Ministry of Infrastructure
and Water Management

Promising Groups for Mobility-as-a-Service in the Netherlands

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KiM | Netherlands Institute for Transport Policy Analysis

Contents

Summary

The early adopters of the Mobility-as-a-Service (MaaS) platform will be people with hypermobile lifestyles. Healthy and active young people who use public transport, own folding bikes and are deeply concerned about the environment will use MaaS before older people of limited mobility, in poorer health and with lower income and education levels. These are the findings of a study of latent demand for MaaS. Four indicators were devised to determine a person's relative potential to use MaaS: Tech-savvy, Renting or Sharing, Multimodal, and Travel Information.

MaaS is defined as a transport concept involving the use of a single digital platform to find, book and pay for trips offered by various transport service providers. The platform not only integrates the transport providers, but also the various transport modes. Such integration makes it easier to compare transport modes according to their trip times, costs, comfort levels, environmental impact and other aspects. To extend this definition, MaaS users are also those who have successfully used the MaaS app on multiple occasions to arrange trips via a variety of transport providers and modalities.

On behalf of the Netherlands Ministry of Infrastructure and Water Management's MaaS team, the KiM Netherlands Institute for Transport Policy Analysis conducted research aimed at determining the groups in Dutch society that are most likely to use MaaS in future. This was no easy task however, as we had to contend with a service that is still in its nascent state, and hence we could not directly determine people's interest levels. Consequently, we focused on MaaS's four key characteristics to gauge potential interest in MaaS. To determine how people 'scored' according to these characteristics, we surveyed 1,547 people via a series of 25 statements and questions, with the subsequent findings expressed as a set of four indicators, called the MaaS Potential Index (MPI). A Lasso regression analysis was then used to link the four indicators to the respondents' most relevant personal characteristics. Furthermore, because our respondents had previously participated in the Netherlands Mobility Panel, we had access to substantial amounts of their personal background information.

The four MPI indicators are:
1. **Tech-savvy**: use of and interest in innovative digital technologies;
2. **Renting or Sharing**: use of and interest in renting or sharing mobility;
3. **Multimodal**: a need to take multimodal trips, and
4. **Travel Information**: a need for detailed and up-to-date travel information

The six key characteristics of MaaS's most promising groups are:
1. Young people score higher than older people;
2. People who frequently use public transport score higher than infrequent users;
3. Frequent flyers score higher than infrequent flyers;
4. Higher educated people score higher than lower educated people;
5. People more deeply concerned about the environment score higher than those who are less concerned or unconcerned, and
6. People who frequently take leisure trips – day trips and visits to restaurants/cafes – score higher than people who take fewer leisure trips.

Other factors also corresponding to high MPI scores include high personal incomes; ownership of folding bikes, motorcycles or speed pedelecs; good health; and frequent use of bicycles. By combining these aforementioned personal characteristics, we arrived at the group of MaaS 'innovators' or 'early adopters' who will be young, healthy and active people that use public transport, own folding bikes and are deeply concerned about the environment. Ultimately, the most promising groups will seemingly consist of people with hypermobile lifestyles, and that is certainly an appropriate target group for an app that facilitates trips.

Based solely on this research, KiM is not in a position to make definitive statements about MaaS's expected market share. If, in an early stage, the product is adapted or (intensively) marketed, it could possibly reach people with different profiles and encourage them to also use MaaS. Furthermore, this study only examined the subject from the perspective of the end user ('the consumer'). But should governments and employers intervene, then MaaS's introduction could take a markedly different course.

The profiles of MaaS's more promising and less promising groups clearly differ. The most promising groups or initial MaaS users will likely travel more than average, and their trip distances will also be longer. Consequently, any assessments making comparisons to the 'average Dutch person' would be misguided. Moreover, a consequence of the early adopter group's use of MaaS could well be their shift from public transport use to other transport modes, because their use of public transport is already higher than average and the MaaS platform offers improved access to other transport options. However, this does not necessarily mean that everyone who uses MaaS will also automatically use public transport less frequently.

1 Introduction

Mobility-as-a-Service (MaaS), a multimodal online platform for finding, booking and paying for mobility services, has captured the attention of policymakers, app developers, mobility service providers and researchers. The KiM Netherlands Institute for Transport Policy Analysis initiated a comprehensive research programme aimed at providing greater insights into MaaS. Our programme makes international knowledge accessible and compiles new insights, as derived from questionnaires and other research methods. In our research programme's first stage, we analysed national and international literature and organised focus groups, as reported in Durand et al. (2018) and Harms et al. (2018a; 2018b).

1.1 Research question and framework

Now KiM reports on a follow-up study in which we quantitatively assessed the relative probability of various groups within the Dutch population to adopt MaaS, using data specifically compiled for this research. Our report's research question is: *Which groups within the Dutch population are relatively most likely to use MaaS?*

Our research aim was not to estimate the absolute number of MaaS users in the Netherlands. Nor did we consider the total demand. Rather, our focal point was the relative comparative positions of the various population groups, whereby one group is more likely to use MaaS than another. We do not know who is in and who is out. This made it complicated to assign the groups appropriate labels. Popular categorisations from the diffusion of innovation theory (Rogers 1962) could have been used, with well-known terms like 'innovators', 'early adopters' and 'laggards'. However, it can be that 'early adopters' turn out to be 'the late majority' as the further uptake of MaaS fails (see also Appendix 2). Rogers' adopter categories can therefore only be applied afterward.

