

Article

Determinants of the Willingness to Use Autonomous Mobility as a Service in Germany

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Abstract: Fully autonomous vehicles, once legally and technically feasible and widely available, have numerous advantages compared to human-driven vehicles, from greater availability and shorter travel times to lower negative environmental emissions and fewer accidents. This, combined with a usage-based form of payment, can massively increase the usage rate of vehicles without the need for high initial investments. This study explores the determinants affecting the willingness to adopt Autonomous Mobility as a Service (AMaaS) in Germany. Utilizing a mobile cross-sectional survey via Pollfish, 400 complete responses of German speakers aged 18 years or older in Germany were collected to assess influential factors. The survey data were analyzed using binary logistic regression analysis. Age, possession of a driving license, and the quality of public transport were identified as significant predictors. Younger people and driving license holders showed a higher willingness to use AMaaS, while low-quality public transport reduced their willingness to use it. This study concludes that targeted strategies for AMaaS implementation should consider these key demographic and infrastructural factors to maximize market penetration and acceptance in Germany.

Keywords: autonomous mobility as a service; mobile cross-sectional survey; willingness to use; binary logistic regression analysis



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1. Introduction

Autonomous vehicles have numerous advantages compared to human-driven vehicles, from greater availability and shorter travel times to lower negative environmental emissions and fewer accidents [1]. Since 2021, it has also been legally permitted in Germany for autonomous vehicles to be operated on public roads and, since 2023, to use the Autobahn and travel at speeds of up to 130 km per hour [2]. While widespread use of fully autonomous cars is still in an early phase, truck freight transport is already partially using so-called platooning, where one person sits and steers in the front truck and several trucks drive in a row [3]. However, particularly with regard to the environmental aspect, there is a significantly greater lever in passenger transport. Within the European Union, passenger cars and motorcycles are responsible for over 60% of all greenhouse gas emissions [4]. The rapid change, especially in individual mobility, towards more environmentally friendly means of transport is therefore of great importance. However, since the average passenger car in Germany is only used three percent of the day and electrically powered vehicles have significantly higher acquisition costs, this change is stalling [5]. The low usage rate of passenger cars also poses major challenges to the infrastructure. Back in 2005, Shoup came to the conclusion that almost a third of the traffic was due to people looking for a parking space [6]. In a more recent study, Cao et al. estimated that, at times, 70% of traffic in Zurich during the day can be attributed solely to the search for a parking space [7]. In a paper published in 2022, Alotaibi and Herrmann came to the conclusion that the use of autonomous vehicles in Edinburgh alone can save up to 86% of vehicles, while travel time and passenger kilometers can be reduced by almost two-thirds [8]. Autonomous

Mobility as a Service (AMaaS) can solve these problems by massively increasing the usage rate of vehicles and offering end users a usage-based form of payment. As a result, more people can be provided with more environmentally friendly vehicles, and end consumers no longer have to bear a high initial investment and ongoing fixed costs. It would be ideal if AMaaS substituted for the need for your own car. Numerous disadvantages of current individual mobility could be eliminated in this way. A general welfare gain for society could be achieved through lower environmental pollution, lower usage costs, fewer traffic jams, and fewer parking spaces. In order for future AMaaS business models to optimally address their target group, this study explores the determinants affecting the willingness to use AMaaS in Germany.

The following article consists of four main sections. In the first section, a comprehensible basis is created. The main terms are defined, and selected studies on the topic of AMaaS are briefly presented in order to show the current state of research. The procedure is then described in detail in the Methodology section, going into detail about the study design, data collection, and data analysis. The last two sections, Results and Discussion, deal with the research results and their implications.

2. Definition of Main Terms and Literature Review

2.1. Definition of Main Terms “Mobility”, “Autonomous Driving”, and “Mobility as a Service”

Although the term mobility is widely used in everyday language, there is no clear definition. Kristoffersen and Ljungberg wrote in 1999, “Mobility is one of those words that are virtually impossible to define in a meaningful way. You either come up with a definition that excludes obvious instances, or your definition is too vague; it fails to shed light on important aspects. At the same time we all have a feeling of what it means” [9] (p. 271). Generally speaking, the word comes from the Latin “mobilis”, which in turn means “to be mobile” [10]. On closer inspection, however, there are now innumerable definitions. In an attempt to create an overview, Hörold already included seven different definitions [11]. Krannich’s definition is most effective for this work. He describes mobility as a temporary physical overcoming of space [12].

With autonomous driving, a computer takes over the control of the vehicle; ideally, a driver is no longer necessary. This creates a wide range of positive effects, such as increased safety, less wear and tear on the roads, and lower energy consumption for driving itself [13]. A distinction is made between six different levels of autonomous driving. At level zero, the driver takes full control; no system intervenes. Assistance systems, such as cruise control or a parking assistant, are assigned to the next higher level. The driver still has to carry out all central actions, such as steering and braking, independently. Level two includes distance-keeping assistants, in which the vehicle brakes and accelerates by itself and always maintains the same distance from the vehicle in front. When the assistant is switched on, the driver no longer has to act actively but always has to be ready to intervene. In level three, the system goes a little further. The driver may temporarily turn away from the traffic and his driving task but must also be ready at any time to have the driving task returned to him by the system at short notice. In level four, the vehicle takes on all tasks associated with driving an automobile. The driver does not have to monitor the system but can intervene at any time and overrule the system. At this level, the system can transfer control back to the driver in certain situations. If the driver does not react, the vehicle parks independently in a suitable position. Only in the last stage is the control back to the driver no longer an option on the system side. Fully autonomous driving is only spoken of at level five. A vehicle that fulfills level five can cover any route with the associated speeds without the need for a person to be the driver [14]. The highest degree of autonomous driving places considerable demands on hardware and software and must be comprehensively regulated both ethically and legally. The advances in hardware over the past few years, in line with Moore’s Law, also enable increasingly complex calculations using software [15]. Artificial intelligence is, therefore, considered a key component of autonomous driving [16]. This is

primarily due to the fact that a large number of factors must be taken into account at the same time in order to be able to make a sufficient decision [17].

The concept of Mobility as a Service, or MaaS for short, has existed for less than a decade and, generally speaking, describes a service that enables end customers to satisfy their mobility needs without having to own their own vehicle. In other words, end customers can use different mobility concepts for a usage-dependent fee. This also includes, for example, taxis and buses. MaaS is, therefore, seen as a key component for reducing emissions and negative externalities [18]. Instead of a high initial investment, in most cases, a subscription is offered, for which end customers can use the mobility offer. Instead of sunk costs, the consumer has marginal costs for usage. In this context, cultural change is also of great importance, as ownership of a car still has a high ideological value [19]. Mobility on Demand, or MoD, is used synonymously with MaaS; both terms refer to the same area [20].

The ideal for AMaaS in the context of this paper is that end customers can use an app to call a car if necessary. This car then drives up to the respective customer and can be used. The customer has the option of whether he then wants to drive to his destination himself or whether he wants to be transported using autonomous driving. The car can then be released again and driven to the next customer. In order for this AMaaS to be fully feasible, autonomous driving, according to level five, is necessary.

2.2. Overview of Selected Studies on the Topic of Willingness to Use AMaaS

In the following section, selected studies on the topic of AMaaS are cited to give an overview. The sources were obtained through unsystematic literature research. The databases EBSCO, Web of Science (WoS), Scopus, and Springer were used as primary sources [21–24].

