Castro-Nuño, Mercedes; Castillo-Manzano, José I.; Fageda, Xavier

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DO MORE TRUCKS LEAD TO MORE MOTOR VEHICLE FATALITIES IN EUROPEAN ROADS? EVALUATING THE IMPACT OF SPECIFIC SAFETY STRATEGIES

AUTHORS

José I. Castillo-Manzano (jignacio@us.es).

Applied Economics & Management Research Group. University of Seville, Spain.

Mercedes Castro-Nuño (mercas@us.es).

Applied Economics & Management Research Group. University of Seville, Spain.

Xavier Fageda (xfageda@ub.edu).

Department of Economic Policy, University of Barcelona, Spain

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Abstract

Truck operations have recently become an important focus of academic research not only because road freight transport is a key part of logistics, but because trucks are usually associated with negative externalities including pollution, congestion and traffic accidents. While the negative environmental impacts of truck activities have been extensively analyzed, comparatively little attention has been paid to the role of trucks in road accidents. A review of the literature identifies various truck-traffic safety related issues: frequency of accidents and their determinants; risk factors associated with truck driver behavior (including cell phone use, fatigue, alcohol and drugs consumption); truck characteristics and facilities (roadway types, specific lanes and electronic stability programs) to improve performance of vehicle maneuvering; and the safety characteristics of heavy and large trucks. However, to date, there seems to have been developed few studies evaluating the complex coexistence of trucks and cars on roads and that may support the implementation of differential road safety strategies applied to them. This paper focuses on the impact on the traffic fatalities rate of the interaction between trucks and cars on roads. We also assess the efficiency of two stricter road safety regulations for trucks, as yet not harmonized in the European Union; namely, speed limits and maximum blood alcohol concentration rates. For this, econometric models have been developed from a panel data set for European Union during the years 1999–2010.

Our findings show that rising motorization rates for trucks lead to higher traffic fatalities, while rising motorization rates for cars do not. These effects remain constant across Europe, even in the most highly developed countries boasting the best highway networks. Furthermore, we also find that lower maximum speed limits for trucks are effective and maximum blood alcohol concentration rates for professional drivers are only effective when they are strictly set to zero. Therefore, our results point to that the differential treatment of trucks is not only adequate for mitigating an important source of congestion and pollution, but that the implementation of stricter road safety measures in European countries for the case of trucks also contributes significantly to reducing fatalities.

In summary, and as a counterpoint to the negative impact of trucks on road traffic accidents, we conclude the effectiveness of efforts made in road safety policy (based on specific traffic regulations by vehicle type imposed by member States) to counteract the safety externalities of freight transportation in the European Union. In certain sense, our study might provide indirect support to public policies implemented at the macro European level to promote multimodal transport corridors. In this respect, there is an increasing focus at the European level on how freight transport can be moved from trucks on roads to more environmentally-sustainable modes, such as rail and ship.

Keywords: Trucks; Road Fatalities; Europe; Speed limits; Blood Alcohol Concentration.

JEL Classification: C23, I18, R41**.**

1. INTRODUCTION.

According to Baindur and Viegas (2011), from 2004 to 2013 the European Union (EU) experienced significant growth in road freight transport of about 60%, adding 20.5 billion tonne-kilometres per year across the EU25 States. According to the European Commission (2013), in 2011 total goods transport activities in the EU27 amounted to 3,824 billion tonne-kilometres. Road transport is the most relevant mode, accounting for 45.3% of this total, compared to 11% rail, 3.7% inland waterways and 3.1% oil pipelines, albeit with differences from one State to another (see, for example, Castillo-Manzano et al., 2013, for a broad consideration of rail-truck freight transport modal distribution).

Consequently, truck operations have recently become an important focus of academic research, not only because road freight transport is the backbone of logistics, but because trucks are associated with negative externalities, including pollution, congestion and accidents (Rowangould, 2013). While the negative environmental impacts of truck operations have been extensively analyzed, comparatively little attention has been paid to the role of trucks in road accidents (Kim and Wee, 2014) despite the fact that, according to the Community Road Accident Database (European Agency for Safety and Health at Work, 2010), transportation vehicle-related accidents are the second largest cause of fatal crashes, and around a third of the deaths in EU workplace accidents are linked to transport.