In this study we researched the *latent demand for MaaS*, independent of the (future) transport services available in people's communities. Moreover, we summarised the 'MaaS potential' in the MaaS Potential Index (MPI). This potential does not pertain to the supply side transport services or complete business case, as this would require us to determine which areas are most suitable for rolling out certain services or where the most extensive transport services are currently situated. Whether or not the MaaS potential subsequently becomes manifest in practice will depend on the transport services offered.

The target group of this research project is as follows. We restricted ourselves to people residing in the Netherlands. Not included in our research are residents of other (European) countries and the former Dutch Antilles, nor temporary residents of the Netherlands, as certain biases could then emerge at international junctions, tourist attractions and in border regions. We also restricted ourselves to adults, because parents often make decisions and determinations for children and youths (activities, development, allowances, and so forth). Additional research could focus on other parties that might play decisive roles in MaaS's dissemination and acceptance, such as governments or employers (see Chapter 6).

1.2 Reader's guide

In Chapter 2 we present MaaS's principal definitions and introduce the MaaS Potential Index, as devised based on previous KiM research (Harms et al., 2018b). In Chapter 3 we discuss our research method: the design, the conducting of fieldwork among a representative segment of the Dutch population, and the method of analysis. We present our findings in Chapters 4 and 5. Chapter 4 describes the MaaS potential indicators and the information that fed these indicators. In Chapter 5 we link the indicators to the background characteristics of the people involved; a process that reveals the profile of the most promising MaaS users. In Chapter 6 we provide an overview of the study's key insights, discuss our findings, and look ahead to possible next steps.

This report has three appendices. The first appendix presents the questionnaire and survey design, while the second and third appendices focus on the analyses' technical details. We refer to the appendices in the main text when it is pertinent or necessary to do so.

2 Insights from previous studies

Much of the confusion surrounding MaaS stems from its loose definitions. Our report therefore begins with our definition of MaaS: a multimodal online platform for finding, booking and paying for door-to-door trips. MaaS's market potential is inextricably linked to its ability to achieve cost and convenience benefits. This chapter concludes with MaaS's characteristics, which are the foundation of the MaaS Potential Index (MPI).

2.1 What is MaaS?

Mobility-as-a-Service (MaaS) is being experimented with in more and more places around the world, although there are major differences in the types of mobility services being offered. An earlier KiM research study provided both an overview of MaaS initiatives and a framework for classifying them. As shown in Figure 1, MaaS can have four levels of integration: integration of information (Level 1); integration of booking and payments (Level 2); integration of the transport services into subscriptions and bundles (Level 3); and integration of societal goals (Level 4).

Using these levels as references is helpful when comparing MaaS initiatives (Figure 1). While many new initiatives call themselves MaaS, they do not actually extend beyond the offering of travel information (Level 1). KiM consequently proposed to restrict the definition of MaaS to Levels 2, 3 and 4; that is, to those initiatives that at minimum involve the integration of finding, booking and paying for trips (Harms et al., 2018b). Most MaaS transport service providers ultimately aim for Levels 3 or 4, but at present they rarely exceed Level 2.

Figure 1 MaaS typology with levels and examples. Derived from Sochor et al. (2017).

4	**Integration of societal goals** Policies, incentives, etc.
3	**Integration of the service offer** Bundling/subscription, contracts, etc.
2	**Integration of booking & payments** Single trip – find, book and pay
1	**Integration of information** Multimodal travel planner, price information
0	**No integration**

UbiGo, whim, GVH Hannovermobil, smile simply mobile, moovit, Qixxit, Google, Transport for London, lyft, Hertz, sunfleet

Platform services have enjoyed strong growth in recent years, and this is partly why there are such high expectations for MaaS (König et al., 2017; Transport Systems Catapult, 2016). MaaS has been dubbed the *Spotify of Mobility* (ITF, 2015), but this is a rather poor comparison. Spotify – and other streaming services – facilitate unhindered, anonymous and simultaneous use, but such a combination is impossible when making (physical) trips. Moreover, the original conveyors of audio recordings (CDs, LPs), as well as video (DVD, Blu-Ray) and software (CD-ROM), have largely become obsolete in recent years. People are not interested in the disc itself, but rather the music, images or software on it. Audio streaming allows multiple people to simultaneously listen to the same audio recording while maintaining high sound quality. Conversely, taking trips will always require 'carriers', like bicycles or cars, unless science fiction's tele-portation becomes reality. One car can only be rented once at any given time, unless the person shares the car with others, which removes the anonymity aspect while also likely causing some inconvenience. Additionally, the quality of rented goods is always an uncertain factor, as the previous renters may return dirty or damaged goods.

We discuss *the use of MaaS* in various sections of this report, focusing on the successful, targeted and repeated use of a MaaS application (or multiple MaaS apps), including the use of diverse transport modes within a certain time period. It is not enough to simply install an app. In our view, only using MaaS to order a taxi or rent a car does not constitute MaaS usage, although combining these two options does. A (free) membership to a MaaS operator also does not constitute MaaS usage. A MaaS app must be used and utilised structurally, extending beyond the exploratory or trial stage. Here we adhere to Rogers' (2003) definition of the adoption of an innovation, that is, the decision to make full use of the innovation as if it were the most obvious thing to do. The innovation thus comes (partly) at the expense of whatever approach the person took in the (recent) past.