Liljamo et al. conducted a representative survey in Finland on the influence of autonomous driving and MaaS offers on the willingness to do so without their own car. Against the background of increasing environmental pollution and lack of space, especially in cities, caused by a high vehicle density, they see a great need to reduce the number of vehicles in the future [25]. According to several studies, around 90% of vehicles could be saved just by using shared autonomous vehicles [26–28]. A study into the possible impact of MaaS in London came to the conclusion that 40% of respondents who do not own a car would not buy a car in the future if MaaS were widely available [29]. In addition, a third of the participants who already have a vehicle stated that they would use it less if MaaS were widely available. Liljamo et al. found in their study that younger people and women tend to be more inclined to do without their own car, but the level of education and place of residence have hardly any influence on this. While only around 40% of those surveyed would do so without their own car, even if they could use public transport to meet all their mobility needs, almost 60% would do so if they could use MaaS to meet their mobility needs. This value increases to almost two-thirds, assuming that autonomous driving would be widely available [25]. As a result, AMaaS concepts can have a significant impact on whether a person plans to buy their own car. If public transport or MaaS offers are sufficient to meet mobility needs, the majority of the study participants can imagine doing so without their own car. While younger people and the female gender tend to have a lower need for their own car, the level of education and place of residence have no effect on this. As a result, according to the authors, AMaaS offers should be introduced, disseminated, and supported in order to counteract the negative consequences of a high vehicle density.

Barbour et al. also examined the willingness of respondents to use AMaaS services. On the one hand, the willingness to own an autonomous vehicle and then make it available to other users for a fee was examined. On the other hand, people were asked about their willingness to use an autonomous vehicle owned by another person or a company. According to these survey results, people who live close to shops and who have been involved in a car accident are more likely to use an AMaaS offer. In contrast, respondents

from households with two or fewer people, Caucasians, and people who commute 45 min or more daily and do not search long for parking are less likely to use an AMaaS service. According to this survey, people with higher education have lower concerns about safety but higher concerns about reliability. Respondents from 3-person households and those who have more than four vehicles available in the household showed more concerns about privacy. Overall, it turned out that younger and more educated people tend to be more inclined to use an AMaaS service [30].

Shamshiripour et al. have more generally studied the travel behavior of people in Chicago and the surrounding area when a MaaS offering is available. It was, therefore, not specifically examined for autonomous MaaS offers but with regard to existing MaaS offers such as Uber or Lyft. The informative value of this article is therefore limited since MaaS, or Mobility on Demand, was defined solely as ridesharing. In their study, they came to the conclusion that people with flexible working hours are more inclined to walk than to take another means of transport. In addition, full-time employees are more inclined to use MaaS offers. This could be explained by the fact that time-efficient transport is particularly important for full-time employees. Likewise, Shamshiripour et al. found that people with their own cars are less willing to use other means of transport, and people from lower income brackets tend to choose public transport. While the results so far are in line with expectations, the study found that people from high income brackets tend to be more inclined to use MaaS offers than to own a car. A possible explanation for this would be that while these people want to travel in a time-efficient manner, they also want to use this time for other activities, such as work [31].

3. Methodology

3.1. Study Design

On 20 January 2024, shortly after 1:00 p.m., the survey was initiated via Pollfish. There was no specific reason for the start of the survey, primarily to ensure constant monitoring. The estimated survey length, or Length Of Interview, or LOI for short, was three minutes. The last relevant and counted response was received around 8:00 p.m., meaning the survey was completed in less than seven hours. The target group was all German speakers in Germany who were at least 18 years old or older. A total of 400 complete and valid responses were collected, and the completion rate was 36%. In total, over 1100 people were approached via random device engagement. The survey consisted of a total of 15 questions, eleven of which were single-selection, three multiple-selection, and one numeric-open question. The complete questionnaire, including unstratified results, can be found in Appendix A, Table A1. Not every participant was asked all 15 questions. A total of 85 participants answered the ninth question by saying that they would not be willing to use an AMaaS service. The specific questions that followed were, therefore, not relevant to them; they were taken directly to the last question. In addition to the answers, Pollfish provides numerous characteristics of the participants. In addition to exact information about response times and durations to each question, the following information is also provided for each participant: Gender, age, year of birth, ethnicity, languages spoken, education level, marital status, number of children, income, employment status, career status, professional position, number of employees in the company, country, state, zip code, city, mobile network operator, mobile phone manufacturer, and mobile OS. The full demographics of the audience can be seen in Appendix B.

3.2. Data Collection

Primary data collection was carried out using a mobile cross-sectional survey through Pollfish. Pollfish enables app developers to monetize their apps. Survey participants are not rewarded directly in monetary terms but instead have the opportunity to access the desired premium function free of charge when using one of the more than 120,000 partner apps by participating in the survey [32]. This method is also known as random device engagement, or RDE for short, with organic samples [33]. Pollfish also claims that it uses

artificial intelligence to identify and filter out fraudulent information [34]. This method of primary data collection, therefore, has numerous advantages. On the one hand, it is one of the fastest forms of data collection. In addition, this method is 75 to 90% cheaper than other comparable methods of data collection, such as random digit dialing, in which people are called at random, or online panels relying on recruiting or assisted crowdsourcing relying on social networks [33,35]. According to its own information, Pollfish has a very wide reach worldwide, with over 3.2 billion consumers as of March 2024 [34]. Summarized, this makes this method comparatively fast, flexible, and cost-efficient. Nevertheless, this method also has a disadvantage. The disadvantage of the survey method is that not every member of the population has the same chance of participating, so the selection is not considered to be random. Therefore, only limited statements can be made about the entire population [36]. However, this problem exists with almost all modern sampling methods, and Pollfish counteracts this by subsequently stratifying the data [37].

Pollfish has been used for a variety of studies that have been published in various journals [38–41]. In addition to being used for publishing in journals, Pollfish is also regularly used for publishing academic books [42,43]. Pollfish also provides post-stratified data. The survey results are subsequently weighted more precisely according to their socio-demographic distribution in the German population and according to age and gender. It is, therefore, an adjustment weighting [44]. The basis for the weighting is the Eurostat census from 2011 [45]. However, only unstratified data were used for the calculations in this article. A survey was carried out with 400 people aged 18 years or older. This is higher than the 95% confidence interval for a population of around 70.1 million Germans aged 18 or older [46,47]. The 95% confidence interval is widespread internationally and is also used in representative health studies [48,49]. The 95% interval has been the scientific standard since the 1880s and represents a compromise between the specificity of the interval and the risk of being wrong [50].

3.3. Data Analysis

The statistical analysis of the survey results was carried out using the paid web-based software DATAtab (<https://datatab.net/statistics-software>, (accessed on 24 January 2024)) with the version as of 24 January 2024. With the help of this software, extensive analyses and evaluations can be carried out. It enables the efficient statistical evaluation of large amounts of data in a short time. DATAtab has already been used in numerous internationally published studies and scientific books in a wide range of disciplines, from IT and finance to medicine [51–54].

