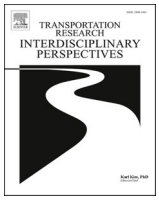
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Going to the Zoo: A comparison of travel time ratios in 21 European cities

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ABSTRACT

Efficient public transport is an essential component of a sustainable transport system. The travel time ratio, i.e. the public transport journey duration divided by the car journey duration of the same trip, can be used to compare the public transport system with the road transport system within and across cities. However, few studies have used the travel time ratio to analyse the efficiency of the public transport system across European cities. The aim of this study was to compare travel time ratios of a typical leisure trip across 21 European capital cities and to examine the association of journey time and travel time ratio with socio-demographic characteristics of cities.

For the purpose of this study trips to the local zoo were selected as a leisure time activity that is comparable across cities in Europe. Within 21 European capital cities random start points were selected based on an 8 km service facilities analysis from the zoo. For each start point to zoo trip the duration and distance of the public transport and car journeys was calculated using the Google Maps Directions API.

Our analysis showed that in all cities public transport journeys take longer than car journeys, with a mean travel time ratio of 2.61 (range 0.98–5.82). No correlation was found between public transport and car journey duration, suggesting that they are influenced by different factors. However, mixed model analyses found no association between socio-demographic characteristics of the cities and public transport journey times. In contrast, mixed models showed that a decrease in the travel time ratio was associated with a larger population size, higher population density, higher percentage of working population, more urbanized land area and more registered cars.

To encourage a modal shift towards sustainable urban transport, we recommend that travel time ratio should be considered in the design of public transport and car infrastructure in cities.

1. Introduction

A good public transport system is an essential component of sustainable cities (Poelman et al., 2020; UN Habitat, 2021). Public transport has multiple benefits, which go beyond providing transportation for local residents and visitors: it reduces congestion, air pollution and greenhouse gas emissions, as well as road traffic accidents; it strengthens the local economy; it promotes healthy lifestyles; it provides equal opportunities to disadvantaged groups (Poelman et al., 2020; UN Habitat, 2021). The United Nations' Sustainable Development Goals (SDG) acknowledge access to adequate public transport as a basic need in urban settings (UN Habitat, 2021). The aim of SDG target 11.2 is for all citizens to be able to use safe, affordable, accessible and sustainable transport systems by 2030, which should be achieved through the expansion of public transport (UN Habitat, 2021). Similarly, the European Green Deal, which was presented by the European Commission (EC) in 2019 and aims to achieve climate neutrality in the European Union (EU) by 2050, lists as one of its benefits an increase in public transport, which in turn will improve the health and well-being of EU citizens and future generations (European Commission). However, the European Commission's Communication "Sustainable and Smart Mobility Strategy – putting European transport on track for the future" mainly focuses on the introduction of low-emission vehicles, and neglects to tackle innovative measures to favour the modal shift from private vehicle to public transport (European Commission, 2020).

The average market share of public transport across EU countries is still relatively low compared to passenger cars, for example in 2019 the market share of passenger cars in the EU27 was 82.5 % (Eurostat, 2019). However, data collected at the city scale shows a larger market share of public transport in urban environments. In a survey of 75 large European

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cities carried out in 2015, it was found that on average 49 % of people use public transport for their commute to work, but the variability was large ranging from 5 % to 73 % (European Commission, 2017).

Over the past twenty years a number of quantitative (Abenoza et al., 2017; Eldeeb and Mohamed, 2020; Lunke et al., 2021; Minelgaitė et al., 2020) and qualitative (Beirão and Cabral, 2007; Dell'Olio et al., 2011; Hine and Scott, 2000) studies have been carried out to identify factors that influence the use of public transport. Common disincentives to public transport use that emerged from these studies are longer travel times, interchanges, waiting time/reliability of service, comfort, cleanliness, safety, and accessibility/ease of use. The importance attributed to each of these factors varies across studies, but travel time has been reported as a significant factor in most studies (Eldeeb and Mohamed, 2020) and especially in studies of potential future public transport users (Dell'Olio et al., 2011).

