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A COMPARATIVE RESEARCH OF URBAN MOBILITY IN POLAND AND GERMANY ON THE BEHAVIOR OF DIFFERENT GENERATIONS

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STRESZCZENIE

BADANIA PORÓWNAWCZE MOBILNOŚCI MIEJSKIEJ W POLSCE I NIEMCZECH NA TEMAT ZACHOWAŃ RÓŻNYCH POKOLEŃ

Rahman Fakhani

Wprowadzenie: Dla rozwoju zorientowanej na przyszłość, zrównoważonej mobilności miejskiej kluczowe jest nadanie priorytetu czynnikom społecznym i środowiskowym. Celem unijnego Zielonego Ładu jest osiągnięcie neutralności pod względem emisji CO_2 do 2050 roku. Szczególnie młode pokolenie może wnieść ogromny wkład w osiągnięcie tych celów poprzez odpowiednie zachowania w zakresie konsumpcji i mobilności. Pole badawcze zachowań transportowych zostało już obszernie zbadane w literaturze. Nie ma jednak wystarczającej ilości badań nad zachowaniami związanymi z mobilnością miejską różnych pokoleń, zarówno akademickich, jak i praktycznych, zwłaszcza w połączeniu z porównaniem międzymiastowym pomiędzy różnymi krajami. *Cel:* Niniejsze opracowanie bada zachowania mobilne różnych pokoleń w ramach badań porównawczych pomiędzy Warszawą a Berlinem. Celem jest zidentyfikowanie podobieństw, ale także różnic wraz z leżącymi u ich podstaw postawami behawioralnymi, aby zapewnić podstawę dla przyszłych działań na poziomie mikro- i makroekonomicznym w celu rozwoju zorientowanej na przyszłość mobilności miejskiej w kierunku zrównoważonego rozwoju, osadzonej w holistycznej koncepcji smart city. ***Metodologia:*** Oprócz przeglądu literatury, przeprowadzono badanie ankietowe, aby uzyskać nowe spostrzeżenia z pogłębionej analizy danych. W odniesieniu do wybranych pokoleń uwzględniono uczestników badania w wieku od 18 do 56 lat. Na podstawie wstępnej analizy czynnikowej przeprowadza się analizę wielomianowej regresji logistycznej oraz testy istotności wraz z określeniem wielkości efektów. ***Wyniki:*** Można zauważyć, że Berlin jest bardziej zaawansowany niż Warszawa w rozwoju zrównoważonej mobilności. Hipoteza, że młodsze pokolenia również zwracają większą uwagę na zrównoważony rozwój w obszarze mobilności, a także częściej korzystają z alternatyw dla samochodu, została potwierdzona jedynie w przypadku Berlina. Ponadto, choć samochód jest symbolem statusu raczej Warszawie niż w Berlinie, nie udało się zidentyfikować w badaniu ogólnego trendu utraty znaczenia przez samochód. Jednakże silne dążenie do zrównoważonego planowania miejskiego i ekspansji transportu publicznego w przyszłości może być traktowane jako wskaźnik, że udział właścicieli samochodów mógłby spaść, gdyby dostępne były również wystarczające alternatywne oferty mobilności w różnych dziedzinach życia. Ogólnie rzecz biorąc, badanie pokazuje, że proces transformacji zrównoważonej mobilności jest wciąż na dość wczesnym etapie rozwoju. ***Wkład teoretyczny i praktyczny:*** Na podstawie zebranych danych z ustrukturyzowanej ankiety uzyskano nowe spostrzeżenia na temat zachowań mobilnościowych różnych pokoleń w Warszawie i Berlinie. Wyniki tego badania mogą być wykorzystane do stworzenia zachęt do zrównoważonych zachowań mobilnościowych, a tym samym znacząco przyczynić się do czystej, bezpiecznej i zdrowej mobilności miejskiej. Koncepcja zrównoważonej mobilności powinna również zostać włączona do strategii inteligentnego miasta i w ten sposób umożliwić podniesienie jakości życia wszystkich mieszkańców.

Słowa kluczowe*: zachowania społeczne i ekonomiczne, zrównoważona mobilność miejska, codzienne dojazdy do pracy, zachowania komunikacyjne różnych pokoleń; smart city*

ABSTRACT

A COMPARATIVE RESEARCH OF URBAN MOBILITY IN POLAND AND GERMANY ON THE BEHAVIOR OF DIFFERENT GENERATIONS

Rahman Fakhani

Background: For the development of future-oriented, sustainable urban mobility, it is crucial to give priority to social and environmental factors. The EU Green Deal aims to achieve CO_2 neutrality by 2050. The young generation in particular can make an enormous contribution in achieving these goals through appropriate consumption and mobility behavior. The research field of transport behavior has already been extensively studied in the literature. However, there is not enough research in the area of urban mobility behavior with regard to different generations, both in science and in practical implementation, especially in combination with an inter-city comparison between different countries. ***Purpose***: This study investigates the mobility behavior of the different generations within a comparative research between Warsaw and Berlin. The aim is to identify similarities but also differences together with underlying behavior attitudes to provide a basis for future measures on a micro- and macroeconomic level to develop a future-oriented urban mobility towards sustainability embedded into a holistic smart city concept. ***Methodology***: Besides literature research, a survey was conducted to obtain new insights from an in-depth data analysis. With reference to the selected generations, survey participants aged 18 to 56 are considered. Based on a preliminary factor analysis, a multi-nominal logistic regression analysis and significance tests together with the determination of effect sizes are executed. ***Results***: It can be seen that Berlin is already further ahead than Warsaw in the development of sustainable mobility. The hypothesis that younger generations also pay more attention to sustainability in the area of mobility and also use alternatives to the car more often was only confirmed for Berlin. In addition, although the car as a status symbol is much more pronounced in Warsaw than in Berlin, a general trend that the car is losing importance could not be identified in the study. However, the strong desire for sustainable urban planning and the expansion of public transport in the future can be taken as an indicator that the share of car owners could fall if sufficient alternative mobility offers were also available for various areas of life. Overall, the study shows that the process of sustainable mobility transformation is still quite in its early stages. ***The theoretical and practical contribution***: Based on data collection from a structured survey, new insights were gained on mobility behavior of different generations in Warsaw and Berlin. The results of this study can be used to create incentives for sustainable mobility behavior and thus make a significant contribution to clean, safe and healthy urban mobility. A sustainable mobility concept should also be embedded in the smart city strategy and thus enable an increased quality of life for all residents.

Keywords: *social and economic behavior, sustainable urban mobility, daily commute, mobility behavior of different generations; smart city*

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LIST OF PUBLICATIONS

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INTRODUCTION

Contemporary cities are often characterized by a hectic pace causing problems, such as growing traffic jams, an increased burden on air quality and more stress in daily life, which negatively affects the mental and physical health constitution of urban residents (Brazier, 2016; Matz et al., 2019; Salvi & Salim, 2019), and also leads to increased mortality (Künzli et al., 2000; Levy et al., 2010). Urban infrastructure and public services in particular are being put under unprecedented strain. By 2050, the world's population is predicted to grow to 9.7 billion people (United Nations, 2019b) and dozens of megacities will grow beyond ten million inhabitants, which will reshape the way in which cities are built and thus also impact citizens' lifestyles. In addition, population growth will further exacerbate climate change (Lam & Head, 2011). The rapid urbanization and the growing expectations of increasingly urban citizens are making the already tense situation even worse, especially when the quality and quantity of measures implemented in practice are insufficient.

To address these problems and to develop a city for the future, the greatest challenge is to focus on sustainability while at the same time maintaining or even improving competitiveness, for example in terms of attracting young and well-educated urban dwellers, businesses and tourists. This requires not only technical innovation, but also a breaking down of established behavioral patterns in order to develop them in the direction of greater sustainability. Since, as in all processes, people can be the problem, but also the solution, it is important that, above all, citizens are involved in the urban development processes. As an elementary basis for this, a livable city is required that serves as a foundation for the social interactions of its citizens. This also includes a well-developed urban mobility as one of the core elements of a well-functioning, networked and vibrant city.

So far, the field of smart city and urban mobility has already been intensively researched in literature from various perspectives. There is a lot of literature with respect to the introduction and critical evaluation of various smart city examples (Ho et al., 2013; Moser et al., 2015; Nuruzzaman, 2018; Saiu, 2017; Zhan & de Jong, 2017), comparisons between different smart cities (K. H. Cheng & Cheah, 2020; D'ascenzo et al., 2019; Fernández-Vázquez & López-Forniés, 2017; Lai et al., 2020; Shamsuzzoha et al., 2021), as well as studies on different areas of the smart city such as smart governance (Pereira et al., 2018; Tomor et al., 2019), smart mobility (Bıyık et al., 2021; Lyons, 2018; Ul-Haq et al., 2013), smart environment (Rachmawati & Pertiwi, 2017) and smart energy (Esmaeilian et al., 2018) and smart living (Kumar, 2020).

Furthermore, in the scientific field of urban mobility, studies have been conducted from a macroeconomic perspective (Banister & Berechman, 2001), the technical perspective (Luque-Vega et al., 2020; Paiva et al., 2021; Satoh & Lan, 2007; B. Singh & Gupta, 2015), with reference to specific areas such as electro-mobility (Ayodele & Mustapa, 2020; C. E. Thomas, 2009) and non-motorized transport (Marshall, 2012; Roşca et al., 2010), or with a focus on the analysis of innovative mobility concepts such as Mobility-as-a-Service (Kamargianni & Matyas, 2017).

So far, the field of behavioral economics has analyzed various personal behavior patterns related to the use of different modes of transportation, but mostly specifically related to certain social groups (Lehtonen et al., 2016; B. Sharma et al., 2019; Zaidi et al., 2017). Other studies also examine reasons and framework conditions that lead to the decision to use a mode of transport and thus have an impact on the modal split (Lopez-Carreiro & Monzon, 2018; Nguyen & Schumann, 2021; Villwock-Witte & Clouser, 2016). Finally, a few studies on mobility behavior have been conducted with reference to specific generations (Suchanek & Szmelter-Jarosz, 2019; Szmelter, 2019) as well as with reference to specific means of transport (Azimi et al., 2021; Cubells et al., 2020).

It can be stated that in the area of possible different mobility behavior patterns between generations, especially in a cross-national context, so far there has been no specific research conducted, neither in the scientific context nor in practical implementation. This scientific work closes the gap by examining the respective capitals of Poland and Germany, Warsaw and Berlin, and analyzing the differences and similarities between the generations within the two cities. In addition, behavioral theories have often been applied in the field of marketing, looking at which products and services can create the greatest possible appeal to customers in order to maximize sales and profits. This research, however, aims to do this with a new perspective and a focus on environmental and social issues.

Both countries under consideration have experienced different external power influences in their respective histories. The inner-European border between Eastern and Western Europe shifted further east from East and West Germany with the Oder-Neisse border after German reunification in 1990. Despite a variety of influences, even after Poland's accession to the EU in 2004 until today, the respective influences from the West (primarily Western Allies) on Germany and on Poland from the East (primarily former Soviet Union) show different developments in the area of economic performance as well as urban development. Still today, those historical events and correlated deep-rooted socio-cultural

behavior are affecting politics as well as mobility patterns. Different historical developments can also be recognized in the maturity of the transport infrastructure.

While in the West the car was already widely established before the fall of the Berlin Wall due to its free market economy and increased prosperity, it is especially evident for the Eastern European countries, including Poland, that the end of the Cold War led to an enormous need to catch up demand for the purchase of one's own car and the personal freedom of movement associated with among man (Berri, 2009; Komornicki, 2003). The strong bond to the own car, which emerged at that time, is still evident in Poland today, as the car is mostly preferred over other means of transport in Poland. In the meantime, however, there are various approaches to transfer know-how from already more developed smart cities to still "learning cities" in order to establish new ways of mobility, taking into account the different framework conditions (Stead et al., 2010). In addition, there are cross-country initiatives that, for example, advance public transport infrastructure (Zilllmer et al., 2021).

Ultimately, however, it is the citizens with their often historically evolved behavior patterns who play an essential role in determining the extent to which they are willing to change their consumption in the long term. Whether the increasing challenges, especially in cities, can be mastered in the future depends decisively on how today's urban planning is aligned and how the younger generations shape the mobility of tomorrow. The most cities worldwide, but also in Europe, are still far from offering sustainable and thus environmentally and socially just mobility. This is demonstrated above all by increasingly congested roads and the associated increase in air and noise emissions.

Therefore, the research objective of this thesis is to investigate the mobility behavior between Generation X (Gen X), Generation Y (Gen Y) and Generation Z (Gen Z) and to identify commonalities, but also differences, as well as underlying behaviors. Within the overall context, the aim is to achieve meaningful results by identifying trends and opportunities for future-oriented and sustainable mobility. For this purpose, the two countries Poland and Germany and in particular Warsaw and Berlin as the respective capitals are analyzed. Based on the overall objective, the following main research questions arise:

(1) What are the main factors influencing mobility behavior in daily commuting?
(2) What is the living situation and how satisfied are the citizens with respect to the living environment?
(3) What are the differences and trends in mobility behavior between the two cities in general?

(4) What are the general differences and trends in mobility behavior between the generations?
(5) What are the differences and trends in mobility behavior between the different generations within both cities of Warsaw and Berlin?
(6) What are the differences and trends in the mobility behavior of the respective generations in a direct comparison between Warsaw and Berlin?
(7) How do the trends in mobility behavior of different generations affect future planning for sustainable transportation infrastructure?

The literature review in the first three chapters provide the framework for exploring the research questions and, based on the results obtained in this thesis, lay the foundation for other possible research topics in the future.

The main research hypotheses are the following:

Table 1: Hypotheses for the comparative research of urban mobility behavior

	Hypotheses
H1	In Berlin, sustainable modes of transport are more developed than in Warsaw, which means that they are also used more frequently in comparison.
H2	There is a trend that younger generations have a more environmentally conscious lifestyle and thus exhibit more sustainable mobility behaviors.
H3	The younger the generation, the more likely it is to use alternative modes of transport to the car, such as bicycles or mobility sharing offerings.
H4	There is a general trend among all generations of a high willingness to use more sustainable transport modes if a sufficient mobility offering is provided.

Source: own illustration

Within the thesis, established models from consumer research are presented, which are then analyzed with reference to urban mobility. To provide the basis for generational comparison, they are considered in the scientific context as well as in relation to practical application in terms of urban life and urban mobility.

Research Design: The research design is founded on a qualitative and quantitative study. To test the hypotheses and answer the research questions, the data collected with the survey is analyzed with reference to the target groups. The data collection process uses a computer-based (online) survey. After data cleaning, depending on the type of question and the type of data obtained, the data is processed accordingly and analyzed using suitable statistical methods.

Size and characteristics of the sample: The target group consists of the Gen X, Gen Y and Gen Z representatives within Warsaw and Berlin. After considering all exclusion criteria, the final sample size consists of 537 participants and thus analyzable data sets, consisting of 246 participants in Warsaw and 291 in Berlin. Of these, the gender distribution in Berlin (male = 52%, female = 48%) deviates only slightly from the actual population distribution (male = 50%, female = 50%). In Warsaw, a greater deviation is discernible. Here, the sample is 63% male (population = 48%) and 37% female (population = 52%). The distribution of the generations shows the opposite picture. While the samples of Gen X, Gen Y and Gen Z in Warsaw show only minor deviations from the total population (max. ± 6%), the deviation in Berlin is considerably higher (max. ± 22%). To ensure the best possible representativeness in the case of gender distribution as well as generations, the sample is weighted accordingly on the basis of actual population figures.

Statistical methodology approach: The statistical analysis is performed on the basis of the final data set. The selection of the applied statistical methods allows to answer the previously established research questions in the best possible way. To reduce the dimensions of the different variables with identification of interrelated patterns, a preliminary exploratory factor analysis is used for all questions with a 5-point Likert scale to group different interdependent variables. A multinomial logistic regression model is applied to analyze the factors influencing the transport mode choice of daily commuting, since more than two transport categories are distinguished. For the comparison of cities and generations, dependency analyses such as the Pearson Chi² test and the one-factor analysis of variance (ANOVA) are used to examine correlations and differences. The determination of the effect strength and thus the degree of the influence factor of certain variables on decision-making is carried out either with Cramer's V or eta, depending on the variable or scale type. Along with the evaluation steps to answer the questions posed, various elements of descriptive statistics are used, which has the advantage of a better visualization of the results.

The thesis is divided into five chapters. Chapters 1.-3. consist of three subchapters each, chapter 4 consists of five subchapters whereas the last chapter 5 consists of four subchapters. The first chapter focuses on the literature review and puts urban mobility into the overall context of a smart city with respect to sustainable development, thus constituting the first part of the theoretical basis. Thereby, in the first section the foundation is laid with the framework condition and definition of the so-defined Sustainable Smart City with its most important aspects and the basic conceptual approach. Furthermore, the various smart city areas are

introduced by showing how they affect the daily lives of all citizens in urban areas. In addition, the essential elements and concepts of urban mobility in the light of worldwide smart city developments are illustrated. The second section of this chapter then defines how sustainable transportation is defined in literature, followed by the investigation of key figures, and main challenges with respect to urban transportation. Since sustainable urban planning has a significant impact on daily commute behavior, essential concepts are shown, followed by a critical view on current policies in the light of sustainability at the end of the section. The third part of this chapter first describes the most important elements necessary for urban mobility from an environmental perspective. This is followed by an outline of current trends in the area of mobility. Then the concept of Mobility-as-a-Service (MaaS) is explained and how the different means of transport can be linked with the integration of technology. The focus is placed on the use of transport modes in the context of a shared economy. Finally, an efficient political framework for the development towards a future-oriented mobility plays an essential role, which is why the concept of Sustainable Urban Mobility Planning (SUMP) with its core elements is explained.

Chapter 2 offers a theoretical approach to the irrationality of transport behavior by first explaining classical and modern consumer theories. From the field of behavioral economics, the foundations are laid to bridge the gap between the psychological underpinnings of human action and economic facts. Behavioral theories, consumer behavior patterns, and decision-making models underlie the decision processes by consumers, provide some clarity on how consumers act, and thus influence the choice of transport mode. The origin of all economic and social behavior has been studied by the traditional economic theories of thought, such as Adam Smith and Alfred Marshall, and is the foundation for the classical theories of behavior such as the Veblenian social-psychological model and the Freudian psychoanalytical model. Later developed models of consumer behavior such as the Howard-Sheth model and the Engel-Blackwell-Miniard model emerged later (from the 1970s and 1980s) and are referred to in this paper as modern models of consumer behavior. Since many modern decision-making models are strongly free market oriented, most focus on consumer influence to increase sales and maximize profit margins, which can be derived from neoclassical theories. Therefore, these theories and models are placed in the overall context of transport behavior with respect to a sustainable and modern urban mobility. Thus, these insights into human behavior form an essential basis for the main section when it comes to analyzing transportation decisions and related issues in the context of a smart and sustainable development of urban areas.

Chapter 3 rounds up the literature review by investigating the transport patterns of different generations. After defining the generations in the first part, essential differences in behavioral patterns between them and trends in the light of mobility are explained. Therewith, besides conducting a comparison of the attitude towards car ownership, the different transport mode choices of the generations and which underlying main reasons are investigated. The third subchapter presents typical characteristics of urban lifestyles in contrast to rural lifestyles and other influencing factors such as socio-demographics. Finally, it is indicated how different urban architectures and planning design can have an impact on urban mobility and transport mode choice.

Chapter 4 of this study provides the basis for the data analysis of the data obtained from the survey. First, essential information and key figures on urban are shown regarding mobility in the two considered countries Poland and Germany with their capitals Warsaw and Berlin. This includes describing the characteristics of urban life in each of the two cities, such as the general economic conditions and the general quality of life. In addition, previous developments in the field of smart cities and in the context of urban mobility are outlined. The research design is then described in detail. This includes an explanation of the process of developing the questionnaire design and the procedure for conducting the survey with the target group. The findings from the pre-test and how these were used in the finalization of the questionnaire are also shown. Furthermore, the structure with reference to the original survey questionnaire (Appendix B: Questionnaire) is shown. The next step presents the data cleaning process and the obtained sample, which serves as the basis for the data analysis. Finally, the applied statistical methods are described, which are used in the further course to answer the research questions.

Chapter 5 presents the results of the statistical evaluation based on the established research design and procedure model, so that the research questions defined in the introduction can be answered and the established hypotheses can be verified. In doing so, two different research models are used for the analysis of the generation related to daily commuting and related to urban living and transport behavior. In addition, a preliminary factor analysis is conducted, the results of which are taken into account in the further process of the evaluation. In the second part, the two cities of Warsaw and Berlin are first compared on the basis of personal living situations. This includes daily commuting distance and travel time, satisfaction with the living environment as well as urban mobility, but also expectations for future developments. In addition, various personality traits are compared based on questions in the areas of professional life and career / education, daily life and social environment, and use of

technology in everyday life. The subsequent focus on urban mobility initially includes the basic own mobility resources (e.g., own car and monthly ticket for public transport) as well as underlying reasons for the choice of transport. In the further course of the study, the perceived comfort of car drivers and the use of sharing services are evaluated. After a sound basis has been created with the comparison of the cities, the generations are compared according to the following procedure: (1) Investigation of generational differences with respect to the total sample, (2) Investigation of differences between generations within Berlin and within Warsaw, (3) Investigation of differences between the cities according to the individual generations (Gen X, Gen Y, and Gen Z). It should be emphasized that statistical significance is determined for the similarities and differences between the generations, and the effect strength is determined for the power of the significance.

CHAPTER 1
URBAN MOBILITY IN A SMART CITY IN THE LIGHT OF SUSTAINABLE DEVELOPMENT PARADIGM

1.1 Smart Cities in the Light of Sustainable Development Paradigm

General Framework Conditions from an Environmental Perspective

Today, 55% of the world's population lives in cities, and by 2050 this is estimated to grow to more than two-thirds, compared to just 30% in 1950 (United Nations, 2018). The OECD countries[1], based on World Bank figures, even show an increase in the degree of urbanization from 62.5% in 1960 to 80.6% in 2018 (The World Bank, 2018b). Furthermore, by 2050 this rate is expected to reach 86%. When comparing these numbers, a year-by-year trend of movement from rural areas to cities can be recognized.

If the entire world population is considered, it shows that since 2007 there have been more people living in urban areas than in the rural areas. At the same time global carbon dioxide emissions have been rising steadily since 1960 but at a much slower rate since 2011 (development global rural / urban population and CO_2 emission see Figure 1).

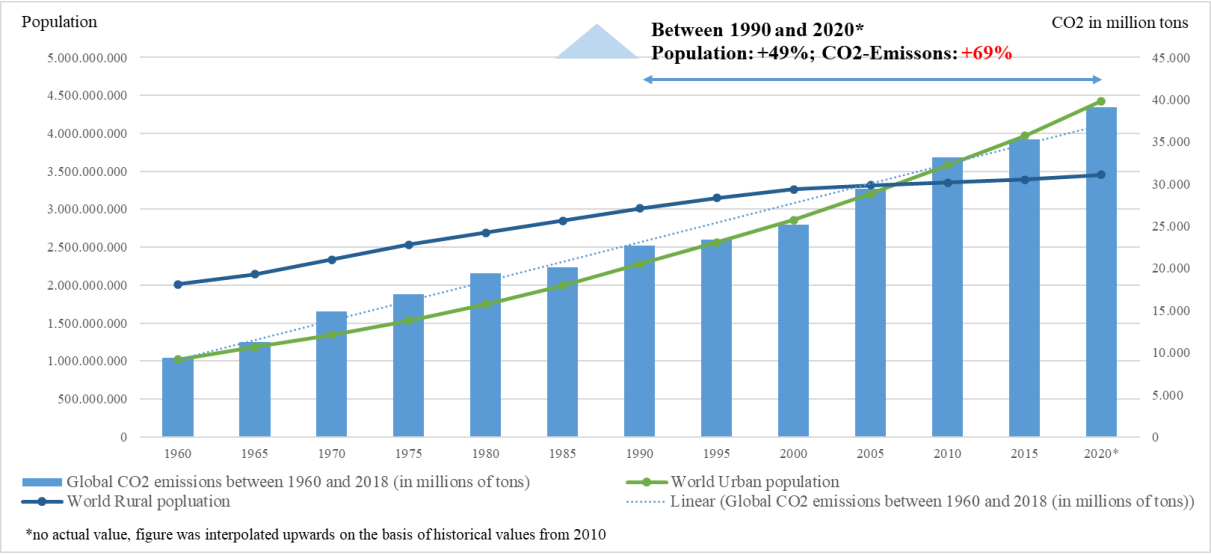


Figure 1: Development of urbanization worldwide between 1960 and 2017

Source: Own illustration based on Global Carbon Project (2020); The World Bank (2000)

[1] OECD = Organization for Economic Co-operation and Development, 35 Member countries in Europe, Americas, Pacific in addition to Israel and Turkey, those nations are committed to accept the principle of a free economy.

A look at the statistics shows a worldwide greenhouse gas emission of approximately 39.1 billion tons of CO_2-equivalent in 2020. According to a forecast, this will increase further to 43.1 billion tons by 2050. In comparison, in 1990 it was 22.7 billion tons, and in 2018 it was over 61% higher compared to 1990 (Global Carbon Project, 2019). The EU is emitting 4,483 million tons or 12.5% of global CO_2 emissions (European Commission, 2019c).

Regarding the degree of urbanization, an analysis of the EU reveals a basically similar trend compared to the OECD countries. Nevertheless, the growth rate of the urban population in the EU is far less significant (OECD: increase between 1960 to 2017 of 211%[2] compared to 54%[3] in the EU).

Observing the development since 1990, the EU has significantly reduced CO_2 emissions with a decrease of 24%[4], while increasing its overall population by 7.2%. However, CO_2 emissions of the strong emerging economies, especially China and India, have been increasing tremendously.[5] Globally, between 1990 and 2017 the population increased by 42% and the CO_2 emissions by 61% (cf. Figure 1). This trend poses a great threat for humankind in terms of air pollution and global warming[6].

If the development continues, it could have profound negative effects for urban areas such as more noise, congestion, and pollution, which is leading to negative impacts to the health condition of the citizens. Especially urban areas are subject to increasing deterioration in air quality as they regularly exceed WHO limits (WHO, 2020). Urban areas account for 60−80% of the global energy use (Johansson, T. B., Patwardhan, A. P., Nakićenović, 2012) and 71−76% of energy-related CO_2 emissions (Intergovernmental Panel on Climate Change, 2014)[7]. The 100 urban areas with the highest carbon footprint are responsible for 18% of global emissions, while they account only for 11% of the world population (Moran et al., 2018). At the same time, however, it should be noted that cities are also mostly the center of manufacturing industry, and

[2] OECD – 1960: 494.753.830, 2017: 1.045.805.422; Source: retrieved April 15, 2020, from https://datacatalog.worldbank.org/dataset/world-development-indicators
[3] EU – 1960: 250.647.832, 2017: 386642104; retrieved April 15, 2020, from https://datacatalog.worldbank.org/dataset/world-development-indicators
[4] The EU is setting an example in this respect, having already saved 24% of CO_2 emissions in 2017 compared to 1990 on the basis of the Kyoto Protocol's targets, thus exceeding the 20% CO_2 emission reduction 3 years earlier; retrieved April 15, 2020, from https://ec.europa.eu/clima/news/articles/news_2013100901_en
[5] Between 1990 and 2018, India's CO_2 emissions increased by 430%, China's by 416% and the United States by 5.8%; cf. Global Carbon Project, December 2019, retrieved April 15, 2020, from globalcarbonatlas.org
[6] The man-made ("anthropogenic") greenhouse effect describes, among other things, the high carbon dioxide content in the Earth's atmosphere, which limits the escape of heat radiated from the Earth into space. This results in an increase in temperature on Earth. Global warming in turn affects the environment (e. g. biodiversity, sea level, weather) as well as the economy and society (e. g. agriculture, energy supply, environmental migration).
[7] The IPCC in currently working on the Sixth Assessment Cycle and will publish the report in 2021; retrieved April 16, 2020, from https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/

many workers commute to work from the surrounding area and thus smaller cities and communities.

The challenge in contemporary cities is to achieve the energy transition to a Sustainable Smart City (SSC) and at the same time to secure prosperity and support the socially disadvantaged inhabitants so that they can lead a dignified life. Simultaneously, CO_2 emissions and environmental pollution (NOx) must be reduced. Furthermore, strains coming from demographic developments and increasing urbanization must be tackled.

Looking at global policy, there is an increasing focus on the environment and sustainability. Numerous regulations and programs are being introduced in this regard. The UN Environment Programme (UNEP) is integrating the environment into cities' long-term strategic planning, focusing on buildings and infrastructure, transport, air pollution, waste and water management, biodiversity, and ecosystems (United Nations, 2020b). Moving toward a more Sustainable Smart City can foster at least some of the 17 Sustainable Development Goals for the world set by the UN for sustainable development in the world, like waste reduction and avoidance of plastic to keep the oceans clean (smart waste), good health (smart health), educate children (smart education), clean water and affordable energy (smart energy and smart infrastructure), jobs for the youth (smart work), protection of the environment (smart environment) and the objectives of sustainable cities and communities itself (United Nations, 2015).

Definition and Conceptional Approach of a Sustainable Smart City (SSC)

There are five phases of urban sustainability development in recent decades, beginning with (1) the globalization of environmental problems and sustainable development in the 1980s, (2) urbanization, (3) sustainable urban development and cities, (4) the era of information and communication technologies and (5) the concept of the smart city (Höjer & Wangel, 2014).

Even though there are many explanations for the term "smart city" in the literature and in practice, there is no consensus on the definition. Some authors focus more on the technological aspect (Bakici et al., 2013; Harrison et al., 2010; Marsal-Llacuna et al., 2015; Velosa, 2013) and some on the impact on economic factors (Cretu, 2012; Kourtit et al., 2012; Zygiaris, 2013). Even though an increasing tendency towards ecological aspects can be observed in literature, social aspects tend to be given secondary consideration. In practical implementation, this is even more evident in a still existing dominant consideration of economic factors. However, some authors stress that such factors are of crucial importance for the

development of a smart city (Caragliu et al., 2011; Romão et al., 2018; Thuzar, 2011). The ICLEI (ICLEI, 2021), an international organization of national and regional local government organizations committed to sustainable development, is also emphasizing the importance to "critically evaluate the impact of technology solutions and ensure that the interests of their citizens are at the core of ongoing smart cities discussion". Finally, a more overall perspective is taken by some authors, which takes into account both social and economic factors (Giffinger, 2007; Kourtit et al., 2012).

Moreover, the question of whether a city is really "smart" from a subjective point of view might be answered differently. A smart city can be understood as a collective term for development concepts in which the processes of a city or community are improved with the application of innovative technologies, thus achieving increased efficiency and sustainability. In the majority, the basic motives for making a city smarter are: (1) to master the challenge of increased urbanization and to counteract increased environmental harm, (2) to make maximum use of technological potential and thereby make processes as effective and sustainable as possible and (3) to provide a high quality of life for all social classes and thus increase the competitiveness of the city in general and also the local economy. Building a smart city often involves combining endeavors of different sectors and merging them into one big whole. Approaches to achieving the goal of smart cities are based on economic, social, institutional, and physical aspects. The underlying objective is to achieve the betterment of the quality of life and thus increase the prosperity of citizens, based on a continuous improvement in infrastructure, environment, technology, leadership, as well as continuous learning (Giridhar Kamath et al., 2019; Schipper & Silvius, 2018). It is therefore crucial to create an infrastructure that enables the smoothest possible interaction between man and machine using information and communication technology (ICT) (Cesana & Redondi, 2017). Furthermore, a smart city gathers data using electronic methods and sensors to provide services and, in the end, solve problems (Mondschein et al., 2021).

A "sustainable city" defined in this way (Allen, 2009; Pollalis, 2016; Satterthwaite, 2017) or "smart city" (Albino et al., 2015; Allwinkle & Cruickshank, 2011), is characterized by the fact that the social, environmental, but also economic dimensions are considered in mutual harmony as far as possible. These are explicit targets for ecological sustainability, such as emitting as little CO_2 and other pollutants as possible, as well as addressing the needs of the current residents and giving future generations equal opportunities, while making the best possible use of ICT (Höjer & Wangel, 2014). From an ecological point of view, this means

above all that the current generation should not claim more resources than can be restored at the same time. According to the UN, in 2050 the global population could require the equivalent of almost three planets to provide the natural resources needed to sustain current lifestyles (European Commission, 2019b; United Nations Climate Change, 2015). The literature review shows that there are different perceptions of how to approach environmental threats, for example by focusing on increased knowledge investment in renewable energy by government policies and by exploring how to reconcile economic growth and a cleaner environment (Silva et al., 2013).

Areas of a Sustainable Smart City and its Key Elements

A Sustainable Smart City (SSC) requires an orchestration of people, processes, city departments, public and private organizations, as well as policies that work together across the smart city ecosystem based on an optimum utilization of technology. This starts with how energy is generated (smart energy), the way people move around (smart mobility), how urban waste is disposed and recycled (smart waste), and how to find a sustainable and comfortable way of living (smart living). An essential element of a smart and participatory society is how citizens are empowered to participate in the democratic process, with a particular focus on smart governance (Kumar, 2020). In conjunction with the competitiveness of an urban area the smart economy aims to provide an environment that makes it attractive to launch companies in the city, so that the incomes of citizens, tax revenue and buying power increases.

In a broader sense, future-oriented smart urban concepts are supplemented by the areas of smart work ("future way of work") and smart education, which is more important than ever, especially after the Covid-19 pandemic situation (Antonacopoulou & Georgiadou, 2021; Bentley et al., 2021; Pokhrel & Chhetri, 2021; Rudolph et al., 2021). The discipline of smart environment also plays a superordinate role in the future redesign of urban living spaces (Rachmawati & Pertiwi, 2017). The individual elements and their interaction with each other have a significant impact on the overall effectiveness and success of an SSC. Increasing innovations introduced into urban city concepts by the latest technological developments are of limited use when considered in isolation. They must also be socially accepted by citizens and, ideally, make a positive contribution to enhancing the quality of life. At the same time, this should take place in harmony with nature. In addition, for the sustainable development of a smart city it is crucial to create an efficient financial framework (Akhmetov et al., 2019; Nesticò & De Mare, 2018). It is important that the state, and ultimately the various levels of government, cities, and municipalities, provide adequate public services and conditions, which is what smart

government is supposed to provide (Anthopoulos & Reddick, 2016). By providing e-government services among the European countries, it can be beneficial for all citizens, but nevertheless access has to be provided not just for the young and more tech-savvy people, but also those with low access to the internet (Lytras & Şerban, 2020). A viable concept must encompass sustainable success factors that are supported by all those involved. The necessity for an efficient interaction between society (inhabitants/citizens), politics, economy, science, and administration (reduction of bureaucracy) means a high degree of complexity, which must be managed.

In principle, concepts can be implemented at the micro and macro levels, depending on their characteristics. Regarding the environment, for example, planting in existing buildings or in public places has a micro-level effect. At the macro level, entire urban landscape concepts can be implemented, such as the complete creation of a new urban park (green spaces) or the creation of an artificial lake and entire building complexes. Examples for macro-level projects are Gardens by the Bay in Singapore (Bellew et al., 2015), the Hanging Gardens in Sydney (Inhabitat, 2017) or the Liuzhou Forest City in China (Xia et al., 2016).

In the relevant literature, different SSC areas are explained with their respective characteristics. For a better picture, the following SSC areas crystallize with their definitions:

(1) Smart living: Maximizing a comfortable and sustainable living of the citizens within the community (Nikki Han & Kim, 2021). In addition, there are interdependencies with the area of health care, for instance with tele-medicine (smart health), social cohesion (smart education & smart society) and educational opportunities (smart education).

(2) Smart health (e-health): Providing 360-degree health care from birth to old age, for instance by providing primary, secondary, and tertiary preventive health care measures, as well as early diagnosis of diseases, thus enabling personalized treatment strategies also based on big data analytics (Chan et al., 2009; L. Liu et al., 2016; Pramanik et al., 2017; Solanas et al., 2014). Other applications are e-ambulance and assisted living smart home systems, where telemetric systems can be used to examine patients, also focusing on elderly people, remotely to maintain their well-being (Almadani et al., 2015a; F. Chen et al., 2020).

(3) Smart education and smart society: Providing interactive technology-enhanced learning throughout the whole lifetime and in accordance with person`s particular individual needs and capabilities (Csikszentmihalyi, 2014; Uskov et al., 2018; Zhu et al., 2016). This is considered systemically relevant at least since the COVID-19 pandemic, it has an enormous importance especially for the younger generation with the interactive personal interaction

with the teacher, and a technology-supported possibility of home schooling (Hung & Wati, 2020; Picciano, 2017). In addition, augmented reality (AR) for smart learning is gaining increasing attention (P. Chen et al., 2017). The focus should be on the human, the so-called smart citizen or on the intelligent citizen (Oliveira & Campolargo, 2015), which is also strongly related to the smart city area of smart governance and thus the creation of a smart society.

(4) Smart work ("new ways of working"): Is characterized by technological change, such as the application of artificial intelligence (Wisskirchen et al., 2017), and by changing behavioral patterns of the younger generations. In addition, it takes into account the possibility for white-collar workers to interactively perform their daily job duties and responsibilities from anywhere, at any time, based on the potential of technology and highspeed internet (Demerouti et al., 2014).

(5) Smart mobility: Enabling an environmentally friendly, efficient, fast, and cost-effective way of transporting people and goods from their place of origin to their destination, while avoiding traffic (Lyons, 2018). The aim of smart mobility is to develop and provide a multi-modal, multi-operator urban transport infrastructure and thus to support sustainable economic growth and competitiveness. Citizens should have access to different modes of transport where the technology is integrated into the transport system.

(6) Smart energy & smart infrastructure: Providing sustainable and efficient energy generation, storage, and distribution combined with optimizing consumption management supported by technology (Ejaz et al., 2017; H. Lund et al., 2017). In this discipline, smart waste is also crucial to achieve the maximum degree of recycling (Esmaeilian et al., 2018). In addition, the development of a good charging infrastructure is a basic prerequisite for successful e-mobility in practice (Ul-Haq et al., 2013).

(7) Smart governance and smart government: Enabling digital and non-discriminatory access to citizen services, thereby strengthening democracy (Pereira et al., 2018). In addition, the transparency of politics and a well-developed opportunity for direct citizen participation in decision-making processes represent an essential strengthening of democracy. Thus, the "smart citizen" should be in the focus (Hemment, Drew; Townsend, 2013).

(8) Smart Economy: A smart economy offers the chance to develop a sustainable high-performance economy and thus increase the competitiveness of a city (Bazzoun, 2019; Vinod Kumar & Dahiya, 2017). Related to a smart economy is the smart factory and building up an Industry 4.0 with the use of sensor technology (IoT), which describes comprehensive concepts of how entire industrial companies as well as branches of industry can align

themselves in a future-oriented way (B. Chen et al., 2017; Shi et al., 2020). The focus lies on machine-to-machine communication and the inclusion of artificial intelligence, which makes it possible for production lines to run completely independently without human intervention and to improve them independently.

An SSC has the ultimate challenge of designing the processes and procedures with all its areas simultaneously being human and environment-centric, by taking into account limited resources. Table 2 lists the different elements with examples that lead to a smart environment with a decreased ecological footprint of a city.

Table 2: SSC measures for improving environmental, social, and economic factors

SSC Area	**Measures**	**Positive effect on environment**	**Positive other effects (incl. related SSC area)**
(1) Smart living	(a) energetic renovation of existing buildings (b) creation of a new sustainable urban living (c) "green" densification of urban areas	+ less environmental pollution and CO_2 emission	+ increased quality of life + improved health condition of citizens
(2) Smart health	(a) better care for sick and elderly people (b) leverage technology, e.g. big data analytics	+ avoidance of traffic through telemetric systems and thus less environmental pollution and CO_2 emission	+ increased health of society, decrease of diseases and mortality rate + higher productivity (smart economy)
(3) Smart education & smart society	(a) leverage technology to improve learning (b) equal access of all citizens to all kinds of knowledge	+ increased awareness for the environment and fellow human beings leads to environmentally friendly behavior by citizens	+ increased human wealth through higher education + improved health condition through increased consciousness of well-being
(4) Smart work ("new ways of working")	(a) more remote work (home office) (b) higher motivation and being "in the flow"	+ reduced traffic volumes (less commuters) and thus less CO_2 emission	+ increased work-life balance + better reconcilability of family and work
(5) Smart mobility	(a) increased offer and use of shared transport services (b) implement more innovative CO_2-neutral drive technologies (c) improved traffic flow through ICT (d) incentive to use public transport, bicycles or to walk	+ less traffic + behavioral change towards environmentally friendly transport modes	+ less physical and mental stress
(6) Smart energy & smart infrastructure	(a) increase of renewable energy sources (RES) (b) increase of energy efficiency through technology	+ less travel and thus less CO_2 emission + reduction noise emission	+ positive impact on the health condition of the citizens + decrease of symptoms caused by physical and mental stress

(7) Smart government and smart governance	(a) introduction of technology-based solutions for better access to citizen services (b) increased transparency and communication between government and citizens (c) direct political participation of citizens	+ trough environmental policies positively affecting all SSC areas + through smart digital public services reduction of traffic and thus CO_2	+ improving citizens' confidence in politics, leading to a more mature democracy + reduced waste of money (e.g. through corruption), increased wealth and reduction of social inequality
(8) Smart economy	(a) establish IoT and improve human to machine communication (b) manufacture climate-friendly products (smart manufacturing: sustainable production and adequate filtering of the pollutants emitted)	+ conserve scarce raw material through higher efficiency + avoid air pollution of industrial production	+ increase in productivity and the ration between raw material and CO_2 emission per thousand GDP
(9) Smart environment	(a) green spaces: (i) preservation of existing spaces (ii) embedment within planning of new urban quarter (b) protection of animal habitats (species diversity) and plants (c) sensors for measuring air quality implement countermeasures like (i) short-term: driving ban for certain vehicles (ii) long-term: increase quota of CO_2-neural transport means	+ better air quality	+ positive influence on humanity and decrease of diseases

Source: Illustration based on own studies and secondary research (Almadani et al., 2015a; F. Chen et al., 2020; Hemment, Drew; Townsend, 2013; Medvedev et al., 2015; S. Moore, 2019; Townsend, 2013; Uskov et al., 2018)

Measures to achieve better air quality in a city have a positive impact on people's quality of life. Large differences in air quality can be monitored around the world. Citizens attach an increasing importance to good air quality (reference to the area of smart society). Thus, in the future, companies will tend to locate where people feel more comfortable to attract more qualified personnel (reference to the area smart economy). Furthermore, the companies themselves must also make sure that they conduct their business as environmentally conscious as possible. Environmental awareness is also increasing in people's eyes, as shown, for example, in a study by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The study shows that the topic "environmental and climate protection" is very important to 64% of respondents in 2018, which means an increase of 11% compared to 2016 (Benthin & Williams, 2019).

Basic Smart City Approaches around the World with Respect to Sustainability

Smart city concepts are on the rise of the political agenda in industrialized and emerging countries worldwide. The Vienna University of Technology launched a benchmark where European medium-sized (urban population of 100,000 to 500,000 inhabitants) and larger cities

(city population of 300,000 to 1,000,000 inhabitants) were analyzed according to the following smart city areas: smart mobility, smart environment, smart people, smart living, smart governance, and smart economy (TU Wien, 2015). Within the medium-sized cities besides Luxembourg, especially the Scandinavian Countries and Austria are top-listed.

With regard to the Asian region, India plans to build 100 smart cities in an initial transformation phase (Khare, 2019; Smartnet, 2018), in order to then transfer the knowledge to 4,000 cities in the country afterwards (S. Khan, 2019). Furthermore, India is conducting a yearly smart city expo to further advance the topic, promote the exchange of knowledge and provide a platform for networking (Exhibition India Group, 2020).

China has initiated the launch of more than 500 smart city pilot projects until 2017 (Aijaz, 2017). The government plans to invest nearly USD 130 billion in smart city technologies between 2020 and 2023, focusing on advanced propulsion systems, AI, distributed power generation, personalized healthcare, and robotics as key cornerstones (Kastner, 2019). When considering the total investment volume, this makes China the leading country in the field of smart cities. According to the experts of Frost & Sullivan, smart cities will have an overall market value of over USD 2 trillion by 2025 based on new market and business opportunities (Valente, 2018). With respect to the environment, the OCED is promoting urban green growth (OECD Green Growth Studies, 2013) and the World Bank Group has already initiated in 2009 a program for supporting eco-cities.[8]

In practice, different paths are chosen for the implementation of a smart city. This certainly depends on important general conditions such as financing possibilities, differences regarding handling with data protection, cultural differences, quality of today's already existing infrastructure and building stock, the social life in the city and the typical habits when using means of transport (Ho et al., 2013; Watson, 2015; Zhan & de Jong, 2017).

For the transformation into a smart city, basically two different approaches are chosen. Either new districts or even entire new cities are completely redesigned and built ("greenfield approach"), or the existing infrastructure, including buildings of all kinds, traffic, energy supply and other areas, are gradually modernized ("brownfield approach").

In any case, a future-oriented city should act as a place of self-fulfillment and social participation. In addition to a well-paid job, a wide range of leisure activities for going out and

[8] The Eco^2 Cities Initiative is an integral part of the World Bank Urban Strategy that was launched in Singapore in November 2009; cf. retrieved May 05, 2020, from https://olc.worldbank.org/content/eco2-cities-model-sustainable-urban-development%C2%A0

having fun, sports, entertainment as well as medical care and a broad offering of public transport means are of great importance. The access to information and science (universities, institutes, libraries, intellectual exchange with like-minded people) as well as places of inspiration through the possibility of creative exchange, events, and ways of inspiration as well as opportunities to help shape their people`s future are of great importance. According to "The Public Realm" by Richard Sennett, cities are places where "strangers meet" and new ideas are born in public space (Hall et al., 2017).

A global survey of 700 municipalities that are members of Local Governments for Sustainability (ICLEI) shows the status of implementation and the challenges of how climate policy is designed and implemented (Aylett, 2014). According to the report, 75% of cities worldwide are engaging with both adaptation climate policy and mitigation threats from climate change and under 24% are focused exclusively on mitigation. In addition, an increasing number of cities are implementing climate change measures into other local government plans (i. e. sustainable development plans). 85% of cities worldwide have conducted an inventory of local greenhouse gas emissions, in 70% of the cases the mitigation efforts have produced measurable emission reductions, but only 23% of reductions have been achieved among local businesses.

The theoretical promise of an SSC is to address all urban challenges and to have an instrument to manage the city in a cost-effective and sustainable way, while improving all services to citizens and businesses in a sophisticated, pragmatic and non-discriminatory way through innovative technical solutions (Townsend, 2013). But when it comes to the practical implementation, things often look different. By analyzing the important parameters, many different focal points can be identified in the smart city projects launched to date, strengths and weaknesses, intentions, and visions of the initiators, but it is also possible to identify certain recurring patterns that often lead to the failure of such projects. In practice, the planned smart city is sometimes viewed similarly to a business or even a controllable machine that is fully predictable rather than realizing that a city is full of problems and challenges where different interests collide (Townsend, 2013).

Based on the lessons learned, and to avoid pitfalls related to smart city references that have not been successful, several approaches could be pursued (Ho et al., 2013; Luque-Ayala & Marvin, 2015; Watson, 2015; Zhan & de Jong, 2017): (1) Starting with a vision, but first resorting to proven concepts, evaluating innovations on a small scale. Then developing them step by step and iteratively and gradually increase the degree of maturity; (2) Providing a realistic picture and specifying concrete realistic interim targets. Realizing initial small projects

with trusted partners and involving smaller companies and start-ups as well as the population. Initial successes can serve as a reference ("success stories") to attract further interested parties and investors; (3) Involving regional institutions (e.g. universities) and also relying on local commitment by building trust in smaller and local companies. Additionally, dedicated cooperation with international firms is still recommended; (4) In addition to monetary parameters, non-monetary hygiene factors (Herzberg, 1959; Triandis & Herzberg, 1967), as well as social and environmental factors should be included; (5) Performing a detailed analysis of all dependencies.

Ultimately, the evolution towards a Sustainable Smart City is not a project that will be completed within a specific timeframe, but a constantly changing endeavor for which there is no fixed deadline. A detailed examination of performance indicators based on neoclassical economics, such as cost-benefit analysis is highly complex and only feasible under uncertainties since today's high investments in sustainable urban development often have a positive effect on the life of people in a city only after a relatively long delay.

1.2 Transportation as a Factor of Sustainable Development

Definition of Mobility and Sustainable Transport

The terms mobile and mobility can be distinguished between the possibility of mobility (state) and the ability to move (Basole, 2004; Kakihara & Sørensen, 2001; Tarasewich et al., 2002). This is done in the dimensions of spatiality (human behavior in relation to geographical locations), temporality ("when" with the sequence, duration and repetition based on human action), and contextuality (situation and the environment in which people carry out their activities). These characteristics of mobility can be extended by a social component (Karamshuk et al., 2011). Transportation is the process of moving people, goods, or services. In sustainable development, transportation is considered a means of employment, economic growth and development, social development, and global trade (Satoh & Lan, 2007).

Transportation alternatives are available with varying costs, travel time, and comfort. In today's cities, individual mobility primarily with one's own motor vehicle competes with publicly available offers (from public as well as private providers) such as scooters, motorcycles, bicycles and increasingly also with other forms of mobility based on the idea of sharing economy. Increasing traffic resulting from the dominant individual commute has many negative side effects such as health impacts, increasing stress and loss of time. A future-oriented

city must therefore develop sustainable mobility concepts at the urban level, which, however, at the same time make reference to the goals at the regional as well as the national level.

To counteract the increase in urban motorized private transport, public transport is being expanded in many cities. However, this too must be oriented toward sustainability and planned for the long term (Tang & Lo, 2008). Possible negative effects on the environment and ultimately on humans were not initially considered as relevant components, partly because their impact was not yet clearly visible. In addition, there is an increasing demand for business and private travel, where the majority of today's transport means still rely on combustion engines.

Therefore, a new paradigm of sustainable transport is needed. The term "sustainable transport" is described in a variety of ways in the literature and a universally accepted definition does not exist. Black (1996) emphasizes the social aspect with reference to future generations: "Transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs". It is also important that sustainable transport is not considered in isolation, but rather that its effects and corresponding measures are taken across sectors and disciplines, in addition to a uniform definition and conceptual design with regard to social policy making and socio-demographic aspects, in order to achieve a better understanding (Jones & Lucas, 2012).

The OECD introduced the concept of an Environmentally Sustainable Transport (EST) and emphasizes the need of a deployment of a broad range of instruments, which includes regulations and standards, fiscal measures, changes in governance arrangements, education, the provision of information, awareness raising, and attitude change, all assembled into coherent packages of instruments applied with careful consideration to phasing (Caïd et al., 2004). To achieve the objectives of the EST, an environmentally sustainable transport system is needed "where transportation does not endanger public health or ecosystems and meets needs for access consistently" with (a) use of renewable resources below their rates of regeneration, and (b) use of non-renewable resources below the rates of development of renewable substitutes and (c) minimizing the impact of the use of land and generation of noise. At the same time, it enables the safe fulfillment of basic access and development needs for households as well as businesses in a manner that is compatible with human and ecosystem health. It also promotes equity for future generations, is also intended to be economically affordable, fair, functional, and efficient, and provides transportation choices. In doing so, it supports a competitive economy and balanced regional development and limits emissions and waste within the planet's capacity to conserve (Eltis, 2019a).

In a broader sense, a "sustainable transport system" allows the development of the needs of the individual by, on the one hand, reaching places of daily need without stress, and, on the other hand, improving the overall mental and physical condition of city dwellers by reducing the emission of pollutants and noise (B. C. Richardson, 1999). Besides individual transport, urban goods movement in terms of freight logistics plays a crucial role and is an additional factor to be considered when planning a sustainable transport system (Russo & Comi, 2012). The analysis of different approaches in practice in the considered cities recommends measures such as urban distribution centers and nearby delivery areas, a smart transportation system, optimizing sustainable performance and railway, and governance measures such as area-pricing. It is important to address the increasing negative effects of freight transport, which are mainly due to congestion of vehicles and the reduction of road capacity. This also has a direct effect on individual transport. The negative environmental, social, and economic effects must be considered specifically in transport concepts and transport policy.

To better understand the discipline of transport, it is important to examine where and in what form the demand for it comes from and how it is expressed in people's private and business lives. Banister (2008) stresses that there are two different types of transport: (1) Travel out of necessity as a derived demand. Its goal is to arrive at a destination at the best price and time consumption. An example is the daily commute to work; (2) Voluntary travel for leisure purposes, such as visiting friends and going to the cinema. On the other hand, with the rise in prosperity, traveling itself is increasingly considered by many as the highest goal. Despite the fact that leisure and holiday traffic has increased enormously, it often plays no significant role in the planning of urban and regional transport (Heinze, 2010).

According to Banister (2011), there are essentially four core elements for sustainable transport: (1) reducing the need for travel through substitution, (2) transport policy measures essentially involving a shift from using one's own vehicle to using public transport, cycling and walking; (3) land use policy measures such as a reduction in the distance to get from A to B, essentially by increasing the density of urban areas and concentrating on polycentric urban regions and ultimately by (4) technological innovations and the resulting increase in efficiency, which should, however, also be accompanied by the necessary change in behavior.

Based on the definition of various authors, sustainable transport can be described as the cross-sector and cross-disciplinary process of transporting people, goods or services that enables comfortable, safe and fast transport and at the same time places as little burden as possible on current and future generations from an environmental and social point of view

(Banister, 2011; Black, 1996; Jones & Lucas, 2012). In this context, environmentally harmful transportation alternatives should be reduced as far as possible or even avoided completely, and the required transport should be mastered to the maximum extent possible by environmentally friendly and healthy means of transportation. From an infrastructure point of view, this includes the best possible utilization of space, and from a user point of view, sustainable behavioral incentives, both optimally supported by technical innovations.

Key Figures and Main Challenges of Urban Transportation

Our desire and increasing need for mobility brings with it some consequences, such as traffic-related air pollution, noise, diminishing green spaces, frequent lack of exercise, and the risk of injury from road accidents (Khreis et al., 2017). With regard to air pollution, it is apparent that an essential part is caused by the traffic sector. Figure 2 is depicting worldwide energy-related CO_2 emission by sector in 2017. Electricity and heat generation cause around 13.60 billion tons (43% of total), while the transport sector causes at least 8.04 billion tons (26% of total) of carbon dioxide emissions, with the two sectors combined accounting for more than two thirds of total CO_2 emissions worldwide.

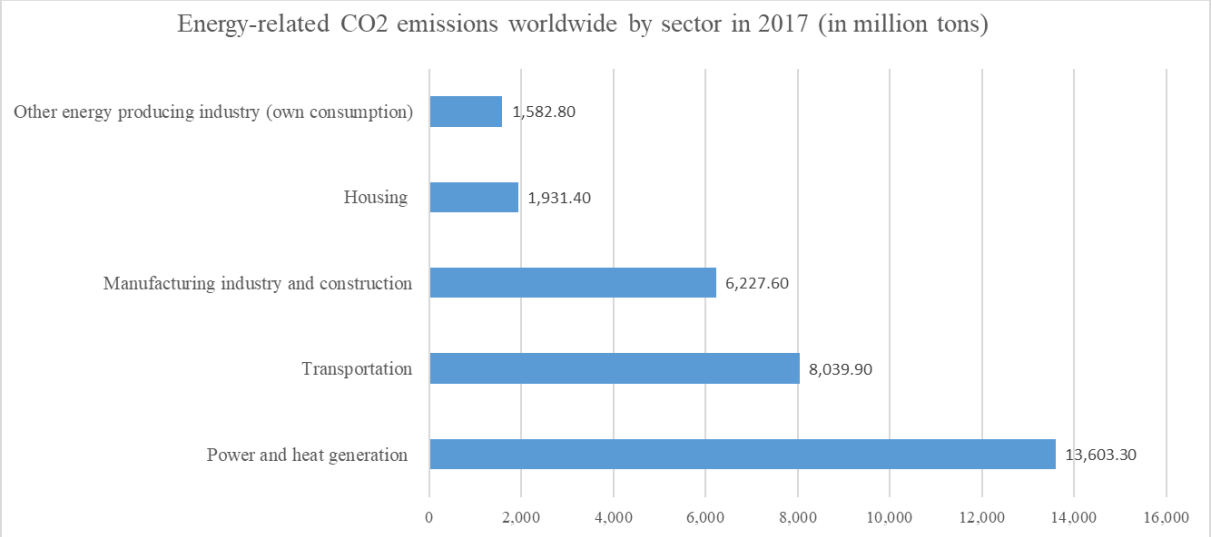


Figure 2: Carbon dioxide - Global energy-related emissions by sector 2017

Source: IEA - CO_2 Emissions from Fuel Combustion 2019, page 23; Published: October 2019; retrieved April 04, 2020, from https://webstore.iea.org/co2-emissions-from-fuel-combustion-2019

Looking at the different modes of transport, in 2015 road traffic emitted the largest share (73%), followed by air traffic with 13% and maritime with 13% (European Environment Agency, 2018a). A closer comparison shows that, looking to the future (forecast for 2050), the transport segment will cause almost as much CO_2 with 6,300 $MtCO_2$ as the sector of industry

with 6,721 $MtCO_2$. Heavy-duty vehicles[9] account for 38% and light-duty vehicles for 36% of the total, making them the major contributors. Furthermore, ship freight accounts for 4% and air freight for 11% of total CO_2 emission in the transport segment (International Energy Agency, 2017).

Historical trends show that the total number of motor vehicles worldwide has actually increased to 1.282 billion (International Organization of Motor Vehicle Manufacturers, 2017), representing a nearly 44% increase in the global vehicle population between 2005 and 2015 (2005: 892 million vs. 2015: 1,282 million). Increasing prosperity and a cheap oil price[10] have been contributing to an exponential growth of motorized vehicles, leading to a continuing dominance of combustion engines around the world.

When comparing the different means of transport, the example of Germany shows the average greenhouse emissions in Table 3.

Table 3: Comparison of Greenhouse gas emissions of different transport means

Means of transport	**Greenhouse gases**[11] [in grams per passenger kilometer]	**Transport mode utilization** [in %]
Bus	32	55
Railway (long-distance traffic)	32	56
Railway (local traffic)	57	28
Road, city, and underground railway	58	19
Urban / public bus	80	19
Car	147	1.5 persons / car
Airplane (domestic flight)	230	71

Source: Janson (2018)

Moreover, when comparing different drive technologies in Europe, traditional engines[12] emit much more CO_2 compared to modern fuel technologies (European Environment Agency, 2017). Compared with traditional drive technologies, vehicles with alternative fuels are emitting in average 27% less CO_2[13].

[9] According to the IEA, heavy duty vehicles (HDVs) are defined on the basis of a gross vehicle weight (GVW) of more than 7.5 tons; vehicles with 7.5 tons or less are referred to as light duty vehicles; retrieved May 05, 2021 from https://www.iea.org/reports/tracking-transport-2020

[10] Until the 1973 oil crisis, the price of oil, adjusted for inflation, rarely exceeded 25 dollars per barrel; retrieved July 03, 2020, from https://www.macrotrends.net/1369/crude-oil-price-history-chart

[11] CO_2, CH3 and N2O in CO_2 equivalents; Reference year 2018; emissions from the provision and conversion of energy sources were considered; coach includes long-distance bus and occasional transport; emissions for rail are based on data on the average electricity mix in Germany; in the case of air travel, all climate-impacting effects were taken into account.

[12] Traditional engines based on internal combustion engines. In the EU-28, petrol emits on average 121.7 g CO_2/km and diesel 116.8 g CO_2/km (2016 value). Between 2000 and 2016, however, it could be reduced by over 31% in the EU (from 177.4 to 121.7 g CO2/km).

[13] These include pure electric, liquefied petroleum gas (LPG), natural gas (NG), ethanol (E85), biodiesel and plug-in hybrid vehicles. Those emit an average of 87.2 g CO_2/km, which is a good 28% less CO_2 compared to petrol engines and 25% less compared to diesel engines.

In the meantime, looking at the EU as a whole, there has been a significant increase in the share of PHEVs (plug-in hybrids) and BEVs (battery electric vehicles) relative to the total vehicle fleet on the road in recent years, from an average of 0.7% in 2014 (Mock, 2015) to 3.6% in 2019 (Diaz et al., 2020). However, this still leaves them at a relatively low level, as their share of the total vehicle population in 2019 is only 0.5 % (ZSW, 2020).[14] Within Europe, Norway is by far the frontrunner with a new car registration rate of 54.3% in 2020.[15] Larger countries in the EU such as Germany and France fall far behind with a low single-digit percentage.

A look at the congestion statistics shows an enormous congestion volume of 50% or more (TomTom, 2021)[16]. The increasing burden of increasing congestion is becoming apparent in many cities in Europe[17]. Particularly in the industrialized countries in the EU, the dominance of the car is very pronounced (Fiorello et al., 2016). In countries such as Italy, Germany, France, Spain, the UK and Poland, the proportion of households owning a car is between 64% and 89%, with the trend continuing to rise (Poushter, 2015). The median in the EU lies at 79%. According to the TomTom traffic index, of the top 20 cities with the most traffic jams worldwide, 8 are from Europe (congestion level of 54% and more), and in total there are 56 European cities in the TOP100 in the worldwide comparison (congestion level of 32% and more).

With growing traffic, there are also increasing dangers, which are not only caused by exhaust fumes, but also by traffic accidents. On a global scale, according to the WHO (W. H. Organization 2018), traffic accidents are now the number one cause of death among children and young adults ages 5 to 29, ranking 8th in all age groups, with a worldwide annual death toll of 1.3 million. This is particularly true in low-income countries, but even in high-income countries, this figure is still relatively high.

Furthermore, increasing traffic and the resulting congestion cause high direct costs (fuel and time lost) and indirect costs (increased cost of doing business), in addition to greenhouse gas (GHG) emissions that are harmful to the environment and people. In Germany, the United Kingdom, and France, for example, these additional indirect costs average between USD 2,400 and USD 2,800 in 2020 for each individual household commuting by car (Centre for Economics

[14] On the basis of an average increase between 2006 and 2015 of 3.7%, the further annual increase between 2016 and 2019 was assumed and correspondingly highly projected.
[15] Source: Norwegian Road Federation (OFV); cf. retrieved January 15, 2021, from https://www.statista.com/chart/23863/electric-car-share-in-norway/
[16] 50% congestion means an extra travel time of 35% more than average trip in uncongested conditions / free flow situation.
[17] Top-Ranking Europe (position worldwide): Istanbul 62% (1), Moscow 61% (2), Kyiv 56% (3), St. Petersburg 50% (7)

and Business Research, 2014), which is equivalent to 5.3% of GDP per capita in Germany, 6.6% in the United Kingdom, and as much as 7.1% in France (International Monetary Fund, 2020).

On the basis of another analysis, it is shown that for every passenger kilometer travelled, additional costs are incurred due to factors such as air pollution, climate change, land consumption, noise, and accidents. These costs are significantly lower for public transport (between 2.1 and 4 cents per km[18]) than for individual travel by car (10.8 cents per km) (Allianz pro Schiene, 2019). Of the total annual traffic costs of 149 billion euros calculated for Germany, 94.5% are attributable to road traffic alone. In addition, of the overall external costs, 41% can be allocated to accidents. An essential part of the overall costs is also connected to the impact on traffic congestion of vehicles circulating for freight transport, as well as of the road capacity reduction caused by vehicle stops for loading or unloading operations, and of goods vehicle pollutant emissions.

Another problem is that the car is parked most of the time and thus takes up a massive amount of space, especially in the city. In the EU, the average daily driving time is one to two hours, depending on the country. This means that between 22 and 23 hours, and thus 92% to 96% of its lifetime, the car is parked and not used (Pasaoglu et al., 2012). Assuming an average value of 94%, out of 8,760 available hours per year, a car parks 8,234 hours in public spaces or on private property, thus blocking any other use of space. At the same time in the OECD EU cities, oil still makes up about 95% of all transport fuels (E. Bannon, 2015). Based on a study by EPA (2013), there are about 237 million parking spaces (37 million public-use and regulated parking spaces and 190 million on-street spaces) in the EU alone With an average parking space of 12 m² (assumption 2.4 x 5 m), this results in a total space requirement of 2.844 billion m² (2,844 km²). This area corresponds to a space requirement almost six times the size of the Warsaw city area (Warsaw area: 517.24 km²). Furthermore, the land areas required for road traffic are not even included in this calculation. In addition, especially in commuter traffic, the car, which in most cases has a capacity of 4 to 5 seats, is usually only used to a fraction of its capacity with only one person. The total average of the car occupancy rate in Europe is usually at about 1.5 (in 2018 for example in Germany: 1.46; in England: 1.60).

Other negative effects of road transport are physical and psychological stress. According to a study conducted in Germany, 5 out of 8 main stress factors for the survey participants are primarily or at least partially attributable to road traffic: lack of parking space (76%), poor roads

[18] Local passenger rail transport: 4 cent / km, long-distance passenger rail transport: 2,1 Cent / km, buses: 3 Cent / km

(66%), high air pollution (55%), traffic noise (54%) and general hecticness (43%) (Krösmann, 2017). The remaining factors are overburdened administration (66%), overcrowded public transport (55%), and garbage and dirt (43%).

The European Commission has addressed the negative effects of increasing individual mobility in urban transport by setting targets for GHG reduction and use of alternative low-emission and renewable fuels. The EU aims to make the mobility of the future more sustainable and environmentally friendly and to support this by building an infrastructure for alternative fuels with long-term investments. Based on EU emissions regulations, CO_2 emissions have already been reduced by 28% between 2001 and 2019 (Diaz et al., 2020).

