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Road safety and sustainability performance: A cross-country analysis

Sotirios Karkalakos[1,2], and *Markos* Tselekounis[1,*]

[1]Department of Economics, University of Piraeus, 18534, Piraeus, Greece
[2]School of Social Sciences, Hellenic Open University, 26335, Patras, Greece

Abstract. In this paper, we study the impact of road safety on sustainability performance in the OECD area. Road safety is proxied by the severity of road accidents, whereas the sustainability performance of each country is captured by its sustainability score. Our dataset covers the period 2000-2021 and consists of 35 OECD countries. The employed panel data analysis unveils a statistically significant negative relationship between the number of severe road crashes and sustainability score. In particular, a unit decrease in the number of deaths per one million inhabitants due to road crashes leads to a half unit increase in the overall sustainability score of a country. Therefore, policy makers should undertake measures that improve the efficiency of the transport system since this translates in higher sustainability performance. Indeed, less severe road crashes do have a positive impact on the economy, the society and the environment, thus contributing to all pillars of sustainable development.

1 Introduction

According to the European Commission, transport contributes around 5% to EU GDP and employs more than 10 million people in Europe, however is also related to greenhouse gas and pollutant emissions, noise, and congestion [1]. Interestingly, transport is also linked to road crashes, which mitigate its positive effects on the economy and the society, as well as deteriorate its negative impact on the environment.

The World Health Organization (WHO) states that more that 1.2 million people around the world lose their lives annually due to road crashes, whereas between 20 and 50 million people suffer non-fatal injuries, with many incurring a disability as a result of their injury [2]. Road crashes represent the eighth leading cause of death worldwide and the global leading cause of death for children and young people aged 5–29 years [3].

Apart from the human suffering they caused, road traffic injuries also pose a serious threat to the global economy since they call for treatment costs for the injured and incur productivity loss of those killed or disabled. In general, road traffic injuries have been found to cost countries 3% of their annual gross domestic product at a global level [2]. In Europe, the yearly cost of road crashes has been estimated at around €280 billion, which corresponds to almost 2% of EU GDP [4-5].

Last, road crashes are related to increased congestion and, subsequently, to more CO_2 emissions. Generally, more efficient and prompt responses to accidents lead to reduced traffic congestion and CO_2 emissions. In particular, freeway accidents account for 72% of congestion [6], whereas the average amount of CO_2 emissions per a freeway accident has been estimated to 398.34 kg [7].

Furthermore, traffic congestion can induce aggressive driving behavior, especially when drivers with a high propensity for aggressive driving engage in anger-provoking driving events [8]. An interesting finding is that drivers adopt a more aggressive behavior also in post-congestion situations [9]. Given that aggressive driving is the most prominent cause of road crashes [10], it can be concluded that congestion increases the likelihood of a road crash. Therefore, congestion is regarded as a negative externality of transport that can intensify the detrimental effects of road crashes on all aspects of sustainable development, namely economic, social and environmental sustainability.

The above-mentioned facts have led to significant initiatives aiming to increase the road safety level worldwide. In November 2017, the WHO, in collaboration with other United Nations agencies and several shareholders, developed a set of 12 voluntary Global Road Safety Performance Targets and service delivery mechanisms, along with the corresponding indicators. These voluntary targets evolve around five risk factors affecting the severity of road accidents: (i) monitoring and management of road safety legislation; (ii) safe road infrastructures; (iii) safe vehicles; (iv) safe driving behavior; and (v) post-crash care.

In the same direction, the EU Member States adopted the 2021-2030 EU road safety policy framework, though which they set as a long-term strategic goal to get close to zero deaths and zero serious injuries on EU roads by 2050 (Vision Zero), as well as a medium-term goal to reduce deaths and serious injuries by 50% by 2030.

* Corresponding author: mtselek@unipi.gr

These objectives are fully aligned with the 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States in September 2015 as part of the 2030 Agenda for Sustainable Development. The 17 SDGs reflect a broad and ambitious plan of action for people, planet, prosperity, peace and partnership. The 17 SDGs are specified in a group of 169 individual targets, two of which are directly related to road safety: SDG 3.6 on halving the number of global deaths and injuries from road traffic crashes; and SDG 11.2 on providing access to safe, affordable, accessible and sustainable transport systems as well as improving road safety for all, especially those in vulnerable situations.

