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The impact of mobility characteristics on public transport and road safety performance in selected European cities

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Introduction

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- **Mobility and transport** have always been important and critical areas for the well-being of people.
- Concerning **transport systems' efficiency**, Public Transport (PT) and Road Safety performance should be examined and measured on a frequent basis.
- Therefore, it is important to identify the factors that affect **PT demand and road safety performance**.
- In order to highlight these factors, it is necessary to use certain **performance indicators**, which quantify the characteristics of Transportation Systems and describe different areas of their services.

Background: PT demand

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- One of the influencing factors is the **population density**, the increase of which has a positive effect on the demand of PT (Souche, 2010).
- Another important factor seems to be the **income**, which negatively affects the use of buses and positively that of cars (Bresson et al., 2004).
- PT **supply** and demand are positively correlated (Bonnel&Chausse, 2000).
- Higher PT **ticket prices** lead to lower PT demand (FitzRoy & Smith, 1998; Bresson et al., 2004).
- An increase in **journey time** leads to a decrease in demand (Walle & Steenberghen, 2006).
- A more general concept often identified in the relevant literature with many different sub-characteristics is the **quality of the services** provided by the PT. Many of these characteristics are quite difficult to study, as their changes usually lead to changes in other factors, such as prices and travel time (Paulley et al., 2006).

Background: Road safety

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- Most of the studies across the literature examine factors mainly related to **driving behaviour, weather conditions and driving environment**.
- There are also several studies that examine the influence of various **socioeconomic factors** on road safety outcomes.
- On the contrary, there are fewer studies dealing with the impact of **mobility characteristics** on road safety performance.
- **PT is probable the safest way to travel**, when examining the road fatality rates by transport mode and distance traveled by passengers (Beck et al. 2007; Savage 2013).
- However, Tasic and Porter (2016) concluded that more **bus stops** lead to more road crashes of all types, possibly due to abrupt changes in the vehicles' speeds and maneuvers.

Objective

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The **objective** of this research is to investigate the impact of various mobility characteristics on the:

i. performance of Public Transport in terms of PT trips per population,

ii. performance of road safety in terms of road fatalities per population.

Data collection

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- Data from the annual reports of the organization of European Metropolitan Transport Authorities (EMTA) were used, which include data on **population, road network, traffic and mobility** of several large European cities.
- The **18 European cities** that were included in the analyses are the following:
  Amsterdam, London, Oslo, Warsaw, Lyon, Paris, Berlin, Madrid, Rotterdam/Hague, Vienna, Manchester, Stockholm, Budapest, Birmingham, Stuttgart, Helsinki, Bilbao and Frankfurt.
- Furthermore, data on **road fatalities** from the European Community database on road crashes (CARE) were also collected.
- A database was developed containing data from these two data sources for the **five-year period** 2014-2018.

Methodological Approach

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- Two different statistical models were developed, using the multiple linear regression for defining the factors that influence: the **demand of PT** (number of trips per 100,000 population) and **road fatalities** per 100,000 population accordingly.
- The basic equation of the **multiple linear regression** model is $Y_i = \beta_0 + \beta_1 * X_{1i} + \beta_2 * X_{2i} + \ldots + \beta_v * X_{vi} + \varepsilon_i$
- The accuracy of the model was assessed through the coefficient of determination **R squared**.
- Moreover, the **elasticity values** were calculated for each independent variable of the model.
  $e_i = (\Delta Y_i / \Delta X_i) * (X_i / Y_i) = \beta_i * (X_i / Y_i)$

Descriptive Statistics

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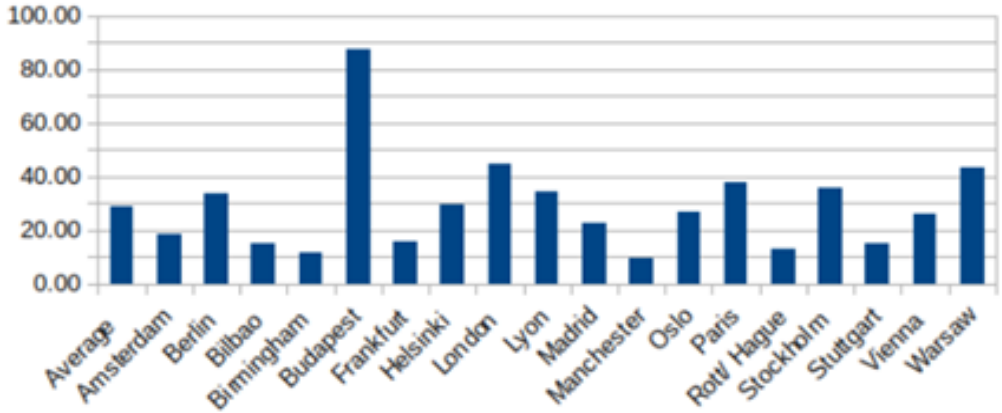
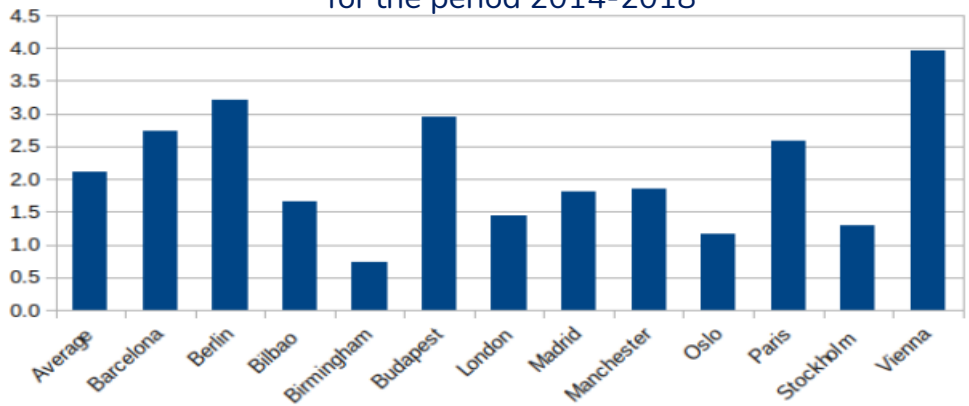
- Before the presentation of the linear regression models' results, some basic **descriptive statistics on the two dependent** variables are provided.
- The highest use of PT per population corresponds to **Budapest**, while the lowest is recorded in **Manchester**.
- Regarding the road safety performance of 12 cities that were also included in the linear regression model for road fatalities per population, it is demonstrated that the highest fatalities rates are recorded in **Vienna**, while the lowest in **Birmingham**.



