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PATTERNS IN THE MOBILITY AND OWNERSHIP OF PRIVATE CARS AND ALTERNATIVE TRANSPORT MODES: THE FOCUS ON WARSAW AND POLAND

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Patterns in the mobility and ownership of private cars and alternative transport modes: the focus on Warsaw and Poland

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Abstract: This article presents an extensive analysis of the private ownership of cars and other transport modes in Warsaw, Poland, with a focus on understanding mobility patterns and exploring sustainable alternatives to private car usage. It provides a comprehensive description of car ownership trends, highlighting the high and growing number of cars per capita in Poland, particularly in Warsaw. The existing transport system in Warsaw, including the public transport network and related policies, is summarized. A literature review examines institutional, socio-economic, and individual factors influencing mobility behaviors and the dynamics of recent changes in car usage and alternative modes of transport. The analysis identifies barriers and opportunities for the adoption of sustainable mobility solutions, while discussing policy implications at the national and international levels.

Keywords: mobility systems, car ownership, public transportation, consumer preferences, sustainable mobility, urban communities

JEL codes: R41, R48, R53, R58, Q54, O18

Note: This research was conducted within the CoMobility project. The CoMobility project benefits from a e2.05 million grant from Iceland, Liechtenstein and Norway through the EEA Grants. The aim of the project is to provide a package of tools and methods for the co-creation of sustainable mobility in urban spaces.

To find more details on the project, see https://comobility.edu.pl/en/homepage/.

1 Introduction

Car ownership in Poland affects the structure of overall mobility characterized by a substantial portion of private car usage in Poland, specifically in its capital, Warsaw. As the goal to develop sustainable mobility systems is set by an increasing number of municipalities in the region, the chances and barriers to the use of alternatives to private car transport modes are studied in more depth. The current article speaks to this literature.

The present article aims to provide an extensive analysis of current and past patterns in the private ownership of cars and other transport modes in Warsaw. It also summarizes the existing transport system in Warsaw and public policy relevant to mobility. Additionally, the article offers a literature review of studies focused on understanding institutional, socio-economic, and individual factors relevant to mobility behaviours, along with the dynamics of recent changes in mobility patterns, with a particular focus on car usage and its alternatives in Warsaw. Lastly, it presents an analysis of barriers and opportunities for the adaptation of more sustainable mobility solutions, as well as a discussion of policy implications in the national and international context.

Unlike many cities in Poland, Warsaw's public transport has been developing steadily and steered towards sustainability continuously over the last decades. Nonetheless, Warsaw remains a city with an increasing number of cars per capita dating back to the 1990s, and changes in sub-urban public transport services reinforced that process. Securing fluent traffic flow and parking spaces have been significant challenges to Warsaw's mobility policy, and recently also, the improvement of air quality became a part of its agenda. The COVID-19 pandemic was a major disruption that affected both the public transport system and individual mobility behaviors. The present article provides a summary of existing studies and a discussion relevant to future developments in this area.

The article refers to scientific articles and technical reports as well as existing national and international survey data from reliable sources (including, but not limited to, Eurostat, Eurobarometer, Polish Household Budget Survey 2010-2018, Warsaw Transport Survey 2015 and 2022, World Values Survey).

2 Private car ownership and use

The motorization rate in Poland is high and grows dynamically. Between 1995 and 2020, the number of passenger cars per 1000 inhabitants has risen 3.5 times, reaching the value of 664.[1] The indicator has been growing yearly with no reverse trends. This tendency led Poland to the third position in the ranking of European Union (EU) countries in 2020, placing it just behind Luxembourg and Italy. The mean value for the EU27 equals 560, with 11 countries exceeding the average. Furthermore, Poland significantly elevates the average number of passenger cars per

[1] All statistics in this paragraph are based on Eurostat data (Stock of vehicles in number and per 1000 inhabitants) [Eurostat].

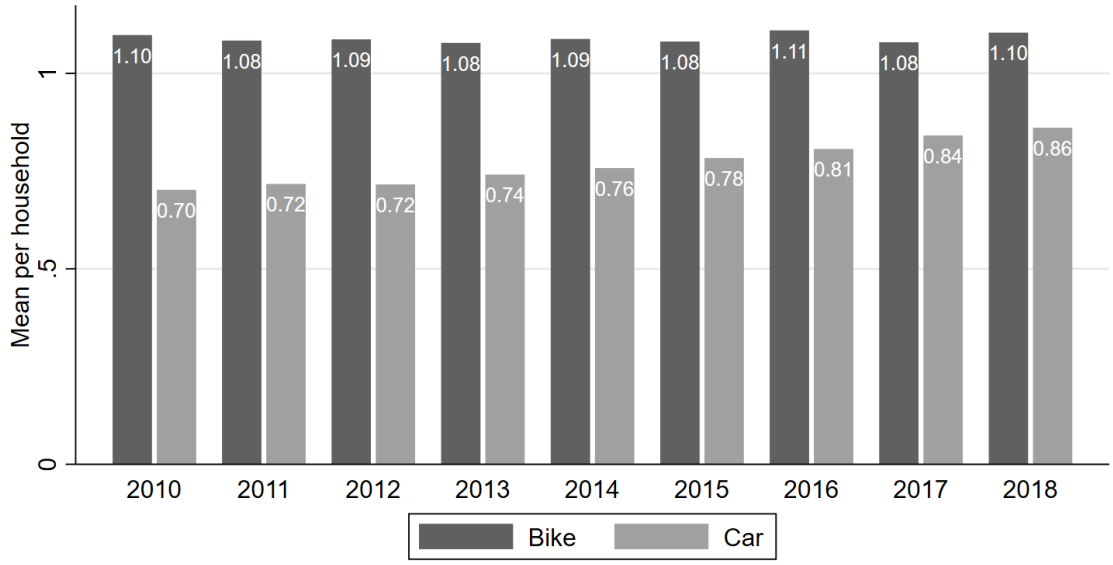

Figure 1: Mean number of bicycles and private cars per household in Poland, 2010-2018
Source: Polish Household Budget Survey 2010-2018.

1000 inhabitants in the Visegrad Group, which equals 520.

Cars are the primary mode of transportation in the entire European Union – over half of EU citizens in 2019 indicated cars as the mode in which they typically spend the highest share of their travel time. The main reasons behind this choice include reducing travel time, increasing one's comfort, and having no other alternatives.[2] 89% of EU citizens claim to use their private car for most of their daily travel. In Poland, the share is a bit higher – 90% of Poles use their own car to travel, and 43% claim it is their main transportation mode. As for other transportation modes, one in five Poles predominantly uses the public transportation system, 17% walk, and 7% use their own bicycles. However, half of the car users in Poland would be ready to change a significant part of their daily mobility to more eco-friendly transportation modes. Nevertheless, it would need not be available, as fast as, and of the same price as using a car.

Our analysis of the Household Budget Survey for 2010-2018 confirms a gradual growth in the number of private cars per Polish household. However, the number of bikes continuously oscillates around 1.1 per household, with no significant changes over time (cf. Figure 1). Urbanek [2018] scrutinized the same dataset for the period between 2000 and 2015, comparing Poland to other EU countries. She demonstrated a significantly higher willingness to increase spending and usage of passenger cars in Poland than in the EU15 countries and other Central and Eastern European countries.

The average number of bicycles (excluding children's bicycles) per household in Poland was stable over 2010-2018 and oscillated around 1.1. However, the average number of cars per household has increased over the nine years - from 0.7 in 2011 to 0.9 in 2018. To take a closer look into these statistics, we study the differences between the disposable *per capita* income groups

[2]All statistics in this paragraph are based on the data from Special Eurobarometer 495 [European Commission, 2020].

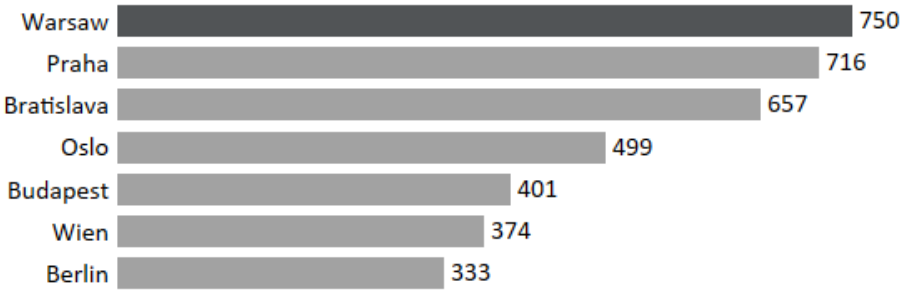

Figure 2: Passenger cars per 1000 inhabitants in 2020
Source: Eurostat (tran_r_vehst), NUTS2

(by deciles), voivodships, and the size of the place of residence.

The Warsaw Metropolitan Area, covering the capital city of Poland and nearby counties, counted up to over 2.3 million passenger cars in 2020.[3] The number translates into 750 cars per 1000 inhabitants and has been rising steadily over the last three years (from 671 in 2017). It is the highest value among all NUTS2 regions in Poland and exceeds the country average by 86. Compared to other European capital cities, the number of passenger cars per 1000 inhabitants in Warsaw is higher than, for example, in Prague and Oslo. Strikingly, the indicator in Warsaw is almost twice as high as in Budapest, Vienna (Wien), or Berlin (cf. Figure 2).