The willingness to use an AMaaS service is nominally scaled with two characteristics. Either someone is willing to use it, or they are not. The same goes for being willing to give up your own car. The variables are, therefore, dichotomous, which is why a binary logistic regression analysis must be carried out. Logistic regression analysis is today the most important form of problem analysis for categorical responses [55]. Binary logistic regression analysis is used for numerous subject areas that affect us in everyday life, from credit scoring to medical research [56,57]. Several factors should be examined to determine the influence they have on the willingness to use an AMaaS offer. The basic formula in the style of Weisburd et al. looks like the following [58]:

$$\text{logit}(p) = b_0 + b_1x_1 + b_2x_2 + \dots + b_Nx_N \quad (1)$$

where

p—Probability that someone is willing to use an AMaaS-Offer

b_0 —Intercept (also called constant)

N—Number of independent variable

b_N —Coefficient

x_N —Independent variable

The dependent variable, *willingness_to_use*, was measured in question nine. People who answered “yes” or “it depends” were assigned the *yes* attribute. Since the specified answers to “it depends” gave particular reasons, such as security and other properties of the respective service, a general willingness to use is assumed. All others were assigned attribute *no*. All available and statistically meaningful attributes were then examined for their significance. These include the following attributes: *Gender*, *age*, *income*, *Driving_license*, *Car_available*, *Average_kilometres_driven*, *Prefers_public_transport*, *Education*, *Married*, *Place_of_residence*, *Public_transport_quality*, *Number_of_children*, *Mostly_car_usage?*, *Employment_status*, *Commute*, *Usage_time_public_transport*. In order to obtain the regression formula with the best possible prediction performance, the attributes were examined for their influence on the so-called area under the curve, or the AUC value for short, of the receiver operating characteristic curve, or the ROC curve for short [59]. A receiver operating characteristics graph measures and represents the performance of a classifier. It comes from the field of machine learning and helps to select the optimal variables. The ROC shows the relationship between sensitivity and specificity. The area under the curve then measures how well the formula performs overall. Typically, the value is between 0.5 and one. The closer the value is to one, the better the performance [60]. The attributes *Married*, *Income*, *Average_kilometres_driven*, and *Prefers_public_transport* had no influence on the AUC value. The attributes *Commute* and *Education* had a negative influence on the AUC value. The highest AUC value of 0.786 was therefore achieved when the following attributes were taken into account: *Gender female*, *Age*, *Driving_license yes*, *Car_available yes*, *Place_of_residence small_town*, *Place_of_residence large_city*, *Place_of_residence medium-sized_city*, *Public_transport_quality*, *Number_of_children*, *Mostly_car_usage? Yes*, *Employment_status employed*, *Area Rheinland-Pfalz*, *Area Baden-Wuerttemberg*, *Area Land Berlin*, *Area Saxony*, *Area North Rhine-Westphalia*, *Area Hesse*, *Area Bavaria*, *Area Lower Saxony*, *Area Saarland*, *Area Saxony-Anhalt*, *Area Thuringia*, *Area Schleswig-Holstein*, *Area Mecklenburg-Vorpommern*, *Area Free and Hanseatic City of Hamburg*, *Area Brandenburg*, *Area Bremen*, *Usage_time_public_transport*.

4. Results

4.1. Audience Demographics and Significance

The following Table 1 is a summary of the most important attributes and an overview of the tests of significance carried out with their associated results.

Table 1. Overview of statistical tests carried out and their results; whether distributions of the attributes of the sample differ significantly compared to the expected distribution in the overall German population.

Attribute	Test	Result	Test Suggestions
<i>Gender</i>	Chi2 Test	$\chi^2(1) = 0.75$, $p = 0.385$	No significant deviation from the population
<i>Age</i>	Kolmogorov–Smirnov	Statistics = 0.07, $p = 0.021$	Significant deviation from a normal distribution
	Kolmogorov–Smirnov (Lilliefors Corr.)	Statistics = 0.07, $p = <0.001$	Significant deviation from a normal distribution
	Shapiro–Wilk	Statistics = 0.96, $p = <0.001$	Significant deviation from a normal distribution
	Anderson–Darling	Statistics = 3.84, $p = <0.001$	Significant deviation from a normal distribution
	One-Sample Wilcoxon Test	$W = 38645$, $z = -0.063$, $p = 0.529$	No significant deviation from the population
<i>Employment_status</i>	Chi2 Test	$\chi^2(1) = 0.1$, $p = 0.752$	No significant deviation from the population
<i>Married</i>	Chi2 Test	$\chi^2(1) = 14.75$, $p = <0.001$	Significant deviation from the population
<i>Area</i>	Chi2 Test	$\chi^2(15) = 13.25$, $p = 0.583$	No significant deviation from the population

The chi-square test has several requirements that must be met in order to use it correctly. The observations must be independent. This means that the selection or outcome

of one observation has no influence on the selection or outcome of another observation. The data must be categorical. The chi-square test is applied to nominal or ordinal data, not metric (continuous) data. Each cell in the contingency table should have an expected frequency of at least five [61]. These requirements were met in all of the chi-square tests carried out.

Participants in the survey were 51% male and 49% female. In the total German population at the end of 2022, the proportion of women aged 18 or older was 51%, and the proportion of men was 48% [62]. A chi-square test was carried out using the statistics program DATAtab to check whether the observed gender distributions in the sample deviated significantly from the expected distributions in the German population. The chi-square statistic (Chi2) of 0.75 is the calculated value of the test statistic. The p -value ($p = 0.385$) is the measure of the statistical significance of the test. A p -value greater than 0.05 indicates that the observed data do not deviate significantly from the expected distribution. In this case, the p -value is greater than 0.05, which means that the null hypothesis (the observed values of the variable “Gender” correspond to the expected distribution) cannot be rejected. In summary, the sample does not deviate significantly from the expected gender distribution in the overall population.

The mean age of all survey participants is 45.31. Four tests for the normal distribution of the sample were carried out via DATAtab. The Kolmogorov–Smirnov, Kolmogorov–Smirnov (Lilliefors Corr.), Shapiro–Wilk, and Anderson–Darling tests all resulted in p -values significantly smaller than the usual significance level of 0.05. This means that it can be said with a high probability that the data are not normally distributed. In further analysis of the age data, non-parametric tests must therefore be used [63]. The mean age of Germans was 44.6 years at the end of 2022 [64]. A one-sample Wilcoxon test was carried out using this average age of Germans. A p -value of 0.529 was obtained, which is above the established significance level of 0.05. Therefore, the one-sample Wilcoxon test result was not significant for the present data, and the null hypothesis was retained. Hence, the sample is assumed to be from a population with a mean of 44.6, $p = 0.529$.

If the participants provided information about their position in the work organization, they were primarily integrated into the non-management staff. Over 13% would rather not provide any information about their position. A total of 9.5% of the participants worked in middle management, and 5% were owners, partners, or chief executive officers.

Overall, two-thirds of participants were employed for wages or self-employed. In order to test whether the distribution of employed and non-employed participants differed significantly from the population, a chi-square test was also carried out. The calculation was complicated by different data on the employment rate, depending on the publishing agency. In addition, the Federal Statistical Office, short DESTATIS, in Germany only publishes employment rates in age groups, which start at 15 to 20. The total number of employed people in Germany was 46.48 million; only people aged 15 and over are taken into account [65]. More current numbers indicate a workforce number in Germany of 46.75 million [66]. Both values differ marginally for this test and have no significant influence on the chi-square test. The number of employed people who are 18 years of age or older was calculated by subtracting the number of employed people from 15 years of age up to and including 17 years of age from the given number of all employed persons [62,67]. If the 0.29 million underage workers are now deducted from the 46.48 million employed, the result is a total of 46.19 million employed people who are 18 years of age or older. If this is now put in relation to the total of 70.1 million Germans who are 18 years of age or older, the employment rate is around 66%. The results of the chi-square test show a chi-square value (Chi2) of 0.1 and a p -value of 0.752. The p -value is the probability value that indicates how likely it is that the observed data were obtained purely by chance if the null hypothesis is true (i.e., there is no difference between the observed and expected data). In this case, the high p -value means that there is no significant difference between the observed employment rate in the sample and the expected rate of 34%. In other words, the data from this survey do not deviate significantly from the expected employment rate.