Many public transport providers now offer online and mobile apps to plan public transport journeys and to estimate travel times. In addition, apps such as Google Maps, Apple Maps or HERE WeGo can estimate travel times for both car journeys and public transport, thereby making comparisons easily accessible to users. Recent studies have used this functionality to analyse the travel time ratio, which is the public transport travel time divided by the car travel time, within Norway (Lunke et al., 2021) and across four cities globally (Sao Paulo, Stockholm, Sydney, Amsterdam) (Liao et al., 2020). The study in Norway found that the travel time ratio is significantly associated with the market share of public transport use, i.e. as the travel time ratio increases the odds of a commuter using public transport decreases (Lunke et al., 2021). This suggests that the travel time ratio should be taken into consideration in the design and expansion of public transport networks, and since expansion of public transport is a key component of the European Green deal, travel time ratio should be relevant to EU transport policy.

Most transport sector studies analyse the rationale behind the use of private cars for systematic travel, while little attention is paid to occasional and recreational trips. This is obviously linked to the need to intervene on a larger number of displacements. But it is important to underline that recreational travel can also generate important externalities in urban areas. For example, in cities where tourism plays a key role, leisure-related travel constitutes the backbone of overall mobility. A similar condition is that in correspondence with sporting events, which often generate congestion managed as an emergency in urban areas, despite having well-known and pre-established cadences. This laissez-faire policy on the use of private cars for recreational travel might generate situations of social exclusion unwittingly supported by the public administration, obviously with the due differences in the various European contexts. Recreational activities are often decentralized from the more central areas precisely in order to avoid congestion; this displacement generally leads them to be located in areas distant from the main corridors of public transport, making them accessible more easily (or exclusively) through private transport, and thus excluding from their use the segment of the population that prefers for economic, age or personal reasons to not own a car.

Based on this premise, the aim of this study is to investigate the correlation between travel modes to a common leisure activity across large European cities and sociodemographic characteristics, in order to create the basis to evaluate a potential social exclusion. This will be done by calculating the travel time ratio between public and private transport and analysing the correlation with demographic, socio-economic and physical characteristics of each city.

The next section presents the method and the application to the case study, i.e. journeys to the zoo in European cities.

2. Materials and methods

To address our research aim we selected a trip to the zoo as the type of journey to be analysed across cities. We selected the zoo as the destination for several reasons: a zoo visit is a common leisure activity for families in European countries, and it often involves multi-generational groups (e.g. children, parents, grand-parents). The target audience of zoos is comparable across cities, unlike the target audience of other leisure activities, e.g. museums and landmarks are present in all large cities, but their target audience may not be comparable between cities. There is typically only one zoo per city, making it a clearly defined destination per city. In most cities, zoos have been located in the same place for extended periods of time, and therefore should be well integrated into the city's transport system. Table 1 shows the estimated opening year of each Zoo, with the oldest zoo being located in Vienna (opened in 1752) and the youngest zoo in Athens (opened in 2000). Only three of the zoos included in this study were opened after 1945 (Athens, Madrid, Oslo), which means the vast majority of zoos were already place during the rapid expansion of the road and transport network following the end of World War 2. This suggests that they should have been integrated into the transport planning decisions of the time. The journey to the zoo is typically done outside of rush hour, and thus is expected to be less affected by barriers such as congestion or high occupancy rates on public transport.

Our method is based on the following steps:

- Selection of cities to be included in our analysis
- Setting of a threshold of origins to reach the facility (zoo)
- Calculation of travel times by private vehicles and public transport
- Statistical analysis

In the following sections, a detailed methodology is provided for each step.

2.1. City selection

We decided to focus on European capital cities. The capital is not necessarily the largest city in a country, but it has a representative status; therefore, we would expect that the capital city has a functioning public transport system. To ensure that the capital cities were large enough to warrant a public transport system, we used statistical data provided by the Organisation for Economic Co-operation and Development (OECD) to select cities with a population greater than 500,000 in their core area (https://stats.oecd.org/Index.aspx?

Table 1
Characteristics of 21 capital cities included in study.

City	Population in the core area	Land area of core area (km^2)	Population density in core area (people per km^2)	Gross domestic product per capita	Estimated opening year of Zoo
Amsterdam	2,127,040	1144	1859	71,490	1838
Athens	3,526,887	1930	1827	37,838	2000
Berlin	3,854,435	1076	3581	45,245	1844
Budapest	1,753,658	525	3339	46,201	1820–30
Copenhagen	736,645	101	7329	62,898	1859
Dublin	556,484	118	4717	94,997	1831
Helsinki	1,177,341	768	1532	58,697	1889
Lisbon	1,924,117	1117	1723	41,509	1905
London	10,386,956	2943	3530	66,470	1828
Madrid	5,531,214	1402	3946	50,469	1972
Oslo	693,494	452	1535	65,600	1966
Paris	10,187,126	2028	5023	69,744	1794
Prague	1,389,382	532	2610	62,947	1931
Riga	624,350	303	2058	39,704	1912
Rome	2,860,628	1328	2154	49,938	1908
Sofia	1,417,766	1826	776	40,411	1888
Stockholm	1,073,052	816	1314	69,404	1891
Vienna	1,911,191	413	4628	55,109	1752
Vilnius	534,973	399	1342	48,122	1938
Warsaw	1,782,611	516	3457	59,173	1928