According to the 2021 Warsaw Barometer, one-quarter of Warsaw citizens drive a private or company car on a daily basis.[4] Furthermore, 11% drive a car at least once a week. However, almost half (45%) have not used a car as a driver in the last three months prior to the survey. Using a car as a passenger is less frequent, but only 23% of respondents have not used it in such a way. Traveling by taxi is significantly less popular among Warsaw citizens – 44% use such service less than once a month, while 46% have not used it in the last three months. Regarding alternative modes of transportation, almost half of Warsaw citizens (46%) use the public transport system daily. Only 7% claim never to use it. One in five uses their bicycle at least once weekly. The share is much smaller in the case of city bikes – only 1% of Warsaw citizens use them at least once a week. Nonetheless, almost 90% believe that Warsaw is a bike-friendly city.

Poland's car ownership prevalence has almost quadrupled over the last 30 years [Kudłak et al., 2022]. The previously mentioned ownership indicators for Poland and Warsaw are high among the EU countries and when compared to other capital cities. Kudłak et al. [2022] highlight two main events that might have added to such rapid growth – the systemic transformation after the fall of communism and Poland's accession to the European Union. Both events boosted the individual willingness to own a car through different underlying mechanisms.

The correlations between disposable income, the number of bicycles, and cars are positive and statistically significant (at the significance level of 0.01). Table 1 below contains the exact values

[3] All statistics in this paragraph are based on Eurostat and Polish Central Statistical Office data (Stock of vehicles in number and per 1000 inhabitants, NUTS2) [Eurostat, Polish Central Statistical Office (GUS)].
[4] All statistics based on Warsaw Barometer (June 2021) [Miasto st. Warszawa, 2012].

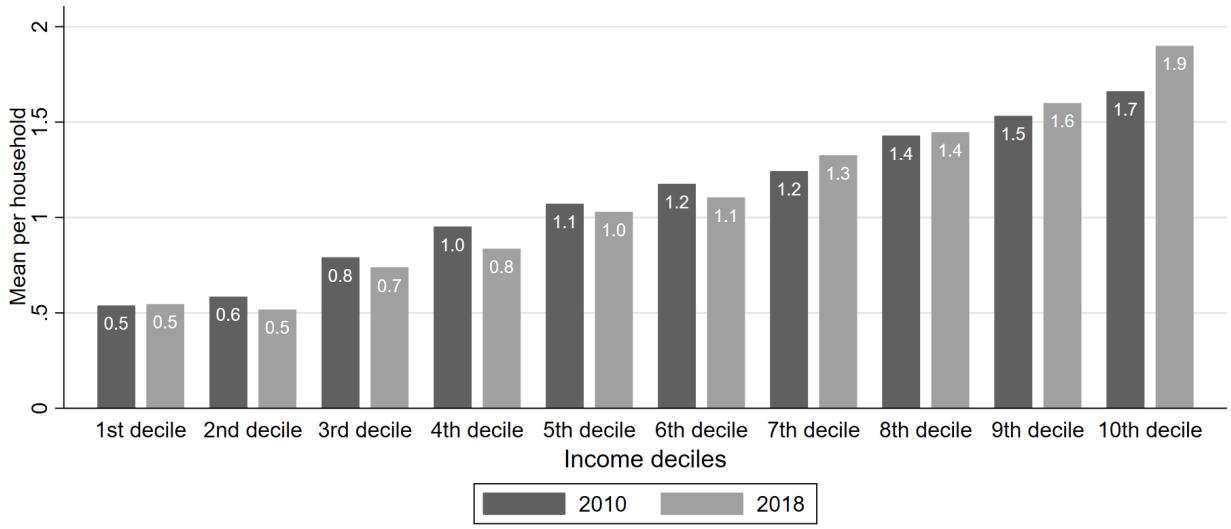

Figure 3: Mean number of bicycles for 2010 and 2018 by income deciles
Source: Polish Household Budget Survey 2010-2018.

for the correlations.

Table 1: Cross-correlation table

Variables	Bicycle	Private car	Income
Bike	1.00		
Private car	0.39*	1.00	
Income	0.33*	0.50*	1.00

Source: Polish Household Budget Survey 2010-2018.

The mean bicycle ownership grows with increasing income, exhibiting significantly higher values for the wealthier cohorts. In 2018, the households from the 10th decile of disposable income owned two bikes on average, while only every second household from the 1st decile had one.

Furthermore, the growth in the average number of bikes between 2010 and 2018 was predominant from the 7th decile up. Below that threshold, the average bike ownership shrank, except for a small growth in the 1st decile (cf. Figure 4).

In the case of private cars, the growth in the average number is noticeable in each income decile group, gaining higher values with increasing income (cf. Figure 5).

The average number of bicycles is the highest in Opolskie voivodship, reaching 1.5 bikes per household. The lowest score is twice smaller and characterizes Małopolskie voivodship (cf. Figure 6). The majority of voivodships have seen a growth in the mean number of private cars between 2010 and 2018 (cf. Figure 7).

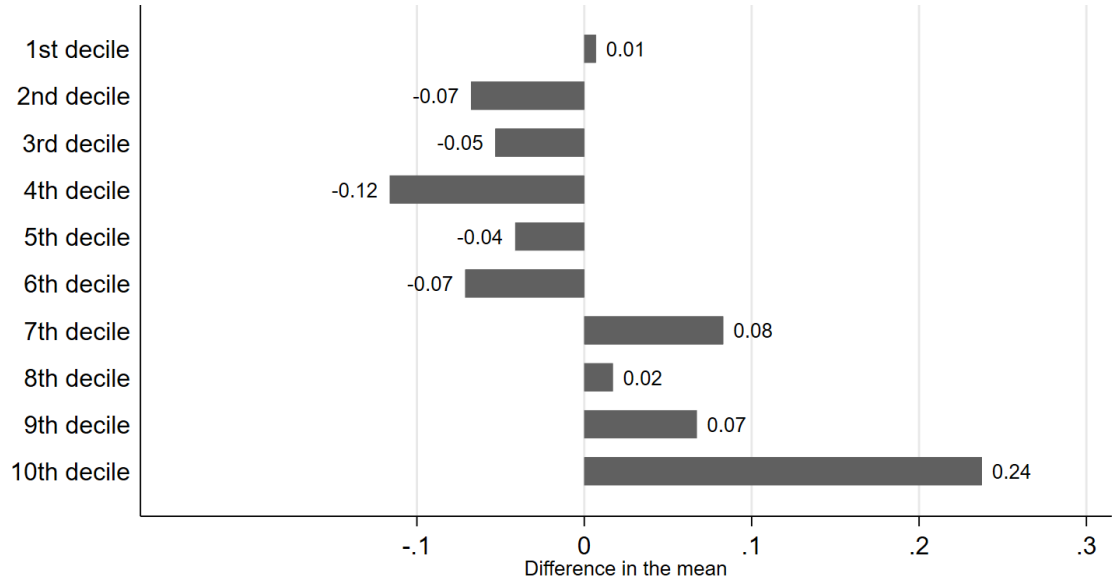

Figure 4: Difference in the mean number of bicycles by income deciles between 2010 and 2018
Source: Polish Household Budget Survey 2010-2018.

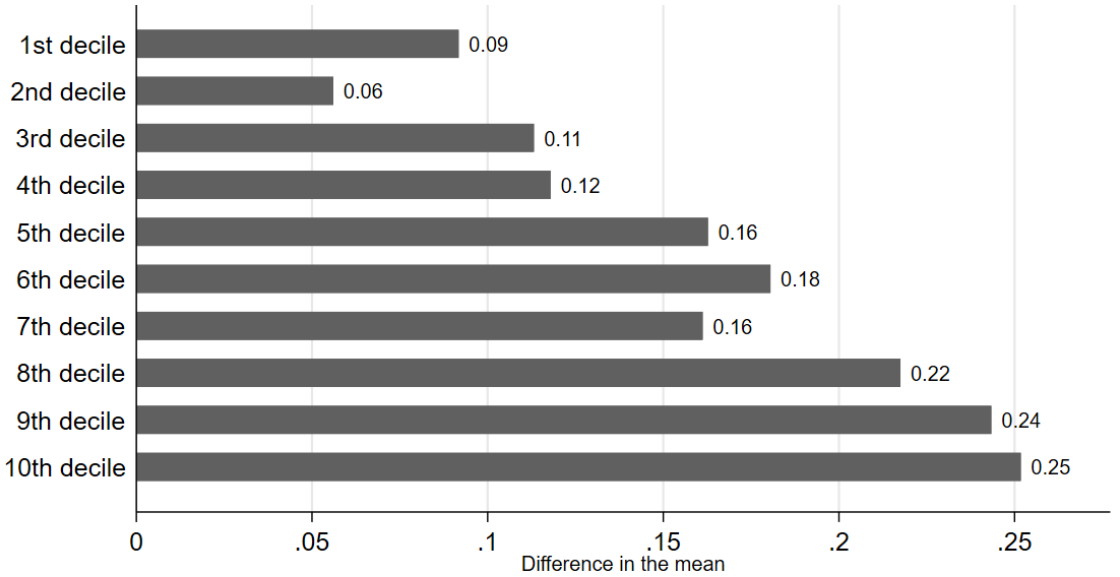

Figure 5: Difference in the mean number of cars by income deciles between 2010 and 2018
Source: Polish Household Budget Survey 2010-2018.