Moreover, the NewClimate Institute has published a report on how CO_2 emissions in the transport sector can be reduced to zero by 2040 in Europe by applying the "avoid, shift and improve" paradigm with the aim of achieving the following total emission reductions: 43% through improvements in vehicle efficiency and alternative technologies (technology of zero emission); 21% by avoiding and reducing the need of transport incl. higher vehicle occupancy and utilization rate; 11% with the shift to environmentally friendly alternatives and modes such as cycling, public transport and rail; 15% with the full ban of internal combustion engines from roads, 10% by switching fuel to zero emission synthetic hydrocarbons (Emmrich & Hagemann, 2020). Another study points out that it is necessary to allow only zero-emission vehicles to be registered by the early 2030s and by 2035 at the latest in order to make a significant contribution to the EU's goal of climate neutrality by 2050 (Transport & Environment, 2018).

With respect to urban areas, a sustainable transport infrastructure is an essential component of a modern city, in addition to energy supply, water and sewage disposal, waste disposal and medical care as the basic elements for a livable city. All sectors, whether private or public, depend on it. All health effects resulting from political measures ought to be monitored and evaluated (Khreis et al., 2017). Only then can a steady and continuous improvement be achieved. In addition, a sustainable transport infrastructure should be embedded in the overall concept of a smart city that takes all these factors into account to solves these problems. The leading smart city areas with this regard are smart governance, smart mobility and smart waste, but they also interact with the other areas. It has been shown that the lack of adequate planning and providing public transport services, is leading to massive losses in the economy (Katoła, 2010).

Concepts in Urban Planning and important Aspects of Sustainable Transportation

Addressing the aforementioned negative impacts of increasing urban traffic should be explicitly considered in any desired innovation and planning of an urban mobility concept. Moreover, the overall objective of urban planning in the area of transportation is to make it easier for people to access transportation services without harming the environment. At the same time, this is expected to increase economic activity in the city and thus increase the GDP of the country as a whole, which in turn can lead to economic growth as well as an improvement in urban development based on innovation (Cadar et al., 2017).

Researchers and planning practitioners have analyzed the impact of the urban form on a number of elements of sustainability, such as social equity, accessibility, ecology, economic performance, pollution, and health. With regard to different urban architectures and the increasing densification in inner cities together with the creation of mixed areas (living, shopping, working), the aim is to reduce daily distances to work and for daily needs (Sarzynski et al., 2006). At the same time, the desire to own a car should be reduced, thus having a significant positive impact on total travel distance and time, e.g. by creating a mixed urban architecture (Cervero & Duncan, 2006). This can be achieved by developing new city districts where workplaces are located near affordable housing and sufficient services for daily errands and leisure activities. Optimization of urban mobility can also be achieved on the basis of redesigning existing urban quarters and buildings.

In addition, to reduce travel demand in general, and thus limit the negative impact of transportation, effective and comprehensive urban land use planning can make a significant contribution. The future design of urban transport infrastructure requires integration into the planning of urban architecture. Looking at previous research, it appears that an increased density is seen as an important factor for a sustainable and social community, but other aspects such as environmental factors and a quality living environment should also be explicitly considered (Dempsey et al., 2012). Forster (2006), for example, assumes that urban densification would achieve sustainability by improving the operation of public transport and by reducing water, electricity, and heat consumption in smaller homes.

Neuman, on the other hand, emphasizes, that it is not primarily a matter of developing a compact city to make it more sustainable (Neuman, 2005). He stresses that compact cities that are truly sustainable are not due to their high density, but rather because local materials, labor and appropriately scalable technologies were used. However, he does not deny that

densification in itself also has positive aspects. In his opinion, in order to disentangle the debate on dense urban development, other factors such as a high rate of employment, increased social and economic interactions, multimodal transport and embedment of a bicycle and pedestrian concept, in addition to a uniform control, planning of implementation of urban development measures and adequate provision of financial resources are necessary.

A further broader perspective of urban planning with regard to sustainable transportation away from pure urban densification includes other factors, such as service quality and network structure (Mees, 2010). Based on case studies throughout the world, e.g. in the Unites States, Canada, Europe, and Australia, it is emphasized that other factors, such as the importance of a good, coherent network and good star-shaped (radiate) connections between different urban areas and the city center, as well as an increased proportion of walking and cycling paths, play a major role in the development of urban areas. Mess (2010) emphasizes, in particular, that in Europe, using Zurich as an example, there are already very good integrated concepts with an increased use of public transport compared. A shift away from the predominant use of individual motorized traffic can be achieved through the provision of efficient and sustainable infrastructure for pedestrians, bicycles, and public transport (dell'Olio et al., 2014). In combination with land use and transportation redesign initiatives, there are also increased positive health impacts, as examples from the field show (Nieuwenhuijsen, 2020).

With regard to public transport, a conducted analysis points out that the favorable line structure with its optimal frequencies and bus sizes depends on centers structures such as (close to) monocentric, a polycentric or a dispersed city, or intermediate cases (Fielbaum et al., 2016). Based on the external conditions, the following line structures were introduced with each characteristics: (1) Direct line structures are favorable if most trips are radial, (2) Exclusive lines structures are only competitive if the percentage of people using public service is quite high, (3) Hub and spoke structures with collecting trips allow for high frequencies and low in-vehicle times, but likely increase the overall travel time and (4) Trunk-feeder structures are preferable for dispersed cities, as their low idle capacity allows for an efficient combination, yielding a balance between fleet sizes and vehicle capacities (Gschwender et al., 2016). A trunk-feeder structure means that there are one or more main arteries along the core city in the center. Finally, from the respective stops, feeders lead to the various city districts and satellites or outskirts. Especially in coastal cities, such a transport infrastructure is often used.

Finally, the inclusion of a people-centered developed process is needed. All approaches and steps must be pursued from the outset and as a continuous and interactive improvement

process throughout all phases, learning from mistakes and failures in good time and initiating appropriate action.

Current Policy in the light of Sustainable Transport Development

Even though in theory possible optimizations of urban transport policy have already been widely researched, there are still a number of obstacles in practice that have to be overcome in order to achieve real improvements. For a sustainable design of the transport system, it is of enormous importance that all experiences from science and practice in connection with the latest technological possibilities are considered from the very beginning of the planning process when developing new urban quarters. At the same time, it is crucial to continuously optimize existing structures intelligently to make the entire transportation chain as efficient and environmentally friendly as possible. Above all, traffic safety must be at the top of the political agenda. To achieve a sustainable transport system, an appropriate policy framework across all sectors should be established that is citizen-centric and practice-oriented (Jones, 2012).

Despite increased traffic, different safety measures have resulted in a decrease of 65% in road fatalities between 1990 and 2016 (OECD, 2017). However, especially more vulnerable road users such as motorcycles, pedestrians, and cyclists are still affected by traffic deaths and serious injuries (WHO, 2017b). The WHO and the United Nations support measures to increase road safety, with a focus on influencing user behavior such as speed management, reducing drunk driving, seat-belt use, increased child restraint use and reducing distracted driving. Other initiatives to increase road safety include the integration of safety-oriented planning. This includes the design and operation of infrastructure for people who are particularly vulnerable compared to other road users and therefore require special protection, such as pedestrians, cyclists and motorcyclists. The WHO initiated a global road safety inspection with the introduction of a star rating system for preventive road management, and with providing access to safe and affordable public transport (WHO, 2017a, 2018a). The WHO provided a framework ("Save LIVES") for a better protection for road users, which stands for "**S**peed management, **L**eadership on road safety, **I**nfrastructure design and improvement, **V**ehicle safety standards, **E**nforcement of traffic laws and **S**urvival after a crash" " (Peden & Khayesi, 2018).

Within the EU, the 7th Environmental Action Programme (EAP) (European Commission, 2016) focuses on various topics to protect nature and strengthen ecology, to promote resource-saving growth and to increase the protection and well-being of people. This

includes in particular the goal of making cities more sustainable and implementing measures for sustainable urban planning and urban design. Under Priority Goal 3, protecting the citizen from environmental pressures, health risks and risks to the quality of life, point 45 refers to air pollution from internal combustion engines and the associated increase in mortality, particularly in cities[19]. In addition, Priority Goal 8 focuses on promoting urban sustainability. Negative aspects mentioned in this context, such as high noise levels, traffic congestion, greenhouse gas emissions, and the loss of green spaces, can be traced back to the transport infrastructure in the core or at least in part. In addition to the necessary integration of environmental sustainability in urban development concepts, the need for efficient coordination between different administrative levels with systematic involvement of regional and local authorities is also emphasized. This has to start with the planning, formulation and development of strategies that affect the quality of the urban environment and continue through to the implementation of concrete programs and measures.

Furthermore, the EU is stressing the focus on expanding and making public transport more attractive, reducing private transport and increasing e-mobility for remaining 'motorized individual transport', and thus reducing CO_2. Further measures to improve air pollution include enforcing speed limits, controlling NOx emissions from cars and trucks, tightening low emission zones for trucks, introducing low emission zones for passenger cars and reducing the emission of Euro 5 and 6 cars with high NOx with a hardware fix financed by the car manufacturer. Within its urban agenda the EU is striving towards sustainable cities with the three pillars smart growth, green growth and inclusive growth (Nabielek et al., 2016). Urban mobility is one of the main cornerstones, which shall contain all of these three pillars.

In developing urban areas towards a more sustainable city, strategic management can provide a modern procedure that aims to consider environmental factors in an overall context (Poister, 2010). There is a need for streamlined interaction between different parties and across different levels of government, from both the public and private sectors, to deliver services in a way that addresses the needs of citizens. In particular, it is crucial to bring together different stakeholders and to address the manifold challenges from the very beginning, for example by developing the transport infrastructure with an intermodular concept and corresponding land use. In that regard, a field-tested approach with a polycentric-oriented sustainable mobility plan implemented in six different cities confirmed that a strong cooperation and a bottom-up

[19] source of mutagenic and carcinogenic polyaromatic hydrocarbons (PAHs) and of dangerous emissions of particulate matter (PM10, PM 2.5 and PM1)

approach can successfully contribute to building effective urban mobility (Kocak et al., 2014). This also means that the mobility behavior of city dwellers with their interests and expectations must be analyzed as part of strategic urban planning to meet the growing challenges of urban transport infrastructure.

With respect to different possible urban mobility developments Miskolczi et al. (2021) established four different scenarios based on six thematic areas: (1) role of automation, (2) sharing mobility, (3) electric vehicles, (4) congestion, (5) greenhouse gas emissions, and (6) social attitudes. According to the most likely scenario, the sharing idea will advance, but only gradually and rather slowly. There are still major challenges in the pursuit of sustainable and innovative development, often due to the current entrenched and complex structures in politics and public administration. Possible reasons for this are still too many bureaucratic hurdles, the lack of will on the part of the political elite, mostly shaped by the older generations, a still very strong lobby, for example, of the automotive and oil industries, and often deeply rooted behavioral patterns and habits with regard to mobility. In order to master these challenges, well-defined steering processes and practical solutions are required that enable a timely and rapid strategic decision-making process in line with the social system based on performance indicators (Head & Alford, 2015).

Furthermore, according to a report for the International Transport Forum of the OECD, there are various restrictions in terms of a possible optimization of price, investment, and regulation with regard to transportation policy (Roy, 2008). One of the reasons for this is the lack of implementation of the existing technology. Instead of considering demand-oriented and flexible roadmaps with the help of technologies and thereby also external costs arising from environmental pollution (on the basis of "marginal social cost pricing"[20]), rigid models are used which are detrimental to the environment. In terms of investment, one of the main issues is that the OECD countries have failed to make worthwhile investments in infrastructure and other transport improvements (Roy, 2008). At the same time, the gap between low-income and affluent households continues to widen. Based on the results of that study, it is becoming apparent that the infrastructure is increasingly dilapidated, especially in the transport sector.

Therefore, major disruptive changes at all levels are necessary for a stronger positioning of the scenario toward technology-enabled mobility. In addition, within the overall development of the transport infrastructure in a Sustainable Smart City, it is critical to measure

[20] Marginal social cost is the total cost paid by society for an additional unit (product or service). It also includes necessary further measures, which include not only direct costs but also indirect costs (e.g. through environmental damage).

and monitor performance, to continuously compare it to the previous status, and to learn from best practice reference examples around the world (Krynauw & Cameron, 2003; Zope et al., 2019). In this way, corrective measures can be taken at any time and an iterative improvement process can be created.

Moreover, to overcome the various obstacles, environmentally related minimum standards of vehicles must be further increased in the sense of sustainable development. Furthermore, innovative, technology-supported traffic management must be established, and a socially and environmentally compatible pricing system must be created to address the different mobility needs and behaviors. For instance, sensors enable traffic flows to be measured and calculated in real time. On this basis simulation to be carried out and optimized scenarios to support future urban planning to be set up with the establishment of self-learning artificial intelligence (Larkin et al., 2018).

With regard to urban planning, the traditional approach of "forecast and provision" in urban transport planning is no longer an option today, since forecasts based on the past are in the very least cases applicable to the projected future. However, according to Banister (2008) the alternative approach with a pure "demand management" is also not target-oriented. He points out that individual consideration of the institutional characteristics of the environment to be analyzed is necessary.

As part of the transport policy measures, the socio-technical perspective should push for a reduction in the space and capacity available for private motorized transport in favor of sustainable modes of transport such as public transport, bicycle lanes to promote active transportation options and sharing models that have a high degree of automation (Jones, 2014). This also includes traffic calming measures, the creation of green spaces, and a related information and marketing campaign by the city.

A good reference example of a modern transport policy and its implementation in practice can be seen in Singapore (Haque et al., 2013). The city is known for its strong economy and world-wide leading in this category[21], offers a high level of security for its residents (Institute of Economics & Peace, 2021)[22], is highly innovative (Dutta et al., 2019) and competitive in terms of digitalization (IMD, 2019), and has the second highest average per capita income[23]. With the three keywords "sustainable, safe and smart", a approach was taken

[21] No. 1 rating in the 2020 Index of economic freedom; cf. https://www.heritage.org/index/ranking
[22] No. 7 in the Global Peace Rating
[23] GDP per capita, retrieved July 10, 2020, from https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD

to do justice not only to the environment but also to citizens in a socially responsible manner. Various safety initiatives have been integrated into the transport planning strategy to minimize injuries and incidents for all road users, including motorists and public transport commuters, but also in particular pedestrians and cyclists. Key success factors are an integrated public transport network between train, metro and bus. This includes, for example, additional fares and priority rules for buses. In addition, sensor technology has been integrated, providing more reliable transport, e.g. to ensure that older road users can continue their journey safely (with the assurance of an extended green phase for safe crossing of roads).

Moreover, to develop a sustainable transport concept, all elements of the entire transport chain with all direct and correlating activities should be considered. In addition to the requirements of economic efficiency with regard to pricing for the customer and the associated creation of incentives, particular attention should be paid to the impact on the environment depending on the choice of the transport mean, in relation to the entire life cycle, and to social factors such as the inclusion of all citizens in the transport policy.

1.3 Urban Mobility in a Smart City

Smart mobility means transitioning away from the primary use of a vehicle with an internal combustion engine in favor of an intermodular, integrated utilization of different modes of transport, such as public transport, walking and cycling, and CO_2-neutral vehicles. Based on literature research, five main trends emerge, which impact urban mobility in a smart city already today and even more in the future: (1) Encouraging of sharing mobility offerings instead of ownership, thus reducing the overall city vehicle traffic; (2) Development of alternative drive technologies such as electric vehicles and hydrogen power combined with autonomous driving; (3) Evolution of two-wheelers in many forms, such as e-bikes, cargo bikes, e-scooters, which is also defined as micromobility; (4) Major improvement and higher use of public transport including the application of technology for a more dynamic and customer-centric urban travelling based on an Environmental Sustainable Transport (EST) infrastructure; (5) Technology-driven interplay of these trends towards highly integrated mobility, supported by innovations based on IoT, big data analytics, artificial intelligence, and deep learning algorithms, among others (Can et al., 2020; Luque-Vega et al., 2020; Paiva et al., 2021; Satoh & Lan, 2007; Schöttle, 2018). IoT enables vehicles to communicate with each other and with other objects in their environment, while maintaining personal privacy. Together, they can prevent accidents and make urban mobility safer and more efficient. By expanding mass transit

and micromobility, urban congestion and air pollution can be reduced, improving air quality.

Essential Elements of Sustainable Urban Mobility

To develop a sustainable and modern mobility, it is necessary to rethink established processes and behaviors, to avoid unnecessary trips or at least make them environmentally friendly, and to maximize the use of technological potential. It is evident that an investment in transportation has a positive impact from a macroeconomic perspective in the long-term perspective, for example, in terms of the Cobb-Douglas production function (Agbelie, 2014), economic growth based on gross capital formation (Pradhan & Bagchi, 2013), and the effective output in terms of GDP per capita (E. Holden et al., 2013). This includes a consideration of factors such as the maturity of current infrastructure, economic strength alongside with skilled labor, and interdependencies between the various transportation segments of road, rail, and air (Banister & Berechman, 2001). Nevertheless, in literature and also in practice, still the strongest focus lies on economic factors. The primary focus in the free market economy today continues to be on maximizing profit margins. Therefore, political measures and specifications are necessary so that special attention is also paid to the ecological and social aspects. These elements must be incorporated into transportation planning policies from the outset to achieve a more sustainable urban mobility. A key indicator as baseline for a development towards a sustainable mobility is the actual energy consumption in relation to the distance traveled, which strongly depends on the means of transport. Modern urban mobility also includes new service models to further improve the living space for citizens.

Even if Battery-electric vehicle (BEV) can significantly improve the air quality in cities, for a real modern and sustainable urban mobility, the entire value chain throughout the life cycle must be considered (Ayodele & Mustapa, 2020). This includes the production process, including the raw material extraction, but also the sustainability of recycling, for example by using recyclable raw material from the beginning (European Environment Agency, 2018b; International Energy Agency, 2020). If a particular process nevertheless causes environmentally harmful effects, it must be ensured that compensatory measures (e.g. afforestation of forest areas) are implemented. In addition, a special focus should be on the long-term usability of the battery, e.g. as an energy storage device for households (Faria et al., 2014). In addition, the fuel cell appears to be a drive technology that can be used as a supplement in the future vehicle fleet of citizens. Its fast charging time, compact design and good range are still an advantage over electric vehicles (C. E. Thomas, 2009). However, due to the comparatively low efficiency and

the high acquisition costs, this technology is more likely to be used in the commercial vehicle sector.

In the meantime, there is broad political support for e-mobility. High premiums for the purchase are initiated from tax money.[24] But a pure one-to-one exchange from an internal combustion engine to an electric vehicle does not have a positive effect on the current congestion and parking problems in urban areas. Moreover, it is necessary for governments around the world to integrate sustainable and intelligent mobility more forcefully into their policies to create incentives for environmentally neutral and effective means of transportation (Zhou, 2012).

The authors, who focus on non-motorized travel (Marshall, 2012; Roşca et al., 2010), point out that alternative approaches to urban mobility are needed. This includes a comprehensive planning of transport with consideration of all areas from an environmental, social, and economic point of view. Especially in inner-city districts there should be a prioritization of pedestrians and bicyclists and a conversion of areas from car-friendly roads and parking to more low-traffic areas and green spaces, such as parks.

Based on a literature review, the following approach to reducing average CO_2 emissions per kilometer driven can be recommended: 1. Increase the efficiency of traditional combustion engines powered by gasoline or diesel combined with an integration of an electric drive (hybrid[25] or plug-in hybrid[26]); 2. Promote sustainable public transport by optimizing the utilization based on demand and supported by technology potentials; 3. Promote cycling and walking through the provision of a well-developed infrastructure and also provide subsidies for them rather than for vehicles, which are increasingly leading to congestion; 4. Improve traffic flow and ensure the safe interplay between the different road users. These measures can be introduced in parallel to solve the problem of increasing traffic congestion effectively and quickly (Arroyo et al., 2020; Luque-Vega et al., 2020; Satoh & Lan, 2007).

Singh and Gupta (2015) make the recommendation based on an intelligent traffic management system (ATMS) that spatial analysis techniques can be provided by supporting a geoinformation based platform. In addition, internet platforms in combination with high-speed

[24] In Germany, for example, the government has decided to subsidize the purchase of an e-car with EUR 3,000 in 2020 as part of the economic stimulus package due to the Covid 19 pandemic. This amount is subsidized in addition to the EUR 6,000 already granted. Cf. https://wallbox.com/en_catalog/ev-incentives-in-germany, 28-01-2021

[25] The normal hybrid car stores electricity while driving, e.g. by recovering braking energy, which can then be used for shorter distances, especially in urban traffic. The main drive still comes from fossil fuels.

[26] The plug-in hybrid can be charged from an external energy source, resulting in a longer range of the plug-in hybrid car, the main propulsion comes from electric energy, resulting in lower overall CO_2 emissions (charging power from renewable sources is assumed).

internet such as 5G (J. Liu et al., 2017) offer better integration of the different modes of transport. Other emerging technologies such as data mining, machine learning and artificial intelligence further raise the potentials, which are mostly not yet sufficiently applied in practice (Zear et al., 2016). Moreover, looking at individual modes in isolation yields limited benefits in practice, as it requires an integrated and embedded approach.

Trends in Urban Planning

The disruptive potential of technology is playing an increasing role, leading to the fact that many everyday activities can be carried out from home (e.g. e-government, online-shopping, e-banking, home office for white collar workers) and thus affecting urban mobility. Nevertheless, the increased delivery service based on online shopping is negatively affecting the overall ecosystem. Transport trucks additionally burden urban life with their exhaust fumes and hinder other road users by parking in the second row. New concepts, such as distributed pick-up points, so-called micro-hubs, in the city in combination with cargo bikes are already either being tested like in Munich (with the smart city project City2Share[27]) or planned by implementing specific measures such as micro-hubs and cargo-bikes into policies and regulations as shown in Brussels (Buldeo Rai et al., 2019). Technologies such as an intelligent transport system and optimized vehicle routing are further examples of how urban goods logistics can be improved towards more sustainability (Taniguchi, 2014). Copenhagen and London are other examples where car traffic has been reduced within the city center in favor of bike lanes and public transport (Ogryzek et al., 2020).

The aspects of a Sustainable Smart City with its opportunities and trends, combined with possible positive ecological and social effects, can also be taken up and concretized with regard to sustainable modern mobility. The following consideration shows various trends with their respective core elements and measures, the associated basic human needs respectively well-being factors as well as the desired characteristics and objectives. The different trends are clustered among four areas as follows: (1) New ways of urban mobility and modern infrastructure; (2) New urban spatial planning and smart living; (3) Smart education and smart working and (4) Smart government, smart governance, and provision of a framework for a smart economy.

[27] Piloting potential applications of electric mobility and sharing approaches, including the use of cargo bikes to deliver packages from micro depots and thus accelerating the traffic flow.

Table 4: Trends and their effects for (1) New ways of urban mobility and modern infrastructure

Trends	**Key elements and measures**	**Typical personal human need / factors for well-being**	**Characteristics / objectives**
(1) New ways of urban mobility and modern infrastructure	(1a) Focusing on public transport (pt) in the city center and connecting the suburbs by giving them priority over private motorized transport (MIV).	Fast, inexpensive and comfortable mobility, especially for daily commuting.	Focus on public transport incl. prioritization over MIV, subsidies for low-cost offers (e.g. pt ticket, and additionally grants / price-reductions for groups such as students, pensioners, low-income earners), smart linking of inner-city transport with the surrounding area.
	(1b) Providing platform-based intermodal mobility (MaaS) by enabling a multimodal, multi-operator urban transportation infrastructure.	The human need to be mobile, whether for commuting to work or to reach a certain destination for errands and leisure activities.	Combination of different transport modes with prioritization of "green" transport means such as bicycle, pt, and shared mobility with an easy-to-use mobile application and integrated billing process.
	(1c) Improve comfort level, accessibility, and tight frequency of the time schedule based on real demand and customer needs in public transport, supported by big data analytics and operational excellence.	Safe, comfortable, punctual, and fast mobility without long waiting times.	Integration of real-time data and dynamic on-demand transportation system and integration of surveillance system (CCTV) to ensure safety.
	(1d) Expand incentives for CO_2-neutral and health-promoting transportation such as bicycling and walking through subsidies and better bike/pedestrian paths.	Desire for a pleasant and healthy life with the need for clean air and green spaces for urban recreation. In addition, decrease overall CO_2-footprint.	Increase non-motorized and CO_2-neutral urban transportation while improving the overall health constitution of citizens (quality of life).
	(1e) Creation of smart parking infrastructure especially for bikes and e-vehicles.	Fast travel from A to B without wasting time.	Exploiting the full potential of ICT from smart parking.
	(1f) Optimization of traffic flow through intelligent transport system (ITS) and integration of related smart city areas within an intelligent traffic management / routing (e.g. smart energy and smart infrastructure).	Urban mobility (daily commute and leisure traffic) with maximum comfort and congestion- and interruption-free traffic.	Avoidance of congestion in intensified urban areas, optimization of the public transport system, and IT integration in intermodal mobility.
	(1g) Promotion and prioritization of alternative environmentally friendly drive technologies such as hybrid, e-mobility, and fuel cell.	Clean air to facilitate health constitution and comfort und sustainable mobility.	Reduce the average CO_2 emissions of the entire fleet by reducing vehicles with combustion engines and taking into account the entire value chain of HEV, BEV and fuel cell vehicles from manufacturing to the recycling process.

	(1h) Develop a sufficient charging infrastructure for PHEV, BEV and fuel cell powered vehicles.	Fast and convenient recharge of vehicles with a minimized time effort.	Promote alternative drive technology by providing comfortable and fast access to infrastructure services.

Source: Illustration based on own studies and secondary research; (1a) (Hickman et al., 2013); (1b) (Cruz & Sarmento, 2020; Jittrapirom et al., 2018; Kamargianni & Matyas, 2017; Smith & Hensher, 2020; Wong et al., 2020); (1c) (Borole et al., 2013; van Oort et al., 2015; Welch & Widita, 2019) ; (1d) (dell'Olio et al., 2014; R. Ewing et al., 2014; Gonzalo-Orden et al., 2014; Jäppinen et al., 2013; Litman, 2012; Roşca et al., 2010); (1e) (Al-Turjman & Malekloo, 2019; Khanna & Anand, 2016); (1f) (Chandra et al., 2017; B. Singh & Gupta, 2015; Wang et al., 2016); (1g) (Alogdianakis & Dimitriou, 2021; Laurischkat et al., 2016); (1h) (Madina et al., 2016; Rahman et al., 2020)

To reduce the dominance of the private car, a sophisticated Mobility-as-a-Service (MaaS) offering, in which different means of transport and related services such as smart parking are intelligently linked with each other, can provide a demand-oriented transport option from the starting point to the desired destination (Cruz & Sarmento, 2020).

One of the overarching goals of a modern infrastructure is to optimize the utilization rate and thus reduce the overall demand for vehicles on the road. In initiating and implementing the various measures, the focus lies on social and environmental aspects, but the economy can also benefit greatly from sustainable change. Thus, despite the recommendation to focus more on public transport and bicycles, there is also an opportunity for automotive companies to participate, for example, in sharing mobility offerings, the development of charging infrastructure (Madina et al., 2016; Rahman et al., 2020) and in intelligent traffic control (Chandra et al., 2017; B. Singh & Gupta, 2015; Wang et al., 2016) through their own know-how, modern vehicles, and service offerings (e.g., in addition to vehicle maintenance, also maintenance of the charging infrastructure could be integrated into the service portfolio).

After long adhering to the traditional pattern of everyone needing their own car and focusing on the internal combustion engine, even large automotive companies are breaking away from previous strategies. An example is the cooperation between the rivals in the premium car segment, Daimler and BMW, in which car sharing services are offered via the app ShareNow (formerly Car2Go from Daimler and DriveNow from BMW) on vehicles from both manufacturers and, in the meantime, from other partners such as Fiat. Vehicles from competitor VW (via provider MILES), as well as scooters and e-scooters and cab rides are also offered via another affiliated app (FreeNow).[28]

Even if urban architecture can only be changed in the long term with a view to sustainability, technologies today already offer high potential, for example in the area of smart

[28] Information based on personal experience with the described apps, Status: 30-01-2021

living and smart health, which can also be exploited in the short and medium term. One of the most important disciplines of urban planning is how to optimize the various daily routes of city dwellers to ensure efficient and convenient mobility. Dense urban areas with a mix of affordable housing and office spaces, shopping facilities, and a distinctive range of leisure activities are prerequisites for a lower commuter rate.

Table 5: Overview of trends and their effects for (2) new urban spatial planning and smart living

Trends	**Key elements and measures**	**Typical personal human need / factors for well-being**	**Characteristics / objectives**
(2) New urban spatial planning and smart living	(2a) Improved spatial planning with an increase in density and with a balanced work and leisure offering.	Well-being and a decent standard of living.	Improve existing city districts and create new urban residential areas where all daily necessities are within a short distance/travel time.
	(2b) Improve well-being by investment in health care by the government, e.g. focusing on tele-medicine.	Well-being and safeguard of a good health constitution.	Provision of a first medical consultation for elderly citizens, but also for all others, thus avoiding unnecessary travel time as well as time wasted waiting in the doctor's office. In addition, the risk of infection is completely avoided.
	(2c) Social interaction between citizens and cohesion of society.	Social security and the need for human exchange.	Exchange via social media and virtual meeting points (e.g. via virtual reality).

Sources: Illustration based on own studies and secondary research (Almadani et al., 2015b; F. Chen et al., 2020; K. Williams, 2017)

It remains to be emphasized that social contacts are indispensable for human needs and that these can only be supplemented and enriched, but never replaced, by digital possibilities.

Table 6: Overview of trends and their effects for (3) Smart education and smart working

Trends	**Key elements and measures**	**Typical personal human need / factors for well-being**	**Key elements and measures**
(3) Smart education and smart working	(3a) Innovative remote learning (e.g. through tele-education).	Desire and right to education to improve individual quality of life.	Provide age-appropriate online education according to the personal needs of different generations.
	(3b) Access to online education of everyone (also for socially disadvantaged social classes).	Social and equal access to education.	Provide access to education regardless of income level and current educational attainment according to the individual needs of citizens.
	(3c) Promotion of environmental awareness.	Increase in personal well-being e.g. through clean air.	Increased awareness of the environment leads to environmentally friendly behavior among citizens.

(3) Smart education and smart working	(3d) Work from anywhere with new channels of virtual collaboration based on ICT.	Individual possibility to organize work and private life in maximum harmony as well as sufficient degrees of freedom and with an increased sense of responsibility.	Increase motivation and self-reliability supported by a flexible work environment. Combine online work with face-to-face social exchanges.
	(3e) New ways of communication (e.g. virtual calls).	Social and business-oriented exchange to optimize information flow and thus save time.	Integrate innovative communication channels such as web sessions and meetings with the use of virtual reality to reduce the need for travel.

Sources: Illustration based on own studies and secondary research (Demerouti et al., 2014; Hung & Wati, 2020; Zhu et al., 2016)

Based on developments in the area of smart working, fundamental trends of a more flexible and remote working environment can be recognized, which also offers the opportunity to reduce travel, especially in the business sector, and thus a possible reduction of the negative environmental impact. Many companies, such as airlines, car rental companies and taxi companies, are therefore faced with the challenge of adapting their business models to the needs of the market towards sustainability.

The next trend is related to public administration. This is particularly difficult in many countries because experience shows that public authorities lag behind the private sector in terms of technological development. The basic aim is to make interaction with the authorities as simple and straightforward as possible for citizens with a connection to mobility. As Table 7 shows, for example, registering and deregistering a vehicle or applying for subsidies for sustainable means of transportation can be done online.

Table 7: Overview of trends and their effects for (4) Smart government, smart governance, and smart economy

Trends	**Key elements and measures**	**"Typical personal human need /**	**Key elements and measures**
(4) Smart government, smart governance, and smart economy	(4a) Digitization of the administrative authority (smart governance)	Easy and unbureaucratic access to administrative processes such as change of residence, re-registration of a car, application for a passport etc.	Unified and centralized portal access via web and app including digital authentication process for requesting, performing and completing citizen services to enhance the overall quality of life in a city.
	(4c) Digital participation in the decision-making process (i-voting).	Desire to have a say in the future development of the city, e.g. subsidy for public transport, creation of more/better bicycle lanes, green areas etc.	Enabling direct co-decision-making opportunities and increasing citizen involvement to meet their needs, thus increasing the attractiveness of the city, leading to healthy growth.

(4) Smart government, smart governance, and smart economy	(4d) Sustainable urban mobility oriented political strategies & policies (e.g. SUMP).	Fast, easy, affordable and comfortable mobility within the urban area.	Develop urban mobility in a sustainable way and improve the quality of life of all citizens by addressing the challenges such as congestion, air/noise pollution, traffic accidents and disorderly parking in an efficient way.
	(4e) Innovation and entrepreneurship	Development of personal strengths and pursuit of ingrained wishes and goals with contribution of own ideas as well as demand for professional and social exchange with others.	Encourage innovation and initiatives e.g. through subsidies and simplified bureaucracy. Launch an overarching city marketing campaign of holding events to promote new ideas for sustainable urban mobility and positively influence citizen`s mindsets.
	(4f) International cooperation: internationalization through technology (e.g. internet-based companies)	Working in a challenging but creative environment with an exchange with people from all over the world to build personal (soft) skills and experience.	Increasing competitiveness, leveraging know-how from different references around the world and promoting mutually beneficial collaboration to improve urban mobility and thus support sustainable growth.

Source: Illustration based on own studies and secondary research (Arsenio et al., 2016; Lindenau & Böhler-Baedeker, 2014; Santos et al., 2010; Un-Habitat, 2013)

In addition, the development of tomorrow's urban mobility will enable the digital inclusion of city residents in the decision-making processes, which will also increase the acceptance of the measures and ensure that the actual needs of the citizens are met. All the trends and possible measures described above can be examined for the qualitative and quantitative potential of the following derived two key factors for sustainable urban mobility: (1) Reduction in travel demand through substitution or reduction in travel distance/duration and (2) Modal split change from private motorized transport to shared transport and cycling/walking. In addition, a further evaluation of the potential positive impact of different focus dimensions such as environment, social (quality of life) and economy can be carried out in relation to the required costs and efforts.

Any emerging trend must also be evaluated in terms of long-term sustainability and should always make a positive contribution to the environment as well as human well-being. Real-life practice shows that this is not always guaranteed. The rapid spread of e-scooters can be cited as an example. Due to their short usage time, high material requirements during the manufacturing process, inefficient recharging processes (Hollingsworth et al., 2019), as well as a short lifetime (Griswold, 2019), they are rather unsuitable for playing an important role in

urban mobility from an environmental perspective. In addition, there is an increased risk of accidents when using them (Badeau et al., 2019; Beck et al., 2019; Vernon et al., 2020). Usually, they do not replace driving distances that would otherwise be covered by the car, because, in comparison, they do not have the speed and comfort (e.g. space for transportation of daily errands etc.). Rather, on average, they cover a distance that is slightly more than walking, but significantly less than by bicycle (civity, 2019). They mostly serve to replace the planned walk and as a fun factor, which is generally not conducive to health, either. Moreover, they are often clogging the sidewalks and are treated badly by users (Perry, 2020). The lesson from such experiences is that any trend must be critically evaluated, and if necessary, appropriate regulations must be put in place to ensure healthy traffic development. Another exemplary trend must be critically analyzed; if users are lured away from public transport by low-cost offers such as Uber or Lyft, it is possible that wrong incentives are created that contribute to urban transport being negatively influenced.

To exploit the maximum potential, it is important to share and collect data from the various areas (data openness), to create uniform standards, and to ensure the cyber security of smart city applications on the basis of innovative technologies (Ullah et al., 2020). Moreover, all these trends and derived measures should never be considered in isolation, as they are mutually dependent and complementary. Thus, it is recommended to perform an analysis within an overarching framework (Banister, 2011).

Mobility-as-a-Service (MaaS)

Mobility-as-a-Service is a type of user-centric demand-oriented mobility service where users can access various mobility services through a joint digital channel, therefore fusing various transport services into one single demand service to provide an optimized journey from A to B that is easily accessible by users. The focus is not primarily on one mode of transportation, tying mobility to ownership of, for example, a car, bike, or scooter, but rather using technology to offer Mobility-as-a-Service, using the various modes of transportation collectively. The number of vehicles operating in a city can be reduced, giving users the chance to make an informed choice when it comes to transport services (Tinnilä, M, 2016). Therefore, users are able to access alternative modes of transport, hence increasing productivity, since people are not slowed down by traffic and congestion, which in turn can be beneficial for a country's economy overall.

The key advantage of the sharing mobility concept is that users have to pay only for the mobility service which they really need and claim. Fixed costs, such as depreciation, insurance, maintenance, and parking space costs are included in the pricing model, as they are borne jointly by the various users on a pro rata basis, which can lead to overall cost benefits if all processes are operate efficiently. According to a study carried out by the Austrian Energy Agency, seven out of ten respondents see MaaS as alternative to vehicle ownership. For 80% of respondents, urban areas without vehicles with combustion engines (zero emission zones) will be part of everyday life in 2030 (Austrian Energy Agency, 2018).

The platform approach and the associated technological possibilities of MaaS can ameliorate the travel experience to provide a suitable offer for everyone based on different user profiles, e.g. with a focus on costs, travel time, and travel comfort. Depending on the desired route and personal preferences, certain means of transport, such as sharing offers, public transport, taxi services or car rental/leasing, or a combination of these, are made available. In addition, real-time data, for example from the current traffic situation, about the availability of sharing offers such as cars, e-scooters (incl. current range based on current charging status), weather conditions and digital public transport timetables can be integrated into the MaaS platform.

The desired route can then be selected via a single app, and at the same time a ticket for the entire trip can be purchased using different means of transport and paid directly using the preselected payment method. The integration of the different public and private providers, as well as the billing and payment process, take place unnoticed by the user in the background. Hence, within a MaaS offering, certain subscriptions or packages can be purchased by the registered user, providing certain further incentives, such as a discount or voucher for related services and products. Based on experiences with the seasonal ticket for public transport, it was recognized that this type of long-term payment decision influences the short-term choice of the transport mode, for example, through the perception of cost benefits (Kamargianni et al., 2016).

In the context of a sustainable MaaS concept, with regard to environmental (e.g. CO_2 reduction) and social aspects (e.g. improved health due to cleaner air), the focus should be on integrating a well-developed public transport network and mobility by bicycle. In this respect, appropriate incentives must be put in place to reduce the attractiveness of personal car ownership and use. Nevertheless, within an effective MaaS concept, different sharing services are to be provided for individual mobility. The different sharing offers are briefly described in the following.

Table 8: Brief description of the main sharing modes used within the MaaS offering

Car sharing: Car sharing mobility service providers usually have hundreds or even thousands of cars in place, which can be used by customers who drive the vehicles themselves. There are basically two different car sharing variants in place. One is the more traditional station-based model, where the user picks up a vehicle at a fixed station and usually has to return it at the same station. The other model is the free-floating model, which is nowadays more common. Within this model, the vehicles are available on public roads and can be located and rented via apps. After the trip, users do not have to return them to a particular rental location. Rather, they can park the vehicles in any public parking space in the car sharing provider's business area. This area usually includes city centers and highly frequented peripheral locations, such as airports and industry parks.
Ride hailing: Ridehailing means to hail someone to share a ride, basically like classic taxi driving. The ride is booked via an app, a driver picks up the passenger at an agreed meeting point and time and takes them to their desired destination. The journey is billed cashless via the app. The ride is provided exclusively for the person who ordered it (possibly plus companions), so it is not shared with other not-known third persons. The best-known and most widespread practical examples are Uber and Lyft.
Ride pooling: Several passengers share a professional driver. Example: Person A has booked a ride pooling service to get to a certain destination. Person B makes a request to the same service provider for the same or a similar route. Its algorithm combines the trips, so both customers are able to share the ride. The single trip may take a bit longer. However, the ride pooling provider can offer lower rates for sharing. As a benefit for the city, through the higher utilization of the car, overall traffic can be positively influenced. Examples for this model are, for instance, uberPOOL, Lyft Line, blablarcar (between cities), and in Berlin BerlKönig.
Car pooling: Describes trips in cars that are shared mostly by private individuals without a commercial background. A person travels from A to B and takes another, who has the same or similar destination, with him. In Germany, it is also called "Fahrgemeinschaft".

Source: Own illustration based on (Kamargianni & Matyas, 2017; Machado et al., 2018; Wong et al., 2020b)

To operate a MaaS offering in a commercially profitable way, the conceptual and technical implementation represents the greatest challenge for operators. By consenting to an anonymized data analysis of user data, mobility services can be steadily improved, the utilization of the various means of transport can be optimized according to demand, and thus a significant improvement in the burden of congestion, air pollution and noise can be achieved. The increased efficiency also allows for high cost-saving potentials to be realized, which can then be passed on to customers, thus significantly increasing the attractiveness of using shared models compared to owning a car or booking individual means of transport separately.

The MaaS market is steadily increasing. For instance, large and established market players are developing cooperative ventures with startups or founding such ventures on their own. There is also a lively exchange between industry and universities. Through the integration of different providers via a defined interface (e.g. API), it can be ensured that the individual processes interact in such a way that an effective MaaS ecosystem and ultimately a customer-centric offer is realized (Kamargianni & Matyas, 2017). Even citizens can be part of the MaaS

offerings, for instance by enabling the use of their own car via the MaaS platform, thus earning money during times when they do not need their vehicle. New business opportunities are emerging and creating jobs in the MaaS market. The total market volume in 2021 equals more than USD 75.5 billion and is expected to grow exponentially to about USD 230 billion in 2025 (Mhojhos Research, 2020). Various criteria are necessary for the effective and sensible dissemination of MaaS, which are presented in the following overview (cf. Table 9).

Table 9: Overview of preconditions for a widespread use of MaaS

Criterion	**Current status**	**Further steps required**
High penetration of smartphones	In 2020: France: 72%; Spain: 84%[29]; Germany: 88%; UK: 87%[30]; Italy: 49%[31]	Possible access to MaaS also for non-smartphone owners (i.e. for elderly people) e.g. through a local ticket office, provision of a monthly mobility pass
Easy-to-use one-stop application with an integrated cashless payment system	Already some user-friendly apps are in place. But partly still lacking offerings of different transport modes and customer-centricity.	Set-up a standard framework for all processes from booking to billing promoted by political initiates for a fair market und sustainable mobility
High coverage of mobile network / connectivity	4G coverage in most European countries quite high (90% or more[32])	Set up high 5G coverage as precondition for IoT communication. Current status in most European countries is less than 5%.
Secure data transfer and data protection.	Today, a lot of providers using technologies and cloud based storages which are located e.g. in the Unites States[33] or China, where data protection is not that pronounced, for instance allowing security services to read and track the data of users.	Ensuring data security based on regulation for storage and use of data and also for data transmission based on an end-to-end encryption.
Willingness to use MaaS / behavioral change	Still many people do not consider Maas as an alternative, due to ingrained behavioral patterns or / and a lack of sufficient MaaS service offerings.	Provide the policy framework with promotion of MaaS (see SUMP definition in the following section) and launch a comprehensive marketing campaign to improve the service.
Raise awareness of the total cost of car ownership	There is a lack of awareness of the total costs of car ownership with an average underestimation of 50% (Andor et al., 2020). Educating people could significantly reduce car ownership.	Educate people on the real costs of car ownership based on SUMP. Ensuring transparent and fair pricing and MaaS offerings that are appropriate for all customer segments, also in comparison to owning a car.

[29] Source for France, Spain, and Germany: Statista Digital Market Outlook; July 2018 (value based on prediction)
[30] Source: Statista Digital Market Outlook; June 2019 (value based on prediction)
[31] Source: Statista Key Market Indicators; July 2020
[32] Source: retrieved January 19, 2021, from https://www.opensignal.com/market-insights; selected value of "4G Availability"
[33] In the United States the Clarifying Lawful Overseas Use of Data Act, the so-called "CLOUD Act", stipulates that the US government may access cloud data from US companies, even if they offer services including cloud storage outside the US.

Achieving a critical mass of users	Some examples show that the MaaS service introduced did not reach critical mass and was therefore discontinued after some time (e.g. Qixxit from Deutsche Bahn in Germany).	Need to address MaaS to all levels of society and especially to young people, who are often open to new concepts, but have a limited budget.
Governance / policymaking	Often there are still too many administrative obstacles and lobby-driven focus on the automotive industry.	Comprehensive transportation policy planning concept towards sustainability required (see next subchapter with regard to SUMP).

Source: Illustration based on own studies and secondary research (Abraha, 2020; Andor et al., 2020; Corporate Europe Observatory, 2015; European Union, 2016; Finger et al., 2015; Fogg, 2020; Jan et al., 2019; Stüber, 2019)

The maturity of MaaS is defined by Cruz on seven levels, starting from the baseline in most cities that there is digital access to information, booking and payment to individual transport media such as car sharing or public transport (Cruz & Sarmento, 2020). In the final stage of development, MaaS is completely networked based on interaction through IoT and supported by artificial intelligence, thus integrating other areas. On the horizontal level, related areas, such as smart parking, intelligent traffic routing, and the integration of the charging infrastructure for vehicles powered by electricity or hydrogen, can be embedded. As MaaS evolves, so will the other systems that are involved in the traveler's day, such as smart workplaces, smart homes, smart cities (reference to chapter 1.1), and general services (e.g. food, groceries, entertainment, sports, culture), to provide a convenient and seamless interface with the traveler's ecosystem, thus enhancing the service offering on a vertical level.

There are different levels to consider when developing and implementing a MaaS concept. Basically, the question to be answered is what kind of mobility service citizens (customers) demand and how the ecosystem of mobility providers can satisfy this demand. Between these two layers, the MaaS mobility concept or platform-based application has to act.

The following overview shows the framework for the MaaS ecosystem, in which the following clusters interact with each other as essential pillars (1) Ecosystem of customer behaviors and needs: analysis of mobility users, (2) MaaS application ecosystem: important parameters for mobility offering and providing citizens mobility experiences, and (3) Mobility supplier ecosystem: interface to third parties.

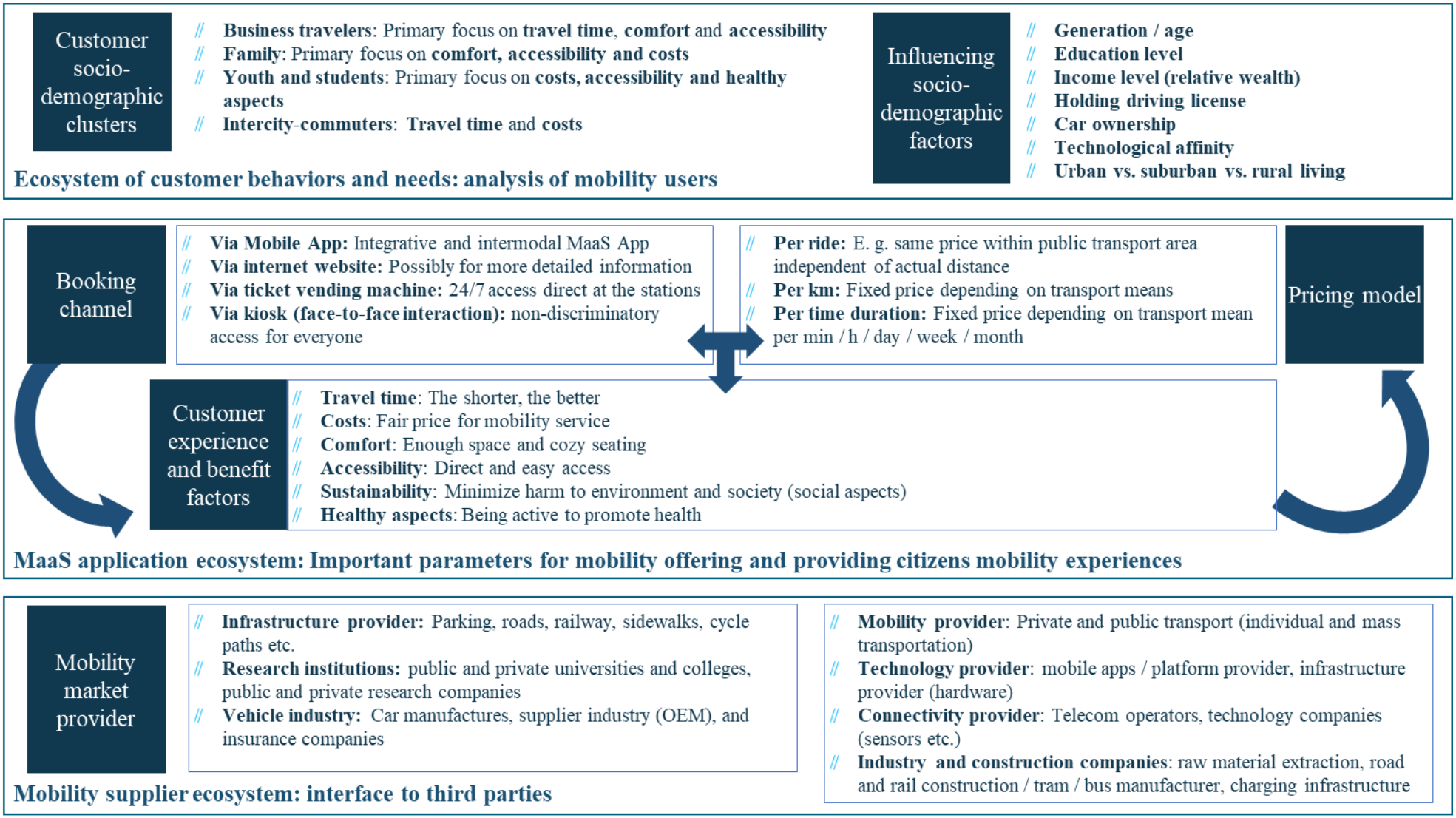


Figure 3: Framework of the MaaS ecosystem

Source: own illustration

When analyzing the behavior of citizens (mobility users), different customer behaviors can be typified with so-called personas, for example, to provide an individual MaaS offer. Personas are an instrument that is primarily used in the field of marketing (K. Lee, 2019; Pruitt & Adlin, 2006; Venzin, 2021) and is often used in customer relationship management. Usually, classical customer segmentation is often based on socio-economic and socio-demographic factors, but neglects the fact that even people of the same age and gender, living in the same neighborhood, with a similar job and salary etc., can have very different personality traits and thus consumption behavior. In the area of mobility, for example, a 35-year-old single, high-income man who lives in a central location may be a passionate car driver and use it to travel as far as possible, both professionally and privately. A colleague with the same job and in the same age however sees the car as an unnecessary and cost-intensive load, which feels to him depending upon purpose of the journey with the flexible selection thereby limited. Instead of incurring the cost of his own car, he prefers to ride his own bicycle, for example, and still has a positive feeling that he is doing the environment, as well as his health, a favor. Therefore, the creation of specified personas can take into account different customer preferences and thus also provide targeted communication.

Moreover, in the meantime, there have been attempts to adapt this to software development (Caballero et al., 2014), but it has hardly been used in the context of mobile offerings. This makes it possible to provide various MaaS offerings that fit the customer's needs. Depending on different demographic influencing factors such as generation/age, education level, car ownership and life situation (e.g. single student living alone in a small (shared) apartment in the city center vs. family living in a house in a suburb), different individual mobility services can be offered.

To provide a suitable offer for different personal needs, more parameters must be considered. Within the MaaS ecosystem, the suitable booking channel may differ, e.g., for the young, an app on the smartphone is usually advantageous, and for the elderly, a "traditional" sales channel, such as the sale of a specific mobility offer via the kiosk face-to-face, might be appropriate. When developing an application, various needs must be taken into consideration in such a way that non-discriminatory access is possible for all user groups. The pricing model may vary depending on the customer's needs or mode of transport, or on the combination thereof. For example, different "mobility packages" can be offered based on the persona type, e.g. depending on the willingness to buy and pay. One aim can be to provide such an attractive MaaS offer that even passionate car owners are willing to use alternative modes of transport

rather than their own car. This could be achieved, for example, if the comfort-level of public transport increases and, in addition, various desired vehicles can be used via sharing models.

To provide such a mobility service for all, the entire provider ecosystem needs to be built, often through strong cooperation between public and private transport providers. As can be seen in Figure 3, many different market players can be involved, from car manufacturers to infrastructure and technology providers and mobility providers, all of which are connected either through the entire value chain (upstream and downstream process) or directly through the mobile application (platform).

The Concept of Sustainable Urban Mobility Planning (SUMP)

SUMP is a comprehensive transportation policy planning concept recommended by the European Commission as a basis to develop urban mobility in a sustainable way. It aims at satisfying the transport needs of people in urban areas (Cadar et al., 2017). Cities that consider urban planning concepts in a holistic way are able to improve their efficiency and air quality, improving people's lives in the process (Camagni, Gibelli, and Rigamonti 2002). The main aim is to provide a basis for improving the quality of life of all citizens by addressing challenges such as congestion, air/noise pollution, traffic accidents and disorderly parking in an efficient way (European Commission, 2021). Already in 2013, the United Nations Human Settlements Programme published a global report on "Planning and Design for Sustainable Urban Mobility", which explains, among other things, the urban mobility challenges, defines the current state of urban passenger transport in developed and developing countries, shows reference examples around the world, puts urban planning in the context of mobility, emphasizes equitable access and affordable urban mobility and considers environmental and economic aspects (Un-Habitat, 2013). Finally, the governance framework should facilitate urban mobility towards sustainability. In addition to intragenerational equity (equity between different population groups within a region / country, but also between countries), a SUMP must also focus on intergenerational equity (equity between current and future generations) through long-term goals (Arsenio et al., 2016).

SUMP is supported and financed by the EU Horizon 2020 (European Commission, 2012) program which focuses on research and innovation towards sustainable development in order to reach the overriding aim of the "European Green Deal" (European Commission, 2019a). The basic concept of SUMP is also briefly described in the ANNEX of the European Commission (European Commission, 2013). In addition, comprehensive information is

provided in cross-national exchange via the platform "Eltis − The Urban Mobility Observatory" with various guidelines and specialized concepts (Eltis, 2019b). Eight crucial principles for a successful SUMP are defined: (1) Plan for sustainable mobility in the entire "functional city"; (2) Define a long-term vision and a clear implementation plan; (3) Cooperate across institutional boundaries; (4) Develop all transport modes in an integrated manner; (5) Involve citizens and stakeholders; (6) Arrange for monitoring and evaluation; (7) Assess current and future performance; (8) Assure quality.

Based on the SUMP evaluation[34], it is shown in which areas the important processes and topics are already sufficiently covered and where there is still a need for action. In addition, useful tips for improvements are displayed for all areas, reference examples ("Good Practices") are shown, a hint to further concepts and detailed descriptions is provided, and tools are shown that can support the various steps across all areas. In addition, there are specific guidance documents for the various technical topics, such as the integration of shared mobility in SUMP (Arndt et al., 2019).

The effective integration of a SUMP concept can make a significant contribution to sustainable mobility, for instance by improving air quality (Pisoni et al., 2019). Indeed, the phased approach is very comprehensive, but also complex based on a classical project approach. It is important to break up the historical bureaucratic structures and to pursue innovative approaches. For instance, based on a digital government strategy, a dynamic adaptive policymaking system can be created that takes into account the learning curve based on continuously gained experience, thus creating a continuous improvement process towards an effective, practice-oriented, and flexible political framework (Jittrapirom et al., 2018; Parcell & Holden, 2013). In doing so, policymakers can draw on practical experience from the agile working environment of the free economy, and also take into account the needs of citizens in a targeted manner. One of the overarching objectives is to reduce the bureaucratic hurdle for private individuals, but also for companies, and to improve and sustain cooperation between public and private institutions. Lessons can also be drawn from the recent experience of the Covid-19 pandemic, in which there have been negative examples where governments around the world have been unable to respond quickly, flexibly, and appropriately to emerging situations (Janssen & van der Voort, 2020). Experience can be drawn from this and adapted to the field of mobility on the basis of a disruptive approach. Another option is to use the internet

[34] The results described are based on an exemplary evaluation performed on the Eltis platform on January 26, 2021.

to engage directly with citizens, using blogs, as practiced by the British government (Ollerhead, 2015), or social media to explore the benefits of more agility in politics. The aim should be to create an administration that is simple and technology-led to reduce bureaucracy.

Neither a purely top-down form of government to enforce development, nor completely leaving the matter to the free market without prescribing any framework, are promising for the introduction of technology-led mobility offerings like MaaS. Not taking into account the interests of citizens on the basis of a top-down approach has already proven unsuccessful before on the basis of the reference examples in smart cities. Based on various governance mechanisms, a combination of the approaches of "governing by enabling", "governing by doing," and "self-governing" is certainly goal-oriented in order to establish MaaS efficiently and sustainably (Audouin & Finger, 2019). For the business model development of MaaS, the legal framework should be designed in such a way that the social and environmental benefits are prioritized instead of primarily maximizing the short-term profit of market participants (Wong et al., 2020a). In addition, specified measures must be implemented, such as the provision of standards for the interoperability of various interfaces. Moreover, measurable indicators should be constantly checked for their effectiveness on the basis of a monitoring system, so that specifications and measures can be adjusted interactively.

Finally, clear sustainability goals must be formulated, financial support and subsidies must be provided, and cooperation with educational institutions such as schools and universities, research institutes, and private-sector companies ("private-public partnership") must be established. This must take place at all levels, from legislation to the level of cities and municipalities.

CHAPTER 2
IRRATIONALITY OF TRANSPORT BEHAVIOR

This study focuses on understanding the urban mobility behavior exhibited by different generations. This requires a literature review on how these behaviors evolve and what factors underlie them. To understand behavior, it is important to examine the driving force that leads as a factor behind consumer decision-making when choosing a mode of transportation in urban areas. Both in the literature and in practice, the primary focus is on the analysis of consumer behavior with the determination of individual responses to satisfy consumer needs and wants. In this process, the consumer identifies the problem to be solved or a certain desire, search for information, classify the options available on the market, draw a conclusion, and select a product or service that best fits his requirements.

Different models can be used to study consumer behavior. Their underlying theories explain what influences the decisions by consumers to purchase certain products or use services and leave out the rest (Tversky & Kahneman, 1981). Human behavior involves all the thoughts, feelings, actions, and decisions that an individual makes and relies on factors like social norms, attitude, core faith and culture. Behavioral economics combines sociology and psychology to understand human behavior (Thaler, 2018).

There is no uniform differentiation between classical and modern behavior models in literature. However, since most of today's consumption behavior analyzes are based on the models developed with the beginning of the 1970s and 1980s, these are distinguished from the classical ones as modern behavior models. In addition to some further developments, however, it also shows that the findings from the classical behavioral models still play an essential role and are reflected in the modern behavioral models.

After providing some basics, the classical models described in the following start in the 18th century and continue until the end of the 1960s. The modern models discussed were developed and often revised around the 1970s and later. Ultimately, current trends and influences enhance the perspective when applying certain models to contemporary practice. This ultimately serves as a basis for the extent to which these theories and models can help to examine today's mobility behavior.

2.1 Classical Consumer Behavior Theories

Influence on Consumer Behavior derived from Traditional Economic Thoughts

Leading economists, such as Adam Smith (1723-1790), Alfred Marshall (1842-1924), John Maynard Keynes (1883-1946), and Milton Friedman (1912-2006), held varying views on what factors influence consumer behavior.

Smith (1776) argued that the behaviors of consumers are motivated by self-interest. He further argued that the ability to identify with a group of people is an essential component of self-identity and an important psychological benefit, which Smith refers to as the special pleasure of mutual sympathy (Dasgupta et al., 2016). Rosenberg (1968) argued, based on a more detailed analysis of Adam Smith's Wealth of Nations, that the relationship between demand and the impact of the availability of new goods on household behavior were crucial determinants and thus influential factors in the development of wealth in different nations.

Neoclassical economists, such as Alfred Marshall and Wilfried Pareto, put forward two basic assumptions in neoclassical theory: (1) decisions are made rationally as long as full information on the benefits of the product or service is available to the consumer (Simon, 2000), and that (2) people maximize expected utility, hence acting in their best interest, which means consumers strive to make purchasing decisions of goods and services that maximize their satisfaction (Teraji, 2018). Moreover, the Marshallian economic model indicates that buyers tend to purchase products that offer them higher satisfaction in reference to their preferred tastes and yet a fair price. The Marshallian surplus (Jacobsen, 1979) describes the difference between the just acceptable price and the actual market price. This means that if a supplier is able to offer a product or service at the market price, which is lower than the accepted price of the customer and exceeds the cost price (considering further costs such as dealer commissions etc.), a profit can be achieved. If a competitor can offer the same quality of a substitute product for a lower price, its sales figures increase. If the income of the buyer is higher, then the sales figures are higher as well. The Marshallian model hypothesizes that the product with the lower price will generate the most sales, assuming that it is not an inferior product.

Dardi (1991) indicated that the Marshallian theory relies on the economic growth doctrine developed by Smith which examines humans who acts through self-interest. Marshallian economics examines how a change in a single variable, such as the price of a product, impacts the behavior of an individual. Morisugi et al. (1995) investigated Marshallian

economics, which rely on money as the common denominator of psychological needs and compare the value of satisfying certain needs in terms of cost. Keynesian economics, on the other hand, indicate that the consumers' decision-making is influenced by uncertain expectations, which include the risks of making a particular choice. Schettkat (2018) observes that this economic model also recognizes the consumers' desire to practice their norms and routines in making choices.

In the theory of monetarism, Friedman argued that if the economy is based on free trade, the government should have less regulatory power, which also leads to an increase in the money supply and thus has a positive impact on the welfare of the population (Lothian, 2009). Moreover, Friedman argued that consumers' savings and consumption decisions depend on permanent, rather than temporary, changes in income levels. Nowadays, based on the financial monetary policies of many countries in the Western world with their central banks, such as the Federal Reserve (FED) in the U.S. and the European Central Bank (ECB), and with further emerging crises with an increasing spread between rich and poor, there is growing criticism of policies based on the theory of monetarism (P. Bolton, 2020).

The Veblenian Social-Psychological Model

The Veblenian social-psychological model is based on the findings of Thorstein Veblen (1857−1929). It is influenced by social anthropological science, which defines a human as a social being who lives according to the cultures and customs of his social environment (Karoui & Khemakhem, 2018). Sociology is dealing with the study of society, where people’s individual needs and desires are created and influenced by group membership and the social environment, which in turn affects their behavior (Dasgupta et al., 2016). Veblen focused his theory on members of the "leisure class" of society, who he believed were influenced more by the desire for prestige than by the fulfillment of utilitarian needs. Daniela (2011) argue that the model conceives of humans as social animals who adhere to the norms of their own culture and to the norms of subcultures in which they feel they belong.

Relationships and dependencies with family, friends, relatives, colleagues and society play an essential role in determining people's behavior. In addition, there is influencing factors from interaction, for example, with political parties, sports clubs, religious associations, etc., which can have a varying impact on one's attitude and behavior depending on the intensity of the connection. In addition, social behavior is influenced by age, gender, education level and other personal parameters like knowledge, the personality of the individual, childhood

experiences, and the individual's goals. Social factors also include religion, culture, background, social class of that individual, as well as ethical variations (Santhosh, 2018).

Veblen's theory still proves useful today, as, for example, a product or service can be better positioned if social influences are better understood.

Pavlovian Learning Model

The Pavlovian learning model, also known as classical conditioning, was founded following the experiments performed by Ivan Pavlov (1849−1936), a Russian psychologist. In this experiment (conducted between 1904 and 1910), feeding a dog was always associated with the ringing of a bell. Pavlov discovered that ringing the bell induced the dog's salivation, regardless of whether food was offered to the dog or not (Finch, 2002). The theory explains how a passively learned, low-involvement associative process results in automatic responses or habits, generated primarily by the repetition of reinforcement (reward) or avoiding threats of responses (Garcí-Hoz, 2003; Pearce, 1987; Pearce & Hall, 1980). From the view of Evans & Rilling (2000), it is through association that learning occurred with human behavior, being conditioned the same way as the dog's process to salivate. Pavlov's theory concluded that much of human behavior results from conditioned reactions.

Pavlov's learning model includes the following five concepts: (1) Drives: internal states of tension activated by unmet needs and desires. Drives include primary biological drives (needs) such as hunger and thirst, and secondary learned drives (desires) such as affiliation, self-esteem, power, and achievement, (2) cues (stimuli): environmental stimuli received through the five senses (sights, sounds, smells, aromas, and tactile stimuli), (3) association: a linkage between two or more stimuli, (4) reactions: a person's response to the cue(s) in an effort to reduce the drive. This includes observable behaviors such as talking and waving as well as unobservable responses such as thinking or learning, and (5) reinforcement: a reward that results from a response to a stimulus that leads to a reduction in drive (Plaud, 2003). Reinforcement increases the likelihood that the behavior is repeated to obtain the reward.

Later, experimental psychologists, including John Watson, continued the research method introduced by Pavlov by including, for example, behavior related to learning, forgetting, and discrimination (Daniela, 2011). As a result, they were able to define a stimulus-response model that examines human behavior based on key concepts such as cue, drive, reinforcement, and response.

The Freudian Psychoanalytical Model

The Freudian psychoanalytic model of Sigmund Freud (1856–1939) profoundly influenced the ideas of humans behavior of the 20th century. Freud argued that psychological forces that shape the behavior of people are largely unconscious, which then results in people being unable to fully understand their motivations (DiClemente & Hantula, 2003). As people grow, their psyche tends to remain the source of drives and urges. These drives and suggestions influence the behavior of consumers to want to obtain a particular product.