DataSetCode=CITIES#). This resulted in a list of 21 cities (Table 1). It should be noted that the majority of the selected cities are also part of the EU Mission 100 Climate-neutral and smart cities by 2030 (https://eurocities.eu/latest/the-100-climate-neutral-and-smart-cities-by-2030/), which is committed to achieve net zero carbon emissions by 2030.

The zoos located in the cities listed in Table 1 are not necessarily the largest zoos within the respective country. For example in the UK, Chester zoo attracts more visitors than London zoo. However, for the purpose of this research the combination of capital city status, population size and presence of a zoo was used as a compromise to set the study parameters.

2.2. Selection of threshold: start and end points for journeys

We used Google Maps to identify the location of the zoo in each selected city, and the coordinates of the zoo were the end points of the journeys. To identify potential start points we calculated the network distance of 8 km from each zoo. We chose a distance of 8 km as this should be easy to cover by car or public transport, but would be too far to walk for a family group. We used the Create Drive-Time Areas tool in ArcGIS Online to identify all possible routes of 8 km lengths from the zoo. For practical reasons, this had to be based on driving routes. The end coordinates of each route were selected as potential start points. We visually inspected each set of routes and manually removed points that were very close to the zoo due to routes doubling back on themselves. To ensure an even spatial distribution of start points across the city, we split the Drive-Time Area into four segments (North, East, South, West) and selected two points at random in each segment, an example is shown in Fig. 1. If two points in a segment were selected that were located on the same street, we replaced one with an alternative random point to avoid identical journeys. This process resulted in eight start points in each city. An interactive map showing the start and end point in each city can be accessed at: https://arcg.is/1Tn1bu.



Fig. 1. Example of start and end point selection. A map of all cities can be viewed at https://arcg.is/1Tn1bu.

2.3. Travel time calculation

We used the Directions API on the Google Maps Platform to calculate the travel time and distance in "driving" and in "transit" mode for each start–end point pair departing at 10:00 local time on 22nd June 2022. Preliminary tests showed that the calculated travel distances in both modes usually exceeded 8 km. For public transport this is expected as public transport routes are less direct. For the car routes this is due to the differences between the ArcGIS online and Google Maps algorithms. The Google Maps algorithm identified the fastest route incorporating live traffic data, which is not necessarily the shortest distance. In a small number of cases the calculated public transport route was less than 8 km long. This was due to specific characteristics of the local infrastructure. For example, Prague Zoo is bordered by the Vltava river to the west and south. There is no bridge for cars to the west of the zoo; therefore, cars have to drive north or south to cross the river, which resulted in a small number of start points in the West located close to the river. However, a passenger ferry crosses the river to the west, which resulted in very short (~2 km) public transport journeys from these Western start points. Although this is clearly an advantage of public transport use, we replaced these start points with start points in the North and South segment to avoid having outliers that would unduly influence our analysis.

2.4. Statistical analysis

For each start–end point pair the travel time and distance by car and by public transport was calculated. Based on this data the travel time ratio and average speed (in km/h) of each journey was calculated. We performed descriptive analyses and pairwise correlation. We analysed the variance within each mode and by city using Levene's test and ANOVA. Furthermore, we used linear mixed models to analyse the association between demographic, socio-economic and physical geography characteristics of each city and the travel time and travel time ratio. We ran univariate models with public transport journey duration, car journey duration and travel time ratio as outcomes. The predictor variables, collected from the OECD and EUROSTAT databases, were:

Demographic	Socio-economic	Physical geography
• Population in the core area in 2020 • Population density in the core area • Percentage of youth population (age 0–14 years) • Percentage of working population (age 15–64 years) • Percentage of elderly population (age > 65 years)	• Gross domestic product per capita • Unemployment rate • Number of registered cars • Number of road deaths per year	• Core land area • Urbanised land area in core • Tree cover • Urbanised land per capita