To date, the relevant literature that has analyzed accidents related to truck-traffic safety issues has mainly focused on the frequency of accidents and identifying determinants (Cantor et al., 2010; Häkkänen and Summala, 2001). Special attention has been paid to the variables that explain accident severity (Chang and Chien, 2013; Lemp, 2011; Zhu and Sirnivasan, 2011) and the strategies that might be effective for prevention (see the review by Mooren et al., 2014); risk factors associated with truck driver behavior, including cell phone use, fatigue and drowsiness, alcohol and drug consumption (Loeb and Clarke, 2007); truck characteristics (dimensions and weights) and technical facilities (roadway types, electronic stability programs) to improve performance of vehicle maneuvering (Mooren et al., 2014); interaction between trucks and other vehicles on roads; rural and urban settings (Chen and Chen, 2011; Gabler and Hollowell, 2000; Harwood et al., 2003; Peeta et al., 2004; Summala and Mikkola, 1994); and the characteristics of heavy and large trucks (Ortega et al., 2014).

Another area of study addresses safety issues regarding differential treatment applied to trucks as a consequence of the peculiar characteristics of these vehicles and their traffic operations (a greater truck mass, weight and dimensions; nighttime and commercial driving schedules) which further increase risk to traffic safety in general (see Choi et al., 2014, for a specification, and Cherry and Adelakun, 2012, for an examination of truck drivers' perceptions). Certain strategies have been developed to palliate these aspects; separating trucks and facilitating their maneuvers (such as lane operations, and differential road safety policies, such as speed limits by vehicle type; specific enforcement) although there seem to have been comparatively few studies evaluating their effectiveness (Cate and Urbanik, 2004; El-Tantawy et al., 2009; Neeley and Richardson, 2009; Qi et al., 2012). In this line, most previous research has explored the characteristics of accidents and associated risks when larger trucks are involved (Chang and Chien, 2013; Dong et al., 2014; Lemp et al., 2011; Zhu and Srinivasan, 2011, among many others).

This paper focuses on the complex nature of the coexistence of trucks and passenger cars by drawing on a panel data set for European countries. Applying econometric techniques to panel data from EU countries for the period 1999-2010 we examine whether greater numbers of trucks and cars on the roads have a negative impact on road safety. We assess the efficacy of two regulations for trucks, not harmonized as yet in the EU, namely, speed limits and maximum blood alcohol concentration (BAC) rates. For this, the article is divided into three sections: apart from this Introduction, Section 2 describes the data and variables, defines the methodology and discusses the resulting estimates; and finally, Section 3 offers a set of concluding remarks with policy implications within the current EU transport policy framework.

2. EMPIRICAL APPROACH.

2.1. Data and variables.

We estimate a model that takes the following form for country *i* during period *t*:

$$Y_{it} = \alpha + \beta_k X_{it} + \gamma_k Z_{it} + \lambda_k W_{it} + \mu_i + \nu_t + \varepsilon_{it} \qquad (1)$$

where Y_{it} is the log of the total per capita fatality rate (within 30 days of the accident, according to the Vienna Convention definition)[1], X_{it} contains the vector of the country's economic and demographic attributes, Z_{it} refers to variables that identify the motorization rates for trucks and passenger cars, and W_{it} are specific variables related to road safety policies. μ_i are country fixed effects that control for omitted time-invariant country-specific variables, ν_t are year dummies that control for the common trend in all the countries in the dataset and ε_{it} is a mean-zero random error.

The data used are for the EU-28 countries from 1999 to 2010. Table 1 provides a description of the variables and the data sources, the unit of observation being the country-year pair. The explanatory variables include factors typically examined in road safety studies (see, for example, Dee and Sela, 2003, and Albalate and Bel, 2012).

[INSERT TABLE 1]

GDP and the square of the GDP are included as explanatory variables to test for a possible non-linear relationship between economic development and road traffic fatalities (Kopits and Cropper, 2005). Indeed, fatality rates may increase with economic development in very poor countries, due to increased exposure to road traffic fatalities. However, the relationship between economic development and traffic fatality rates may become flat or even reverse after a certain wealth threshold has been reached (Bishai et al., 2006).