Freud developed a topographical model of the mind, whereby he described the features of the mind's structure and function. Freud used the analogy of an iceberg to describe the three levels of the mind. The consciousness is only the tip of the iceberg that rises out of the water and is the mental activity we know about (Green, 2019). It comprises thoughts and perceptions. The majority of the mind is "below sea level", making it invisible from the outside (Sibi, 2019). The preconscious includes things that humans could perceive if they wanted to or tried to. It consists of memories and stored knowledge. Below that level, the unconscious layer includes things humans are not aware of and cannot be aware of and is the most important part of the mind. The unconscious acts as a kind of repository of primitive desires and impulses (e.g., sexual and aggressive impulses), held and mediated by the preconscious realm.

The Freudian psychoanalytical model is based on three concepts: the id, the ego, and the superego, each of which is responsible for different behavioral expressions (Daniela, 2011). The id is part of the unconscious mind and comprises two instincts: Eros and Thanatos. These originate from Greek mythology and stand for life and death instincts. They comprise things such as fears, violent motives, selfish needs, irrational wishes, immoral urges, as well as shameful and traumatic experiences. The unconscious is a memory from which one's personality has emerged. The ego is the link between the id and the superego, which is responsible for transforming drive expressions into socially accepted behavior. The drives are often repressed from consciousness by denial or by their transformation into socially accepted expressions, but they cannot be completely eliminated or controlled and may appear in the form of various manifestations.

Subjective Probability Approach and the Expected Utility Theory

Frank Ramsey's subjective probability approach disagrees with the view taken by Keynes that the subjectivity of probabilities does not matter so much. In Ramsey's view, probability is related to the knowledge of each individual and not to a disembodied body of

knowledge (Ramsey, 1928). Thus, there is an objective relationship between knowledge and probabilities. Ramsey's subjective probability approach examines the difference between the concepts of probability in logic and physics. The concepts of subjective probability are due to personal beliefs formulated by individual knowledge about probabilities. Thus, the conclusions of subjective probabilities are based on the observations of an individual's personal beliefs.

Neumann-Morgenstern's utility theorem (1947) acts as basis for the expected utility theory and shows that, in certain instances, an individual making decisions and facing risky outcomes behaves in a certain way to maximize their expected value over the potential outcomes in the future (Abdellaoui, 2002). In decision theory, subjective expected utility is used to determine how a possible outcome is perceived as a risk when making a decision in the present. Thereby, the characteristic of individual behavior is axiomatized on the basis of Leonard Jimmie Savage's subjective (personal) expected utility, which leads to an extension to include the personal utility function and a personal probability distribution. Savage's scientific work is based on the previously established foundations of Ramsey and Neumann.

Savage's subjective expected utility includes factors such as aversion to uncertainty or ambiguity (J. Zhang, 2002). According to Savage, it is problematic when an expected outcome is potentially ambiguous since a possible deviation sheds new light on the action previously committed and might have influenced the decision. The subjective expected utility expresses that preferences should be used in evaluation only when all possible outcomes are unambiguous. The key point in Savage's theory is the state, the events and the consequences that occur on the basis of a decision and resulting actions.

The key points in Savage's theory are the state, action, and the consequences that occur on the basis of a decision. According to this theory, rational individuals choose among particular options when faced with a complex situation with the help of preferences and their risk appetite (Stuart et al., 1987). An individual compares the expected utility values when choosing between risky prospects (Binmore, 2017). The theory defines the sum of the products and utility over all possible outcomes. From what Savage argues, decision-makers have beliefs that influence their choice of behaviors. The model associates the degree to decide with the beliefs developed from making repeated trials. Gilboa et al. (2020) indicates that an accurate description of all relevant uncertainties with their defined causal relationships between the measurement procedure and the measured phenomenon are not fully observable. Therefore, decision problems can be constructed to show preferences over actions, but further models in combination or extension

to Leonard Jimmie Savage's expected utility theory must be applied for a coherent type of decision-making.

Maslow's Hierarchy of Needs

One of the most known theories regarding human behavior is Maslow's hierarchy of needs, which was introduced by Abraham Harold Maslow (1908−1970). It helps to define and rank human needs and demands. This theory suggests that people are motivated to fulfil basic needs before they move to others that are considered more advanced (McLeod, 2018). The main idea behind Maslow's hierarchy theory is that a human need, such as the need for leisure, as long as it is not satisfied, will always dominate and influence human behavior to strive for that need until it is satisfied. Only when a lower-tier need is fulfilled, humans will look to satisfy higher-tier needs.

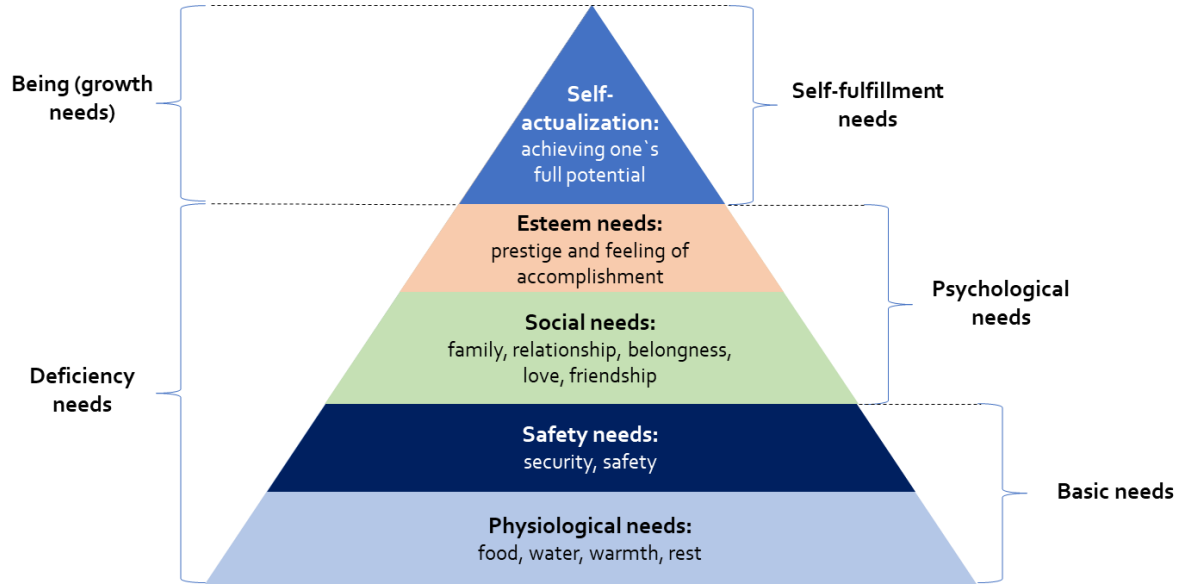


Figure 4: Maslow's hierarchy of needs

Source: Own representation based on (Hopper, 2020; A. Maslow, 1987; A. H. Maslow, 1954)

Maslow's Hierarchy of Needs identifies five levels: (1) The physiological needs that comprise at the lowest hierarchy level of the basic amenities of life, including air, water, food, shelter, and clothing; (2) Needs for safety, including environmental, physical, and emotional safety and protection. (3) Social needs that includes family, love, affection, belonging, friendship, and care; (4) The esteem needs, such as the prestige from owning a luxury car or a nice house, but also achieving a certain career or position in a company or building one's own successful venture, thus achieving financial independence; (5) The self-actualization need

involves living up to one's potential, including creative development, and achieving all that one is capable of (Hopper, 2020; Júnior et al., 2018).

The first two level of physiological and safety needs represent the basic needs which are mandatory to be fulfilled by every human, before striving for the next hierarchy of needs within the pyramid. The third and fourth level of belongness and love need as well as the esteem need are defined as psychological needs. The first four levels of the pyramid are referred to as deficit needs, and the top level of "self-actualization" is referred to as growth or being needs. Deficit needs arise because of deprivation and are intended to motivate people when they are not met. Moreover, the longer such needs are denied, the stronger the motivation to fulfill them becomes. As soon as these needs are fulfilled, motivation decreases. Only the last hierarchy level corresponds to the so-called being (growth) need, where the opposite is true, and motivation increases when this need is fulfilled. The prestige needs from the fourth level can also be less material, such as starting a family, inventing something, or completing a sporting challenge.

In an adapted version of the pyramid of needs, Maslow divided the level of self-actualization into four different areas: (1) the cognitive need for knowledge and education, understanding of the world, curiosity and exploration, (2) needs on the beauty, balance, aesthetics, etc., (3) the self-actualization needs established earlier with the realization of personal potential, search for personal growth with the desire to "become all that one is capable of"; and finally (4) transcendence needs motivated by values that go beyond the personal self and limits such as questions about the meaning of life, the desire to do something good etc. (A. H. Maslow, 1961, 1970).

In addition, to reach the next hierarchical level in the pyramid, not all needs within a level necessarily have to be met (A. Maslow, 1987). Nevis point out that there can be different interpretations of the different levels and their variables of Maslow`s pyramid of needs when observing people from different cultures and places in the world, and generalization is difficult (Nevis, 1983). Maslow (A. Maslow, 1987) clarified that the order of needs can be flexible depending on external circumstances or individual differences. For example, he notes that for some people the need for self-esteem is more important than the need for love. For others, the need for creative fulfillment may supersede even the most basic needs. Especially in today's prosperous society, there is often a tendency for people to work for a certain status and career, but after reaching their goals, dissatisfaction sets in and the desire for change and self-

realization emerges. The validity of the model depends on various factors such as language, cultural practices, and symbolic meanings.

2.2 Modern Consumer Behavior Models

Besides the common focus of science on individual decision-making, more recent studies broaden the perspective. They also investigate the interplay between social aspects, different cultures, the social environment as well as personal circumstances in practice (Cairns et al., 2014).

Prospect Theory − Review in the Context of Consumer Decision-Making

The prospect theory (1979) by Daniel Kahneman and Amos Tversky is defined as a psychological choice theory that applies in behavioral economics and behavioral finance (Kahneman & Tversky, 2018). They first investigated the apparent human behavioral anomalies and contradictions. Their theory describes how decisions are made in situations with individually assessed risk. When people are offered a choice in a particular way, they want to avert a risk that may arise (Tversky & Kahneman, 1992). The theory finds wide adoption in empirical studies of decision behavior in gambling, where alternatives are distinguished in terms of probability of occurrence in the context of a possible monetary gain (Barberis, 2012). Nowadays, it is applied in particular in behavioral economics.

The understanding of individual risk behavior depends on the estimated certainty of an event occurring. As a rule, individuals behave in a risk-averse manner and, in the case of positive events, prefer to receive a smaller but more certain gain. If the chances of a higher gain are possible, but with an individually overestimated risk, they tend to refrain from doing so. Still, when the same choice is formulated differently and offered to them, they tend to change towards risk-seeking behavior (Kusev et al., 2019; Walther & Münster, 2021).

When faced with a possible negative experience, people are generally reluctant to accept a certain loss, so in this case they are more risk averse. A possibly much higher loss in the future is accepted as a consequence. This is often evident in stock speculation, where individuals accept an increased loss in the hope that the price will point back to the profit zone instead of exiting in time with a small loss and reducing the risk of loss. The result is an S-shaped value function of the decision makers, which is concave in the positive range and convex in the negative range (Broll et al., 2010; Paddock et al., 2015). The theory finds that when individuals

are given two choices that both will end up with the same results, they will choose the one that will give them a greater perceived gain (Jhala et al., 2019).

Based on the results of controlled studies, individuals tend to assess the loss and gain perspectives in a manner considered asymmetric. These are aspects that influence the behavior of people in the market when they want to purchase a product or use a certain service. In addition, the so-called endowment effect affects behavior, stating that people tend to value a good more when they own it than when they do not (Kahneman et al., 2011; Svirsky, 2014).

Satisficing Model according to Herbert Simon

The satisficing model according to Herbert Simon (1916−2001) argues that utility is the satisfaction that a consumer gets when consuming a certain good or service (Graham & Isaac, 2002). The total utility is the number of units a consumer gains in a given period of time from consuming a good, service, or activity. The greater the level of a consumer's total utility, the greater the level of satisfaction that consumer is gaining (Ekström et al., 2017).

Herbert Simon's satisficing model shows that humans undergo three stages when making decisions. These are: the intelligence phase, in which one gathers information about a decision; the design phase, in which one decides how to make the decision; and finally the selection phase, in which one commits to a solution by applying the design. When an individual is deciding, they usually have an objective that is driving them toward a certain goal (Cruz-Cárdenas & Arévalo-Chávez, 2018).

Another factor that has not yet been considered on the basis of economic decision theories with reference to bounded rationality is the question of whether and how emotions influence decision-making (Hanoch, 2002; Sonne Nørgaard, 2018). In this context, they influence a large number of decisions we are confronted with on a daily basis. Therefore, if one wants to make an objective decision, one should learn as much as possible about one’s emotions and their impact on decision-making.

Another aspect that influences people's mood and emotions is the environment (Schwartz & Cuadros, 2017). For example, research has shown an increase in consumer spending when there is good weather (Murray et al., 2010). Seasons also affect consumer's decisions.

Howard Sheth Model

The Howard-Sheth model (1969) posits that psychological and social influences constrain buying behavior even in the case of incomplete information (Farley & Ring, 1970). The model conceptualizes all aspects that influence a purchase decision, the evaluation and the reaction to a product or service of the consumer at a given time (Vijay & Kumar, 2020). In the model, certain variables are influenced by each other. For example, the Howard-Sheth model illustrates that attitude influences purchase via intention (Hunt & Pappas, 1972). It analyzes, moreover, external symptoms of behavior, thought processes, and reactions that are not directly observable.

The model assumes that the consumer behaves rationally when buying, that the process is repeatable, and that it is the result of incentives as influencing factors that originate in the environment (input variables). It categorizes these influences as hypothetical constructs and theoretical variables that play a central role in a conceptual process consisting of five parts: stimulus inputs, exogenous variables, perceptional constructs, learning constructs, and response outputs (M. Evans et al., 2009; Farley & Ring, 1970).

Stimulus inputs result from the way a consumer is approached as well as the social environment (Zeithaml, 1988). These include significant stimuli (features of a product or service such as price, quality, product distinctiveness and accessibility), symbolic stimuli (impacting verbal or visual features on the consumer), and social stimuli (social environment such as family, workplace, friends, and society). The social stimuli cannot be controlled by a service or product provider. The way the buyer perceives and understands these stimuli in particular has a fundamental impact on the decision-making process. Thus, it builds the baseline for the hypothetical construct with the psychological variables that influence consumer behavior abstractly and not directly during the decision-making process. A further distinction is made between perceptual and learning constructs. Perception refers to attention to stimuli and sensitivities as well as receptivity and blocking of information. The learning is the attitude, the opinion as well as the knowledge of a consumer, which influence his evaluation and thus the decision. The perceptual construct assumes that when the buyer is exposed to the marketer's message through advertising, they experience an attentional response that depends on their sensitivity and receptivity to the stimuli in question. However, not all information can be successfully conveyed, sometimes resulting in message uncertainty or "stimulus ambiguity" (Uekermann et al. 2010). This information gap can influence a buyer's reaction to the

information search and consequently trigger a perception bias when the personal search is misunderstood or distorted to conform to established beliefs and the social environment.

Response outputs are the effects on decisions about a purchase of a product or perception of a service based on consumer preferences. Overall, the following steps are involved: (1) attention: scope of information taken in after the buyer is exposed to a stimulus, (2) brand awareness and perception: scope of information actually processed and stored in the buyer's memory, (3) attitude: formation of attitude toward products; (4) intention: decision to buy or not to buy a particular product; (5) the actual behavior based on the decision leading to the purchase or non-purchase.

Figure 5 illustrates the Howard-Sheth model by depicting the processes and interdependencies with the environmental factors of buying behavior explained previously. Thereby, the social and cultural characteristics affect the various elements from motive to attitude to intention.

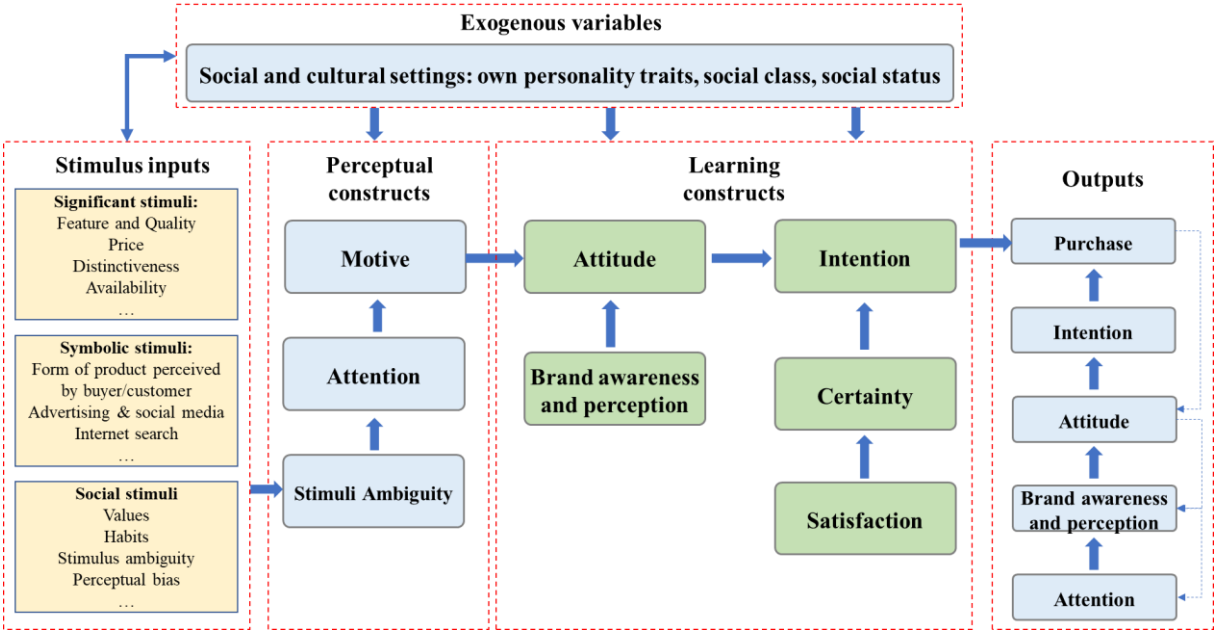


Figure 5: Howard Sheth Model

Source: own depiction adapted from Howard and Sheth (Howard & Sheth, 1968)

In addition, other exogenous variables (not covered by Howard and Sheth) have an important influence on the decision. These include the individual value of a product or service for the consumer, personal character traits, membership of a social group, financial purchasing power and any associated time pressure related to the urgency of a particular need.

A study by O'Brien (1971) revealed that attention causally precedes attitude and intention, and attitude and intention were each causally precedes purchase. The model of Howard and Sheth can also be enriched with the five stages of a consumer buying decision (Perreau, 2014; Stone & Desmond, 2007). Starting with (1) the "need recognition", which is driven to action by a need or desire, via (2) the phase of collection of data for alternatives, (3) evaluation of alternatives including their advantages and disadvantages, (4) making the purchasing decision, and rounding up the model with (5) the "post purchasing behavior". The latter point can be considered with the after sales services and marketing campaigns to retain the customer in the long term.

Theory of Reasoned Action and the Theory of Planned Behavior

The theory of reasoned action (TRA) was developed in the late 1960s by Martin Fishbein and Icek Ajzen. It is concerned with how the pre-existing attitudes and behavior of an individual play an important role in the process of making decisions and, therefore, can predict the individual's decision (Pookulangara et al., 2011). The theory was developed following the traditional attitude measures' failure to predict behavior. Hence, it was an improvement over information integration theory. Initially, Ajzen (2012) stated that this theory is based on the idea that the most efficient and simplest way to predict consumer behavior is to find out whether the person would actually perform a certain behavior. Thus, this theory considers the behavioral intention or attitude as the key towards a person displaying certain behaviors (Fishbein & Ajzen, 1975).

Shimp & Kavas (1984), who examined this theory, argued that the core of this model is based on the circumstantial evidence that the consumers tend to act on their behavior based on their intention to obtain an anticipated outcome. Hale et al. (2002) supported this rationale by assuming that consumers in this case are considered as rational agents who act in what they perceive to be in their best interest. A consumer only takes a specific action when a specific outcome is expected. From the consumer's decision to the end of the action, the consumer retains the possibility to change his mind and choose a different approach.

Overall, the behavior intention influences the actual behavior. The determinant of intention consists of the attitude towards performing a certain behavior, which is enhanced with the subjective norms associated with this behavior. Hence, influencing "background factors" also play a role for the individual behavior, such as general attitudes to certain topics, personal values, traits, emotions, intelligence, age, gender, education, income, religions, experience,

knowledge etc. The personal attitude towards behavior assumes that based on a personal belief, an expected positive or negative outcome will occur. This is supplemented by the subjective norm, also expressed by the "normative pressure", which explains the pressure and expectation expressed by society, more precisely by the people around somebody like family and friends. They can affect how someone is motivated to comply, based on positive and negative norms and how they agree or disagree with a certain behavior. The TRA was originally developed to predict voting behavior and is thus a non-repetitive process as the context changes. This led to the criticism that the model is not suitable for predicting behaviors that are continuous or repeatable (Mohanachandran & Govindarajo, 2020; K. Singh et al., 1995). After applying the TRA in practice, it was revised and enhanced by the determinant of the perceived control over the behavior and therefore provided a more holistic approach, which resulted in the theory of planned behavior (TPB). The perceived control explains how an external influence can affect an individual's perceived control, thus influencing decision-making intentions and behavior (Ajzen, 1991). It thereby encompasses the extent to which an individual can exercise control over a behavior.

Sutton (2001) investigated the further development of the TRA to the TPB considering that multiple behaviors cannot be performed simply at will, but require skills, resources, and opportunities for them to be successfully executed. In the extension of TPA to TBP, perceived behavioral controls are included that are of a less volitional nature. When attempting to influence an individual's behavior, persuasive messages can be constructed to change the components of the theories (TRA and TBP). In doing so, persuasive appeals may attempt to change belief strength, belief evaluation, normative beliefs, motivation to comply, control beliefs, or perceived power (Hale et al., 2002). Normative beliefs and behaviors are derived from social norms and socially accepted behaviors. In this process, choices or decisions can be decomposed into probabilities and preferences, which consist of a combination of beliefs and preferences (van der Pligt 2015). A similar aspect of these models is that they are based on the assumption that individuals are able to make decisions that are logical and reasoned. By evaluating the available information, certain behaviors are achieved.

The main elements and differences of the TRA, TPB and IBM are depicted in Figure 6.

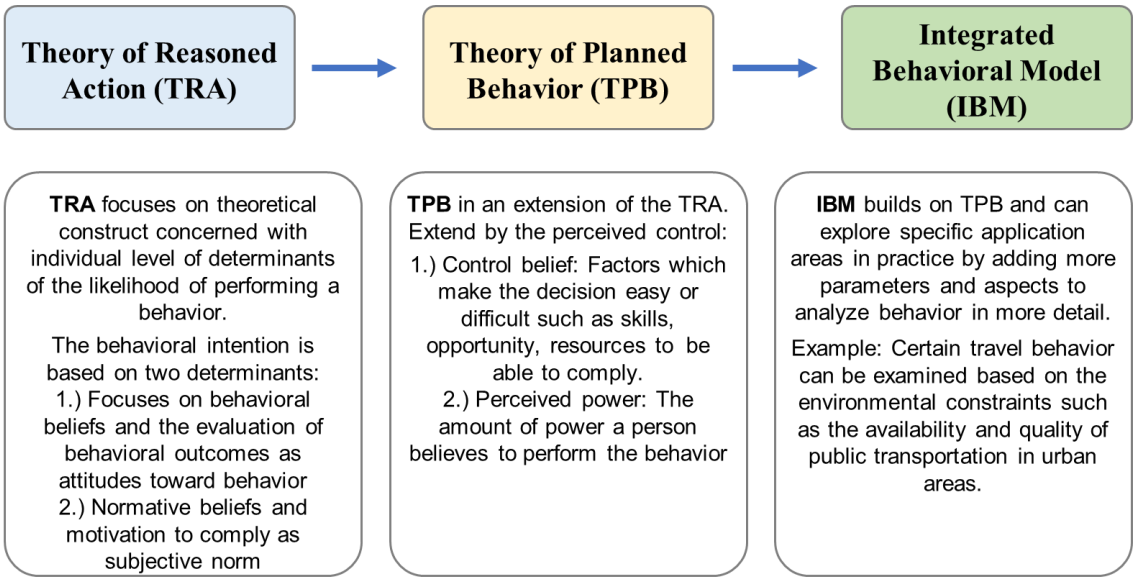


Figure 6: The main elements and developments from TRA to TPB and IBM

Source: Own illustration based on Hale et al. (2002); Shimp and Kavas (1984); Sutton (2001)

In the real world, the decision someone is going to take depends on the control beliefs and the perceived power, which together end up in the perceived control.

The degree of control belief depends on the factors such as capabilities, opportunities, resources, etc., and thus influences the desired behavior. Perceived power refers to the existence of factors that can facilitate or impede the performance of a behavior. It contributes to a person's behavior and ultimately to decision-making (Staats, 2004; Sutton, 2001). When a person's behavioral intention is positively influenced by high control beliefs, but perceived power is low, then individual perceived control and inhibits decision-making behavior.

The theory of TPB predicts that a positive attitude towards the act or behavior, positive social norms and a high level of perceived control are the best predictors forming a behavioral intention and ultimately lead to a display behavior or act.

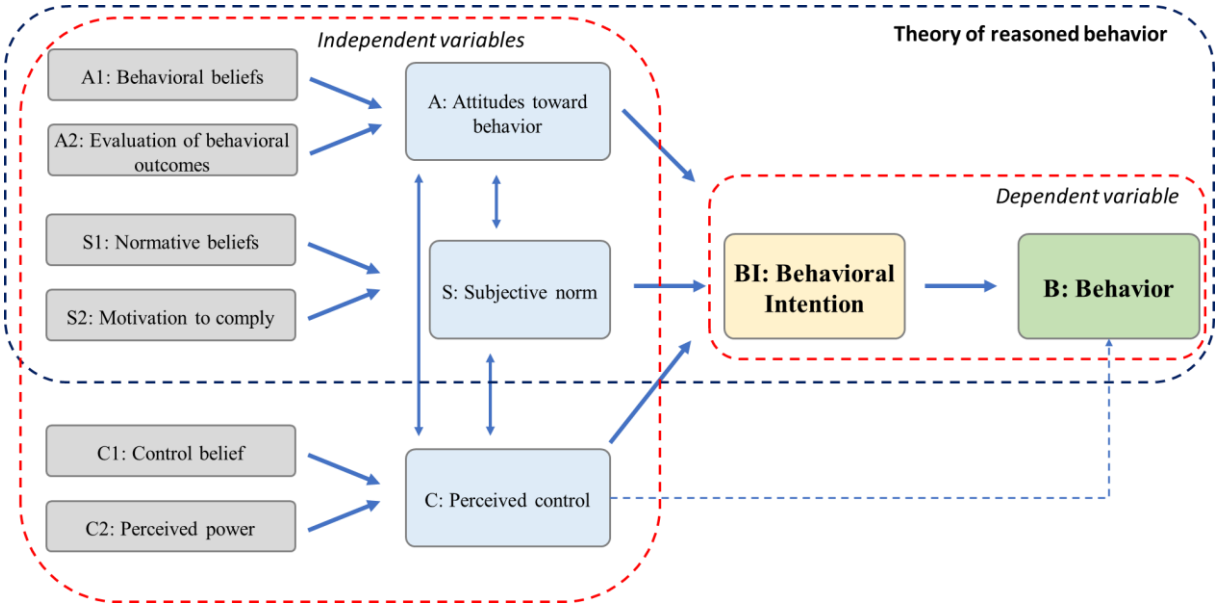


Figure 7: Basic construct of the theory of planned behavior (TPB)

[Source: Own illustration]

The complementary third factor in TPB versus TRA is perceived control over behavior (C), as indicated by self-efficacy or the capability to perform the intended behavior. This is defined as the subjectively perceived difficulty or ease of performing a behavior.

The TPB has a wide range of applications in practice. According to an analysis by Bosnjak, Ajzen, and Schmidt (2020), the TPB model has been applied in fields such as environmental health research, educational research, science, as well as business and management. Research examples include alcohol consumption and its impact on health, as well as observations of voter behavior, which allow conclusions to be drawn about the form in which the targeted electorate should be addressed. The mood of the population regarding membership in the EU can also be analyzed in this context.

The integrated behavioral model (IBM) is de facto not a separate or enhanced model that can be used universally. Rather, it offers the possibility of adapting the TPM model to a specific industry and field of application with the incorporation or adaptation of certain parameters or perspectives. Examples of this are the behavior of citizens in elections (Holbert et al., 2021) or research on the background of behaviors of different population groups in the field of health care (McAfee et al., 2019). It can also be applied to the analysis of consumer behavior of young people, who have been raised in the digital world with internet and mobile devices readily available, to extend the model with technology self-efficacy (Kahawandala & Peter, 2020a).

Engel-Kollat-Blackwell (EKB) and Engel-Blackwell-Miniard Model (EBM)

This theory (developed between 1968 and 1972) examines the behavior of consumers as a decision-making process composed of five steps or activities that occur within a particular period. According to Engel et al. (1995), this decision theory include related variables separated into various categories that include components such as information input, information processing, product-brand evaluation, internationalized environmental influences, general motivating influences and other variables impacting the decision process (Stankevich, 2017). According to Huang (2007), the five stages that define how consumers make purchase decisions (decision process) include recognition of the problem or need, searching for information, evaluation of alternatives, purchase choice, and final outcome. Fasi (2017) examined this theory, indicated that consumers tend to define what is ideal for them where they are influenced by internal stimuli.

In 1990, the EKB model was revised to the Engel-Blackwell-Miniard Model (EBM), resulting in some changes among the different variables / components (Mehta et al., 2020). Besides the addition of personal influencing factors such as consumer resources and personality combined with other variables like motives and lifestyle, the different interdependencies between those variables were considered extending the model to a more comprehensive approach.

As depicted in below, the EKB model can be clustered into five domains. The first step, the information input, is that consumers remember the (marketing) materials they see. Various stimuli, such as advertisements on TV and magazines and social media, can be induced as input variables. This information can be absorbed by the consumer, who then begins to process this information. Once the consumer has collected the data, they proceed into information processing, where they compare the obtained data with previous experiences and expectations (Blackwell et al., 2001).

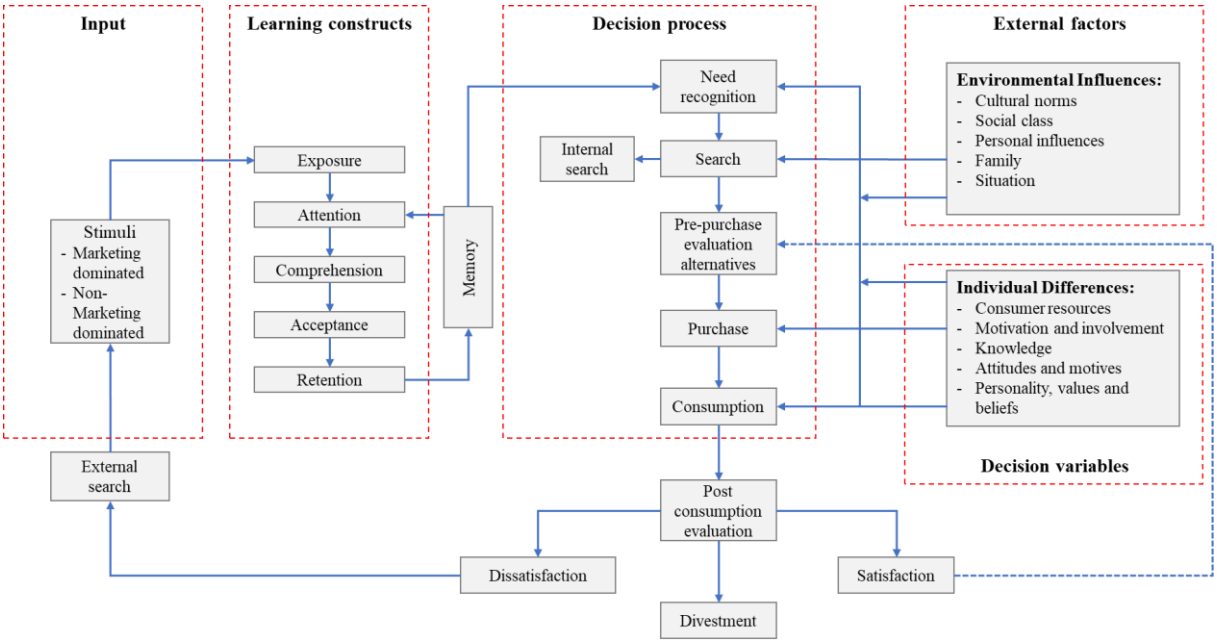


Figure 8: Engel-Blackwell-Minard Model

Source: own depiction adapted based on the EBM model by Engel, Blackwell and Minard

After the consumer has gained a certain level of attention and is able to understand the benefits of a particular product or service, they then go into the decision phase after a certain period of reflection and decide to buy or not to buy on the basis of rational insights. Just in the case the consumer is not generally averse to buying a product or using a service, the acceptance and the retention phase is leading to the circumstance that the product or service is remembered. However, memory comprises a wide-ranging spectrum. It involves information about the characteristics of a product or service, but also about its brand and about competitors. Knowledge about the specific benefits and the right timing are also important. Thus, a consumer may postpone a purchase decision because they assumes that the price will drop in the future.

Through the stored information, the consumer is now in a position to search for and evaluate possible alternatives. This is preceded by the recognition of a problem or a need that must be satisfied. After various alternatives have been weighed up, a purchase is made, which ultimately leads either to satisfaction or dissatisfaction, depending on how strongly one's own needs have been met by the product or service. The duration of use or the renewed purchase of a product or use of a service depends on the degree of satisfaction. Depending on experience, the consumer tends to trust a specific seller or a particular brand.

The various elements of the decision-making process are influenced by a number of decision variables and external factors. The decision variables differ for each individual and depend on the actual (time and financial) resources, the strength of the motivation to satisfy a

need, the personal attitude, value and belief etc. The attitude involves the willingness to evaluate possible alternatives with their advantages and disadvantages. Needs are the main variable of motivation, which influences all stages of the decision-making process. Activated needs, defined as a perceived difference between an ideal state and the present state sufficient to activate behavior, result in stimulated behavior or drive that is channeled toward specific goals and results in an incentive. Personality, values, and beliefs are the subject of psychological research, which focuses on individual traits, values, beliefs, and preferred behaviors that collectively characterize market segments. Values internalize an individual's beliefs about accepted behavior and manners. They can either be implied socially through shared beliefs about a particular affiliation, that is, what is generally accepted and recognized, or they can be projected onto one personally (Blackwell et al., 2001).

In addition, external factors enter into the decision-making process. These are significantly influenced by the cultural norms coming from the family and the personal situation, e.g. in terms of work and the quality of partnership, society, belonging to a certain social class, family situation etc.

Furthermore, Mowen (1988) shows that with a one-sided perspective of certain aspects such as the evaluation of the quality with a product, changes can cause strongly negatively with customers. An important aspect is thereby the emotions of the customers, which are connected with a certain product or a mark. Basically, important psychological processes with reference to the emotions and feelings, but also to their characteristics on the decision, as well as the experience and the behavioral perspective for the comprehensibility of the logical decision process are to be considered.

Further important Consumer Behavior and Decision Models

1.) The Power of the Pennies-a-day Effect

The power of Pennies-a-Day (PAD) influences the purchase based on the price offered to lower the price hurdle. It takes into account when the buyer evaluates a single alternative where he can decide whether to accept the seller's offer or leave it. The PAD strategy aims to reframe a large total costs position into a small regular spend (daily, weekly, monthly) and results in reducing the perceived cost of a transaction (Gourville 1998). The "pennies-a-day" method is also expressed with the term "temporal reframing" (Dholakia, 2019). Instead of having to pay a higher amount all at once, the consumer has to pay numerous small installments over a longer period of time, which lowers the barrier to being able to afford a product or

service. As a result, the buyer often decides to purchase an item that they would normally avoid if there was a one-time payment to be made.

Nowadays, with the zero-percent policies of central banks, the model is very widely used on the consumer market within the framework of an installment payment plan without any interest for the customer. This approach is attractive for the buyer to satisfy his consumption needs. It leads consumers to purchase goods or experiences such as a vacation trip that they could not usually afford, which often leads to excessive spending as a result (R. K. Holden & Nagle, 1994).

2.) The Power of Storytelling

The attention of listeners differs significantly whether a rather monotonous monologue is delivered or whether a story is presented with enthusiasm including different pitches and thus appeals to curiosity and personal emotions and also strengthens the imagination. It has been proven that the brain can better process this effective form of communication (Suzuki et al., 2018).

This applies equally to the placement of a product or a service. The story of a reference customer or a social role model, e.g., an actor or an influencer linked to social media, arouses the interest of other potential consumers through enthusiasm, for example, for the distinctive quality and user experience (N. F. Lund et al., 2018; McDonald, 2020; Pera & Viglia, 2016). Storytelling can also be used to achieve a desired behavior that does not directly pursue monetary goals. An example is a change in behavior with a focus on sustainability and social issues.

The power of storytelling is that if an individual gets to learn from other people's experiences, they are challenged or strengthened by the story. In addition, it can change mindsets or attitudes about a particular issue through influential communication (Bennett, 2013). An important field of application for storytelling on the personal level is not only to be found on the business-to-consumer level but should also be developed on the business-to-business level (Gilliam & Flaherty, 2015). Management in particular should focus on building a deeper understanding of the cognitive processes and train its employees accordingly so that a trusting and personal business relationship can be established.

An effective tool for storytelling is the creation of personas. Persona-focused storytelling is essential to branding. Depending on the target customer group, personal stories are created, which can have a positive effect on the branding of a company or brand (Herskovitz

& Crystal, 2010). The creation of a brand personality establishes a long-term emotional bond with the customer. By linking to a personal story with a clearly understandable identification figure, a sustainable emotional bond can be built (Stephen & Malcolm, 2010). Well-known companies such as Nike, IKEA and McDonald's successfully use personas for their brand strategy.

For creating personas, the target group is analyzed and addressed. Different socio-economic factors (e.g., age, gender, place of residence, income, education and profession) as well as personal traits, based on factors such as values and culture, behavioral patterns and attitudes, motivation and desires, are embedded into the concept. Therefore, in online advertising, companies strive to collect and analyze as much data as possible about customer preferences in order to provide individualized offers. With traditional channels like TV commercials, this is becoming increasingly difficult, because the individual cannot be addressed in a personalized way. With larger audiences, it is essential to tell stories in such a way that as many viewers as possible are addressed, as they cannot be targeted by individual messages. This includes focusing on emotions and values that are universally shared among most people, for example, a sense of family, friendship and shared humanity.

3.) The Power of Technology

Technological progress is simultaneously praised and viewed by many as highly critical due to various concerns. It can be used to increase efficiency and improve a social and sustainable society, but at the same time it stirs up fears about the displacement of jobs through automation, the abandonment of self-determined handling of personal data, and the control of increasingly autonomous regimes and tech giants.

When customer behavior is analyzed, a strong focus on technological self-efficacy is of fundamental importance (Bandura, 1977; Sherer et al., 1982). This stems from learning theory and deals with the question of the extent to which people are convinced that they are capable of successfully implementing a specific task or problem solution that requires the use of technology. Personal expectations and confidence in the ability to solve these tasks with the help of technology play a key role in this regard. Venkatesh, Thong, and Xu (2012) developed a unified theory of acceptance and use of technology (UTAUT), which includes, besides self-efficacy, the factors task-technology fit, performance expectancy, and other personal factors such as individual needs and desires, ingrained values, habits and beliefs, which lead to a particular attitude toward technology and ultimately to user behavior.

4.) The power of social media on consumer behavior

Social networks offer companies the opportunity to connect with customers and to influence them with the right content that helps them make decisions. A wide range of studies indicate a growing influence of social media on people, communication and society (al Akayleh, 2021; Dheenadhayalan & Sandeep, 2020; Miles, 2019).

Nowadays, hardly anyone wants to do without the opportunities and benefits associated with social networks (Acodez, 2022; Dean, 2021). For many, they are so established and popular in everyday life that they consciously or unconsciously accept a disproportionate distraction from other everyday things. Younger generations in particular are heavily influenced by social media, which plays a role in how they think, behave and act, thus affecting social contacts with friends and family, but also everyday life (Phoon, 2017). The constant distractions that social media offers have been shown to decrease productivity, personal experience and in certain areas such as driving, the risk of accidents. The increasing influence, especially among the younger population, provides many opportunities, but also dangers that must be considered (Uhls et al., 2017).

2.3 Transport Behavior in the Light of Consumer Behavior Models

Basics Factors influencing Transport Behavior

Travel behaviors have been researched over the years by using people's attitudes to help predict and explain people's travel patterns (R. H. Ewing, 1973; W. Zhang et al., 2021). The study of behavioral patterns, which includes an investigation of the underlying reasons, is multilayered and depends on factors such as values, beliefs, habits and motivation. Consumer behavior mirrors the complexity of human nature, in the study of which it is necessary to take into account internal motives of consumers, including their psychological elements, the influence of culture, as well as environmental and sociological determinants (Bujari, 2017). In addition, multiple external features are affecting transport behavior, for instance accessibility, safety, profitability, integration, and efficiency.

Ewing (1973) used psychological theory to try to predict the choice of transport mode. Socio-psychological differences and travel preferences are an influencing factor, since people choose a mode of transport that suits their preferences and desires. Particularly important attributes for this are time and cost. Ewing further point out that a distinction must be made between positively valued time and negatively valued time. For example, waiting time is

perceived by those affected as being of little benefit compared to travel time. Based on the psychological theory, a correlation to socio-economic aspects can be drawn. For instance, people who have a high income and value their comfort even more are generally paying less attention to price, as their primary focus lies on fast and comfortable transport. In contrast, those who earn less depend on transport modes such as public transport if they cannot afford their own vehicle. With daily commuting, there is often an additional conflict between the desired distance to work or education facility on the one hand, and the associated transportation costs versus the cost of living, which should be affordable, on the other. Many low-income earners prefer to live near their workplace to reduce travel costs. However, many jobs are located in the city center, where people with low incomes cannot afford the high cost of rent. As a result, these people have no choice but to live on the outskirts of cities and use public transport, as it is usually the cheapest way to commute.

Adequate measures are required to position the various travel attributes in such a way that they present an advantageous benefit for all urban citizens. For example, to increase the benefit ratio for public transport, its frequency can be increased and thus the waiting time reduced. Furthermore, the waiting time can be made as pleasant as possible (e.g., with entertainment or the possibility to bridge the waiting time with errands such as small purchases).

When choosing an appropriate means of transport, the individual must be aware of the personal advantage or value added. To understand how people behave, it is important to detect the type of motivations in daily mobility. In addition, the necessary incentives and offers for city residents must be investigated in order to develop an ecologically sustainable society. The desire for a certain service or product also depends on effectively tailored communication to possible users. Furthermore, human behavior determines the choice of transport mode for a particular type of need. Behavioral theories, consumer behavior, and decision-making models go hand-in-hand when it comes to the decisions consumers make in choosing a certain transport mode (Banyte et al., 2016). Moreover, according to Schiffman et al. (2012), there are two types of consumers: personal and organizational consumers, where consumers purchase goods and services for personal use, and organizational consumers purchase goods and services to run an organization or business, respectively.

Mobility service providers have to understand consumer behavior in order to develop strategies that include these behavioral needs, personal traits and feelings of consumers. For instance, a study shows that an increased use of active transportation such as bicycling and walking is related to feelings of flexibility and freedom, as well as aspirations for achievement

(Arroyo et al., 2020). Positive attitudes toward health, the environment, and desire social influence also lead to an active lifestyle. At the same time, the study shows that the more someone is interested in self-improvement (power, hedonism) and conservation (security, conformity-tradition), the less likely they are to use sustainable transport modes.

Kroesen, Handy, and Chorus (2017) point out that contrary to the focus of most literature, the effects of behaviors on attitudes are much more pronounced than vice versa, and thus probably the effects of attitudes on travel behavior are often overestimated. Moreover, people who are confronted with dissonance are more likely to change their attitude than their behavior. This means, for example, that a positive attitude toward the environment does not necessarily lead to a change in consumer behavior. For example, a person may be aware of the environmental impact of their car compared to alternative means of transportation but may be more concerned about comfort or simply not have an adequate alternative to travel the daily distance to work. Moreover, travel behavior based on habits can be assumed to be relatively stable over time and therefore usually requires a significant trigger, changing a job or place of residence, or significant changes in the general conditions (e.g., driving ban, newly created offer of alternative means of transport) to initiate a change in behavior (Scheiner, 2007).

Each transport mode comes with perceived individual advantages and disadvantages, which affect people's choices to travel. For example, many people consider the public transport in a city as time-wasting and not safe enough. They also don't like traveling with strangers or having to stand in a crowded train or bus. In addition, studies show that lack of reliability, which is the responsibility of transit agencies, is one of the reasons people stop using public transport (McMahon, 2013). The same applies for wrong or misleading trip information and delayed departure, or long waiting time at transfer stops. All these factors can be a barrier to public transport, causing fewer people to use public transport and to opt for cars instead. Based on the previously mentioned literature, the following Table 10 compares the main urban transportation modes with their respective advantages and disadvantages in terms of personal behavior patterns and impact on society.

Table 10: Comparison of different transport modes of typical advantages and disadvantages

Means of transport	Advantages	Disadvantages
Own car with combustion engine	Flexible use, individualized travel, feeling of freedom, high personal sense of safety	High personal and society costs, air pollution, increase of traffic jams and parking issues, high land-use per capita.
Own car with alternative propulsion technology (e.g., electric, hydrogen)	Flexible use, individualized travel, feeling of freedom, environmentally friendly during use, high personal sense of safety	Comparatively high (life cycle) costs, increase of traffic jams and parking issues, high land-use per capita, worry over lack of range and charging infrastructure
Public transport / railway (local traffic)	Comparatively cheap, environmentally friendly, low effective land use per capita, high traffic safety	Depending on the timetable, often less comfortable, too crowded during peak time, no privacy while travelling
Bike	Cheap, environmentally friendly, low effective land use per capita, good for health well-being, fast and flexible at least for short distances	Partly low personal sense of safety, not suitable for long urban transport.
Walk	Cheap, environmentally friendly, low effective land use per capita, good for the health well-being	Suitable only for short distances (< 2 km), otherwise too much time investment needed, high personal sense of safety
Sharing offerings (e.g. car sharing, ride hailing)	Flexible, no fixed costs, fast, for urban mobility cheaper compared to an own car, better utilization of available cars.	Low availability especially in smaller cities, relatively high land-use, still relative high air pollution depending on propulsion system

Source: Own depiction based on Arroyo et al. (2020); Banyte et al. (2016); McMahon (2013)

The advantages and disadvantages shown above represent a general tendency based on the predominantly available facts and are individually dependent on the circumstances in a city and also on people's personal situation. For example, for a health-oriented and passionate cyclist who lives centrally in the city, the transport mode of choice may be obvious. For people who live in a suburb and attach a high place or status value to their car, they are more likely to stick to that mode of transport. Especially when it comes to cycling, the personal perception of safety in road traffic often plays a major role (Lehtonen et al., 2016; B. Sharma et al., 2019; Zaidi et al., 2017). Furthermore, general conditions, such as the infrastructure, are decisive. For example, if public transport is well developed in a city with high levels of traffic congestion, driving one's own car becomes increasingly unattractive. A good example of this is the borough of Manhattan in New York, where short distances of up to two miles are covered faster by bicycle than by car, according to the mobility report (Trottenberg, 2019). Due to the city's high density and well-developed infrastructure, such as the New York Metro, public transport is popular and widely used (Tong, 2015). Especially in comparison to the rest of the country, which is dominated by private car use, New York City occupies a special position.

Impact of Classical Consumer Behavior on Urban Mobility Behavior

Dasgupta et al. (2016) observe that ecological and sociological aspects correlate. From a sociological standpoint, consumers are part of their society while ecologically, they can meet social and personal needs within the social-ecological system. Thus, the foundational / classical theories explain consumer behaviors from economic, ecological, and sociological angles.

For instance, residents in urban areas base their choice on prices, which can best be explained by the Marshallian economic model. In a survey commissioned by Zipcar (2014), millennials are leaders compared to Baby Boomers when finding alternatives other than driving. For deciding on their mode of transport, they consider reducing the time spent on the road and sometimes lowering the costs of owning a car, as explained by the Marshallian economic model. Ultimately, important business indicators such as sales, profits, and economic viability are affected by consumers' purchasing decisions.

The findings of Hopkins and Stephenson (2014) correspond more to the Veblenian psychological model. They show that young people in particular follow the trend of their peers by seeking alternatives to driving, as their decision is shaped by their desire for ecological and social connectivity. As revealed by Daniela (2011), humans are social animals who want to conform to the norms of their culture and the standards of subcultures which grant them easier ways of operating and interacting with each other. Thus, they want to save money from not owning a car and welcome the collaborative consumption movement. Most of them prefer to participate in sharing programs such as car sharing in order to save money for significant milestones in life, including retirement, college tuition, and housing, among other aspects.

Coming from the Veblenian social-psychological model, the psychological factor describes the perception of a need or certain situation. This includes the personal ability to learn or understand information to form an individual attitude. The psychological factors that influence an individual's decisions include personal motivation, attitudes, and beliefs. Those factors can also affect modal choices, for instance choosing public transport over an own car (Nguyen & Schumann, 2021).

The stimulus-response model, based on the Pavlovian learning model, is supported in a study by Lopez-Carreiro & Monzon (2018), which investigated cycling behavior, particularly among young people who have increasingly shifted their mobility to "soft" forms of mobility, including cycling, due to certain incentives. Special incentives, such as free bike rental, could facilitate a shift towards a more sustainable urban mobility (Villwock-Witte & Clouser, 2016).

Moreover, in recent years, in a lot of countries in Europe, there has been a further shift toward ride hailing or car sharing as alternative mobility services.

The expected utility theory can help understand decisions on the utility mobility means in urban places among generations. With the advancement in technology, citizens in urban areas use the internet to identify and book means of transport that give them the best services to realize the value for their money and to reduce complexity based on user-friendly apps. The attitude and experience of using cars as a mode of transportation forms the basis of their beliefs. In addition to the fact that today more people are studying and earning money later in life, the expected utility theory shows that the expected utility and value of owning a car is increasingly dwindling in comparison to alternative offers, including the new possibilities of sharing services.

Impact of Modern Consumer Behavior Models on Urban Mobility Behavior

According to the Prospect theory certain risks are assessed differently by people. With regard to urban mobility, this can mean that an established car driver switches to public transport on a trial basis, hoping for cost-saving or increased comfort. However, having a negative experience at this point, e.g., by missing an important appointment due to long delays or train cancellations, can negatively influence his attitude toward that means of transport in the future. As a result, users might prefer to stick to using their own cars, even though public transport reliability is now a given, with benefits over daily rush hour congestion, because they estimates the risk of another severe delay to be higher than it actually is. In addition, the endowment effect can play a role, causing people to stick to a certain transport mode like their own car compared to using sharing offerings, as they value a good more if they own it.

Herbert Simon's satisfaction model can also be applied to the choice of means of transport. Most daily decisions are part of people’s routines, but certain events, such as a job change and the associated move, can lead to a reorientation of mobility. In this case, when an individual is looking for the fastest possible and at the same time most cost-effective transport for their daily commute, they should be enabled to obtain sufficient information so that their decision is well-founded and made to their personal satisfaction.

Maslow's hierarchy of needs can also be a basis to understand human needs and behavior with respect to travelling. The basic need to move within a city arises from the fact that we need to get to work and fulfill other daily needs, for example, shopping for groceries in the supermarket (Mokhtarian et al., 2015). Individual sensibilities play a role in the choice of

transportation. For example, two different people may consider travelling by bicycle because they want to be active and think of it as beneficial from a health perspective. One of them assesses the danger of road traffic as lower than the other and in the end actually takes the bicycle. The other chooses not to bike, despite the apparent advantages over other modes of transportation, preferring instead to take a car or public transport because they see their basic need for safety as not being met. Even though environmental factors should play a fundamental role in urban development, the potential should exist in a city for citizens to reach all levels of Maslow's pyramid and thus experience maximum self-development (Aruma & Hanachor, 2017).

The flexibility and inclusiveness of the Howard-Sheth model can be applied to a variety of decision-making situations. To reach the attention of (potential) customers and thus influence their purchase intention, the product or service can be advertised to the target groups through the use of social media. Social stimuli result, among other things, from rooted values and habits based on the social environment and, therefore, also affect stimulus inputs and thus attention. Brand awareness and perception influence attitude, but also values, habits etc., while these in turn play an important role in attention, which then influences motive and indirectly again attitude. Brand awareness and perception facilitate certainty, which can have a positive impact on the purchase decision. With the satisfaction of a similar purchase experience from the past, the certainty can be positively influenced, leading to a continuous relationship and possibly creating a long-lasting relationship between supplier and consumer. This model can also be applied to the provision of mobility services, for example, to investigate the influence of the environment, the knowledge and experience of current users and how they deal with the information provided (Reddipalli, 2020).

According to the theory of reasoned action (TPA) and the theory of planned behavior (TPB) by Fishbein-Ajzen, for the placement of a product or a service, a corresponding decision of the consumer or the customer should be combined with a positive experience on the basis of the of considered action. At its core, the theory assumes the intention to choose a product or service. Marketers can learn several lessons from the theory of reasoned action. First, when marketing a product to consumers, marketers must associate a purchase with a positive result, and that result must be specific. Second, the theory highlights the importance of moving consumers through the sales pipeline. Marketers must understand that long lags between initial intention and the completion of the action allows consumers plenty of time to talk themselves out of a purchase or question the outcome of the purchase.

Spangenberg & Lorek (2019) suggest combining the TPB with social practice theory and complementing it with political economy to implement effective policy interventions. These include, for example, individual personality traits such as skills, habits, values, and attitudes, social aspects such as cultural conventions, social norms, and material/formal institutional factors, which include, for example, infrastructure, technologies, and legal and administrative frameworks. With reference to urban mobility, monetary but also non-monetary incentives can be created to influence the choice of means of transport. A certain reputation of a transport means such as the car, public transport or the bicycle can influence one's own behavior. For example, creating awareness about the negative impact of using one's own car, while creating incentives to ride a bike instead, has a positive effect for the environment, but also for one's own health. At the same time, infrastructure plays a major role. Many city dwellers, for example, shy away from cycling because there are no designated bike lanes and thus the individual feeling of safety is not given. The Netherlands represents a good example of how traffic planning infrastructure that favors cyclists has a positive effect on the choice of mode of transport (la Paix et al., 2021; Ton et al., 2019; Verduzco Torres et al., 2021).

Together with the trend towards more sustainable consumer behavior, which includes urban mobility, convinced car drivers, for example, can also move towards using alternative means of transport. With reference to the TPA, the subjective norm, which is caused by the changed behavior of society towards sustainability, can stimulate the car driver to influence his choice of means of transport. However, various influencing factors are necessary to bring this about. For example, an increased cost awareness about the actual costs for the own car, a correspondingly improved offer of public transport as well as of sharing offers can lead to a change of the own attitude in a certain behavioral direction in a personal comparison of the different options. Both internal and external factors have been influential in impacting the choices that consumers make.

The complementary third factor is perceived control over behavior (C), expressed by self-efficacy or the ability to perform the desired behavior, and extends the TPA model to the TPB. As an example of urban mobility, even if there is a basic willingness to use public transport instead of one's own car, due to a missing connection and also no easy possibility of a park & ride offering, this behavioral intention might not be executed in practice. In addition to the behavioral intention (BI), the behavioral control (C) also plays a role with regard to the perceived behavioral control (C2) as well as on the basis of the control conviction (C1) as a predictor for the behavior (B). This refers to the control a person has de facto over being able

to perform a certain behavior. Also, such cases can be explained when a certain behavior (B) is not exhibited despite a high level of intention (BI). This can occur in the case when behavioral control is completely removed from the person concerned.

For a practical application to urban mobility, the TPB can be adjusted based on the integrated behavioral model (IBM). The IBM considers for instance social and identity aspects, which are addressed by the so-called variable self-identity (SI), which can act as a predictor of intention independent of subjective norms (Dermody et al. 2015; Thorbjørnsen, Pedersen, and Nysveen 2007; van der Werff, Steg, and Keizer 2013). SI indicates the extent to which a person meets certain criteria associated with a particular social role. For example, a basic positive attitude toward health or the environment also affects consumer mobility behavior.

The Engel-Kollat-Blackwell method can be applied, for example, when urban citizens have several modes of transportation to choose from. To encourage a sustainable urban mobility, cities' policies have to consider two important periods with respect to the Engel-Kollat-Blackwell (EKB) model in which the consumers' input is most valuable. In the initial information phase, marketers must provide consumers with sufficient information about the mobility offer to encourage them to consider the more sustainable option (direct marketing).

In the external influence phase, cultural norms can be influenced, at least in the long term, by campaigns that encourage urban residents to use environmentally friendly modes of transportation. For an adequate placement of mobility services, a combination of modern instruments, such as social media, but also traditional approaches such as billboards or advertising in local newspapers, should be used to address all generations and social classes as far as possible. Furthermore, different offers have to be provided to reach a high penetration rate. A study shows, for example, that younger and usually financially weaker buyers tend to pay more attention to low-priced and discounted offers (Mehta et al., 2020). Older shoppers, on the other hand, pay more attention to product quality and convenience. Depending on country-specific conditions, the need for and prioritization of certain influencing factors can differ between generations, but also across generations.

In order to apply the EKB method more comprehensively in practice, it is important to investigate the (changed) consumer behavior, to determine the essential factors for increasing satisfaction, and thus to establish a preferred purchasing behavior not only once, but also in future decision-making.

Description of the Theory of Modal Choice: A Social-Economic Consideration

The individual decision process and thus the influence on urban transport behavior is based on personal preferences, which are particularly influenced by the environment. The environment, in turn, depends on the aggregate of economic, cultural and social life (Paulssen et al., 2014). Depending on the expression of this dimension in conjunction with individual preferences, different lifestyles emerge. A lifestyle leads to the pursuit of certain activities and interests, creating an individual pattern of how people invest their time and money. The global trend towards modern consumer goods shows that increasingly people identify with a certain product or service because it satisfies a certain need (K. Cohen, 2019). The identification with a lifestyle brand leads to a special loyalty of the customer by fulfilling certain personal wishes and thus reflecting the perceived quality of life of the individual. Once a certain level of trust in a product or service has been achieved, which often depends on the establishment of an important level of awareness of a brand or specific service offering, most consumers remain loyal to this offering, also with regard to their acquired habit.

With respect to mobility, a particular car or brand can give individual feelings of freedom, power, speed, status, and control. Nevertheless, there are also trends that create a new type of identification. Car ownership can be individually associated with negative attributes, such as the responsibility to maintain the car, which creates a repetitive cost (e.g., for maintenance, tire change, repair) or an associated negative feeling of damaging the environment etc.

Furthermore, Guerra et al. (2018) indicated that consumer mobility behavior is disrupted by new mobility trends, including autonomous vehicles, shared mobility, and Mobility-as-a-Service (MaaS). The impact of technology and social media on consumer behavior includes making it easier for users to access information and make decisions faster (Jose, 2017). Lopez-Carreiro and Monzon (2018) also highlighted factors including comfort, time, comfort, cost, safety, environmental concern, and identity creation as essential in influencing the choice of transport mode.

Nielsen (2015) argues that the transportation system should improve quality of life and also better connect suburbs by ensuring reliable, effective, integrated, safe, and multimodal transportation for diverse groups. Opting for an environmentally friendly mode of transport may arise from a sense of moral obligation to behave in a sustainable manner (K. Cohen, 2019). However, studies show that these values tend to influence behavior indirectly (Lind et al., 2015). Even if such values can influence more environmentally friendly travel behavior, at least over

time, these aspects must always be combined with an additional focus on comfort, efficiency (e.g., shortest travel time), safety, and price attractiveness. In the case of sharing services, car sharing in particular is a potential alternative to owning a car in urban regions. Factors that positively influence usage compared to owning a car or other means of transport include price attractiveness, proximity of the vehicle to the desired departure point, comparatively effective benefits and satisfaction with the current travel pattern, parking options, and the influence of social networks (Durand et al., 2018; Paundra et al., 2017).

In addition to a better infrastructure based on sustainable transport concepts with the creation of a corresponding offer, today's challenges in urban mobility require a change in behavior, which must be promoted by a smart public policy. According to Munhoz et al. (2020), this policy defines the more current and comprehensive way to understand a smart city where existing knowledge is integrated with experiences in the innovative city. The policy allows the combination of intelligence aspects and the use of technology to enable sustainability. As a result of the smart public policy, technologies such as car sharing applications have become the drivers of mobility especially in urban areas.

CHAPTER 3
BEHAVIORAL PATTERNS OF DIFFERENT GENERATIONS

Since the main focus of this research lies on the analysis of the urban mobility behavior of different generations, this chapter explores the characteristics of the different generations, based on a literature review. It should be noted that typical mobility behavior can never be sharply differentiated between age groups in a generalized manner. However, fundamental trends can be derived on the basis of factors such as different value concepts, important historical experiences, and external trends, such as technological change.

To create a sound basis for the subsequent core consideration of the study, these trends are examined in more detail with regard to behavioral patterns in the field of urban mobility. For this purpose, the different generations with their typical socio-economic characteristics are first defined and then differences and similarities are explained.

Subsequently, the concept of generations is presented in the light of urban mobility and how this can affect current and future travel behavior. Finally, this chapter explores what relationships exist between urban transportation infrastructure and mobility behavior. It acts as a further basis for better placing and evaluating the survey results from the primary data collection in the overall context for the city comparison between Warsaw and Berlin.

3.1 Generation as a Subject of Economic and Social Research

Generations are defined by specifying the years in which someone was born. At least in the case of the adult population with its relations to social processes, four main generations are defined: the Baby Boomers, Generation X (Gen X), Generation Y (Gen Y), and Generation Z (Gen Z) To differentiate generations, the literature examines differences in values, individual primary needs and desires, preferences, and specific patterns of behavior (Çelik & Gürcüoğlu, 2016).

There is no uniform consensus in literature on the exact definition of the age range of the different generations. Therefore, in this study, such ranges are applied that are most frequently used with reference to socio-demographics. The stated values and beliefs emerge predominantly during childhood, adolescence, and young adulthood (Lubinski et al., 1996; Meglino & Ravlin, 1998). For example, work values remain relatively stable from early adolescence through young adulthood. An, Heinen, and Watling (2021) pointed out, that any

time the three dimensions of age, time period and (birth) cohort must be taken into account when considering the behaviors of the different generations.

Baby Boomer Generation

The Baby Boomers, born from 1946 to 1964 (Duh & Struwig, 2015; Littrell et al., 2005; Obal & Kunz, 2013; Rahulan et al., 2015; K. C. Williams & Page, 2011), can also be separated between leading-edge, born between 1946 and 1954, and trailing-edge Baby Boomer, born between 1955 – 1964 (Ting et al. 2018). Their parents mostly belong to the silent generation defined by the experience of World War II. The leading-edge and the trailing-edge Baby Boomer can be distinguished mainly by the fact that they experienced different historical, political, and social events in their younger years and that they were shaped by divergent values (Bulbeck, 2006; Olito, 2020). At least the younger Baby Boomers were able to live more affluent lives compared to their parents. The leading-edge Baby Boomers were also increasingly committed to civil rights and women's rights (Guzman, 2020). In addition, different economic crisis, which led to a downturn, made this younger cohort of the Baby Boomers more pessimistic about the future (Smoller 1992; Zimmer 1979). Moreover, they have experienced an increase in youth unemployment (Strauss & Howe, 1991). The newly created prosperity among the population also gave rise to a new hope among the Baby Boomers. Their generation has significantly impacted the economy, society, and various businesses (Benoit & Ragot, 2018; Ting et al., 2018). Myers and Ryu (2008) point out that the huge Baby Boomer generation has been a dominant force in the housing market, and thus the economy, for decades.

Baby Boomers are characterized by values such as a desire for freedom, a connection to family and human relationships, but at the same time they are self-confident and determined (Gadomska–Lila, 2020). In addition, they are the oldest generation in today's workforce, which has to adjust to the introduction of computers and keep up with technological developments, especially when it comes to the ability to engage with technology and use it for one's own benefit (Twenge et al. 2010). Since they did not grow up with this technology, it is usually more difficult for them to engage with new circumstances and process new and complex information (Morris et al., 2005).

Sandeens (2008) shows that Baby Boomers want to consolidate and develop their careers through continuous education. They are known for a "live to work" attitude due to their ambitiousness and their desire for advancing their career, but this also means that their leisure time and family life suffer, and that their relationships with acquaintances become increasingly

businesslike, with new friendships arising primarily from the work environment (Cochran et al., 2009; Lubinski et al., 1996; Smola & Sutton, 2002). The Baby Boomer generation is more likely to stay with the same company for their entire working live, and changing companies is relatively rare (Deal 2007). Their mentality to work hard is also reflected by the fact that they are motivated by their position and prestige, and that work is very clearly reflected in their personality profile (S. Kane, 2019). Although there are certain trends in working practices between generations, studies indicate that these differences are quite weak, for example, in the willingness to work overtime and to remain loyal to the employer for a longer period of time (Becton et al., 2014; Macky et al., 2008). Today, Baby Boomers are gradually reaching retirement age and thus pose a major challenge to the economy, both by losing their labor force or by financing their pensions.