If the people who did not provide any information about their income are excluded, then the median income is in the salary group between 22 and 44 thousand euros gross income. The median gross income in Germany across the economy as a whole is 40,812 euros per year [68]. The German median gross income is, therefore, also in the median salary group of the sample. Since the data were determined exclusively in salary bands, the significance test here is also of little significance.

Almost half of all participants said they had no children. Around 22% each said they had one child or two children. Only two participants reported having six or more children. Since the Federal Statistical Office records data on children per household and not per resident as in the survey, a significance test cannot be implemented.

Around 40% of all participants stated that they were married. The Federal Statistical Office publishes data on how many residents in Germany are married by age. According to this, 49% of all Germans who are 18 years old or older are married. The null hypothesis (H_0) for this chi-square test is that there is no difference between the observed and expected frequencies, while the alternative hypothesis (H_1) states that there is a difference. The test statistic (χ^2) is 14.75, and the p -value is less than 0.001. In this case, the p -value is less than 0.05, which means that there is statistically significant evidence that the proportion of married people in this sample is significantly different from the expected proportion. Therefore, the null hypothesis is rejected, and it is concluded that there is a significant difference between the proportion of married people in the sample and the expected proportion. However, it must be taken into account that almost 60% of the participants stated that they were married or lived with their partner. Although the Federal Statistical Office collects data on civil partnerships, these are not published according to years of life.

Four percent of the participants were post-graduates, and around 18% had a university degree. Exactly 40% of the participants have a degree from a vocational or technical college. The most commonly used channel to take part in the survey was the cell phone. Just over a quarter of all participants took part in the survey using an Android phone, and just over 28% took part via an Apple cell phone. A total of 44% of participants took part via the web.

There were participants in the survey from every federal state. Since dedicated data for the population distribution by the federal state are available, a chi-square test was also carried out for the distribution of sample participants by the federal state [69]. The chi-square test, in this case, has a test statistic of 13.25 with 15 degrees of freedom. The p -value is 0.583. A p -value greater than 0.05 indicates that there is no significant difference between the observed and expected data. Therefore, the null hypothesis cannot be rejected because the observed distribution of the population in the sample corresponds to the expected distribution in the federal states. In order for the chi-square test to be mathematically meaningful, one vote with “unknown” was removed from the calculation.

Pollfish also provides data on the number of employees related to the participants' respective jobs. Around a quarter of the participants stated that they did not work or preferred not to provide any information. A tenth of the participants worked for large companies with more than 5000 employees. The remaining participants work for smaller companies, although no particular size stands out.

4.2. Factors Influencing the Willingness to Use AMaaS

A binary logistic regression analysis was performed to examine the influence of *Gender female*, *Age*, *Driving_license yes*, *Car_available yes*, *Place_of_residence small_town*, *Place_of_residence large_city*, *Place_of_residence medium-sized_city*, *Public_transport_quality*, *Number_of_children*, *Mostly_car_usage? Yes*, *employment_status employed*, *Area Rheinland-Pfalz*, *Area Baden-Wuerttemberg*, *Area Land Berlin*, *Area Saxony*, *Area North Rhine-Westphalia*, *Area Hesse*, *Area Bavaria*, *Area Lower Saxony*, *Area Saarland*, *Area Saxony-Anhalt*, *Area Thuringia*, *Area Schleswig-Holstein*, *Area Mecklenburg-Western Pomerania*, *Area Free and Hanseatic City of Hamburg*, *Area Brandenburg*, *Area Bremen* and *Usage_time_public_transport* for the variable *Willingness_to_use* and to predict the value “yes”. The full results can be seen in the following Table 2.

Table 2. Results of the binary logistic regression analysis, which looks at how the predictors influence the likelihood of the willingness to use an AMaaS offer with significant *p* values highlighted.

	Coefficient	Standard Error	z	<i>p</i>	Odds Ratio	95% Conf. Interval
Constant	23.66	38,156.83	0	1	18,839,415,659.06	0–Infinity
Gender female	−0.25	0.29	0.87	0.385	0.78	0.44–1.38
Age	−0.02	0.01	2.37	0.018	0.98	0.96–1
Driving_license yes	1.15	0.51	2.27	0.023	3.17	1.17–8.58
Car_available yes	0.52	0.49	1.06	0.291	1.68	0.64–4.37
Place_of_residence small_town	−0.31	0.41	0.76	0.445	0.73	0.33–1.63
Place_of_residence large_city	0.57	0.5	1.13	0.259	1.76	0.66–4.73
Place_of_residence medium-sized_city	−0.29	0.43	0.68	0.498	0.75	0.32–1.73
Public_transport_quality	−0.31	0.11	2.81	0.005	0.73	0.59–0.91
Number_of_children	−0.22	0.13	1.71	0.087	0.8	0.62–1.03
Mostly_car_usage? yes	0.35	0.34	1.04	0.301	1.42	0.73–2.74
Employment_status employed	0.44	0.32	1.4	0.161	1.56	0.84–2.9
Area Rheinland-Pfalz	−21.48	38,156.83	0	1	0	0–Infinity
Area Baden-Wuerttemberg	−22.39	38,156.83	0	1	0	0–Infinity
Area Land Berlin	−23.57	38,156.83	0	1	0	0–Infinity
Area Saxony	−21.02	38,156.83	0	1	0	0–Infinity
Area North Rhine-Westphalia	−22.37	38,156.83	0	1	0	0–Infinity
Area Hesse	−21.56	38,156.83	0	1	0	0–Infinity
Area Bavaria	−22.28	38,156.83	0	1	0	0–Infinity
Area Lower Saxony	−21.85	38,156.83	0	1	0	0–Infinity
Area Saarland	−22.13	38,156.83	0	1	0	0–Infinity
Area Saxony-Anhalt	−21.79	38,156.83	0	1	0	0–Infinity
Area Thuringia	−21.68	38,156.83	0	1	0	0–Infinity
Area Schleswig-Holstein	−20.91	38,156.83	0	1	0	0–Infinity
Area Mecklenburg-Vorpommern	−0.9	40,697.91	0	1	0.41	0–Infinity
Area Free and Hanseatic City of Hamburg	−1.18	40,367.15	0	1	0.31	0–Infinity
Area Brandenburg	−0.57	40,734.95	0	1	0.56	0–Infinity
Area Bremen	−45.09	41,107.66	0	0.999	0	0–Infinity
Usage_time_public_transport	0.01	0	1.62	0.106	1.01	1–1.01

Logistic regression analysis shows that the model as a whole is significant ($\text{Chi}^2(28) = 77.19$, $p < 0.001$, $n = 400$). As described above, all selected variables have a positive influence on the quality of the model in the form of the AUC value. However, only three variables turned out to be statistically significant.