The influence of the quality of the transport infrastructure is also considered with the inclusion of a motorway density variable. In this regard, a negative relationship is expected between the quality of transport infrastructure and road traffic fatality rates (Noland, 2003).

Furthermore, two control variables are included relating to the percentage of vulnerable population in the country (Langford et al., 2006; Braver and Trempel, 2004). The first variable is for the population over 60 years old. The second variable considered is for the percentage of population aged from 20 to 39 years. Risk exposure may be higher for a younger population because younger road users usually take more risks, while the impact of accidents may be higher for older road users as morbidity and mortality are higher for older populations (see Yee et al., 2006).

[1] This is the dependent variable typically used for assessing road traffic fatalities, as there is a clearer interpretation of policy variables.

One of the innovative contributions of the analysis lies in the distinction drawn between two motorization rates: the number of trucks and the number of passenger cars per capita. In this regard, a country's aggregate level of motorization is usually taken into account in studies on the determinants of road traffic fatalities (Albalate, 2008; Albalate and Bel, 2011; Kopits and Cropper, 2005). It is not clear what relationship with road traffic fatalities should be expected. On the one hand, higher levels of motorization may imply higher exposure to road traffic accidents. On the other hand, more developed countries may enjoy better infrastructure and vehicles, more advanced policies and more beneficial social attitudes towards road safety (such as major post-accident medical care, see Castillo-Manzano et al., 2014). In our context, we examine a possible differential impact between the motorization rates for trucks and passenger cars.

Finally, as in previous studies (e.g., Eisenberg, 2003; Elvik, 2012; Loeb, 2007), the effects of specific policies that may have an influence on road safety traffic fatalities are analyzed.

A variable is included that captures the application of points-based driving licenses. On the basis of earlier research, such as Castillo-Manzano et al. (2014), an index variable is introduced as an explanatory variable that takes the value of one if a penalty driving license system is applied, two if a demerit driving license system is applied and zero if no points system is applied. This variable is used to examine the effects of the introduction and application of any points system to driving licenses on traffic fatality rates.

We also consider specific road safety measures for trucks using two dummy variables that identify maximum BAC rates of professional drivers below 0.5 g/l and 0 g/l, respectively. Additionally, the maximum speed limits for heavy goods vehicles are also considered. To contribute to the scarce previous literature on road safety strategies for different vehicle types, here attention is placed on these policies when specifically applied to trucks.

In this regard, the aim is to test the effectiveness in reducing road traffic fatalities of maximum blood alcohol concentration rates and speed limits for trucks. In keeping with recent studies, it is expected that stricter regulations for truck drivers may have a positive impact on road safety (see Saifizul et al., 2011 for speed limits and Živković et al., 2013 for BAC rates).

2.2. Results and discussion.

Estimates of this type are liable to present problems of heteroscedasticity and temporal autocorrelation in the error term. Indeed, the Wooldridge test for autocorrelation in panel data shows that there may be a problem of serial autocorrelation that needs to be addressed. However, the Breusch-Pagan/Cook-Weisberg test indicates that we do not have a heteroscedasticity problem. We also apply the panel unit root test, as developed by Levin et al. (2002), which can be regarded as an augmented Dickey-Fuller (ADF) test when lags are included. This test indicates that our dependent variable does not present a non-stationarity problem.

Taking these test results into account, the estimation was performed using the ordinary least squares (OLS) method assuming an AR(1) process in the error term. Given that the two dummies identifying the maximum BAC rates are highly correlated, we ran separate regressions with each dummy as the explanatory factor. Note country year dummies are included that control for omitted time-invariant country-specific variables and year dummies that control for the common trend across all the countries in the dataset. Hence, our approach is essentially identical to that of estimating a fixed effects regression model, which has the advantage of allowing us to control for any omitted variables that correlate with the variables of interest and which do not change over time. Table 2 contains the results of the estimates.