Generation X

People belonging to Generation X (Gen X), also known as the post-baby boom generation, were born between 1965 and 1980 and are therefore between 41 and 56 years old in 2021(Katz, 2017). While the start year of this generation is relatively frequently mentioned in literature as 1965, there is hardly any agreement on the last year. In this study, the year 1980 is used as a suitable approximation (Fishman, 2016; Jerome et al., 2014; Obal & Kunz, 2013; Papenhausen, 2009).

The Gen X have a strong commitment to fulfilling their parenthood as best they can. Thus, the compatibility of career and family is particularly important to them. Unlike previous generations, they consciously encourage their children to pursue a different lifestyle and job than they do (Rohm Nulsen 2021). Their behavior is increasingly influenced by values such as family, friends, and work-life balance, which is leading to a more pragmatic and flexible attitude (Dabija et al., 2018). Compared to the Baby Boomers, Gen X is more known for their attitude "work to live". In addition, Gen X tends to be more direct, appreciates open and honest communication, and is better able to handle criticism compared to the younger Generation Y (Schnitzer and Fabiano 2019).

In addition, they like to work in a hybrid model (combination of office and home) and try to integrate their family life into their professional life as much as possible. Moreover, the average age of founding a successful business is 45, which speaks for a high level of entrepreneurial skills among Gen X (Azoulay et al., 2018). Gen X values freedom and responsibility and tries to overcome challenges on its own (Indeed Editorial Team, 2021). One

of the biggest fears of Gen X is being replaced by younger managers or by technological development and thus losing their professional identity (Haserot 2017).

With respect to work and learning skills, Gen X in their younger years shows that they are increasingly accepting change, approaching situation with an open mindset and are independent and resourceful (Bova & Kroth, 2001). In doing to, they are more embracing of technology, willing to be lifelong learners, and want to be more involved in the design process as they overcome challenges (Kohnen, 2002; Lankard, 1995). With the uprise of the internet, Gen X is also getting more into the new online world, using it for their shake and increasingly using social networks, especially Facebook (Lewis 2021).

Gen X exhibits consumer behavior, is price-conscious, and ideally wants customized products and services tailored to their individual needs and lifestyle (K. C. Williams & Page, 2011). In this context, sufficient information readiness as well as technological support are important. An evaluation of sustainable consumption behavior shows that the older generation (Baby Boomer and older) lags behind the younger generation, with Gen X also falling between the two groups in this respect (Fullerton et al., 2019). Ivanova et al. (2019) show that Gen X has a lower intention to buy sustainable products compared to Gen Y. At the same time, there are indications that through awareness and advertising campaigns, the basic conception is present, and decision-making could be influenced accordingly.

Generation Y

Generation Y (Gen Y), also known as Millennials, followed Gen X. The majority of their parents belong to the Baby Boomer generation, but also to Gen X. Depending on the literature, Gen Y is also referred to as digital natives, although a distinction must be made between the older and younger members. While the older millennials have experienced the digital transformation that brought about the internet, smartphones etc., and were generally able to quickly get used to the "new world" and adapt accordingly, the younger cohorts of Gen Y grew up with these technologies from the beginning. For Gen Y in particular, there are a wide variety of definitions of birth cohorts in the literature (R. N. Bolton et al., 2013; Cui et al., 2003; Holt, 2018; Hume, 2010; Li et al., 2013; Martin & Turley, 2004). The main consensus which is used in this study locates the age span between the years 1981 to 1995, corresponding to an age between 26 and 40 years in 2021. This cohort is considered as fair-minded and intelligent, even more so than their parents' generations. Holt (2018) describes Gen Y as a curious generation that wants to know why and for what purpose they are investing their time.

For Gen Y, work-life balance is even more important than it is for the previous Gen X. They are less willing to be subordinated to rigid corporate hierarchies, want to be more actively involved, and want a flexible workplace (Dimovski, 2020). Compared to Baby Boomers, they are less likely to have the mentality of a workaholic, rather following a lifestyle attitude of "work to live". They are less inclined toward hard work and subordination in the corporate hierarchy in order to possibly climb the career ladder (Holt et al., 2012). From their perspective, increasing flexibility of working hours leads to higher motivation and satisfaction levels and thus increased commitment to the employer, as they can also integrate leisure and family activities into daily life (Ng et al., 2006; L. T. Thomas & Ganster, 1995). In addition, they tend to be critical of authoritarian leadership and sometimes challenge it. However, if the leadership style is positive from their perspective, they look to role models for advice and imitation. In today's workplace, Baby Boomers still have the most influence on Gen Y, so it is even more important to build mutual understanding and rapport between them (Twenge & Campbell, 2012). Gen Y sees work primarily as a source for funding leisure activities and travel, whereas the older generation of the Baby Boomers sees work as an essential part of their lives (Twenge et al., 2010).

Evcil (2018) points out that the younger generation not only strives for a work-life balance but is also increasingly looking for variety and international networking and exchange. Cennamo and Gardner (2011) indicate that the values and motivational factors of different generations should be taken into account by companies to retain employees in the long term. Appreciation, self-responsibility, good teamwork, regular constructive feedback, flexibility in working hours, and fulfilling work are much more important to them in terms of being motivated (Graybill, 2014). They want fewer distractions from colleagues, meetings, phone calls etc., to take over personal responsibility and also the freedom to choose where to work.

Gen Y loves its freedom and is more likely to change employers if the framework no longer suits them (Ensari, 2017). A study by Breitsohl & Ruhle (2012) with respect to Germany shows that the Gen Y workforce is more satisfied with their income and has a more positive outlook to the future regarding life and job satisfaction, as well as economic and job stability compared to Gen X. Continuing education is important for them and new skills ease stressful situations. Nowadays, Gen Y is taking on more responsibility by assuming leadership positions and introducing new values and management styles that are replacing the more old-fashioned, hierarchy-oriented behavior of the Baby Boomers and partly by Gen X and shaping a leadership style at eye level with their employees (Birk, 2016). In the process, new character traits emerge

that can be beneficial for socially responsible business ethics in practice, so that the current problems can also be addressed in a sustainable manner (Rasch and Kowske 2012). Furthermore, entrepreneurship is particularly strong among Gen Y, with many wanting to self-actualize by starting their own business (Mihalcea et al., 2012).

A study conducted shows that Gen Y's top three fears related to work life are being stuck in personal and career development, not achieving career advancement, and that their job does not match their personal vision and strengths (universum, 2014). Nevertheless, according to the study by universum, the majority of the generation think that they will enjoy a higher standard of living than their parents. Gen Y's behavior and habits are determined by their values, purpose in life and morals. This includes social and environmental awareness. They believe that human values count more than the pursuit of profit and want to play a part in alleviating people's poverty (M. Cheng, 2019). This generation is also more open-minded and tolerant i.a. due to increased globalization, better and cheaper travel opportunities, the increasing spread of social networks etc. (Twenge et al., 2015). Increased informational enlightenment with the new value concepts leads increasingly to a heightened health consciousness (Hoffower, 2019).

Gen Y, constituting largest population group worldwide, shows through their personality traits, which are also shaped by the outside world and new opportunities, that they often consciously or unconsciously implement the sustainable development goals established by the UN (Bali Swain & Yang-Wallentin, 2020; United Nations, 2019a). Increased networking via social media on the internet, the ever better and cheaper opportunities to travel, and the increasing education of Gen Y, lead to the fact that they are more tolerant, more committed to peace, equality, prosperity and the environment (Bali Swain & Yang-Wallentin, 2020).

Based on the behavior theory of the IBM, explained in the chapter before, taking into account the predictor, a study shows that the environmentally responsible identity is more pronounced in Gen Y than in Gen X (Ivanova et al., 2019). This coincides with an increasing change in society towards a more environmentally conscious and sustainable lifestyle. Hume (2010) points out that Gen Y has a compassionate humanistic understanding of sustainability.

In addition, technological developments such as computers, cell phones, laptops, tablets and the increasing spread of social media, such as Facebook began with this generation (Skinner et al., 2018). According to Kim (2018), one of the most important historical events defining millennial technology was the introduction of computers connected to the internet.

Generation Z

As with the other generations, for Generation Z (Gen Z) the defined age span differs in literature (Ensari 2017; Gould, Nalepa, and Mignano 2020; Tulgan 2016; Turner 2013; White 2017). For this study, people born between 1996 and 2012, thus being aged between 9 and 25 years in 2021, are defined as Gen Z. Members of Gen Z have mainly Gen X and GenY parents. Gen Z has a wide range of different labels in the literature such as Digital Natives (a term that other researchers already apply to Gen Y), iGeneration, GenTech, or PostMillenials.

Gen Z is the first generation which from the early beginning of childhood has largely been surrounded and influenced by technological changes, with many of them never having experienced a life without internet and mobile devices (Kahawandala & Peter, 2020b; Naci Çoklar & Tatli, 2021; A. Turner, 2015). Thus, they are considered to be internet connected, communicating, computerized, content-centric, community oriented and open to change (Dolot A., 2018). Through online communication, society has become accustomed to being increasingly networked as individuals rather than socially embedded in groups. In some cases, the number of virtual followers or friends is even perceived as more important than real friends in real life (Rainie & Wellman, 2021). As a result, many members of Gen Z can no longer imagine a life without digital media and invest a great deal of time in this area. Social media, in particular, captures the attention and plays a key role in shaping the behavior of Gen Z (Rospigliosi, 2019).

Another perspective is provided by a representative study with reference to Sweden, which examines the personality traits of different generations (Church & Burke, 1994; McCrae & Costa, 1987). It shows that Internet use among the younger generation is more related leisure and social networking, while among the older generations it is more related to conscientiousness, information and compulsory activities, and less related to leisure activities (Roos & Kazemi, 2021).

Gen Z is future-oriented and characterized by unity, realism and diversity (Moore, Jones, and Frazier 2017). Together with their often strongly developed idealism, they have a desire to improve the world. In particular, the current youngest generation of adolescents as well as young adults often turn their backs on what they see as failed policies, especially in the face of increasing climate change with its negative consequences (Hurrelmann & Albrecht, 2021). Thereby, an essential aspect is focused on a rethinking towards more sustainability as well as the moral responsibility towards future generations (Eide & Kunelius, 2021).

Furthermore, the young generation has been particularly affected by the worldwide Covid-19 Pandemic and the resulting restrictions implemented by governments. Missing sports activities, and social contacts causes them to suffer from loneliness and other negative influences on mental and physical health, which are likely to have long-term negative consequences (Kumar et al., 2020; United Nations, 2020a). According to some studies, the accompanying educational gap due to lack of insight or the overload of parents homeschooling their children is already evident and is likely to lead to an increase in health disorders and youth unemployment (Albrecht et al., 2021).

A study of Ensari (2017) shows that compared to older generations, members of Gen Z are more introverted, have less self-confidence, as well as a lower need to succeed, even though these factors might still develop with age. With regards to education and professional life, a recent study conducted in various countries around the world shows that 82% of young people show a positive attitude towards a work environment that requires interaction with and reliance on technology and automation (Sawyer & Stouffer, 2021). Gen Z appreciate a dynamic working environment, quick advancement of technologies, a variety of tasks, and freedom in completing them.

It is becoming increasingly important for Gen Z to spend a balanced amount of time between their job and leisure activities. They think even less of hierarchy than Gen Y and want to meet their superiors and colleagues equally at eye level. They want a job they enjoy and are passionate about, and they tend to be impatient about getting things done. Furthermore, their primary aim is not to be promoted and successful from a professional point of view if it comes at the price of merely performing tasks assigned to them by their superiors and by investing hundreds of hours of unpaid overtime. This type of leadership style, which was followed by the Baby Boomers and also in part by Gen Y, is often perceived as "old-fashioned" by the still young Gen Z (S. Bannon et al., 2011). At the same time, they tend to lack patience when things don't go as expected or take longer. Gen Z expect a dynamic work environment with meaningful tasks from their employer. They like to be creative and are more willing to react quickly to different situations (Gadomska–Lila, 2020). If they are not passionate about a topic, they are less willing to work overtime because they do not see any added value in it.

Gen Z are more entrepreneurial, innovative and passionate and at the same time they desire a collaborative workplace with peer-to-peer communication also with their supervisor without any hierarchy hustle (Half, 2015). Their top priorities are opportunities for career growth, generous pay and making a positive impact with a meaningful job to society. Moreover,

the increasing number of "digital nomads" in this generation shows that they can and even want to work from anywhere in the world, completely independent of a home or work location (Abram, 2006; Makimoto & Manners, 1997; Thompson, 2018).

Fullerton et al. (2019) ague that Gen Z is more inclined to environmentally friendly consumer behavior compared to older generations. A study shows how different generations react to a crisis situation, in this case to the global Covid-19 pandemic. While economic concerns are equally pronounced among Baby Boomers, Gen X and Gen Y, fears about compromising one's own health and losing one's own job increase with age (Eger et al., 2021).

The youngest cohort is Generation Alpha (Gen Alpha), born entirely in the 21st century. They are still in their infancy (9 years or younger); however, they too will shape the future with new values and character traits. Since Generation Alpha is not yet relevant to this study, no further explanation is provided.

In addition to the different manifestations of today's behaviors between generations, different generations can also be examined over a period of time. Enam and Konduri (2018) indicate, for example, that today's younger generation, compared to individuals in the same age group from previous generations, make more personality-based decisions and have a shorter life span of work due to more frequent and longer study.

3.2 Concept of the Generations in the Light of Mobility

Comparison of the importance of car ownership between the generations

Herrenkind et al. (2019) stress that there are differences in travel behavior across generations in terms of attitudes toward cars and their influence on car ownership, car trips, and driver's license ownership. A study with reference to a demographically aging society shows that due to availability and increasing wealth, the older generation of Baby Boomers in particular has a higher car ownership rate than 20 years ago (R. J. Hjorthol et al., 2010). The strong connection between Baby Boomers and their cars may also have been caused by the rapid development of the automotive industry at that time, which for the first time made it possible for a broad mass of people to finance their own car (Strauss & Howe, 1991).

The older generations of Baby Boomers and Gen X are more materialistic because, according to Maslow's pyramid (Skelsey Guest, 2018), they express the fulfilment of self-esteem by owning a particular model and brand of car. They perceive the car not only as an efficient means of transport, but also as a status symbol that conveys a sense of freedom, privacy

and excitement (Clifton et al., 2013; K. Cohen, 2019). Especially for Baby Boomers, the car used to be an expensive luxury item in their younger years. Those who could afford a car were considered to be people of high social status. Consequently, the Baby Boomers grew up with the belief that owning a car was an essential part of life and considered car ownership a must-have. They are used to car ownership showing a person's wealth, status in society, or even a central focus point of meaning. Moreover, for many of them, obtaining a driver's license was like a rite of passage, indicating the transition from childhood to adulthood. For the elderly generation, it used to be important if a career position or a promotion came with a company car. Overall, Baby Boomers tend to be car-centric throughout their lives. Another study confirms the dominance of car drivers, especially among the older generation of the Baby Boomers and also Gen X (Olsson et al., 2020). In the late Baby Boomer generation, car dominance decreases somewhat, but this may be due to the fact that at least the older cohorts generally have a lower need for everyday mobility due to retirement.

The younger generations, compared to the older ones, tend to put more emphasis on the practicality of the car and less on the fact that a particular model represents, for example, a special sense of value or status (Tuncali et al., 2018). Moreover, feelings of esteem associated with freedom and the car as a status symbol are less pronounced in Gen Y and especially Gen Z than in Gen X and ethe Baby Boomers (Clifton et al., 2013; K. Cohen, 2019). The subjectively perceived added value of owning a car is increasingly difficult to convey, especially when sufficient alternatives are being made available and values, such as an orientation toward greater sustainability, are becoming more pronounced than before. Hence, younger generations tend to perceive it as a burden to commit to the obligation of car ownership with its associated costs. They prefer to be free and are often unwilling to bear the high costs of purchasing and maintaining their own car, which leads to an increased use alternatives such as ride-hailing or ride-sharing services (Eliot, 2019; Tuncali et al., 2018). Júnior et al. (2018) point out that, particularly among Gen Z, ownership and user preferences are changing in such a way that, although they like to use products and services, a claim to ownership is less pronounced. Another factor influencing their decision are existing financial obligations, such as paying off student debt, which is why a lower percentage own a car (Enam and Konduri 2018). A trend with regard to Germany already emerged a few years ago, when a sharp decline in car use was discernible among Gen Y. Between 1998 and 2008, both the number of registered cars and car ownership fell by around 30% (Villwock-Witte & Clouser, 2016).

A study by Herrenkind et al. (2019) expresses that in Germany and other industrialized countries, the interest of young people in holding a driver's license and owning a car is decreasing. With regard to the younger Gen Y, when it comes to buying a car, environmental and brand image-related factors are more likely to have an influence on the purchase decision, while social and personal factors as well as brand loyalty are more important for Baby Boomers (Davey & Balakrishnan, 2017). Despite the still existing dominance of the car, Gen Y and Gen Z exhibit less favorable attitudes towards private car ownership. Boström (2020) argues that millennials make choices depending on the value they expect to get from owning a car or car sharing.

Another important aspect is that most car owners massively underestimate the actual costs of purchase and maintenance (Andor et al., 2020; Sendtner, 2021). Moreover, in addition to the actual costs incurred by the motorist, there are lifetime costs that must be borne by society (Becker et al., 2012; Gössling et al., 2022). The analyses are based on an average calculation of the three most popular models in Germany from the small car, medium class and SUV segments. Due to costs, among other things, for air and noise pollution, , a resulting lower life expectancy, investments for road construction and maintenance, as well as restrictions for other road users such as cyclists and pedestrians, an additional average of about 5,000 € per vehicle and year is incurred, which the car owner does not bear himself. If car drivers were more aware of the actual costs, i.e., not only fuel consumption but also other expenses such as depreciation, insurance, taxes, and repair costs, they are likely to be increasingly less willing to continue owning a car. In addition, the study shows that if the additional costs, which so far have to be borne by society, were to be charged to car owners, many of them could not afford car ownership any more. It is to be noted that a financial calculation of the damage caused by air and noise pollution shows a purely economic consideration. For a comprehensive study of the effects of car ownership, social and ethical considerations would also have to be taken into account.

A comparison of transport choices between generations

Compared to their older peers, today's younger generations prefer even more to live in densely populated urban areas and thus have significantly more transportation choices, leading to increased use of public transit, bicycling, and walking (An et al., 2021; Case & Schipinski, 2015; Olsson et al., 2020). A study conducted by Duff & Phelps (2019) shows that besides using car (49%), Gen Y are walking (23%), use public transport (16%), cycle (8%), scooter /

motorcycle (7%), car pool (7%), car sharing (6%), taxi (5%), and ride sharing (5%).[35] In addition, the younger generations also tend to live more frequently in households with no or fewer vehicles, and thus drive less and use non-motorized transportation more frequently than earlier cohorts when they were at the same age (Blumenberg et al., 2016; Kuhnimhof et al., 2012).

Young adults show an increasing interest in using intermodal transport services that combine different modes of transport, such as public transport, car sharing and bike sharing (K. Cohen, 2019; Davis et al., 2012). As life preferences, lifestyles, and fundamental attitudes change, young urban residents are shaping the characteristics of a "shared economy"[36] (Hamari et al., 2016; Menon et al., 2019; Ranzini et al., 2018). Offerings such as car sharing are finding increasing popularity in cities[37], leading to an decrease in car ownership (Menon et al., 2019; Susilo et al., 2019). An analyses by An et al. (2021) confirms the trend that people tend to be less multimodal with increasing age. Moreover, the study points out that an initial change in mobility behavior in favor of multimodality can already be observed among Gen X, and this shift is even more pronounced among Gen Y. While Gen X tends to consider alternatives to the car, such as public transport and sharing services, as a supplement to their own car, it is becoming apparent, especially in urban regions, that Gen Y and above all Gen Z can imagine increased mobility without their own car.

Cohen (2019) argues that ride sharing is also a viable alternative, making it increasingly easy, especially for the technology-savvy Gen Y and Gen Z, to travel without thinking about owning a car and the obligations that accompany it. A study considering socio-economic tests with the inclusion of interaction effects and attitudinal factors shows for Gen Y that there is a significant positive preference for more frequent use of ride hailing, while the preferences of the older cohorts (Gen X, Baby Boomers) show no significant effect on ride-hail frequency (Asgari et al., 2021). With respect to new transportation technologies such as a shared autonomous vehicle, the willingness to substitute one's own car may also depend on socio-economic factors (Menon et al., 2019). Gen Y individuals with a college degree are more willing to forgo a household vehicle, which may be an indicator that they are seeking a more

[35] In total, it adds up to more than 100% percent, since more than one means of transportation could also be selected in the daily mode choice

[36] The sharing economy is an economic model defined as a peer-to-peer (P2P) based activity of acquiring, providing, or sharing access to goods and services that is often facilitated by a community-based on-line platform.

[37] Number of carsharing vehicles increases between 2010 and 2021 (projection) 1,900%, Source: CAR - Center for Automotive Research), June 2017; retrieved April 18, 2020, from http://www.cargroup.org/wp-content/uploads/2017/07/Technology_Roadmaps.pdf and expected car sharing user worldwide in 2025 of 36 million which is more than 500% more than in 2015, Source: Frost & Sullivan, August 2016; retrieved April 18, 2020, from https://store.frost.com/future-of-carsharing-market-to-2025.html

sustainable lifestyle compared to their older peers. Through such alternative shared means of transportation, there is potential to do without at least a second vehicle within the same household.

A study by Polzin et al. (2014) indicates that the number of young urban residents who have a driver's license is decreasing. Furthermore, observed changes show that younger travelers postpone or even forgo obtaining their driving license completely if they live near public transfer possibilities (le Vine & Polak, 2014; Nurul Habib, 2018). Another factor leading to a reduction in car driving is a well-developed and accessible transportation infrastructure, which increases the likelihood of commuting by public transport or rail (Brown et al., 2016; R. Hjorthol, 2016; Lavieri et al., 2017). It also increases the quota of public transport annual ticket users and bicycle ownership (Habib et al., 2018). Sometimes young people in particular increasingly opt for an alternative, non-motorized mode of transport for certain occasions and thus drive less, even if they own a car.

A survey by Suchanek and Szmelter-Jarosz (2019) identifies young adults with more specific reference to Gen Y who show variation in their purposes for choosing particular transport means. They observe that the choice of any mobility mode is based on the services that users receive. Gen Y's attitude towards mobility in urban areas is influenced, for example, by opinions about the sharing economy, the existence of a driver's license, and also by gender. With reference to Poland, the study notes that unlike many other studies, younger generations do not fundamentally have a more positive attitude towards the environment. Moreover, the results show that study participants born in the 1980s are more ecologically oriented than the younger cohort born in the 1990s. It also shows that women have a more positive attitude toward environmental care than men. In addition, the survey shows that people who do not have a driver's license or a car use more sustainable means of transport such as public transport but are also more interested in using new mobility services such as Mobility-as-a-Service (MaaS). A study by Parzonko et al. (2021) confirms that in Poland Gen Z is generally less environmentally aware than Gen Y.

Reasons for transport mode choice

When analyzing the primary reason for choosing transportation, different prioritizations emerge. A study conducted by Duff & Phelps (2019) identifies the main reasons for choosing transportation, with cost topping the list, followed by proximity to destination, reliability, lack of other options, environmental benefits, and ability to work / get things done. Mayo and

Taboada (2020) indicate safety, accessibility, travel costs, comfort and the environment as the primary reasons for the transport mode choice. Buehler et al. (2017) identify factors such as safe bicycle parking, accessibility of public transport, and road quality as key factors in young adults' decisions to choose an alternative transport means to the car. Users with positive attitudes towards health and the environment are preferring active modes of travel, even though in the overall mode split the group is quite small in percentage terms (Maia et al., 2020). Furthermore, this study shows that people with lower incomes are more likely to use public transport and higher income groups are more likely to prefer personal vehicles. The study also reveals that, taking all factors into account, owning a car has a higher priority than public transport. Nevertheless, it shows that when there are different alternatives to choose from, car use tends to be lower (Ryan, 2020). In addition, comfort is, especially for the older generation, a primary factor for owning and using a car

In addition, comfort is, especially for the older generation, the primary factor who do not want to do without their own car. Furthermore, there is a positive correlation between travel satisfaction and life satisfaction, with travel satisfaction being an important factor across all generations (Olsson et al., 2020).

In addition to creating a price incentive and demonstrating the potential benefits of a product or service, it is important, especially for the younger generation, that the entertainment value and experience are not neglected (spectrio, 2015). Beyond that, according to Slivar, Aleric, and Dolenec (2019), Gen Y and Gen Z prefer the company of friends when making trips and are highly likely to announce the trips they make on social media. Hopkins and Stephenson (2014) provide an additional perspective by analyzing the different mobility cultures with a focus on how Gen Y can positively influence future mobility behaviors in society and highlight various factors that play a role in behavioral characteristics, norms, and socio-logical aspects. In doing so, they point out that significant changes can only occur if a change in mobility culture takes place across different generations and social levels. It is important to show how and why aspects such as personal attitudes, habitual practices, and social norms interact to initiate change, and what external influences play a role in that change, or even risk preventing it (Circella et al., 2016).

Overall, Cohen (2019) indicates that in the future, the dominance of car ownership will gradually reduce as trends in demographics, technological change, and attitudes toward mobility behavior will permanently change. His study also shows that individuals' transportation choices are based on social practices that are influenced by people's culture,

social groups, and realities. When designing sustainable mobility, it is important to make it socially fair and environmentally compatible for people, but at the same time economically viable, and to promote mobility behaviors that lead to lasting changes in the individual and the collective (Prus & Sikora, 2021).

3.3 Mobility Behavior in relation to Urban Living

Impact of Urban Lifestyles to Urban Mobility

The greatest differences in mobility behavior as a result of sociodemographic and socio-economic aspects exist between residents who live in a city and those who live rurally. In addition, whether someone lives centrally in a city or rather in an outlying district or suburb has an impact on mobility patterns. In all cases, citizens need to be able to access important facilities such as schools, hospitals and offices, as well as shopping facilities.

In most European urban areas, increasing gentrification and densification can be observed, caused primarily by a strong influx of high-income individuals, which in turn is one of the main factors influencing the continuously rising rental price index.[38] At the same time, there is a trend of established urban populations moving to the surrounding areas, either due to the increasing inner-city rents or changes in life stages, which leads to a further expansion of the metropolitan region (Keil, 2018). The resulting growth in quantitative demand for mobility is arguably the most important factor influencing the availability of public and private transportation services, as well as the need and desire to own a car. Nevertheless, despite the fact that the need for a car is generally higher in rural areas due to a lack of alternatives, a study shows that even a certain share of Gen Y does not own a car and also Gen X partly used to ride a bicycle to school (Pucher & Renne, 2013; Villwock-Witte & Clouser, 2016). However, the study also shows that especially in rural regions, income is much lower than in urban areas and thus some could not afford a car even if they wanted to. Moreover, in urban regions, there are better mobility offers, but many more people in the city can also afford a car due to a higher income.

In addition, attitudes and behaviors of people from different generations have a significant impact on travel behavior in urban and rural areas. A study reveals three basic classes

[38] With respect to Berlin for instance housing prices in Berlin had grown between 2011 and 2021 by 153% [retrieved April 10, 2022, from https://www.wohnungsboerse.net/mietspiegel-Berlin/2825. By comparison, the harmonized consumption-oriented consumer index (HVPI) had raised by only 18% in the same period [retrieved April 10, 2022, from https://ec.europa.eu/eurostat/de/web/hicp/data/main-tables; The annual averages between 2011 and 2021 were considered. If the city center itself is considered the increase is even much higher (> 200%).

with different behavioral characteristics: (1) Urban mostly younger and independent commuters who have many daily necessities in close proximity, are very cost and time sensitive, but also less affluent and more likely to have an intermodal use profile; (2) Suburban residents, who tend to have poor public transport access, are very car-dominant, and accordingly use little transportation other than their own cars; and (3) Suburban residents of the older generation, who commute less, enjoy bicycling, and would prefer to move back to the city (Circella & Alemi, 2017; A. Myers et al., 2017). The first class comprises a good half, the second a little more than a third and the third class only a tenth of the respondents. Especially in rural areas, providing alternative transportation to the car is a major challenge, as the places where daily needs are met are usually farther away and there is no corresponding need for mass transportation.

In addition, trends can be identified between genders and other social-demographic factors in cities that lead to different mobility behaviors. A study conducted in Sweden over a period of 30 years shows that there are still differences between men and women in their leisure activities and travel behavior, although these are increasingly disappearing among the youngest generation in particular (Susilo et al., 2019). The study also shows that various lifestyles and factors such as personal situation, whether someone is married, in a partnership or single, and whether someone has children (in a partnership or as a single parent) also influence the number of trips and the type of travel behavior. Another aspect of the decision on the means of transport with regard to gender is the perceived feeling of safety, which is also confirmed by many statistics. Many women will not take city trips if they perceive that it will be unsafe for them; therefore, most women prefer to use private means and not public transport (Clifton et al., 2013). As a result of this, within the improvement of the public transport infrastructure there should be a strong focus on safety with protection of women, elderly and disabled persons.

Furthermore, the emergence of new technologies has significantly influenced urban lifestyles and consumer behavior. While Gen Y has experienced significant technological changes like social media and virtual working in their teens, Gen Z has been growing up with these technologies from the beginning (Olsson et al., 2020). Further advancements include smartphone app-based mobile sharing services, and the possibility of using innovative Mobility-as-a-Service in the so-called sharing instead of owning model. They overwhelmingly use their mobile phones for daily tasks and are well organized in social groups. Nevertheless, Newbold & Scott (2017) argue that 48% of Gen Z use word-of-mouth as the source of choice when making purchase decisions, despite growing up during the technology era.

Impact of Urban Architecture

In respect to urban architecture, various studies on mobility behavior have shown that urban development projects aimed at optimal land use with increased density can lead to a reduction in traffic volumes and, in particular, in motorized private transport (Grazi & van den Bergh, 2008; E. Holden & Norland, 2005; Næss, 2011; Wiedenhofer et al., 2013). Jamal & Newbold (2020), for instance, point out that older generations prefer to live in places that are close to important facilities and infrastructure. This is especially the case for compact urban architectures that have a high population and residential density and are therefore well connected. Furthermore, in a society moving toward non-discriminatory to transportation for all generations, consideration must be given to the limited mobility of older age groups (Páez et al., 2007). Larkin et al. (2018) establishes that members of Gen Z are the most urbanized group of the young adults that prefer walking and using transit as they live in dense urban areas. They prefer to live in a place where the way to work or study is short or easily accessible on foot, by bike or by public transport (Davis et al., 2012). This means that such aspects must be given appropriate consideration in transportation modeling and urban architecture. As a result, for example, vertically integrated mixed-use projects are increasingly emerging in walkable neighborhoods connected to public transit.

Following their analysis of different urban forms, Jacques and El-Geneidy (2014) suggest that urban architecture interacts with personal behavioral characteristics. Ma and Cao (2019) indicate that the subjectively perceived environment also influences travel behavior. For example, cyclists and pedestrians perceive the environment in a more positive manner because of the direct reference and due to the lower speed compared to cars. It also shows that the car is often used primarily out of necessity and for lack of alternatives. It is revealed that the use of alternative means of transport to one's own car, such as public transport and cycling, are perceived more consciously and taken into account as an influencing factor in the choice of a place of residence (Ma and Cao, 2019).

A study by Jeihani and Zhang (2013) shows that if housing is well connected to alternative means of transport, residents drive about 20% less with their car. A possible approach to reduce personal automobile travel is a transit-oriented development (TOD), which combines housing with retail, office, and commercial space that is linked to good and closely timed transit service. These include, for instance, streetcar, subway, and regional trains to promote sustainable development in the form of better integration of land use and transportation (Abutaleb et al., 2019). Many daily trips can be covered quickly on foot, by bicycle or by public

transport if the urban infrastructure is developed accordingly. By optimizing land use, another study shows that a 5% increase in the pedestrian friendliness of a neighborhood can result in 6.5% fewer vehicle miles traveled (Frank et al., 2006). On this basis, it can be seen that in metropolitan areas with a well-developed infrastructure with good services, many people are willing to change their mobility behavior as long as the added value can be recognized and perceived in comparison to motorized individual transport (MIT). The results of the study conducted by Circella et al. (2016, 2018) show that sharing services, such as ride hailing (providers such as Uber and Lyft), can be a component of future transportation planning, to substitute trips with one's own car. On the other side the study points out the threat that trips might be replaced with sharing mobility services that would otherwise be completed either by public transport or active means of transportation such as the bicycle.

For future urban planning, two different approaches are to be combined: on the one hand, the revitalization of existing districts in the city center, and on the other hand new transit-oriented developments (TOD) on the outskirts of the city, which have a high population density while offering a diverse range of work and leisure opportunities. It also introduces the possibility of increasing proximity and availability of jobs in urban areas (Yan et al., 2020).

CHAPTER 4
METHODOLOGY OF URBAN MOBILITY BEHAVIOR

To establish a framework for answering the research questions posed in the introduction of this thesis, the first two subchapters describe urban mobility in Warsaw and Berlin on the basis of literature and data research. Finally, in the third subchapter, a comparison of important parameters between the two countries Poland and Germany as well as between the considered cities Warsaw and Berlin takes place.

Based on the survey results, the data obtained can be operationalized and provide insights for testing the hypothesis and answering the research questions. Thus, the questionnaire design with its structure and the applied survey approach is described in the fourth subchapter within the scope of the research design and the methodology. Moreover, some requirements of the sample size and quality, the data obtaining process and the data preparation are described, which act as a crucial basis for the statistical data analysis.

In the last part of this chapter the applied statistical methods for the city and generational comparison are presented, which include the factor analysis, the binary and multi-nominal logistic regression model and the single factor analysis of variance (ANOVA).

4.1 Status Quo and Future Prospects of Urban Mobility in Poland

Urban living in Poland

Historically, Poland's position in the Soviet sphere of influence meant that its economy was for large parts of the 20th century modelled as a planned economy. This resulted in a comparatively low level of industrial innovation and technological progress. Moreover, even after the fall of the Soviet Union, with a rapprochement to the West, power relations at the corporate level often remained intact, so that this counteracted a proper structural change in favor of the citizens (Siegelbaum, 2004). Other factors, such as high emigration from the former Soviet states to Western countries, led to further effects on the domestic economy and labor market (Mekvabishvili & Atanelishvili, 2017).

However, especially since Poland joined the EU in 2004, a gradual catching up of economic performance with Western European countries can be observed on the basis of increasing neoliberal attitudes (Węcławowicz, 2016). Nevertheless, Poland's economic performance and the general income level of the population lag behind other European

countries. In general, at the level of urban development, there has been a move away from socialist ideals to urban planning that has a stronger connection to the free market economy (Węcławowicz, 2016). This is also evident in the area of transport infrastructure and housing construction, which to this day still shows significant potential for increases in efficiency and modernization standards.

Poland shows an urbanization rate of 60% in the year 2020 (The World Bank, 2020). It is interesting to note that in Poland, contrary to the global trend, the number of citizens living in urban areas has been declining slightly since around 2002. At the same time, however, the total population is shrinking. In addition, a distinction must be made between residents who live centrally, in the immediate vicinity of larger cities, and those who really do live in rural regions. Although a certain degree of income inequality is evident in Poland, there is a trend for this to decline. However, similar to other Eastern European countries, the risk of poverty and lower income is still significantly higher in rural areas than in urban areas (Graca-Gelert, 2018).

A comparison of cities within Poland shows that Warsaw has the highest per capita income (Kachniewska et al., 2018). New figures for 2020 show a Gross Domestic Product (GDP) per inhabitant of about 133,000 PLN for Warsaw (Sas, 2021) which approximates to about EUR 27,000. However, the very slow growth in Warsaw compared with other cities indicates that the market is apparently already relatively saturated. In addition, further influx from the urban surroundings or other regions is relatively low. The current growth (year 2022) in the population is only 0.27% (World Population Review, 2022).

A study examining city life in the fields of housing, income, work, community, education, environment, civil society, health, life satisfaction and safety, shows that also Warsaw ranks first in Poland. Warsaw performs particularly well in the index values of income, work and health care (Włodarczyk, 2015). It also shows that a great deal of EU funding has been used to improve the various areas. The study concludes that residents find living in the city attractive, as there are not only opportunities on the labor market, but also entertainment and cultural offerings, a well-developed infrastructure, and growth opportunities.

Status Quo Developments in the Area of Smart City

In a study by Mercer on the quality of life in cities, Warsaw ranks 82nd (out of 231 cities worldwide[39]) and thus well behind other European cities (Mercer, 2019). The study analyzes different bigger cities around the world. In a more recent study from 2021 in the area of cost of

[39] The higher the rank, the better is the quality of life.

living, in which 227 cities were compared, Warsaw is ranked 164th (2020: 169th). This means in the case that the cost of living is relatively low compared to the income level.[40]

Within Europe there are efforts to learn from each other through cooperation and based on an agile and cooperative ecosystem for smart cities that created livable, attractive and resource-efficient cities (McKenna-Percy, n.d.). Within the framework of the EU project "SHAR-LLM" (funded by the H2020 program), for example, the so-called Sharing Cities[41] London, Milan and Lisbon defined as "Lighthouse cities", are cooperating in the development and implementation of an efficient smart city concept.

Horizon 2020 was a research and innovation funding program initiated by the EU for the period 2014-2020 with a budget of almost 80 billion euros, in which measures within the framework of smart city projects were also funded. The primary goal is to combat climate change through innovation and thus support the achievement of the UN Sustainable Development Goals (SDGs) and ensure global competitiveness (European Commission, 2020). It also acts as a successor program to the previously implemented 7th Framework Program of the EU (Talko, 2016).

Among the three key principles of "People, Place, Platform" ten audacious goals were set to develop replicable solutions, for example, on local renewable energy sources, e-mobility, urban living, and smart business. One of the main objectives is to integrate innovative solutions into the established infrastructure. Bordeaux, Burga and Warsaw, which are referred to as "follower cities," are to benefit from the experience gained there and transfer successful implementation projects to their own cities. From the overall funding of EUR 28 million, EUR 24.7 million are financed by the EU program. Launched in 2016, the project aims to raise around EUR 500 million in private capital to increase the number of cities to 100, which will then benefit from the collaboration and experience of the "lighthouse cities". For Warsaw, local working groups have been established to promote a transformation into a modern, sustainable city. The primary focus is on solutions for energy efficiency, natural environment and low greenhouse gas emissions in the areas of urban planning, energy networks, building construction, transport, waste management and water and wastewater management (Schmid, 2016).

[40] The higher the rank, the higher are the costs of living.
[41] Sharing Cities are pioneers in the field of Smart City, on whose experience other cities, the so-called "Following Cities" should benefit. The basis for this is intelligent city solutions to meet similar needs within complex urban environments. The primary goal is to increase the social, economic and environmental value of a city.

Moreover, within the framework of the FP7 and H2020 programs, various smart city initiatives in Poland could also be financed, even if, for example, the amount of H2020 with about EUR 3.7 million is relatively small compared to other large countries such as Spain, United Kingdom, France and Germany (Lewandowska & Gołębiowski, 2018). In this context, Warsaw also receives support at the international level on the basis of stronger cooperation, with a focus on environmental protection. As an indication of the comparatively small amount of EU funding for Poland, it should be noted that various projects were able to apply for support, but apparently no sufficient proposals were submitted from Poland in terms of quality and quantity to convince the jury. Other factors for Poland's low success rate may include insufficient engagement by Polish companies and the government with potential national and international cooperation partners for instance based on a public private partnership (Lewandowska, 2017; Nowak, 2010) and missing trust in the market (Danik, 2009).

Beyond the projects supported by the EU, hardly any smart city project was launched in Poland until the mid-2010. In particular, there were no overarching smart city initiatives coming from the government or the on a city council level. Initially, the majority of the projects are executed by companies without a significant involvement of external partners and with a primary focus on financial benefit (Kustra & Brodowicz, 2016). In 2017, a cooperation was also initiated with the Czech Republic, Hungary and Slovakia to build an integrated platform for intelligent solutions at the urban and regional level, in which various experiences and ideas can be incorporated (Il-Sook, 2021). This time, various companies were comprehensively involved to achieve, for example, an improvement in traffic communication, an increase in energy efficiency, as well as an optimization of management and provision.

Moreover, a report by Knight Frank (2018) shows that in the development of a smart city, Warsaw has already pushed various measures such as smart mobility with the provision of bike rental as well as car sharing via an app, the focus on smart environment aspects such as various energy saving measures, but also the planting of new green spaces as well as the active involvement of citizens in decision-making processes through smart government. Recent studies indicate that, with some delay, certain changes toward a smart city are being increasingly focused on Poland and an increasingly broad debate is taking place in the country, investigating the potential for gradual change based on innovation (Masik et al., 2021). Institutional change in terms of community participation, digitalization of service delivery, and a focus on addressing social needs in urban development are also expected to play a predominant role. In this context, it is possible to draw on empirical values from abroad, which

are already more advanced in smart city development. According to Masik et al. (2021), Warsaw should focus in developing sustainable and smart city solutions based on technologies such as AI, IoT, Big Data analytics and VR/AR. The various solutions are divided into four categories: (1) urban transportation and communications infrastructure, (2) urban planning and care for residents, (3) environmental protection, pollution, and sustainable energy, and (4) public services, resources, and administration.

Status Quo Developments in the Area of Smart Mobility

Initial measures have been adopted in Warsaw based on EU funding for a Sustainable Urban Mobility Plan (SUMP). These include an increase in public transport coverage. However, a report shows that there is currently no concrete implementation plan for the strategies. For example, there are no specific targets in terms of modal share (European Court of Auditors, 2020). In addition, only 37% of Warsaw's urban area is covered by spatial plans, which limits the effectiveness of urbanization design for urban mobility.

Within the framework of the smart city approach, a study shows various potential development scenarios in which the Warsaw transport system can achieve significant CO_2 reductions by 2050 (Zawieska & Pieriegud, 2018). However, to achieve the reduction targets set by the EU, far-reaching transformations are required, especially in the transport and energy sectors. Moreover, the decarbonization of the transport sector depends on various other factors, and future emissions can vary significantly depending on the practical implementation of the targeted measures. Various technology-based approaches, such as optimized traffic management and traffic signal control, intelligent parking management, replacement of combustion engine vehicles with zero-emission alternatives, autonomous vehicles, the development of intelligent public transport and the intermodulation of different modes of transport (MaaS) are expected to achieve the CO_2 reduction targets.

4.2 Status Quo and Future Prospects of Urban Mobility in Germany

Urban Living in Germany

By 2020, about 78% of the people in Germany live in cities or urban regions (The World Bank, 2018a). Especially in the last decade an increasing imbalance between growing cities with their suburbs and rural regions can be recognized (Zech, 2018). There is a strong exodus from the countryside to cities, and it is becoming increasingly difficult to find skilled workers in the rural areas. Moreover, an increasing trend of dying out of small cities with a loss of population, a lack of good infrastructure and social services can be observed (Baumann, 2016; Steinführer, 2020; Steinführer & Küpper, 2020).

An analysis by Scharf (2001) shows that there are more elderly people over 65 in percentage terms in the western states of Germany (so-called "old federal states") than in the eastern states (so-called "new federal states"). Especially in rural areas, very few people live together with their adult children or grandchildren, but they often live nearby. In 2018 and 2019, the public television in Germany conducted a major study that investigated living conditions among different areas of life (ZDF, 2019). In the country comparison shown there, Munich ranks first as the third-largest city in Germany overall. The factors work & living, leisure & nature and health & safety were analyzed. In a comparison of 401 cities and districts in Germany, Berlin was only ranked on place 189. Factors such as a high unemployment rate, high poverty, the negative relationship between income and housing costs, and a high crime rate mean that the areas of work & housing and health & safety in Berlin fall far behind in comparison. Nevertheless, the range and quality of recreation and nature is still very good (7th place). Even if there are no extreme differences in prosperity between urban and rural regions compared to other countries, there are, for example, major differences between smaller cities and communities in the vicinity of urban agglomeration compared rural regions (Zech, 2018a). For some areas, especially in the eastern part of Germany, the forecast shows that the population will shrink by almost a third by 2035. Younger and well-educated residents in particular are moving to big cities.

For cohabiting couples or families in a household where both are employed, it is increasingly common that at least one of the partners has to accept a longer commute to work. The consequences of this are not only increasing stress, but also less time for errands, hobbies and family. Women are increasingly having children later in life or even not at all, as there is a

greater focus on their careers, among other things (Federal Agency for Civic Education, 2020; Federal Statistical Office Germany, 2019).

Status Quo Developments in the Area of Smart City

A well-known study for the comparison of the quality of life in cities around the world is conducted by Mercer, an international consulting firm with a focus on asset management. The three German cities Munich, Düsseldorf and Frankfurt are among the top 10 and Berlin ranked on 13th place (Mercer, 2019). Compared with other cities, such as those in the USA or Asia, many European cities offer a good balance in the various criteria, such as good political and social environment, economic and socio-cultural environment, medical and health aspects, public services and transport, and natural environment[42]. In a recent study from 2021 in the area of cost of living, Berlin is situated at rank 60 (2020: rank 82; Warsaw rank: 164), noting that the higher the rank, the higher the cost of living in relation to income level (Mercer, 2021).

With respect to a smart city strategy, a Roland Berger study places Vienna, London, St. Albert (Canada), and Singapore at the top of global rankings (Roland Berger, 2019). In a Europe-wide comparison, however, Berlin is performing increasingly better thanks to various measures and is among the TOP10 cities in Europe (Wilson, 2020).

In a nation-wide comparison, according to a survey aiming to establish a digital ranking for Germany's major cities, Berlin is only in the 9th place behind cities such as Hamburg, Munich and Cologne, which means that Berlin has deteriorated by 2 places compared to 2020 and even by 5 places compared to 2019 (Pfefferle, 2021). However, in the area of mobility, Berlin is strong and has even improved to the 2nd place behind the national leader - Hamburg. A total of 133 parameters were analyzed in the study, which were weighted according to importance, resulting in a total of 36 indicators. These in turn are clustered according to the following five topics: (1) public administration, (2) IT and communication, (3) Energy and environmental, (4) Mobility, and (5) Society (citizens participation).

At the national level, the German Federal Ministry of the Interior, for Construction and Home Affairs supports the dialogue for smart cities by sharing experiences across the country, but also internationally (Federal Ministry of the Interior, 2022). In addition, financial support is provided to various smart city projects. A wide range of smart city initiatives are already being implemented in Berlin.

[42] retrieved April 20, 2022, from https://www.mercer.com/newsroom/2019-quality-of-living-survey.html

The initial step was taken with the launch of a smart city strategy for Berlin in April 2015 (Senate Chancellery, 2015). An initially high commitment, also in the direction of a coordinated approach with the participation of all stakeholders, was somewhat lost due to the election and change of government in 2016. At the beginning of 2021, as part of the "Smart Cities Model Project" program, Berlin has developed a new, ambitious smart city strategy. In addition, a Green Paper with thought-provoking ideas on specific topics has been developed, which consolidates into a White Paper that sets out rules for planned implementation in practice.

As part of the Urban Development Concept Berlin 2030[43] published by the Senate of Berlin, a catalog of measures was developed, which describes various concrete actions along the thematic clusters (1) Spatial structural measures, (2) Organizational measures, (3) Regulatory and pricing policy measures, (4) Information and communication, and (5) Infrastructural measures related to pedestrian traffic, bicycle traffic, public transport, road traffic and commercial traffic (Senate Department for Urban Development, 2015).

The focus of the city of Berlin is also clearly on a strong involvement of citizens, for instance by offering a platform with a "public knowledge repository" designed to enable citizens to actively participate in the idea development and decision-making process. With the so-called CityLAB, a public experimental laboratory for the city of the future has been implemented, in which the public administration works together with science, startups and companies, but above all in dialog with the citizens, to create (process) innovation and new forms of social participation (Technologiestiftung Berlin, 2022).

A prominent example of Berlin's smart city vision is the usage of the old Berlin-Tegel Airport after its final closure in spring 2021. This large-scale urban development project is used for the testing and implementation of new solutions and innovations to address the diverse challenges of urban life and to aim for a new future urban living concept including sustainable mobility. The total area of 211 hectare provides space for up to 1,000 companies, 5,000 Students and up to 20,000 employees. This new innovative district includes a mix of research, a hub for various startups, new modern and smart residential neighborhoods, an innovation park, and conference and accommodation facilities (Urban Tech Republic, 2022). The main idea is to provide an location, where specialists and creative people, but also all citizens, come together

[43] The urban development concept Berlin 2030 identifies future challenges, outlines development perspectives and sets priorities for their implementation. The focus is derived from the vision of increasing the quality of life as well as the competitiveness of the city. This includes, among other things, sustainable design in terms of climate and energy, as well as the development of sustainable mobility integrative with the citizens in the coexistence of a modern and socially responsible society.

to create the conditions for being able to implement the jointly developed solutions and innovative processes with an integrated and iterative approach in the entire Berlin urban area and beyond (Sack, 2022). The focus lies on sustainable buildings, eco-friendly mobility, recycling, sustainable future technologies and clean water.

Another interesting smart city project in Berlin has been taking place already for several years on the so-called "EUREF-Campus", a 5.5-hectare technology- and research center in which international companies and start-ups from the field of energy, sustainable development, and mobility operate. Overall, there are more than 150 companies and research facilities located with 5,000 employees on the campus. Already since 2014 the campus has been meeting the CO_2 climate targets for the year 2050 (R. Müller, 2022). In addition, the various innovation-oriented companies of the federally owned mobility and transport group "Deutsche Bahn" are being established there (EUREF AG, 2022).

On the smart city website of Berlin, there is also a map overview in which the current smart city projects can be displayed and selected (Senate Office Berlin, 2021). A direct link to the projects provides quick access to further details on the various smart city projects[44].

Status Quo Developments in the Area of Smart Mobility

There were only about 10,000 cars in Germany in 1906. By 1959 the number had already reached 3.5 million (Hoffmann, 1965). Since then, the car stock in Germany increased to more 47.1 million in 2019, which means a growth of more than 1,000% within around 60 years (Federal Motor Transport Authority (KBA), 2020a). This results in an average of more than 87 vehicles on German roads per hundred driving license holders (Federal Motor Transport Authority (KBA), 2020b). Moreover, it can be observed that since the beginning of the 21st century, the car market has saturated. Within the last almost twenty years, the growth was just at 10%.[45] At the same time the total length of traffic jams in Germany increased from 321,000 km in 2002 to 1,528 million km in 2018, an increase of almost 500%.[46]

A study shows that 43% of German citizens commute for more than 90 minutes every day (Kiecz, 2016). In Berlin, this figure is as high as 47.1%. The study also reveals that 77% of respondents say they find public transport efficient. They cite that their use is stress-free (68%), fast (44%), inexpensive (43%), and more environmentally friendly (27%). About 32% of survey

[44] retrieved July 03, 2022, from https://smart-city-berlin.de/projects-map
[45] Source: Kraftfahrt-Bundesamt (German Federal Motor Transport Authority)
[46] Source: ADAC (German leading automobile club with more than 20 million members)

respondents say that commuting causes them stress when they use public transport. The main reasons cited are recurring technical problems (79%), associated with longer waiting times and delays, as well as aspects such as overcrowding (73%) and pollution (49%).

Based on a statement from the Federal Statistical Office of Germany with regard to the daily commutes of employed and self-employed persons, the overall average distance for a return trip is about 34 km for which a commuter needs 51 minutes on average per day (Federal Statistical Office of Germany, 2022). Another but older source reveals a daily average distance travelled by each Berliner of 20 km which requires spending about 70 minutes for travelling in total a day (Senate Department for Urban Development, 2015).

In 2015, Berlin developed a smart city strategy divided into six different fields of action, one of which is smart mobility. Within a "city of short distances", the focus lies on sharing offers and autonomous vehicles, self-determined mobility, traffic concepts, electromobility and network integration, traffic control and traffic safety, and urban logistics. Moreover, the published Green Paper describes a vision for a digital Berlin, in which, among other things, the Berlin Mobility Act of 2018 is to be further developed and a Mobility 4.0 master plan is to be drawn up (Schwarz, 2018). In this regard, MaaS is also expected to play an important role.

Especially in recent years, the Berlin Senate has been pursuing a change from a city dominated by combustion engines to an intermodal use of transport with a focus on public transport and the expansion of bicycle lanes. Buses with internal combustion engines are gradually being replaced by electric and hydrogen propulsion. Different projects are being coordinated in the areas of pedestrian traffic, bicycle traffic, buses and trains, and local transportation plans (Senate Department for Environment, 2021). The goal is to achieve CO_2-neutrality established in the inner part of the city (S-Bahn ring) by 2030. Motorized private transport is to be gradually reduced and, in the medium term, vehicles with internal combustion engines are to be completely banned from the central city core and later beyond it as part of the Zero Emission Zone, which will be initially within the Berlin S-Bahn ring (Reupke, 2021). Currently 74% of trips in the city of Berlin are already made by bicycle, buses, and trains, or on foot.[47] In addition, to specify the strategy with respect to urban mobility, the urban development plan (StEP) for the action period of transport until 2030 was developed. Based on the so-called "environmental alliance", consisting of pedestrian and bicycle traffic, as well as public transport, the share of trips not covered by cars is planned to continue to rise from an

[47] retrieved November 15, 2021, from berlin.de/mobilitaetswende

already high value of 74% to 82% in 2030. Only the remaining 18% should then take place with motorized individual transport, but this should be CO_2 emission neutral.

With a focus on the substitution of the own car by joint mobility offers and mixed urban use to create new open spaces, different smaller projects have been launched. In some neighborhoods, the focus is on how the newly created space can be utilized for various urban living initiatives, such as small recreational areas with public gardens, car, bike and e-scooter sharing opportunities, and the creation of traffic-calmed areas with safe playgrounds for families with children (Neue Mobilität Berlin, n.d.).

Another interesting mobility project is the Urban Quarter 4.0 ("Stadtquartier 4.0"), where the development of a future-oriented, sustainable logistic that is adapted to a city's needs is to take place (Rybarczyk, 2022). Within the project the following focus areas are approached: (1) Logistics management, geared to the avoidance and bundling of flows of goods in specific quarters, including analysis, planning and specification; (2) Avoidance of transports: local cultivation of food; (3) Compatible handling: modular transfer and handling system; (4) Shifting transport, e-commercial vehicle sharing; (5) Use of e-load wheels and e-utility vehicles. The main focus is on social processes and sustainable urban transformation. Based on the pilot project in Berlin Friedrichshain-Kreuzberg, the aim is to achieve good transferability to other neighborhoods, for which the follow-up project Stadtquartier 4.1 was launched.

Overall, CO_2 emissions in the transport sector throughout Germany are to be cut by almost half by 2030 (Kaiser, 2022). Berlin also has the goal of being climate-neutral by 2045 (Lehmann, 2022).

4.3 Comparison between Warsaw and Berlin

Demographics, Economic Factors and Population Structure

To establish a baseline for the comparison of the cities of Warsaw and Berlin, first several key demographic parameters between Poland and Germany are compared. They show that even though the area of Germany is only slightly larger than that of Poland (+14%), Germany has over twice as many inhabitants as Poland (+216%) and thus has a higher population density (+76%). In addition, the degree of urbanization in Germany with about 78%, is considerably higher than in Poland, where it is at around 60%.

The average age in both countries is among the highest in the world. However, with a median age of 41.8 years, the population of Poland is still considerably younger than the one in

Germany with 46.6 years. Germany even has the second oldest population in the world after Japan (Ritchie & Roser, 2020).

Table 11: Comparison demographic facts between Poland and Germany

	Measure	Value Poland	Value Germany	Unit
Demographics	Population	38,354,000	82,886,960	Inhabitants in total
	Area size	312,685	357,022	km²
	Population density	123	232	inhabitants/km²
	Urbanization [in total]	22,789,800	64,509,000	Urbanized inhabitants in total
	Urbanization [percentage]	60.0	77.5	%
	Average age	41.8	46.6	years
	Employment rate	73.6	79.2	as % of the population aged 20 to 64
	Unemployment rate	5.5	5.0	%
	Rate of retired people	24.2	26.1	%

Details and sources see Appendix A: Details to basic figures and key mobility indicators

Both countries have a comparatively high rate of retired people due to the high proportion of older people (approx. one quarter of the total population). The unemployment rate is relatively similar in both countries, at around 5%. A comparison of economic factors shows that Germany has a total economic output (GDP) which is about 6 times higher than that of Poland (USD 3,846 billion as compared to USD 596 billion). Per capita, the values are USD 41,259 in Germany and USD 14,588 in Poland. It is interesting to note that while purchasing power (PPP) in Germany is slightly higher at USD 50,922, in Poland it is more than twice as high as GDP per capita at USD 32,238. In an EU-wide ranking of purchasing power, Germany is well above (value of 121) and Poland well below (value of 76) the average value expressed by the value of 100 as a reference. The higher the value, the more one can afford for their money.

The inflation rate in Poland is significantly higher at around 8% compared with around 5% in Germany in 2021. Due to various developments such as the current crises, the financial policy of the central banks and various political measures, the inflation rate is currently rising very sharply in both countries, which in turn is further reducing real purchasing power.

An important indicator of the cost of living is the significant increase in housing costs compared with overall inflation (house pricing index). Over the past 10 years, housing costs

have risen by a total of 51% in Poland and by as much as 109% in Germany compared with the base level in 2012. At the same time, the home owner rate is significantly higher in Poland than in Germany (+70%).

Table 12: Comparison of economic factors between Poland and Germany

	Measure	Value Poland	Value Germany	Unit
Economic factors	GDP total	596	3,846	in billion USD
	GDP per capita	14,588	41,259	USD per capita
	Purchasing Power Parity[48] (PPP)	32,238	50,922	USD per capita
	Ranking PPS[49] within EU	76	121	Average EU-27: 100
	Average salary in EUR	1,292[50]	4,168	EUR / month net
	Inflation rate (monthly average in 2021)[51]	5.31	8.01	% [Harmonized Index of Consumer Prices]
	Maximum personal tax rate	32	45	%
	House Price Index	151	209	last 10 years
	Home owner rate	85.6	50.4	%

Details and sources see Appendix A: Details to basic figures and key mobility indicators

Coming from the country comparison, the next step investigates key indicators and facts with regards to demographics and mobility parameters between Warsaw and Berlin. The ratio of total inhabitants between Germany and Poland is relatively similar in relation to the two capitals (both ratios about 2.2 to 1). Warsaw with 1.8 million inhabitants is by far the largest city in Poland, followed by Krakow (approx. 800,000 inhabitants), Lodz (approx. 672,000 inhabitants) and Wroclaw (approx. 642,000 inhabitants). The situation is similar in Berlin, which in terms of population is more than twice as large as the second largest city, Hamburg (approx. 1.8 million inhabitants), followed by Munich (approx. 1.4 million inhabitants) and Cologne (approx. 1.0 million inhabitants). Although Berlin has a much greater land area than Warsaw (+72%), on average one inhabitant in Berlin has an area of about 237 m², which is about 22% less than in Warsaw, where it is about 288 m². Warsaw consists of 18 different districts (Statistical Office in Warsaw, 2013). Berlin has 12 administrative districts, which in turn are divided into 96 local areas (berlinmap360, 2022).

[48] Purchasing power parity (PPP) indicates how many currency units a given quantity of goods and services costs in different countries. This takes into account the actual country-specific purchasing power for goods and services and compares it with macroeconomic variables such as gross domestic product (GDP). A uniform conversion to a specific currency thus makes different countries internationally comparable.
[49] The purchasing power standard (PPS) is a notional monetary unit used for economic comparisons within the European Union. The PPS is applied to eliminate distortions due to differences in price levels between different countries.
[50] 5,995 PLN calculated in EUR according to exchange rate from 14th of April 2022: 1 PLN = 0.2155
[51] in the current year 2022 (execution of the study was summer 2021) the HVPI is further increasing with 10.9% in Poland and 7.3% in Germany with respect to March 2022

Table 13: Comparison of basic numbers and demographics between Warsaw and Berlin

	Measure	Value Warsaw	Value Berlin	Unit
Demographics and socio-economic	Population	1,794,166	3,769,962	Inhabitants in total
	Area size	517.24	891.68	km²
	Population density	3,469	4,228	inhabitants/km²
	City structure	18 city districts	12 administrative districts divided in 96 local areas	-
	Average age	42.0	42.6	years
	GDP total	50.35[52]	154.63	billion EUR
	Average salary (gross)	1,645[53]	3,484	EUR
	Average salary (gross, normalized with PPP)	4,288	3,484	EUR
	Unemployment rate	1.7	8.5	%
	Number of students	235,000	202,224	people
	Percentage single-households	32.6	52.7	%

Source: Own illustration based on own different sources e.g., from the statistic offices in Poland and Germany and other sources; details of the different measurement indicators and sources cf. Appendix A: Details to basic figures and key mobility indicators

A comparison between the two cities shows that the average age of residents in Warsaw (42.0 years) is almost equal compared to Berlin (42.6 years). In Warsaw, many more residents have paid jobs, which leads to the situation that the unemployment rate is only a fifth of that in Berlin. Total GDP in Berlin is about three times higher than in Warsaw. In terms of average salary, Berliners earn more than twice as much as people in Warsaw. However, it is necessary to consider the effective purchasing power, for which purchasing power parity can be used.[54] Since the cost of living, for example for rent, but also many other everyday things are cheaper in Poland, this effectively shows a deviating actual purchasing power.

In addition, Warsaw has significantly more students than Berlin, especially in relation to its population. While Berlin has 53 students per 1000 inhabitants, Warsaw has 131. When looking at single households, the rate of 52.7% in Berlin is the highest in Germany. In Warsaw, the figure is significantly lower at 32.6%.

In the next step, the population structure is depicted in more detail in comparison. It shows that the age structure in Poland and Germany is relatively similar in terms of gender distribution, but also in terms of the ratio of children to young people (up to and including 17 years), adults of typical working age (18 to 64 years) and retirement age (65 years and older).

[52] 233,63 PLN calculated in EUR according to exchange rate from 14th of April 2022: 1 PLN = 0.2155
[53] 7,633 PLN calculated in EUR according to exchange rate from 14th of April 2022: 1 PLN = 0.2155
[54] This is at a ratio of 1.78 to 1, i.e. with 1.000 EUR in Germany, PLN 1.780 must be earned for the same purchasing power in Poland. Therefore, the average income of 7.633 is now divided by this value, which then corresponds to 4.288 EUR.

In both countries, there are slightly more women than men. With around 22% of retired people in both countries, a global comparison confirms that their populations are relatively old. In Poland this share has increased particularly strongly in the last decade (by 28% between 2011 and 2021, whereas in Germany it rose by only 3.3% between 2010 and 2022).

Table 14: Comparison of Poland vs and Germany − Clustering of age groups with respect to age, working age and genders

	Measure	**Value Poland** [inhabitants in total in million]	**Value Poland** [share in % of population]	**Value Germany** [inhabitants in total in million]	**Value Germany** [share in % of population]
Details population	Population ≥ 18 years	31.23	81.4	69.41	83.5
	Population female	19.68	51.6	42.39	51.2
	Population male	18.50	48.5	40.41	48.8
	Pre-working age (0-17)	6.96	18.2	13.75	16.5
	Working age (18–59/64)[55]	22.89	60.0	51.14	61.5
	Post-working age (60/65 and more)	8.34[56]	21.8	18.27	22.0
	Baby Boomers	8.47	22.1	19.27	23.2
	Generation X	8.29	21.5	18.28	22.0
	Generation Y	8.20	21.4	15.91	19.1
	Generation Z[57]	3.24	8.5	7.10	8.5

Source: Own illustration based on own different sources cf. Appendix A: Details to basic figures and key mobility indicators

When comparing the demographic structure between the countries and their respective capitals, the Baby Boomer, Gen X, and Gen Y cohorts show relatively similar values for both Warsaw and Berlin. In Berlin, there is only a +0.7% difference in the case of Gen X compared to the overall value of Germany. For Gen Y in Berlin (+3.0%), the share of the urban population is also somewhat higher than in Germany as a whole. The difference is much larger for Gen Y in Warsaw, where the share is 33.5%, which is 12.1% higher than in the total population of Poland. Moreover, Gen X is about equally represented in both cities compared to their nation-wide value.

[55] Working age in Poland is defined differently depending on gender: for men, the age range is between 18 and 64, for women between 18 and 59.
[56] Age at which people usually end their careers, based on source assumed for men: 65 years and more and for women: 60 years and more.
[57] A different age classification serves as the data basis for the generations for Warsaw and Berlin. Therefore, a linear approximation of the given age groups with corresponding population figures was made to the age groups of the generations defined in this work.

Table 15: Comparison of Warsaw and Berlin − Clustering of generations

[all values are rounded to thousand and the first decimal point for the percentage value]

	Measure	**Value Warsaw**[58] [inhabitants in total]	**Value Warsaw** [share in % of population]	**Value Berlin** [inhabitants in total]	**Value Berlin** [share in % of overall population]
	Baby Boomers	371,000	20.7	793,000	24.1
	Generation X	365,000	20.3	748,000	22.7
	Generation Y	602,000	33.5	723,000	22.1
	Generation Z	171,000	9.5	271,400	8.2

Source: Own illustration based on different sources cf. Appendix A: Details to basic figures and key mobility indicators

After cumulating the four generations shown, it becomes apparent that about 16% in Warsaw and about 23% in Berlin do not belong to any of these defined generations. That is, they are either under 18 years of age or 75 years and older.

Comparison of facts and figures with respect to urban mobility

Some facts in the areas of socio-economy and socio-demography as well as key mobility indicators between Warsaw and Berlin are compared on the basis of data research to create a further foundation for the subsequent comparison of cities and generations. A European comparison shows that the traffic situation is dominated by cars in both investigated countries, Poland in the third place with 642 cars per 1,000 inhabitants and Germany on the sixth rank with 575 cars per 1,000 inhabitants (Brandt, 2021). However, it is interesting to note that Berlin has by far the lowest number of cars in Germany in relation to the number of inhabitants, with only 330 cars per 1,000 citizens (Federal Bureau of Statistics Germany, 2020). In contrast, the percentage of car users in Warsaw is even higher than the Polish national average. In both cities, average fuel costs are relatively high in relation to per capita income, although in Warsaw in particular, a relatively large share of income is invested into the own car.

