity rate. This suggests that all lorry drivers have equal fatalities, serious injuries and slight injuries per accident, possibly because fatality severity rate is more dependent on vehicle size and mainly concerns the collision opponents rather than the lorry occupants.

Bus driver's age shows a quite different pattern. In this case, older drivers (taken as the 55-64 age group, due to lack of sufficient sample in the >65 group) tend to be involved in accidents with more fatalities (almost double severity rates), and slightly more serious and slight injuries. Given that no other considerable variation in the severity rates per bus driver age is observed, it is indicated that older bus drivers are involved in more severe bus accidents. This could be attributed to increased bus occupancy; it is likely that some insufficiency in the driving skills or behaviour of older bus drivers, (e.g. inadequate crash avoidance manoeuvers), results in more severe accident consequences for their vehicle and thus more severe bus passenger injuries. It is also interesting to note that bus drivers of 55-64 years old have slightly lower uninjured driver rates, which suggests that the more severe consequences of their accidents are also suffered by themselves.

Table 2. Number of casualties per lorry- or bus-involved accident in Greece 2002-2006, per lorry or bus driver age (Source: NSSG, Processing: NTUA/DTPE)

Severity rates	Lorry driver age*			
	25-34	35-54	55-64	**All**
Uninjured drivers	1.04	1.04	0.97	**1.02**
Fatalities	0.16	0.19	0.18	**0.17**
Serious injuries	0.16	0.13	0.15	**0.23**
Slight injuries	1.16	1.15	1.18	**1.18**
Severity rates	**Bus driver age***			
	25-34	35-54	55-64	**All**
Uninjured drivers	1.20	1.21	1.12	**1.19**
Fatalities	0.08	0.11	0.25	**0.12**
Serious injuries	0.13	0.13	0.18	**0.14**
Slight injuries	1.26	1.29	1.43	**1.30**

* may be double-counted in multiple vehicle accidents

Table 3 presents the distribution of road accidents fatalities in lorry- or bus-involved accidents per accident type and area type, together with the respective distribution of non-lorry- or non-bus-involved accidents. It is noted that exposure is assumed to be constant across accident types, and therefore the related distributions are representative of fatality risks (Golias & Yannis, 2001). Moreover, by calculating the difference between the proportions of fatalities of each accident type in lorry-involved and non-lorry involved accidents, it is possible to identify accident types in which lorry involvement is systematically associated with more fatalities.

The results indicate that lorry-involved accident fatalities inside urban areas are mostly associated with head-on (increased by +6%) or at-angle (increased by +10%) collisions, whereas non-lorry-involved fatalities inside urban areas are mostly associated with run-off-road or fixed object collisions. Outside urban areas, the correlation of lorry-involved fatalities with head-on and at-angle collisions is even more pronounced (i.e. higher positive differences between lorry-involved and non-lorry involved fatalities). This is in accordance with previous studies (Blower et al. 1993; Khorashadi et al. 2005), where increased lorry-accident severity in rural areas was found. Although more than 25% of fatalities are pedestrians, lorry involvement is only slightly more associated with pedestrian fatalities inside urban areas (+3,5%).

A similar picture is obtained when examining bus-involved fatalities, which are clustered in head-on collisions (around +10-12% in relation to non-bus-involved fatalities) or at-angle collisions (around +18-20% in relation to non-bus-involved fatalities) both inside and outside urban areas. However, bus-involved fatalities are less likely to concern pedestrians, both inside (-5%) and outside (-3%) urban areas than non-bus-involved fatalities.