In addition, we manually created two binary variables to indicate cities with underground public transport, and cities that only had bus public transport (i.e. no light rail). All models were nested by city, to account for within city correlation, as shown in Eq. (1) below, where Y_i is the outcome variable, $\beta_1 Predictor$ is the fixed effect of the predictor variable, and $\alpha_{c[i]}$ is the random effect of the city:

$$Y_i \; N\left(\alpha_{c[i]} + \beta_1 Predictor, \sigma^2\right) \tag{1}$$

$$\alpha_c \; N(\mu_\alpha, \sigma_\alpha^2)$$

All analyses were carried out in R v4.4.1 (R CoreTeam, 2023). The next section presents the results of the trip calculation and the travel time ratio between the two modes; then, regression analyses with independent variables are carried out to evaluate the inclusiveness of the transport services.

3. Results

3.1. Overall results

A summary of the journey duration and average speed by public transport and car, as well as the travel time ratio is provided in Table 2. The mean travel time ratio was 2.61, ranging from 0.98 to 5.82.

3.2. Comparison by city

Fig. 2 shows box plots of the estimated journey duration by public transport and car for each city. It can be seen that, with the exception of Madrid, there is a clear separation between the travel modes, i.e. public transport journeys always take longer than car journeys. The durations of car journeys in Madrid are an outlier compared to the other cities, the median duration in Madrid (35.5 min) is 17.2 min longer than the median duration of the other 20 cities (18.3 min). Using Levene's Test for Homogeneity of Variance, we found that the variance of the public transport journey durations is equal across the cities ($F = 1.2$, $p = 0.3$); however, the variance in the car journey durations is borderline heterogenous ($F = 1.7$, $p = 0.05$) (this finding persisted, even when Madrid was removed from the analysis). Analysis of variance showed a significant difference between cities in both modes (Public transport: $F = 4.78$, $p < 0.001$, Car: $F = 17.09$, $p < 0.001$). Pairwise comparisons using Tukey's HSD showed that for public transport Sofia, Rome and Dublin differ from the other cities (Supplementary materials Figure S1), while for car journeys comparisons were more complex, with only Madrid consistently different to other cities (Supplementary materials Figure S2).

Fig. 3 shows boxplots of the travel time ratios from eight starting locations to the zoo. It can be seen that Madrid has the smallest travel time ratio (median = 1.21); however, this is due to the long car journey durations in Madrid, rather than an efficient public transport system. The largest travel time ratio was found in Lisbon (median = 4.17), which has the shortest car journey durations, but comparatively long public transport journey durations. Levene's test for Homogeneity of Variance showed that the variance across the cities is heterogenous ($F = 1.9$, $p = 0.01$), and Analysis of variance also showed a significant difference between the cities ($F = 7.87$, $p < 0.001$). Pairwise comparisons using Tukey's HSD showed that the cities at the extremes of the distribution (i.e. Madrid, Lisbon, Sofia, Prague) differed from the other cities (Supplementary materials Figure S3).

3.3. Comparison by mode

Fig. 2 shows a clear separation between public transport journey durations and car journey durations. This can be confirmed by looking at a scatterplot of the data (Fig. 4), which shows that public transport journeys always take longer (except for two cases in Madrid) than the car journeys. Pairwise correlation analysis showed no correlation between public transport journey durations and car journey durations (Spearman's rho = 0.01).

3.4. Analysis of factors associated with journey time

Descriptive tables of the predictor variables are shown in the Supplementary material (Tables S1 and S3). Our analysis using univariate linear mixed models showed no association between the public transport journey duration and any of the predictor variables shown in Section 2.4. For the car journey duration we found significant associations with the population in the core area and with the populations density. As the population or population density in the core area increases the journey time by car also increases (population (per 100,000): $\beta = 5.17$, 95 % CI = 1.37–8.97, $p = 0.01$; population density: $\beta = 0.071$, 95 %CI = 0.001–0.142, $p = 0.05$). The analyses showed significant associations between travel time ratio and a number of variables (Table 3, the results

Table 2
Summary of results from travel time calculations.