It is apparent that the citizens of Warsaw are more often stuck in traffic jams and have to put up with correspondingly more time delays than in Berlin. In Warsaw, a driver loses an average of 154 hours per year on average. In Berlin, that's still 105 hours lost to traffic jams. Assuming 55 years of an active lifetime from adulthood, this means that a Warsaw citizen spends a total of 0.91 years stuck in traffic, and a Berlin citizen still spends a total of 0.66 years, valuable time which could be used much more senseful.

[58] Since there are no direct statistics on the various age groups for the city of Warsaw, the Masovian Voivodeship ("Mazowieckie"), and here the proportion of the urban population was used (3.4 million). This, in turn, was broken down linearly on a pro rata basis for the city of Warsaw.

Table 16: Comparison of Warsaw and Berlin − Key mobility indicators

	Measure	Value Warsaw	Value Berlin	Ratio / Remarks
Key mobility indicators	Car use	76.4	33.0	% of the population
	Relative fuel costs	32nd	24th	The higher the rank, the lower the relative costs; ranking of 38 cities
	Congestion level world rank	30th	79th	The higher the rank the more traffic; ranking from 1 to 404
	Traffic congestion index	37%	30%	Extra time spend during rush hour compared to baseline non-congested conditions
	Time lost in rush hour	154	105	hours per year on average per car driver
	Public transport frequency	189	442	trips per stop per day
	Public transport coverage	77	75	% of city area
	Public transport expense	2.8	3.9	% of monthly income
	Public transport vs car speed	24th	15th	ranking of 38 cities
	Percentage of green spaces	8.7	27.0	% of city area

Source: Own illustration based on different sources cf. Appendix A: Details to basic figures and key mobility indicators

The mobility behavior of city dwellers depends on a variety of factors. In addition to personal influencing factors and habit patterns, the range of mobility options available as an alternative to one's own car is also of decisive importance. In this context, public transport plays a significant role. The frequency of service in Berlin is significantly better than in Warsaw (+233%). Calculated over the entire 24-hour day, there is a public transport trip every 3.3 minutes per stop in Berlin (it can be different lines and corresponding routes). In Warsaw the corresponding number is only every 7.6 minutes. In relation to the effective income, a ticket for public transport is slightly more expensive in Berlin (3.9%) than in Warsaw (2.8%). With about three quarters of the city area, both cities are equally well connected to public transport. To provide an important alternative to the car, speed and thus travel time is a particularly important factor. Berlin offers significantly more effective and faster public transport connections (rank Warsaw: 29th vs. Berlin: 15th of 38 cities in comparison).

As an important factor for air quality as well as for local recreation opportunities, sufficient green spaces in a city are important (Krajnik et al., 2019; Nieuwenhuijsen et al., 2017). In Berlin, the proportion of green spaces is more than three times higher than in Warsaw.

Sources could be found that show the modal split of both cities, but in practice a direct comparison is not purposeful. Depending on the study, different assumptions and calculation models were used. Therefore, the two cities are considered separately. A systematic comparison

is impeded by the fact that in most cases a person uses not only one, but several means of transport in practice. Therefore, either complicated calculation models with certain assumptions or strong simplifications have to be made. For example, the following basic calculation principles can be established: (1) quantifying the distribution of the number of trips and thus neglecting the difference distances and travel durations; (2) simplifying the primary mode of transport for certain purposes, such as daily commuting; (3) detailing travel time per mode of transport with reference to the purpose (e.g., differentiating between daily commuting and leisure travel).

A comprehensive survey with 17,000 study participants on the modal split with a special focus on gender differences shows that women in Warsaw are more willing to use public transport or active transportation (such as walking or taking a bicycle) even though they have a car (Maciejewska & Miralles-Guasch, 2020).

Table 17: Modal split by gender in percentage with respect to trip frequency

	Means of transport	**Women**	**Men**	**Difference**
Modal split Warsaw	Public transport (bus, subway / tram, short- and long-distance train)	54.1%	41.3%	12.8%
	Motorized individual vehicle (primary car, motorbike, scooter)	25.4%	42.8%	17.4%
	Active (bicycle, on foot)	20.5%	15.9%	4.6%

Source: (Maciejewska & Miralles-Guasch, 2020)

By looking further at the different age groups, it can be seen that for the working population between the ages of 18 and 65, the difference becomes greater with increasing age (Maciejewska & Miralles-Guasch, 2020). For example, in the age group 46-64, 21.0% fewer women use private cars, while 15.6% more use public transport.

With reference to Warsaw, it can be seen that despite a very high rate of residents having access to their own car (76.4%, see Table 16), almost half of the trips are nevertheless made using public transport. These figures could indicate that often the car is not used exclusively, but rather as a supplement.

For Berlin in particular, more comprehensive data is available on the basis of the study "Mobility in Cities" (Thomsen, 2020). To resolve the aforementioned calculation issue for the unambiguous assignment of means of transport as far as possible, a corresponding methodology

was established (Hubrich et al., 2019). For instance, the use of different means of transport was mapped in such a way that, on the one hand, the mainly used transport means was determined and, on the other hand, a hierarchy was created on the basis of the means of transport with the greatest distance-related performance. This means that the longer a mode of transportation travels, the higher it was prioritized.

For Berlin, there is a clear trend away from motorized individual transport (MIV) toward the so-called "environmental alliance", which consists of public transport, cycling and walking. These modes of transport together already account for around three quarters of all journeys made. Based on the methodology described above, the analysis results in the following modal split: public transport 27%; bicycle 18%; motorized private transport 26%; on foot: 30%.[59] The study is designed to be conducted every 5 years. It shows that while public transport and walking remained almost the same in 2018 compared to 2013, more people travel by bicycle (+5%) and fewer by car (-4%).

The study was further broken down in detail to the various city districts and evaluated separately, but also aggregated (cf. Table 18). The overview shows that the car still achieves the highest average speed (22.8 km/h), but that people who travel by public transport travel slightly further distances on average.

Table 18: Travel indicators of different transport means for Berlin

	Means of transport	**Travel time per way in min**	**Distance per way in km**	**Average speed in km/h**
Travel indicators Berlin	Public transport (bus, subway / tram, short- and long-distance train)	40.5	10.2	15.1
	Motorized individual vehicle (primary car, motorbike, scooter, ride sharing)	23.9	9.1	22.8
	Bicycle	19.1	3.7	11.6
	On foot	14.0	0.9	3.8

Sources: (Thomsen, 2020)

[59] Due to rounding up or down, the total value does not add up to 100

4.4 Research Design and Methodology

Questionnaire Design, Pre-test and Applied Survey Tool

For the data collection, a comprehensive questionnaire with quantitative but also qualitative questions was developed to address the target groups of Gen X, Gen Y and Gen Z. The survey was conducted using an online-based survey tool. To assess the questionnaire in practice with regard to its validity, comprehensibility and measurement of the time required by respondents to complete it, a pre-test was conducted with a test group. After the revision of the questionnaire to the final version, the survey was conducted for the city comparison in Warsaw and in Berlin.

Various studies and surveys in the fields of smart city (Baccarne et al., 2014; Cretu, 2012; Georgiadis et al., 2021; Sánchez-Corcuera et al., 2019; Zygiaris, 2013), urban mobility (Alyavina et al., 2020; Marshall, 2012; Mayo & Taboada, 2020; Mola et al., 2020; Schulz et al., 2021) and the mobility behavior of different generations (An et al., 2021; J. W. Kane & Tomer, 2014; Olsson et al., 2020; Suchanek & Szmelter-Jarosz, 2019; Tuncali et al., 2018) were analyzed to support the development of the questionnaire. Baccarne et al. (2014) point out that it is particularly important that a city-managed instrument should ensure systematic governance of the various governmental, but also private-sector, stakeholders to enable a combination of top-down policy and bottom-up interaction. With regard to the various smart city areas, the fields of environmental protection, a pleasant and smart living situation, and effective mobility seem to be particularly important (Georgiadis et al. 2021). However, the prioritization may vary depending on the region and the city. Across the various studies, it is apparent that effective and sustainable integration of technology must be oriented towards people and their right to self-determination over their data (Z. Khan et al., 2017; Lim et al., 2018; Sánchez-Corcuera et al., 2019; Velosa, 2013). Certain studies also link specific application areas to a particular generation. Bak and Borkowski (2019) for example, studied the perception of information and communication technologies (ICT) solution changes among young transport users. They found that access to a private car does not need to be a limiting factor for the use of public transport if efficient and mature technologies are used and can promote sustainable transport behavior.

In addition, to obtain an aim-oriented survey process, first some preconditions were defined. A maximum of 25 (clustered) questions with regard to the research topic were defined. Furthermore, users were asked to anonymously provide general information about themselves in order to obtain socio-demographic and socio-economic information such as gender, age,

living situation, education level etc. Length plays an important role, especially in online surveys. There is usually a negative correlation between the length of the survey and the response rate, but also with the complexity of the questions (M. Liu & Wronski, 2018). Regarding the optimal length of an (online-based) survey, there are different indications in the literature. While some consider a duration of 30 minutes to be appropriate to ensure the attention of the majority of respondents (H. Sharma, 2022), other sources indicate an ideal duration of between 10 and 15 minutes (B2B International, 2022; Revilla & Höhne, 2020; Revilla & Ochoa, 2017). To achieve the highest possible response rate and at the same time to be able to collect sufficient data, the questionnaire used in this research paper has been designed in such a way that it can be completed within 12 to 15 minutes. The quality and time requirements were evaluated within the scope of the pre-test.

The questions are designed according to the general relevance for the population and aim to question the daily travel behavior relevant to practice. This means that the questions must be easy to understand and practically self-explanatory. If necessary, additional explanations are given in the comment line. In the beginning, some questions are placed that are especially appealing to the respondent and arouse interest to promote the motivation to fill out the questionnaire to the end. The socio-demographic and socio-economic questions are asked in the end, as those are often answered somewhat reluctantly by the participants (e.g., questions about disposable income). These more personal questions sometimes bother participants, as some people are unwilling to disclose personal information even if the survey is conducted anonymously, which as experience has shown leads to a higher dropout rate. If questions of this kind are asked at the end, participants may still refuse to answer them, but at least the previously asked questions have usually been answered as far as possible. Moreover, it is important to ask as few open-ended questions as possible and rather ask questions that can be answered by pure selection and simple clicking to reduce the dropout rate (Galesic, 2006).

In the beginning, all survey participants were informed that all answers they provided would be voluntary, anonymous and confidential. To avoid seasonal bias, participants were asked about their usual travel behavior or related to certain average values. In order to minimize the influence of seasonal weather on mode choice among the various study participants, all data collection was conducted within the same one-month period. In addition, all data was collected in aggregated form and evaluated anonymously for a group. Participants are asked to fill in the questions truthfully and to the best of their knowledge. The questionnaire was initially created in English, as the language of the PhD thesis is English. However, to make it accessible to local

participants in both countries, the survey was translated to German (for the survey in Berlin) and Polish (for the survey in Warsaw). In both cities, participants were able to answer the question either in English or the mother language.

Based on the findings and derived measures, the questionnaire was redesigned. The final version comprises a total of 18 (clustered) questions with multiple choice answers mostly based on a 5-point Likert scale and having in the majority categorical (ordinal / nominal) and partly continuous (ratio) variables. Due to time and evaluation reasons, only closed questions were applied.

The questions are covering the following areas (compare also Figure 9):

- Personal values of different generations to provide an overall framework for their behavior of the different generations: Questions regarding professional life and career / education, daily life and social environment and the use of technology on a daily basis.
- Questions regarding urban mobility, modal split, travel behavior and aspects like travel time and travel distances for daily commute and leisure time travelling. These constitute the core element of the survey and aim to answer main aspects to test the hypothesis.
- Questions regarding future living in a smart city to investigate correlations between ways of living and urban mobility. In addition, the aim of this part is to put urban mobility into the context of a smart city, building the baseline for rounding up the topic and providing an outlook to the future within the conclusion of the dissertation.
- General questions of social-demographic and social-economic factors like living location, gender, living situation and income, access to a car, bike etc. This information provides the framework for the survey and enables intergenerational comparison.

Personal values of different generations	**Urban mobility and travel behavior**	**Future living in a smart city**	**General information**
○ Professional life and career / education ○ Daily life and social environment ○ Use of technology in daily life	○ Modal split and choice of transport mode ○ Use of sharing offerings ○ Travel distances & travel time ○ Daily car use	○ Future urban mobility ○ Future living regarding the impact on urban mobility ○ Future working connection with mobility	○ Socio-economic factors like age, gender, job or education status, income, living location ○ Holding driving license and use of monthly/annual season-ticket for public transport ○ Access to car and bike
Variable data types & scale: ○ Categorical (Ordinal) with 5-point Likert scale ○ Scale: strongly agree; agree; neither agree nor disagree; disagree; strongly disagree	**Variable types:** ○ Numeric (Discrete): e. g. Selection of daily transport use and means of transport ○ Categorical (Ordinal); Scale: very good; good; neutral; bad; very bad; not applicable/relevant	**Variable types**: ○ Categorical (Ordinal) with 5-point Likert scale ○ Scale: from very important to very unimportant; from strongly agree to strongly disagree; from very satisfied to very dissatisfied	**Variable types:** ○ Numeric (Continuous) ○ Categorical (Nominal) ○ Categorical (Ordinal)

Figure 9: Overall structure of the questionnaire and applied variable types and scales

Source: Own illustration based on questionnaire design

The final version of the questionnaire in English can be found in Appendix B: Questionnaire.

Execution of the Survey and Sample Requirements

For the collection of primary data based on the final questionnaire, the survey was conducted in Warsaw (WAR) and Berlin (BER) at the same time between May 25 and June 25, 2021. The target group was derived based on the considered urban citizens of Warsaw and Berlin and the different generations. The final sample was selected based on the inclusion criteria for Gen Z, Gen Y and Gen X (survey participants aged 18 to 56) as well as the place of residence (WAR and BER).

Participants from the Baby Boomer generation are excluded as they are not the focus of the study, and the overall sample size (n = 59) is relatively small for getting a statistical significance.

Depending on the statistical method used and the research question, a sample should have a certain minimum size (Malone et al., 2016). For most applications, such as a Pearson correlation analysis, a sample size of 200 is sufficiently large to obtain statistically significant and thus meaningful statements (Memon et al., 2020). Some researchers are even proposing a sample size of at least 250 (Oribhabor & Anyanwu, 2018). However, it should be noted that depending on the research area and applied statistical method based on the research question, the samples may have different significance (Boddy 2016; Malterud, Siersma, and Guassora 2016).

To achieve a possible balance between the quality of the results and the effort required for data collection, the aim was to achieve between 220 and 250 evaluable responses for Warsaw and Berlin. From experience, it can be assumed that only about 15 to 30% of the invited participants provide a valid response (Deutskens et al., 2004). In order to achieve the target total of 480 respondents assumed, it can therefore be expected that between 1,600 and 3,200 people need to be invited to participate in the survey in order to achieve this target quota.

Obtained Data and Data Preparation

It must be emphasized that even within urban areas there is a difference in where someone lives, e.g., in the inner circle of a city or rather in the suburbs, which affects e.g., the choice of means of transport. Nevertheless, no general specific differentiation is made in this study. However, factors such as distance and time spent on the daily commute are considered based on the questions asked in the questionnaire. The inclusion criterion for the urban region

for both cities was a radius of 50 kilometers from the inner-city center based on Google Earth, which resulted in investigated urban areas for Warsaw and Berlin with the same area size.

Since it soon became clear that it would be more efficient to conduct a survey of this scale with the help of third party support, two different private research companies were contacted based on market research and a corresponding offer was requested. Besides the service quality, an important criterion was a balanced group of participants across the different generations as well as a sufficient number of potential survey respondents for Berlin, but particularly Warsaw, since the participation rate was lower there in comparison. A secure and efficient execution of the survey with external support could also be ensured by the previously set requirement on the survey tool for the technical possibility of a smooth interface to third parties / service providers. An improved generation-distribution-rate could be achieved by a targeted addressing of the different age groups.

Participants who did not adequately complete the survey or did not answer the questionnaire in a meaningful and sufficient manner were excluded. Various methods are used to identify these, e.g., control questions, logical tests etc. Moreover, besides the place of residence, other exclusion factors, such as a too short response time, are defined and thus the data set is marked with insufficient quality and therefore not considered in the data analysis. Overall, about 20% of the data set (survey participants) were not qualified based on the exclusion criteria. In the end and including the support of the external research company, a sample of n = 263 (~ 44% of the whole sample) for WAR and n = 333 (~ 56% of the whole sample) for BER could be achieved. From this overall sample with a total of 596 valid answers, about 6.4% (38 participants) still had a partly incomplete data set, where in most cases at least one value is missing. It is known from applied statistics that missing values in the evaluation can lead to various problems, which are hardly avoidable. There are statistical techniques in place which investigate missing values and provide different approaches to handle the problem and minimize the negative impact for the incomplete data set (Houari et al., 2014; Morimoto, 2021; Soysal et al., 2018).

A closer look reveals that certain questions were frequently not answered. Some methodological procedures, such as factor analysis, completely exclude data sets where individual data are missing. Finally, after a step-by-step analysis and substitution for the different variables, 583 complete data sets were generated (Warsaw: 259 [44.4%]; Berlin: 324 [55.6%]). Thus, a total of 13 more data sets were excluded. A look at the generations shows that most exclusions occurred in the Baby Boomer generation (a total of 8). This can be seen as

rather favorable due to the subject matter of the study, as this group is not considered in this research work. For the other generations, only a few or even none were excluded (Gen Z: 0; Gen Y: 3; Gen X: 2). Therefore, it can be fundamentally assumed that the data quality is not significantly negatively affected for further statistical analysis. After subtracting the Baby Boomer (n = 54, of which 8 were already excluded as described above) not considered, a sample size of n = 537, divided into 246 data records for Warsaw and 291 data records for Berlin, can ultimately be used for the analysis.

The developed questionnaire is based on a logical sequence that is optimized for smooth completion by the study participants. For an optimized factual-logical evaluation, however, a partially deviating clustering is carried out with respect to the statistical evaluation. It should be noted, though, that this does not lead to inaccurate evaluations, as the data collected remain the same. In addition, various decodings were carried out, which are useful for an evaluation with SPSS version 22. These include, for example, coding in binary values (1/0) such as the holding of a driver's license or access to a bicycle. Furthermore, other simplifications were made. For the number of persons in the household, for example, a binary division was made between single-households and not-single households (multiple-person-households). The same applies to the occupational or educational standard, where a simplified distinction is made between employed and non-employed.

Other categories, such as the level of education, were divided into four different categories for Poland and Germany based on the International Standard Classification of Education (ISCED). For all questions with a 5-point Likert scale, the inverse value is also assumed. This results in an index which, with an increasing value, also corresponds to higher agreement. The selection criteria for these questions in the questionnaire were based on the fact that the value "1" was defined with the highest agreement value (for instance "I strongly agree") and 5 for the lowest value (for instance "I strongly disagree").

To obtain an appropriate representation of generational and gender distribution, data collected through the survey were weighted using relevant generational and gender structural characteristics from secondary data (Rudnicka, 2022; Statistics Poland, 2022)[60]. Since Berlin and Warsaw differ in this respect, the two cities were weighted separately and taken into account accordingly in the data analysis using SPPS Statistics 22.0. Below, the comparison between the

[60] for Warsaw data were interpolated based on the age population numbers for urban areas for the Voivodship of Mazowieckie [all data processed according to age groups, date of data processing: 07th October 2021]

distribution of the sample size with actual data from secondary data for Warsaw and Berlin is shown as a basis for the weighting of the sample size.

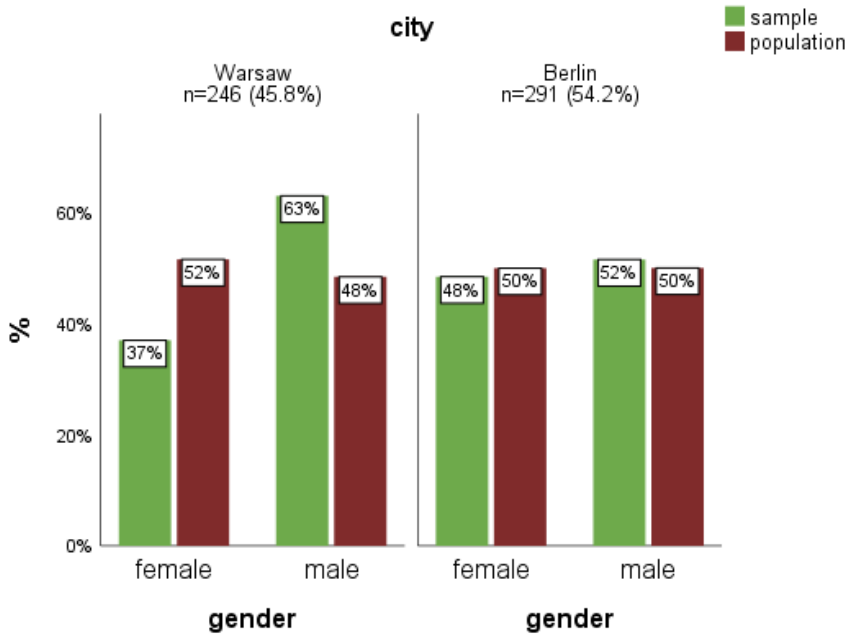


Figure 10: Comparison between origin and adjusted sample size based on secondary data for genders

Source: Own illustration based on data analysis

For Berlin, the sample size in terms of gender distribution shows a relatively good approximation to the real figures. For Warsaw, the higher rate of male participation in particular has been statistically adjusted accordingly.

For the generation distribution, the picture is the contrary. While a rather good approximation of the sample distribution to the actual figures could be achieved for Warsaw, a certain deviation is evident for Berlin, especially for Gen X and Gen Y, which must be weighted accordingly on the basis of a comparison with the secondary data collection (cf. Figure 11).

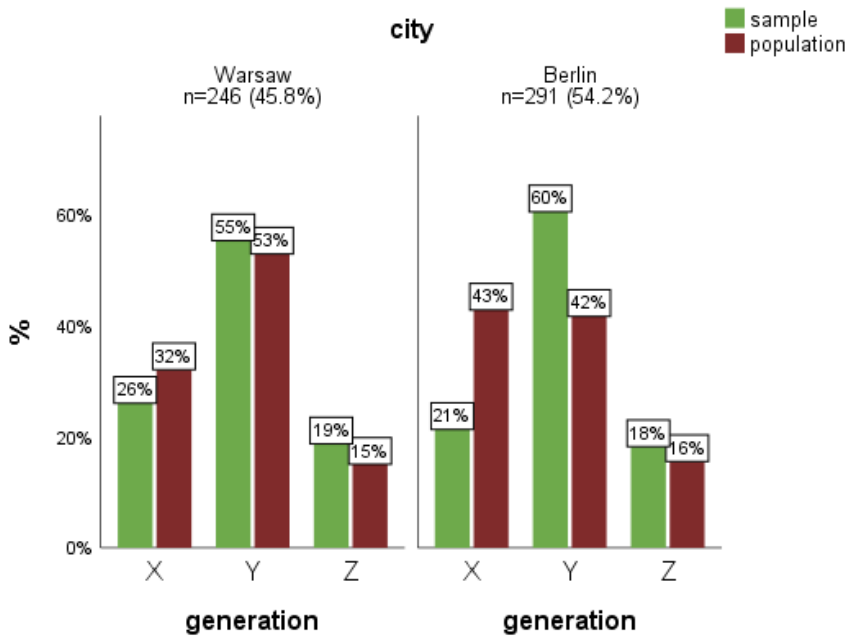


Figure 11: Comparison between obtained sample and population based on secondary data
Source: Own illustration based on data analysis

The aim of weighting is to achieve results that correspond more to reality and thus to establish the greatest possible representativeness. It is important to find the right balance between complexity and effort of the data generation and the statistical evaluation with the actual result quality. Further refinements regarding the weighting would mean a considerable additional effort or increase the computational complexity, which, however, would be counterbalanced by a limited added value (further improvement of the accuracy).

Therefore, the following further simplified assumptions apply:

- In Berlin as well as in Warsaw, the gender distribution is the same in each generation.
- For the city distribution, the sample distribution (actual) is assumed as the target (Berlin: 54%; Warsaw: 46%).

4.5 Applied Statistical Methods in Urban Mobility Research

For the analysis of the obtained and cleaned data set based on the conducted survey, different statistical methods aim to answer the research questions posed in the introduction and achieve meaningful results. The core of the work is to compare the two cities Warsaw and Berlin with respect to the different generations.

In classical statistics, a distinction is made between dependency analyses and interdependency analyses. In the context of this work, both types of analysis are applied. First,

correlations and differences based on dependency analyses such as the Pearson Chi² test and the one-way analysis of variance (ANOVA) are used within this research. Moreover, to reduce the complexity with the grouping of different variables, explorative factor analysis is applied to all questions with a 5-point Likert scale, which is a statistical interdependency analysis (H. Lee, 2014). In addition, various elements of descriptive statistics are used, which on the one hand provide a good starting point for data analysis and on the other hand can describe results in tabular and graphical form.

This section acts to briefly describe the various statistical methods used in this study. Their practical application in the data analysis as well as the linkage to the research questions is subsequently done in chapter 5 in the presentation of the results.

(1) Factor Analysis for reducing complexity

Factor analysis is defined as a method of multivariate statistics and is used to identify correlations between different variables in such a way that the different dimension and thus complexity can be reduced (H. Lee, 2014). This means variables based on different questions can be clustered and thus act as a basis for further comparison. In doing so, multiple relationships are analyzed to identify patterns based on factors behind these relationships. In this process, empirical observations of many different variables are clustered onto a few underlying latent variables ("factors").

Furthermore, a distinction is made between exploratory and confirmatory factor analysis (Decoster & Hall, 1998). The exploratory factor analysis (EFA), which is applied in this research, does not test hypotheses based on certain expected relationships, but rather aims to explore unknown correlations based on the analyzed variables to determine the underlying factors. Combining variables into factors facilitates interpretation, and a single factor or a small number of factors can be used in further analyses instead of many variables, solving the potential problem of collinearity.

In this process, besides newly generated variables (factors), new hypotheses about causal relationships can be generated and afterwards applied for subsequent analysis. The larger the sample, the more precise the results (Mundfrom et al., 2005).

Based on the questionnaire design, the goal is to group the ordinally scaled variables with a 5-point Likert scale. This method was primarily used for a large part of the questions, in which the statements posed are to be rated ordinally in the various categories (e.g., strongly agree; agree; neither agree nor disagree; disagree; strongly disagree). Therefore, within the

multivariate procedure the factor analysis is executed by performing a principal component analysis (PCA), which is an extradition method used for EFA (Bro & Smilde, 2014; Drennan, 2009; Gewers et al., 2021; Vidal et al., 2016) to discover certain structures and to search complex data for significant correlations and covariances between different variables. Thus, the number of observed variables is reduced to a smaller number of principal components that explain most of the variance, leading to a reduction of dimensions and thus complexity. The variables applied for this analysis are listed together with their characteristics and scale type and can be found in the Appendix C: Details variables.

Moreover, for a comprehensive interpretation of the factors, the analysis of the "rotated component matrix" based on Varimax in conjunction with a Kaiser normalization was chosen to ensure good interpretability (James, 2009). It is an orthogonal rotation method that minimizes the number of variables with high loadings for each factor.

(2) Binary and Multi-nominal Logistic Regression for the Daily Commute Model

The binary logistic regression model is a classical theory of discrete decision theory and as the name suggests it requires a binary code (e.g. 0 and 1). It is also called a logit where the regressand, i.e. the characteristic to be explained, is understood as a two-point distributed random variable and the regression function based on the distribution function of a logistic distribution is interpreted as a probability model. A typical application model in the area of transportation decision-making would be, for example, the comparison between individual transportation means, such as the car, and mass transportation means such as public transport. The multi-nominal logistic regression can examine the influence of an independent variable (IV) on a nominal dependent variable with more than two categories. As a practical application in the field of urban mobility, it can be used, for example, to analyze the usage differentiation between different modes of transportation such as bicycle, car, and public transport.

Logistic regression is considered to be relatively robust, also because the data analyzed do not have the necessary prerequisite of normal distribution and variance homogeneity (Scott et al., 1991). Parameter estimates can also be determined in odds ratios, which can be interpreted as the chances of success of the outcome variable versus its failure. The omnibus test is then used for the analysis of the quality level of the applied model, which is a likelihood ratio chi² test comparing the model set up to the reference model. The α (alpha)-value of 0.05 is defined as the accepted significance level (Anastasiou et al., 2020; Futschik et al., 2019; Hak et al.,

2018). Therefore, the fit of the model is present if Sig. ≤ .05, i. e. it is better than the reference model.

In the field of urban mobility science, multinomial logistic regression is used in a wide range of fields, e.g. with reference to the daily choice of transport mode (Eluru et al., 2012; S. Müller et al., 2008) or as a correlation analysis between urban transport infrastructure and mobility behavior (Broberg & Sarjala, 2015).

(3) Applied Statistics for Analyzing the Group Differences between Generations

(a) Descriptive Statistics

For a comprehensible presentation of the results, classical statistical methods such as frequency distribution, class formation of data, calculation of arithmetic mean and mean value, standard deviation, variance and the position measure are used. With reference to mobility, there are various practical examples that deal, for example, with the choice of means of transport (Delmelle & Delmelle, 2012), the incentivization of environmentally friendly and healthy travel behavior (Uttley & Lovelace, 2016) or with a more historical macro-economic question (Bayane & Yanjun, 2017).

(b) ANOVA (single factor analysis of variance) and ANOVA robust test

The single or simple factor analysis of variance (ANOVA) is suitable for comparing means between more than two groups that are independent of each other, i.e. unconnected (H. Lee, 2014). A statistical population is subdivided into disjoint subpopulations by specifying an arbitrarily scaled grouping characteristic and described with respect to a metric characteristic. The null hypothesis assumes that there are no differences between the means of all of the groups. A prerequisite for carrying out the analysis of variance is a prior test for equality of variance and a normal distribution of the sample data. The null hypothesis is rejected if the deviation of the group means from the overall mean is high.

The analysis of variance can only provide information about whether there is a difference between the tested groups. It does not reveal between which groups this difference lies. Therefore, a group comparison can be performed, for example, with a post hoc test or with the help of contrasts. These methods perform multiple comparisons of means to determine the significant differences between the individual groups.[61]

[61] E.g., according to Turkey for the case of variance homogeneity and the Games-Howell test for unequal variances

In the case of continuous (ratio) variables the significance test is based on an ANOVA robust test and the effect size is determined with the value of "eta" (Grizzard & Shaw, 2017): $eta^2 = SS_{effect} / SS_{total}$. SS_{effect} is the sum of squares for the effect of the independent variable under study and SS_{total} is the total sum of squares for all effects, errors, and interactions in the ANOVA calculation (J. T. E. Richardson, 2011). After resolving the equation, the following formula is obtained for eta accordingly:

$$(1)\ \text{eta} = \sqrt{\frac{SSeffect}{SStotal}}$$

After a determination of the strength, the direction can also be determined on the basis of descriptive statistics (mean value and delta value observation). The continuous (ratio) variables in the study are mostly based on the 5-Point-Likert scale and thus meet the requirements of normal distribution and variance homogeneity. Moreover, the sufficient size of the sample is supporting the assumption ("The law of large numbers") (Mitchell, 2021).

(c) Pearson's chi-squared test

The Pearson's chi-squared test for independence (also represented as chi^2-test or X^2-test) is a statistical hypothesis test used to determine if two categorical or nominal variables are most likely related or not. for

It compares the observed frequencies with the theoretical frequencies to be expected under the assumption of independence (J. H. Kim, 2007). The stronger this deviation, the greater the correlation or dependence.

Moreover, an effect size can be determined, which is an estimate of the strength of an effect of one variable on another (Grizzard & Shaw, 2017). The relative strength of the Pearson's correlation coefficient provides information about an existing or non-existing statistical relationship.

To calculate the effect size, different statistical methods are used depending on the scaling of the target variable (dependent variable) (H.-Y. Kim, 2017). Cramer's V is used to determine the effect size for nominally scaled variables and can be considered as a normalized χ^2. It is calculated directly from the χ^2-statistic of the sample size, as shown below.

$$Cramér's\ V = \sqrt{\frac{x^2}{n * m}}$$

x^2 = test statistics of x^2 test, n = sample size; m = minimum

Cramer's V is based on Chi² and takes values between 0 and 1. The higher the value, the stronger the correlation. The nominally scaled variables are used primarily in questions that ask about different categories that cannot be placed in a specific order. Examples of this are questions about the primary means of transport for daily commuting, questions about current occupational or educational status, but also all questions that can be answered with yes or no, i.e. in binary form. For the ordinally scaled target (independent) variables in the study, Cramer`s V is also used to determine the effect size.

(d) Summary of Statistical Methods for the City and Generational Comparison

According to the survey technique, the target variables can be divided into three categories with regard to their metrics: target variables with nominal, with ordinal and with continuous (ratio) scale level. Depending on those scale levels, different statistical test procedures and statistical parameters are applied:

Table 19: Types of variables and applied statistical method

Scale level of the target variable	Significance test	Standardized effect size for city differences
Nominal	Chi²-test	Cramer's V
Ordinal	Chi²-test	Cramer's V
Continuous (ratio)	ANOVA robust test	eta

Source: Own illustration based on Kühberger et al. (2014)

In addition to significance, the effect size also plays an important role in the analysis of city differences. Relevant city differences are present when the effect size reaches a value of at least 0.1, i.e. at least weak city differences are present (see Table 20 "effect size"). With an eta/correlation value greater than 0.3 and a maximum of 0.5, a medium effect, and with a value greater than 0.5, a large effect can be assumed (J. Cohen, 1988).

Table 20: Effect size and related criteria

Effect size	Cramer's V	eta / correlation
Small	>= 0.1 – 0.3	>= 0.1 – 0.3
Medium	> 0.3 – 0.5	> 0.3 – 0.5
Large	> 0.5	> 0.5

Source: own illustration based on (J. Cohen, 1988)

It should be noted that many questions have been answered on a 5-point Likert scale. Due to the dimension reduction on the basis of a factor analysis, these have been converted into continuous variables. Therefore, the determination of the effect size is also done with eta.

Depending on the sample size, the significance may be different and must be evaluated accordingly in context (Kühberger et al., 2014). The significance depends on the number of cases, so that even effect sizes smaller than 0.1, i.e. relatively weak city / generations differences, can become significant with a large sample size ($n > 150$), whereas with a small sample size ($n < 50$), possible relevant differences would not be discussed due to a lack of significance (Grizzard & Shaw, 2017).

The discussion of city differences therefore concentrates on characteristics that show at least weak city differences. For characteristics with effect sizes smaller than 0.1, it is assumed that city differences are not relevant, even if a significant test result may exist in individual cases.

If subgroups with smaller numbers of cases are analyzed, such as car users, public transport users etc., the focus is on characteristics with at least weak city differences, even if these are not significant due to the smaller numbers of cases in the subgroups. Such relevant but non-significant results are marked separately.

CHAPTER 5
URBAN MOBILITY BEHAVIOR OF DIFFERENT GENERATIONS – A MODEL APPROACH

This chapter describes the results based on the statistical analyses of the collected data from the survey in Warsaw and Berlin. Besides the literature review, Chapter 4 with its secondary data analysis, description of the data collection process with an outline of the questionnaire structure, and illustration of the procedure for data collection in conjunction with an explanation of the statistical methods used in this research, provides a basis for the results presented in this chapter.

The first step introduces the general research model applied to answer the research questions. In addition, a factor analysis is performed, as this constitutes another essential basis for the statistical analyses to be carried out subsequently. The first key research investigation analyzes the main factors influencing mobility behavior during daily commuting with regard to the total sample. In the second step, a direct city-to-city comparison is conducted between Warsaw and Berlin. Various areas of urban life that influence mobility behavior are examined. For a consistent research approach, the following questions are used: (1) How do people live?; (2) What are the personality traits that characterize a person and how do they imagine the future?; and (3) How do people act and behave with regard to urban mobility?

In the third part, based on the previously established findings, a comprehensive comparison of generations is conducted. General trends and differences between the generations are examined based on the overall sample, followed by an investigation of similarities and differences between the generations within the two cities of Warsaw and Berlin, but also with the respective generations in a direct city-to-city comparison.

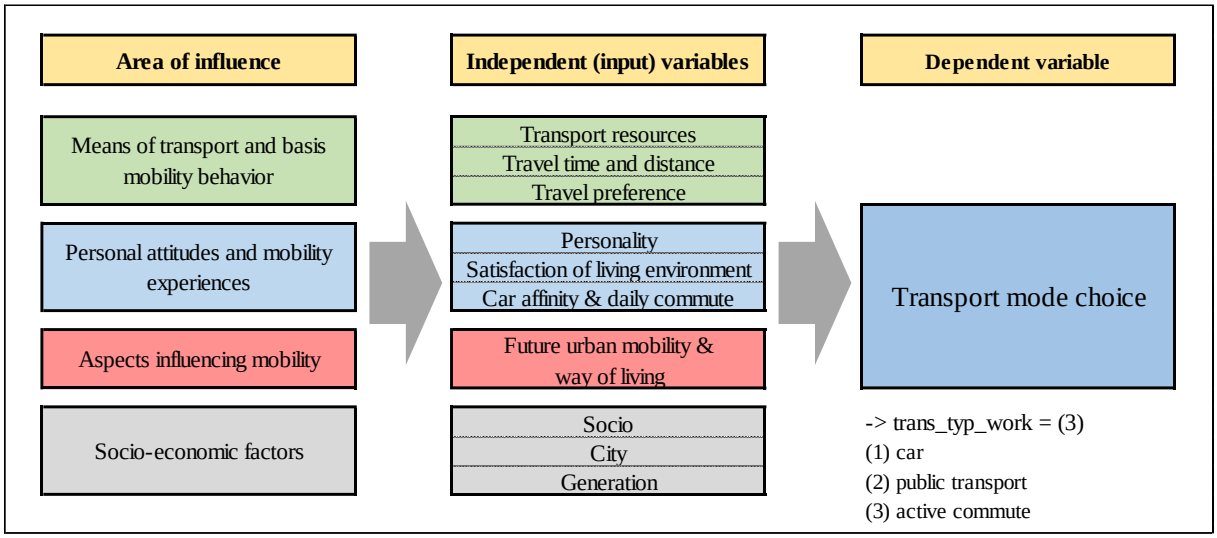
5.1 Research Model and Factor Analysis

Research Model for Daily Commute

One of the most important elements in urban mobility is the daily commute to work or to an educational institution. In this context, various influencing factors at different levels can play a role in the decision-making process when choosing the means of transport. Even nowadays with increasing mobility offers, it is possible to vary between means of transport depending on the day of the week or to use different means of transport in combination, in most

cases there is still an individual trend to prefer a certain means of transport. In order to investigate significant influencing variables for this, the various variables were thematically clustered (cf. Figure 12) and examined step by step. The results are shown in chapter 5.2.

Figure 12: Basic research model approach for "daily commute"



Means of transport and basis mobility behavior: Within the model, variables are first considered that may represent an important and direct factor influencing the transport mode choice. In addition to whether someone has a driver's license and, moreover, access to their own car in the household, there are possible other resources that may play a role in the daily commute. These are, in addition to the ownership or availability of a bicycle, whether someone has a monthly or annual ticket for public transport. Another important aspect is the distance for daily commute and the related travel time.

Personal attitudes and mobility experiences: In further investigation, the focus is on various personality traits, which can vary individually depending, for example, on values, experiences, or the social and ecological environment. The basic personality values are based on the survey questions about professional life and career/education, aspects of daily living and the social environment, as well as the use of technology in everyday life (full questionnaire see Appendix B: Questionnaire). Satisfaction with the residential environment is about one's own perception of the quality of living. This includes, for example, the location with regard to the infrastructure with various shopping and leisure activities and the accessibility of public transport, but also a pleasant air and noise environment. In addition, it concerns the feel-good factor and the quality of living in one's own property, also in relation to the actual living costs to be paid. The last factor within the group of personality-related characteristics is the

importance and significance of having a own car and the perceived satisfaction with daily commuting.

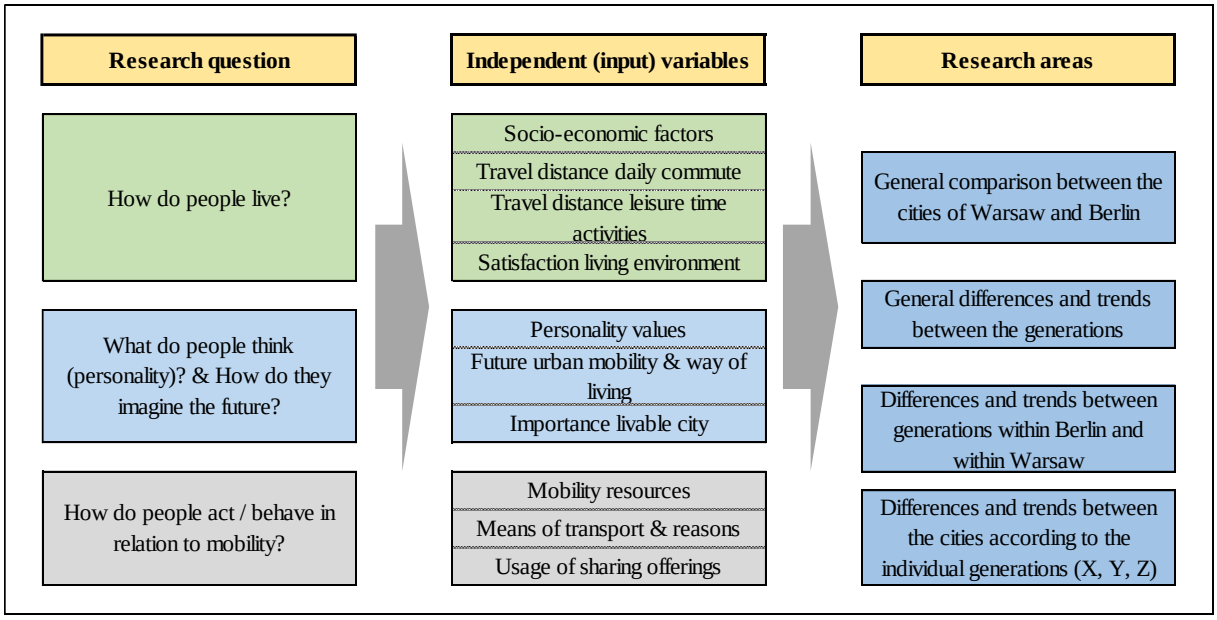
Aspects influencing mobility: This field is connected with future urban mobility and preferred lifestyles. This includes aspects such as the desire for CO_2 reduction and for developments toward more sustainable mobility, the characteristics of leisure activities and recreational opportunities, but also the question of closeness to nature and family orientation as well as personal attitudes toward urban life.

Socio-economic factors: In the last step of the evaluation, the socio-ecological and socio-demographic factors influencing the choice of means of transport for daily commuting are examined. In addition to gender, the question of occupation, housing situation and income, the final step is to analyze whether there are significant differences in the factors that influence daily commuting between the two cities studied, Warsaw and Berlin, and between generations.

Research Model for Urban Living and Transport Behavior

For the comparative analysis between Warsaw and Berlin, the following research model shown in Figure 13 applies for the city comparison (chapter 5.3) and the generations comparison of different aspects of urban mobility behavior (survey structure see chapter 4.4).

Figure 13: Basic research model approach for the comparison of the cities and generations



Source: own illustration of the research model created with Microsoft 365 Excel

In addition to focusing on transport mode choice and related reasons, the survey conducted for this study investigates other aspects of urban mobility behavior. On this basis,

the different input variables are evaluated along a schematic construct that is defined in the research model shown in Figure 13. The urban and intergenerational comparison is conducted along these three leading questions by embedding the corresponding variables in such a way that mobility behavior can be examined both in the context of the housing situation and in relation to urban mobility in terms of a livable city.

Based on the first overall research question "How do people live?", the following specified questions should be answered by the analysis: (1a) "How is the living situation of urban citizens?", (1b) "What are the average daily commuting and leisure travel distances?", and (1c) "How satisfied are the citizens with respect to the direct living environment?"

In second place are the overall research questions "What do people think (personality)?" and "How do they imagine the future?", from which the following specific questions can be derived, which are to be answered by the analysis: (2a) "What are the different personality traits?", (2b) "What are the future expectations with regard to urban mobility and way of living?", (2c) "What are important aspects and elements of a livable city?", (2d) "What do the citizens thing about possible measures towards the development of urban mobility"?

In regard to the third overall research question, "How do people act / behave in relation to mobility?", the following questions are broken down to be answered by the analysis: (3a) "What are the main mobility resources available?", (3b) "What is the modal split and the main reason for choosing a particular mode of transport for the daily commute?", (3c) "What is the perceived value of the car and the comfort associated with it?", and (3d) "How pronounced is the use of sharing offers?"

Along with these central research questions, first a direct city comparison between Warsaw and Berlin and then the generation comparison is carried out, which is the core component of this study. On the one hand, the three Gen X, Gen Y and Gen Z within and, on the other hand, the respective generations between the two cities are carried out.

Factor Analysis

The following results obtained from the factor analysis are used as one of the main bases for further statistical analysis to answer the research questions. Based on the analysis of the rotated component matrix, the personality values are shown in Table 21.

Table 21: Derived factors from **"Personality"**

	Personality			
	(1) Technology	**(2) Flexibility**	**(3) Social exchange**	**(4) Discipline**
Rotated component matrix	f_pers_tech	f_pers_flex	f_pers_soci	f_pers_disc
TU2	**0.685**	0.213	-0.174	0.261
TU1	**0.658**	0.007	0.158	-0.059
PE1	**0.526**	0.285	0.039	-0.224
TU3	**0.523**	-0.146	0.388	-0.322
LS3	-0.018	**0.813**	0.205	0.046
PE3	0.303	**0.690**	-0.103	-0.017
PE2	0.416	-0.426	0.202	0.328
LS4	-0.020	0.124	**0.746**	0.188
LS1	0.096	-0.041	**0.645**	0.027
LS2	0.335	0.357	0.377	-0.035
TU4	-0.059	-0.038	0.001	**0.756**
PE5	-0.014	0.003	0.150	**0.686**

Extraction method: principal component analysis, rotation: varimax with Kaiser normalization, the rotation has converged in 7 iterations.

Source: own calculations with the use of SPSS version 22

Depending on the sample size as well as with reference to various literature references, factors with a factor loading with a value above .500 can be interpreted as sufficiently meaningful and are included accordingly in the naming of the factors (Shrestha, 2021; Watkins, 2018; B. Williams et al., 2010; Yong & Pearce, 2013). These factors are marked in bold in the depicted tables. The different values are either positively or negatively correlated to the underlying factors. There are some other variables with factor loading close to .500 that are related to the factors "(1) Technology", "(2) Flexibility" and "(3) Social Exchange", such as PE2[62] (factor loading of 0.416 for (1) and -0.426 for (2)) and LS2[63] (factor loading of 0.335 for (1), 0.357 for (2), and 0.377 for (3)), but as they are below the threshold of .500, the variables have a lower effect on the determined factors.

The analysis based on the personality lead to four different factors (1) Technology comprising i.a. the affinity and openness for the adaption of new technology, use of mobile apps, social media and alternative information sources in daily life; (2) Flexibility i.a. including the willingness to change and adapt even if it means moving away from family and friends for

[62] I would like to arrange my everyday life as well as my life as flexible as possible, e.g. flexible working hours/location, possibility for a time-out for my self-fulfillment such as a trip around the world, for an additional study etc.
[63] I would like to arrange my everyday life as well as my life as flexible as possible, e.g. flexible working hours/location, possibility for a time-out for my self-fulfillment such as a trip around the world, for an additional study

better career options; (3) Social exchange including the behavior of sharing one's own experiences for the sake of a reference person both in private and in professional everyday life. Furthermore, it includes the personal willingness to accept opinions and feedback from others in a benevolent manner; and (4) Discipline includes the perceived importance of separating one's personal life from one's work/educational life. Interestingly, this factor is also related to the ability to complete certain tasks without being interrupted.

Within the next area "satisfaction residential environment", the factor analysis revealed two factors: (5) is about personal satisfaction with the proximity to and accessibility of public transport and the proximity to one's own workplace or educational institution, but also to locations of daily needs such as the supermarket, doctors' offices, retail outlets, as well as facilities for leisure activities such as the gym, restaurants and bars; (6) is essentially the quality and value for money (living expenses incl. costs for the apartment / house) of one's living space and its immediate surroundings, such as nearby parks, sufficient calm and recovery away from the hustle and bustle of a big city, as well as clean air.

The area "urban living" generates two factors. Factor (7) is about the underlying variables of the need to own a car and the feeling of freedom that may come with it. For many, the car is a status symbol. Interestingly, many respondents declare the car to be indispensable, but at the same time express that they prefer more environmentally friendly means of transport. This is often at odds with practice, as even today owning a car emits significantly more CO_2 on average than alternative means of transport such as public transport and, above all, active means of transport such as the bicycle and walking (Janson, 2018b). Factor (8) is based on the personal feeling that the daily commute is pleasant and not too stressful, and even that the time is positive and can be used for personal purposes.

Table 22: Derived factors from "Satisfaction" and "Urban living"

Satisfaction			**Urban living**		
Variables	**(5) Proximity and accessibility of public transport, shopping, work**	**(6) Quality of the environment, cost-benefit-ratio of housing**	**Variables**	**(7) Importance car / status symbol**	**(8) Comfort of daily commute**
	f_sat_prox_pt	f_sat_qual_env		f_ub_car	f_ub_com
FL1.7	**0.816**	0.000	UB4.7	**0.811**	0.082
FL1.1	**0.754**	0.097	UB4.1	**0.811**	-0.015
FL1.3	**0.663**	0.198	UB4.2	**-0.549**	-0.344
FL1.2	0.410	0.352	UB4.4	0.097	**0.901**

FL1.5	0.119	**0.782**	UB4.5	0.041	**0.821**
FL1.4	0.057	**0.734**	UB4.6	-0.181	0.065
FL1.6	0.150	**0.686**	UB4.3	0.349	0.139
			UB4.7	0.811	0.082

Extraction method: principal component analysis, Rotation: Varimax with Kaiser normalization; Left side − Derived factors from **"Satisfaction"**; the rotation has converged in 3 iterations. Right side − Derived factors from **"Urban living"**; the rotation has converged in 6 iterations.

Source: own calculations with the use of SPSS version 22

The last area of the factor analysis comprises future urban mobility and the way of living. Three factors were obtained from eleven different variables. In the case of factor (9), the opinion is in favor of various measures that should gradually lead to a transformation to sustainable urban mobility. These include a ban on internal combustion engines from 2030, tax privileges for environmentally friendly drive technologies, and the promotion and subsidization of alternative means of transport and innovative traffic concepts. This also includes the reduction of individual traffic with the creation of new traffic-calmed zones, an expansion of pedestrian and bicycle paths, and the creation of new green spaces.

Table 23: Derived factors from "Future urban mobility & way of living"

	Future urban mobility & way of living		
Rotated component matrix	**(9) Desire for CO_2 reduction and for a development towards sustainable mobility**	**(10) Focus on leisure activities / relaxation, relationship with nature and family orientation**	**(11) Urban living lifestyle**
	f_sc_co2	f_sc_leisure	f_sc_lifestyle
SC4.2	**0.808**	-0.163	-0.073
SC4.1	**0.785**	-0.037	0.089
SC4.3	**0.677**	0.190	0.127
SC4.4	**0.667**	0.160	0.005
SC4.5	0.375	0.340	0.282
FL2.4	-0.074	**0.720**	0.093
FL2.3	0.175	**0.615**	-0.058
FL2.6	-0.269	**0.523**	-0.237
FL2.5	0.179	0.407	-0.122
FL2.2	-0.056	-0.225	**0.841**
FL2.1	0.144	0.009	**0.814**

Extraction method: principal component analysis, Rotation: Varimax with Kaiser Normalization, the rotation has converged in 5 iterations.

Source: own calculations with the use of SPSS version 22

Factor (10) relates to the desire for active leisure time and the desire to spend time with one's family. This factor also correlates positively with the personal sense of importance of living in one's own property and having or striving to acquire property. The last factor (11)

relates to the desire to live either in the city or in the countryside. The respective advantages and disadvantages are assessed differently by each individual.

The following Table 24 summarizes the different areas shown before and evaluates the goodness of the factor solution.

Table 24: Results factor analysis overview

Area	KMO	Bartlett chi	Bartlett df	Bartlett sig	factors #	expl. variance
Personality values	0.646	639.8	66.0	0.000	4	52.60%
Satisfaction	0.717	521.9	21.0	0.000	2	52.52%
Urban living	0.572	506.6	21.0	0.000	3[64]	67.28%
Future urban mobility & way of living	0.680	923.1	55.0	0.000	3	51.20%

Established criteria for a good factor solution: 1.) KMO > 0,6, 2.) expl. Variance > 50%, 3) for each factor not less than 2 high factor-loadings (> 0.5), 4) well interpretable naming of the resulting factors.

Source: own calculations with the use of SPSS version 22

Based on the factor analysis, all values above .600 are considered as sufficiently suitable based on the Kaiser-Meyer-Olkin (KMO) criteria. Only for UB is the KMO value ≤ 0.6, but the explained variance is sufficiently high at 67.3%.

5.2 Main Factors affecting Daily Commute

Background and Research Question

The process of deciding on the best transport means depends on various individual factors. The following study focuses on the daily commute to work or to the educational institution. Mobility for leisure activities such as meeting friends, shopping, going to the cinema or going on vacation is not considered. As influencing variable for the decision, factors such as the place of residence and the associated mobility options usually also play a decisive role (Berg & Ihlström, 2019). The importance of various factors such as comfort, cost, speed, environmental impact etc. may vary from person to person (Banister, 2008).

With regard to the research question (1) "What are the main variables influencing daily commute in respect to Warsaw and Berlin?", in the questionnaire the following question regarding transportation choices for daily commute is asked: "Given a typical week, what means of transport do you usually use to get to work / education facility?". In the focus consideration, different means of transportation could be selected as an answer: (1) own car,

[64] one factor was neglected, as a clear functional classification and naming is not practicable

(2) car sharing, (3) public transport, (4) bike, (5) long distance train, (6) taxi, (7) others. For the analysis of the daily commute travel behavior, those transport mode options where clustered as follows:

- car, which comprises own car, car sharing, and taxi [(1), (2), (6)]
- public transport (pt) and long distance train [(3), (6)]
- active modes of transport (ac), which encompasses bike and walking [(4), (7)[65]] .

Data Analysis

1.) Bivariate Pre-analysis for the Model "Daily commute"

Based on the factor analysis (cf. chapter 5), the established 11 factors together with the remaining variables are applied as a baseline for the execution of a bivariate pre-analysis. Overall, based on the query structure of the questionnaire, different potential influencing factors (independent variables) could be clustered to different areas: (A) distance (km) and mobility resources; (B) personality; (C): satisfaction; (D) urban living; (E) future urban mobility & way of living; (F) socio-demographics; and (G) city (WAR, BER) and generation (Z, Y, Z). An overview with the listed factors / variables is depicted in Table 25.

Table 25: Selected variables potentially influencing the choice of transport mode for daily commute compiled based on the factor analysis and other variables

Area	**Description focus area with independent variables**
A1: Distance (1 variable)	Average distance traveled on a weekday / working day; variable: trans_km_work
A2: Mobility resources (4 variables)	Access to a car and bicycle in the own household, holding a driving license, holding of a monthly / annual public transport ticket; variables: ress_car, ress_bicy, ress_lic, ress_pt_tick
B: Personality (4 variables)	The dimension reduction (factor analysis) derived the following four variables: technology (f_pers_tech), flexibility (f_pers_flex), social exchange (f_pers_soci), discipline (f_pers_disc).
C: Satisfaction (2 variables)	The dimension reduction (factor analysis) derived the following two variables: proximity and accessibility of public transport, shopping, work (f_sat_prox_pt) and quality of the environment as well as cost-benefit-ratio of housing (f_sat_qual_env).
D: Urban living (2 variables)	The dimension reduction (factor analysis) derived the following two variables: Importance car / status symbol (f_ub_car), comfort of daily commute (f_ub_com).

[65] Under "others", for example, walking was filled in, other entries such as "none at all, as I am working remotely" were cleaned up as part of the data analysis.

E: Future urban mobility & way of living (3 variables)	The dimension reduction (factor analysis) derived the following three variables: desire for CO_2 reduction and for a development towards sustainable mobility (f_sc_co_2), focus on leisure activities / relaxation, relationship with nature and family orientation; focus on leisure activities / relaxation, relationship with nature and family orientation (f_sc_leisure); and urban living lifestyle (f_sc_lifestyle).
F: Socio-demographics (5 variables)	Demographic and socio-economic factors: gender (soc_male), working vs. non-working (soz_work); living for rent or in an owned home (soc_howner); single household (soz_single_hh), disposable monthly income (soz_income)
G: City (WAR, BER), generation (X, Y, Z) (2 variables)	Differences between the analyzed cities of Warsaw and Berlin and the different generations of Gen X, Gen Y and Gen Z with regards to transport mode choice for daily commute.
"Long list": in total 23 factors	

Source: own illustration based on the results of the factor analysis executed with SPSS version 22

The aim is to identify further potential significant variables (predictors) influencing the choice of transport in daily commute and to avoid multicollinearity. Thereby, the significant (Sig. ≤ .05) bivariate correlation between the independent with the dependent variable "trans_typ_work" (criterion / dependent variable) is determined. In contrast to the model, which can include several influencing factors, the bivariate approach treats each potential influencing factor separately. The following overview shows the selected variables that form the basis for the multinomial logistic regression that is performed subsequently.

Table 26: Results of the bivariate pre-analysis

Variable ("short list")	**chi²**	**sig.**
trans_km_work_x	9.398	0.009
soc_howner	37.672	0.000
ress_pt_tick	49.873	0.000
ress_lic	48.763	0.000
ress_car	89.441	0.000
ress_bicy	22.976	0.000
f_ub_com	23.006	0.000
f_ub_car	57.733	0.000
f_sat_prox_pt	30.381	0.000
f_pers_tech	8.334	0.016
f_pers_flex	10.863	0.004
f_sc_co2	26.654	0.000
trans_min_work_x	11.700	0.003
soz_income	9.689	0.008
f_sc_lifestyle	8.251	0.016
x_berlin	6.142	0.046
f_sat_qual_env	6.048	0.049

Source: own calculations with the use of SPSS version 22

Starting from a total of 23 potential influencing factors ("long list"), of which 11 are from the factor analysis and 12 are from the areas A, F, and G, the bivariate pre-analysis shows that 17 ("short list") of the 23 factors of the "long list" have a significant bivariate correlation.

The results based on the statistical analysis of the total sample show that certain factors do not play a significant role in daily mobility behavior. This includes if a person lives alone or not, gender, and current work situation. However, other studies conducted previously have shown that aspects of living situation, place of residence, socio-economic aspects such as occupational status can play a significant role (Clifton et al., 2013; Herrenkind et al., 2019; Olsson et al., 2020; Saigal et al., 2021; Susilo et al., 2019). In the present study, there could be various reasons why these influencing variables are not significant. In the case of daily commuting, for example, the reasons could be that there is a similar pattern between the genders within the two cities considered, but also between the specific generations in a direct comparison of cities. Whether someone is employed could be an aspect that differentiates the influencing variables in a different context. Another important aspect of the job situation is that in the present sample, the rate of non-employment is very low and, moreover, many students often work part-time, following the increasing trend.

Furthermore, of the 11 factors listed from the factor analysis, 3 are not significantly relevant for the choice of transport mode for daily commuting. The factors include (3) social exchange, (4) discipline with focus on work-life balance, and (10) leisure activities as well as the balance with family. A more detailed description has already been carried out previously in the factor analysis.

2.) Multinominal logistic regression

For the transport mode choice model, a multinominal logistic regression (MLR) is used for statistical analysis, which is a model of decision theory. The multinominal categorization takes place with the variable name "trans_typ_work", which is defined as the dependent variable, by coding the car with "0", public transport (pt) with "1" and active modes of transport (ac) with "2", nominally scaled. The category "car" is chosen as reference category. The remaining target categories are pt and ac. For the model development only the 17 factors with a significant bivariate correlation are used. The target variable "trans_type_work" has three categories. The objective is to determine which variables have a significant influence on the choice of transport mode for daily commute.

To select the influencing factors for the final model a stepwise model selection procedure was used. In the end, from the 17 potential influencing factors with a significant bivariate correlation just 11 factors show a significant influence in the final model. The following overview shows these influencing factors of the final model after the multinominal logistic regression has been conducted.

Table 27: Results of the MLR with the significant influencing variables in the final model

	Likelihood-Ratio-Test		
	chi²	**df**	**p-value**
Constant term	83.411	2	0.000
trans_km_work_x	4.231	2	0.121
soc_howner	11.150	2	0.004
ress_pt_tick	50.652	2	0.000
ress_lic	21.091	2	0.000
ress_car	32.962	2	0.000
ress_bicy	19.535	2	0.000
f_ub_com	23.512	2	0.000
f_ub_car	8.684	2	0.013
f_sat_prox_pt	11.048	2	0.004
f_pers_tech	7.826	2	0.020
f_pers_flex	22.924	2	0.000

The chi² statistic represents the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is calculated by omitting an effect from the final model. This is based on the null hypothesis that all parameters of this effect are 0.

Source: own calculations with the use of SPSS version 22

Distance (km) plays only a minor role for the mode choice decision sig(total) = 0.121, i. e. this influencing variable is not significant ($\alpha > 0.05$). However, distance (km) acts as a control variable that was included in the model despite its lack of significance in order to adjust the model with respect to different distances. Moreover, the omnibus test is performed, which is used to evaluate the model. The omnibus test results in χ^2 (22) = 281.234, $p \leq .001$, providing evidence that the model fit is sufficient.

Table 28: Omnibus-test final model

Model	**Likelihood-Ratio-Test**		
	Chi²	df	p-value
final model	281.234	22	0.000

Source: own calculations with the use of SPSS version 22

In addition, a Nagelkerke-R^2 of .475 for the final model as a quality measure for the statistical explanatory power of the estimated logit model is a good variance resolution (medium

effect) according to the recommendation of Backhaus et al. (2016). Overall, the Nagelkerke R^2 and the omnibus test show a solid reliability and significance of the model.

Table 29: Pseudo-R-Quadrat value

	Nagelkerke
Pseudo-R-Quadrat	0.475

Source: own calculations with the use of SPSS version 22

The VIF-values are close to 1. This means that the model shows no indication of multicollinearity (Akinwande et al., 2015), thus also the estimated B-values are not collinearity biased.

Table 30: Multicollinearities between the independent variables of the model

Influencing factor	**Tolerance**	**VIF**
trans_km_work_x	0.939	1.065
soc_howner	0.846	1.182
ress_pt_tick	0.952	1.050
ress_lic	0.890	1.123
ress_car	0.683	1.464
ress_bicy	0.927	1.079
f_ub_com	0.891	1.123
f_ub_car	0.673	1.485
f_sat_prox_pt	0.851	1.175
f_pers_tech	0.885	1.130
f_pers_flex	0.960	1.042

Source: own calculations with the use of SPSS version 22

Results

The model coefficients show the deviation from the reference category. The B-value represents the estimated regression coefficient. The deviation is expressed from the reference group "car", if negative then car is preferred, if positive then there is a preference for using either public transport (pt) or active commute (ac).

The partial Nagelkerke R^2 indicates the respective importance of an influencing variable with respect to the transportation mode decision of daily commuting. The influencing variables in the final regression model are ordered by importance.

The overview below (Table 31) shows the various influencing variables in the model with their respective effects (B) and significance.

Table 31: Final model "daily commute"

	Public transport		Active commute		Total	Importance
Influencing factor	**B**	**Sig**	**B**	**Sig**	**Sig**	**Nagelkerke R^2 partial**
ress_pt_tick	1.495	0.000	0.066	0.845	0.000	0.068
ress_car	-2.339	0.000	-1.831	0.001	0.000	0.044
f_ub_com	0.298	0.018	-0.496	0.009	0.000	0.031
f_pers_flex	-0.582	0.000	-0.375	0.029	0.000	0.030
ress_lic	-2.604	0.004	-0.998	0.359	0.000	0.028
ress_bicy	-0.812	0.018	1.150	0.060	0.000	0.026
soc_howner	-0.262	0.285	-1.166	0.001	0.004	0.014
f_sat_prox_pt	0.322	0.009	0.529	0.006	0.004	0.014
f_ub_car	-0.158	0.268	-0.558	0.004	0.013	0.011
f_pers_tech	-0.346	0.006	-0.279	0.108	0.020	0.010
trans_km_work_x	-0.011	0.176	-0.025	0.062	0.121	0.005

Constant blanked out, Nagelkerke R^2 = .475, Omnibus test: p-value ≤ .001

Source: own calculations with the use of SPSS version 22

The two most important influencing variables are the existence of a monthly/annual ticket for public transport (ress_pt_tick with 6.8% based on Nagelkerke R^2) and access to a car in one's own household (ress_car with 4.4% based on Nagelkerke R^2). The study confirms the correlation, which is readily derivable in practice, between good access to a car in one's own household and the choice of transport mode for daily commute. This is also confirmed by various other studies (Duff & Phelps, 2019; Herrenkind et al., 2019). However, a closer look at the individual data shows that a certain proportion of respondents have access to a car but use other means of transport such as public transport or bicycles for their daily commute. This can have various reasons such as increased traffic volume and congestion during rush hour, the weather, the perceived need for physical activity, costs, or a lack of affordable parking facilities at the destination. The availability of certain resources thus significantly determines the decision of the mode of transport. Users of monthly or annual tickets clearly prefer public transport ($B = 1.495$; $p \leq 0.001$). However, if a car is available, then this mode of transport is preferred for the daily commute to work or to the educational institution ($B(pt) = -2.339$; $p \leq 0.001$; $B(ac) = -1.831$; $p \leq 0.001$).