Table 3. Fatalities distribution per accident type and area type in Greece 2002-2006, in accidents with and without lorry/bus involvement (Source: NSSG, Processing: NTUA/DTPE)

		Lorry			Bus		
Area type	**Accident type**	involved	not involved	**Difference**	involved	not involved	**Difference**
Inside urban area	Ran-off-road	2.9%	12.9%	**-10.0%**	0.0%	11.2%	**-11.2%**
	Head-on collision	12.8%	6.5%	**6.3%**	17.4%	7.5%	**10.0%**
	Rear-end collision	7.5%	4.5%	**3.0%**	5.5%	5.1%	**0.4%**
	Pedestrian	27.7%	24.2%	**3.4%**	20.2%	25.1%	**-4.9%**
	Side collision	6.7%	3.7%	**2.9%**	8.3%	4.2%	**4.1%**
	At-angle collision	30.5%	20.1%	**10.4%**	41.3%	21.6%	**19.7%**
	Fixed object collision	8.7%	22.6%	**-13.9%**	7.3%	20.2%	**-12.9%**
	Other	3.3%	5.5%	**-2.2%**	0.0%	5.2%	**-5.2%**
	Total	**100.0%**	**100.0%**		**100.0%**	**100.0%**	
Outside urban area	Ran-off-road	9.9%	24.1%	**-14.2%**	2.2%	21.4%	**-19.2%**
	Head-on collision	23.2%	14.5%	**8.7%**	28.0%	16.1%	**11.9%**
	Rear-end collision	9.6%	5.9%	**3.7%**	6.0%	6.8%	**-0.8%**
	Pedestrian	7.3%	7.8%	**-0.5%**	4.9%	7.8%	**-2.8%**
	Side collision	3.2%	1.9%	**1.3%**	8.2%	2.0%	**6.2%**
	At-angle collision	35.8%	18.9%	**16.9%**	39.0%	22.3%	**16.7%**
	Fixed object collision	6.7%	18.9%	**-12.1%**	11.0%	16.2%	**-5.2%**
	Other	4.3%	8.1%	**-3.8%**	0.5%	7.4%	**-6.9%**
	Total	**100.0%**	**100.0%**		**100.0%**	**100.0%**	

In Table 4, the effect of lighting conditions on lorry or bus related fatalities is jointly examined with accident types; in this case, exposure is also taken into account as explained previously when comparing accident types. In this case, however, due to very small samples of lorry- and bus-involved fatalities at night, some grouping was considered to be meaningful, namely as regards the critical accident types of head-on and at-angle collisions. Lighting conditions are distinguished into daylight and night (including twilight and night-time).

The results confirm that both lorry and bus fatalities results from increased head-on or at-angle collisions in relation to non-lorry and non-bus fatalities both at daylight and during the night. Moreover, lorry-involved fatalities from head-on or at-angle collisions are by +8% increased at night compared to non-lorry-involved fatalities. The pattern is more intense as regards bus related fatalities, where head-on and at-angle collisions are over-represented both at daylight and night, however a further increase of +18% is observed at night.

Although increased lorry-accident severity at night was found in other studies (Blower et al. 1993), the present results can not be directly associated with fatality risk at night, given that the differences in exposure between daytime and night-time are not eliminated when comparing daylight vs. night. In particular, lorry and bus traffic is higher outside urban areas at night (i.e. in terms of vehicle-kilometres travelled), and this may explain their increased involvement in head-on or at-angle collisions at night. This is in accordance to the findings concerning area type, where head-on and at-angle collisions of lorries and buses were over-represented in rural areas, compared to other accident types.

Table 4. Fatalities distribution per accident type and lighting conditions in Greece 2002-2006, in accidents with and without lorry/bus involvement (Source: NSSG, Processing: NTUA/DTPE)