Although road safety contributes to sustainability performance through the SDG targets, the overall link between these two variables has yet to be isolated. The goal of this paper is to perform a cross-country analysis of the relationship between road safety and sustainability performance in OECD area.

The employed panel data analysis unveils a statistically significant negative relationship between the road safety level of each country and its sustainability score. Although this finding indicates the existence of positive direct effects of reduced road crashes on sustainability performance, the analysis of the results also show the presence of indirect effects working through several SDG targets. For instance, less severe road accidents translate into less traffic and constant speeds resulting in less CO_2 emissions and more satisfied citizens by the overall transport system.

The rest paper is organized as follows. Section 2 describes the methodology used to assess the impact of road safety on sustainability performance. Section 3 presents the main findings of the empirical analysis, whereas Section 4 discusses the results and draws some policy implications. The final section concludes.

2 Methodology

This section presents the empirical analysis conducted to estimate the effect of road safety on sustainability performance in the OECD area.

Road Safety is proxied by the number of deaths (per 1.000.000 inhabitants) due to road accidents, hence this index reflects the severity of road crashes. Obviously, such severe accidents are those that crucially affect the economy and the society as a whole, while posing significant traffic congestion and CO_2 emissions. The relevant data has been collected by the official website of OECD (https://data.oecd.org/transport/road-accidents.htm) and measures the evolution of deaths (per 1.000.000 inhabitants) due to road accidents from 2000 to 2021 for the OECD countries presented in Table 1.

Table 1. Sample OECD countries.

ISO	country	ISO	country
AUS	Australia	ISR	Israel
AUT	Austria	ITA	Italy
BEL	Belgium	JPN	Japan
CAN	Canada	KOR	Korea, Rep.
CHE	Switzerland	LTU	Lithuania
CHL	Chile	LUX	Luxembourg
CZE	Czech Republic	LVA	Latvia
DEU	Germany	MEX	Mexico
DNK	Denmark	NLD	Netherlands
ESP	Spain	NOR	Norway
EST	Estonia	NZL	New Zealand
FIN	Finland	POL	Poland
FRA	France	PRT	Portugal
GBR	United Kingdom	SVK	Slovak Republic
GRC	Greece	SVN	Slovenia
HUN	Hungary	SWE	Sweden
IRL	Ireland	USA	United States
ISL	Iceland	-	-

The following figure illustrates the evolution of the average number of deaths (per 1 million inhabitants) due to road crashes in the sample OECD countries, as well as the respective average number when the sample is divided in European and non-European countries.

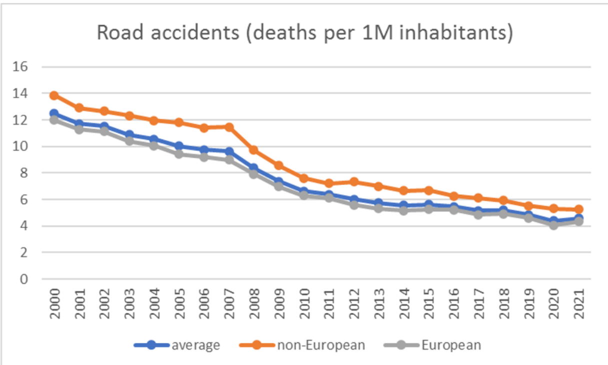

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Fig. 1. The evolution of the road safety index for the sample countries (in average terms).

It is evident that there is a gradual decrease in the number of deaths attributed to road crashes, meaning that the overall road safety level in the OECD area increases over time. However, the European countries seem to be more efficient in reducing the severity of road accidents compared to the non-European ones.

In addition, the sustainability performance of each country is proxied by its sustainability score calculated by the Sustainable Development Solutions Network (SDSN) in a yearly basis. SDSN publishes each year the Sustainable Development Report, whereas the relevant data is available in the companion website (https://dashboards.sdgindex.org/explorer).