2.2 Added value of MaaS

MaaS's market potential – the number of people actively using a MaaS app within a certain period – largely depends on cost, convenience, choice and customisation, or the 'four C's, as summarised by Harms et al. (2018).

If people clearly benefit from using MaaS and recognise these benefits, MaaS's diffusion among consumers could be rapid. Here, the perceived convenience and cost benefits play greater roles than the actual benefits (Planing, 2014). One potential barrier however is that people are particularly inept at keeping track of how much they spend on personal travel, routinely underestimating the total amounts (Harms et al., 2018a; Turrentine & Kurani, 2007).

We interpret the terms 'freedom of choice' or 'options' broadly. The option to choose between various transport modes is important, as is the option of choosing between various types of passenger cars, bicycles or vans, and although people do not yet have specific uses for these options, the knowledge that such options and their eventual uses exist is often sufficiently compelling for them. However, one must avoid offering wholly irrelevant options, like the car sharing option to a person who does not have a driver's license, as this can denigrate the entire concept for that person. Additionally, people have very different trip patterns and travel needs. MaaS must therefore offer users customised products; this is crucial to promote the use of MaaS.

2.3 What determines the differences in MaaS's potential use among various groups?

In this section we briefly focus on the insights we derived from literature for identifying MaaS's most promising groups. These insights are incorporated in our approach (Chapter 3) and reflected in our findings (Chapter 4). A generic, theoretical starting point is our belief that the group most likely to embrace MaaS can be traced back to that group's need for MaaS's basic features. Because MaaS is still in a nascent state, directly assessing MaaS's potential was not an attractive approach to take in this study.

MaaS is a platform that makes it easier *to take trips*, and hence it is particularly interesting for people who travel (with some regularity) or need to travel and whose trips are generally more complex than simply walking to the nearest street corner. Avid travellers are therefore a more promising MaaS group than hermits. Those with the greatest need for help from a MaaS app will likely be people travelling to unfamiliar destinations (Harms et al., 2018a). From this perspective, the most likely MaaS users will be people who frequently take business trips or city excursions.

MaaS is a *multimodal* platform, a place where different types of transport modes converge in a single interface (MaaSLab, 2018; MuConsult, 2017; Strömberg et al., 2018). As such, MaaS particularly appeals to people who do not want to use the same transport mode for every trip. Consequently, current travel behaviour and certain unmet needs are good starting points. Due to its multimodal character, MaaS is generally expected to attract current public transport users (Jittrapirom et al., 2018), as these people already travel multimodally to catch a bus, tram or train, or to travel onwards from that point. Moreover, the public transport system is unsuited for all trip purposes, destinations and times, and thus public transport users must routinely use a range of transport modes. Public transport passengers are generally already multimodal (Molin et al., 2016).

Rental cars and rental bikes are often part of the multimodal platform, and there is also talk of fully arranged door-to-door trips. MaaS is therefore associated with *a shift from ownership to use* (Jittrapirom et al., 2017; Lyons et al., 2019). On the one hand, the need to own vehicles decreases as easy access to shared and rental vehicles increases, while on the other hand, vehicle ownership implies certain fixed costs that tip the choice process in favour of the transport modes that people own (Sherman, 1967), thereby impeding full use of MaaS (Durand et al., 2018). To temporarily refrain from using one's own car is considered costly (Akerlof, 1995). People who have above-average interest in renting or sharing need to have a vehicle at their location, currently do not have a vehicle or must share a vehicle with other members of their household or social network.

MaaS is a *digital online* platform that people will primarily access via smartphones. Owning and using smartphones or other mobile devices are therefore preconditions to using MaaS, but not all preconditions have necessarily been met: mobile data bundles, effective use of devices, trust in the app suppliers and technology, privacy issues and other factors are also important (Harvey et al., 2019 Pangbourne et al., 2018). Certain socially vulnerable groups, including illiterate or digitally challenged people, are unlikely to adopt MaaS, and such people are presumably also underrepresented in the Netherlands Mobility Panel (MPN) sample that KiM used in this research (see Chapter 3).

MaaS is a *new service*. At present we primarily envision local, temporary and small-scale applications that remain unknown to the larger groups in society (Durand et al., 2018). When it comes to trying or actually regularly using new products or services, not all social groups are equally adventurous, and while this of course differs from service to service, the possibility also exists that more generic personal characteristics could be identified as signifying a person is more receptive to trying something new (Rogers, 2003; Planing, 2014).

Intermezzo: MaaS's market potential

Demand for MaaS in the Netherlands falls outside the scope of this research, but it does directly impact our findings, and hence it is prudent to gain some insights into the demand for MaaS from other studies. How large is the market for MaaS in the Netherlands? At the time of this report's publication, KiM had not previously researched this question.

Based on various international studies, we arrived at a MaaS bandwidth of 0 to 45% for the adult population (ITS Australia, 2018; Caiati et al., 2018; Ratilainen, 2017; Ho et al. 2018; Matyas and Kamargianni, 2018a; 2018b; Transdev, 2017). For the Netherlands specifically, we determined a bandwidth of 0 to 38%. However, it is difficult to compare these findings, because MaaS is interpreted freely, the samples differ by size and region, and the methods used vary considerably.