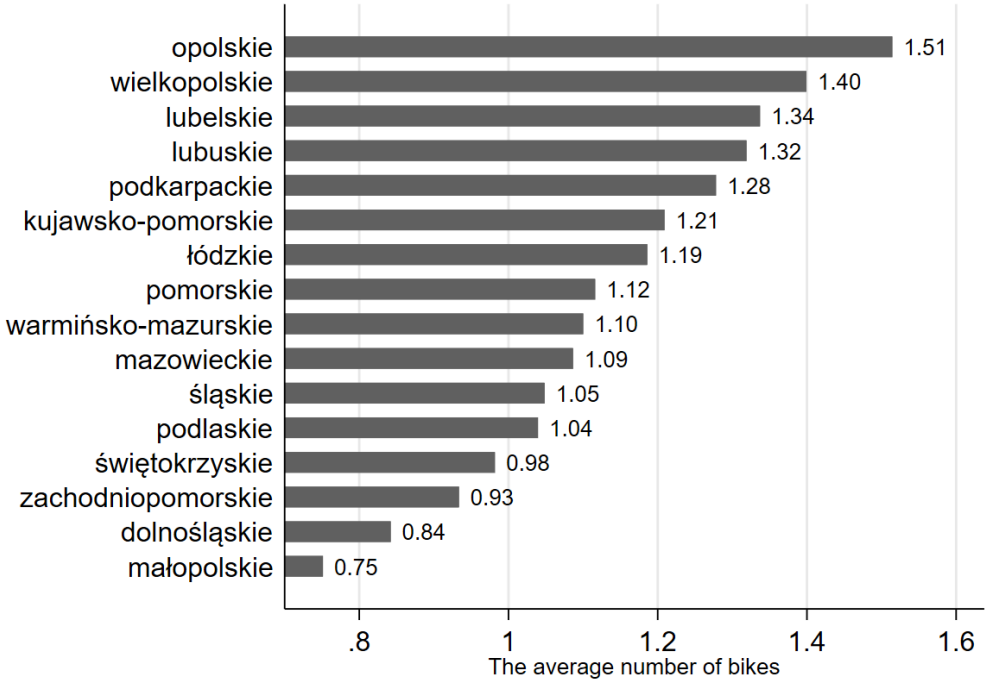

Figure 6: Mean number of bicycles in 2018 by voivodship
Source: Polish Household Budget Survey 2010-2018.

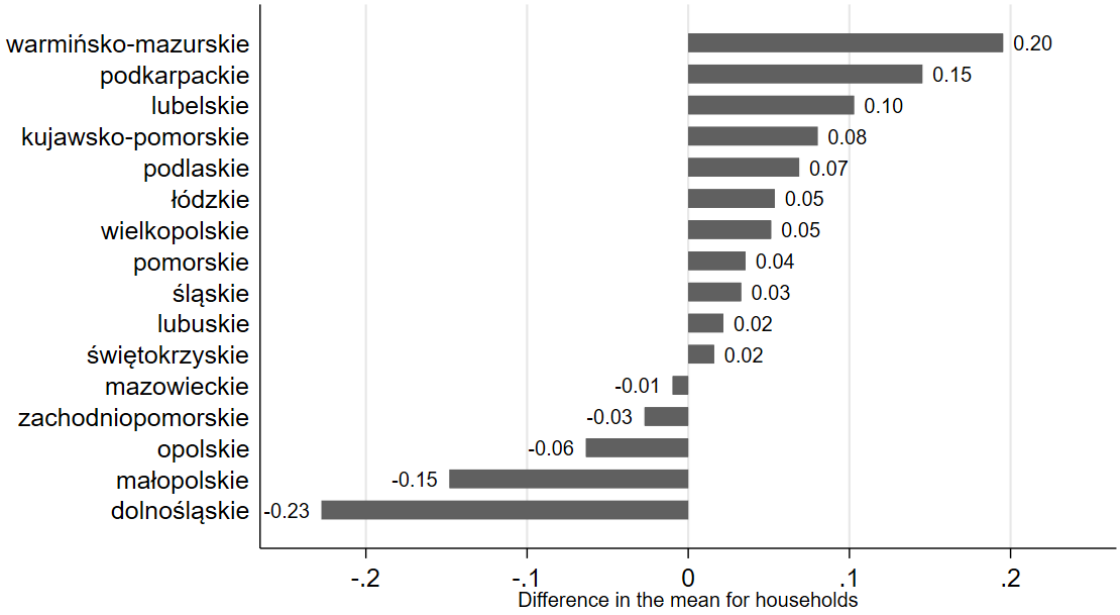

Figure 7: Change in the mean number of cars between 2010 and 2018 by voivodship
Source: Polish Household Budget Survey 2010-2018.

3 Transport system in Warsaw

3.1 Main components of the transportation system

Warsaw Public Transport[5] (WPT) is a network comprising buses, trams, subways, a rail network, and a bicycle-sharing system. The city government allocates 20% of its budget to the WPT [ZTM, 2021].

The body that manages all means of the WPT is the Public Transport Authority[6] (PTA). It provides transportation in a metropolitan area of more than two million residents in cooperation with the local governments of 34 sub-Warsaw municipalities. The transportation network in Warsaw is approximately 3,600 km, and outside the capital, about 1,400 km. In 2021, public transportation carried 809.4 million passengers [ZTM, 2021]. This was 7% more than in 2020 and 33% less compared to 2019, partially due to COVID-19 [Biuro Strategii i Analiz Urzędu Miasta Stołecznego Warszawy, 2021].

The PTA service area is divided into two ticket zones. In Zone 1, enclosed within city limits, passengers may travel with all PTA tickets. Traveling in Zone 2, which extends to the Warsaw suburbs and includes the whole metropolis, requires a ticket for Zone 2 or Zones 1+2.

Bus transportation is the most crucial component of public transportation in Warsaw, particularly in other municipalities of the Warsaw agglomeration, where subways and trams are not operated. Historically, buses have been the main mean of public transport in Warsaw since 1920, rapidly expanding until the II World War, during which the buses ran on and off. After the destruction of Warsaw, it was easier and cheaper with buses than with trams to develop new routes and start new lines, and that is when they became the primary transport mode, with bus passengers exceeding the number of tram passengers in 1974 [Krzyżakowa, 1987].

As of 2022, there were 177 bus lines within Zone 1, 39 lines between Zones 1 and 2, 41 night lines, and 47 lines that are outside of the urban-suburban zoning and operate in neighboring agglomeration communes and cities, connecting them with zoned transportation [ZTM, 2022]. Bus services carry 50% of public transport passengers [ZTM, 2021]. The buses are administered by the Municipal Bus Company[7] (MBC). In addition to the MBC, PTA contracts out some bus services to private companies selected through a tender process, operating primarily in the suburban area. However, the tram network is being invested in and systematically expanded within the city borders.

The tram system is the oldest element of the Warsaw integrated transportation system, with the first horse tram line operating in 1866, railroad trams from 1881, and electric trams from 1908, when it served 42 million passengers, which increased to 76 million in 1911 [Bystroń, 1977]. Currently, 23% of public transport passengers are carried by trams in 26 regular lines [ZTM, 2021] managed by the municipally-owned Warsaw Trams.[8] Nearly 90% of the tram tracks are separated from other traffic [Stachyra and Dylewska, 2021], and 75% of Warsaw intersections are covered by priority

[5] In Polish: *Warszawski Transport Publiczny (WTP)*.
[6] In Polish: *Zarząd Transportu Miejskiego (ZTM)*.
[7] In Polish: *Miejskie Zakłady Autobusowe*.
[8] In Polish: *Tramwaje Warszawskie sp. z.o.o.*

for the trams [ZTM, 2021], thus making it a traffic jam-free transport option.

The location of all trams and buses operated by PTA is monitored in near-real time. This is based on GPS receivers located in vehicles and wireless communication between vehicles and the IT systems of PTA. In this way, the most recent location updates are regularly uploaded to the server back-end of PTA. The bus and tram location data are publicly available via the Open Data portal of the City of Warsaw [Urząd Miasta st. Warszawa, 2015]. This provides the geo-coordinates of up to approx. 2000 vehicles at the same time, as this is the number of buses and trams operated at peak hours by the PTA. Importantly, the open data service available in the open data portal provides only the most recent known location for each of the vehicles. To know delays or collect historical data, extra client modules, such as modules performing the fusion of location data with schedule data, have to be implemented. The schedules are also available as one of the Open Data resources. Moreover, location updates are also available for some of the vehicles not in service, which can be observed especially in the early morning, i.e. before the first planned departure of a vehicle, and late evening, i.e. after the last planned departure of a vehicle.

The third most used transport means in Warsaw is the subway, which serves 22% of Warsaw passengers, although it consists of just two lines of 36 kilometres. The first line, M1, opened in 1995 and runs vertically through the left side of Warsaw (in relation to the river Vistula vertically cutting through the city). For the first few years, it operated only from the southern end to the centre of Warsaw. It was completed in 2001 when it reached the northern part. A few of the first stations of the second line, M2, opened in 2015. It cuts through Warsaw, more or less from west to east, and currently has 18 stations. It crosses M1 in one of the central stations. Completion of the line (21 stations) is scheduled for 2026. In 2021 the third line was approved to be built. It will run on the right side of Warsaw, share one station (the National Stadium) with M2, and as of now, will consist of 6 stops, to be completed in 2028.