Other resources such as having a driver's license (ress_lic) as well as the permanent availability of one's own bicycle (ress_bicy) have an effect that corresponds to the expectations in practice. Having a driver's license has a similar effect to having permanents access to a car in one's household. Using a car does not necessarily mean driving oneself; rather, people can ride with other household members or join carpools, as well as use a taxi or ride-hail service

like Uber. In addition, if a bicycle is available, the likelihood of using the bicycle is slightly, but not significantly, increased (B(ac) = 1.150; p = 0.060).

The third most important influencing factor is the established factor on the comfort of daily commuting (f_ub_com). Individuals who perceive their commute as relaxed tend to prefer public transport (B(pt) = 0.298; $p \leq 0.05$). In addition, the results show that individuals who are flexible and open to changes in life, such as changing their working location (f_pers_flex), prefer the car compared to public transport (B(pt) = -0.582; $p \leq 0.001$) and active modes of transport (B(ac) = -0.375; $p \leq 0.001$).

Respondents for whom owning and driving a car is perceived as a feeling of freedom and even as a status symbol (f_ub_car) are more inclined to choose the car as their preferred means of transportation. It is interesting to note, however, that the influence on the mode choice decision is significant compared to active mode of transport, but not to public transport (B(pt) = -0.158; p = 0.268; B(ac) = -0.558; $p \leq 0.01$).

Furthermore, the residential situation plays an important role in the choice of transport mode. The housing situation is taken into account in the model with two variables. The first is whether people own their home (soc_howner), and the second refers to how satisfied they are with the proximity to public transport and other daily necessities (f_sat_prox_pt). Both affect their choice of transportation for daily commuting. People who live in their own homes tend to prefer the use of a car. The more satisfied people are with their proximity to public transport, the more likely they tend to use that means of transport. However, it can be seen that in this case the preference for active commute is even stronger than for public transport (B(pt) = 0.322; $p \leq 0.01$; B(ac) = 0.529; $p \leq 0.01$). Finally, technological affinity is significant in the model, albeit with a less strong influence. The higher the affinity for technology, the more likely the car is to be preferred, but only significantly compared to public transport (B(pt) = -0.346; $p \leq 0.01$).

The last section examines whether either the two cities of Warsaw and Berlin or the different generations act as a significant influencing factor in the choice of transport for daily commuting. Already in the bivariate preliminary analysis conducted first, there is no significant difference between the generations (sig. = 0.148). In the analysis between the cities, the criterion for significance is just fulfilled (sig. = 0.046) but is omitted in the next step of the multinominal logistic regression analysis in the final model (variable "x_berlin" with sig. = 0.468). In summary, it can be concluded that there is no significant difference in the mode choice for daily

commuting between the different age groups. Also, whether someone lives in Warsaw or in Berlin does not play a significant role in this respect.

The following graph illustrates with a matrix on the abscissa (x-axis) the B-value of public transport and on the ordinate (y-axis) the B-value of active commute in each case compared to the car. The size of the circle corresponds to the degree of importance (Nagelkerke R^2 partial).

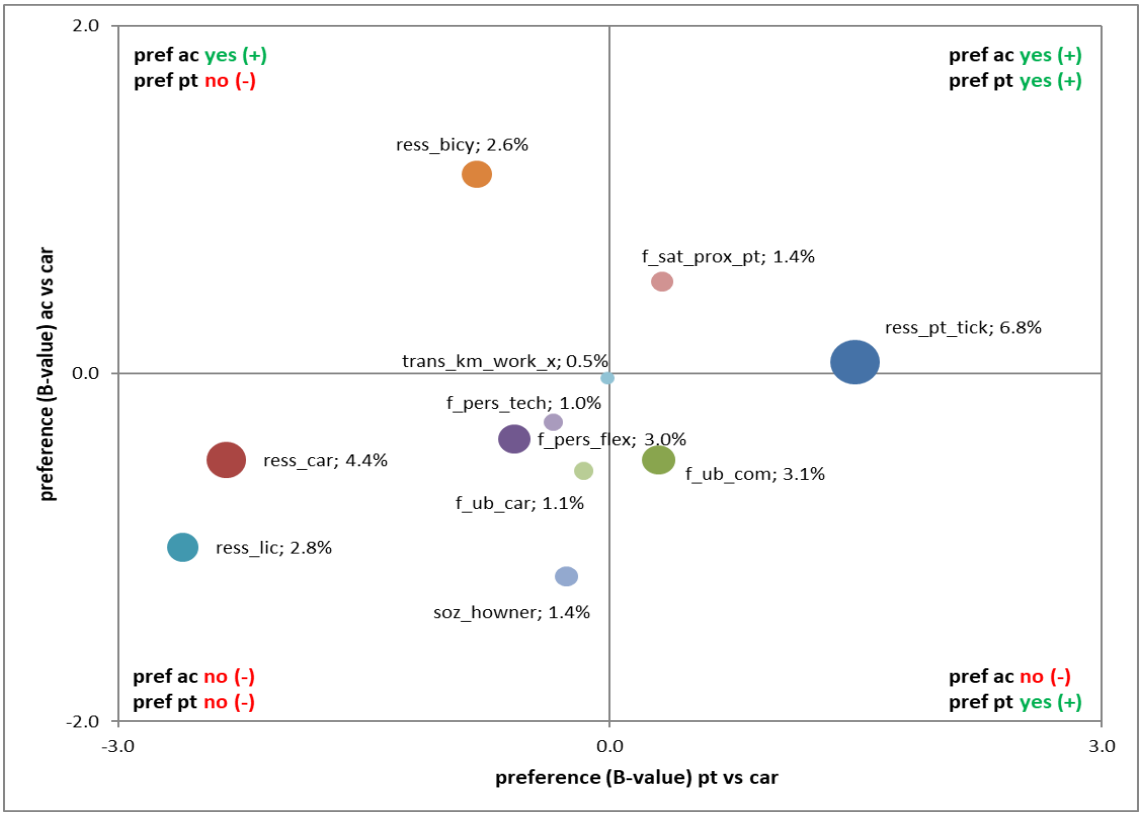


Figure 14: Matrix of estimated regression coefficient (B) for model "daily commute"

Active commute and public transport versus car; percentage value represents the Nagelkerke R^2

Source: own illustration based on statistical analysis

The established model can act as a foundation or influencing factor in the transportation planning of urban living spaces. Furthermore, on the basis of the different influencing variables, personality profiles can be set up to promote sustainable traffic planning in a goal-oriented manner. For example, people who have a monthly or annual ticket for public transport and perceive a good comfortability of daily commuting, but at the same time do not have a car, tend to use public transport (Σ B(pt) = 1.792). On a somewhat reverse interpretation, it may well be that people who tend to use public transport find the daily commute a positive experience and make good use of the time. For example, they use the time to read a book, listen to a podcast, or plan the next few days.

In contrast, it can be seen that individuals who have a driver's license and also access to a car in their own household, have a greater focus on flexibility and therefore prefer the car over using public transport for their daily commute to work or education (Σ B(pt) = -5.525). Overall, it is clear that owning a bicycle has a positive effect on its use. However, all other significant influencing factors have a negative effect on it, i.e., away from the use of one's own bicycle and toward the car. For example, it can be seen that home owners who simultaneously have a driver's license, access to their own car as well as a bicycle in the household nevertheless tend to use the car more (Σ B(ac) = -2.845).

As another scenario, people who own a ticket for public transport, are satisfied with the accessibility to the next stop, and also with daily commuting, show a strong preference for using public transport (Σ B(pt) = 2.114). These results show the importance of a well-developed public transport network with fast and comfortable connections to different parts of the city with a high frequency.

The detailed results of the analysis of the multinominal logistic regression analysis of the model "daily commute" can be found under Appendix D: Details analysis from the multinominal logistic regression of the model "daily commute".

5.3 Results of the City Comparison of Urban Living and Urban Mobility Behavior

Results of the city comparison between Warsaw and Berlin

Based on the research model depicted in chapter 5.1 the variable "city" with the two compared cities Warsaw and Berlin acts as a grouping variable for the analysis of differences. For this variable, it is examined which target variables show particularly strong city differences. Furthermore, various aspects are investigated where the situation is similar between Warsaw and Berlin, meaning there are no significant differences.

The detailed results of the statistical analysis to determine significance and effect sizes related to variable type can be reviewed in Appendix E: Details statistical results of the city comparison: Warsaw vs. Berlin.

(1) Analysis of the Living Situation of Urban Citizens

In the first part of the study, in addition to the basic socio-demographic factors, various aspects of the personal living situation are analyzed that can have an impact on mobility

behavior. Besides asking whether someone owns or rents their home, a distinction is made between single and non-single households based on the number of people living in the household. Furthermore, the income level is another indication. For example, a possible influencing variable is whether the study participants can afford an apartment in the city center.

Moreover, the distance and duration for the daily commute to work, but also for leisure activities, plays a role in the choice of transport mode. A particularly short or long route can be one of the indicators for the preferred choice of a particular mode of transport. However, in practice, this strongly depends on the existing transport infrastructure when making a decision. Examples of this are fast public transport or well-developed bicycle paths.

Ultimately, the place of residence (e.g., central or more outside the city center) leads to different lengths and durations of everyday urban travel. The satisfaction with urban living is also related to whether someone perceives trips with various means of transport more pleasant or annoying and how positively or negatively the immediate living environment is experienced. While certain city dwellers tend to prefer short daily journeys, others are happy to accept longer journeys in order to live farther out in the countryside.

(a) Socio-economic Factors ("How is the living situation of urban citizens?")

Relevant differences are only found for home ownership (variable "soc_howner") and single households (“soz_single_hh“). In Warsaw, 68.1% of the respondents own their home, whereas in Berlin only 28.8% do. Overall, home ownership represents the variable with the highest significance and strength among the socio-economic variables.

Regarding the question whether someone lives alone or not (variable "soz_single_hh"), the result represents a borderline case in terms of significance. Despite the lack of a sufficient effect size (Cramer's V = 0.096), a significance is available (χ^2-test; $p \leq 0.05$). Due to the relatively high number of cases, even a value that is just below the effect size threshold can turn out to be significant. In addition, there are more single households in Berlin (25.3%) than in Warsaw (17.5%).

Table 32: Results significance for home ownership and single households

Variable	Warsaw	Berlin	Cramer's V	Sig.	n
soc_howner	68.1%	28.8%	0.394	0.000	537
soz_single_hh	17.5%	25.3%	0.096	0.026	537

Source: own calculations with the use of SPSS version 22

Next, the income level based on the personal disposable income per month is compared, defined as net income after deductions such as taxes, cost for health insurance etc. A statistically significant difference between Warsaw and Berlin can be demonstrated (X^2-test; $p \leq 0.001$, Cramer's V = 0.209).

The income of the study participants was for both cities predominantly relatively high. To obtain a comparative value between Poland and Germany, the income values for Warsaw were standardized to the income level of Germany applying purchasing power parity (PPP).

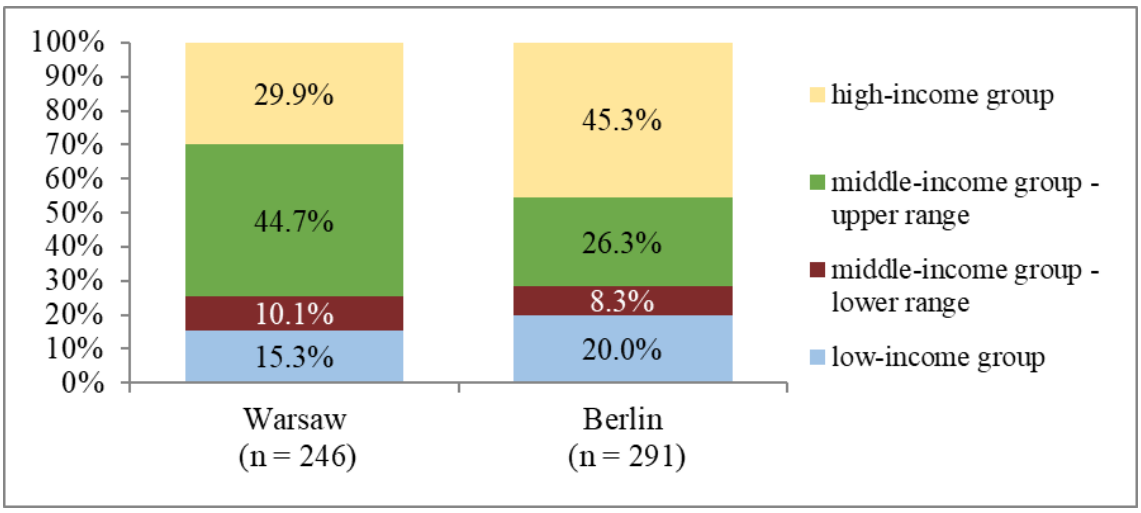


Figure 15: Comparison of the personal disposable income level between Warsaw and Berlin[66]

Source: own illustration based on the calculations with Microsoft 365 Excel

It can be seen that in Berlin a high number of participants (45.3%) belong to the high-income segment, a number that is much higher than in Warsaw (29.9%). In Warsaw, the largest proportion is in the upper-middle income segment (44.7%). Berlin, on the other hand, shows that slightly more participants are in the lower income segment (20.3% compared to 15.3% in Warsaw). However, this could be due to the fact that there are more students in Berlin who do not work in parallel, as the descriptive statistics show. A further analysis using a crosstab indicates that in Berlin students who do not work are in the lower income range in 79.2% of the cases, while in Warsaw that number is only 64.3%.

A comparison of the level of education between Warsaw and Berlin also shows that there is no significant difference between Warsaw and Berlin (X^2-test; $p > 0.05$, Cramer's V = 0.078). In Warsaw 56.1% and in Berlin 52.7% of the study participants have a Master`s degree or even higher. Just 27.2% in Warsaw and 28.0% in Berlin have no academic degree.

[66] For Berlin / Warsaw: low-income group: ≤ 1,500 € / < 2000 zł; middle-income group – lower range: 1,500 to 2,000 € / 2,000 to 3,000 zł;; middle-income group – upper range: 2,000 to 3,000 € / 3,000 to 4,250 zł; high-income group: > 3,000 € / > 4,250 zł

(b) Travel Distance and Time of Daily Commute and Leisure Travelling ("What are the average daily commuting and leisure travel distances?")

Taking a look at the distance of daily commute, in average Warsaw citizens have a shorter distance (round trip) by 5.4 kilometers compared to Berlin (see Table 33). The duration for the daily commute is relatively similar with about 45 minutes each for the daily round trip between Warsaw and Berlin. These findings from the study confirm the results from secondary data research (see chapter 4.3). It becomes clear that due to an increased traffic volume with frequent traffic jams in Warsaw, a longer travel time by car is required for the same distance.

Table 33: Results of statistical analysis for travel distance and time

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig. robust***	**eta****
trans_km_work_x	13.750	19.122	-5.372	0.000	0.192
trans_min_work_x	45.969	44.873	1.096	0.705	0.015
trans_km_leis_x	16.279	19.405	-3.126	0.013	0.100
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

The situation for leisure travel is similar. On average the distance in Warsaw is 3.1 kilometers shorter than in Berlin. The significance of the difference is confirmed by the statistical analysis, but the effect size is rather weak (ANOVA robust test; $p \leq 0.05$; eta = 0.100).

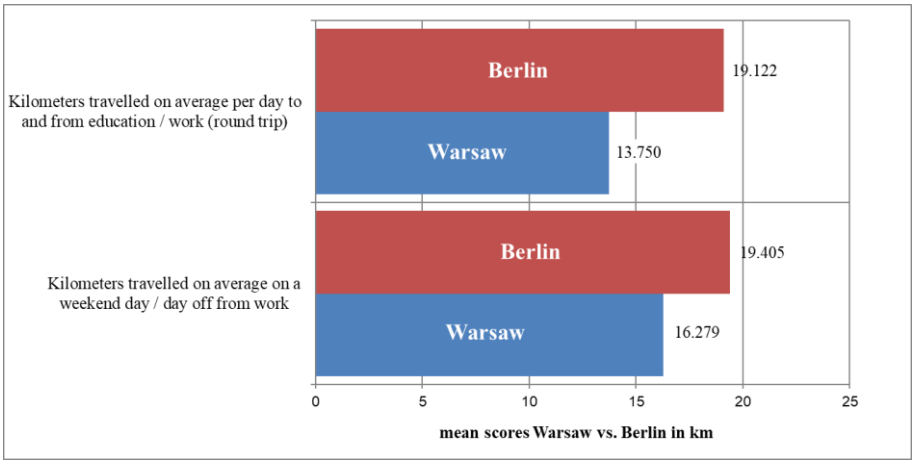


Figure 16: Mean value in kilometers daily commute and leisure time travelling

The longer distance in Berlin compared to Warsaw may possibly be derived from the fact that the area of Berlin is substantially larger or also because there are more residents commuting to the city from further away.

(c) Satisfaction with living environment ("How satisfied are the citizens with respect to the direct living environment?")

Based on the clustered answers resulting from the factor analyses executed before (cf. chapter 5), it can be seen that the degree of satisfaction with regard to the proximity and accessibility of public transport, shopping possibilities, and the way to work or educational institution in Warsaw is not significantly different to Berlin. In principle, infrastructure measures in the area of public transport can also have a positive effect on their use, as can be seen in the example of Poznan, and thus create an incentive away from the private car (Gadziński & Radzimski, 2016).

Table 34: Results statistical analysis regarding satisfaction with living environment

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig. robust***	**eta****
f_sat_prox_pt	-0.059	0.066	-0.125	0.130	0.061
f_sat_qual_env	-0.074	0.053	-0.127	0.128	0.062
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

Similar statistical results appear for the satisfaction in regard to the quality of the environment and the cost-benefit-ratio of housing. This comprises the quality and value for cost expenditures of one's living space and its immediate surroundings, such as nearby parks, sufficient peace and quiet away from the hustle and bustle of a big city, and clean air. It can be concluded that the satisfaction with both established factors with regard to the living environment are similar in Warsaw and Berlin.

Even though there are various studies showing that an increasing density in urban areas can lead to an improvement in infrastructure and thus to shorter daily commutes (Banister, 2011; Forster, 2006), other aspects such as environmental factors and a high-quality living environment must also be taken into account in urban planning (Dempsey et al., 2012). Different examples around the world like Gardens by the Bay in Singapore, Hanging Gardens in Sidney and Liuzhou Forest City in China show how this is possible (Bellew et al., 2015; Inhabitat, 2017; Xia et al., 2016). Jeihani and Zhang (2013) demonstrate that a good public transport connection to one's home can lead to about 20% less car traffic. Furthermore, one of the EU's main objectives under the 7th Environmental Action Program is to promote urban sustainability, which includes green growth and combating the loss of green spaces (European Commission, 2016; Nabielek et al., 2016).

(2) Personality Values and Future Expectations regarding Urban Mobility and Lifestyle

First, this section examines how personality traits differ between Warsaw and Berlin on the basis of the available sample. For this purpose, also the previously established factors are used (cf. chapter 5.1). Various psychological and social behavior patterns can influence those personality traits, leading to certain habits, values and beliefs, which are impacting mobility behavior. Different personality types also lead to certain lifestyles and desires in terms of mobility behavior and future-oriented goals. The last part shows different possibilities for the design of a future smart city and the attitudes and opinions of the study participants.

(a) Personality values ("What are the different personality traits?")

With the inclusion of the robust standard error in the one-factor analysis of variance[67] (ANOVA), a statistically significant difference was demonstrated for the factors "technology" and "social exchange". The eta-value estimates the variance and is a measure of the effect size. The higher the value, the better the effect size. This statistical approach aids in identifying the main differences between Warsaw and Berlin.

Table 35: Results statistical analysis regarding satisfaction of living environment

	City			**Effect**	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig. robust***	**eta****
f_pers_tech	0.272	-0.168	0.439	**0.000**	**0.222**
f_pers_soc	-0.179	0.162	-0.341	**0.000**	**0.173**
f_pers_flex	-0.048	0.057	-0.105	0.194	0.053
f_pers_disc	0.009	-0.074	0.082	0.308	0.041
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

Figure 17, which is depicted below, shows the B-value as main indicator for the strength of the difference between Warsaw and Berlin. Positive values indicate a higher value / better value and a negative value a lower / worse value for Warsaw compared to Berlin.

[67] Because variance homogeneity was not met (Breusch-Pagan tests < 0.05), the robust standard error and significances were calculated in the analysis of variance.

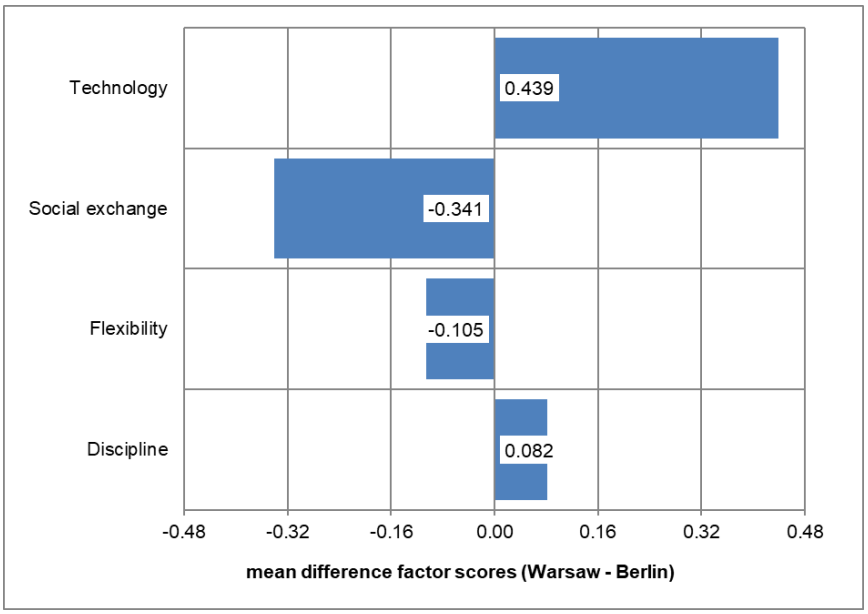


Figure 17: B-value as main indicator for strength of the difference between Warsaw and Berlin

Technology comprises i.a. the affinity and openness for the adaption of new technology, for instance by using mobility apps and social media as well as the willingness to obtain different information also from alternative sources in daily life besides the main media channels. The results show that technology affinity in Warsaw is much higher than in Berlin.

The next significant factor with a medium effect size of social exchange comprises the behavior of sharing one's own experiences for the sake of others, both in private and in professional everyday life. This includes the personal willingness to accept opinions and feedback from others in a benevolent manner. This factor is significantly more pronounced in Berlin than in Warsaw.

The factors flexibility (willingness to change and adapt) and discipline (importance of work-life-balance and ability to complete certain tasks without being interrupted) have neither a sufficient significance nor effects size, leading to the situation that no difference between Warsaw and Berlin could be proven.

In the relevant literature, the question of how technology affects our daily lives has been studied from multiple perspectives. In the context of smart work, for example, there are increasing opportunities to work more efficiently from home or around the world (Demerouti et al., 2014; Wisskirchen et al., 2017). This, in turn, can affect our mobility behavior and, accordingly, also prevent transport routes and thus possibly also CO_2 emissions. By better integrating technology for optimal usability and ease of use, people can be convinced to use it to their advantage (Bandura, 1977; Sherer et al., 1982; Venkatesh et al., 2012).

New mobility trends, such as autonomous vehicles and sharing offers or MaaS, can also disruptively change the mobility behavior of city dwellers (Guerra et al., 2018). They enable citizens to access information faster and more directly through technology or social media to make informative and quick decisions.

The social aspect with the will to respond to others and to share one's own knowledge also correlates with the willingness to adapt one's own behavior on the basis of certain value concepts. Thus, according to Cohen (2019), a decision to choose an environmentally friendly mode of transport can arise from a moral obligation to act sustainably. The influence of role models, as well as one's own peers with today's increased awareness through social media, can also play a crucial role in transport mode choice (Durand et al., 2018; Paundra et al., 2017).

(b) Future urban mobility & way of living ("What are the future expectations with regard to urban mobility and way of living?")

The desire for a CO_2 reduction and for a development towards sustainable mobility is more pronounced in Berlin than in Warsaw. The factor set up includes the opinion of residents on various measures related to urban change with the focus mentioned here on the design of sustainable and effective urban mobility (details see chapter 5.1). Especially when urban planning creates the opportunity for active recreation, this can lead to a higher sense of health among urban residents when actively used (Pawlikowska-Piechotka & Sawicka, 2013).

According to a study on Austrian citizens, seven out of ten respondents see MaaS as an alternative to vehicle ownership, and as many as 80% of respondents expect urban areas without vehicles with combustion engines (zero-emission zones) to be part of everyday life by 2030 (Austrian Energy Agency, 2018). To reduce pollutant and noise emissions, from a socio-technical perspective, transport policy measures can include a reduction in land and capacity used for private motorized transport in favor of sustainable modes of transport such as public transport, bicycle lanes to promote active transport options and sharing models with a high degree of automation (Jones, 2014).

The desire for active leisure time and the wish to spend time with the family is higher in Warsaw than in Berlin. This factor also correlates positively with the personal sense of importance of living in one's own property and having or striving to have property. With regard to lifestyle, which is connected to life in an urban city, there appears to be no significant difference between the two cities.

Table 36: Aggregated results of the statistical analysis for future urban mobility & way of living

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig. robust***	**eta****
f_sc_leisure	0.155	-0.113	0.268	**0.001**	**0.136**
f_sc_co2	-0.082	0.160	-0.241	**0.002**	**0.123**
f_sc_lifestyle	0.043	-0.005	0.048	0.557	0.024
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

(c) Important aspects and elements of a livable city ("What are important aspects and elements of a livable city?")

Urban mobility is an important area in the context of a smart city and thus also a fundamental component of a livable city. The study participants were asked about factors that are particularly important to their quality of life and that make the city worth living in. For developing a Sustainable Smart City, those aspects should be taken into account for the planning concept.

Figure 18 below shows the results of the descriptive statistics comparing Warsaw and Berlin.

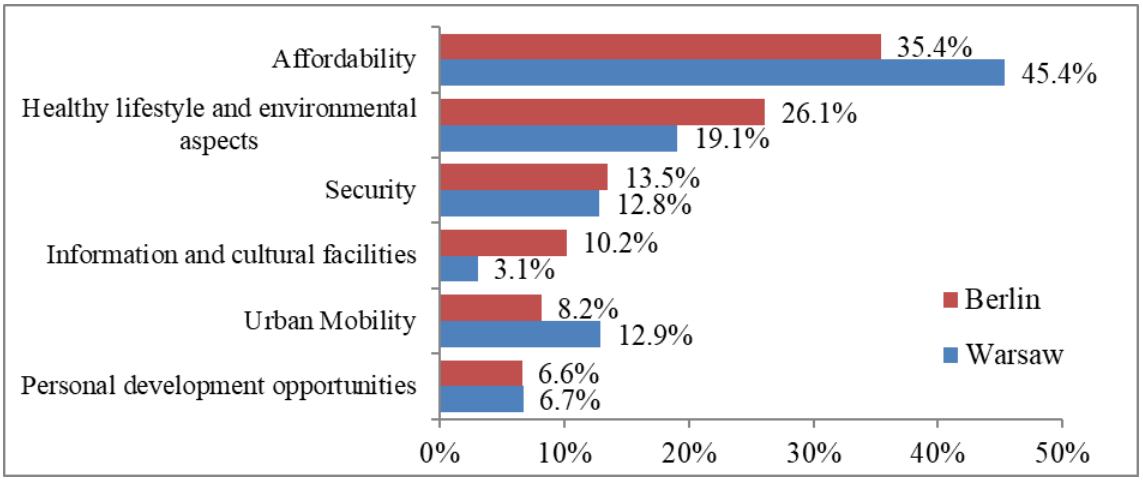


Figure 18: Descriptive statistics important aspects for a livable city – Comparison Warsaw and Berlin

The highest percentage of the people in Warsaw (45.4%) and in Berlin (35.4%) voted affordability to be the most important aspect for a livable city. Still there is a significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.05$, Cramer's V = 0.103). Affordability includes a reasonable standard of living that sets income levels in relation to living expenses such as rent, food, and leisure activities.

The aspect of having a healthy lifestyle and environment, which for instance means a high offering in the health and sports sectors as well as the availability of sufficient green spaces and local recreation, was voted into second place in both cities. In Berlin 26.1% and in Warsaw 19.1% of the survey participants selected this aspect as the most important one for a livable city. A statistical significance in difference is not given (X^2-test; $p > 0.05$, Cramer's V = 0.083).

Table 37: Descriptive statistics and significance in difference of important smart city aspects

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig.***	**Cramer's V****
imp_lc_facil	3.1%	10.2%	-7.1%	**0.001**	**0.137**
imp_lc_afford	**45.4%**	**35.4%**	+10.0%	**0.017**	**0.103**
imp_lc_health	**19.1%**	**26.1%**	-7.0%	0.054	0.083
imp_lc_mobil	12.9%	8.2%	+4.7%	0.072	0.078
imp_lc_secure	12.8%	13.5%	-0.7%	0.784	0.012
imp_lc_oppo	6.7%	6.6%	+0.1%	0.991	0.001
*Chi²-test significance calculated **variables sorted by effect size Cramer's V					

Source: own calculations with the use of SPSS version 22

Furthermore, the desire for information and cultural facilities such as educational institutions, libraries, museums, and possibilities for (international) social exchange is much higher in Berlin (10.2%) than in Warsaw (3.1%), which is confirmed by the significance test (X^2-test; $p \leq 0.05$, Cramer's V = 0.137).

Personal opportunities for participation, for example in the future planning of urban development, are rated as less of a priority. Adequate informational and cultural services seem to be comparatively less important, especially in Warsaw. An efficient and affordable urban mobility plays a rather minor role compared to aspects mentioned before. Urban development should therefore focus primarily on the factors of affordability and health-related well-being, but without neglecting the aspects less evaluated in this study, because all elements are interrelated.

(d) Major possible measures towards the development of urban mobility ("What do the citizens thing about possible measures towards the development of urban mobility"?)

Regarding mobility in the light of smart cities, opinions were asked about important future developments in terms of living in an ideal city. It should be noted that of the four different measures proposed, up to two answers could be selected.

For Warsaw there is a strong focus on improving the road construction combined with an increase in the creation of parking facilities to avoid traffic jams and thus ensure a better flow of the street traffic. There is a significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.001$, Cramer's V = 0.207), which is confirmed by the fact that almost twice as many participants are in favor of this measure compared to Berlin (see variable "imp_ul_road_cons" in Figure 22).

With regard to the focus on technological innovations such as mobility apps (e.g., MaaS), digital elections and citizen participation, as well as digital city guides, Berliners (29.9%) are significantly more positive than Warsaw citizens (19.6%). Moreover, the difference between these groups is significant (X^2-test; $p \leq 0.05$, Cramer's V = 0.119).

The improvement of public transport is attributed to a higher importance in Berlin (48.2%) than in Warsaw (40.2%). Based on the statistical analysis there is no significant difference between them (X^2-test; $p > 0.05$, Cramer's V = 0.079).

The highest level of agreement in both cities can be found in a greater focus on sustainable urban planning, which means, for example, creating sufficient green spaces, promoting CO_2-neutral transportation, reducing waste, and improving the recycling process. In Warsaw 60.4% and in Berlin even 65.4% are in favor of those developments towards a smart city worth living in. A statistically significant difference between Warsaw and Berlin cannot be proven (X^2-test; $p > 0.05$, Cramer's V = 0.053).

Although Warsaw shows a strong focus on the car, the desire for sustainable urban planning, which also includes CO_2-neutral transport, is the factor with the highest consent in the further development of urban mobility. This can be a good indicator showing that with an improvement of the overall mobility infrastructure and expansion of sustainable locomotion, such an offer would be used more, as long as it is a valid alternative to the car.

Table 38: Descriptive statistics and significance difference of smart city measures

	City			**Effect**	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig.***	**Cramer's V ****
imp_ul_road_cons	37.0%	18.6%	+18.40%	0.000	0.207
imp_ul_tech_inno	19.6%	29.9%	-10.30%	0.006	0.119
imp_ul_pt	40.2%	48.2%	-8.00%	0.068	0.079
imp_ul_sust_plan	60.4%	65.4%	-5.00%	0.220	0.053
*X^2-test significance calculated **variables sorted by effect size Cramer's V					

Source: own calculations with the use of SPSS version 22

With reference to the various behavioral models with regard to mobility behavior, there is evidence in the literature that an attitude toward the environment does not necessarily lead to a change in consumption behavior (Kroesen et al., 2017). For example, a positive basic attitude toward sustainability and CO_2-neutral mobility does not necessarily lead to changes in one's own mobility behavior. For example, when choosing one's own car, other factors such as subjectively perceived comfort, flexibility, the feeling of freedom play a higher role than the real desire to change consumption behavior. Therefore, even greater incentives must be created to achieve a desired change in thinking. Certain habits also remain relatively stable over time and often require a significant trigger for change, such as a change of job or place of residence or significant changes in the general conditions such as a driving ban or newly created offers of alternative means of transport (Scheiner, 2007).

(3) Differences in Urban Mobility Behavior in Warsaw and Berlin

(a) Basic Mobility Factors ("What are the main mobility resources available?")

In the first part of the analysis, the variables that are assigned with a binary value (0 = no; 1 = yes) are evaluated. The percentage values for the variables shown in Table 39 indicate the following aspects:

- ress_bicy = ownership or permanent access to bicycle in household
- ress_car = ownership or permanent access to a car in household
- ress_lic = holding a driving license
- ress_pt_tick = having a monthly/annual ticket for public transport

The analysis shows that there are only weak differences between the two cities.

Table 39: Basic mobility factors with binary values

	City			**Effect**	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig.***	**Cramer's V****
ress_lic "yes"	84.0%	94.2%	-10.20%	**0.000**	**0.163**
ress_bicy "yes"	76.8%	86.7%	-9.90%	**0.003**	**0.127**
ress_car "yes"	78.9%	70.4%	8.50%	0.026	0.096
ress_pt_tick "yes"	51.9%	51.2%	0.70%	0.848	0.008
*significance calculated **variables sorted by effect size Cramer's V					

Source: own calculations with the use of SPSS version 22

Based on the effect size of Cramer's V, relevant differences are only found for the resources bicycle and driving license. The percentage of driving license holders is very high in both cities. Approximately 94% of Berliners surveyed have a driver's license, while in Warsaw

this percentage is 84%. A similar trend can be seen for the availability of a bicycle in the household. In Berlin, 86.7% of households have a bicycle, in Warsaw 76.8%.

Car access within the own household is also relatively high, but here the situation is reversed. The share is higher in Warsaw with approx. 79% than in Berlin with approx. 71%. The effect size for the availability of a car, with a Cramer's V value of 0.096, is just below the nominal value of 0.100, but the difference is significant (χ^2-test $p = 0.026$).

The two cities do not differ in terms of the availability of a monthly/annual public transport ticket. In both Berlin and Warsaw, the share of households with a public transport ticket is relatively high at around 51%. The relatively small differences are also reflected by the descriptive statistics (see Figure 19).

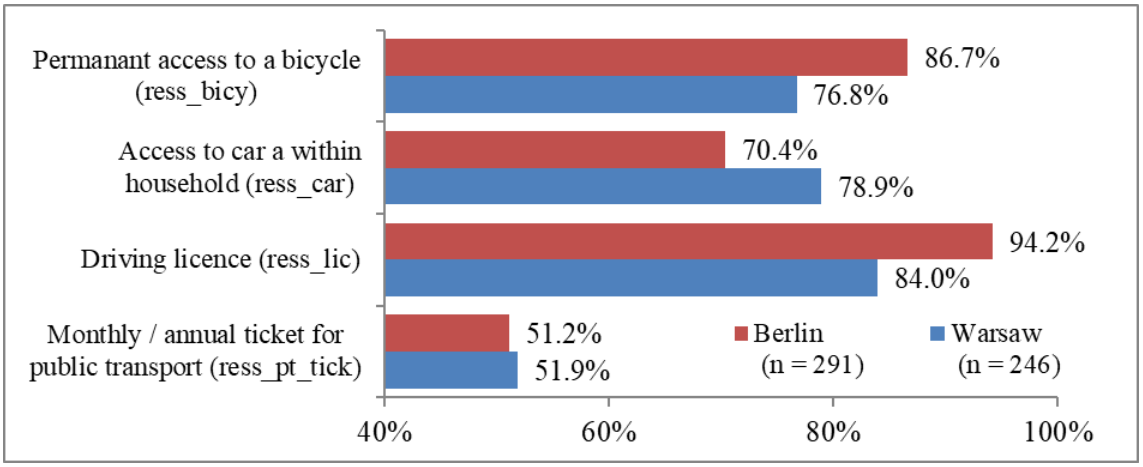


Figure 19: Overview descriptive statistics for the mobility resources

(b) Modal Split and Reason for Transport Mode Choice ("What is the modal split and the main reason for choosing a particular mode of transport for the daily commute?")

Participants in the study were asked about their main transport mode for daily commute in a typical week. Based on the statistical analysis, the χ^2-test shows that for daily commute there is a significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.05$, Cramer's V = 0.108). Despite the very high rate of study participants with access to a car in the household, it appears that in both Warsaw and Berlin more than half use public transport for their daily commute to work or to the educational institution.

Even if active means of transportation, i.e., bicycling or walking, are relatively poorly represented, it can be seen that the value in Berlin is almost twice as high as in Warsaw. However, the generally low rate is already due to the fact that in the vast majority of cases, bicycles and even more so walking are only considered for relatively short distances.

Table 40: Modal split in Warsaw and Berlin for daily commute

	Daily commute	
Transport mode	**Warsaw**	**Berlin**
Own car / taxi / car sharing	35.7%	31.7%
Public transport / long distance train	54.4%	51.1%
Active commute (bike & on foot)	9.9%	17.2%
total n	246	291
Work: X^2-test, $p \leq 0.05$, Cramer's V = 0.108		

Source: own calculations with the use of SPSS version 22

For more detailed consideration, the analysis of the underlying reasons for transport mode choice for daily commute is broken down into the three clustered options car, public transport (pt) and active commute (ac). For daily commute, it can be seen that only "pt" has a significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.05$, Cramer's V = 0.245). Although there is no direct significance for "car" (χ^2-test; p = 0.081), this is more likely due to the smaller sample size (n = 178). By increasing the number of participants, this variable would likely also become significant. The effect size is also relatively high (Cramer's V = 0.235), which indicates at least a certain difference between Warsaw and Berlin. No significance is demonstrated for active commuting. However, the sample size (n = 75) is relatively small, which reduces the significance and makes the result less meaningful.

Table 41: Statistical significance of the reasons for the different transport mode options

Daily commute	**Effect**		**Sample size**
Reason	**Sig.***	**Cramer's V ****	**n**
Public transport / long distance train	**0.005**	**0.245**	282
Own car / taxi / car sharing	0.081	0.235	178
Active commute (bike & on foot)	0.743	0.191	75
*X^2-testsignificance calculated; **variables sorted by effect size Cramer's V			

Source: own calculations with the use of SPSS version 22

The descriptive statistics show in both cities that comfort was the primary reason for using the car, indicating that many urban citizens probably perceive alternative modes of transportation as less convenient and more cumbersome. The sustainability factor is hardly present among car drivers in Berlin and not at all in Warsaw. In the choice of public transport (pt), the cost factor was significantly more pronounced in Warsaw than in Berlin.

The accessibility of transport modes such as public transport, car sharing etc. is equally indicated as a reason. In the case of active commute (ac), i.e., by bicycle or on foot, the health aspect is strongly pronounced, whereas it plays almost no role as a reason for the car and public

transport. Overall, many more people in Berlin ride their bicycles or walk to work or educational institutions on a daily basis.

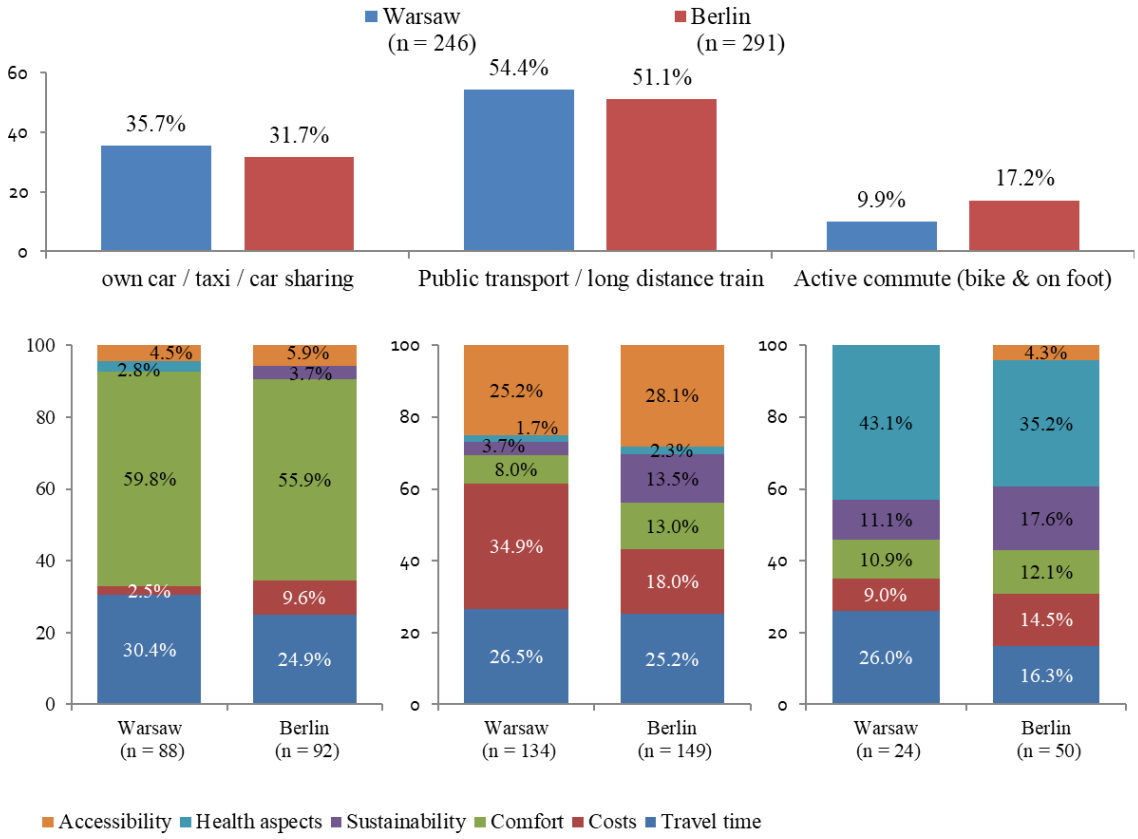


Figure 20: Modal split and main reasons of transport choice for daily commute

[All values below 1% are not shown in the graphic.]

Source: own illustration based on the calculations with Microsoft 365 Excel

In a study related to Warsaw, it is confirmed that although cyclists are aware of the advantages such as speed and flexibility, they see the lack of good cycling infrastructure and the feeling of insecurity related to the behavior of motorists as major obstacles (Iwińska et al., 2018). This is one of the reasons why bicycles are used more for leisure and less for daily commuting, which is also reflected in the user rate in this study.

Participants in this study were also asked about their main transport mode for leisure time activities such as meeting friends and family, shopping, and sports activities.

Compared to daily commuting, it is evident that the car is used more often as a means of transportation during leisure time. Reasons for this could be, for example, that many people prefer to leave their cars at home during their commute to work due to the high volume of traffic

and traffic jams, or that households with several people have a car, but only one person uses it to get to work/training. In addition, the car is likely used for leisure activities together with the partner or family. In Warsaw, in particular, people continue to use public transport in a third of cases. In Berlin, the use of active means of transport is even more pronounced than in Warsaw (27.1% vs. 12.9%). In Berlin, active commuting (27.1%) even surpasses public transport (25.2%) when it comes to the choice of transport mode.

Table 42: Comparison Warsaw vs. Berlin for the different transport modes for leisure travelling

	Leisure travelling	
Transport mode	**Warsaw**	**Berlin**
Own car / taxi / car sharing	53.9%	47.7%
Public transport / long distance train	33.1%	25.2%
Active commute (bike & on foot)	12.9%	27.1%
total n	246	291
Leisure: X^2-test, $p \leq 0.001$, Cramer's V = 0.178		

Source: own calculations with the use of SPSS version 22

Statistical analysis is again broken down into three clustered options. The highest effect size can be seen for public transport (X^2-test; $p \leq 0.05$, Cramer's V = 0.304), which means there is a difference between Warsaw and Berlin. Comparing the daily commute, this value is even more pronounced (Cramer's V = 0.304 compared to Cramer's V = 0.245 for pt in daily commute). In addition, there is a significant difference for car (X^2-test; $p \leq 0.05$, Cramer's V = 0.250). For active commute, there is no significant difference between Warsaw and Berlin.

Table 43: Significance test for transport mode choice and reason for leisure travelling

Daily commute	**Effect**		
Transport mode	**Sig.***	**Cramer's V****	**n**
Public transport / long distance train (pt)	0.014	0.304	155
Own car / taxi / car sharing (car)	0.005	0.250	272
Active commute (bike & on foot) (ac)	0.337	0.229	111
*X^2-testsignificance calculated **variables sorted by effect size Cramer's V			

Source: own calculations with the use of SPSS version 22

When investigating the underlying reasons for the transport mode choice, descriptive statistics show that in both cities, alike to daily commute, comfort was the primary reason for using the car. This is followed by travel time, where Warsaw surpasses Berlin by 9.1%.

Particularly in the case of public transport, Warsaw shows that costs are an important motivating factor, with a percentage that is almost twice as high as in Berlin. Berliners focus more on the environmental factor, which in turn is almost four times as high at 23.1% compared

with 4.7% in Warsaw. The remaining reasons are relatively similarly pronounced between both cities.

With regard to active commuting, by far the most important reason is the health aspect, which is even higher in Warsaw (62.2%) than in Berlin (40.3%). For a more detailed analysis, the total share of these groups and thus the sample is too small to obtain meaningful findings. Nevertheless, this could be an interesting area for further research.

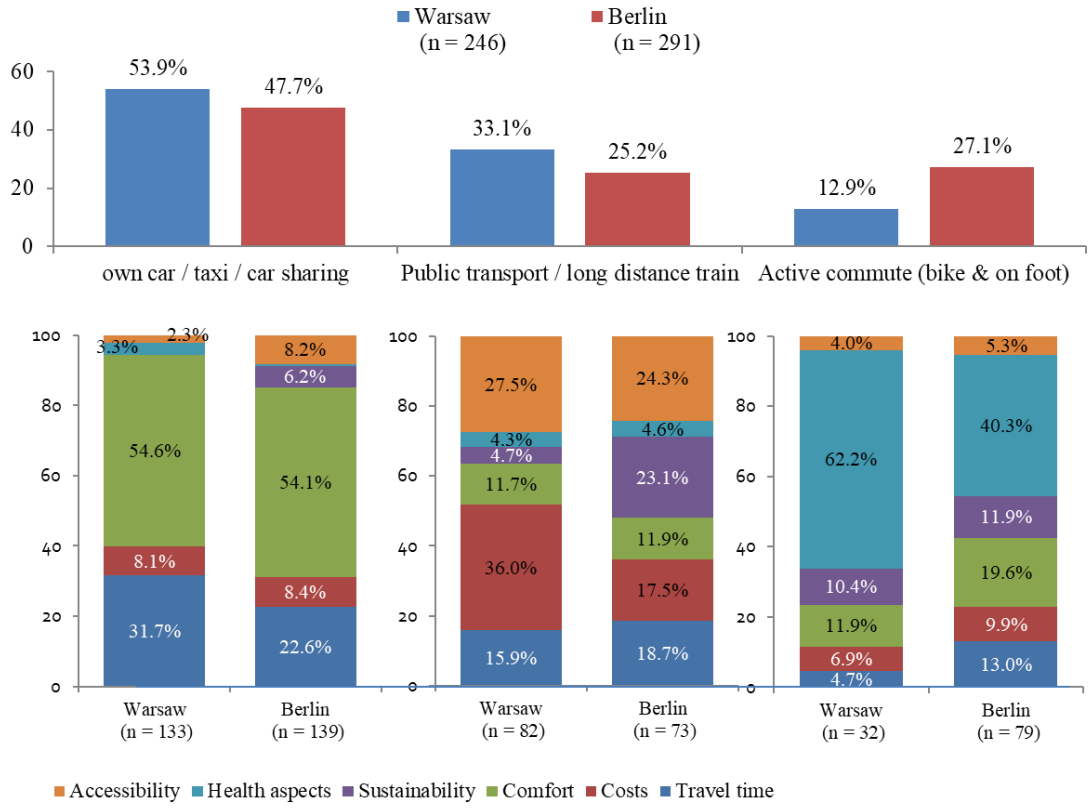


Figure 21: Modal split and main reasons of transport choice for leisure travelling

[All values below 1% are not shown in the graph]

Source: own illustration based on the calculations with Microsoft 365 Excel

Even with reference to the study participants who have access to their own car in the household, it reveals that public transport is used less frequently for leisure time activities compared to daily commute. Here in particular, great potential can certainly be derived, since ultimately the car stands unused most of the time. Thus, adequate sharing offers can certainly create incentives for traditional car drivers. Even though relatively few in Warsaw use active means of transportation such as bicycling or walking for leisure, most of the participants cite health issues as the main reason.

(c) Car use and perceived comfort of daily commute ("What is the perceived value of the car and the comfort associated with it?")

The need to own a car is much more distinctive in Warsaw than in Berlin. Besides being a comfortable travel possibility, the car expresses a distinct feeling of freedom for many urban citizens. Furthermore, it is associated with perceived value as a status symbol. There is a statistically significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.001$; eta = 0.216).

Besides the fact that Warsaw citizens are more often using their own car for urban mobility, the perceived comfort of daily commute is better in Berlin than in Warsaw. The statistical analysis confirms a significant difference between Warsaw and Berlin (X^2-test; $p \leq 0.05$, Cramer's V = 0.121).

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig. robust***	**eta****
f_ub_car	0.226	-0.198	0.424	**0.000**	**0.216**
f_ub_com	-0.143	0.101	-0.244	**0.003**	**0.121**
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

(d) Sharing Offerings ("How pronounced is the use of sharing offers?")

When comparing the mobility sharing offerings in Warsaw and Berlin, a significant difference can be demonstrated for car sharing (X^2-test; $p \leq 0.001$, Cramer's V = 0.249), bike sharing (X^2-test; $p \leq 0.001$, Cramer's V = 0.168), and for ride hailing (X^2-test; $p \leq 0.001$, Cramer's V = 0.166).

Table 44: Results of the statistical significance analyses for sharing offerings

	City			Effect	
Variable	**Warsaw (mean)**	**Berlin (mean)**	**B (delta) WAR vs. BER**	**Sig.***	**Cramer's V ****
trans_carshare	13.2%	35.0%	-21.80%	**0.000**	**0.249**
trans_bikeshare	27.0%	13.7%	13.30%	**0.000**	**0.168**
trans_ridehail	29.5%	16.0%	13.50%	**0.000**	**0.166**
trans_ridepool	4.5%	6.2%	-1.70%	0.381	0.038
trans_carpool	7.2%	5.7%	1.50%	0.490	0.030
*X^2-test significance calculated **variables sorted by effect size Cramer's V					

Source: own calculations with the use of SPSS version 22

While many people in Berlin use car sharing services more frequently, bike sharing is more popular in Warsaw. Ride-hailing, i. e. offers such as Uber and Lyft, is also more used in

Warsaw than in Berlin. Ride pooling, i. e., services in which several people use a vehicle together, and car pooling (privately organized) are equally underrepresented and based on the statistical analysis also not significant.

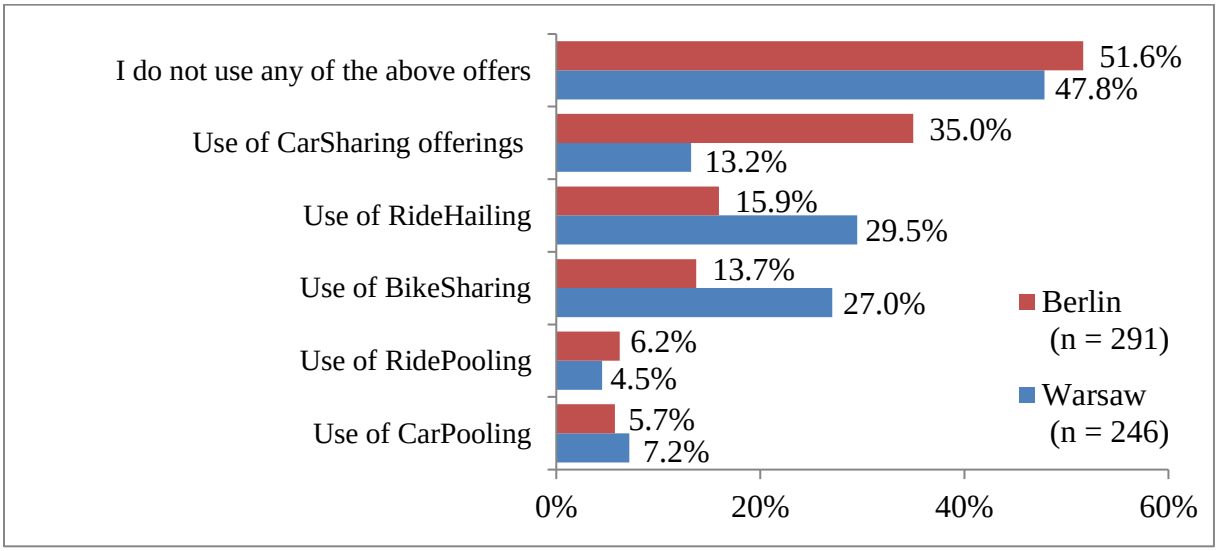


Figure 22: Results of the descriptive statistics − Comparison of Warsaw vs Berlin for sharing offerings

Source: own illustration based on the calculations with Microsoft 365 Excel

Overall, the results show that about half of all participants do not use sharing services at all, which reveals potential for the further development of sharing services. The fact that in Warsaw significantly more participants use bike sharing (+13.3%) aligns with the study result that around 10% fewer participants in Warsaw have access to their own bicycle in the household. The opposite is true for car ownership compared to car sharing. In Berlin car sharing offer is used significantly more than in Warsaw (+21.8%), but also fewer citizens (8.5%) have access to their own car in the household (WAR: 78.9%; BER: 70.4%). Such findings provide initial indications that the framework conditions can also have a different impact on mobility behavior. These include, for example, the quality of the transport infrastructure such as the road network, but also the availability of public transport and sharing services. The average values for Warsaw and Berlin of the different sharing offerings and the ranking within the two cities are shown below.

Table 45: Overview descriptive statistics for sharing offerings − Warsaw vs. Berlin

Area: Sharing offerings	Overall	Warsaw		Berlin	
Variable	**Value**	**Value**	**Rank**	**Value**	**Rank**
trans_carshare "yes"	25%	13.2%	3	35.0%	1
trans_ridehail "yes"	22%	29.5%	1	15.9%	2
trans_bikeshare "yes"	20%	27.0%	2	13.7%	3
trans_carpool "yes"	6%	7.2%	4	4.5%	5
trans_ridepool "yes"	5%	4.5%	5	6.2%	4
No use of sharing offerings	50%	47.8%	-	51.6%	-

Source: own calculations with the use of SPSS version 22

Studies show that a Mobility-as-a-Service offering based on various sharing services can lead to a substitution of the own car in particular if car owners were more aware of the actual running costs (Cisterna et al., 2022; Vij et al., 2020).

5.4 Results of the Generations Comparison for Warsaw and Berlin

Data Analysis and Statistical Methods

The variable "x_gen" with the three compared Gen X, Gen Y and Gen Z acts as a grouping variable for the analysis of differences. Based on the previously established factors (cf. factor analysis in chapter 5.1) and definition of the other variables, the focus is on examining the areas in which the generations differ significantly.

With reference to the data collection in this study, various target variables are classified in terms of their metrics. Depending on the (ratio) scale level, different statistical significance analyses are performed analogous to the description in chapter 5.3. For the comparison of the generations within the two cities of Warsaw and Berlin, but also for the direct comparison of the respective generations of the cities, additional descriptive statistical results are used with the application of frequency analyses and mean value comparisons.

Results of the Generations Comparison between Warsaw and Berlin

The comparison of the generations conducted in the following represents an essential core of the present scientific work and focuses on intergenerational differences, trends, and similarities. It also refers to the previously conducted study on the main factors influencing daily commuting and the general city comparison between Warsaw and Berlin. This means, for example, that the factors previously established on the basis of the factor analysis continue to

be applied in the comparison. In addition, reference is made to the variables already described in detail to present concrete differences and thus to reduce redundancy as far as possible.

Due to the high number of variants and pairwise comparisons in total, the following steps are carried out for a goal-oriented evaluation:

1. Investigation of generational differences and trends with respect to the total sample
2. Investigation of differences and trends between generations within Berlin and Warsaw
3. Investigation of differences and trends between the cities according to the individual generations (Gen X, Gen Y, Gen Z) in a city comparison

The individual steps are built on each other. To avoid redundancies and to keep the results comprehensible, only those aspects that provide meaningful results are presented. The basis for this is a comprehensive statistical evaluation of all variants, the results of which can be viewed in the detailed presentation in Appendix F: Details statistical results of the city comparison and Appendix G: Details statistical results of the generational comparison. For a consistent approach, the evaluation structure is based on the previously conducted city comparison.

(1) Analysis of the Living Situation of Urban Citizens

(a) Socio-economic Factors ("How is the living situation of urban citizens?")

There is a clear trend in the level of education, i. e. the older the generation, the better educated they are (Variable "soc_edu"; X^2-test; $p \leq 0.001$, Cramer's $V = 0.325$). It should be noted that the trend is dominated by Gen X and Gen Y in particular. Gen Z deviates from this, which can be derived from the fact that they are often still studying and therefore do not yet have an academic degree. Hence, the percentage of academics in Gen Z is relatively low compared to Gen Y and Gen X. In a generational comparison, Gen Y is most likely to have a master's degree[68] (67%), slightly ahead of Gen X (56%), where more participants have a high school or vocational degree without a college education. This also confirms the trend that among the Gen Y, more people are enrolled in study programs compared to previous generations (Charzyńska et al., 2012; Rahlf, 2015).

[68] Or an equivalent educational qualification such as a country-specific national diploma or magister, especially before the Bologna process-based standards were introduced.

Table 46: Comparison of generations − descriptive statistics and significance for education

Educational level	**Generation**			**Effect**	
Variable: soc_edu	**X**	**Y**	**Z**	**Sig.**	**Cramer V**
ISCED level 1-2	4.0%	2.9%	9.0%	**0.000**	**0.325**
ISCED level 3-4	22.8%	11.1%	62.3%		
ISCED level 5-6	17.2%	18.7%	18.4%		
ISCED level 7-8	56.0%	67.3%	10.3%		

Source: own calculations with the use of SPSS version 22

The distribution of the respective highest educational attainment between the generations is relatively similar in Warsaw as well as in Berlin.

Income and wealth tend to rise with age as well as with the education degree. This is also evident from the findings of this research. There is a significant difference in income between the generations (Variable "soz_income"; X^2-test; $p \leq 0.001$, Cramer's V = 0.268). The fact that a significant share of young members of Gen Z (48.5%) is in the lowest income bracket can be explained with the fact that this generation is still in education. They either do not yet work or only work part-time alongside their studies, which in turn leads to a lower income. At the same time, only 15.8% are in the top income bracket, which in turn means that they are already earning very well at a young age (18-25 age group). Accordingly, Gen Y (38.7%) and Gen X (46.9%) are more frequently represented in the highest income group.

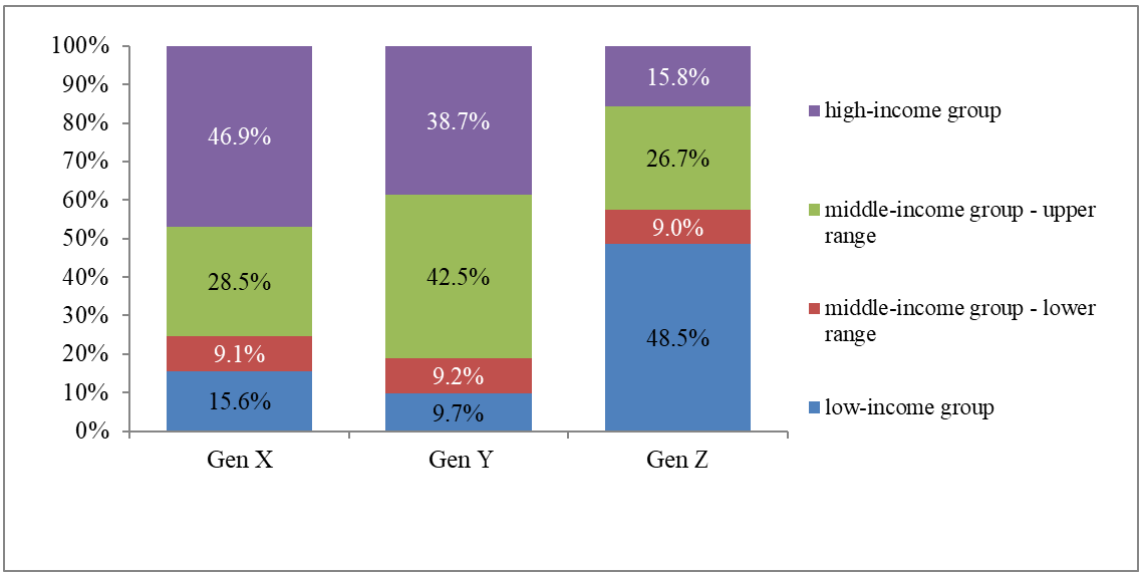


Figure 23: Comparison personal disposable income level between generations[69]

[69] low-income group: < 1,500 €; middle-income group – lower range: 1,500 to 2,000 €; middle-income group – upper range: 2,000 € to 3,000; high-income group: > 3,000 €

If Warsaw and Berlin are considered separately, both cities show a significant trend between the generations. It is noticeable that people in Gen X earn above average somewhat more frequently in Warsaw (82.7%) than in Berlin (70.6%). The top income category, in turn, is slightly more represented in Berlin (52.9%) than in Warsaw (37.3%). This cannot be directly explained by the higher level of education (ISCED level 7-8 in Berlin at 53.1% and in Warsaw at 60.2%). It is reasonable to assume that a high level of education has an even more positive effect on income in Berlin than in Warsaw. As expected, both Warsaw (46%) and Berlin (51%) show that the young Gen Z is in the lower income range (adjusted with the PPI at the price level of Germany of below EUR 1,500) and thus also significantly below the average (net wage in 2021 on average at about EUR 2,200[70]).

When asked whether someone has a job or not, it appears in line with the previously established finding that there is generally a significant trend between the generations here as well (variable "soc_work"; X^2-test; $p \leq 0.001$, Cramer's V = 0.347).

Accordingly, it can be seen that a large majority of Gen Y (95%) and Gen X (93%) are working, either as employees or self-employed. The significant trend is confirmed in the generational comparison within Warsaw and Berlin. In contrast, the comparison of the respective generations between Warsaw and Berlin does not show any significant differences. Compared to the national average, however, the working population is significantly overrepresented, showing that it was predominantly people with jobs who were surveyed. In addition, the respondents are primarily of working age. Gen Z is an exception, with a relatively large number of prospective academics still in training. The proportion of people in this age group who are not in employment is around 35% in both Warsaw and Berlin.

The next step is to compare the living situation. The results show that there is no significant difference between the generations in the overall analysis in terms of home ownership (Variable "soc_howner"; X^2-test; $p = 0.101$). However, when Warsaw is considered on its own, a very high discrepancy emerges in comparison to Berlin. While less than a third of Berlin residents own their homes (Gen X: 29%, Gen Y: 31%, Gen Z: 23%), more than 2/3 of Warsaw residents own their homes (Gen X: 87%, Gen Y: 60%, Gen Z: 54%). It is interesting to note that even the share of the youngest Gen Z (aged 18-25) is more than 30% higher than in Berlin. There is also a strong trend from the younger to the older generation, since Gen X in

[70] retrieved May 04, 2022, from https://de.statista.com/statistik/daten/studie/370558/umfrage/monatliche-nettoloehne-und-gehaelter-je-arbeitnehmer-in-deutschland/

particular lives predominantly in property (variable "soc_howner"; X^2-test; $p \leq 0.001$, Cramer's V = 0.288).

Table 47: Results significance for home ownership and occupational status

	Generation			Effect	
Variable	**X**	**Y**	**Z**	**Sig.**	**Cramer V**
soz_work "yes"	93.25%	94.73%	65.06%	**0.000**	**0.347**
soc_howner "yes"	51.74%	46.02%	36.89%	0.065	0.101

Source: own calculations with the use of SPSS version 22

Gen Z is usually still too young and less wealthy to acquire property and also often has a different focus such as flexibility and travel. Nevertheless, more than half of them in Warsaw live in property, which could also indicate that they still live in their parents' house or have already inherited property. Gen Y is currently in the age group where many are thinking about having their own property or already live in their own home. However, there is a trend around the world that Gen Y is less able and less willing to afford their own home than previous generations (Bergeron, 2022; Paz-Pardo, 2022). Among the reasons are an uncertain market situation, changing lifestyles (desire and the possibility of not being tied to a specific place), increasing inflation, and the extreme rise in real estate prices, especially in the last decade.