The Dutch studies revealed the following scenario. Bingen (2017) found that 11% of the Dutch population would use MaaS if the services offered were equal to those offered in the Smile or Ubigo pilots. However, if more services were offered than the ones in those pilots, an additional 17% of the population could be tapped, amounting to a total market share of 28% in this optimistic scenario. Elsewhere, Caiati (2018) – in a sample primarily comprised of adult residents of Amsterdam and Eindhoven – arrived at a total of 0 to 17% of her respondents. Research conducted by TNO and the city of Rotterdam found that 38% of Rotterdam's residents were open to MaaS (De Romph, 2019); the researchers arrived at this percentage via a questionnaire included in a residents' panel, whereby the respondents were shown an (entertaining) video about MaaS and then asked direct questions about their interest. Koopal et al. (2018), applying to the Dutch context coefficients derived from a Ho et al. (2018) study conducted in Sydney, Australia, arrived at a 4 to 22% bandwidth for the Dutch population, as based on a conservative use of MaaS (*pay per use, focus on public transport, no single trips using a shared car permitted*) and a progressive use of MaaS (*extensive bundle, emphasis on cars, but single trips using a shared car permitted*), respectively. The Dutch researchers' intention to replace the Sydney coefficients with estimates for the Netherlands would undoubtedly result in different percentages and bandwidths.

Such sizeable bandwidths stem from the fact that we not only examined diverse studies, but that one study already provided a bandwidth based on a different supply of transport services or different prices. The question here is whether we must account for a higher MaaS usage rate due to lower prices. Moreover, the question remains as to whether it would be cheaper to use a taxi, shared car or bus via the MaaS app or via the companies that provide the relevant services (for example, Uber, Car2GO or NS Dutch Railways). The MaaS platform must also be funded.

We have a few remarks about these studies:
- The studies KiM examined are largely based on *stated preferences*, primarily via a choice experiment. Because the MaaS platform is still in a nascent stage, little or no reliable information was available about MaaS's actual adoption.
- The researchers examined only a slice of the country's entire population (for example, ITS Australia, 2018), and their samples were primarily derived from urban or metropolitan areas (for example, Caiati et al., 2018; Ratilainen, 2017; Ho et al. 2018). In terms of transport services and demand for MaaS, urban areas are generally deemed more promising, but this implies that studies conducted solely in urban areas present overly optimistic estimates of MaaS's potential for an entire country (Kamargianni et al., 2018; Kamargianni et al., 2015). The researchers conducting these studies stated that their findings should not be taken as representative of an entire region or country.
- The sample size was occasionally limited, therefore a 2 to 5% margin of error must be applied to the estimates, in addition to the estimates' degree of uncertainty.

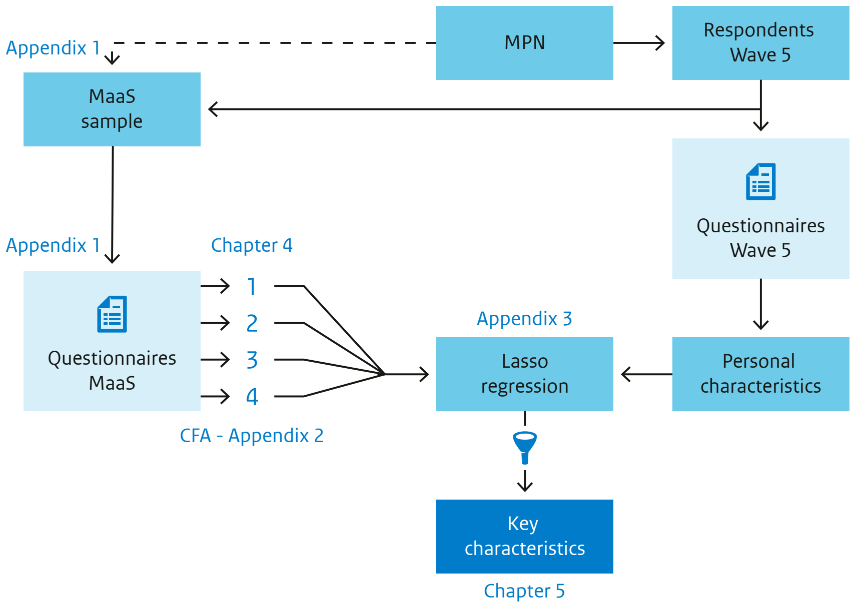
- Numerous studies noted that their samples were skewed (Matyas & Kamargianni, 2018a; 2018b; Ho et al., 2018; Ratilainen, 2017), meaning that one or more groups were overrepresented and others underrepresented. Self-selection could play a role here, meaning that the sample was comprised of people with above-average interest in the product.
- Various studies assume that only bundles are offered (Level 3 in Figure 1), but, according to some studies (ITS Australia, 2018), bundles are a less popular option than paying per use.

Ultimately, all estimates are uncertain. Moreover, three of the four studies conducted in the Dutch context (Caiati et al., 2018; De Romph, 2019; Koopal et al., 2018) are likely biased, as the samples were drawn from urban areas.