		Minimum	25 %ile	Median	Mean	75 %ile	Maximum
Public transport	Duration of journey (min)	25.0	40.0	46.4	47.8	53.4	84.0
	Average speed (km/h)	7.2	11.2	12.8	13.1	14.4	21.7
Car	Duration of journey (min)	11.2	15.9	18.5	19.6	21.7	39.7
	Average speed (km/h)	15.9	26.2	29.5	30.8	35.2	58.1
Travel time ratio		0.98	2.05	2.55	2.61	3.09	5.82

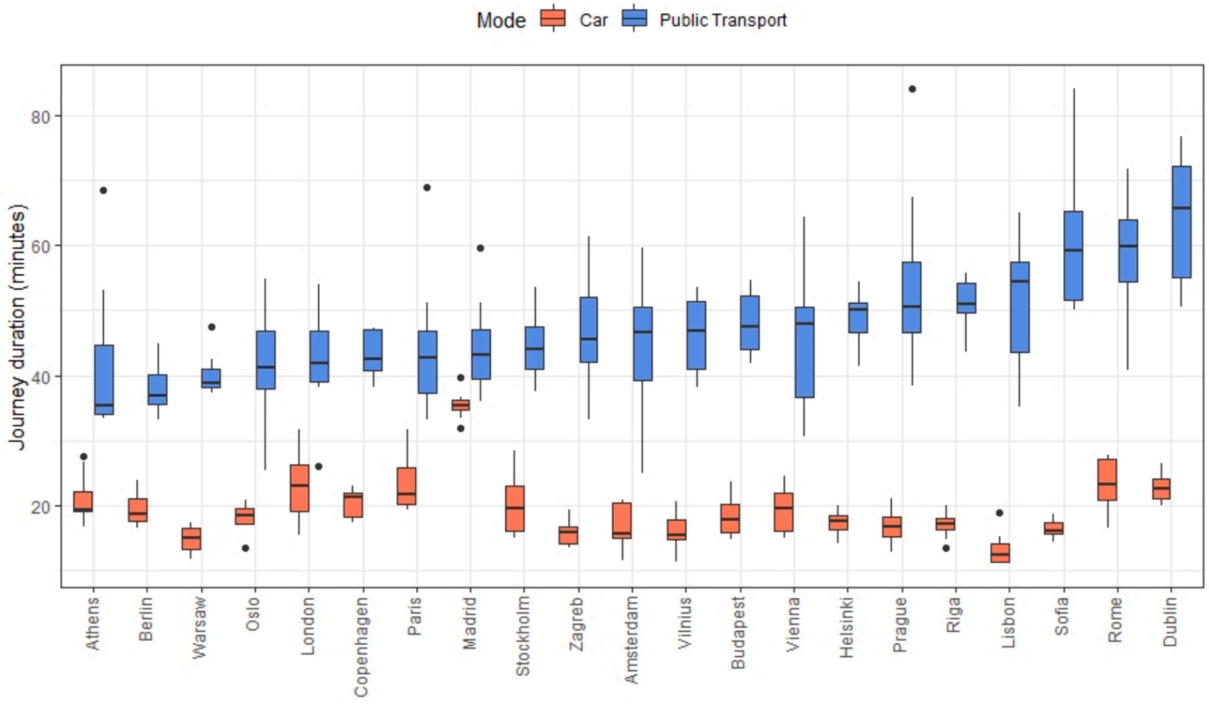


Fig. 2. Distribution of journey duration by city and travel mode.

of variables showing no association with travel time ratio are shown in Table S4). A larger population, a higher population density, and a higher percentage of working age population are associated with a decrease in the travel time ratio. Moreover, more urbanised land area in the core and more registered cars are associated with lower travel time ratios.

4. Discussion

This study compared the length of time it takes to travel a threshold of 8 km to the zoo by public transport and by passenger car in 21 capital cities in Europe. It was found that there is a clear difference between the length of public transport and car journeys, with public transport journeys taking more time in almost all cases. No correlation was found between public transport and car journey duration, suggesting that they are influenced by different factors, even though they have the same start and end coordinates. The difference in duration was present in all cities that were studied; however, further analyses showed that there were also differences between cities, indicating heterogeneity across Europe. To some degree this is expected, as each city will have individual challenges related to transport infrastructure.