(b) Travel Distance and Time of Daily Commute and Leisure Travelling ("What are the average daily commuting and leisure travel distances?")

Although there is a significant difference between the generations in the distance of daily commute, it is relatively weak. It is interesting to note that Gen Y has the shortest distance for daily commuting. A possible reason for this could be that young and relatively high-earning academics prefer to live centrally in the city and a small apartment is sufficient for them, since most of them do not yet have their own children living in their own household. In addition, many workplaces are located centrally in the city. The situation is similar for leisure activities. For leisure activities, significance is also present, albeit with a rather low strength.

Table 48: Results mean value and effect for travel time

	Generation			Effect	
Variable	**X**	**Y**	**Z**	**Sig. robust***	**eta****
trans_km_work_x	19.08 km	15.35 km	17.32 km	**0.016**	**0.116**
trans_km_leis_x	20.48 km	17.27 km	16.33 km	**0.035**	**0.105**
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

A comparison in Warsaw with regards to daily commute shows that there is hardly any difference between the generations. In Berlin, the oldest Gen X and the youngest Gen Z cover almost the same distance, averaging around 21 km. Gen Y deviates slightly with 17 km and also has a significant difference to Gen X (variable "trans_km_work_x" for Berlin; ANOVA robust test; $p \leq 0.05$; eta = 0.127). The comparison of the cities shows that Berlin has a slightly longer average daily commute distance (Gen X: +7 km, Gen Y: +4 km, Gen Z: +7 km), which may be due to the larger area size of the city compared to Warsaw (see chapter 4.3). Gen Y travels the least distance on average in both cities. One possible indicator could be that Gen Y already earns well in their job as well as preferring the city lifestyle, which could mean that this generation tends to live more centrally.

In terms of commuting time, there is no significant difference between the generations either in Warsaw or Berlin. The daily commute time for all generations is about 45 minutes (± 1 minute) in Warsaw and between 39 minutes (Gen Z) and 49 minutes (Gen X) in Berlin, with Gen Y almost exactly in between at 43 minutes.

Table 49: Results city comparison of travel distance and time with regard to the generations

Area: Travel distance	Mean value Warsaw			Mean value Berlin		
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Gen X**	**Gen Y**	**Gen Z**
trans_km_work_x [in km]	14.65	13.16	14.14	21.37	17.03	20.80
trans_min_work_x [in min]	44.38	46.69	46.03	49.44	43.32	39.34
trans_km_leis_x [in km]	17.70	13.16	14.14	21.77	18.68	16.27

Source: own calculations with the use of SPSS version 22

(c) Satisfaction with Living Environment ("How satisfied are the citizens with respect to the direct living environment?")

In the case of satisfaction with the accessibility of public transport, daily shopping and daily work, there is only one significant difference between Gen X and Gen Y after pairwise comparison between the three generations (factor "f_sat_prox_pt"; ANOVA robust test; $p \leq 0.05$; eta = 0.108). If this is further broken down to the cities (comparison of the respective samples by themselves), a significant difference between these two generations can be found only in Warsaw but not in Berlin (factor "f_sat_qual_env" for Warsaw; ANOVA robust test; $p \leq 0.05$; eta = 0.122).

Table 50: Results statistical analysis generations regarding satisfaction with living environment

	Mean value			Effect	
Satisfaction with living environment	**Gen X**	**Gen Y**	**Gen Z**	**Sig. robust***	**eta****
f_sat_prox_pt	0.159	-0.080	0.029	0.033	0.106
f_sat_qual_env	0.027	-0.024	0.019	0.840	0.024
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

There is no trend across the generations in terms of satisfaction with the quality of the environment and with the cost-benefit ratio of one's own living space (factor "f_sat_qual_env"; ANOVA robust test; $p > 0.05$; eta = 0.024). Further statistical analyses also show that this factor is perceived relatively independently of the age group in both Warsaw and Berlin, as well as in the comparison of the different generations between the two cities.

(2) Personality Values and Future Expectations with regard to Urban Mobility and Way of Living

(a) Personality Values ("What are the different personality traits?")

Based on the clustered questioning according to different personality traits, four essential factors were previously established from the factor analysis. In terms of technology affinity, a clear trend emerges and confirms that younger generations deal with innovations more often and more consciously (factor "f_pers_tech"; ANOVA robust test; $p \leq 0.001$; eta = 0.166). An increased enthusiasm for technology is also evident among the younger generation, particularly with regard to the use of mobility apps on their cell phones. The comparison of the cities shows that across all generations, affinity for technology is significantly higher in Warsaw than in Berlin. The mean value analysis shows differences between Warsaw and Berlin (mean values; Gen X: +0.33, Gen Y: +0.22, Gen Z: +0.40). The trend between the generations is significant only in Warsaw (factor "f_pers_tech"; ANOVA robust test; $p \leq 0.01$; eta = 0.215). The mean value between the generations within Warsaw confirms the significant difference (Gen X: 0.01, Gen Y: 0.27, Gen Z: 0.56).

The next personality value contemplated is social competence, which includes personal commitment and sharing one's knowledge and experience to help others. In addition, the willingness to reflect through the feedback of others and not just being focused on oneself plays a role in this factor. In Gen Y (mean value: 0.08) it is slightly more pronounced than in Gen X (mean value: 0.05), while the youngest Gen Z (mean value: -0.22) is comparatively behind

(factor "f_pers_soc", Z vs. Y; ANOVA robust test; $p \leq 0.05$; eta = 0.112). One reason for this could be that Gen Z, who are often still in education and therefore still in the process of acquiring relevant knowledge and experience, which can then be shared with others. Another indication could be that the increasing dominance of online media and social communication platforms such as Instagram and TikTok is affecting the development of certain social skills, especially among the younger generations (Fuller, 2022; Jimenez & Morreale, 2015; Rachel, 2018; Zelsdorf, 2014).

Table 51: Results statistical analysis generations regarding personality traits

	Mean value			**Effect**	
Personality traits	**Gen X**	**Gen Y**	**Gen Z**	**Sig. robust***	**eta****
f_pers_tech	-0.221	0.091	0.216	**0.000**	**0.166**
f_pers_soc	0.049	0.083	-0.218	**0.021**	**0.112**
f_pers_flex	-0.175	0.090	0.114	**0.006**	**0.129**
f_pers_disc	0.241	-0.124	-0.273	**0.000**	**0.197**
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

The direct comparison of the individual generations between the two cities shows that the defined social competence is more pronounced in Berlin than in Warsaw (mean values; Gen X: +0.30, Gen Y: +0.37, Gen Z: +0.25). Gen Y has the comparably highest value in both Warsaw (-0.124) and Berlin (0.243), but the greatest difference between the two cities is also evident in this generation. The youngest Gen Z has the lowest social competence in both cities (WAR: -0.340; BER: -0.085).

The younger generations also find it easier to be flexible and adapt to change processes (factor "f_pers_flex"; ANOVA robust test; $p \leq 0.05$; eta = 0.129). In this respect, Gen Z is slightly more flexible than Gen Y. However, both generations distinguish themselves relatively strongly from Gen X, which experiences more difficulty in doing so. In the generational comparison within the cities, only Berlin confirms the significance and thus a trend that the younger the generation, the more flexible they are (factor "f_pers_flex"; ANOVA robust test; $p \leq 0.01$; eta = 0.164). Moreover, descriptive statistics indicate that Gen Z and Gen Y are more flexible compared with Gen X. A direct generational comparison shows that the residents of Berlin are more flexible than those of Warsaw (Gen Y: +0.07; Gen Y: +0.15; Gen Z: +0.20).

With regard to discipline and the desire and ability to clearly separate private life and work, the trend is the opposite. This is more pronounced among Gen X than among Gen Y and

above all Gen Z (factor "f_pers_disc"; ANOVA robust test; $p \leq 0.001$; eta = 0.197). In connection with the affinity for technology and the increasing possibility of being able to work from anywhere, it is apparent that the various areas of life are becoming increasingly intertwined, particularly among the younger generation. There is increasingly a less strict separation between working time and leisure time. It is interesting to note that in Berlin there is only a meaningful difference between Gen X and Gen Y (difference of the means of +0.59), whereas the values of Gen Y and Gen Z are almost equal. Both cities show a significant trend that the older the generation, the more pronounced their discipline (factor "f_pers_disc"; WAR: ANOVA robust test; $p \leq 0.05$; eta = 0.167; BER: ANOVA robust test; $p \leq 0.001$; eta = 0.275). In the direct generational comparison, Gen Z is almost on par in Warsaw (mean value: -0.288) and Berlin (mean value: -0.256). For Gen X (+0.18) and especially for Gen Y (+0.36), the average value is higher in Berlin than in Warsaw.

(b) Future Urban Mobility and Way of Living ("What are the future expectations with regard to urban mobility and way of living?")

Looking at the generations as a whole, there is a significant difference in the perceived need for leisure activities and time with family between Gen Y and Gen X. Gen Y values active leisure time and spending time with the family higher in Berlin than Gen Z (factor "f_sc_leisure"; ANOVA robust test; $p \leq 0.01$; eta = 0.124; difference at mean +0.29). This finding is confirmed by various studies (Cochran et al., 2009; Ng et al., 2006; Smola & Sutton, 2002). Analyzing both cities separately, this trend is evident in the case of Warsaw (factor "f_sc_leisure" for Warsaw; ANOVA robust test; $p \leq 0.01$; eta = 0.233), but it is interesting to note that the trend reverses again for Gen Z. The mean value for Gen Z is almost the same as for the older Gen X, but clearly below the value for Gen Y (-0.39). Even though an overall significant trend between the three generations could not be confirmed for the participants in Berlin, the reverse trend for Gen X is visible among them. Comparing the generations between the cities, Warsaw shows a relatively small difference compared to Berlin in the case of Gen X (-0.10) and Gen Z (-0.13). This is more pronounced for Gen Y (-0.39).

The desire for CO_2 reduction and for a development toward sustainable mobility is most pronounced among Gen Y. The difference between Gen Y and Gen X is most pronounced (factor "f_sc_co2"; ANOVA robust test; $p \leq 0.01$; eta = 0.125; difference of the means +0.30). When comparing the generations in the cities, it can be seen that there is a significant trend between the generations only in Berlin (factor " f_sc_co2"; ANOVA robust test; $p \leq 0.01$; eta = 0.197). In terms of the means, it can be seen that all three generations are more pronounced in Berlin

than in Warsaw. As in other cases, the biggest difference between Berlin and Warsaw can be recognized for Gen Y (mean +0.39).

With respect to the overall sample, there is no significant trend between the generations in the field of lifestyle. However, the significance analysis within the cities shows that there is a significant trend between the generations in Warsaw (factor "f_sc_lifestyle "; ANOVA robust test; $p \leq 0.05$; eta = 0.152). The mean analysis shows that especially the youngest Gen Z in Warsaw attributes a higher value to the lifestyle of a city with its wide range of professional and leisure opportunities compared to Gen Y (+0.31) and Gen X (+0.23). The comparison of the cities shows that the average value of Gen Y (+0.39) in Warsaw is significantly higher than in Berlin, followed at a greater distance by Gen Z (+0.13) and Gen X (+0.10).

Table 52: Aggregated results of the statistical analysis for future urban mobility & way of living in terms of generations

Future urban mobility & way of living	**Mean value**			**Effect**	
Personality traits	**Gen X**	**Gen Y**	**Gen Z**	**Sig. robust***	**eta****
f_sc_leisure	-0.163	0.131	-0.091	**0.003**	**0.136**
f_sc_co2	-0.127	0.169	0.058	**0.004**	**0.133**
f_sc_lifestyle	0.004	-0.034	0.175	0.161	0.077
*homogeneity assumption not met; robust significance calculated **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

(c) Important Aspects and Elements of a Livable City ("What are important aspects and elements of a livable city?")

The survey asked for the most important aspects of a livable city. Six different choices were given, but only the most important aspect should be selected. An efficient and affordable mobility offer plays a relatively low important role in the comparison. Especially for the oldest Gen X, this topic is less relevant in comparison (WAR: 9.3%; BER: 3.2%). Nevertheless, a trend can be detected for Berlin, which means that for the younger generation the mobility offering is more important than for the older generation (X^2-test; $p \leq 0.01$, Cramer's V = 0.186). In Warsaw, the value is even higher for the middle Gen Y (16.0%) than for the youngest Gen Z (10.0%).

Table 53: Results generational city comparison for elements of a livable city

Area: Elements of a livable city	Mean value Warsaw			Mean value Berlin		
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Gen X**	**Gen Y**	**Gen Z**
imp_lc_mobil "yes"	9.30%	**16.00%**	10.00%	3.23%	9.69%	**17.81%**
imp_lc_facil "yes"	3.23%	3.89%	0.00%	11.25%	10.24%	7.11%
imp_lc_afford "yes"	**43.74%**	**41.38%**	**62.87%**	**41.98%**	**30.15%**	**31.38%**
imp_lc_health "yes"	**26.66%**	**19.12%**	2.85%	**24.27%**	**28.40%**	**24.93%**
imp_lc_secure "yes"	9.39%	14.04%	**15.72%**	14.58%	13.64%	10.04%
All values ≥ 15% are marked in **bold**						

Source: own calculations with the use of SPSS version 22

There is also relatively little demand for the opportunity to inform oneself and to further educate oneself professionally and culturally (variable "imp_lc_facil"). A trend between the generations is not statistically evident. It is particularly striking that not a single study participant in Gen Z in Warsaw felt this aspect to be most important (Berlin 7.1%).

By far the most important aspect of a livable city is the factor of affordability in order to be able to maintain a certain standard of living. This finding is reasonable because all areas of life, such as home ownership and the organization of leisure activities depend decisively on the financial component. However, no significant trend between the generations can be demonstrated neither in Warsaw, nor in Berlin. The highest value by far, 62.9%, is found among the youngest Gen Z in Warsaw, almost twice as high as in Berlin (31.4%). For Gen X, the value is almost the same in both cities (WAR: 43.7% vs. BER: 42.0%). When comparing the overall value, Warsaw (average values across Gen X, Gen Y and Gen Z: 45.5%) shows a significantly higher value than Berlin (average value across Gen X, Gen Y and Gen Z: 35.4%).

In the aspect of a healthy lifestyle and an environmentally conscious way of life, there is no apparent significant trend between the generations in the total sample (variable "imp_lc_health", $p = 0.149$). With reference to the cities, however, a trend emerges in Warsaw (X^2-test; $p \leq 0.05$, Cramer's $V = 0.194$). There is a significant difference between Gen X (26.7%) and Gen Y (19.1%) and the youngest Gen Z (2.9%), which would indicate that the health and environmental awareness in Warsaw increases with age. In Berlin there is no trend between the generations in terms of health. In a direct city comparison of the generations, among the oldest Gen X, both cities have a relatively equal level of importance (WAR: 26.7%; BER: 24.3%). Among Gen Y (WAR: 19.1% vs. BER: 28.4%) and especially among Gen Z (WAR: 2.9% vs. BER: 24.9%), the value with respect to a healthy lifestyle and environmental consciousness in

Berlin is significantly higher. With the low value in Warsaw, Gen Z hardly seems to be concerned about this issue.

A high sense of security, which also goes hand in hand with a low crime rate, is apparently a minor concern in both cities (variable "imp_lc_secure"). The values for all three generations are very similar at around 13 to 14%, leading to the fact that the trend is statistically not evident. Within the generational comparison between the cities, for Gen X, the value in Berlin (14.6%) is somewhat higher than in Warsaw (9.4%). For Gen Z it is the opposite, the value in Warsaw (15.7%) is 5.7% higher than in Berlin (10.0%).

The possibility of personal development opportunities, which comprises actively representing one's own interests, for example in the form of citizen participation in the decision-making process in urban development, is rated low in importance by all aspects (variable "imp_lc_oppo"). The percentage of people for whom this is the most important aspect of a livable city is below 10% across all generations in both cities, which leads to a lack of significance in respect to trends. Reasons for the low values can be the following: a lack of interest, other personal priorities, and in addition, it might be an indication for the fact that many citizens take a rather critical view of politics and those in power are often not genuinely close to the people (Unzicker, 2020; Wilczek, 2021).

(d) Major possible measures towards the development of urban mobility in a smart city ("What do the citizens thing about possible measures towards the development of urban mobility"?)

Based on the current situation, various strategies can be pursued in the context of urban planning to develop urban life with primary reference to mobility, depending on the focus, needs of the city's inhabitants and available financial resources. To gain an insight into the preferences of the citizens of Warsaw and Berlin and on how these differ, four different basic orientations and related measures in the context of sustainable urban development were provided for selection. From among these, up to two responses could be selected that were felt to be comparatively most important.

When comparing the overall mean values, the following ranking of the importance of the essential aspects can be set up: 1. Sustainable urban planning; 2. Public transport; 3. Individualized vehicle transport infrastructure; 4. Technological innovations.

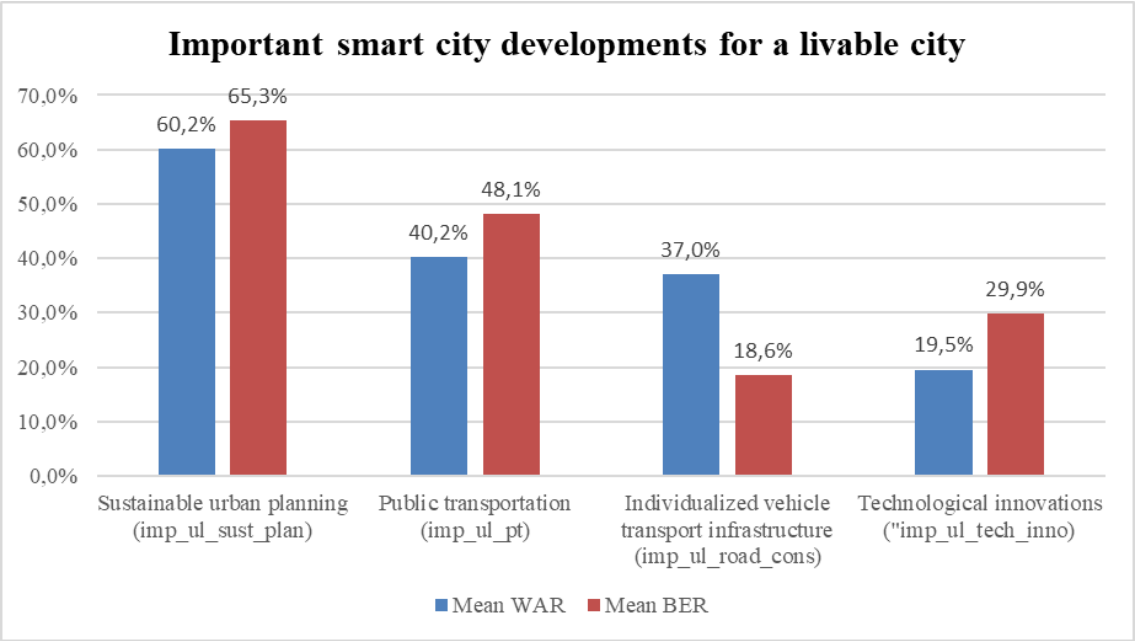


Figure 24: Important smart city developments for a livable city

Source: Own illustration based on data analysis

By far the highest level of agreement in both cities is shown for the desire to focus on sustainable urban planning to make the city more livable across the board, primarily by creating green spaces, making processes more efficient, and improving air quality. There is no significant difference between generations (variable "imp_ul_sust_plan"; X^2-test; $p = 0.69$). The highest approval rating when comparing within cities is in Warsaw among the youngest Gen Z (64.3%) and in Berlin among the middle Gen Y (71.5%).

The result in this part of the study on possible new urban development options for sustainable mobility shows the desire of most citizens for a well-founded approach. Various areas of urban mobility are intertwined in the process. The aim is not necessarily to position one particular mode of transport over the other and thus make it an either-or decision, but rather to link the various transport options in an integrative manner so that, depending on individual needs, the best mode or mix of modes can be offered for the relevant purpose (Ambrosino et al., 2016; Gebhardt et al., 2016; Oostendorp et al., 2019).

In terms of the need and desire for the expansion and improvement of public transport, which ranks second in importance in both cities, there is generally a significant trend between the generations (variable "imp_ul_pt"; X^2-test; $p \leq 0.05$, Cramer's V = 0.131), which can be confirmed only for Berlin ($p \leq 0.001$, Cramer's V = 0.230). The agreement value is more pronounced for Gen X in Berlin than in Warsaw (+22.4%), but it is rather similar for Gen Y (-1.7%) and for Gen Z (-4.3%). This in turn may indicate that the current public transport

infrastructure in Warsaw is not well developed enough and therefore does not present a real alternative to owning a car in most cases (Goch et al., 2018; Móscicka et al., 2019). Moreover, it may be one of the reasons for the significantly higher car ownership rate in Warsaw compared to Berlin. In Berlin, there is significantly higher agreement among Gen X (61.4%) compared to Gen Y (39.8%) and Gen Z (34.3%) in terms of the satisfaction with the public transport. One of the reasons for this may be that younger generations tend to prefer living centrally in the city, and it is precisely here that they feel the public transport network is already well enough developed.

Moreover, the results show that, especially in Berlin, a focus on car traffic with the expansion of traffic roads as well as an increased creation of parking spaces (variable "imp_ul_road_cons") was selected second least of the four choices (Gen X: 12.9%, Gen Y: 22.7%, Gen Z: 23.3%). The already mentioned finding that the vast majority of residents, especially in Warsaw, have permanent access to their own car in the household and also have a higher passion for owning their own car is confirmed by the higher value in Warsaw compared to Berlin (+18.4%), which is about twice as high.

Despite the focus on the improvement of the individual vehicle infrastructure being lower in Warsaw compared to the other urban development measures, it is still higher compared to Berlin (Gen X: +24.7%, Gen Y: +16.4%, Gen Z: +5.3%). A comparison of the generations shows a different picture when comparing both cities. In Warsaw the Gen X (37.6%) and the Gen Y (39.1%) have an almost equally high agreement rate, which is slightly higher than for Gen Z (28.6%). In Berlin the situation is contrary to Warsaw, with Gen Z (23.1%) as the youngest generation having the highest agreement on the road infrastructure, with just a minor difference to Gen Y (22.7%). Surprisingly, in Berlin the oldest Gen X (12.9%), which according to references in the literature (Dutzik et al., 2014) is more enthusiastic about cars than Gen Y and Gen Z, has the lowest agreement value.

The results show that technological innovations were the least selected of the four choices in both cities. Nevertheless, there is a significant trend between the generations in general (variable "imp_ul_tech_inno"; X^2-test; $p \leq 0.05$, Cramer's V = 0.124). Moreover, the trend is statistically confirmed only in Berlin, where it shows that the younger generation considers technological innovations to be more important than the older generation (variable "imp_ul_tech_inno"; X^2-test; $p \leq 0.05$, Cramer's V = 0.144). However, in both cities, the value is significantly higher among Gen Y (WAR: 21.8% vs. BER: 34.7%) and Gen Z (WAR: 27.2% vs. BER: 37.9%) compared to Gen X (WAR: 12.3% vs. BER: 22.3%).

Table 54: Generational city comparison for important urban developments for a livable city

Urban developments for a livable city	**Mean value Warsaw**			**Mean value Berlin**		
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Gen X**	**Gen Y**	**Gen Z**
imp_ul_road_cons "yes"	**37.57%**	**39.05%**	28.59%	12.92%	22.66%	23.31%
imp_ul_tech_inno "yes"	12.52%	21.82%	27.16%	22.29%	**34.69%**	**37.90%**
imp_ul_pt "yes"	**38.99%**	**41.47%**	**38.56%**	**61.36%**	**39.81%**	**34.31%**
imp_ul_sust_plan "yes"	**60.91%**	**58.90%**	**64.29%**	**61.36%**	**71.54%**	**59.83%**
All values ≥ 30% are marked in **bold**						

Source: own calculations with the use of SPSS version 22

(3) Differences in Urban Mobility Behavior in Warsaw and Berlin

(a) Basic Mobility Factors ("What are the main mobility resources available?")

In the first part on urban mobility behavior, the basic resources are compared. It can be seen that the older the respondents are, the more likely they are to have a driver's license. However, a significant trend is only found in Berlin (variable "ress_lic"; X^2-test; $p \leq 0.01$, Cramer's V = 0.202). In Berlin, almost every representant of Gen X has a driver's license (98.3%), while the number is slightly lower in Gen Y (93.8%), and significantly lower in Gen Z (84.16%). In Warsaw, only about 75% of Gen Z have a driver's license which may be an indicator that a driver's license is no longer as desirable among the younger generation compared to the earlier generations. Another influencing factor is the relatively young age which might relate to a financial situation in which an individual is unable to afford the driver's license. However, whether Gen Z respondents will still obtain a driver's license at a later point in time cannot be predicted on the basis of the findings in this study. With 90.4% of Gen X and 82.5% of Gen Y in Warsaw, it is clear that most people still attach great importance to a driver's license and that it is an important prerequisite for mobility.

The following Figure 25 shows the comparison of the main mobility resources of the different generations within Warsaw and Figure 26 within Berlin.

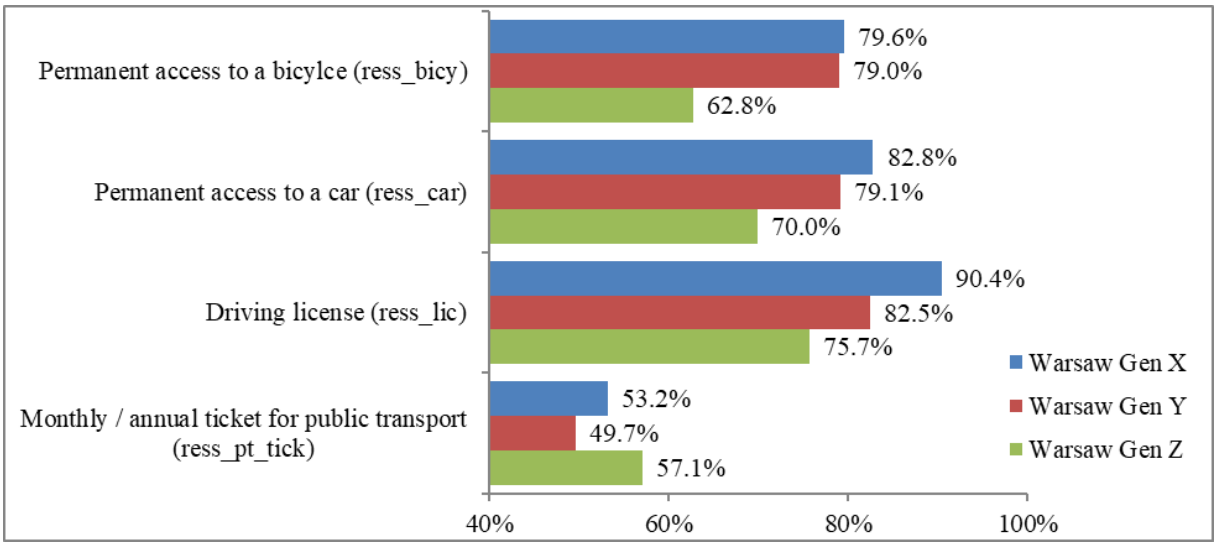


Figure 25: Overview descriptive statistics for the mobility resources for Warsaw

Source: own illustration based on the calculations with Microsoft 365 Excel

Even though fewer people in Warsaw have a driver's license than in Berlin, there are more who have permanent access to a car in the household. In Warsaw, there are about 10% more in GEN X (82.8% vs. 72.7%) and about 12.7% more in Gen Y (79.1% vs. 66.4%). Only Gen Z diverges from this, with 4.8% more in Berlin having access to a car (74.8% vs. 70.0%). There is no significant trend between the generations in either city with respect to holding a driving license.

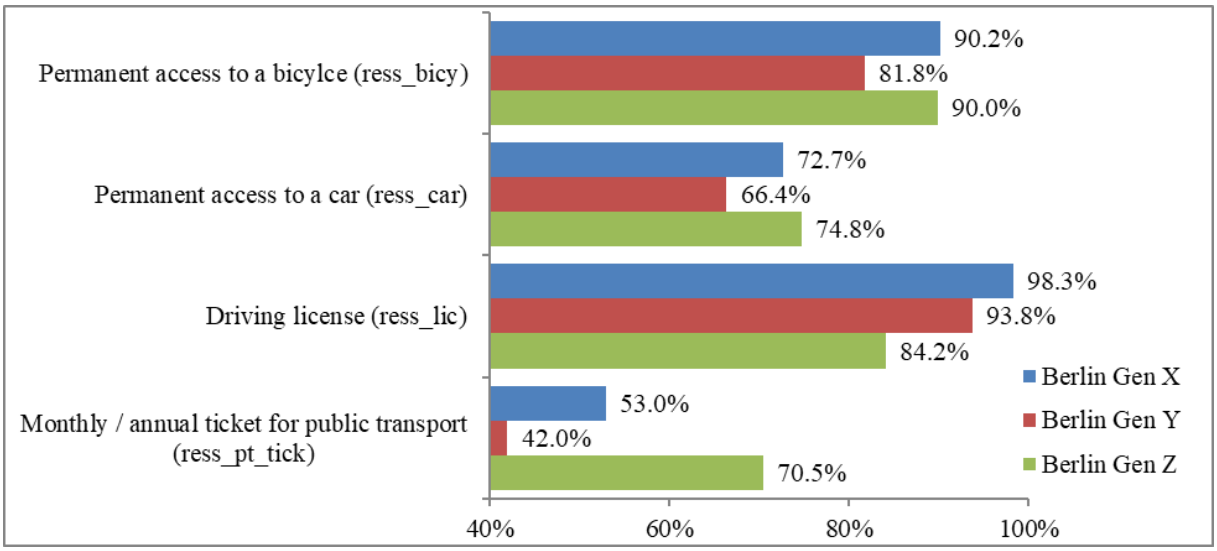


Figure 26: Overview descriptive statistics for the mobility resources for Berlin

Source: own illustration based on the calculations with Microsoft 365 Excel

Among people who have constant access to a bicycle, the rate for Gen X and Gen Z is particularly high in Berlin, at around 90% in each case. Gen Y falls behind with a value of

81.8%, which is almost on a par with the rate in Warsaw (79.0%). The rate of Gen X in Warsaw is about 10% lower than in Berlin, and the Gen Z rate is even about 27% lower.

Moreover, there is no significant trend between the three generations either in Warsaw or Berlin (variable "ress_bicy"; X^2-test; WAR: $p = 0.07$, BER: $p = 0.13$). If the actual use of the means of transport for daily commuting, but also for leisure activities, is considered, it becomes apparent that access to one's own bicycle plays a rather subordinate role in the choice of means of transport. Although the majority of people in both Warsaw and Berlin own a bicycle, most of them use it as a supplementary means of transport rather than as a primary one.

Deviating from this is a trend with respect to the permanent ownership of a public transport ticket, which is only confirmed by the sample of the citizens in Berlin (variable "ress_pt_tick"; X^2-test; $p \leq 0.01$, Cramer's V = 0.196). In Berlin, especially the young Gen Z with a value of more than 70% showed a significantly higher value than Gen Y with 42%. In Warsaw, despite Gen Z having the highest ticket ownership rate, the value is more than 13% lower than in Berlin, at about 57%. These figures are consistent with the higher rate of car ownership in Warsaw. It is noteworthy that in Warsaw, and especially in Berlin, many people from the young Gen Z have both access to a car and use the option of public transport.

Table 55: Descriptive statistics of the overall generational comparison and related effect value

Important aspects for a livable city	**Mean value**			**Effect**	
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Sig.***	**Cramer's V****
ress_lic	95.3%	87.9%	80.4%	**0.001**	**0.165**
ress_car	76.6%	73.0%	72.6%	0.630	0.041
ress_bicy	86.1%	80.4%	77.7%	0.156	0.083
ress_pt_tick	53.1%	46.0%	64.5%	**0.012**	**0.129**
*X^2-test significance calculated **variables sorted by effect size Cramer's V					

Source: own calculations with the use of SPSS version 22

In summary, it appears that in both cities residents more often have access to a car in the household than a monthly public transport ticket. Furthermore, based on the present results, it can be assumed that while there is a preferred mode of transport for the majority, many keep open the option of public transport as well as using their own bicycle.

(b) Modal Split and Reason for Transport Mode Choice ("What is the modal split and the main reason for choosing a particular mode of transport for the daily commute?")

When it comes to the choice of transport mode for daily commuting there is not trend between the generations in general (variable "trans_typ_work"; X^2-test; $p > 0.05$, Cramer's V = 0.080). In Berlin, it is particularly noticeable that the oldest Gen X has a relatively similar prevalence to the youngest Gen Z. Gen Y deviates from this more significantly. Within Berlin, citizens of Gen Y use public transport much less than Gen X (-19.5%;) and Gen Z (-15.2%), but more often the car (Gen Y vs. Gen X: +9.9%; Gen Y vs. Gen Z: +9.5%), and also active means of transport such as the bicycle (Gen Y vs. Gen X: +9.6%; Gen Y vs. Gen Z: +5.7%). In Warsaw, it is interesting to note that while about 57% of Gen Y have a monthly pass for public transport, 70% use it. This suggests that some people are more likely to buy one-way tickets than a monthly / annual ticket.

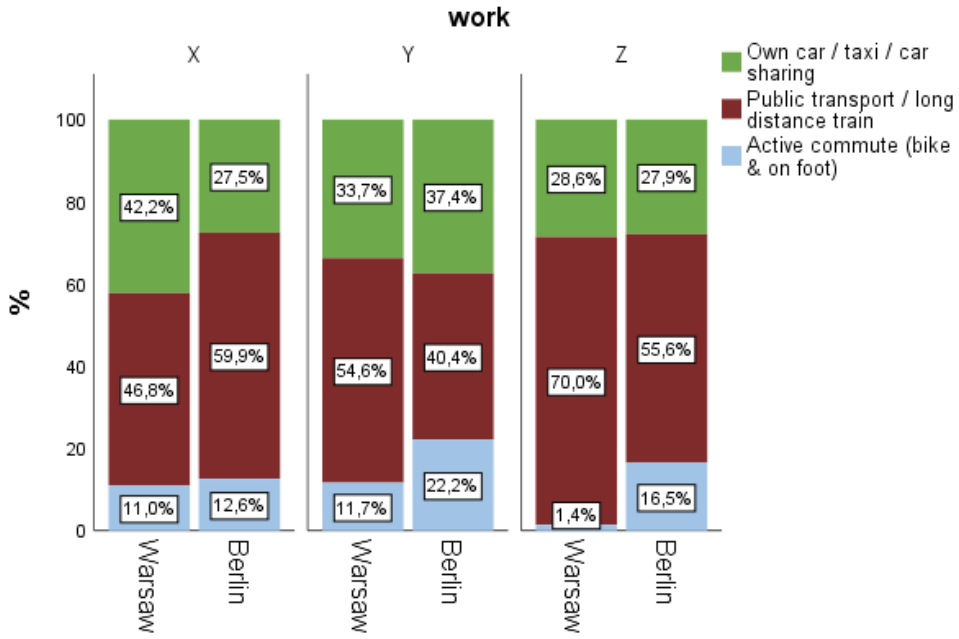


Figure 27: Comparison of the generations for transport mode choice for daily commute

Source: own illustration based on the calculations with Microsoft 365 Excel

When comparing the respective generations between the two cities, some differences between the generations emerge. While the values for Gen X are almost the same in terms of active means of transport (WAR: 11.0%, BER: 12.6%), there is a considerable difference in Gen Y (WAR: 11.7%, BER: 22.2%) and especially in Gen Z (WAR: 1.4%, BER: 16.5%). Gen Z in Warsaw seems to almost avoid completely riding a bike or walk to work. Basically, this may indicate that the young inhabitants of Warsaw are reluctant to use active means of transportation. However, other reasons such as a longer commute to work or educational cities

as well as infrastructural constraints (e.g. lack of or insufficiently well-developed bicycle lanes) may also play a significant role. The vast majority (70.0%) of Gen Z travels by public transport and partly also by car (28.6%). In Berlin, the car driving rate among the youngest Gen Z is almost the same (27.9%), and among Gen Y in Berlin (37.7%) it is even slightly higher than in Warsaw (33.7%). In Warsaw, Gen Y with about 54.7% use public transport more often than in Berlin, where it is 40.4%. For the older Gen X, the opposite is true. 59.9% in Berlin and 46.8% in Warsaw use public transport. Moreover, in Warsaw, the trend in car use is that the older people are, the more likely they are to use the car. In the case of public transport, the trend is reversed: the younger people are, the more frequently they use it for their daily commute.

When examining the underlying reason that influence the choice of transport, it becomes apparent that there is a significant difference between the generations in terms of daily commuting only in Berlin (variable "trans_reas_work"; X^2-test; $p \leq 0.05$, Cramer's V = 0.184). Looking at the descriptive statistics, it can be seen that for Gen X in Warsaw, travel time (32.9%) is the most important factor, ahead of comfort (28.2%) and cost (20.1%). In Berlin, on the other hand, besides comfort (27.6%), travel time (24.2%) and good access to nearby transportation options such as a bus stop or car sharing services (22.6%) are important for the citizens. The issue of sustainability is hardly a factor in Berlin (8.0%) and even receives no attention at all in Warsaw (0.0%). For Gen Y, the situation is relatively similar in Warsaw. The order of the 4 most important reasons remains the same, only the percentages differ. The situation is somewhat different for the most recent Gen Z. Here, the primary influencing factor is the issue of cost in both Warsaw (27.1%) and Berlin (28.8%). For Gen Z comfort also ranks second in both cities (WAR: 22.9%, BER: 24.0%). Close behind on third place in Warsaw is good access to nearby transportation (22.8%). In Berlin the sustainability factor (18.8%) is one of the top 3 influencing factors for Gen Z in the choice of transportation for daily commuting.

Table 56: Underlying Reason for daily commute: city comparison between generations

Daily commute	**Generation X**		**Generation Y**		**Generation Z**	
Reason	**Warsaw**	**Berlin**	**Warsaw**	**Berlin**	**Warsaw**	**Berlin**
Accessibility	7.9% (5)	22.6% (3)	17.7% (4)	12.5% (4)	22.8% (3)	13.3% (4)
Comfort	28.2% (2)	27.6% (1)	27.0% (2)	26.1% (2)	22.9% (2)	24.0% (2)
Costs	20.1% (3)	9.6% (4)	19.4% (3)	14.8% (3)	27.1% (1)	28.8% (1)
Health aspects	10.9% (4)	8.0% (5)	3.9% (5)	8.5% (6)	4.3% (6)	1.6% (6)
Sustainability	0.0% (6)	8.0% (5)	3.9% (5)	11.4% (5)	7.2% (5)	18.8% (3)
Travel time	32.9% (1)	24.2% (2)	28.2% (1)	26.7% (1)	15.7% (4)	13.6% (4)

Source: own calculations with the use of SPSS version 22

Different studies confirm that above all factors such as comfort / convenience, in addition to other influencing factors such as cost, safety and environmental awareness, significantly affect the choice of transport mode. In addition, it is shown that a sense of moral obligation leads to more sustainable action, but this is mostly associated with an additional focus on factors such as comfort, efficiency, travel time and price attractiveness (K. Cohen, 2019; Lind et al., 2015). This means that many transport users are only willing to change their consumption behavior if this does not restrict them in the previously mentioned other influencing factors, or only slightly from their point of view. This fact is also confirmed by the findings from this study.

In the next step, the most important reasons for the various means of transport for daily commute are analyzed. As shown in Figure 28, there is a very strong focus on comfort in the case of the car. This is even more pronounced for Gen Y and Gen Z in Warsaw than in Berlin. The reverse is true for Gen X, where comfort is much more pronounced in Berlin than in Warsaw. Behind that, travel time is an important factor, which plays a much greater role in Warsaw than in Berlin (+17.8%), especially among the older Gen X (40.4%). Only in Berlin do costs take a slightly higher priority among Gen Z when using their own car (22.1%).

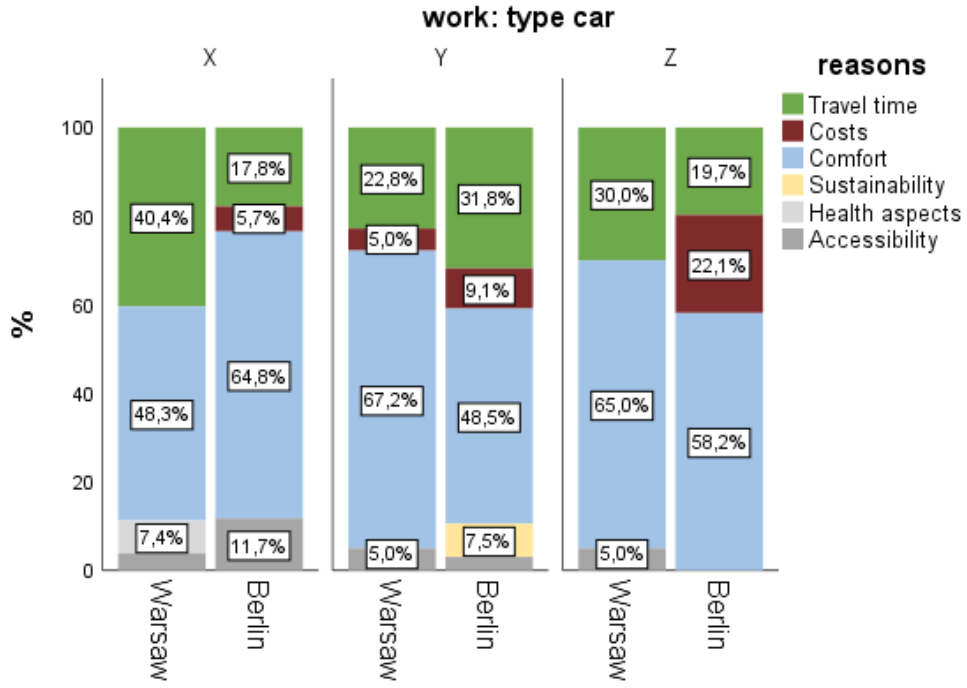


Figure 28: Reasons for own car / taxi / car sharing with respect to daily commute

In Warsaw, participants of Gen Z do not mention costs at all. This may be due to the fact that they are aware of the possible higher costs of car ownership, but for the perceived high level of comfort (65.0% for Gen Z in Warsaw) they are also willing to bear these costs. The

factors of sustainability and health play a very subordinate role in the choice of means of transport for the car.

The reasons for choosing public transport are more mixed. In Warsaw, cost is the most important reason. Interestingly, the older Gen X (43.0%) as well as the younger Gen Z (38.8%) have a relatively similar importance in comparison, while Gen Y (29.3%), which is in between in terms of age, has a significantly lower value.

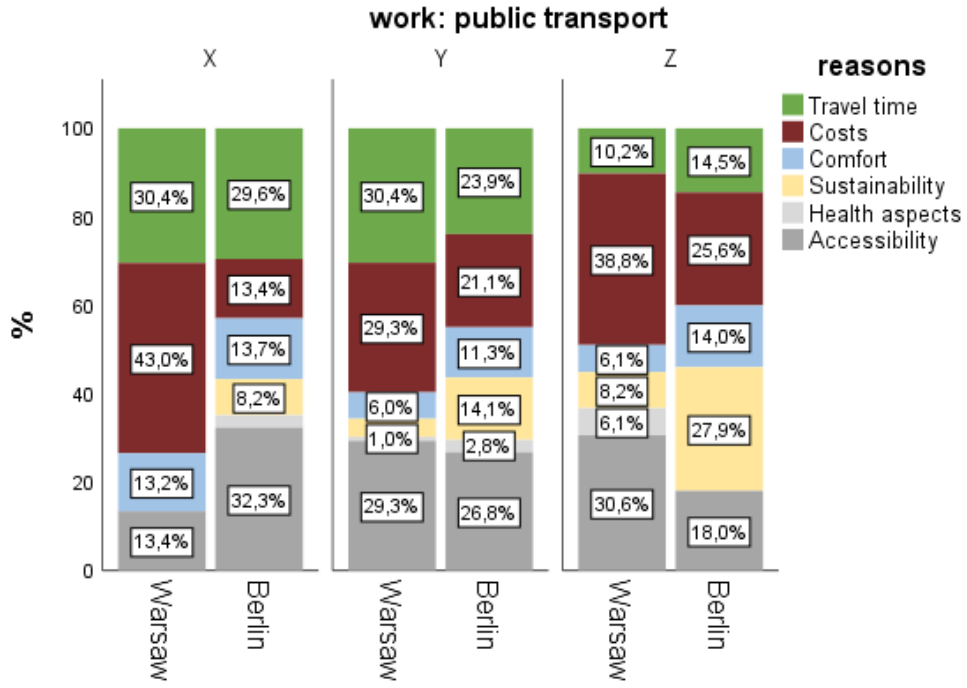


Figure 29: Reasons for public transport with respect to daily commute

Good accessibility and access to public transport are comparatively important in Warsaw especially for the young Gen Z (30.6%) and in Berlin for older Gen X (32.2%).

The remaining reasons are rather underrepresented. The exception here for Gen Z in Berlin is the issue of sustainability (27.9%). It is a surprise that the other generations apparently see the sustainability aspect for public transport rather less as a reason to choose this way of getting around the city. While they may perceive it to be sustainable, they may consider other reasons to be more important, or that the offer is not promising enough to be a real alternative to the car.

Even if the active means of transport are rather underrepresented in comparison, the factors of sustainability and health are clearly more pronounced compared to the car and public transport. This applies, for example, to Gen Z in Berlin, where the majority perceive the costs (51.1%) followed by the factors "sustainability" and "health" (19.6% each) as important reasons

for their decision. The picture is relatively different for Gen Y in Berlin. The most important reasons are health (33.3%) and travel time (23.1%). This may also be an indicator that the higher-earning members of Gen Y can afford an apartment in the city center and are therefore more likely to use a bicycle to commute to work due to the shorter distance. For the remaining generations, especially in Warsaw, the low rate of use of active means of transport makes a meaningful evaluation less likely (cf. Figure 27).

(c) Car Use and perceived Comfort of Daily Commute ("What is the perceived value of the car and the comfort associated with it?")

The previous analysis has shown that there is a significant difference between Warsaw and Berlin in the importance of the car (factor "f_ub_car"), which goes hand in hand with the perception of it as a status symbol. However, there is no significant trend between the generations in general, same applies to the generational comparison in Warsaw (X^2-test; $p = 0.991$) and in Berlin (X^2-test; $p = 0.508$). A comparison of the mean values shows that Warsaw has a rather consistently high importance across all generations. In Berlin, the car as a status symbol plays the least important role for the youngest Gen Z. It is interesting to note that the importance of owning a car in Berlin is less pronounced among the older Gen X than among Gen Y (difference of mean value of -0.10).

Regarding the question of how the daily commute is perceived, there is no significant difference between the generations (cf. Table 57). The descriptive statistical analyses for Gen X and Gen Z in Warsaw show relatively similar negative perceptions. Gen Y in Warsaw has a more positive perception in comparison. In Berlin, the daily commute is viewed better by those two generations (Gen X and Gen Z) in comparison to Warsaw, however it tends to occupy a neutral role. Gen Y in the inner-city comparison in Berlin also stands out from Gen X and Gen Z as it seems that they feel somewhat positive about daily commuting. Overall, all generations in Berlin perceive the daily commute as more pleasant than in Warsaw. The similarity, however, is that Gen Y seems to perceive commuting in both cities comparatively the most pleasant.

Table 57: Mean values Gens and related effect value for car use and comfort of daily commute

	Mean value			**Effect**	
Car use & comfort of daily commute	**Gen X**	**Gen Y**	**Gen Z**	**Sig. robust***	**eta****
f_ub_car	-0.077	0.018	-0.023	0.582	0.042
f_ub_com	-0.071	0.071	-0.090	0.182	0.075
*homogeneity assumption not met; robust significance calculated; **variables sorted by effect size eta					

Source: own calculations with the use of SPSS version 22

(d) Sharing Offerings ("How pronounced is the use of sharing offers?")

When analyzing the overall sample, there is a significant trend between the generations for bike sharing and for ride hailing (cf. Table 58). The significant trend between the generations for bike sharing is only confirmed in Berlin (variable "trans_bikeshare"; X^2-test; $p \leq 0.01$, Cramer's V = 0.227). Nevertheless, compared to Berlin, Warsaw citizens use the option of renting a bike from time to time more frequently, which especially applies for Gen Y (32.8%) and a bit less for Berlin (20.0%). For the youngest generation Gen Z, the use of bike rental is almost equal (WAR: 21.4% vs. BER: 21.7%). For the older Gen X, the citizens of Warsaw (20.2%) are using this offer much more than Gen X from Berlin (4.7%). Overall, however, the rate is still relatively low, which may be due to the fact that the majority of residents own their own bike and therefore have little need to rent an additional bike. Another indicator why people do not use bike sharing instead of their own bicycles can be due to a lack of or insufficient supply, or because the purchase costs for a bicycle are still comparatively low. It can be seen that, viewed across the board, around 60% of Gen Y and Gen Z already make use of sharing services, while the figure for Gen X is significantly lower at around 35%.

Table 58: Results of the statistical significance analyses for sharing offerings with regard to generations

Area: Sharing offerings	**Mean value**			**Effect**	
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Sig.***	**Cramer's V ****
trans_ridehail "yes"	11.8%	**27.9%**	**30.1%**	**0.000**	**0.196**
trans_bikeshare "yes"	10.7%	**26.6%**	**21.6%**	**0.000**	**0.184**
trans_carshare "yes"	**20.6%**	**28.0%**	**27.0%**	0.184	0.079
trans_carpool "yes"	4.3%	6.8%	10.3%	0.226	0.074
trans_ridepool "yes"	3.6%	7.9%	5.4%	0.282	0.069
No use of sharing offerings	64.3%	41.8%	39.1%	0.225	0.000
*X^2-test significance calculated **variables sorted by effect size Cramer's V All significant variables and values ≥ 15% for the sharing offerings are marked in **bold**					

Source: own calculations with the use of SPSS version 22

Based on the fact that more car sharing is used in Berlin than in Warsaw, it can be seen that Gen Y (43.2%) has a particularly strong demand for this type of sharing mobility. In Berlin, the youngest Gen Z (30.4%) and the oldest Gen X group in the scope (28.6%) are similarly represented with respect to car sharing. In Warsaw, only Gen Z (22.9%) shows some use of car sharing. Gen Y (13.8%) and even more Gen X (7.8%) use this mode of transportation within the city only relatively marginally.

Ride hailing (variable "trans_ridehail") also shows a significant trend between generations (X^2-test; $p \leq 0.001$, Cramer's V = 0.196). This is confirmed at the city level by Warsaw (X^2-test; $p \leq 0.05$, Cramer's V = 0.167) and Berlin (X^2-test; $p \leq 0.001$, Cramer's V = 0.232). Especially in Warsaw, ride-hailing is relatively widespread (Gen X: 20.4%, Gen Y: 31.2%, Gen Z: 42.8%), and the trend can be clearly read from the figures. The younger the generation, the more widespread the use of this type of sharing offer is. In Berlin, the user rate for ride-hailing is lower and, moreover, it can be seen that Gen Y (24.4%) uses it slightly more than the younger Gen Z (19.7%). Price differences in the two cities may also play a role, as the ride hailing market in Germany in particular is more heavily regulated as a competitor to the taxi industry (Amin, 2016; Visser et al., 2015). The user rate for Gen X (6.35%) is very low in Berlin (overview numbers cf. Table 59).

Ride pooling and car pooling are not discussed in detail with regard to the generational comparison, since these two sharing services are hardly used in both cities and, moreover, no significance is evident. Similar to the overall comparison between the generations, it can be seen that especially the older Gen X use less sharing services compared to Gen Y and Gen Z. The share of non-users among Gen Z citizens in Berlin is even higher than in Warsaw (+5.9%).

Table 59: Results descriptive statistics for sharing offerings − generational comparison between Warsaw and Berlin

Area: Sharing offerings	**Mean value Warsaw**			**Mean value Berlin**		
Variable	**Gen X**	**Gen Y**	**Gen Z**	**Gen X**	**Gen Y**	**Gen Z**
trans_ridehail "yes"	**20.4%**	**31.2%**	**42.8%**	6.4%	**24.4%**	**19.7%**
trans_bikeshare "yes"	**20.2%**	**32.8%**	**21.4%**	4.7%	**20.0%**	**21.7%**
trans_carshare "yes"	7.8%	13.8%	**22.9%**	**28.6%**	**43.2%**	**30.4%**
trans_carpool "yes"	6.3%	7.3%	8.6%	3.1%	6.2%	11.7%
trans_ridepool "yes"	1.6%	5.5%	7.2%	4.8%	8.5%	3.9%
No use of sharing offerings	60.7%	43.1%	37.2%	66.6%	40.3%	40.8%
*X^2-test significance calculated **variables sorted by effect size Cramer's V All values ≥ 20% for the sharing offerings are marked in **bold**						

Source: own calculations with the use of SPSS version 22

CONCLUSIONS

The research objective aimed to investigate behavioral patterns of different generations in the field of urban mobility, based on a city comparison between Warsaw and Berlin. To answer the research questions, an analysis of data obtained through a survey was conducted in addition to a literature review. When examining these two cities, it is particularly important to take into account the different framework conditions of the past decades, as they have experienced different political and cultural influences that may have shaped their respective mobility behaviors differently. Moreover, consumer behavior, of which mobility behavior is a part, is fundamentally influenced by the consumer's social environment with its established subcultures and norms. These can be pronounced differently depending on society and generation. The fact that consumer behavior is influenced by social circumstances can already be traced back to Veblen's social psychological model from the 19th century.

The general literature and data research provided basic insights for the city comparison between Warsaw and Berlin. Overall, economic performance in terms of GDP and average salary is significantly higher in Berlin than in Warsaw. However, if effective purchasing power is taken into account, Warsaw shows an even greater effective income than Berlin on the basis of purchasing power parity. The unemployment rate is much lower in Warsaw than in Berlin. Vice versa, the number of single households is significantly higher in Berlin than in Warsaw. The demographic structure is relatively similar in both cities, with Berlin having slightly more residents of the Baby Boomer generation, but Warsaw having more residents of the Gen Y. Gen X and Gen Z are somewhat equally represented in both cities (± 2.5%).

A direct comparison of smart city maturity to date shows that development in Berlin is significantly more advanced than in Warsaw. A number of projects have already been successfully realized. In addition to incremental improvements in various districts, completely new urban quarters are being planned and implemented according to the smart city principle. Some initiatives have already been launched in Warsaw, but the degree of maturity toward a smart city is still relatively low. Attempts are being made to learn from other cities in Europe and to adapt successful models to local conditions in the course of international exchange.

Overall, the research conducted shows that the transition to sustainable mobility in both cities is still relatively in its beginning stages. The example of Warsaw makes it clear that established behavior patterns cannot simply be changed overnight. Some progress in the field

of sustainable urban mobility can be seen in Berlin, and Warsaw can also learn from these developments and experiences.

A direct comparison of the traffic figures shows that the volume of traffic jams is much higher in Warsaw, especially during rush hour. An indication might be, among others, the car ownership rate, which is more than two times higher in Warsaw than in Berlin. Moreover, public transport is better developed in Berlin. Although there are no comparable values for the modal split, there is a tendency for public transport and active modes such as cycling and walking to be used more frequently in Berlin.

As a basis for the target group analysis, data was collected by means of a computer-assisted (online) survey. After taking into account all exclusion criteria, a total of 537 valid data sets were obtained, 246 of them from Warsaw and 291 from Berlin. The gender distribution in Berlin is relatively balanced (male = 52%, female = 48%), whereas in Warsaw it deviates more clearly from the actual population distribution (male = 63%, female = 37%). Most of the survey participants come from Gen Y (Warsaw = 55%, Berlin: 60%). The gender and generational distributions were weighted on the basis of the actual population to achieve better representativeness.

The first hypothesis, which states that sustainable transport modes are more developed in Berlin than in Warsaw, leading to more frequent use, can be confirmed for bicycles, but not for public transport. This finding is somewhat surprising, since based on the literature research, public transport in Warsaw is less well developed than in Berlin. Despite the proven strong perception of the car as a status symbol as well as the high ownership rate, more than half of the citizens in Warsaw use public transport for their daily commute. One possible reason for this could also be the significantly increased risk of congestion compared to Berlin. Generally, homeowners are more likely to use their own car. Nevertheless, there is a willingness to use alternative means of transport to the car if there is an appropriate offer.

The second hypothesis, that there is a trend for the younger generation to have a higher sense of sustainability, can be accepted for Berlin, but has to be rejected for Warsaw. However, the fact that the younger generation tends to use alternative means of transport more often can be confirmed in both cities. The exception to this is the use of bicycles in Warsaw, which are hardly used by the youngest Gen Z in particular. This fact may be related to a lack of expansion measures in the bicycle infrastructure. A significant trend that the car is becoming less important for the younger generation could not be confirmed either, but the importance of the car for all generations is significantly lower in Berlin than in Warsaw. Fundamentally, the

residents' desire for a sustainable mobility development is more pronounced in Berlin than in Warsaw, which is also shown among all three generations considered. One reason for this may be the stronger car dominance in Warsaw, but also that smart city concepts and projects in the field of sustainable mobility have already been more advanced by various projects in Berlin than in Warsaw. Another aspect might be the cultural and political influence due to the fall of the Soviet Union, which is more evident in Poland than in Germany. The new and later gained freedom in Poland as well as in East Germany to afford a car and to move freely within Europe may still have a stronger effect on the emotional bond to the own car.

The third hypothesis, that the younger generation is more likely to use mobility sharing services, was confirmed in both cities. The study also shows that there is a trend among the young generation in particular toward using alternative means of transport. Sharing services are used equally by about half of the study participants in both cities. However, there is a greater focus on car sharing in Berlin and on ride hailing and bike sharing in Warsaw. While almost 2/3 of the younger Gen Y and Gen Z use sharing services in Warsaw and Berlin, only slightly more than 1/3 of the older Gen X do so. Mobile applications such as MaaS, in which different means of transport can be used intermodally, are one of the main pillars to reduce car ownership. Younger citizens in particular can increasingly imagine doing without their own car in the future and will thus make a significant contribution to the sustainable transport transition.

The fourth hypothesis, that there is an increased willingness to use alternative and environmentally friendly means of transport if there is a corresponding mobility offer, was also confirmed by this study. In both cities the desire for sustainable urban planning is quite high. The figure is particularly high in Warsaw for the youngest Gen Z (64%) and in Berlin for the middle Gen Y (72%). The study results show two different trends, which at first glance harbor a certain ambiguity. On the one hand, there is still a high level of car dominance, while on the other hand the desire for further development in the area of urban mobility toward greater sustainability is relatively high. This may be due to the fact that, from the perspective of many consumers, the infrastructure for sufficient alternatives to the car is not yet available. In addition, further development of the road network and parking infrastructure in both cities appear to be of secondary importance compared to alternative transport concepts especially for the younger generation. This again indicates that alternatives to the car would indeed be used more often if a corresponding offer was available. With regard to the use of bicycles, especially in Warsaw, it might be that many citizens do not dare to ride in the immediate vicinity of cars, as still today only a few streets are equipped with separate bicycle lanes. Different trends in

mobility behavior between generations could be identified. Although these represent a good starting point, it is not advisable to generalize or consider them in isolation, for example when initiating measures appropriate to the target group. In addition to personal attitudes and perception, as well as socio-economic factors such as income and education level, many other factors have an influence when it comes to how city dwellers get around. Affordable housing in the city center or close to work and to facilities for daily needs play just as important a role as the quality of the transportation infrastructure. For example, it is apparent that the better and more efficient the public transport and bicycle infrastructure, the more likely city dwellers are to forego their own cars. Still others will not give up their car even then, because for them it is a symbol of freedom and flexibility, or even a status symbol, in addition to personally perceived comfort. In this case, the costs play a subordinate role.

Compared to the previously conducted studies in the field of mobility behavior, the analysis of different generations between two European capitals shows interesting findings, which other scientists in the field of transportation can build on. For example, in the planning of urban mobility, the implementation of new technological transport concepts must take into account the different historical and cultural backgrounds of societies. Different political and economic framework conditions as well as the characteristics of the transport infrastructure combined with individually rooted behavior patterns of the different generations in Warsaw and Berlin have also shaped mobility behavior differently over time.

It is therefore of utmost importance that political and private sector decision-makers create framework conditions that allow for the development convincing and innovative mobility offers, and to initiate corresponding advertising campaigns to break down ingrained behavioral patterns. How well certain measures are accepted by citizens can be a decisive factor in the transition toward more sustainable urban mobility. In doing so, citizens of all age groups should be involved in the decision-making process, but also in the implementation processes, so that innovative mobility concepts find broad acceptance among the population and lead to a change in behavior. In Berlin, for instance, a number of initiatives are already evident in which information events are being held and innovative intermodal transport concepts are being tested in various parts of the city in the context of a smart city.

In addition, the results of this study indicate that an inexpensive monthly ticket for public transport and the existence of a car in the household are important factors influencing the choice of transport. Since the main reasons for choosing one's own car for the daily commute are comfort and travel time, alternative options, such as public transport, bicycles and sharing

services, need to take these factors into account in urban mobility concepts in order to meet the primary needs of citizens. The study also indicated that, in addition to price, good accessibility and connectivity have a decisive influence on the use of public transport. In the case of bicycle use, the health aspect plays an overriding role.

With regard to further urban planning, it became clear that most citizens would like to see an approach in which innovative solutions are implemented in a socially inclusive manner. For many, it may not be a matter of choosing one mode of transportation over the other and thus making an either-or-decision. Rather, it is important to link different transport options in such a way that the best mix of transport means can be offered for the individual's respective needs. To initiate a sustainable mobility turnaround in the cities, various measures can be introduced by city councils. These include, for example, a driving ban for combustion engines or CO_2-emitting vehicles, higher taxes on gasoline and diesel, or an increased promotion of alternative means of transport such as sustainable sharing offers, bicycles, and public transport, ideally as part of an integrated and intermodal spot-to-spot offer based on a Mobility-as-a-Service approach. In addition, more traffic-calming zones with pedestrian and bicycle paths, more green spaces and a reduction in the number of parking spaces can be used as part of environmentally friendly infrastructure development. The introduction of low-cost or even free, tax-financed public transport with the goal of reducing car traffic could be another important piece of the puzzle for environmentally oriented urban mobility. In order to shift the focus away from the car, an environmental mobility premium could be introduced instead of a one-sided subsidy for certain groups such as car drivers.

The overall goal should be to build a sustainable ecosystem to future-proof urban mobility in a way that maximally reduces air pollution and other negative impacts such as noise and accidents. Many problems, like the sharp increase in the number of vehicles on the roads around the world which is accompanied by negative effects such as congestion, waste of time and money because of traffic and physical and mental stress, noise emission, accidents etc., must be tackled with comprehensive measures. At the same time, mobility should be affordable for the general public. This is the only way to achieve a change that will enable future generations to live in prosperity and health.

This analysis of the mobility behavior of different generations contains a few limitations, but its findings can provide a foundation for further research. For example, a detailed comparison between the mobility behavior of residents living in the city center and those living close to the city or on the outskirts could provide valuable insights. When

comparing the cities of Berlin and Warsaw, the study also pointed out the different historical backgrounds. Due to the divided Germany until 1990, a possible further investigation between a West German and an East German city with regard to urban mobility would certainly be interesting. Also a comparison of these cities with another city in Poland could provide interesting insights. For example, to what extent an East German as well as a West German city differs significantly from an East European city in terms of the different generations.

Since every decision, like the choice of means of transport, is based on personal value norms, behavioral convictions and normative factors shaped by society. To explore these more deeply and integrate them into an innovative mobility campaign, the theory of planned behavior (TPB) can be applied to specify the different underlying personality traits and anchored behavior patterns in relation to different generations, also in a cross-national comparison.

To create certain incentives in the direction of sustainable modes of transport, the model developed in this work on the various factors influencing the choice of means of transport can be applied in practice in the next step. This means together with the different values and norms from the TPB, personality profiles, so-called personas, can be established in order to develop individualized mobility concepts and offers. The various trends from the generational comparison should be included, but within the generations and depending on the city, different personas should also be developed in order to really address the various needs and wishes of the city dwellers.

The Engel-Kollat-Blackwell (EBK) model described in this thesis could also be applied in further consideration. As external factors as well as influencing variables for the individual differences of the generations, the results with regard to personality characteristics, socio-economic and socio-demographic factors as well as trends in urban mobility from this study can be included. From sustainable urban development, both public-legal and private-sector institutions can positively influence desired decisions towards sustainable transport developments by examining the extent to which different input factors (stimuli) are perceived and processed by different personas.

Another external factor that has to be taken into account is the outbreak of the Corona pandemic during the course of this study, which was accompanied by lockdowns that are likely to have disrupted mobility behaviors. For many white-collar jobs, home office became the norm, and students were often home schooled with the support of technology. Because this study does not analyze this effect in greater detail and the survey was conducted before the

pandemic, it would be interesting for subsequent studies to analyze possible lasting changes in mobility behavior that resulted from the lockdown measures in Warsaw, Berlin, and beyond.

Ultimately, it would also be important as a basis for further planning of urban mobility and development towards a Sustainable Smart City to investigate the extent to which the pandemic has affected the different generations in different countries around the world and what risks but above all also opportunities have emerged.