3 Research method

To answer this study's research question, KiM distributed a questionnaire among a representative selection of the Dutch population aged 18 and older (n = 1,547). Our questionnaire included statements and questions devised to calculate scores according to the MaaS Potential Index (MPI). Because all respondents to our questionnaire had also participated in the Netherlands Mobility Panel (MPN), we had access to extensive information about their background characteristics. To determine the profiles of the most promising groups, we linked the MPI's four indicators to the respondents' background characteristics via Lasso regression analysis, as depicted in Figure 2.

Figure 2 Flow chart of research process



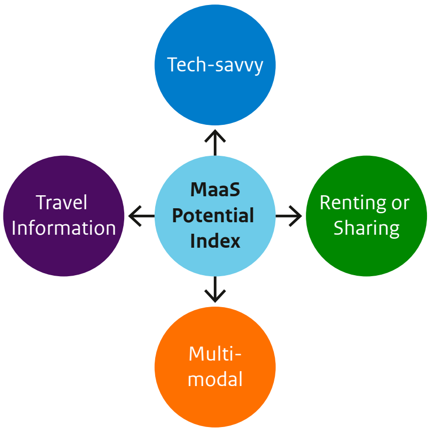
3.1 MaaS Potential Index

Based on Chapter 2's concluding observations, we devised four indicators for determining the relative likelihood that a person would use MaaS:

- The extent to which a person is *Tech-savvy*. By this we mean how interested they are in new technology and its applications, as well as their tendency to be among the first to use new tech-driven products and services. An online digital platform's characteristics and novelty aspect are therefore bundled.
- *Renting or Sharing* in practice or having an interest in doing so. A person's tendency to rent or share transport modes, possibly instead of owning them. At issue here is how much importance a person attaches to owning and using his/her own car and how open they are to alternatives, like car sharing.
- The extent to which a person is or wants to be *Multimodal*. It matters whether a person has experience using public transport and alternating their use of cars, bicycles and public transport, or whether they primarily travel by car.

- Need for *Travel Information*. At issue here is how often a person searches for current (integrated) travel information during and prior to a trip. Use of travel information likely correlates to taking trips or more specifically to taking unfamiliar trips, whereby people are unfamiliar with the various travel options and routes available to them.

Figure 3 MaaS Potential Index (MPI)



We used this conceptual model with four indicators to determine MaaS's relative potential for use among various groups in the Dutch population. These four indicators collectively are called the MaaS Potential Index, or MPI for short (Figure 3). In the following chapter (Chapter 4), we comprehensively detail the statements and questions used for determining the scores according to the indicators.

3.2 Data: questionnaire in the Netherlands Mobility Panel

We devised a questionnaire that served to feed the MPI with relevant data (Appendix 1). Where possible, respondents were asked direct questions about how they use travel information or rent transport modes, for example. In other cases, we instead used statements designed to indicate a person's interests, such as in new products or services. Respondents were presented with six statements aimed at gauging their enthusiasm for opportunities afforded by new technologies, for example. This resulted in a questionnaire with a pre-estimated 12-minutes to complete. Appendix 1 provides an overview of the questionnaire and its statements and questions.

The fieldwork was conducted in the summer of 2018 (from 13 June to 1 July), using the CAWI (Computer-Assisted Web Interviewing) method. The prospective participant – aged 18 and older – received an email explaining the research and containing a unique link to our online questionnaire. Respondents to our questionnaire had also participated in the Netherlands Mobility Panel (MPN), as well as the NIPO base (the Kantar Public internet survey). The MPN, a multi-year research study that has been running since 2013, chronicles the living situations and mobility behaviour of a set group of households and respondents over time, thereby allowing researchers to observe changes in the relationships between travel behaviour and personal and household characteristics, as well as other mobility-influencing factors (for a detailed description, see http://www.kimnet.nl/mobiliteitspanel-nederland and Hoogendoorn-Lanser et al., 2015).

Of the 2,150 prospective participants collectively representing the Dutch population, 1,621 people (approximately 75%) completed the questionnaire – an excellent response rate. However, upon closer inspection, some responses were deemed unreliable (see Appendix 1 for data cleansing criteria and procedures). After cleansing the data set, we found 1,547 respondents suitable for analysis. To bolster the sample's representativeness, we devised weights for each participant based on certain representativeness criteria (Appendix 1).

Given the abovementioned number of observations, we arrived with 95% certainty at a 2% margin of error for each answer in the questionnaire. To illustrate: if we concluded that 46% of respondents answered a question positively, we could surmise with 95% certainty that between 44 and 48% of Dutch adults would answer that question or statement positively, meaning, from a statistical perspective, that we were capable of reaching fairly robust conclusions about the Dutch population aged 18 and older.

Because the MPN is a *household* panel, we generally aimed to engage all household members in the research. For MaaS, looking beyond the level of the individual seemed justified: household members often share vehicles, collectively agree on large investments and jointly manage household budgets (Chapter 5). KiM therefore made it possible for multiple members of one household to participate in the research. However, because we excluded people younger than 18 from our target group, our sample's household compositions are unrepresentative of Dutch households. This was also not the objective. Of the 1,547 selected respondents, 1,058 observations were classified as solo observations: these people were not connected to other people from the same household. The final data set included 414 respondents who were from the same household as one other person, thereby involving 207 households. Those two household members were not always partners, however, as other types of relationships also occurred. The data set included 21 households that provided three observations, and three households appeared four times in the data set. In 175 cases we were certain that a (married/common-law) couple comprised or headed the household, and we subjected these couples to additional analysis.