[INSERT TABLE 2]

The outcomes are in line with results published elsewhere (Loeb and Clarke, 2007). Thus, a non-linear relationship is found between road traffic fatality rates and a country's level of economic development; the quality of transport infrastructure is confirmed to have a significant effect on road safety, and a rising percentage of vulnerable population is shown to increase traffic fatalities.

The coefficient associated with the number of passenger cars per capita is negative and statistically significant, while the coefficient associated with the number of trucks is positive and statistically significant. The motorization rate can be considered to be related to developments within private transportation. It should be remembered that higher motorization rates may have two different effects on road traffic fatalities: 1) greater exposure to accidents, and 2) better infrastructure and vehicles, and more advanced policies and social attitudes towards road safety. The results for the passenger car variable suggest that the second effect is dominant (in line with Smeed's Law; Smeed, 1949; Smith, 1999), while the results for the number of trucks suggest that the first effect dominates. Indeed, in line with previous researchers like Chang and Chien (2013), it seems that countries with more trucks on the roads experience more traffic fatalities, as accidents involving trucks usually have a greater risk of producing severe injuries or fatalities, due mainly to the car/truck size disparity.

In fact, although small trucks seem to contribute more to congestion than private cars (Nitzsche & Tscharaktschiew, 2013) and longer and heavier trucks may appear to be associated with lower accident rates (see e.g., Lemp et al., 2011) given the fact that they may reduce traffic flow speeds (Anastasopoulos et al., 2012), authors such as Cantor et al. (2010) conclude that trucks in general have to contend with more hazardous situations – vehicles have a greater mass, drivers are exposed to worse driving conditions (longer distances and nighttime schedules), there is greater elasticity to weather conditions, vehicles have to undertake more dangerous maneuvers, and, as a consequence, face more severe accident outcomes.

We also find that speed limits are effective in reducing road traffic fatalities (in line with Saifizul et al., 2011) while the penalty point system applied to driving licenses is not so effective (Castillo-Manzano and Castro-Nuño, 2012). Finally, BAC rates for professional drivers are only effective when the maximum rates are strictly set to zero (Živković et al., 2013).

3. CONCLUSIONS.

This paper examines the coexistence of trucks and cars on roads and how this influences the number of fatalities that come from traffic accidents. Econometric models were developed using a European Union (EU) panel data set for the 1999–2010 period. The impact of two road safety regulations for trucks (as yet not harmonized by EU members) is also evaluated: permitted speed limits and maximum blood alcohol concentration rates.

The results in Table 2 offer clear, broad and robust empirical evidence (based on the situation in 28 countries) of the negative effects that a greater number of trucks have on traffic accident rates. These effects remain constant across Europe, even in the most highly developed countries boasting the best highway networks. As such, this study's findings offer indirect support to public policies implemented at the macro European level to promote multimodal transport corridors. Increases in freight transportation demand and need alternative non-road modes of transport to be developed. There is an increasing focus at the European level on how freight transport can be moved from trucks on roads to more environmentally-sustainable modes, such as rail and ship (see Rich et al., 2011).

In this respect, Short Sea Shipping (SSS) has attracted a lot of attention as an initiative in recent years (Douet and Cappuccilli, 2011) for reducing the conspicuous congestion found on the highways in some EU countries (see Wang et al., 2013 on the UK case); and specifically, the 'Motorways of the Sea' (MoS) are oriented towards providing regular, efficient and high quality maritime logistics services between States (see, for example, Castillo-Manzano and Asencio-Flores, 2012, on the promotion of SSS and MoS in the EU, and Baindur and Viegas, 2011 for an in-depth analysis of expectations and concerns about MoS).

On the other hand, the freight rail system seems to offer an alternative for transporting goods. In this respect, previous studies, such as Rowangould (2013), conclude that the reduction in truck journeys that would result from shifting goods traffic from road to rail would result in fewer accidents, less congestion, lower maintenance costs, and fewer air pollutant emissions.