The overground rail network in Warsaw consists of three carriers. Public Transport Authority manages only local commuter rail services in the Warsaw metropolitan area, Fast City Rail[9] (FCR). However, two other train companies/solutions operate within the Zones and extend to other Mazovian region towns and communes - Mazovian Rail[10] and Warsaw Suburb Rail[11]. All the residents who have a 30-day or a 90-day ticket to either or both of the Zones may use their service within that ticket (1-day and 3-day tickets too, only single trip and 20-minute tickets are excluded from that integrated tariff offer).

3.2 Cost of the transportation tickets

Long-term tickets in the Warsaw met area are available for periods of 1 and 3 months. The price of a full fare 3-monthly Zone 1 ticket is PLN 280, equal to 4% of the gross median salary in Warsaw[12],

[9] In Polish: *Szybka Kolej Miejska*
[10] In Polish: *Koleje Mazowieckie*.
[11] In Polish: *Warszawska Kolej Dojazdowa*.
[12] Median gross salary in Warsaw in 2021: 7320 PLN

while for Zones 1+2 - PLN 460. The fine for travelling without a ticket is PLN 266 (PLN 159.6 if paid immediately or PLN 186.2 within seven days).

Children under the age of 7 and pupils of the Warsaw metropolitan area's primary schools (aged up to 15) are eligible for free travel on Warsaw Public Transport. Afterwards, and long as they are still in school or studying until the age of 26 (or 35 for postgraduate students) are entitled to a 50% discount on the tickets. Moreover, for families of at least three children living in Warsaw and paying income taxes, special fares allow for a ticket for each such child until the age of 21, to cost PLN 99 for a metropolitan (both Zones) ticket. Senior residents above the age of 65 are entitled to a metropolitan area ticket for PLN 50 per year. To encourage residents to pay their income taxes in Warsaw and rewards them for doing so, additional discounts per so-called Varsovian card are offered both on the full fare and student tickets, which then (for Zones 1+2) for adult results in a 3-monthly cost of PLN 250 and PLN 125 for a student ticket.

3.3 Public bicycles and strategy for sustainable mobility

Apart from the described above components of the Warsaw transportation system, there is a growing network of bicycle routes that complement and often substitute other transportation means. Currently, Warsaw consists of 638 km of bicycle routes and lanes and 81 km of shared pedestrian and bicycle lanes. However, bicycle roads are fragmented in many city areas.

Public Transport Authority also manages the public bicycle-sharing system, Veturilo. Currently, there are over 380 Veturilo stations and over 5,500 bicycles available. There are ten stations with electric bikes and six stations with small bikes [WTP, 2022b]. These public bikes are available during the season from the beginning of March to the end of November. To use public bikes, one must create a user account with personal details and deposit a minimum of PLN 10. The first 20 minutes of each rental is free, and for the first hour, the fee is PLN 1 [Veturilo, 2022]. The city also offers cargo bikes to rent for free, for up to 72 hours, from 9 locations around the city, open from spring to autumn.

To encourage residents living further away to use public transport within the city, a system of Park & Ride parking allows, during the hours of operation of the parking lots, free parking of vehicles for those who present a valid public transportation ticket (all the tickets starting from the 24-hour tickets and longer). Otherwise, there is a fixed fee of PLN 100 per day for renting a parking space [WTP, 2022a]. As of 2022, there are 16 P&R parkings, 12 of which also include bicycle parking. These parking lots are located near the peripheral stops of public transport means. They allow drivers to leave their car in a safe place to transfer to public transportation and continue their journey to the city centre.

Another mobility policy aimed at encouraging the use of public transport and increasing the turnover of parked vehicles in Warsaw is the Paid Unguarded Parking Zone (PUPZ) in Warsaw. It extends from the centre to the surrounding districts and operates on weekdays between 8 am and 8 pm. The first hour costs PLN 4.50, the second PLN 5.40, the third PLN 6.40, and the fourth and every subsequent PLN 4.50 each. Thus, 12 hours of parking in PUPZ amounts to PLN 56.8.

Fees can be paid at the parking meter or using the mobile payment system with one of the two applications. The fine for parking without paying is PLN 200 (if paid within seven days; PLN 300 afterwards). For residents living in the area of the PUPZ, there are yearly subscriptions either for PLN 30, allowing one to park 150 meters from the place of residence or for PLN 600, if extended to a whole delimited area.

The current Strategy for Sustainable Development of the Warsaw Transport System, called the #Warsaw2030 Strategy, aims at increasing the share of environmentally friendly transportation modes. It assumes further development and provision of new tram and metro lines and the provision of electric buses. The city governors also plan on extending the Paid Parking Zone to further districts to nudge people into changing their mobility patterns. There is a new pedestrian/bicycle bridge over the Vistula river under construction (to be put into service in 2026). The new bike lines and renovated sections are primarily intended to connect existing routed into a coherent network so as to enable bicycle travel over longer distances.

3.4 E-scooters in Warsaw

Micromobility, especially e-scooters, has also been an important element of the urban transport system in Warsaw and a disruptor of everyday mobility. The first shared e-scooters appeared in Warsaw at the end of 2018, initially treated as a curious but irrelevant mode of transport. Nevertheless, by 2022 there were already about 21 thousand shared e-scooters in the city and four major providers of this service: Bolt, Lime, Dott and Tier. Warsaw is responsible for almost 25% of the entire shared e-scooter market in Poland, estimated at approximately 94 thousand e-scooters in 161 cities, according to the report by Smart Ride - an online outlet dedicated to urban micro-mobility in Poland [Smart Ride, 2022]. Shared e-scooters are also a major part (80%) of the shared mobility market in Poland, followed by shared bicycles (20%) and a minimal share of electric motorcycles (0.5%).

This dynamic market growth is also reflected in the modal shift. According to the 2022 Bicycle Traffic Survey in Warsaw, e-scooters accounted for more than 7% of two-wheeled traffic on average. What's more, in some areas of the city, their share was as high as 18% of two-wheeled traffic. These data are a direct indication of the growing importance of this mode of transport, as 2022 traffic monitoring conducted in Warsaw revealed.

The growing popularity of shared e-scooters poses certain challenges. At the beginning of their use, the mobility of e-scooters was not regulated by Polish law. Parking problems (abandonment of e-scooters all over the city) and users' safety were the biggest challenges. However, by 2023 most of the problems had been solved. In May 2021, a law regulating the basic principles and definitions related to e-scooters, such as their technical conditions and equipment for these vehicles, was implemented in Poland. In 2022, Warsaw signed an agreement with the main providers of shared e-scooters, according to which parking of electric scooters is allowed only in designated areas (the City of Warsaw is planning about 250 such parking areas throughout the city) or, if there are no such locations, on the pavements. The agreement also imposes a 20 km/h speed limit for e-

scooters operating within the city and an even stricter limit (12 km/h) in selected areas of the city. In addition, service providers must pay a monthly fee to the city, which amounts to approximately PLN 50,000 per company, depending on the size of the fleet.

3.5 Performance of the Warsaw public transport system and residents' perception

The performance of public transport in Warsaw varies depending on the mode of transportation and the time of day. During peak hours, the system can become overcrowded, leading to delays and longer wait times, particularly for buses, which, unlike the subway and the majority of trams, share the streets with private cars. As the city suffers from extensive traffic jams, not only during rush hours, there is an increasing number of lanes where buses are privileged. Currently, there are 69 kilometres of bus lanes, half of which are in effect 24/7. The others are restricted to buses (and registered taxi cabs) during peak traffic hours on weekdays. Nonetheless, the delays of buses are the most frequent compared to other modes. Overall, in 2021, 16% per cent of buses arrived late at bus stops [ZTM, 2021].

Nonetheless, buses are chosen by 58% public transport users as their preferred mode of transportation. Trams and subway are the next most popular choices, with 17% and 15% of the population respectively choosing them as their preferred mode of transport. In terms of residents' perception, the majority are generally satisfied with the public transportation system in Warsaw. Over 80% of respondents state that public transportation in the city is convenient, efficient, and reliable [Miasto st. Warszawa, 2012]. The convenience of reaching the destination while commuting is also positively rated at 80%; however, 15% of the respondents state that they would choose a public transport option instead of a private car if there were not worried about the delays [Miasto st. Warszawa and DANAE, 2019].

The city also found that the majority of respondents felt that public transportation was safe and secure and that the city was making a good effort to improve the public transportation system.

3.6 Transport in Warsaw after COVID-19

The COVID-19 pandemic brought about substantial changes to various aspects of daily life, including transportation and commuting patterns. In this subsection, we aim to compare and analyze the transportation habits of people in Warsaw before and after the pandemic by analyzing two large samples of mobility behaviours in 2015[13] and 2022[14]. We will examine the differences in transportation use based on age, the purpose of the trip (school or job), gender, and trip duration. Simple graphs will be used to visualize and compare the data.

Before delving into the analysis, it is crucial to note the limitations of the comparison due to differences in data collection methods between the 2015 and 2022 datasets. The following points summarize these differences:

[13] Warsaw Transport Survey, In Polish: Warszawskie Badanie Ruchu (WBR). See Appendix for more details.
[14] Sustainable Urban Mobility Plan (SUMP) Survey. See Appendix for more details.

- Purpose of Trip: The 2015 dataset contains all the data for all trip purposes, while the 2022 dataset only focuses on school and job-related trips and does not include, for instance, trip duration or means of transport data for other trip purposes.
- Age Range: The 2015 dataset includes all ages from 6 and above, while the 2022 dataset only covers people aged 16 and above.