3.3 Method: statistical analysis and machine-learning technique

The following section focuses on the information used to compile the four indicators that collectively represent the MaaS potential (Chapter 4), while also providing highly insightful descriptive statistics. The aforementioned weights served to continuously correct the slight imbalances in our sample's figures (Appendix 1).

We used a confirmatory factor analysis to arrive at an indicator – or latent variable – from the various statements and questions (Harrington, 2009). Latent variables were always normalised and standardised. The findings have an approximate average of zero and standard deviation of one. Comparing the indicators is easier because they have the same starting point and diffusion. However, this can create the impression that the Netherlands is at a similar stage on all fronts, which is not yet the case, as detailed in the next chapter.

We used a machine-learning technique to arrive at the most relevant selection of background characteristics; namely, a multivariate multiple linear regression analysis with a *Least absolute shrinkage and selection operator* (Lasso). This technique allowed us to link people's background characteristics to the four indicators at once and equally.

The mixed-effects model we used for the final estimates (Hox, 2010) made it easier to calculate the relative importance of the categorical or ordinal variables. Moreover, the model accounted for the fact that our sample occasionally included more than one respondent per household, while the previously mentioned regression model did not. In the literature, this multi-stage approach – a Lasso regression followed by a model of selected variables – is called *Relaxed Lasso* (Meinshausen, 2007); this is explained further in Appendix 3.

4 A better understanding of the indicators

We used four indicators to determine a person's relative MaaS potential. These indicators focused on interest in innovation and technology (Tech-savvy), willingness to rent and share (Rent or Share), extent of a multimodal mindset (Multimodal), and need for travel information (Travel Information). We used multiple leading statements and questions to support the indicators, which collectively form the MaaS Potential Index (MPI).

4.1 Tech-savvy

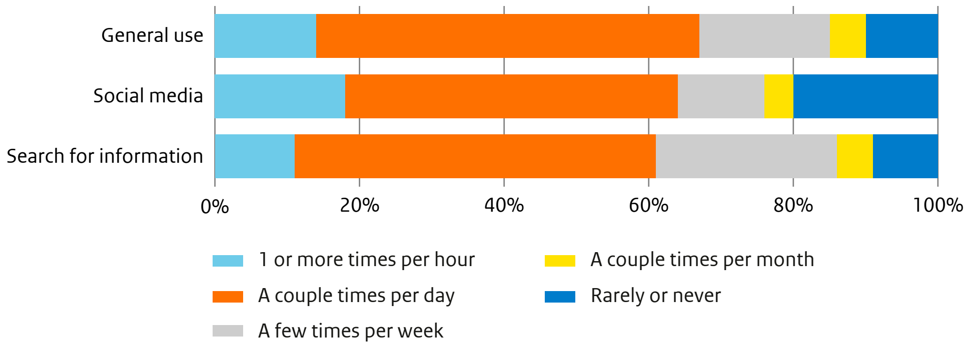
According to our definition, having a smartphone or tablet is a precondition to using MaaS. Our sample reveals that 90% of Dutch adults own smartphones, while some 69% have access to tablets. Approximately two out of every three Dutch adults have both a smartphone and tablet. Conversely, 5% of Dutch adults do not have smartphones or tablets, according to our sample.

Because KiM relied on an internet panel, the information pertaining to people's ownership of smartphones and tablets could have a slightly positive bias. However, recent data from Statistics Netherlands (SN) confirms a similar figure: in 2018, 90% of Dutch people connected to the internet via their telephones (SN Statline, 2018). Generally, the penetration rate in the Netherlands for relatively new, handheld computer devices is extremely high (SN, 2018).

However informative, ownership data about smartphones and tablets alone is insufficient in the context of MaaS potential. Additional preconditions include the availability of mobile internet (Wi-Fi, 4G), the ability to successfully and purposefully operate the devices, and properly functioning devices, with broken screens, dead batteries, ransomware and outdated operating systems obstacles to the latter. Consequently, the statements we devised for the *Tech-savvy* profile focused on the actual use of the devices.

To determine how often people used their smartphones (or tablets), we inquired about the extent to which they searched for information, used social media, and used smartphones or tablets: a majority of Dutch adults stated that they performed these activities daily (Figure 4). Social media had the greatest contrast between frequent and sporadic use: 18% of the people said they used social media one or more times per hour, while 20% said they never used social media. We determined that social media use was largely irrelevant for the MPI, so we excluded it when devising the *Tech-savvy* indicator.

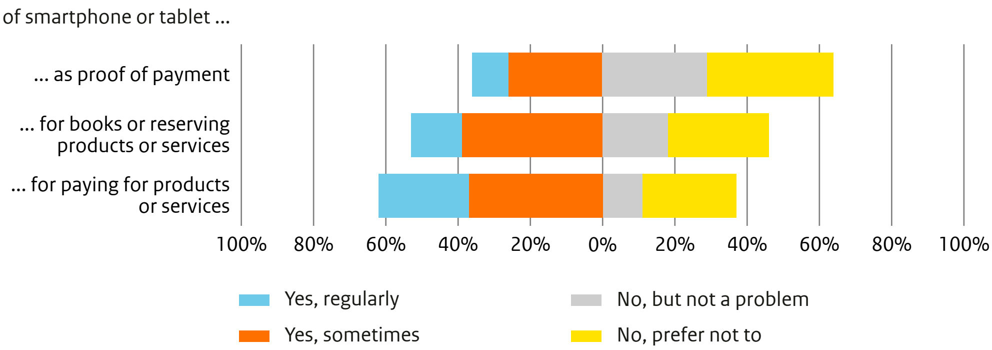
Figure 4 Use of smartphones or tablets for various purposes