Consequently, the empirical evidence offered by this research is especially timely given that the European Commission is currently considering a controversial proposal to remove cross-border use and length restrictions for trucks (as established under Directive 96/53/EC), thus opening the door to the introduction of *mega trucks* or *gigaliners* (up to 25 meters in length and 60 tonnes in weight). Such vehicles are already circulating in some Scandinavian member States with less advanced rail systems (including Sweden and Finland) as a solution to their congestion and pollution problems (see Ortega et al., 2014, for a cost-benefit analysis). It is true that if there were a rise in the mean size of European trucks while the volume of goods transported remains constant, this would mean fewer trucks on European roads. And this, according to our findings, would reduce mortality rates on European roads (and even more so if the hypothesis defended by Anastasopoulos et al., 2012, is considered, that large trucks calm the traffic, by making other road-users proceed more slowly).

Finally, and as a counterpoint to the negative impact of trucks on accident rates, the results presented here support the effectiveness of efforts made in road safety policy (based on specific traffic regulations by vehicle type imposed by member States) to counteract the negative externalities of freight transportation in the EU. For example, if, as is expected, alcohol consumption aggravates traffic accidents in which trucks are involved, the results in

Table 2 suggest that specific public policies should be introduced to reduce alcohol consumption by truck drivers, such as bringing down the maximum rates allowed for professionals of this type.

In short, our findings show that the differential treatment of trucks is not only appropriate for mitigating an important source of congestion and pollution, but that the implementation of stricter road safety measures in the case of trucks also contributes significantly to reducing fatalities.

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TABLES

TABLE 1. Variables used in the empirical analysis.

Variables	Description	Source
Per capita fatalities	Fatality rates per million inhabitants	CARE (EU road accidents database)
Motorization_trucks	Number of registered trucks/1000 inhabitants	EUROSTAT,UNECE
Motorization_cars	Number of registered passenger cars/1000 inhabitants	EUROSTAT,UNECE
Per capita GDP	Per capita gross domestic product in International Comparable Prices (US$ at 2005 prices and PPP)	EUROSTAT
Motorway density	Number kms of motorways divided by km^2 of the country	EUROSTAT, UNECE
Old	% population over 60 years old	EUROSTAT
Young	% population aged 20-39 years	EUROSTAT
BAC_05, BAC_0	Dummy variables that takes a value of 1 where the maximum BAC rate allowed for professional drivers is less than 0.5 g/l, or 0 g/l respectively	European Commission Road Safety Website
Point system	Index variable that takes the value 1 if the penalty system driving license is applied; 2 if the demerit system driving license is applied; 0 if any point system is applied	European Transport Safety Council (ETSC)
Speed limits	Maximum speed limits for heavy good vehicles – over 3,5 t (km/hour)	European Commission Road Safety Website

TABLE 2. Results of estimates (OLS with an AR-1 disturbance)

	Dependent variable: Fatalities rate per capita	
Independent variables	**Regression with BAC_05 as explanatory variable**	**Regression with BAC_0 as explanatory variable**
Motorization_cars	-0.0009 (0.0002)***	-0.0009 (0.0002)***

Motorization_trucks	0.0022 (0.0007)***	0.0022 (0.0007)***
Per capita GDP	0.000045 (0.000010)***	0.000045 (0.000010)***
Per capita GDP^2	-3.44e-10 (7.54e-11)***	-3.44e-10 (7.54e-11)***
Motorway density	-0.08 (0.02)***	-0.08 (0.02)***
BAC_05	0.29 (0.34)	-
BAC_0	-	-0.34 (0.11)***
Point_system	-0.009 (0.013)	-0.009 (0.013)
Speed limits	0.022 (0.004)***	0.017 (0.003)***
Old	0.06 (0.01)**	0.06 (0.01)**
Young	0.02 (0.007)***	0.02 (0.007)***
Country dummies	YES	YES
Year dummies	YES	YES
R-Sq.	0.97	0.97
Test joint sign (Wald χ^2)	73663.91***	59811.14***
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity (Ho: Constant variance)	1.01	1.01
ADF test – nonstationarity (Ho: nonstationarity)	-7.02***	-7.02***

Wooldridge test – autocorrelation (Ho: First-order autocorrelation)	54.52***	54.52***
Number observations	311	311

Note 1: Standard errors are given in brackets.

Note 2: Statistical significance at 1% (***), 5% (**), 10% (*).