These limitations will affect the final results of the analyses. For instance, the 2022 dataset underrepresents elderly people in the analysis of the means of transport as most of the elderly people neither go to school nor work anymore. It also does not include data on children and adolescents younger than 16, and as a result, commuting by foot is overrepresented in the 2015 dataset, as many younger children walk to school.

In the analysis, we will present our findings using simple graphs to compare the two datasets. The graphs will focus on the following aspects:

1. Means of transport distribution (public transportation, private cars, biking, and walking)
2. Age distribution of commuters
3. Purpose of the trip (school vs. job)
4. Gender distribution of commuters
5. Trip duration distribution

The main point of the comparison is the means of transport; therefore, we report other items, such as the trip's purpose, through their interaction with the means of transport. For the sake of readability and clarity in our visualizations, text labels representing 1 per cent or less have been omitted from the plots.

Between 2015 (Figure 8) and 2022 (Figure 9), the most significant differences in mobility choices across age groups are the decrease in the percentage of people travelling on foot and the increase in the use of private transport. There is a slight decrease in public transport usage overall, while the use of bicycles remains relatively stable. In the 15–19 age group, there is a notable increase in public transport usage from 35% in 2015 to 71% in 2022, which is the highest percentage among all age groups in 2022. Meanwhile, the 65 and above age group experienced a significant decrease in public transport usage from 50% in 2015 to 31% in 2022, with a corresponding increase in private transport usage from 20% to 51%. These shifts within specific age groups highlight the growing reliance on public transport among younger individuals and a stronger preference for private transport among the elderly, which may be related to the COVID-19 pandemic.

In comparing the trip motivation data for 2022 (Figure 10) and 2015 (Figure 11), there are some noticeable differences in the choices for school and work trips. For school trips, there is a significant decrease in the percentage of students travelling on foot from 34% in 2015 to 9% in 2022 and an increase in public transport usage from 49% to 75%. The use of private transport for school trips also decreased slightly from 15% in 2015 to 7% in 2022.

For work trips, there is an increase in private transport usage from 36% in 2015 to 48% in 2022. Public transport usage for work trips saw a decline from 53% in 2015 to 37% in 2022, while

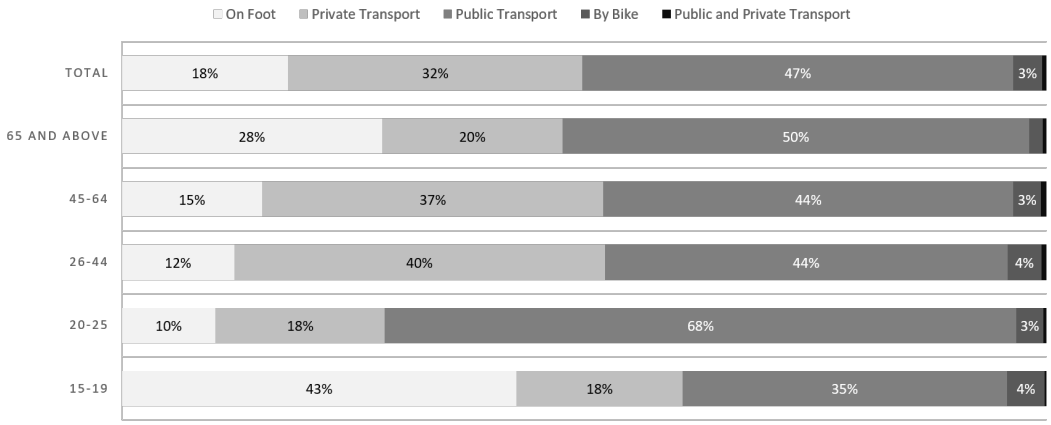

Figure 8: Means of transportation by age groups in 2015

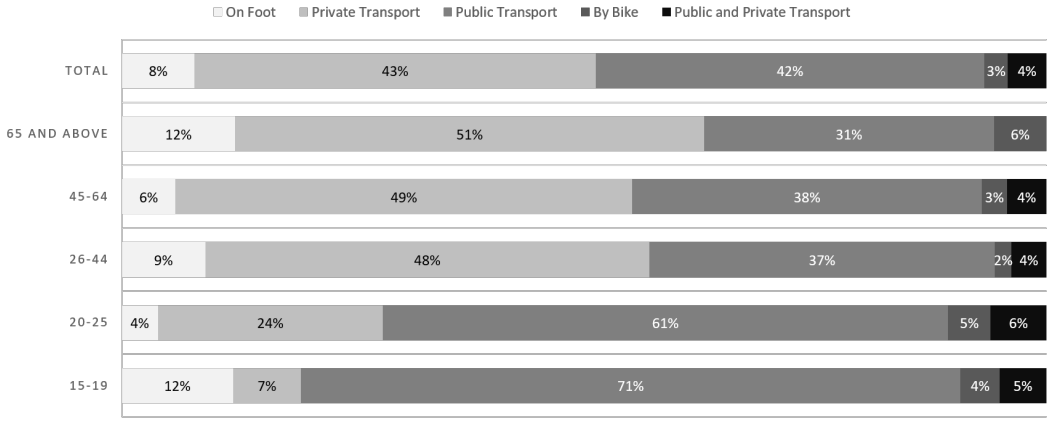

Figure 9: Means of transportation by age groups in 2022

the percentage of people travelling on foot remained relatively stable at 7% in 2015 and 8% in 2022. The use of bikes and combined public and private transport for both school and work trips experienced minor changes.

These trends indicate a growing preference for public transport among students and an increased reliance on private transport for work-related trips.

When comparing trip duration and transport means data for 2015 (Figure 12) and 2022 (Figure 13), there are several notable differences. In 2022, the percentage of trips lasting 16-30 minutes increased for private and public transport and the combined public and private transport category, compared to 2015. For private transport, the percentage rose from 37% to 40%, and for public transport, it increased from 34% to 43%. For the combined public and private transport category, the percentage went up from 18% to 27%.

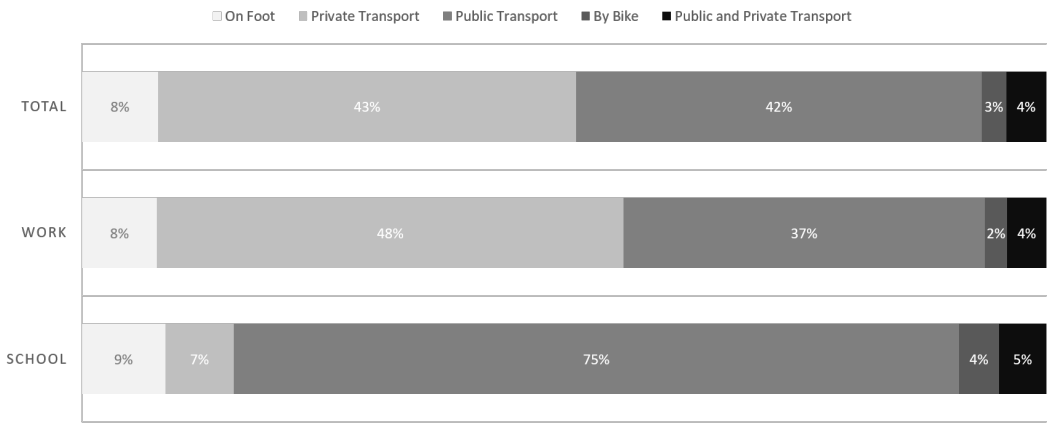

Figure 10: Motivation of trips in 2022

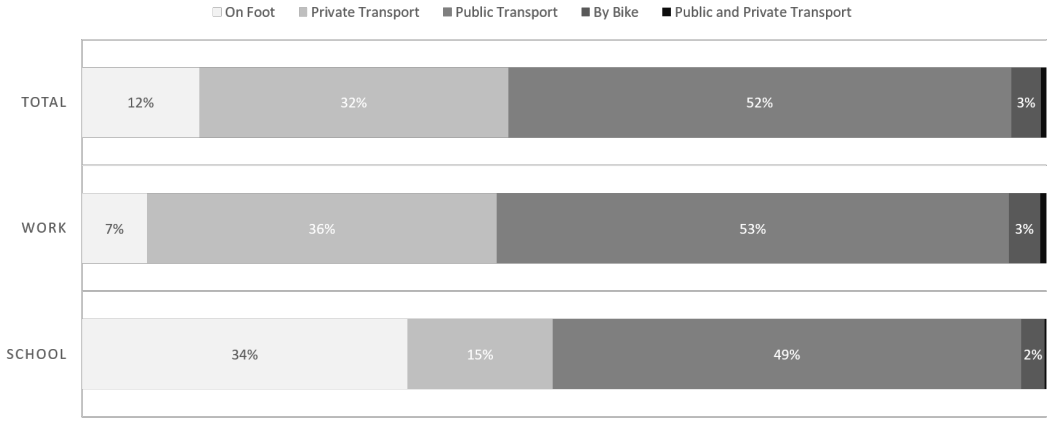

Figure 11: Motivation of trips in 2015

Additionally, the percentage of trips lasting 31-45 minutes increased in 2022 for public transport, from 23% to 32%, and for the combined public and private transport category, from 20% to 48%. Conversely, the percentage of trips lasting more than 60 minutes decreased for private and public transport, from 6% to 1% and from 11% to 4%, respectively.