People in the Netherlands routinely make payments using mobile devices (Figure 5). Some 25% of Dutch adults said they routinely used their smartphones or tablets to pay for goods and/or services, while an additional 37% said they occasionally did so. Such high percentages are likely due to the rise of internet banking and the availability of payment apps; moreover, some banks, by phasing out other banking options, actively encourage smartphone and tablet use. We note, however, that one quarter of Dutch adults avoid using the internet for banking. Similarly, smartphones or tablets are rarely used for proof of payments (barcodes, QR codes, for example): only 10% of Dutch people said they routinely used mobile devices for proof of payments, while an additional 26% said they occasionally did so.

Notably, in a series of three statements related to mobile device use, making payments scored higher than making bookings or reservations, for which a possible explanation is that making online payments is now virtually fully optimised, while it remains difficult to find desired goods and/or services (Van Deursen & Van Dijk, 2019).

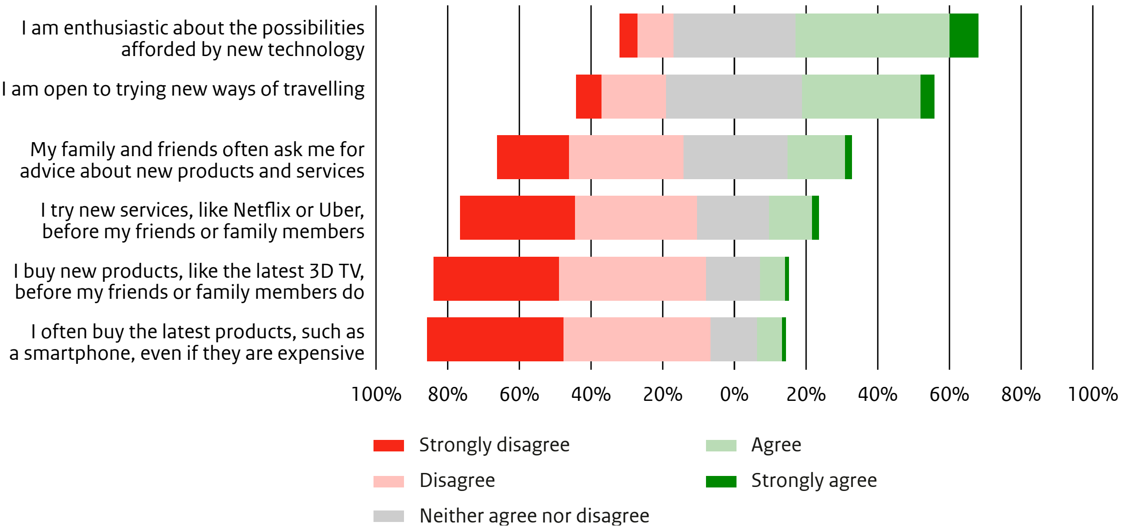
Figure 5 Paying and ordering with mobile devices



Six statements aimed at gauging the respondents' interest in new products and services (Figure 6) produced the most consistent answers in the entire questionnaire. Consistency does not necessarily mean that the respondents gave the same answers, however, but rather that their answers were consistent with one another and did not contradict previous answers. The most divergent responses were to a statement about trying new ways of travelling; those who responded positively to that statement were not necessarily positive about the other statements, and vice versa.

The most positive responses were to a statement about enthusiasm for new technology; a small majority was enthusiastic about 'the possibilities afforded by new technology'. That statement was followed sequentially by a statement about being open to trying new ways of travelling, to which 4% responded extremely positively and another 33% positively. There were clearly more positive than negative responses. Comparatively, the most negative responses pertained to the actual purchasing of new (tech) products. The trying of new services, like Netflix or Uber, had an average score in that series of statements, while only 13% of people said they would try new services before their family or friends.

Figure 6 Statements about new products and services



We used the following statements for the **Tech-savvy** indicator (Appendix 2):
- Five statements about the use of smartphones or tablets;
- Six statements about new technological products or services.

4.2 Renting or sharing instead of owning

MaaS in many respects is about renting or sharing, which can mean renting or sharing bicycles or cars with fellow residents of the area, as well as renting or leasing vehicles. Consequently, analogies are often made to other rental systems, like platforms where people rent tools, clothes and homes. Our questionnaire featured questions about people's use of and interest in eight types of renting in what is called the new sharing or platform economy, although in this context 'sharing' is a misleading term, as the products are paid for, which is in fact renting.

