Furthermore, even in two countries with many similarities the selected proxy measure variables can provide reasonable results, when exposure data are not available. Similar socio-economic characteristics: Greece and Cyprus.

Models have been developed for each proxy for two Mediterranean countries with many similar socio-economic characteristics: Greece and Cyprus. For Cyprus the best model is a restricted LRT model with fuel consumption as the proxy variable. This means that the model is considered to be applicable to Cyprus for their guidance and assistance throughout this research. The authors would also like to thank all the partners of the "OVAOT" project working group on time series analysis and forecasting, led by Dr. Heike Lassarre and Dr. Emmanuelle Dupont, for their constructive comments and suggestions. The contribution of the National Experts Group of the European Commission in the data and information collection is also acknowledged.

The table (right) shows the SUTSE models estimated for Greece. Three different models were estimated, one for each proxy for the exposure: the "vehicle" in circulation, (ii) GDP, and (iii) fuel consumption. The beta coefficients indicates that none of these models suggest that the fatalities data and the exposure proxies are correlated for the considered time period (1995-2010). However, when one considers the trends of the fatalities-time series, two different trends appear: an increasing one until 1995 and a decreasing one thereafter.

Therefore, three more SUTSE models were estimated, this time considering only the data from 1995 until 2010, i.e. the fatality data with the downward trend only.

### Structural time-series models (Greece)

Based on the results of the SUTSE models analysis, three models are considered for Greece (for the period 1995-2010):
- An LRT model in which the fatalities are not assumed to be correlated with the available exposure measures.
- URT models in which the fatalities are considered to be correlated with the respective proxy for exposure (i.e. GDP and fuel consumption).

Based on the diagnostics and predictive performance, the selected model is the restricted LRT using the GDP data.

**Summary statistics (excerpt) of estimated SUTSE models (Greece)**

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Model results and prediction validation for considered models (Greece)

The left subgraphs show the results of the restricted LRT-GDP model. The projection of the GDP for Greece appears to follow a downward trend all the way to 2020. The reason for this trend is that the model detects the drop in the GDP in the last couple of years (due to the recession) but has no way to tell whether this trend will be reversed at some point. One way to overcome this would be to add another intervention variable to the model, which would indicate that the last few observations are part of a temporary recession phenomenon. This variable could then be used to indicate when the recession is expected to be over. Another way to indicate the same point is to add an intervention to the model which would be to fit the slope of the exposure. However, the latter option would imply that the necessary would start from the first predicted point (i.e. 2001), which is clearly not the case. Therefore, the approach of an intervention variable has been selected, using 2013 as the last recession year. The (more reasonable) results of this model are shown in the right subgraphs.

**Forecasting results (Cyprus)**

For Cyprus the best model is a restricted LRT model with fuel consumption as the proxy variable. This means that the model is considered to be applicable to Cyprus for their guidance and assistance throughout this research. The authors would also like to thank all the partners of the "OVAOT" project working group on time series analysis and forecasting, led by Dr. Heike Lassarre and Dr. Emmanuelle Dupont, for their constructive comments and suggestions. The contribution of the National Experts Group of the European Commission in the data and information collection is also acknowledged.

### Discussion and Conclusion

Developing credible road safety forecasting models is a key prerequisite to assessing and improving future road safety. One of the key requirements (and often the weakest link) in this process is reliable and up-to-date exposure data. While some countries may have the appropriate data, e.g. vehicle-kilometers as the suitable variable for exposure, many countries and regions face limitations. One practical way to overcome this issue is to identify and use appropriate proxy variables that could be used instead of the actual exposure variables. In this research, three alternative (and in general widely available) variables are considered as suitable exposure proxies: (i) number of vehicles in circulation, (ii) GDP and (iii) fuel consumption. A number of different structural time-series models have been developed for each proxy for two Mediterranean countries with many similar socio-economic characteristics: Greece and Cyprus.

Based on the findings of this analysis, a number of observations can be drawn:
- Proxy variables can provide reasonable results, when exposure data are not available.
- In two countries with many similarities, such as Greece and Cyprus examined in this research, the selected proxy measure does. This suggests that the underlying conditions make a variable a suitable proxy for exposure is complex and needs further investigation.

The findings of this research also suggest a number of directions for future research. Beyond the obvious need for investigation of more proxies, as well as application in more countries and regions, a useful test would see data from a country or region that does have exposure data to compare the predictive results of models using the proxy measure results those obtained with models directly using exposure. As the available data sample is rather small for such comparisons models, it is expected that larger time-series would lead to better models. The investigation of the impact of other parameters (such as the size of the region) is also an interesting endeavor, e.g. in smaller regions (such as Cyprus and Greece) the annual number of accidents can fluctuate a lot, compared to larger regions such as Germany or the US.

### Acknowledgements

The authors are grateful to Dr. Sylvia Tzouveleki, Dr. Efstathios Athanassopoulos and Prof. Nikos Koutsopoulos for their guidance and assistance throughout this research. The authors would also like to thank all the partners of the "OVAOT" project working group on time series analysis and forecasting, led by Dr. Heike Lassarre and Dr. Emmanuelle Dupont, for their constructive comments and suggestions. The contribution of the National Experts Group of the European Commission in the data and information collection is also acknowledged.

### ASSESSMENT OF EXPOSURE PROXIES FOR MACROSCOPIC ROAD SAFETY PREDICTION

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**Abstract**

Road safety is a major global health problem and no effort should be spared in trying to limit its impacts. Modelling road safety is a complex task, which needs to consider both the quantitative impact of specific parameters, as well as the underlying trends that cannot always be measured or observed. Macroscopic data are often not available, or not in the format that they are desired. Therefore, it is often required to attempt to consider alternative sources of data, which may be correlated with the modelled phenomenon. One of the potential sources of alternative proxy variables for macroscopic road safety modeling, using three suitable exposure proxies: (i) number of vehicles in circulation, (ii) GDP and (iii) fuel consumption. Several structural time-series models have been developed for each proxy for two Mediterranean countries with many similar socio-economic characteristics: Greece and Cyprus.

Based on the findings of this analysis, a number of observations can be drawn. Proxy variables can provide reasonable results, when exposure data are not available. Furthermore, in two countries with many similarities the selected proxy measure offers. This suggests that the underlying conditions that make a variable a suitable proxy for exposure is complex and needs further investigation.