The percentage of trips lasting up to 15 minutes by bike increased significantly from 39% in 2015 to 62% in 2022, while trips lasting 46-60 minutes by bicycle disappeared entirely in 2022. Overall, the total percentage of trips lasting 16-30 minutes and 31-45 minutes increased, while the percentage of trips lasting 46-60 minutes and more than 60 minutes decreased in 2022 compared to 2015. These trends suggest a shift towards shorter-duration trips across most transport modes.

4 Understanding mobility behaviours

The literature differentiates several groups of car ownership determinants. The traditional economic determinants cover, among others, GDP growth, specific policies, characteristics of the tax systems and car-related prices [Oakil et al., 2016]. However, researchers claim that such factors

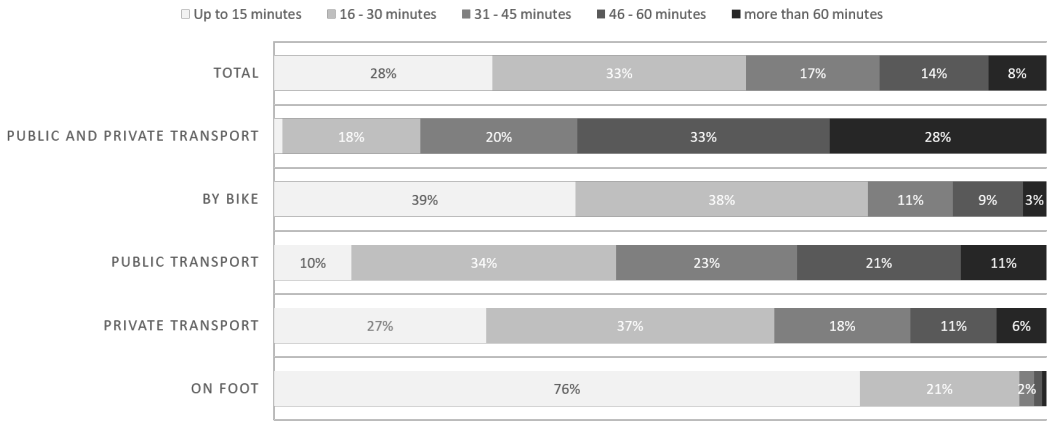

Figure 12: Duration of trips in 2015

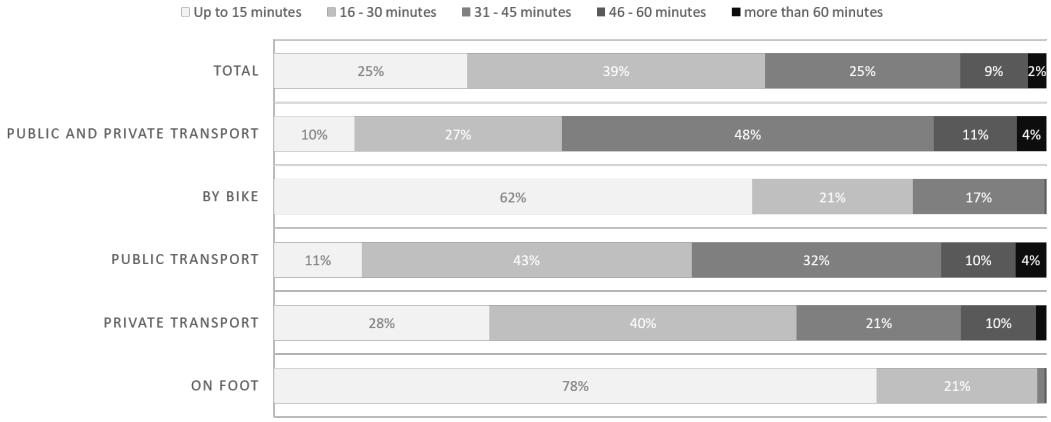

Figure 13: Duration of trips in 2022

may be too aggregated to capture “the diversity and various dynamics underlying aggregate car travel demand and how it changes” [Goodwin and Van Dender, 2013]. Furthermore, even though policies such as vehicle use restrictions or increases in car prices may reduce car ownership [Yang et al., 2022], the impact of such changes may differ between groups of citizens, leaving, for example, the citizens of rural areas worse off [Dargay, 2002]. Hence, the policies must be introduced carefully, considering the perspectives of all interested parties.

The infrastructure and urban planning, linked to the accessibility, reliability and quality of various transport modes, may also impact the decision to own a car. The improvements in the provision of public transport, such as increasing accessibility, timetable frequency or reducing prices, can translate into reduced car use [Redman et al., 2013, Papu Carrone et al., 2021]. Nevertheless, the changes in individual behaviour require more than just better public transport characteristics. Intrinsic motivators play a crucial role in building long-lasting transportation habits [Redman et al., 2013]. Hence, individual characteristics and psychological inclinations are considered to affect car ownership and use. Household and individual socio-demographic characteristics can significantly alter car ownership decisions [Oakil et al., 2016]. Studies demonstrate that car ownership is posi-

tively associated with income levels, driver's licenses and household composition – the number of adults and children (e.g. [Dargay, 2002, Prillwitz et al., 2006, Papu Carrone et al., 2021]). Therefore, certain life events trigger car ownership. For example, its growth is influenced by the birth of the first child, marriage, and changes in monthly income [Prillwitz et al., 2006]. Furthermore, it may be related to relocations and can differ between generations. Papu Carrone and Rich [2021, p. 144] demonstrate such changes in Denmark - they find that "the young age cohorts (between the age of 18 and 37 years) today are less likely to acquire cars compared to the same age cohorts observed 10 years ago". Indeed, recent years have seen some generational shifts in the propensity to own a car. Klein and Smart [2017] find out that the levels of car ownership among Millenials are lower in comparison to the previous generations, linking it predominantly to their economic status.

Car ownership itself is a significant determinant of car use. For example, Wootton [1999] demonstrated that owning a car multiplies the number of car journeys more than two times. Besides car ownership, Gärling and Friman [2018] divide factors impacting car usage into three groups: instrumental, economic and psychological. The instrumental group of determinants encompasses activity-related factors, such as the necessity of travelling to work, shopping or participating in leisure activities. In other words, it relates to "fulfilling biological needs, social obligations and personal desires" [Gärling and Friman, 2018, p. 569]. Furthermore, it covers spatial characteristics of one's environment related to the dispersion between people and their activities destination, distance and road infrastructure. However, they underline that the provision of public transport solutions mediates the final choice of transport mode.

The economic determinants of car use are mainly related to the cost-benefit analysis of travel time and the value of an individual's time. Faster journeys often become more attractive with increasing income due to the rising perceived value of time [Gärling and Friman, 2018]. While looking at the psychological determinants of car use, Gärling and Friman [2018] highlight the importance of a car as an indicator of one's status, independence and personality. Even though in advanced economies private cars are treated as everyday tools more than luxury [Gärling and Friman, 2018], they may still constitute a status symbol in the former Soviet bloc, even among those who were born after the transformation to a market economy [see, e.g. Pojani et al., 2018], leading to increase willingness to use a car. Summing up, the determinants of car ownership and car use are multifaceted. They relate not only to individual characteristics and psychological inclinations but also to the household composition and regional or country provision of alternative services and infrastructure. Hence, any policy aiming to reduce car ownership and use requires an in-depth inquiry into the abovementioned conditioning factors.

5 Communism legacies

The infrastructure of the public transport system has been improving steadily over the last decades, but mobility, to a large degree, is based on private car ownership in Warsaw and Poland in general. Mobility as a service is provided mainly by private operators and is not integrated with the public

transport system, except for the city bike service.

Strong preference for private ownership underlying a number of economic decisions in Poland

The individual data from Life in Transition Survey (see Table 2) show that the impact of being exposed to communism and living in a country belonging formerly to the Soviet bloc affects car ownership and behaviours as well as attitudes related to environmental protection, keeping other relevant factors constant.

We find that individuals living in the Soviet bloc are significantly more likely to own a car (by 17 % per cent on average) and less sensitive to climate protection, i.e. less willing to contribute financially to climate protection activities and less likely to be a member of the relevant organization.

At the same time, individuals in the Soviet bloc are highly more likely to own a bicycle (by 26 % on average, keeping other relevant factors constant), which might signal a large room for improvement and potential for active mobility progress.

Table 2: Effects of exposure to communism on car and bike ownership and attitudes towards climate protection

	Car	Bicycle	WTP climate protection	Env. org. member
Soviet bloc	0.1678***	0.2636***	-0.1423***	-0.02708***
	(0.0178)	(0.0183)	(0.0194)	(0.0074)
N	41543	41543	36829	41543
R^2	0.216	0.158	0.125	0.022
Years under communism	0.01195***	0.005174***	0.004629***	-0.0002885
	(0.0017)	(0.0017)	(0.0017)	(0.0006)
N	28677	28677	25939	28677
R^2	0.170	0.180	0.140	0.018

Source: Author's own analysis based on data from Life in Transition, wave 3.
Note: Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Drawing on the data from the recent Central European Survey conducted in 2021 and 2022 in Austria, Czech Republic, Germany, Slovakia, Hungary, and Poland, we find interesting effects of communism.