The coefficient for the *age* variable is $b = -0.02$ and is therefore negative. This means that an increase in *age* is associated with a decrease in the probability that the dependent variable is “yes”. The *p*-value of 0.018 shows that this influence is statistically significant. The odds ratio of 0.98 means that a one-unit increase in the variable *age* increases the

probability that the dependent variable is “yes” by 0.98 times. This means that younger people, in particular, are more willing to use an AMaaS service.

The coefficient for the *driving_license yes* variable is $b = 1.15$ and is therefore positive. This means that if the value of the *driving_license* variable is *yes*, the probability that the dependent variable is “yes” increases. The p -value of 0.023 shows that this influence is statistically significant. The odds ratio of 3.17 means that if the *driving_license* variable is *yes*, the probability of the dependent variable being *yes* is increased by 3.17 times. In this case, the chances that people with a driving license will be willing to use AMaaS increase by about 217% compared to people without a driving license. In other words, people with a driving license are more likely to use autonomous mobility compared to people without a driving license.

The coefficient for the variable *Public_transport_quality* is $b = -0.31$ and is therefore negative. This was asked in question eight. The lower the value, the better the quality of public transport was assessed. The negative coefficient $b = -0.31$ for *Public_transport_quality* indicates that as the quality of public transport improves (i.e., lower values for this variable), the probability that someone is willing to use an AMaaS increases. The p -value of 0.005 confirms that this relationship is statistically significant. The odds ratio of 0.73 means that if the quality of public transport worsens by one unit, the odds of the dependent variable being “yes” are 0.73 times the previous value. Since lower values for *Public_transport_quality* mean higher quality, improving the quality (i.e., decreasing the value) would actually lead to an increased probability of using the AMaaS. In other words, higher public transport quality (lower *Public_transport_quality* values) leads to a higher willingness to use an AMaaS service.

5. Discussion

The present study examines the willingness to use autonomous mobility services (AMaaS) in Germany and identifies age, possession of a driving license, and the quality of public transport as significant predictors. However, this study also showed that marital status, income, average kilometers driven, preferred means of transport, commuting behavior, level of education, gender, availability of a car, place of residence (small town, large city, medium-sized city), number of children, employment status, regions in Germany, and duration of use of public transport had no significant influence on the willingness to use AMaaS. Compared to previous studies, there were some similarities and differences. Liljamo et al. found in their study that younger people and women are more likely to do without their own car, but education level and place of residence have little influence on this. These results are partially consistent with the results of this study, which also found that younger people are more willing to use AMaaS. Gender, however, had no significant influence on the general willingness to use it. Another study by Barbour et al. examined the willingness of respondents to use autonomous mobility services. They found that people who live near stores and have been in a car accident are more likely to use an autonomous mobility option. In contrast, respondents from households with two or fewer people, Caucasians, and people who commute 45 min or more daily and do not spend much time looking for a parking space are less likely to use an AMaaS service. These results differ from those of this study, which found no significant influence of commute or place of residence on willingness to use AMaaS. However, the time spent looking for a parking space, proximity to shops, and previous car accidents were not part of this study. Overall, these results complement the existing literature by providing further insights into the factors that influence willingness to use AMaaS, focused on Germany. They also provide valuable information for developing targeted strategies for implementing AMaaS in order to maximize market penetration and acceptance in Germany. These results show that younger people may be more open to new technologies and that having a driver’s license may imply a higher affinity for mobility solutions. The fact that the high quality of public transport increases the willingness to use AMaaS could indicate that people with access to efficient transport systems appreciate it when they always have the option to

switch to alternative forms of mobility. This overall highlights the importance of integrating AMaaS into existing transport networks to create a complementary relationship. The results suggest that targeted strategies for implementing AMaaS should consider demographic and infrastructural factors in order to achieve maximum market penetration and acceptance in Germany. In particular, marketing and education initiatives should target younger demographics and driver's license holders while highlighting the benefits of AMaaS. Future research could focus on examining the psychological and social factors that influence AMaaS adoption, as well as assessing the long-term effects of AMaaS on transportation behavior and urban planning. This study provides key insights for policymakers, urban planners, and companies involved in the development and deployment of AMaaS services and contributes to understanding how autonomous vehicle technologies could transform the mobility landscape.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study by Pollfish.

Data Availability Statement: Publicly available datasets were analyzed in this study. These data can be found here: <https://www.pollfish.com/dashboard/results/279830464/655662773> (accessed on 4 April 2024).

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Appendix A

Table A1. Overview of all questions and actual, non-stratified results of the complete survey translated from German to English.

Question (Type)	Answer Options	Result
Q1 Which term best describes where you live? (Single-selection)	A1—Large city (at least 100,000 inhabitants)	A1—25.75%
	A2—Medium-sized city (at least 20,000 to less than 100,000 inhabitants)	A2—30.75%
	A3—Small town (at least 5000 to less than 20,000 inhabitants)	A3—24.00%
	A4—Rural community (less than 5000 inhabitants)	A4—19.50%
Q2 How do you typically get most of your commute when you do not work from home? (Single-selection)	A1—Car	A1—52.00%
	A2—On foot	A2—6.75%
	A3—Bus	A3—7.75%
	A4—Long-distance train (ICE, IC, etc.)	A4—0.50%
	A5—S-Bahn or subway	A5—4.00%
	A6—Regional train	A6—2.50%
	A7—Tram	A7—1.50%
	A8—Taxi	A8—0.00%
	A9—Bicycle	A9—7.25%
	A10—E-scooters	A10—0.00%
	A11—Scooter or moped	A11—0.50%
	A12—I work exclusively from home	A12—4.25%
	A13—I am currently unemployed	A13—10.25%
	A14—Different (Please specify)	A14—2.75% *

Table A1. Cont.

Question (Type)	Answer Options	Result
Q3 Which means of transport do you prefer to use to cover distances in everyday life? (Multiple-selection)	A1—Car	A1—69.00%
	A2—On foot	A2—37.00%
	A3—Bus	A3—16.75%
	A4—Long-distance train (ICE, IC, etc.)	A4—4.75%
	A5—S-Bahn or subway	A5—11.50%
	A6—Regional train	A6—7.50%
	A7—Tram	A7—7.25%
	A8—Taxi	A8—2.50%
	A9—Bicycle	A9—31.00%
	A10—E-scooters	A10—3.50%
	A11—Scooter or moped	A11—2.75%
	A12—Other (Please specify)	A12—0.50% **
	A13—None of the above	A13—0.50%
Q4 Do you currently have a driving license that allows you to drive a car (driver's license class B)? (Single-selection)	A1—Yes	A1—87.50%
	A2—No	A2—12.50%
Q5 Does your household have a car that you can use regularly? (Single-selection)	A1—Yes	A1—86.50%
	A2—No	A2—13.50%
Q6 How many kilometers do you cover on average every day? (Single-selection)	A1—0 to 10 km	A1—32.00%
	A2—Over 10 to 50 km	A2—48.75%
	A3—Over 50 to 100 km	A3—14.75%
	A4—Over 100 to 500 km	A4—0.50%
	A5—Over 500 to 1000 km	A5—0.50%
	A6—Over 1000 km	A6—0.00%
Q7 How much time in minutes do you spend on average per day on working days in local public transport (ÖPNV for short)? (OpenEndedNumerical)		Maximum 70, Upper quartile 30, Median 2.5, Lower quartile 0, Minimum 0
Q8 How would you describe your connection to the public transport network at home? (Single-selection)	A1—Very good: I can easily access various means of transport, and the connections are frequent.	A1—26.00%
	A2—Good: I have access to at least one means of transport, and the connections are sufficient.	A2—31.00%
	A3—Average: I have access, but transportation is not always reliable or frequent.	A3—20.50%
	A4—Bad: There are few connections, and transport is difficult to access.	A4—11.75%
	A5—Very bad: I have little or no access to public transport.	A5—6.50%
	A6—Not applicable: I do not use public transport.	A6—4.25%
Q9 Suppose you had the opportunity to use a service where you could use an app to call a car that would drive up to you fully automatically. The vehicle can then be used as your own or can take you to your planned destination fully automatically. It will then be released to other users. Could you imagine using a service like this? (Single-selection)	A1—Yes	A1—69.00%
	A2—No	A2—21.25%
	A3—It depends (Please specify)	A3—9.75% ***

Table A1. Cont.