The following figure illustrates the evolution of the average sustainability score in the sample OECD countries, as well as the respective average number when the sample is divided in European and non-European countries.

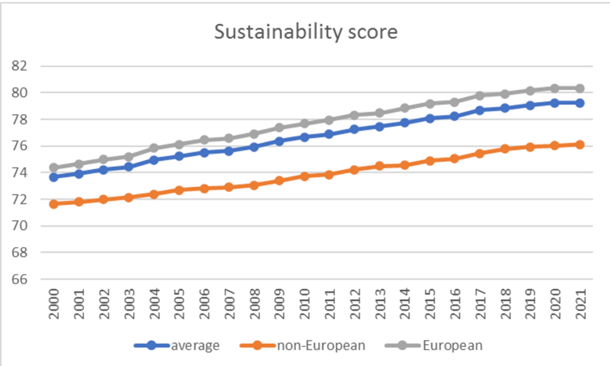

Fig. 2. The evolution of the sustainability score for the sample countries (in average terms).

From Figure 2, it can be concluded that the sustainability performance in the OECD area continuously increases, with the European countries contributing more than the non-European ones to this improvement.

In order to better understand the relationship between road safety level and sustainability performance in each country, a cross-country comparison is provided based on the latest available data (i.e., for the year 2021). Each dot in Figure 3 represents the performance of each sample country with respect to the road safety level and the sustainability score index.

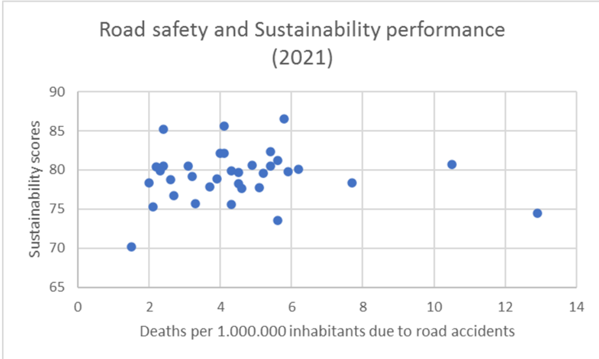

Fig. 3. Road safety level and sustainability performance at a country level for 2021.

The above figure reveals that high sustainability scores are generally correlated to less deaths due to road crashes, although this is not always the case. Perhaps, country-specific characteristics affect this relationship, hence an empirical analysis is needed to draw more reliable results. Given the nature of the available data, a panel data analysis is conducted to estimate the impact of road safety on sustainability performance in the OECD area. Therefore, the number of deaths (per one million inhabitants) serves as the independent variable, whereas the sustainability score reflects the dependent variable.

3 Results

The ultimate goal of the empirical analysis is to estimate the coefficient of the severity of road accidents, which indicates the impact of a marginal change in the number of deaths (per one million inhabitants) due to road crashes on the sustainability score.

The results of the analysis under a model with fixed effects are summarized in Figure 4. On the contrary, Figure 5 presents the main findings when random effects are considered.

```
Fixed-effects (within) regression               Number of obs     =        770
Group variable: country_id                      Number of groups  =         35

R-sq:                                           Obs per group:
     within  = 0.6188                                         min =         22
     between = 0.0170                                         avg =       22.0
     overall = 0.0374                                         max =         22

                                                F(1,734)          =    1191.26
corr(u_i, Xb)  = -0.3142                        Prob > F          =     0.0000
```

SustainabilityScore	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
RoadAccidentsdeathsper1M	-.4980713	.0144307	-34.51	0.000	-.5264017	-.469741
_cons	80.32199	.1184485	678.12	0.000	80.08945	80.55453
sigma_u	4.0916473					
sigma_e	1.2144141					
rho	.9190398	(fraction of variance due to u_i)				

F test that all u_i=0: F(34, 734) = 225.08 Prob > F = 0.0000

Fig. 4. Main findings of the model with fixed effects.

```
Random-effects GLS regression                   Number of obs     =        770
Group variable: country_id                      Number of groups  =         35

R-sq:                                           Obs per group:
     within  = 0.6188                                         min =         22
     between = 0.0170                                         avg =       22.0
     overall = 0.0374                                         max =         22

                                                Wald chi2(1)      =    1170.74
corr(u_i, X)   = 0 (assumed)                    Prob > chi2       =     0.0000
```

SustainabilityScore	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
RoadAccidentsdeathsper1M	-.4952689	.0144747	-34.22	0.000	-.5236388	-.466899
_cons	80.30062	.6351807	126.42	0.000	79.05568	81.54555
sigma_u	3.6724391					
sigma_e	1.2144141					
rho	.90142761	(fraction of variance due to u_i)				

Fig. 5. Main findings of the model with random effects.