Table 3: Effects of beliefs on services quality on private ownership

	Car	Parking place	Bicycle
Cross-section			
Private services over public	0.06560***	0.03598***	0.01367
	(0.0070)	(0.0071)	(0.0146)
N	10015	10015	10015
R^2	0.113	0.200	0.064
Panel fixed effects			
Private services over public	0.07964***	0.03847***	0.01819
	(0.0140)	(0.0129)	(0.0143)
N	5951	5951	5951
R^2	0.122	0.187	0.070

Source: Author's own analysis based on data from Central-European Survey, waves 1-2.
Notes: 'Private services over public' stands for the belief that "private services are usually of a higher quality than public services" measured on 4-point scale. Standard errors in parentheses. In cross-section estimation standard errors are robust to heteroskedascity and clustered by country. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We find that a belief that public services are of lower quality than private makes people more likely to possess their own car and private parking place (cf Table 3). As for the use of mobility services, we find that individuals with more pro-social attitudes are more likely to use public and shared mobility services (cf Table 4). Specifically, the willingness to sacrifice individual needs for the common good makes people more inclined to use public buses, rent bicycles, utilize Uber, and engage in carpooling. The effect size is largest for the use of public transport.

Table 4: Effects of pro-social attitudes on use of mobility services

	Public bus	Rented bicycle	Rented car	Uber	Blablacar	Car pooling
Cross-section						
Common good	0.07006***	0.02267**	0.009786	0.02495**	0.01154*	0.03475***
	(0.0079)	(0.0059)	(0.0070)	(0.0091)	(0.0050)	(0.0058)
N	10015	10015	10015	10015	10015	10015
Panel FE						
Common good	0.04293***	0.01937***	0.009938*	0.01641	0.009015**	0.03990***
	(0.0122)	(0.0065)	(0.0052)	(0.0107)	(0.0036)	(0.0100)
N	5951	5951	5951	5951	5951	5951

Source: Author's own analysis based on data from Central-European Survey, waves 1-2.
Notes: 'Common good' stands for the attitude "I am ready to limit my individual comfort for the common good" measured on 4-point scale. Standard errors in parentheses. In cross-section estimation standard errors are robust to heteroskedascity and clustered by country. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5 shows that there is a significant relationship between communism and examined attitude and belief. Proper interpretation of these results requires acknowledgement of four relevant phenomena: firstly, all individuals living in the Soviet bloc were exposed to the regime transformation that could yield additional effects to the sole exposure to communism; secondly, individual effects of exposure to communism can be identified using two alternative various control groups (only individuals unexposed to communism living in former Soviet bloc or these individuals, as well as those living in the countries, never exposed to communism); thirdly, a possible intergenerational transformation of preferences; and finally, the differences between countries pre-existing introduction to communism. In order to be able to make a distinction between transition and individual exposure to communism effects, we run two separate analyses: one for the entire sample using the dummy for the Soviet bloc and one for the subsample of the former Soviet bloc using the dummy for individual exposure to communism. Hence, we can treat the coefficient on the Soviet bloc as a measure of the effects driven by the communist regime legacy (including the transformation period) while the coefficient on the exposure to communism captures the lower bound – taking into account preferences transmission – of the effects driven by communist institutions persistence. Due to little variation over time in the outcome variables and none in the explanatory variables, panel data analysis cannot provide any additional insight. Therefore, we use only the OLS approach to this analysis.

Table 5: Effects of communism on attitudes and beliefs

	Private over public services	Common good
Soviet bloc	-0.004944	-0.06847***
	(0.0037)	(0.0013)
N	11268	11268
R^2	0.041	0.021
Exposure to communism	0.01639***	0.04334
	(0.0024)	(0.0187)
N	6898	6898
R^2	0.015	0.026

Source: Author's own analysis based on data from Central-European Survey, waves 1-2.
Notes: 'Private services over public' stands for the belief that "private services are usually of a higher quality than public services". 'Common good' stands for the attitude "I am ready to limit my individual comfort for the common good". Standard errors in parentheses. Robust standard errors clustered by country in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We find that exposure to communism (being born before 1989, controlling for age, country, place of living, and other relevant factors) made people living in the former Soviet bloc significantly more likely to share the belief that private services are of a higher quality than public ones. This suggests that in the absence of free markets, the quality of available public services under communism enhanced the positive perception of the quality of services offered by private providers by 2 %. We also find a positive effect of the exposure to communism on pro-social attitudes, specifically on willingness to pay more attention to the common good, which is in line with other studies focused on the preferences in Germany [Alesina and Fuchs-Schündeln, 2007].

We document a sizeable negative effect of a 7 % reduction in the pro-social attitude in formerly communist countries as compared to Austria and Western Germany. The effect could reflect the pre-existing differences in the attitudes towards the common good, suggesting a lower prevalence of pro-social attitudes in societies of the formerly communist countries, yet it cannot be tested due to a lack of historical data. Assuming equal or larger levels of pro-social beliefs in the countries adopting communism in Central Europe as compared to Western Europe, detrimental effects on the willingness to take into account the common good can be credited to the adaptation of the free markets after exit from the communist regime.

Taking into consideration also the effects of the regime transformation, we find that the difference between individuals living in and outside of the former Soviet bloc in their beliefs on the is negligible. This finding suggests that access to privately delivered services on the free markets started with the regime transformation period and reduced the beliefs of the superiority of private over public services.

6 Conclusions

In conclusion, the rapid growth of private car ownership in Warsaw and Poland is a multifaceted issue that has been influenced by historical events, such as the regime transformation and Poland's accession to the EU, and a range of socio-economic factors. Despite the development of Warsaw's public transport system, the city still faces challenges regarding traffic congestion, parking spaces, and air quality. The #Warsaw2030 Strategy aims to promote sustainable mobility solutions and improve the overall transport infrastructure, with a focus on environmentally friendly alternatives.

Understanding mobility behaviours is crucial for designing effective policies and interventions. Factors such as car ownership, instrumental determinants, economic incentives, and psychological aspects all play a role in shaping individual choices. To encourage more sustainable transportation practices, policymakers should consider a comprehensive approach that takes into account the diverse factors affecting mobility decisions, the needs of various population groups, and the importance of providing accessible, reliable, and affordable alternatives to private car use.

In light of the ongoing global concerns about climate change, urbanization, and public health, the findings of this article underscore the importance of developing effective, context-specific policies and measures to promote sustainable mobility solutions in Warsaw and other urban areas in Poland. By doing so, cities can improve the quality of life for their residents, contribute to the global fight against climate change, and foster more resilient, inclusive, and sustainable urban communities for the future.

References

Alberto Alesina and Nicola Fuchs-Schündeln. Goodbye Lenin (or not?): The effect of communism on people's preferences. *American Economic Review*, 97(4):1507–1528, 2007.

Biuro Strategii i Analiz Urzędu Miasta Stołecznego Warszawy. Raport o stanie miasta. Warszawa 2021, 2021. URL https://um.warszawa.pl/documents/56602/53230519/2021+Raport+o+stanie+miasta_na+stronę.pdf/09a68b9b-ae46-ce35-a644-e549e4e005da?t=1654684206740.

Jan Stanisław Bystroń. *Warszawa*. Number 10 in Biblioteka Syrenki. Państwowy Instytut Wydawniczy, Warszawa, 1977. ISBN 83-7388-111-5.

Joyce M Dargay. Determinants of car ownership in rural and urban areas: a pseudo-panel analysis. *Transportation Research Part E: Logistics and Transportation Review*, 38(5):351–366, September 2002. ISSN 13665545. doi: 10.1016/S1366-5545(01)00019-9. URL https://linkinghub.elsevier.com/retrieve/pii/S1366554501000199.

Directorate-General for Communication European Commission. Special Eurobarometer 495: Mobility and transport, 2020. URL http://data.europa.eu/88u/dataset/S2226_92_1_495_ENG.

Eurostat. Eurostat database. URL https://ec.europa.eu/eurostat/data/database.

Phil Goodwin and Kurt Van Dender. 'Peak Car' — Themes and Issues. *Transport Reviews*, 33(3): 243–254, May 2013. ISSN 0144-1647, 1464-5327. doi: 10.1080/01441647.2013.804133. URL http://www.tandfonline.com/doi/abs/10.1080/01441647.2013.804133.

Tommy Gärling and Margareta Friman. Economic and Psychological Determinants of Ownership, Use and Changes in Use of Private Cars. In Alan Lewis, editor, *The Cambridge Handbook of Psychology and Economic Behaviour*, pages 567–594. Cambridge University Press, 2 edition, February 2018. ISBN 978-1-316-67634-9 978-1-107-16139-9 978-1-316-61390-0. doi: 10.1017/9781316676349.020. URL https://www.cambridge.org/core/product/identifier/9781316676349%23CN-bp-19/type/book_part.

Nicholas J. Klein and Michael J. Smart. Millennials and car ownership: Less money, fewer cars. *Transport Policy*, 53:20–29, January 2017. ISSN 0967070X. doi: 10.1016/j.tranpol.2016.08.010. URL https://linkinghub.elsevier.com/retrieve/pii/S0967070X16305571.

Krystyna Krzyżakowa. Zapiski statystyczne. In *Kalendarz Warszawski'88*, page 139. Krajowa Agencja Wydawnicza, Warszawa, 1987. ISBN 83-03-01684-9.

Robert Kudłak, Wojciech Kisiała, and Bartłomiej Kołsut. Uncovering the Determinants of Car Ownership in Poland. *SSRN Electronic Journal*, 2022. ISSN 1556-5068. doi: 10.2139/ssrn.4159841. URL https://www.ssrn.com/abstract=4159841.