Question (Type)	Answer Options	Result
Q10 If you could imagine using such a service, which payment model would you prefer? (Single-selection)	A1—A monthly subscription where I can use the service unlimitedly	A1—27.54%
	A2—A monthly subscription where I can choose different mileage packages	A2—20.29%
	A3—A monthly subscription where I can choose different minute packages	A3—2.90%
	A4—Payment based on the minute	A4—4.35%
	A5—Payment based on kilometers	A5—40.22%
	A6—I would only use the service for free	A6—3.99%
	A7—Other (Please specify)	A7—0.72% ****
Q11 How much would you be willing to pay per month in euros if you had unlimited use of a vehicle? (Single-selection)	A1—Less than 50 euros	A1—25.36%
	A2—More than 50 to 100 euros	A2—45.65%
	A3—More than 100 to 200 euros	A3—18.84%
	A4—More than 200 to 300 euros	A4—6.16%
	A5—More than 300 to 400 euros	A5—2.90%
	A6—More than 400 to 500 euros	A6—1.09%
	A7—More than 500 euros (Please specify)	A7—0.00%
Q12 What qualities would be important to you in such a service? (Multiple-selection)	A1—High-quality, upper-class vehicles	A1—17.75%
	A2—Selection of different vehicles (e.g., small car, middle class, upper class, van, etc.)	A2—57.25%
	A3—Purely electrically powered vehicles	A3—21.74%
	A4—Can be used throughout Germany (e.g., to drive to another city)	A4—61.59%
	A5—International usability (e.g., to go on vacation with the vehicle)	A5—20.29%
	A6—Option to have the vehicle drive you	A6—25.36%
	A7—An all-inclusive price where you do not have to pay based on usage	A7—26.09%
	A8—Other features (Please specify)	A8—0.72% *****
Q13 Would you be willing to give up your own car if such a service with the aforementioned characteristics were available to you? (Single-selection)	A1—Yes	A1—60.87%
	A2—No	A2—23.55%
	A3—I do not have my own car	A3—12.68%
	A4—Only under the following conditions (Please specify)	A4—2.90% *****
Q14 What is the maximum number of minutes you would wait for an autonomous vehicle? (Single-selection)	A1—Less than 5 min	A1—4.35%
	A2—More than 5 to 10 min	A2—39.49%
	A3—More than 10 to 15 min	A3—35.51%
	A4—More than 15 to 20 min	A4—10.14%
	A5—More than 20 to 30 min	A5—7.97%
	A6—More than 30 min (Please specify)	A6—2.54% *****
Q15 Why would you not be willing to use such a service? (Multiple-selection; only if Q9 is “No”)	A1—I do not need a car	A1—15.75%
	A2—I drive my own car	A2—61.00%
	A3—I do not want to share a car	A3—23.00%
	A4—Different reasons (Please specify)	A4—10.50% *****

* Q2 specified answers: 9x “pensioner” and 1x “a mix of the most efficient methods”. ** Q3 specified answers: “overhead railway” and “the easiest situationally”. *** Q9 specified answers: “How expensive and safe it is”, “Cost, safety, and quality”, “This needs to be tested a lot more or made safer”. “If I do not have my own car at the moment and the whole thing is cheap, otherwise, I would use the bike”. “So far, I prefer to drive my car myself. If that is no longer the case, that would be a possibility”. “Above all, I would have to find out more about the safety of such cars, but also about the prices”. “Price”, “The concept sounds sensible, but the implementation would be complicated”, “Whether it is really safe”, “the price”, “Often, too many people”, “If I did not have a car, then yes”. “It would always have to be available”. “How safe and how high are the costs?” “How much does it cost, and how safe is it?” “I am not entirely sure if I would use something like that”. “How much does the fun cost?” “Whether I can also access it on the PC, how much does it cost?” “How in a hurry I am and where I want to go”, “Costs are crucial, as is availability for short-term needs”; “on the costs and insurance coverage”; “price and flexibility”; “It’s all a question of the price and if it would be cheaper than owning a car. However, there is also a safety issue with fully automatic driving without a driver”. “How safe this technology is until then”, “I do not know”, “The price”, “Costs, contractual conditions, reliability”, “price-performance ratio, security, trust”, “How

other people are", "if I need it urgently", "only when I really need it; usually I do not need a car", "How expensive that is". "It is not always possible to get such a service in our area". "It depends on the price and whether it is accessible everywhere". "How reliable the service is", "Price", "It depends on how safe something like this is in terms of driving and not causing a car accident". **** Q10 specified answers: "As part of a public transport ticket", "Mix of everything". ***** Q12 specified answers: "without delay", "fully autonomous even on my construction sites in the forest and fields without public transport connections". ***** Q13 specified answers: "It is always available". "Easy availability, location-independent use", "That I can access a vehicle any time I need the service", "Vehicles are always available", "if the service works on schedule without any delays", "The car must be available quickly and always". "Only if the monthly subscription is very cheap and the car is available to me quickly", "when I no longer have the confidence to drive myself". ***** Q14 specified answers: 2x "60 min". ***** Q15 specified answers: "If it takes too long for the car to arrive or is too expensive", "Not at the moment, but I would definitely try it out and consider the option of switching completely". "I would be willing to use the service, so I have no other option to answer here". "Money problems", "I said I would use the service", "perhaps unreliable", "I do not believe in self-driving cars". "I do not fully trust autonomous driving yet". "Should it be unreliable?" "I would be willing to do that". "I would be ready for that". "If it is expensive", "Other", "too dangerous", "I would like to use a service like this". "Price/Cost", "Would be too expensive", "No", "PROBABLY TOO EXPENSIVE, I COULD NOT AFFORD". "Still uncertain", "Fear of autonomous driving", "Too uncertain how things are going", "Cleanliness of the car", "If it is too expensive", "I did not even say I did not want to use it", "skepticism", "There is no such vehicle", "Unfortunately, often unreliable", "I am willing to use the service even if I have my own car". "too expensive", "Too much exhaust fumes", "I want to save my money", and "I would be willing to use such a service if the price is reasonable". "I would be ready for it", "I am sitting in a wheelchair", "Price", "No". "I am willing to use such a service; I am even very happy!" "I would be willing to use such a service". "WHO said I would NOT use this?????" "I want to be able to choose when I want to use this service, but not give up my own car entirely". "I want to drive the vehicle myself and not have it driven fully automatically".

Appendix B

Overview of audience demographics is provided by Pollfish.