Public transport journeys were not associated with any of the predictors analysed. This suggests that the design and operation of the public transport system is not influenced by demographic and socio-economic variables at the city scale. In contrast, car journeys were found to take longer in cities with a larger population and higher population density. Analyses of the travel time ratio showed that lower travel time ratios, i.e. more similar public transport and car journey duration, were associated with higher population (number and density), a larger working age population, more urbanisation, and more cars. Due to the fact that none of the variables were associated with public transport, it is possible that the association between these variables and travel time ratio is mostly driven by their association with car journey duration, rather than by their association with public transport journey duration. However, in this context it should be noted that several of the socio-economic variables, such as unemployment rate, number of registered cars and number of road deaths contained missing data, which may have affected the results.

Table 3 shows that the travel time ratio decreases as the population and population density increases. This could be related to the fact that cities with a low population density may be spread out over a larger geographic area, i.e. “urban sprawl”. Cities with urban sprawl characteristics tend to provide more favourable conditions for car travel, than for public transport (Frumkin, 2002). In contrast, densely populated and urbanised areas (see variable urbanised land area) may provide more favourable conditions for public transport, particularly, if an underground or metro system is available. A higher percentage of working population also decreases the travel time ration (Table 3). This could suggest that cities with a larger working population have implemented a more efficient public transport, due to increased demand. Alternatively, this could also suggest slower car travel times, due to more rush hour

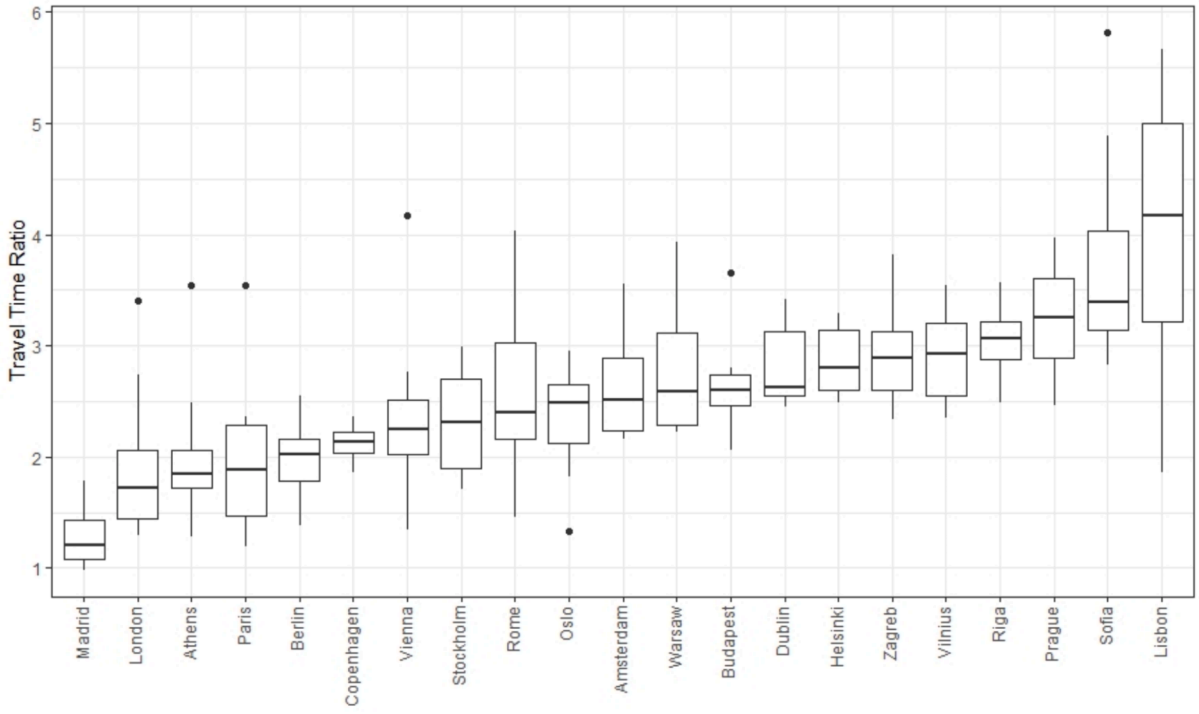


Fig. 3. Travel time ratios in 21 European cities.