Miasto st. Warszawa. Barometr Warszawski, 2012. URL https://um.warszawa.pl/waw/warszawa-w-liczbach/barometr-warszawski6.

Miasto st. Warszawa and DANAE. Badanie jakości życia mieszkańców warszawskich dzielnic. Technical report, 2019.

Abu Toasin Md Oakil, Dorien Manting, and Hans Nijland. Determinants of car ownership among young households in the Netherlands: The role of urbanisation and demographic and economic characteristics. *Journal of Transport Geography*, 51:229–235, February 2016. ISSN 09666923. doi: 10.1016/j.jtrangeo.2016.01.010. URL https://linkinghub.elsevier.com/retrieve/pii/S0966692316000119.

Andrea Papu Carrone and Jeppe Rich. A micro-model of car ownership dynamics: are preferences changing? *Transportation Letters*, 13(2):138–147, February 2021. ISSN 1942-7867, 1942-7875. doi: 10.1080/19427867.2020.1716473. URL https://www.tandfonline.com/doi/full/10.1080/19427867.2020.1716473.

Andrea Papu Carrone, Mayara Moraes Monteiro, and Jeppe Rich. Modelling car ownership dynamics based on irregularly spaced panel data. *Travel Behaviour and Society*, 25:223–232, October 2021. ISSN 2214367X. doi: 10.1016/j.tbs.2021.07.008. URL https://linkinghub.elsevier.com/retrieve/pii/S2214367X21000703.

Elona Pojani, Veronique Van Acker, and Dorina Pojani. Cars as a status symbol: Youth attitudes toward sustainable transport in a post-socialist city. *Transportation Research Part F: Traffic Psychology and Behaviour*, 58:210–227, October 2018. ISSN 1369-8478. doi: 10.1016/j.trf.2018.06.003. URL https://www.sciencedirect.com/science/article/pii/S1369847817302930.

Polish Central Statistical Office (GUS). Database of Polish Central Statistical Office (GUS). URL https://stat.gov.pl/.

Jan Prillwitz, Sylvia Harms, and Martin Lanzendorf. Impact of Life-Course Events on Car Ownership. *Transportation Research Record: Journal of the Transportation Research Board*, 1985 (1):71–77, January 2006. ISSN 0361-1981, 2169-4052. doi: 10.1177/0361198106198500108. URL http://journals.sagepub.com/doi/10.1177/0361198106198500108.

Lauren Redman, Margareta Friman, Tommy Gärling, and Terry Hartig. Quality attributes of public transport that attract car users: A research review. *Transport Policy*, 25:119–127, January 2013. ISSN 0967070X. doi: 10.1016/j.tranpol.2012.11.005. URL https://linkinghub.elsevier.com/retrieve/pii/S0967070X12001692.

Smart Ride. Jest już 94 tys. sharingowych e-hulajnóg w 161 miejscowościach w Polsce. Rowerów też przybyło, 2022. URL https://smartride.pl/jest-juz-94-tys-sharingowych-e-hulajnog-w-161-miejscowosciach-w-polsce-rowerow-tez-przybylo

Rafał Stachyra and Margarita Dylewska. Dostępność sieci tramwajowej w prawobrzeżnej Warszawie. In Małgorzata Budnik-Minierska, Urszula Strugała, and Kamil Roman, editors, *Wspolczesny swiat*, pages 29–48. ArchaeGraph Wydawnictwo Naukowe, Lodz, 2021. ISBN 978-83-66709-85-0. OCLC: 1325610337.

Anna Urbanek. Car-Oriented Mobility Culture from the Point of View of Polish Households' Expenditures. In Michał Suchanek, editor, *New Research Trends in Transport Sustainability and Innovation*, pages 3–14. Springer International Publishing, 2018. doi: 10.1007/978-3-319-74461-2_1. URL http://link.springer.com/10.1007/978-3-319-74461-2_1. Series Title: Springer Proceedings in Business and Economics.

Urząd Miasta st. Warszawa. Otwarte dane - czyli dane po warszawsku, 2015. URL https://api.um.warszawa.pl/.

Veturilo. Veturilo - Warszawski Rower Publiczny, 2022. URL https://veturilo.waw.pl/.

J. Wootton. Replacing the private car. *Transport Reviews*, 19(2), January 1999. ISSN 0144-1647, 1464-5327. doi: 10.1080/014416499295592. URL http://www.tandfonline.com/doi/abs/10.1080/014416499295592.

WTP. Parkingi, 2022a. URL https://www.wtp.waw.pl/parkingi/.

WTP. Rower miejski Veturilo, 2022b. URL https://www.wtp.waw.pl/rower-miejski-veturilo/.

Hongtai Yang, Guocong Zhai, Xiaohan Liu, Linchuan Yang, Yugang Liu, and Quan Yuan. Determinants of city-level private car ownership: Effect of vehicle regulation policies and the relative price. *Transport Policy*, 115:40–48, January 2022. ISSN 0967070X. doi: 10.1016/j.tranpol.2021.10.025. URL https://linkinghub.elsevier.com/retrieve/pii/S0967070X21003073.

ZTM. Raport Roczny ZTM 2021, 2021. URL https://www.ztm.waw.pl/wp-content/uploads/2022/05/Raport-Roczny-ZTM-za-rok-2021.pdf.

ZTM. Informator Statystyczny, 04.2022, April 2022. URL https://www.ztm.waw.pl/wp-content/uploads/2022/06/www_BIULETYN-KWIECIEN-2022.pdf.

7 Appendix

7.1 Data sources

Household Budget Survey[15] - The individual data comes from the annual Household Budget Survey conducted by Statistics Poland and covers households' outgoings, consumption and receipts, which allows for investigating the living standards of the Polish population. This report's analysis spans nine years, from 2010 to 2018, and incorporates weights for households provided by the Polish Central Statistical Office. Households falling into the top and bottom 1% of disposable income were removed from the sample. Observations lacking information on the number of bikes were also removed. Eventually, the sample consists of 308 635 households, approximately 35 000 per year.

Life in Transitions[16] - The individual data on citizens from central and eastern European countries undergoing regime transition from Soviet communism comprised three waves of data collection between 2006 and 2016. The surveys are coordinated by European Bank for Reconstruction and Development in cooperation with World Bank. The wave 3 database provides information characteristics, attitudes and behaviours of individuals from 51 thousand households located in 34 countries, including formerly communist countries and a few Western European ones (Cyprus, Italy, Germany, and Greece).

Central-European Survey - The individual panel data on citizens from central and Eastern European countries undergoing regime transition from Soviet communism comprised two waves of data collection: 2021 and 2022. The surveys are conducted by the University of Warsaw as a part of the Excellence Initiative Research University in Priority Research. Both waves of the database

[15] https://stat.gov.pl/badania-statystyczne/badania-ankietowe/badania-spoleczne/badanie-budzetow-gospodarstw-domowych-bbgd/.
[16] https://litsonline-ebrd.com/.

provide information on the characteristics, attitudes and behaviours of 11,383 individuals living in Austria, the Czech Republic, Germany, Slovakia, Hungary, and Poland.

Warsaw Transport Survey 2015 (WBR)[17] - The Survey was conducted in spring 2015 at a representative sample of 9000 households in all Warsaw districts, yielding a sample of 17000 individuals. The interviews took place face to face with trained interviewees, who asked questions related to the origins and destinations of travel, reasons for each travel (a so-called motivation), times and modes of transport for each travel as well as basic demographic characteristics (age and gender). The methodology of the survey and the questionnaire employed in WBR 2015 are consistent with precious transport surveys that took place in Warsaw in the past (previous one in 2005).

Sustainable Urban Mobility Plan (SUMP) Survey - The survey was conducted in spring 2022 as an element of SUMP for the Warsaw Metropolitan Area. It sampled almost 8000 individual respondents and concerned their travels to work or school (i.e. *obligatory* travel) due to limited willingness to travel during the ongoing COVID-10 pandemic at the time of the survey. It also provides information on the satisfaction with the transport infrastructure in respondents' neighbourhoods.

7.2 Methodological details

In the analysis of the private ownership and mobility services based on the Central-European Survey (Section 5), we estimate the following model:

$$Y_{i,c,t} = \beta_0 + \beta_1 X_{i,c,t} + \beta_2 Z_{i,c,t} + \epsilon_{i,c,t}$$

where $Y_{i,c,t}$ is the individual *i*'s living in country *c* outcome variable observed at time t; $X_{i,c,t}$ - an explanatory variable and $Z_{i,c,t}$ control variables, namely: age (in 2nd polynomial), gender, current education level, country of residence, and place of living (big city, suburbs of a big city, small town, countryside, outside of countryside). Robust standard errors are clustered by country. Ordinary Least Squares are applied for the sake of simplicity in the interpretation of results.

In testing hypothesis 1, the outcome variable is behaviour (ownership and use of mobility services), and the explanatory variables are pro-social attitudes (pro-social) or beliefs on the quality of private versus public goods. In the further analyses, we examine mechanisms underlying the attitude and the belief with two measures of communism effects in two separate estimations: firstly, a dummy equal to one if individuals lived under communism for at least 1 year and secondly, a dummy for living in the region that belonged to Soviet bloc.

We conduct the cross-section analysis using Ordinary Least Squares (OLS) as well as panel data analysis with Fixed Individual Effects (FE), if applicable.

[17] https://transport.um.warszawa.pl/-/wbr-2015.

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