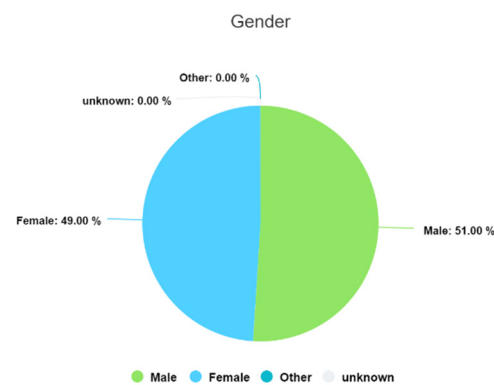


Figure A1. Gender distribution in the audience.

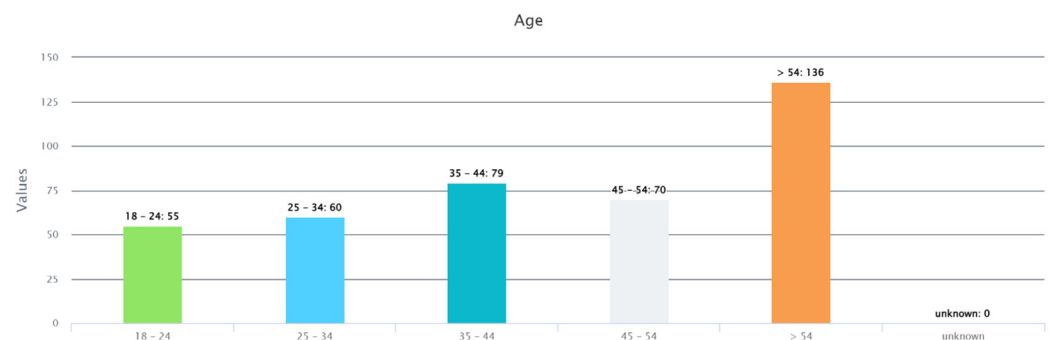


Figure A2. Age distribution in the audience.

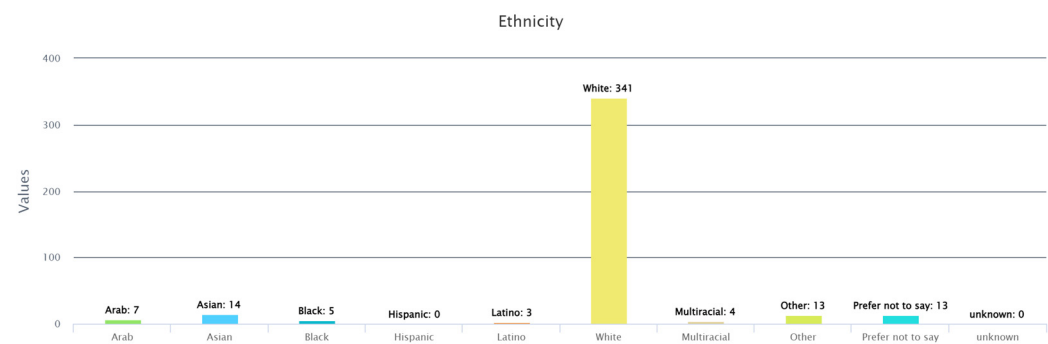


Figure A3. Ethnicity distribution in the audience.

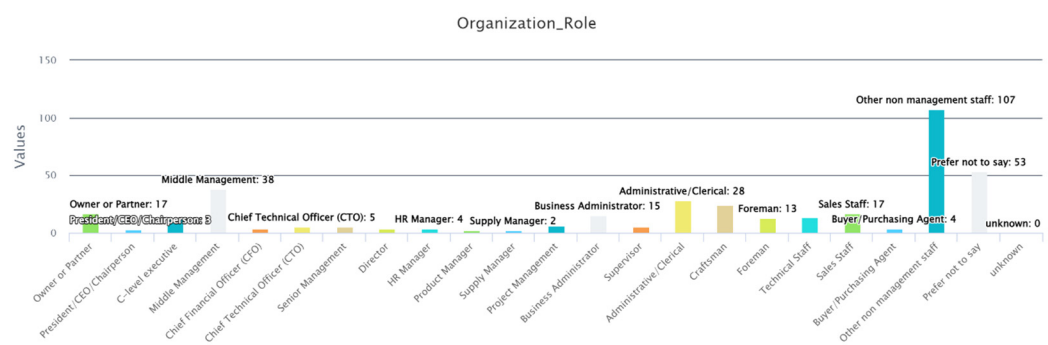


Figure A4. Distribution of organizational roles in the audience.

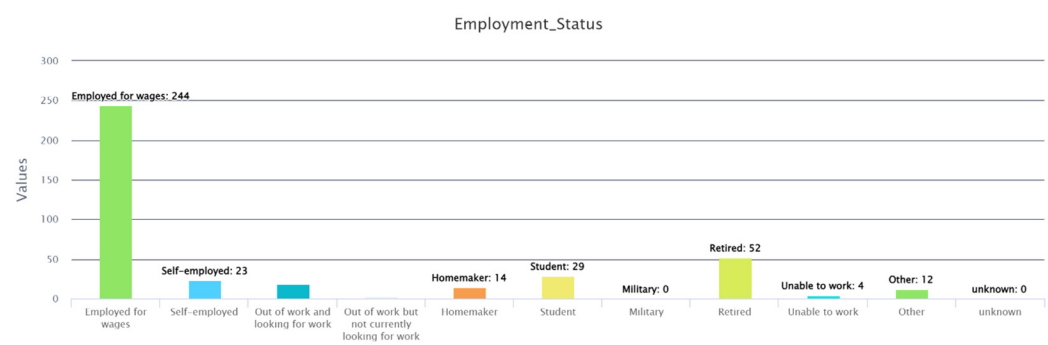


Figure A5. Distribution of employment status in the audience.

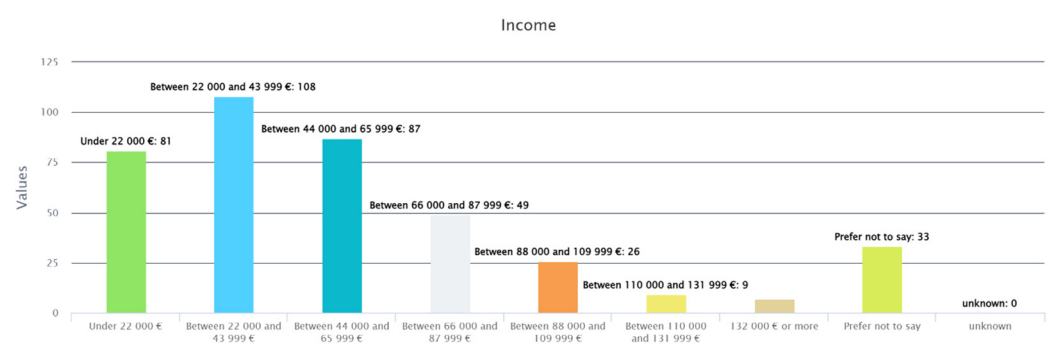


Figure A6. Distribution of income levels in the audience.