		Lorry			Bus		
Lighting	**Accident type**	involved	not involved	**Difference**	involved	not involved	**Difference**
Daylight	Ran-off-road	6.9%	18.0%	**-11.1%**	2.3%	15.5%	**-13.2%**
	Head-on or at-angle collision	54.0%	36.5%	**17.5%**	62.3%	40.4%	**21.8%**
	Rear end collision	7.9%	4.7%	**3.2%**	7.4%	5.5%	**1.9%**
	Pedestrian	15.5%	14.7%	**0.7%**	12.6%	15.0%	**-2.5%**
	Side collision	6.1%	3.2%	**2.8%**	11.4%	3.7%	**7.7%**
	Fixed object collision	5.8%	15.5%	**-9.7%**	3.4%	13.3%	**-9.8%**
	Other	3.8%	7.3%	**-3.4%**	0.6%	6.6%	**-6.0%**
	Total	**100.0%**	**100.0%**		**100.0%**	**100.0%**	
Night	Ran-off-road	7.3%	19.6%	**-12.3%**	0.0%	18.1%	**-18.1%**
	Head-on or at-angle collision	50.2%	24.4%	**25.7%**	66.4%	27.5%	**38.9%**
	Rear end collision	10.4%	5.7%	**4.6%**	3.4%	6.6%	**-3.1%**
	Pedestrian	15.6%	16.2%	**-0.5%**	7.8%	16.3%	**-8.6%**
	Side collision	2.0%	2.4%	**-0.3%**	3.4%	2.3%	**1.2%**
	Fixed object collision	10.7%	25.3%	**-14.6%**	19.0%	23.0%	**-4.0%**
	Other	3.9%	6.5%	**-2.6%**	0.0%	6.2%	**-6.2%**
	Total	**100.0%**	**100.0%**		**100.0%**	**100.0%**	

4. CONCLUSIONS

In this paper, basic parameters of accidents involving lorries or buses in Greece were investigated. Initially, the accident severity rates (number of casualties per accidents) were calculated for accidents with and without bus or lorry involvement, revealing increased severity of bus- or lorry-involved accidents in terms of fatalities. Moreover, increased slight injury severity was found in bus-involved accidents. Lorry accident severity was found to be independent of lorry driver age. On the contrary, older (55-64 years old) bus drivers were associated with increased fatalities and injuries per bus-involved accidents.

Additionally, the distributions of lorry- or bus-involved accidents per area type, accident type and lighting conditions were calculated, using non-lorry- or non-bus-involved accidents as control groups. The results suggest that lorries and buses are clearly over-represented in multiple vehicle accidents, and in head-on or at-angle collisions fatalities in particular, both inside and outside urban areas, both during daylight and night. However, these particular lorry and bus accident types were even more increased in rural areas and at night, a result that may reflect exposure patterns.

These results confirm previous studies as regards the increased severity of lorry-or bus-involved accidents. They also reveal some interesting effects, which may be partly due to particularities of the Greek setting. For instance, the strong association of buses and lorries with head-on and at-angle collisions, especially outside urban areas and at night lighting conditions may imply an important role of the road environment. Road safety infrastructure interventions, such as better physical separation of traffic flows, improved road lighting, together with systematic enforcement of lorry and bus related traffic rules (e.g. speed limits, overtaking etc.) especially in the rural road network may thus contribute in the reduction of these critical types of accidents. Measures towards the full separation of lorry or bus traffic, such as truck lanes (de Palma et al. 2008), are not considered to be currently applicable in Greece.

The increased severity rate concerning slight injuries in bus accidents may be partly attributed to the increased vehicle occupancy; a number of related measures may be examined for the improvement of bus passengers' safety, such as improved seat design, mandatory seat-belt wearing and improved evacuation procedures (IRU, 2005). As regards the association of older drivers with more bus-involved casualties compared to the other age groups, continuous training and more systematic evaluation of driving skills may be recommended. It should be examined whether the 5-year renewal of professional license framework of the current Traffic Rules (Ministry of Transport, 2007) is sufficient for that particular group of drivers. A number of driver of in-vehice driver assistance systems may also assist drivers in safer driving (IRU, 2005). In any case, respecting driving and rest times for lorry and bus drivers of all ages is underlined in most existing studies (Campbell, 1991).

A more extensive research, including combined analysis of more roadway, vehicle and driver characteristics should focus on important parameters identified in the literature such as road curvature, vehicle size and configuration and driver experience. The use of exposure data, such as the amount of vehicle-kilometres travelled, or alternatively the number of registered vehicles and licensed drivers would allow for the estimation of accident risk rates. Unfortunately, such data is currently not available or not accessible in Greece.

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