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LIST OF TABLES

LIST OF FIGURES

Appendix A: Details to basic figures and key mobility indicators

Details and sources for the city comparison of Warsaw and Berlin in the tables depicted in subchapter 4.3

Measure	Details	Source Value of Poland / Warsaw	Date of data Warsaw	Source Value Germany / Berlin	Date of data Berlin
Population Country	Germany: Average annual growth of 0.05% between 2002 and 2019; i.e. 84 million inhabitants by 2040 according to forecast Poland: First half of 2021	https://warszawa.stat.gov.pl/en/ https://stat.gov.pl/en/topics/population/	30.06.2021	https://download.statistik-berlin-brandenburg.de/70fd75104b57d0fa/83cc240d450f/21-02-10.pdf	31.12.2020
Urbanization	Germany: Assuming urbanization of 80% in 2040 approx. 67,184,000 inhabitants	https://databank.worldbank.org/reports.aspx?source=world-development-indicators#	2021	https://databank.worldbank.org/reports.aspx?source=world-development-indicators#	2021
Area size	-	https://www.indexmundi.com/factbook/compare/germany.poland/geography	-	https://www.indexmundi.com/factbook/compare/germany.poland/geography	-
Population density	Number of inhabitants per km²; calculated value: Population / Area size	as above		as above	31.12.2020
Average age	-	https://ugeo.urbistat.com/AdminStat/en/pl/demografia/dati-sintesi/warszawa---srodmiescie/1465108/4	2022	https://de.statista.com/statistik/daten/studie/1095771/umfrage/bevoelkerung-berlins-nach-altersgruppen/	31.12.2020
Percentage people in paid work	-	https://warszawa.stat.gov.pl/en/		https://www.berlin.de/berlin-im-ueberblick/zahlen-und-fakten/	31.12.2019
Unemployment rate Warsaw / Berlin	-	https://ycharts.com/indicators/warsaw_in_unemployment_rate_micsa#:~:text=Basic%20Info,long%20term%20average%20of%204.75%25.	Apr 2022	https://www.berlin.de/en/news/7536315-5559700-unemployment-rate-in-berlin-decreases.en.html	May 2022
Percentage of retired people	-	https://stat.gov.pl/en/topics/living-conditions	2019	https://www.deutsche-rentenversicherung.de/DRV/DE/Ueber-uns-und-Presse/Presse/Meldungen/2020/201216_zahl_der_rentner_steigt.html	2019

GDP total, GDP per capita, PPP, average salary in EUR, maximum personal tax rate	-	https://tradingeconomics.com/poland/indicators	April 2022	https://tradingeconomics.com/germany/indicators	April 2022
GDP Warsaw / Berlin	-	https://www.ceicdata.com/en/poland/esa-2010-gdp-by-region/gdp-warsaw#:~:text=Poland%20GDP%3A%20Warsaw%20data%20was,to%202015%2C%20with%2016%20observations.	2015	https://www.ceicdata.com/en/germany/esa-2010-gdp-by-region/gdp-berlin	2020
Average salary	-	https://warszawa.stat.gov.pl/en/warsaw/	February 2022	https://www.bz-berlin.de/berlin/tabuthema-gehalt-das-verdienen-die-berliner	2021
Number of students	-	https://wbj.pl/	academic year 2018/2019	https://www.berlin.de/en/news/7118890-5559700-more-students-in-berlin-fewer-in-branden.en.html	Winter semester of 2021/2022
Employment rate Warsaw / Berlin		https://warszawa.stat.gov.pl/en/warsaw/	February 2022	https://www.statistik-berlin-brandenburg.de/erwerbstaetigkeit	2021
Percentage single-households	2013	https://warszawa.stat.gov.pl/download/gfx/warszawa/pl/defaultaktualnosci/753/8/1/3/nsp_2011_zamieszkane_budynki.pdf		https://www.gfk.com/de/presse/Anteil-der-Singlehaushalte-in-Deutschland-nimmt-zu/	21.01.2021
Inflation rate	HICP as indicator of inflation and price stability for the European Central Bank (ECB) across EU countries.	https://www.inflation.eu/en/	April 2022	https://www.inflation.eu/en/	April 2022
House Price Index	Reference value 100 is 2012, so in total the increase within 10 years	https://tradingeconomics.com/poland/housing-index	Dec 2021	https://tradingeconomics.com/germany/housing-index	Feb 2022
Home Ownership Rate	-	https://tradingeconomics.com/poland/indicators	Dec 2020	https://tradingeconomics.com/germany/indicators	Dec 2020
Ranking Purchasing Power Standard (PPI) within EU	-	https://www.bpb.de/kurz-knapp/zahlen-und-fakten/europa/70546/bruttoinlandsprodukt-bip-pro-kopf/	2020	https://www.bpb.de/kurz-knapp/zahlen-und-fakten/europa/70546/bruttoinlandsprodukt-bip-pro-kopf/	2020

Pre-working age, working and post-working age, population male / female.	Working age in Poland is defined differently depending on gender: for men, the age range is between 18 and 64, for women between 18 and 59. In Germany, there are different data bases from different years; for the older data from 2011, a linear interpolation of the age groups to the current population was performed.	https://stat.gov.pl/en/national-census/national-population-and-housing-census-2021/national-population-and-housing-census-2021/preliminary-results-of-the-national-population-and-housing-census-2021,1,1.html	31.03.2021	Destatis, German Federal Statistical Office (Statistisches Bundesamt), cf. https://www-genesis.destatis.de/genesis/online?operation=sprachwechsel&language=en; urbanization statistics: World Bank; UN DESA, https://databank.worldbank.org/reports.aspx?source=world-development-indicators; https://www.statista.com/statistics/454349/population-by-age-group-germany/#professional; BMAS: German Pension Insurance Fund ("Deutsche Rentenversicherung")	2011 / 2019 / 2021
Generation Z, Y, Z and Baby Boomers WAR / BER	Gen Z: Born between 1996 and 2012 [in 2021: 9 to 25 years] Gen Y: Born between 1981 and 1995 [in 2021: 26 to 40 years] Gen X: Born between 1965 and 1980 [in 2021: 41 to 56 years] Baby Boomers: Born between 1946 and 1964 [in 2021: 57 to 75 years]	https://stat.gov.pl/en/topics/population/population/ https://stat.gov.pl/en/topics/population/population/population-size-and-structure-of-population-and-vital-statistics-by-territorial-division-as-of-december-31-2012,3,7.html [https://zhujiworld.com/pl/435570-warsaw/]	09.02.2022 / 31.07.2020	https://www-genesis.destatis.de/genesis/online?sequenz=statistikTabellen&selectionname=12411&language=en#abreadcrumb -Federal Statistical Office, Wiesbaden 2022; https://de.statista.com/statistik/daten/studie/1095771/umfrage/bevoelkerung-berlins-nach-altersgruppen/#professional	31.12.2020 / 2021
Car use	Calculated value of cars divided by total population	https://stat.gov.pl/en/topics/transport-and-communications/transport/road-transport-in-poland-in-the-years-2018-and-2019,5,6.html	31.12.2020	https://www.berlin.de/berlin-im-ueberblick/zahlen-und-fakten/	31.12.2019
Relative fuel costs	The average cost of fuel relative to income per capita. We calculated the affordability of fuel by averaging prices from the city's gas stations and comparing them to mean net monthly income.	https://urbanmobilityindex.here.com/city/warsaw/	2018	https://urbanmobilityindex.here.com/city/berlin	2018
Traffic congestion index	A 25% congestion level means that on average, travel times were 25% longer than during the baseline non-congested conditions. This means that a 60-minute trip driven in free-flow condition will take 15 minutes longer when the congestion level is at 25%.	https://www.tomtom.com/en_gb/traffic-index/warsaw-traffic/	2021	https://www.tomtom.com/en_gb/traffic-index/berlin-traffic/	2021

Time delay in traffic	A measure of the extra time spent driving due to traffic congestion. Calculated by comparing journey times for 100km (62 mi) travelled during peak times (6-10AM and 4-8PM on weekdays) with journey times for those roads when traffic moves freely.	as above	2018	as above	2018
Public transport frequency	A measure of how often a public transport service calls at a public transport stop. Calculated based on average numbers of trips per public transport stop, per day.	as above	2018	as above	2018
Public transport expense	The cost of a monthly transport pass as a percentage of monthly income. We calculated this based on the relative costs of a monthly public transport ticket and mean net monthly income.	as above	2018	as above	2018
Public transport coverage	The total area of the city within 1km of a public transport stop, relative to the total area of the city	as above	2018	as above	2018
Percentage of green spaces	The percentage of a city's area which is covered in accessible green space. Calculated by considering the area covered by green spaces, such as parks, lakes, and woodland, relative to the total area of the city.	as above	2018	as above	2018
Public transport vs car speed	The ratio between average journey time by public transport and by car (excluding time spent parking). We randomly selected random points of interest around the city and then compared average journey times between them, at hourly intervals between 6AM and 8PM.	as above	2018	as above	2018
Car use	Calculated value of cars divided by total population	https://stat.gov.pl/en/topics/transport-and-communications/transport/road-transport-in-poland-in-the-years-2018-and-2019,5,6.html	31.12.2020	https://www.berlin.de/berlin-im-ueberblick/zahlen-und-fakten/	31.12.2019
Relative fuel costs	The average cost of fuel relative to income per capita. We calculated the affordability of fuel by averaging prices from the city's gas stations and comparing them to mean net monthly income.	https://urbanmobilityindex.here.com/city/warsaw/	2018	https://urbanmobilityindex.here.com/city/berlin	2018

Appendix B: Questionnaire

Questions regarding personal values

Please rate how much you agree with the following statements

Professional life and career / education

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
Career and a high salary play an important role for me.	◯	◯	◯	◯	◯	◯
Long-term (job) security is important to me (open-ended employment contract).	◯	◯	◯	◯	◯	◯
For a great/unique job/project opportunity, I am willing to move to another place, even if I would move away from my family and friends (location more than 100 km away from the current resident).	◯	◯	◯	◯	◯	◯
I plan my work / education activities (daily duties) in advance and use a calendar (analog or digital).	◯	◯	◯	◯	◯	◯
I find it easy to complete a task to the end without interrupting it.	◯	◯	◯	◯	◯	◯
I prefer to work in a team rather than on my own.	◯	◯	◯	◯	◯	◯

Please rate how much you agree with the following statements

Daily life and social environment

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
The opinions of others and feedback from family, friends and colleagues are important to me.	◯	◯	◯	◯	◯	◯
I would like to arrange my everyday life as well as my life as flexible as possible, e.g. flexible working hours/location, possibility for a time-out for my self-fulfillment such as a trip around the world, for an additional study etc.	◯	◯	◯	◯	◯	◯
I like changes and can easily adapt to them (e. g. new boss, new employer, move to another place because of work or private reasons etc.).	◯	◯	◯	◯	◯	◯
I share my experiences, my knowledge, and my ideas as transparently as possible to support/help others.	◯	◯	◯	◯	◯	◯
I am worried about the future (e.g. change / loss of my current standard of living, losing my job etc.).	◯	◯	◯	◯	◯	◯
My generation (and perhaps the next) will have to solve many serious problems (e. g. environmental destruction) caused by previous generations.	◯	◯	◯	◯	◯	◯

Please rate how much you agree with the following statements

Use of technology in daily life

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
I have no problem to try and apply new technologies and incorporate them into my everyday life (e.g. digital cell phone tickets, paying by cell phone, mobility apps etc.).	◯	◯	◯	◯	◯	◯
It is important for me to seek information from alternative channels and social media in addition to mainstream media such as major TV stations and their websites (e. g. New York Times, The Guardian, Spiegel or other local channels).	◯	◯	◯	◯	◯	◯
I cannot do without my mobile device (e.g. smartphone, tablet etc.) in my everyday life.	◯	◯	◯	◯	◯	◯
I try as much as possible to separate my private life from my work/educational life (daily duties), e. g. turning off work email and cell phone after a certain hour.	◯	◯	◯	◯	◯	◯

Questions regarding mobility and travel behavior: Choice of transport

Given a typical week, what means of transport do you usually use to get to work / education facility?

Travel behavior - Daily choice of transport for the way to work / educational institution

- ◯ own car
- ◯ carsharing
- ◯ public transport (e. g. tram, bus, metro etc.)
- ◯ bike
- ◯ long distance train
- ◯ taxi
- ◯ others or more than one transport mean (please define): _____

Given a typical week, what means of transportation do you use most often during your leisure time, in situations such as meeting friends and family, shopping, sports activities, etc.?

Travel behavior - Daily choice of transport for leisure activities

- ◯ own car
- ◯ carsharing
- ◯ public transport
- ◯ bike
- ◯ long distance train
- ◯ taxi
- ◯ others or more than one transport mean (please define):

What is the main reason for your choice of transportation to get to work / educational institution?

Please select only the reason that is most important to you

- ◯ Travel time
- ◯ Costs
- ◯ Comfort
- ◯ Sustainability
- ◯ Health aspects (e. g. being active)
- ◯ Accessibility (e. g. nearby car sharing station, public transport)

Questions regarding mobility and travel behavior: Sharing offerings and daily travel patterns

Which of the following sharing offers do you use regularly (usually more than once a month)?

- [ ] CarSharing (e. g. ShareNow, Sixt Share, weShare)
- [ ] RideHailing (service offerings like Uber and Lyft)
- [ ] RidePooling (service offerings like blablarcar and getaround and CleverShuttle)
- [ ] CarPooling (Provider like blablacar or private organized with friends / colleagues etc.)
- [ ] BikeSharing, e-Scooter or (electric) rental bicycles
- [ ] I do not use any of the above offers
- [ ] others (please define): _____

How many kilometers do you travel on average per day to and from education / work (round trip)?

You can ignore the question if you do not commute, e.g., work from home all the time, regardless of the Covid situation

◯ below 5 km ◯ 5 to 10 km ◯ 10 to 20 km ◯ 20 to 30 km ◯ 30 to 50 km ◯ 50 to 100 km ◯ more than 100 km

How many kilometers do you travel on average on a weekend day / day off from work?

◯ below 5 km ◯ 5 to 10 km ◯ 10 to 20 km ◯ 20 to 30 km ◯ 30 to 50 km ◯ 50 to 100 km ◯ more than 100 km

My total time spend per day to and from education / work (round trip) is on average about…

◯ less than 10 minutes ◯ 10 to 20 minutes ◯ 20 to 30 minutes ◯ 30 to 40 minutes ◯ 40 to 60 minutes ◯ more than 1 hour ◯ more than 2 hours

Please rate to what extent the following statements apply to you

You can rate your answer on a scale from "I strongly agree" to "I strongly disagree"

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
Owning a car gives me a feeling of freedom.	◯	◯	◯	◯	◯	◯
I prefer to use means of transport which are environmentally friendly.	◯	◯	◯	◯	◯	◯
My daily errands take longer than I would like.	◯	◯	◯	◯	◯	◯
The way to work/school is enjoyable for me and I am able to make positive/good use of this time for myself.	◯	◯	◯	◯	◯	◯
I find the way to work / educational facility stressful / too long and feel like I am wasting time.	◯	◯	◯	◯	◯	◯
If I could (e.g., for financial reasons), I would move to a place closer to work/education.	◯	◯	◯	◯	◯	◯
I don't necessarily need an own car.	◯	◯	◯	◯	◯	◯

Questions regarding mobility and travel behavior: Use of car

The next questions are only relevant if you own a car. If you do not own a car, you can skip these questions and move to the next page.

How many kilometers do you drive your car per year?

◯ less than 5,000 km ◯ between 5,000 and 10,000 km ◯ between 10,000 and 15,000 km ◯ between 15,000 and 20,000 km ◯ between 20,000 and 30,000 km ◯ more than 30,000 km

How much do you spend on average per month on your car for petrol/diesel/electricity, insurance, repairs and maintenance etc. (please give an approximate estimate in EUR)?

If you have more than 1 car, please provide the model of your most used car

Questions regarding mobility in the light of smart cities

Which of the following is most important to you for a livable city?

You can select only one aspect (most important)

- ◯ Affordability: Standard of living, i.e. income levels and costs (e.g. rent, leisure activities, etc.) should be reasonable.
- ◯ Urban Mobility: Efficient and affordable mobility services such as public transportation, car/bike sharing, carpooling.
- ◯ Healthy lifestyle and environmental aspects: High offering in the health and sports sector, sufficient green spaces and local recreation.
- ◯ Security: A high level of perceived safety and sufficient measures for a safe city with a low crime rate.
- ◯ Information and cultural facilities: Educational institutions, libraries, museums, social (international) exchange.
- ◯ Personal development opportunities: Citizen participation in the decision-making process on urban development, liberal values and opportunities to pursue one's own interests.

In the further development towards a smart city − which of the following are most important to you in terms of living in an ideal city?

You can select up to two aspects

- ☐ Focus on technological innovations such as mobility apps (e. g. MaaS), digital elections and citizen participation and digital city guides.
- ☐ Increased focus on sustainable urban planning; e. g. the creation of sufficient green spaces, promotion of C02-neutral transport, reduction of waste and improvement of the recycling process.
- ☐ Increased focus on road construction and increased creation of parking facilities in order to avoid traffic jams and thus allow traffic to flow.
- ☐ Improve public transportation overall while making it affordable (e. g., subsidized monthly/annual public transportation passes) and efficient (fast and comfortable travel from A to B).

How strong do you agree / disagree on the following measures towards future urban mobility?

You can rate your answer on a scale from "I strongly agree" to "I strongly disagree"

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
Ban on driving combustion engines or CO2-emitting vehicles, e. g. for newly registered vehicles from 2030 (with certain exceptions).	◯	◯	◯	◯	◯	◯
Increase in the tax on non-CO2-free drive technologies such as gasoline and diesel.	◯	◯	◯	◯	◯	◯
Increase of subsidies for alternative means of transport such as sustainable sharing services, bicycles, public transport - e. g. introduction of an environment-related mobility bonus instead of subsidizing certain clusters such as motorists / automotive industry.	◯	◯	◯	◯	◯	◯
Creation of traffic-calmed zones, pedestrian and bicycle lanes, increasing the width of sidewalks, green spaces and reducing the number of roads and parking spaces.	◯	◯	◯	◯	◯	◯
Introduction of free, tax-financed public transport with the aim of reducing car traffic (example "Free Tram Zone" in Melbourne).	◯	◯	◯	◯	◯	◯

Questions in the field of "future living" with regard to the impact on urban mobility

How satisfied are you with the current situation of your home / living surrounding?

You can rate your answer on a scale from "I am very satisfied" to "I am very dissatisfied"

	I am very satisfied	I am satisfied	Neither nor / neutral	I am dissatisfied	I am very dissatisfied	not applicable / not relevant
Proximity to daily necessities facilities (supermarket, doctor, shops, gym, restaurants, bars etc.)	◯	◯	◯	◯	◯	◯
Proximity to family and friends	◯	◯	◯	◯	◯	◯
Proximity to workplace / place of education	◯	◯	◯	◯	◯	◯
Quality of the environment (quite / nice neighborhood, clean air, access to a garden / near park etc.)	◯	◯	◯	◯	◯	◯
Size and quality / characteristics of the apartment / house (modernity, coziness, existence of terrace / balcony etc.)	◯	◯	◯	◯	◯	◯
Total expenses of the apartment/house	◯	◯	◯	◯	◯	◯
Accessibility to public transport (train / bus / subway / tram station)	◯	◯	◯	◯	◯	◯

Way of living: Please rate to what extent the following statements apply to you

You can rate your answer on a scale from "I strongly agree" to "I strongly disagree"

	I strongly agree	I agree	Neither nor / neutral	I disagree	I strongly disagree	Not applicable / relevant
I like to live in a big city because that's where I have the greatest opportunities to spend my free time (e. g. culture / history, bars / nightlife, sports activities, sightseeing etc.). It is enough for me to go out of the city from time to time to be more in nature.	◯	◯	◯	◯	◯	◯
I prefer to live in the countryside (near the nature, sea etc.), because the peace and clean air makes me feel more comfortable, more rested and I can live a healthier life.	◯	◯	◯	◯	◯	◯
I prefer to live an active lifestyle, that mean I like to enjoy my spare time outside / in the nature, like to experience adventure etc.	◯	◯	◯	◯	◯	◯
I want to spend as much time with my partner / family / friends during my free time.	◯	◯	◯	◯	◯	◯
I assume that technological progress and innovation will reduce the future need for urban mobility, for example: the possibility of working from home; delivery services for daily goods; virtual fitness training, video chats etc.).	◯	◯	◯	◯	◯	◯
Property (own flat / house, valuables) is important to me.	◯	◯	◯	◯	◯	◯

General information

How old are you?

Please provide just the number.
Important information for the analysis of the different generations. Reminder: All data will be treated anonymously.

What is your gender?

Important information for the analysis of the different generations. Reminder: All data will be treated anonymously.

- ◯ female
- ◯ male
- ◯ diverse

Where do you live?

City / town, e.g. Warsaw / Wroclaw / Gdansk

Please enter your postal / zip code from your place of residence.

E.g. 00-138 (Warsaw-Mokotów)

What is your living situation?

- ◯ home rented
- ◯ home owned (apartment or house)

How many people live in your household (incl. children)?

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6 or more

What is your current job or education status?

You can select more than one answer if needed (e.g. part-time study beside the job)

- ☐ high school student or similar
- ☐ college / university student or similar
- ☐ in a vocational training program (e.g. vocational school)
- ☐ employed
- ☐ self-employed
- ☐ on leave (e. g. parental leave, protracted illness illness)
- ☐ unemployed / seeking work
- ☐ retired
- ☐ other (please define) _____

What is your highest education level?

- ◯ Completion of elementary school (lower secondary school, usually 8 or 9th grade)
- ◯ Secondary school diploma (e. g. in Germany "Mittlere Reife", in UK the British "GCSE")
- ◯ Vacational eduction / technical school
- ◯ Upper seconday school (high school or similar)
- ◯ Bachelor degree or quivalent
- ◯ Master degree or equivalent
- ◯ Doctoral degree
- ◯ Other (please define): _____

Do you have a driving license?

- ◯ yes
- ◯ no

How many cars does your household hold (incl. company car)?

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3 or more

Do you have a bicycle (or alternatively do you always have access to a bicycle, e.g. within the household)?

- ◯ yes
- ◯ no

Do you have a monthly/annual season-ticket for public transport? (or alternatively do you always have access to a monthly/annual season-ticket, e.g. from a roommate in the household)

- ◯ yes
- ◯ no

What is your total personal disposable income per month (net income after deductions such as taxes, cost for health insurance etc.; but not apartment rental costs and consumables like car, voluntary membership in sports clubs etc.)?

Reminder: All data will be treated anonymously.

- < 750 zł
- 750 do 1000 zł
- > 1,000 do 1,500 zł
- > 1,500 do 2,000 zł
- > 2,000 do 3,000 zł
- > 3,000 do 3,500 zł
- > 3,500 do 4,250 zł
- > 4,250 do 5,750 zł
- > 5,750 do 7,000 zł
- > 7,000 zł
- [ ]

You did it. Once again, thank you very much for your support. This means a lot to me.

If you have any comments or feedback on the survey, I would appreciate it if you would use the box below to do so.

Otherwise, please click directly on "Done" at the bottom right.

Appendix C: Details variables

var_name	var_label	Scale	label_code	label_name
x_gen	Generation	Nominal	1	Z
x_gen	Generation	Nominal	2	Y
x_gen	Generation	Nominal	3	X
soz_male	Gender	Nominal	0	no
soz_male	Gender	Nominal	1	yes
x_city	City	Nominal	1	Warsaw
x_city	City	Nominal	2	Berlin
soc_howner	Home owner	Nominal	0	no
soc_howner	Home owner	Nominal	1	yes
soz_single_hh	Single household	Nominal	0	no
soz_single_hh	Single household	Nominal	1	yes
soz_work	Job or education status	Nominal	0	no
soz_work	Job or education status	Nominal	1	yes
soz_income	Total personal disposable income per month	Nominal	1	low-income group
soz_income	Total personal disposable income per month	Nominal	2	middle-income group - lower range
soz_income	Total personal disposable income per month	Nominal	3	middle-income group - upper range
soz_income	Total personal disposable income per month	Nominal	4	high-income group
ress_lic	Driving license	Nominal	0	no
ress_lic	Driving license	Nominal	1	yes
ress_car	Access to car based on cars in household	Nominal	0	no
ress_car	Access to car based on cars in household	Nominal	1	yes
ress_pt_tick	Monthly/annual season-ticket for public transport	Nominal	0	no
ress_pt_tick	Monthly/annual season-ticket for public transport	Nominal	1	yes
trans_min_work	How many kilometers do you travel on average per day to and from education / work (round trip)?	Ordinal	1;2;3;4;5;6	below 5 km, 5 to 10 km; 10 to 20 km; 20 to 30 km; 30 to 50 km; more than 50 km
trans_min_work_x	How many kilometers do you travel on average per day to and from education / work (round trip)?	Continuous	-	7.5 km, 15.0 km; 25.0 km; 35.0 km; 40.0 km; 65.0 km (average values)

trans_km_leis	How many kilometers do you travel on average on a weekend day / day off from work?	Ordinal	1;2;3;4;5;6	below 5 km, 5 to 10 km; 10 to 20 km; 20 to 30 km; 30 to 50 km; more than 50 km
trans_km_leis_x	How many kilometers do you travel on average on a weekend day / day off from work?	Continuous	-	7.5 km, 15.0 km; 25.0 km; 35.0 km; 40.0 km; 65.0 km (average values)
PE1	Career and a high salary play an important role for me.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
PE2	Long-term (job) security is important to me (open-ended employment contract).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
PE3	For a great/unique job/project opportunity, I am willing to move to another place, even if I would move away from my family and friends (location more than 100 km away from the current resident).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
PE4	I plan my work / education activities (daily duties) in advance and use a calendar (analog or digital).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
PE5	I find it easy to complete a task to the end without interrupting it.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
PE6	I prefer to work in a team rather than on my own.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS1	The opinions of others and feedback from family, friends and colleagues are important to me.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS2	I would like to arrange my everyday life as well as my life as flexible as possible, e.g. flexible working hours/location, possibility for a time-out for my self-fulfillment such as a trip around the world, for an additional study etc.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS3	I like changes and can easily adapt to them (e.g. new boss, new employer, move to another place because of work or private reasons).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS4	I share my experiences, my knowledge, and my ideas as transparently as possible to support/help others.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS5	I am worried about the future (e.g. change / loss of my current standard of living, losing my job).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
LS6	My generation (and perhaps the next) will have to solve many serious problems (e.g. environmental destruction) caused by previous generations.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
TU1	I have no problem to try and apply new technologies and incorporate them into my everyday life (e.g. digital cell phone tickets, paying by cell phone, mobility apps).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
TU2	It is important for me to seek information from alternative channels and social media in addition to mainstream media such as major TV stations and their websites (e.g. New York Times, The Guardian, Spiegel or other local channels).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
TU3	I cannot do without my mobile device (e.g. smartphone, tablet) in my everyday life.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
TU4	I try as much as possible to separate my private life from my work/educational life (daily duties), e.g. turning off work email and cell phone after a certain hour.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree

UB4.1	Owning a car gives me a feeling of freedom.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.2	I prefer to use means of transport which are environmentally friendly.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.3	My everyday errands last longer than I like to be.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.4	The way to work/school is enjoyable for me, and I am able to make positive/good use of this time for myself.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.5	I consider the way to work / educational facility stressful / too long and feel like I am wasting time.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.6	If I could (e.g. financially), I would move to a place closer to work/education facility.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
UB4.7	I don't necessarily need a own car.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
imp_lc_afford	Affordability: Standard of living, i.e. income levels and costs (e.g. rent, leisure activities) should be reasonable.	Nominal	0	no
imp_lc_afford	Affordability: Standard of living, i.e. income levels and costs (e.g. rent, leisure activities) should be reasonable.	Nominal	1	yes
imp_lc_mobil	Urban Mobility: Efficient and affordable mobility services such as public transport, car/bike sharing, carpooling.	Nominal	0	no
imp_lc_mobil	Urban Mobility: Efficient and affordable mobility services such as public transport, car/bike sharing, carpooling.	Nominal	1	yes
imp_lc_health	Healthy lifestyle and environmental aspects: High offering in the health and sports sector, sufficient green spaces and local recreation.	Nominal	0	no
imp_lc_health	Healthy lifestyle and environmental aspects: High offering in the health and sports sector, sufficient green spaces and local recreation.	Nominal	1	yes
imp_lc_secure	Security: A high level of perceived safety and sufficient measures for a safe city with a low crime rate.	Nominal	0	no
imp_lc_secure	Security: A high level of perceived safety and sufficient measures for a safe city with a low crime rate.	Nominal	1	yes
imp_lc_facil	Information and cultural facilities: Educational institutions, libraries, museums, social (international) exchange	Nominal	0	no
imp_lc_facil	Information and cultural facilities: Educational institutions, libraries, museums, social (international) exchange	Nominal	1	yes
imp_ul_tech_inno	Focus on technological innovations such as mobility apps (e.g.MaaS), digital elections and citizen participation and digital city guides.	Nominal	0	no
imp_ul_tech_inno	Focus on technological innovations such as mobility apps (e.g.MaaS), digital elections and citizen participation and digital city guides.	Nominal	1	yes

imp_ul_sust_plan	Increased focus on sustainable urban planning, e.g. the creation of sufficient green spaces, promotion of $C0_2$-neutral transport, reduction of waste and improvement of the recycling process.	Nominal	0	no
imp_ul_sust_plan	Increased focus on sustainable urban planning, e.g. the creation of sufficient green spaces, promotion of $C0_2$-neutral transport, reduction of waste and improvement of the recycling process.	Nominal	1	yes
imp_ul_road_cons	Increased focus on road construction and increased creation of parking facilities in order to avoid traffic jams and thus allow traffic to flow.	Nominal	0	no
imp_ul_road_cons	Increased focus on road construction and increased creation of parking facilities in order to avoid traffic jams and thus allow traffic to flow.	Nominal	1	yes
imp_ul_pt	Improve public transport overall while making it affordable (e.g., subsidized monthly/annual public transport passes) and efficient (fast and comfortable travel from A to B).	Nominal	0	no
imp_ul_pt	Improve public transport overall while making it affordable (e.g., subsidized monthly/annual public transport passes) and efficient (fast and comfortable travel from A to B).	Nominal	1	yes
SC 4.1	Ban on driving combustion engines or CO_2-emitting vehicles, e.g. for newly registered vehicles from 2030 (with certain exceptions).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
SC 4.2	Increase in the tax on non-CO_2-free drive technologies such as gasoline and diesel.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
SC 4.3	Increase of subsidies for alternative means of transport such as sustainable sharing services, bicycles, public transport - e.g. introduction of an environment-related mobility bonus instead of subsidizing certain clusters such as motorists / automotive industry.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
SC 4.4	Creation of traffic-calmed zones, pedestrian and bicycle lanes, increasing the width of sidewalks, green spaces and reducing the number of roads and parking spaces.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
SC 4.5	Introduction of free, tax-financed public transport with the aim of reducing car traffic (example "Free Tram Zone" in Melbourne).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.1	Proximity to daily necessities facilities (supermarket, doctor, shops, gym, restaurants, bars etc.)	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.2	Proximity to family and friends	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.3	Proximity to workplace / place of education	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.4	Quality of the environment (quite / nice neighborhood, clean air, access to a garden / near park etc.)	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.5	Size and quality / characteristics of the apartment / house (modernity, coziness, existence of terrace / balcony etc.)	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL1.6	Total costs of your apartment / house	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree

FL 2.1	I like to live in a big city because that's where I have the greatest opportunities to spend my free time (e.g. culture / history, bars / nightlife, sports activities, sightseeing etc.). It is enough for me to go out of the city from time to time to be more in nature.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL 2.2	I prefer to live in the countryside (near the nature, sea etc.), because the peace and clean air makes me feel more comfortable, more rested and I can live a healthier life.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL 2.3	I prefer to live an active lifestyle, which means I like to enjoy my spare time outside / in the nature, like to experience adventure etc.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL 2.4	I want to spend as much time with my partner / family / friends during my free time.	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL 2.5	I assume that technological progress and innovation will reduce the future need for urban mobility, for example: the possibility of working from home; delivery services for daily goods; virtual fitness training, video chats etc.).	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree
FL 2.6	Property (own flat / house, valuables) is important to me	Ordinal	1;2;3;4;5	I strongly agree; I agree; Neither nor / neutral; I disagree; I strongly disagree

Appendix D: Details analysis from the multinominal logistic regression of the model "daily commute"

trans_typ_work		B	standard error	Wald	df	p-value	odds ratio	95% CI for odds ratio	
								lower bound	upper bound
car vs public transport	Constant term	5.252	1.009	27.123	1	0.000			
	trans_km_work_x	-0.011	0.008	1.829	1	0.176	0.989	0.973	1.005
	soc_howner	-0.262	0.245	1.144	1	0.285	0.769	0.476	1.244
	ress_pt_tick	1.495	0.246	37.066	1	0.000	4.458	2.755	7.213
	ress_lic	-2.604	0.904	8.307	1	0.004	0.074	0.013	0.435
	ress_car	-2.339	0.483	23.435	1	0.000	0.096	0.037	0.249
	ress_bicy	-0.812	0.343	5.589	1	0.018	0.444	0.227	0.870
	f_ub_com	0.298	0.126	5.607	1	0.018	1.347	1.053	1.723
	f_ub_car	-0.158	0.143	1.225	1	0.268	0.854	0.645	1.130
	f_sat_prox_pt	0.322	0.123	6.829	1	0.009	1.380	1.084	1.757
	f_pers_tech	-0.346	0.127	7.422	1	0.006	0.708	0.552	0.908
	f_pers_flex	-0.582	0.127	21.010	1	0.000	0.559	0.436	0.717
car vs active commute	Constant term	1.341	1.264	1.127	1	0.289			
	trans_km_work_x	-0.025	0.013	3.481	1	0.062	0.975	0.950	1.001
	soc_howner	-1.166	0.359	10.552	1	0.001	0.312	0.154	0.630
	ress_pt_tick	0.066	0.338	0.038	1	0.845	1.068	0.550	2.074
	ress_lic	-0.998	1.088	0.842	1	0.359	0.369	0.044	3.108
	ress_car	-1.831	0.548	11.157	1	0.001	0.160	0.055	0.469
	ress_bicy	1.150	0.611	3.542	1	0.060	3.157	0.954	10.454
	f_ub_com	-0.496	0.191	6.738	1	0.009	0.609	0.419	0.886
	f_ub_car	-0.558	0.194	8.280	1	0.004	0.573	0.392	0.837
	f_sat_prox_pt	0.529	0.193	7.499	1	0.006	1.698	1.162	2.479
	f_pers_tech	-0.279	0.173	2.585	1	0.108	0.757	0.539	1.063
	f_pers_flex	-0.375	0.172	4.767	1	0.029	0.687	0.491	0.962

reference categorie: car

Appendix E: Details statistical results of the city comparison: Warsaw vs. Berlin

(i) All variables listed with nominal or ordinal scale

var_ab	var_av	CramerV	CramerV_Sig	Spearman	Spearman_Sig	n_test
x_city	imp_lc_afford	0.103	0.017	-0.103	0.017	537
x_city	imp_lc_facil	0.137	0.001	0.137	0.001	537
x_city	imp_lc_health	0.083	0.054	0.083	0.054	537
x_city	imp_lc_mobil	0.078	0.072	-0.078	0.072	537
x_city	imp_lc_oppo	0.001	0.991	0.001	0.991	537
x_city	imp_lc_secure	0.012	0.784	0.012	0.784	537
x_city	imp_ul_pt	0.079	0.068	0.079	0.068	537
x_city	imp_ul_road_cons	0.207	0.000	-0.207	0.000	537
x_city	imp_ul_sust_plan	0.053	0.220	0.053	0.221	537
x_city	imp_ul_tech_inno	0.119	0.006	0.119	0.006	537
x_city	ress_bicy	0.127	0.003	0.127	0.003	537
x_city	ress_car	0.096	0.026	-0.096	0.026	537
x_city	ress_lic	0.163	0.000	0.163	0.000	537
x_city	ress_pt_tick	0.008	0.848	-0.008	0.848	537
x_city	soc_edu	0.078	0.358	-0.033	0.449	537
x_city	soc_howner	0.394	0.000	-0.394	0.000	537
x_city	soz_income	0.209	0.000	0.083	0.054	537
x_city	soz_male	0.018	0.678	0.018	0.679	537
x_city	soz_single_hh	0.096	0.026	0.096	0.026	537
x_city	soz_work	0.020	0.639	-0.020	0.640	537
x_city	trans_bikeshare	0.168	0.000	-0.168	0.000	537
x_city	trans_carpool	0.030	0.490	-0.030	0.491	537
x_city	trans_carshare	0.249	0.000	0.249	0.000	537

x_city	trans_nouse	0.036	0.409	0.036	0.410	537
x_city	trans_reas_leis	0.189	0.002	0.100	0.021	537
x_city	trans_reas_work	0.165	0.012	0.090	0.036	537
x_city	trans_ridehail	0.166	0.000	-0.166	0.000	537
x_city	trans_ridepool	0.038	0.381	0.038	0.382	537
x_city	trans_typ_leis	0.178	0.000	0.112	0.010	537
x_city	trans_typ_work	0.108	0.043	0.082	0.059	537
x_city	x_gen	0.120	0.021	0.084	0.052	537

(ii) All variables listed with metric scale

variable	W mean	B mean	delta	se robust	T	Sig. ANOVA	95% CI lower bound	95% CI upper bound	eta²	eta	Chi²	df	Sig. Breusch-Pagan
f_pers_tech	0.272	-0.168	0.439	0.078	5.630	0.000	0.286	0.592	0.049	0.222	126.947	1.000	0.000
f_ub_car	0.226	-0.198	0.424	0.078	5.459	0.000	0.271	0.576	0.047	0.216	131.289	1.000	0.000
trans_car_cost	338.527	209.956	128.570	31.364	4.099	0.000	66.898	190.243	0.043	0.208	122.129	1.000	0.000
trans_km_work_x*	13.750	19.122	-5.372	1.110	-4.839	0.000	-7.552	-3.192	0.037	0.192	149.443	1.000	0.000
f_pers_soc	-0.179	0.162	-0.341	0.079	-4.330	0.000	-0.495	-0.186	0.030	0.173	137.543	1.000	0.000
f_sc_leisure	0.155	-0.113	0.268	0.079	3.375	0.001	0.112	0.424	0.018	0.136	120.952	1.000	0.000
f_sc_co2	-0.082	0.160	-0.241	0.079	-3.052	0.002	-0.397	-0.086	0.015	0.123	125.466	1.000	0.000
f_ub_com	-0.143	0.101	-0.244	0.081	-3.014	0.003	-0.403	-0.085	0.015	0.121	100.856	1.000	0.000
trans_km_leis_x*	16.279	19.405	-3.126	1.257	-2.488	0.013	-5.594	-0.658	0.010	0.100	157.373	1.000	0.000
f_sat_qual_env	-0.074	0.053	-0.127	0.083	-1.526	0.128	-0.290	0.036	0.004	0.062	80.244	1.000	0.000
f_sat_prox_pt	-0.059	0.066	-0.125	0.082	-1.516	0.130	-0.287	0.037	0.004	0.061	72.746	1.000	0.000
f_pers_flex	-0.048	0.057	-0.105	0.081	-1.301	0.194	-0.264	0.054	0.003	0.053	123.497	1.000	0.000
f_pers_disc	0.009	-0.074	0.082	0.081	1.021	0.308	-0.076	0.241	0.002	0.041	94.832	1.000	0.000
f_sc_lifestyle	0.043	-0.005	0.048	0.082	0.588	0.557	-0.113	0.209	0.001	0.024	96.232	1.000	0.000
trans_min_work_x	45.969	44.873	1.096	2.893	0.379	0.705	-4.586	6.779	0.000	0.015	106.226	1.000	0.000

Comments:

Variables also include those one, which were transformed from ordinal values to metric values based on the factor analysis; se = standard error; T = robust test statistic (t-value); Sig. ANOVA = robust significance of the difference between the cities; partial eta² = Strength of the difference normalized [0 to 1], the higher the stronger the difference; Chi² = Test statistic for testing the condition of variance homogeneity based on the Breusch-Pagan test; df = degrees of freedom of the Breusch-Pagan test; Sig. Breusch-Pagan test = Significance of Breusch-Pagan test, if ≤ 0.05, then variance homogeneity is not met, variance homogeneity is not met for all tests.

*Data was obtained based on a question with an ordinal scale (different distance groups); for evaluation purposes, an adjusted variable was transformed with a continuous scale based on the mean of each distance group.

Appendix F: Details statistical results of the city comparison

(i) Comparison of the generations: overall sample (nominal values)

Variable

imp_lc_health	Gen X	Gen Y	Gen Z	Sig.	Cramer V
no	74.80%	76.41%	85.01%	0.149	0.084
yes	25.20%	23.59%	14.99%		
imp_lc_facil	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	91.86%	93.05%	96.09%	0.367	0.061
yes	8.14%	6.95%	3.91%		
imp_lc_secure	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	87.43%	86.15%	87.40%	0.899	0.020
yes	12.57%	13.85%	12.60%		
imp_ul_pt	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	47.32%	59.33%	63.78%	0.131	0.010
yes	52.68%	40.67%	36.22%		
imp_ul_tech_inno	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	81.50%	71.97%	66.93%	0.016	0.124
yes	18.50%	28.03%	33.07%		
imp_ul_sust_plan	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	38.82%	35.00%	38.16%	0.688	0.037
yes	61.18%	65.00%	61.84%		
ress_bicy	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	13.91%	19.63%	22.27%	0.156	0.083
yes	86.09%	80.37%	77.73%		
ress_car	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	23.37%	26.99%	27.39%	0.630	0.041
yes	76.63%	73.01%	72.61%		

Variable

imp_lc_mobil	Gen X	Gen Y	Gen Z	Sig.	Cramer V
no	94.42%	87.04%	85.71%	0.129	0.012
yes	5.58%	12.96%	14.29%		
imp_lc_afford	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	57.34%	64.04%	54.45%	0.193	0.078
yes	42.66%	35.96%	45.55%		
imp_lc_oppo	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	94.15%	93.32%	91.34%	0.718	0.035
yes	5.85%	6.68%	8.66%		
imp_ul_road_cons	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	77.52%	68.86%	74.31%	0.120	0.089
yes	22.48%	31.14%	25.69%		
imp_ul_pt	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	47.32%	59.33%	63.78%	0.010	0.131
yes	52.68%	40.67%	36.22%		
ress_pt_tick	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	46.90%	54.00%	35.51%	0.012	0.129
yes	53.10%	46.00%	64.49%		
ress_lic	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	4.74%	12.08%	19.64%	0.001	0.165
yes	95.26%	87.92%	80.36%		
soc_howner	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	48.26%	53.98%	63.11%	0.101	0.065
yes	51.74%	46.02%	36.89%		

Variable

imp_lc_health	Gen X	Gen Y	Gen Z	Sig.	Cramer V
no	74.80%	76.41%	85.01%	0.149	0.084
yes	25.20%	23.59%	14.99%		
imp_lc_facil	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	91.86%	93.05%	96.09%	0.367	0.061
yes	8.14%	6.95%	3.91%		
imp_lc_secure	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	87.43%	86.15%	87.40%	0.899	0.020
yes	12.57%	13.85%	12.60%		
imp_ul_pt	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	47.32%	59.33%	63.78%	0.131	0.010
yes	52.68%	40.67%	36.22%		
imp_ul_tech_inno	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	81.50%	71.97%	66.93%	0.016	0.124
yes	18.50%	28.03%	33.07%		
imp_ul_sust_plan	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	38.82%	35.00%	38.16%	0.688	0.037
yes	61.18%	65.00%	61.84%		
ress_bicy	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	13.91%	19.63%	22.27%	0.156	0.083
yes	86.09%	80.37%	77.73%		
ress_car	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	23.37%	26.99%	27.39%	0.630	0.041
yes	76.63%	73.01%	72.61%		

soc_work	Gen X	Gen Y	Gen Z	sig	Cramer V
no	6.75%	5.27%	34.94%	0.000	0.347
yes	93.25%	94.73%	65.06%		

Variable

imp_lc_mobil	Gen X	Gen Y	Gen Z	Sig.	Cramer V
no	94.42%	87.04%	85.71%	0.129	0.012
yes	5.58%	12.96%	14.29%		
imp_lc_afford	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	57.34%	64.04%	54.45%	0.193	0.078
yes	42.66%	35.96%	45.55%		
imp_lc_oppo	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	94.15%	93.32%	91.34%	0.718	0.035
yes	5.85%	6.68%	8.66%		
imp_ul_road_cons	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	77.52%	68.86%	74.31%	0.120	0.089
yes	22.48%	31.14%	25.69%		
imp_ul_pt	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	47.32%	59.33%	63.78%	0.010	0.131
yes	52.68%	40.67%	36.22%		
ress_pt_tick	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	46.90%	54.00%	35.51%	0.012	0.129
yes	53.10%	46.00%	64.49%		
ress_lic	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	4.74%	12.08%	19.64%	0.001	0.165
yes	95.26%	87.92%	80.36%		
soc_howner	**Gen X**	**Gen Y**	**Gen Z**	**Sig.**	**Cramer V**
no	48.26%	53.98%	63.11%	0.101	0.065
yes	51.74%	46.02%	36.89%		

trans_bikeshare	X	Y	Z	Sig.	Cramer V
no	89.30%	73.38%	78.44%	0.000	0.184
yes	10.70%	26.62%	21.56%		

trans_carshare	Gen X	Gen Y	Gen Z
no	79.45%	72.04%	72.98%
yes	20.55%	27.96%	27.02%

Sig.	Cramer V
0.184	0.079

trans_ridehail	Gen X	Gen Y	Gen Z
no	88.20%	72.06%	69.89%
yes	11.80%	27.94%	30.11%

Sig.	Cramer V
0.000	0.196

trans_nouse	Gen X	Gen Y	Gen Z
no	35.70%	58.25%	60.86%
yes	64.30%	41.75%	39.14%

Sig.	Cramer V
0.225	0.000

trans_carpool	X	Y	Z
no	95.66%	93.21%	89.73%
yes	4.34%	6.79%	10.27%

Sig.	Cramer V
0.226	0.074

trans_ridepool	X	Y	Z
no	96.44%	93.05%	94.65%
yes	3.56%	6.95%	5.35%

Sig.	Cramer V
0.282	0.069

soc_edu	Gen X	Gen Y	Gen Z
ISCED level 1-2	3.95%	2.88%	8.99%
ISCED level 3-4	22.82%	11.13%	62.33%
ISCED level 5-6	17.19%	18.72%	18.41%
ISCED level 7-8	56.03%	67.28%	10.27%

Sig.	Cramer V
0.325	0.000

soz_income	Gen X	Gen Y	Gen Z
low-income group	15.61%	9.66%	48.51%
middle-income group - lower range	9.08%	9.21%	9.02%
middle-income group - upper range	28.46%	42.48%	26.72%
high-income group	46.85%	38.66%	15.75%

sig	Cramer V
0.000	0.268

trans_reas_work	Gen X	Gen Y	Gen Z
Accessibility	16.89%	15.19%	17.58%
Comfort	27.83%	26.56%	23.47%
Costs	13.66%	17.16%	28.06%
Health aspects	9.14%	6.12%	2.82%
Sustainability	4.91%	7.50%	13.54%
Travel time	27.56%	27.47%	14.53%
ztotal	100.00%	100.00%	100.00%

Sig.	Cramer V
0.013	0.145

trans_reas_leis	Gen X	Gen Y	Gen Z
Accessibility	9.97%	10.12%	17.43%
Comfort	36.71%	35.34%	26.12%
Costs	9.77%	14.02%	23.59%
Health aspects	14.74%	10.41%	8.90%
Sustainability	5.50%	7.13%	15.79%
Travel time	23.31%	22.98%	8.16%
ztotal	100.00%	100.00%	100.00%

Sig.	Cramer V
0.000	0.171

trans_typ_work	Gen X	Gen Y	Gen Z
Active commute (bike & on foot)	11.98%	16.74%	9.71%
own car / taxi / car sharing	33.21%	35.48%	28.17%
Public transport / long distance train	54.81%	47.78%	62.11%
ztotal	100.00%	100.00%	100.00%

Sig.	Cramer V
0.141	0.080

trans_typ_leis	Gen X	Gen Y	Gen Z
Active commute (bike & on foot)	23.04%	20.66%	14.38%
own car / taxi / car sharing	54.43%	51.59%	37.93%
Public transport / long distance train	22.52%	27.75%	47.69%
ztotal	100.00%	100.00%	100.00%

Sig.	Cramer V
0.130	0.001

(ii) Comparison of the generations: overall sample (continuous (ratio) variables)

Descriptive statistics			
Mean value	**Gen X**	**Gen Y**	**Gen Z**
f_pers_disc	0.241	-0.124	-0.273
f_pers_flex	-0.175	0.090	0.114
f_pers_soc	0.049	0.083	-0.218
f_pers_tech	-0.221	0.091	0.216
f_sat_prox_pt	0.159	-0.080	0.029
f_sat_qual_env	0.027	-0.024	0.019
f_sc_co2	-0.127	0.169	0.058
f_sc_leisure	-0.163	0.131	-0.091
f_sc_lifestyle	0.004	-0.034	0.175
f_ub_car	-0.077	0.018	-0.023
f_ub_com	-0.071	0.071	-0.090
trans_car_cost	240.295	277.984	297.867
trans_km_leis_x	20.479	17.268	16.329
trans_km_work_x	19.082	15.345	17.320
trans_min_work_x	47.713	44.792	42.838

Global values	
sig_anova	**eta**
0.000	0.197
0.006	0.129
0.021	0.112
0.000	0.166
0.033	0.106
0.840	0.024
0.004	0.133
0.003	0.136
0.161	0.077
0.582	0.042
0.182	0.075
0.357	0.074
0.035	0.105
0.016	0.116
0.474	0.050

Pairwise comparison of generations					
X versus Y		**X versus Z**		**Z versus Y**	
Sig.	**eta**	**Sig.**	**eta**	**Sig.**	**eta**
0.000	0.162	0.000	0.181	0.158	0.057
0.004	0.116	0.017	0.097	0.820	0.009
0.709	0.015	0.044	0.082	0.012	0.102
0.001	0.131	0.000	0.148	0.222	0.050
0.008	0.108	0.290	0.043	0.349	0.038
0.590	0.022	0.952	0.002	0.690	0.016
0.002	0.125	0.094	0.068	0.242	0.047
0.002	0.124	0.538	0.025	0.030	0.088
0.684	0.017	0.155	0.058	0.050	0.079
0.322	0.040	0.640	0.019	0.686	0.016
0.123	0.062	0.876	0.006	0.150	0.058
0.217	0.064	0.160	0.073	0.661	0.023
0.044	0.081	0.021	0.093	0.509	0.027
0.005	0.114	0.328	0.040	0.225	0.049
0.366	0.037	0.254	0.046	0.623	0.020

Comments analysis approach:

1. Conduct global significance test across the three generations to see if there is any significant difference at all.
2. If the global significance is present, then the significances in the generational comparison serve to describe the differences between the groups more precisely.

Appendix G: Details statistical results of the generational comparison

(i) Comparison of the generations: city sample (nominal values)

Variable

imp_lc_health	Gen X	Gen Y	Gen Z	sig	Cramer V
no	73.34%	80.88%	97.15%	0.010	0.194
yes	26.66%	19.12%	2.85%		
imp_lc_mobil	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	90.70%	84.00%	90.00%	0.287	0.101
yes	9.30%	16.00%	10.00%		
imp_lc_facil	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	96.77%	96.11%	100.00%	0.481	0.077
yes	3.23%	3.89%			
imp_lc_afford	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	56.26%	58.62%	37.13%	0.082	0.143
yes	43.74%	41.38%	62.87%		
imp_lc_secure	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	90.61%	85.96%	84.28%	0.461	0.079
yes	9.39%	14.04%	15.72%		
imp_lc_oppo	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	92.32%	94.43%	91.43%	0.749	0.049
yes	7.68%	5.57%	8.57%		
imp_ul_road_cons	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	62.43%	60.95%	71.41%	0.569	0.068
yes	37.57%	39.05%	28.59%		
imp_ul_tech_inno	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	87.48%	78.18%	72.84%	0.133	0.128
yes	12.52%	21.82%	27.16%		

Variable

imp_lc_health	Gen X	Gen Y	Gen Z	sig	Cramer V
no	75.73%	71.60%	75.07%	0.762	0.043
yes	24.27%	28.40%	24.93%		
imp_lc_mobil	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	96.77%	90.31%	82.19%	0.007	0.186
yes	3.23%	9.69%	17.81%		
imp_lc_facil	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	88.75%	89.76%	92.89%	0.684	0.051
yes	11.25%	10.24%	7.11%		
imp_lc_afford	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	58.02%	69.85%	68.62%	0.132	0.118
yes	41.98%	30.15%	31.38%		
imp_lc_secure	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	85.42%	86.36%	89.96%	0.824	0.036
yes	14.58%	13.64%	10.04%		
imp_lc_oppo	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	95.31%	92.12%	91.27%	0.481	0.071
yes	4.69%	7.88%	8.73%		
imp_ul_road_cons	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	87.08%	77.34%	76.69%	0.099	0.126
yes	12.92%	22.66%	23.31%		
imp_ul_tech_inno	**Gen X**	**Gen Y**	**Gen Z**	**sig**	**Cramer V**
no	77.71%	65.31%	62.10%	0.049	0.144
yes	22.29%	34.69%	37.90%		

imp_ul_pt	Gen X	Gen Y	Gen Z	sig	Cramer V
no	61.01%	58.53%	61.44%	0.899	0.029
yes	38.99%	41.47%	38.56%		

imp_ul_sust_plan	Gen X	Gen Y	Gen Z	sig	Cramer V
no	39.09%	41.10%	35.71%	0.825	0.040
yes	60.91%	58.90%	64.29%		

ress_pt_tick	Gen X	Gen Y	Gen Z	sig	Cramer V
no	46.77%	50.31%	42.90%	0.746	0.049
yes	53.23%	49.69%	57.10%		

ress_bicy	Gen X	Gen Y	Gen Z	sig	Cramer V
no	20.40%	20.96%	37.21%	0.072	0.146
yes	79.60%	79.04%	62.79%		

ress_lic	Gen X	Gen Y	Gen Z	sig	Cramer V
no	9.59%	17.52%	24.29%	0.126	0.130
yes	90.41%	82.48%	75.71%		

ress_car	Gen X	Gen Y	Gen Z	sig	Cramer V
no	17.17%	20.88%	30.03%	0.333	0.095
yes	82.83%	79.12%	69.97%		

soz_edu	Gen X	Gen Y	Gen Z	sig	Cramer V
ISCED level 1-2		3.44%	5.72%	0.000	0.369
ISCED level 3-4	23.34%	11.42%	72.84%		
ISCED level 5-6	16.05%	18.22%	12.87%		
ISCED level 7-8	60.62%	66.93%	8.57%		

imp_lc_howner	Gen X	Gen Y	Gen Z	sig	Cramer V
no	12.62%	39.62%	45.70%	0.000	0.268
yes	87.38%	60.38%	54.30%		
ztotal	100.00%	100.00%	100.00%		

imp_ul_pt	Gen X	Gen Y	Gen Z	sig	Cramer V
no	38.64%	60.19%	65.69%	0.000	0.230
yes	61.36%	39.81%	34.31%		

imp_ul_sust_plan	Gen X	Gen Y	Gen Z	sig	Cramer V
no	38.64%	28.46%	40.17%	0.184	0.108
yes	61.36%	71.54%	59.83%		

ress_pt_tick	Gen X	Gen Y	Gen Z	sig	Cramer V
no	46.98%	57.97%	29.47%	0.004	0.196
yes	53.02%	42.03%	70.53%		

ress_bicy	Gen X	Gen Y	Gen Z	sig	Cramer V
no	9.79%	18.20%	10.04%	0.128	0.119
yes	90.21%	81.80%	89.96%		

ress_lic	Gen X	Gen Y	Gen Z	sig	Cramer V
no	1.67%	6.24%	15.84%	0.003	0.202
yes	98.33%	93.76%	84.16%		

ress_car	Gen X	Gen Y	Gen Z	sig	Cramer V
no	27.29%	33.56%	25.22%	0.394	0.080
yes	72.71%	66.44%	74.78%		

soz_edu	Gen X	Gen Y	Gen Z	sig	Cramer V
ISCED level 1-2	6.46%	2.27%	11.66%	0.000	0.301
ISCED level 3-4	22.50%	10.82%	53.74%		
ISCED level 5-6	17.92%	19.26%	22.95%		
ISCED level 7-8	53.12%	67.65%	11.66%		

imp_lc_howner	Gen X	Gen Y	Gen Z	sig	Cramer V
no	70.83%	69.39%	77.35%	0.566	0.063
yes	29.17%	30.61%	22.65%		
ztotal	100.00%	100.00%	100.00%		

soz_income	Gen X	Gen Y	Gen Z
low-income group	9.49%	10.19%	45.70%
middle-income group - lower range	7.78%	11.95%	8.57%
middle-income group - upper range	45.45%	47.65%	32.86%
high-income group	37.28%	30.21%	12.87%

sig	Cramer V
0.000	0.267

soz_income	Gen X	Gen Y	Gen Z
low-income group	19.48%	9.08%	50.81%
middle-income group - lower range	9.90%	6.26%	9.38%
middle-income group - upper range	17.71%	36.93%	21.70%
high-income group	52.91%	47.73%	18.11%

sig	Cramer V
0.000	0.288

soz_work	Gen X	Gen Y	Gen Z
no	4.75%	5.40%	35.71%
yes	95.25%	94.60%	64.29%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.000	0.360

soz_work	Gen X	Gen Y	Gen Z
no	8.02%	5.13%	34.31%
yes	91.98%	94.87%	65.69%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.000	0.333

trans_bikeshare	Gen X	Gen Y	Gen Z
no	79.79%	67.21%	78.61%
yes	20.21%	32.79%	21.39%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.092	0.139

trans_bikeshare	Gen X	Gen Y	Gen Z
no	95.31%	80.01%	78.30%
yes	4.69%	19.99%	21.70%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.001	0.227

trans_carshare	Gen X	Gen Y	Gen Z
no	92.22%	86.21%	77.14%
yes	7.78%	13.79%	22.86%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.103	0.136

trans_carshare	Gen X	Gen Y	Gen Z
no	71.36%	56.83%	69.58%
yes	28.64%	43.17%	30.42%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.055	0.141

trans_carpool	Gen X	Gen Y	Gen Z
no	93.74%	92.67%	91.43%
yes	6.26%	7.33%	8.57%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.920	0.026

trans_carpool	Gen X	Gen Y	Gen Z
no	96.88%	93.78%	88.34%
yes	3.12%	6.22%	11.66%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.136	0.117

trans_ridehail	Gen X	Gen Y	Gen Z
no	79.60%	68.77%	57.20%
yes	20.40%	31.23%	42.80%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.033	0.167

trans_ridehail	Gen X	Gen Y	Gen Z
no	93.65%	75.60%	80.28%
yes	6.35%	24.40%	19.72%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.000	0.232

trans_ridepool	Gen X	Gen Y	Gen Z
no	98.39%	94.51%	92.85%
yes	1.61%	5.49%	7.15%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.192	0.116

trans_ridepool	Gen X	Gen Y	Gen Z
no	95.21%	91.47%	96.11%
yes	4.79%	8.53%	3.89%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.461	0.073

trans_nouse	Gen X	Gen Y	Gen Z
no	39.28%	56.94%	62.84%
yes	60.72%	43.06%	37.16%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.019	0.180

trans_nouse	Gen X	Gen Y	Gen Z
no	33.43%	59.66%	59.24%
yes	66.57%	40.34%	40.76%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.000	0.258

trans_reas_leis	Gen X	Gen Y	Gen Z
Accessibility	7.78%	10.52%	18.57%
Comfort	35.96%	37.58%	22.84%
Costs	12.52%	15.92%	31.46%
Health aspects	12.52%	11.67%	7.15%
Sustainability	1.52%	2.13%	8.57%
Travel time	29.70%	22.19%	11.42%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.032	0.200

trans_reas_leis	Gen X	Gen Y	Gen Z
Accessibility	11.36%	9.69%	16.50%
Comfort	37.19%	32.95%	28.81%
Costs	8.02%	11.98%	17.15%
Health aspects	16.15%	9.07%	10.34%
Sustainability	8.02%	12.49%	21.70%
Travel time	19.27%	23.83%	5.50%
ztotal	100.00%	100.00%	100.00%

sig	Cramer V
0.037	0.182

trans_reas_work	Gen X	Gen Y	Gen Z
Accessibility	7.88%	17.68%	22.84%
Comfort	28.18%	26.98%	22.86%

sig	Cramer V
0.053	0.192

trans_reas_work	Gen X	Gen Y	Gen Z
Accessibility	22.60%	12.51%	13.27%
Comfort	27.61%	26.11%	23.97%

sig	Cramer V
0.032	0.184

Costs	20.11%	19.36%	27.14%
Health aspects	10.91%	3.89%	4.30%
Sustainability		3.89%	7.15%
Travel time	32.93%	28.20%	15.72%
ztotal	100.00%	100.00%	100.00%

Costs	9.58%	14.79%	28.81%
Health aspects	8.02%	8.52%	1.61%
Sustainability	8.02%	11.38%	18.77%
Travel time	24.17%	26.69%	13.57%
ztotal	100.00%	100.00%	100.00%

trans_typ_leis	**Gen X**	**Gen Y**	**Gen Z**
Active commute (bike & on foot)	10.91%	16.62%	4.27%
own car / taxi / car sharing	64.24%	53.66%	32.86%
Public transport / long distance train	24.85%	29.72%	62.87%
ztotal	100.00%	100.00%	100.00%

sig	**Cramer V**
0.001	0.197

trans_typ_leis	**Gen X**	**Gen Y**	**Gen Z**
Active commute (bike & on foot)	30.73%	25.00%	22.65%
own car / taxi / car sharing	48.23%	49.36%	42.08%
Public transport / long distance train	21.04%	25.64%	35.27%
ztotal	100.00%	100.00%	100.00%

sig	**Cramer V**
0.354	0.087

trans_typ_work	**Gen X**	**Gen Y**	**Gen Z**
Active commute (bike & on foot)	11.01%	11.67%	1.42%
own car / taxi / car sharing	42.22%	33.69%	28.56%
Public transport / long distance train	46.77%	54.65%	70.01%
ztotal	100.00%	100.00%	100.00%

sig	**Cramer V**
0.190	0.111

trans_typ_work	**Gen X**	**Gen Y**	**Gen Z**
Active commute (bike & on foot)	12.60%	22.18%	16.50%
own car / taxi / car sharing	27.50%	37.41%	27.86%
Public transport / long distance train	59.90%	40.41%	55.65%
ztotal	100.00%	100.00%	100.00%

sig	**Cramer V**
0.038	0.132

(ii) Comparison of the generations: city split (continuous (ratio) variables)

	Descriptive statistics Warsaw			Global values Warsaw	
Mean value	**Gen X**	**Gen Y**	**Gen Z**	**sig_anova**	**eta**
f_pers_disc	0.124	0.081	-0.288	0.028	0.167
f_pers_flex	-0.221	0.005	0.019	0.289	0.098
f_pers_soc	-0.150	-0.124	-0.340	0.282	0.099
f_pers_tech	0.008	0.271	0.564	0.002	0.215
f_sat_prox_pt	0.097	-0.201	0.103	0.064	0.146
f_sat_qual_env	-0.091	-0.079	-0.041	0.963	0.017
f_sc_co2	-0.207	-0.053	-0.010	0.454	0.079
f_sc_leisure	-0.097	0.353	-0.032	0.001	0.233
f_sc_lifestyle	-0.086	-0.014	0.320	0.050	0.152
f_ub_car	0.236	0.219	0.231	0.991	0.008
f_ub_com	-0.226	-0.072	-0.218	0.473	0.077
trans_car_cost	300.980	362.770	331.281	0.646	0.072
trans_km_leis_x	17.969	15.441	16.379	0.529	0.071
trans_km_work_x	14.648	13.162	14.138	0.696	0.053
trans_min_work_x	44.375	46.691	46.034	0.912	0.027

	Descriptive statistics Berlin			Global values Berlin	
Mean value	**Gen X**	**Gen Y**	**Gen Z**	**sig_anova**	**eta**
f_pers_disc	0.302	-0.283	-0.256	0.000	0.275
f_pers_flex	-0.151	0.156	0.219	0.009	0.164
f_pers_soc	0.151	0.243	-0.085	0.140	0.106
f_pers_tech	-0.339	-0.047	-0.165	0.053	0.129
f_sat_prox_pt	0.191	0.013	-0.053	0.184	0.098
f_sat_qual_env	0.087	0.019	0.086	0.804	0.035
f_sc_co2	-0.086	0.341	0.132	0.001	0.197
f_sc_leisure	-0.197	-0.041	-0.156	0.421	0.070
f_sc_lifestyle	0.051	-0.050	0.015	0.675	0.047
f_ub_car	-0.239	-0.138	-0.301	0.508	0.062
f_ub_com	0.009	0.181	0.051	0.314	0.081
trans_car_cost	203.293	201.146	259.679	0.274	0.113
trans_km_leis_x	21.774	18.679	16.274	0.079	0.120
trans_km_work_x	21.371	17.031	20.802	0.035	0.137
trans_min_work_x	49.435	43.324	39.340	0.149	0.104

Comments analysis approach:

1. Comparison of the mean values of the generations within Warsaw and Berlin as well as in cross-national comparison
2. Conduct global significance test across the three generations in both cities to see if there is any significant difference between them