In both cases, there is a negative relationship between the number of deaths (per one million inhabitants) due to road crashes and the sustainability score index. In the former case, the relevant coefficient is -0.4980713, whereas in the latter is -0.4952689. Both coefficients are statistically significant ($p < 0.001$), suggesting a strong negative relationship between the number of severe road accidents and sustainability score. The above findings indicate that, on average, one less death (per one million inhabitants) due to road accidents in a given country is associated with an increase of approximately 0.5 unit in its overall sustainability score.

4 Discussion

The empirical findings also suggest that approximately 61.88% of the variation in the sustainability score can be explained by changes in the number of severe road accidents, after accounting for country-specific effects. Furthermore, the F-statistic (225.08) and the associated p-value (0.0000) imply that the country-specific effects are collectively significant, meaning that there are significant differences in the sustainability performance across countries that are not explained by the level of road safety alone.

Therefore, even though road safety directly affects the sustainability performance of countries through (only) two SDG targets, its overall impact seems to be much higher. This reveals the presence of indirect effects working through several other SDG targets as road safety indirectly affects the national economy, the society and the environment.

For instance, less severe road accidents translate into less traffic and constant speeds resulting in less CO_2 emissions, which are related to climate change goals. In this direction, actions aiming to reduce road accidents, such as investing in improving road infrastructures and incorporating cutting edge technologies into the overall transport system, do have a positive effect on sustainability goals related to economic growth, innovation, and sustainable cities.

Therefore, countries should enhance the efficiency of their transport systems as the derived benefits are expected to more than compensate the required cost. In particular, policy makers should undertake measures and actions that improve the road infrastructure, by investing in its quality, while ensuring its proper maintenance. In addition, the qualitative upgrade of the transport system should ensure that no one is left behind, while increasing the utility of the users. Moreover, the relevant legislation should also be aligned with the goal of improving the overall driving behavior. Last, environmental issues should be incorporated into national strategies for road safety in a pursuit to gradually renew the vehicle fleet and better manage road traffic conditions.

To sum up, road safety can be seen as the cornerstone of the transition towards a green, smart and resilient transport system as the one envisioned by the European Commission in its “Sustainable and Smart Mobility Strategy”.

5 Conclusions

The crucial role of road safety for economic growth, social development and environmental protection has extensively been underlined by the World Health Organization (WHO). In collaboration with other United Nations agencies and several shareholders, the WHO developed a set of 12 voluntary Global Road Safety Performance Targets which are fully aligned with the 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States in September 2015.

Indeed, two SDG targets are directly related to road safety, namely SDG 3.6 on halving the number of global deaths and injuries from road traffic crashes; and SDG 11.2 on providing access to safe, affordable, accessible and sustainable transport systems as well as improving road safety for all, especially those in vulnerable situations.

The goal of this paper was to elaborate on the direct link between road safety and sustainability performance. For this purpose, a cross-country empirical analysis was performed to estimate the impact of deaths due to road crashes on the overall sustainability score in the OECD area.

Based on a panel data analysis, we confirmed the original hypothesis that a higher degree of transport safety is positively correlated with the overall sustainability performance at a country level. In particular, it was found that a unit decrease in the number of deaths (per one million inhabitants) due to road crashes in a given country is associated with an increase of approximately 0.5 unit in its overall sustainability score.

This finding justifies policy actions towards investing in more efficient transport systems to deal with the detrimental effects of road accidents on all aspects of sustainable development. These initiatives might span from targeted road safety legislation to improved road infrastructures and enhanced post-crash care.

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