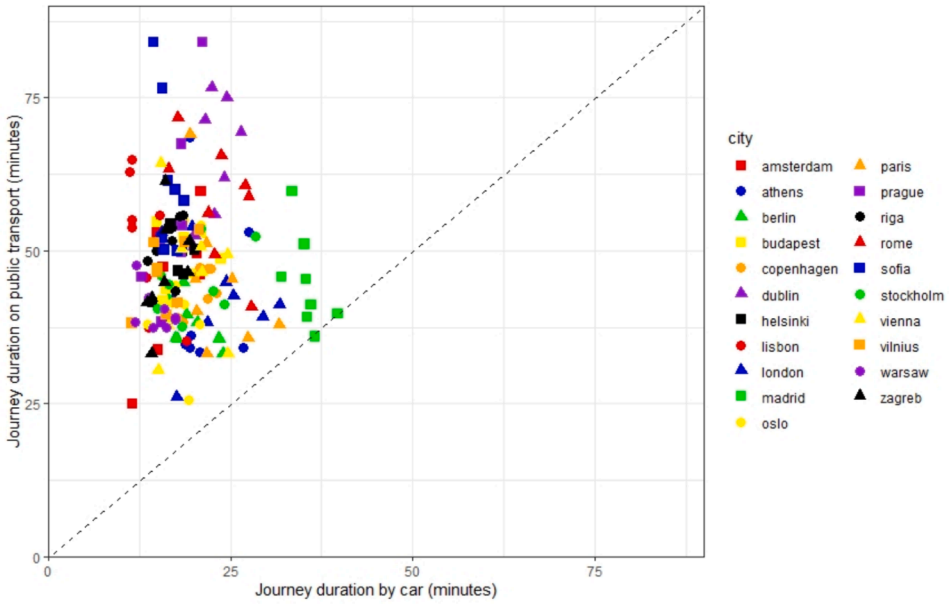


Fig. 4. Scatterplot comparing journey duration by public transport and by car.

traffic and congestion. Since we did not observe an association between public transport journey duration and working population, the second explanation may be more likely. This could be further supported by the fact that a larger number of registered cars also decrease the travel time ratio. Cities with more cars are likely to experience more congestion, resulting longer car journeys.

The most comparable study to this study, is a study based in Norway by Lunke et al. (2021). The study by Lunke et al. (2021) used data from the Norwegian National Travel survey to determine the mode of transport, and the start and end points of commutes. It then used Google Maps API to calculate travel times by public transport and car, which showed a mean travel time of 67 min by public transport and of 26 min by car. These mean travel times are longer than the mean travel times in our study, which is not surprising since the Norwegian study included urban and non-urban commutes and the commuting distance varied. The mean travel time ratio in the Norwegian study was 2.87, which is slightly larger than the mean travel time ratio in our study (2.61). The Norwegian study also included a logistic regression analysis, which used travel mode (public transport or car) as the outcome and a number of trip related (travel time ratio, number of transfers, distance to public transport stop, waiting time at interchange, location, trip distance) and individual characteristics (gender, age, education, household income)

Table 3
Variables associated with travel time ratio.

Variable	β	95 %CI	p	Marginal R^2
Population in core area (per 100 000)	-1.19×10^{-2}	-2.06×10^{-2}, -3.18×10^{-3}	0.01	0.146
Population density (people per km^2)	-1.91×10^{-4}	-3.46×10^{-4}, -3.56×10^{-5}	0.02	0.125
Percentage of working population	−0.19	−0.38, -6.34×10^{-3}	0.04	0.095
Urbanised land area (per 1000 km^2)	−0.80	−1.55, −0.06	0.04	0.101
Number of registered cars (per 1000 cars)	-3.14×10^{-4}	-6.23×10^{-4}, -5.28×10^{-6}	0.05	0.133

variables. In their analysis all variables showed a significant association with travel mode, except for waiting time at interchanges. Travel time ratio had a strong negative effect on the odds of using public transport (OR = 0.45, S.E. = 0.049), which means a commuter becomes less likely to use public transport, as the difference between the public transport and car travel time increases. Their regression model was also used to predict the public transport share based on the travel time ratio. At a travel time ratio of 1, the public transport share in Oslo is predicted to exceed 60 % and outside of Oslo 30 %.

However, as the roadmap for the New EU urban mobility framework has highlighted, indicators (such as modal split) are lacking for many urban areas, because EU Member States are not required to collect and provide it (European Commission, 2021). Within EU Member States urban transport is predominantly addressed at the local level, for example through the development of Sustainable urban mobility plans (SUMPs). Updated guidelines to develop SUMPs were published by the EU in 2019 (Rupprecht et al., 2019). These guidelines detail the process to develop a SUMP, but they do not set any numeric targets or goals for public transport in cities. Furthermore, many large cities have not developed or implemented a SUMP yet, as they are not mandatory.