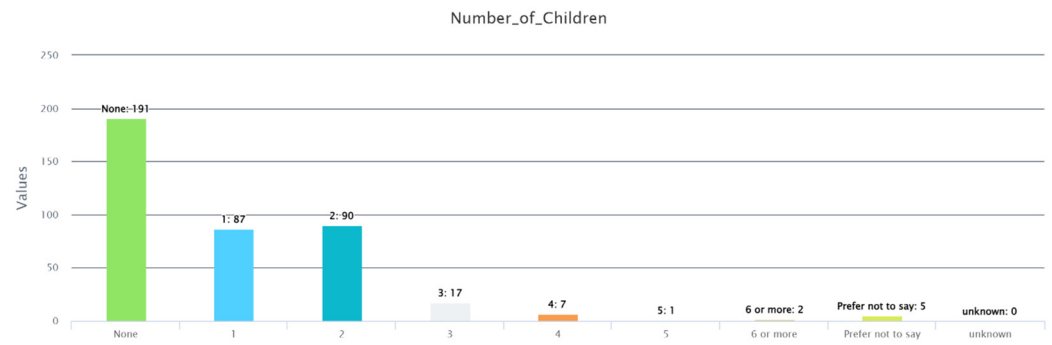


Figure A7. Distribution of the number of children in the audience.

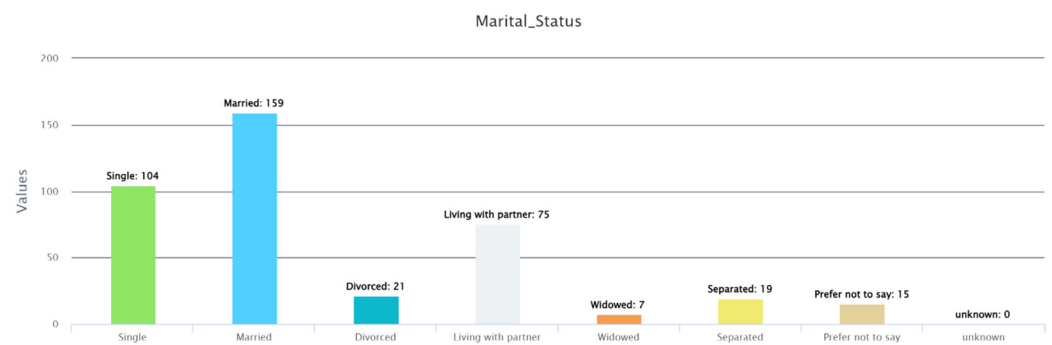


Figure A8. Distribution of the marital status in the audience.

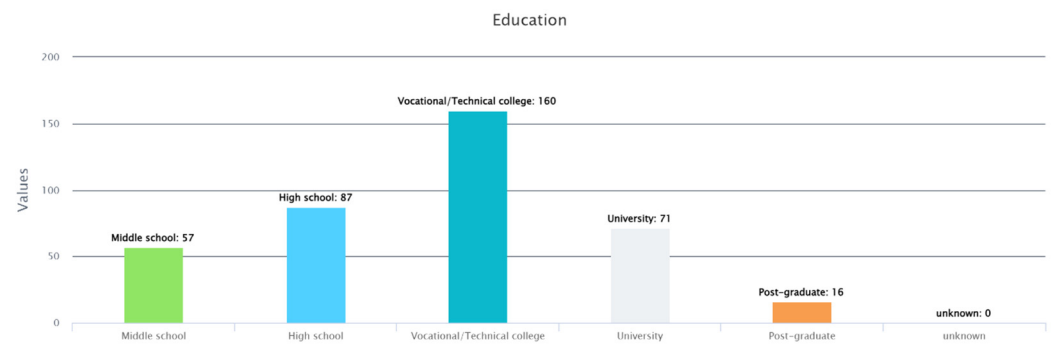


Figure A9. Distribution of the education status in the audience.

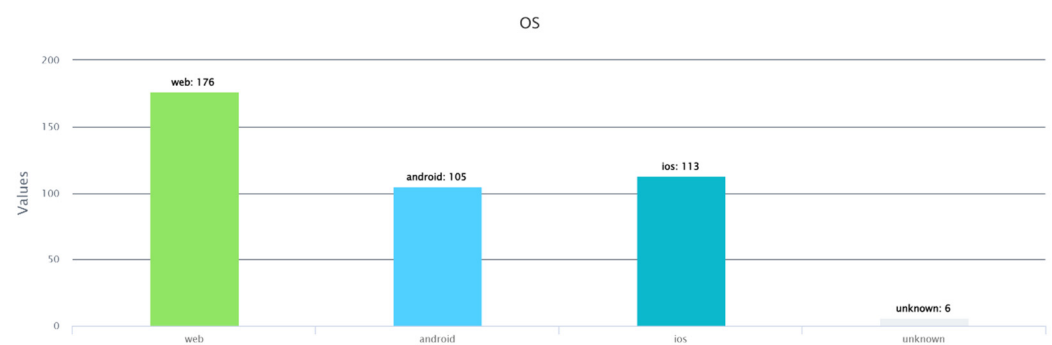


Figure A10. Distribution of the used operating system to the audience.

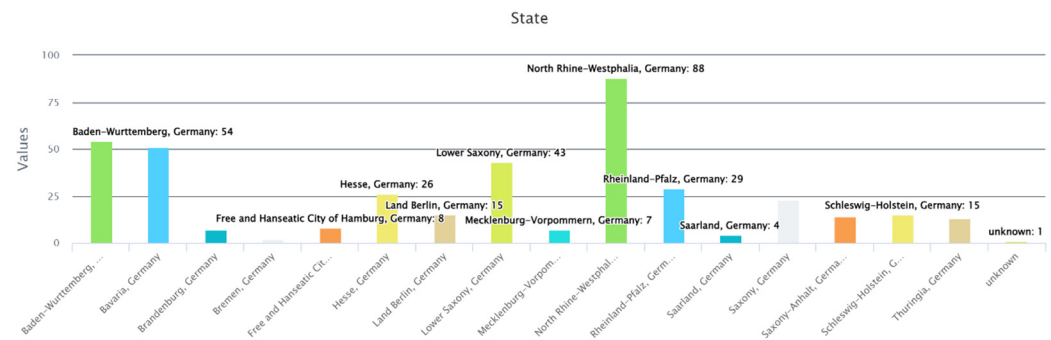


Figure A11. Distribution of the states in the audience.

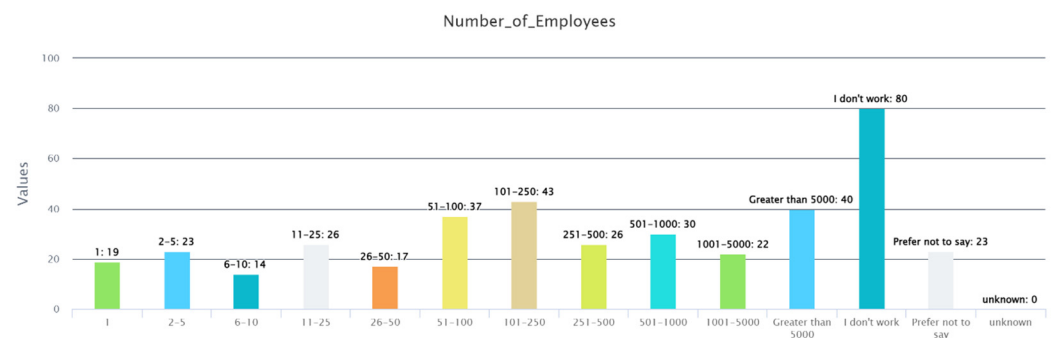


Figure A12. Distribution of the number of the employer's employees in the audience.

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