Average PT trips (in millions) per 100,000 population for the period 2014-2018



Average road fatalities per 100,000 population for the period 2014-2018

Model for PT trips per 100,000 population (18 cities)

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Variables	Estimate	Pr(>|t|)	Absolute Elasticity	Relative Elasticity
(Intercept)	36.37	0.004	-	-
Bus & Tram Stops/ 100,000 inh.	0.025	0.052	0.26	1.44
GDP per capita (€)	0.00048	0.038	0.81	4.46
Metropolitan Area Population density	0.00454	0.003	0.18	1.00
Car Ownership in PTA area/ 100,000 inh.	-0.00048	0.013	-0.92	-5.08
Public PT operator (ref. private)	13.12	0.008	0.26	-
Single trip ticket PTA area (€)	-10.30	0.001	-0.99	-5.46
Adjusted R^2			0.279	

- An increase in the **price of a single trip ticket** is associated negatively with PT demand. PT passengers choose PT instead of passenger cars, mainly due to reduced costs. Therefore, as the ticket prices increase, this advantage of PT decreases and passengers may turn to other solutions such as their passenger cars, which outperform PT in terms of travel time, comfort and reliability.
- More **infrastructure facilities** of buses and trams have a positive effect on PT demand. When a higher percentage of the population has easy and quick access to a PT stop, then the probability of preferring it, in comparison with their passenger car increases, since the travel time may not differ significantly.
- Moreover, **public operation** of PT has a positive impact on PT demand.
- Non-transportation factors that affect the demand of the PT are GDP, population density and car ownership per inhabitant. The **GDP and population density** are positively correlated with PT demand, while the opposite is the case for **car ownership**.

Model for fatalities per 100,000 population (12 cities)

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Variables	Estimate	Pr(>|t|)	Absolute Elasticity	Relative Elasticity
(Intercept)	6.784	<0.001	-	-
Modal Split in PTA area - Soft modes	-3.119	0.031	-0.52	2.77
GDP per capita (€)	-0.00002	0.001	-0.46	2.45
Metropolitan Area Population density	-0.00016	0.006	-0.19	1.00
Bus & Tram Stops/ 100,000 inh.	-0.00148	0.084	-0.28	1.47
Tram Speed	-0.10370	<0.001	-1.56	8.23
Adjusted R^2			0.632	

- **Soft transport modes** such as walking and cycling are an important factor that could lead to road fatalities decrease. In most European cities, there is a very well organized infrastructure network, such as wide sidewalks and bicycle lanes, which provide the required safety to the road users. So, as long as the road infrastructure allows it, these transport modes can be considered quite safer than motorized vehicles due to significantly lower speeds.
- **PT infrastructure** is of particular importance for road safety. These transport modes operate at much lower speeds than passenger cars and provide a satisfactory level of safety to their passengers. At the same time, many and well-organized PT facilities in combination with the improved functional PT characteristics, make them more attractive which could be beneficial for the reduction of road fatalities.
- Critical for road safety performance also seems to be some other non-traffic factors such as **population density and GDP**. An increase in population density means an increase in vehicles and traffic congestion, leading to significantly lower speeds. Therefore, even in the event of a road crash, this may not be so severe. At the same time, a general economic development leads to road fatalities decrease.

Conslusions

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- **Population density, GDP** per capita and the **number of bus and tram stops** per population are three factors that affect both the demand of PT and the level of road safety in the selected European cities.
- The application of the **PT demand model** indicated that more bus and tram stops, increase of GDP, higher population density and public operation of PT have a positive impact on PT demand in contrast to the car ownership and the increase of PT fares that have a negative impact on PT demand.
- Finally, the **road safety model** demonstrated that population density, bus/tram stops, modal share of active travelling modes, GDP and tram speed have a negative relationship with the dependent variable, showing that as these independent variables increase, road fatalities per population decrease.

Recommendations

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- As it was revealed, price of PT tickets is very important for PT demand. Therefore, it is recommended to keep these **prices as low as possible**.
- At the same time, the **construction of additional bus and tram facilities** is recommended, so that they are easily accessible by everyone.
- Emphasis should also be given to the **infrastructure of soft transport modes**.
- **Walking and cycling** should be promoted as they could assist to road fatalities reduction. For this reason, it is crucial to develop the appropriate safe infrastructure for these transport modes, which could lead residents to prefer them instead of passenger cars.

Thank you!

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