Travel time ratio was also analysed in a study by Liao et al. (2020), which used geotagged tweets to create time-resolved origin–destination surfaces in four cities. Liao et al. (2020) used HERE Traffic data, the OpenStreetMap road network, and General Transit Feed Specification to estimate travel times by car and by public transport. The mean travel time ratio ranged from 2.0 to 2.2, which is lower than the mean in our study. It was found that in Stockholm and Amsterdam public transport travel times can be shorter than car travel times, if the trip distance is <3 km and the trip takes place during peak rush hour. However, if trip distances are >3 km the travel time ratio increases rapidly. This suggests that people living in Stockholm and Amsterdam, who commute a short distance to work are incentivised to use public transport. But people who commute over longer distances or who travel outside of rush hour are not.

Recent reports (Poelman and Dijkstra, 2015; Poelman et al., 2020) analysed access to public transport in European cities. They categorised the population's access to public transport into five groups (very high, high, medium, low, no access) based on the distance to the nearest public transport stop and the frequency of services. A comparison of the European capital cities showed that Madrid and Vienna had the largest proportion of population with very high access to public transport. However, in our analyses public transport travel times in Madrid and Vienna fell into the medium range, when compared across 21 cities. This demonstrates the complexity of public transport systems, and that distance to a stop and frequency of service alone, do not guarantee an efficient traversal across the city.

This is the first study to compare travel time ratios across 21 capital cities in Europe. Our study shows that large travel time ratios are found across cities, indicating that this is not simply a localised problem of a single city having made poor decisions in their transport planning. In the context of the previous study in Norway (Lunke et al., 2021), which found that an increase in travel time ratio decreases the modal share of public transport use, there could be a danger of a negative feedback loop with public transport decreasing resulting in further increases in travel time ratio and so on. A shift away from public transport would clearly impact the EU's emission targets and its goal of climate neutrality, as set out in the European Green Deal. To avoid this, strategic goals for public transport efficiency and travel time ratios should be considered at the European level.

This study has several strengths. The tool (Google Directions API) that was used in this study, is based on very large international traffic and transport datasets. This means that the methodology used is relatively robust. Furthermore, it is scalable and transferable to other destinations, e.g. museums or sporting events, which would attract a different demographic. Another important strength of this study is its wide geographic coverage, including cites in Northern, Southern, Western and Eastern Europe. Due to this wide geographic coverage the number of origin points per city had to be limited, which is the main limitation of this study. Another limitation is that the analyses were based on a single day. Temporal variability in travel times is likely; however, we selected a weekday and a starting time outside of rush hour, to make conditions as representative as possible. We inspected the location of each zoo on a map and found that the zoos were located within the main urban area of the city, i.e. not at the outskirts. However, we acknowledge that this may not be the case for zoos in capital cities around the world, e.g. Sydney zoo is located at the outskirts of the city. Therefore, the findings from this study should be considered within the urban and transport development context of large European cities. Further analytical work would be required to determine, if they could be extrapolated to cities outside of this context.

To collect predictor variables for the regression analyses we used recognised international and EU databases to ensure validity and comparability of the data. Unfortunately, many socio-economic parameters are only reported at the country level, and obtaining variables at the city level was challenging due to missing data. To overcome this issue, we are planning to focus on a small number of cities in future studies, which will allow us to use local datasets.

5. Conclusions

This study has shown that taking public transport to travel to a typical leisure time activity, such as a zoo visit, takes longer than traveling by car in 21 European capital cities. Assuming that families have access to a car, this means that there is little incentive for a family group to travel by public transport. Although the European Green Deal lists an increase in public transport as its goal, there are currently no EU wide strategies and no targets for a public transport market share. We suggest that travel time ratio should be taken into account in the design of public transport and car infrastructure, to achieve the EU targets for climate neutral cities and to ensure their sustainability within the framework of the UN SDGs.

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CRediT authorship contribution statement

Anna Mölter: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Nadia Giuffrida:** Writing – review & editing, Conceptualization. **Francesco Pilla:** Writing

– review & editing, Funding acquisition.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Anna Molter reports financial support was provided by European Commission. Anna Molter reports a relationship with European Commission that includes: funding grants. Francesco Pilla reports a relationship with European Commission that includes: funding grants. Nadia Giuffrida reports a relationship with European Commission that includes: funding grants. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trip.2024.101161.

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