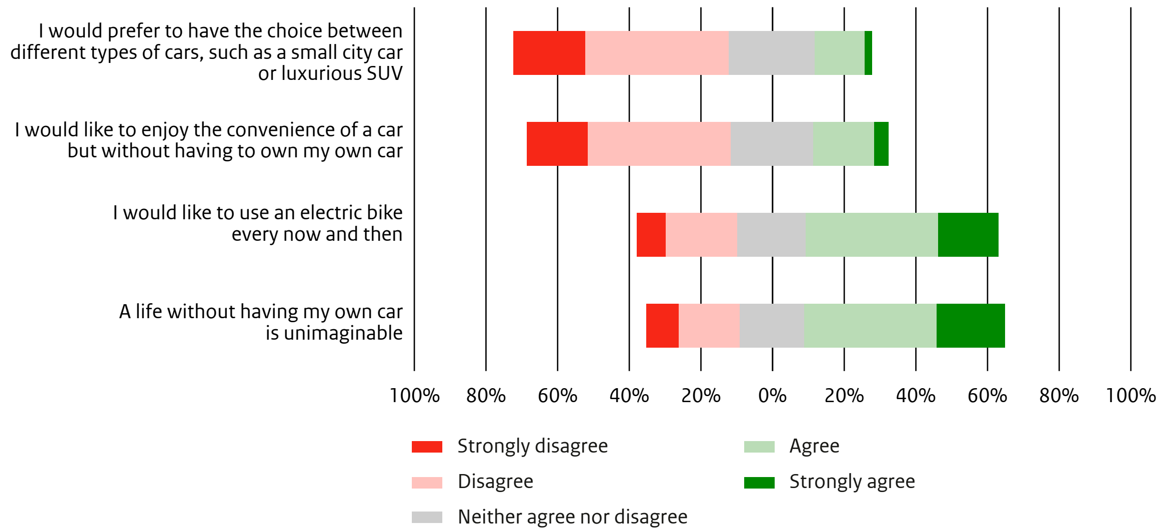
The majority of adults in our sample expressed little interest in renting or sharing cars (Figure 7); some 60% responded negatively to a statement about having a choice between different types of cars, while 57% responded negatively to the statement about enjoying the convenience of a car without having to own one. More people said they strongly agreed with that latter statement than they did with the former statement (3.5% and 1.5%, respectively), yet it is still a very small percentage. Nevertheless, this group in theory would be a particularly promising group for car sharing.

The statement about enjoying the convenience of a car without owning one derives from a previous study conducted in London (Kamargianni et al., 2018), where 48% of car owners responded negatively to that statement and 32% positively. Among Dutch car owners, 62% responded negatively to the statement and 16% positively, which supports the earlier assertion about MaaS likely finding more fertile breeding grounds in urban areas (Chapter 2). Here we have compared a metropolis (London) to an entire country (the Netherlands).

For a majority of respondents, life without owning a car is unimaginable (Figure 7), with 19% strongly agreeing with that statement and 37% agreeing, while virtually all were people who at the time had cars at their disposal. Of the respondent who did not own cars, 32% strongly disagreed with that statement, while just 2% of car owners strongly disagreed.

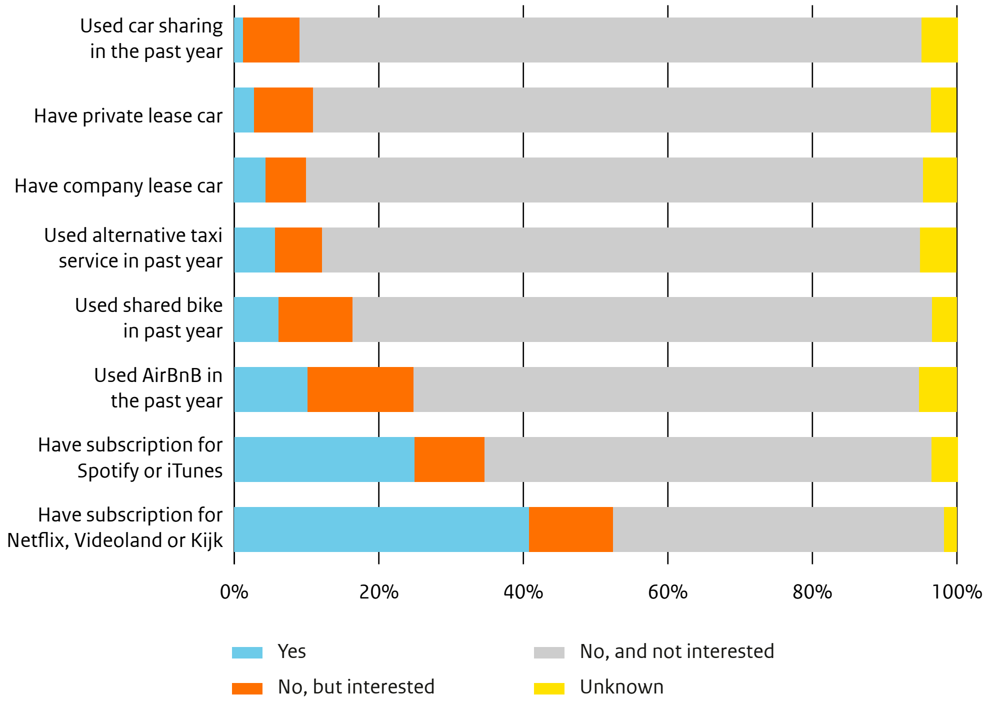
A slight majority of respondents were positive about occasionally using e-bikes (Figure 7), yet more than a quarter said they found no added value in it. That statement, and the previous one, proved largely unuseful in devising the MPI, failing to add any additional information, so they were excluded from the questionnaire.

Figure 7 Statements about interest in renting and the importance of ownership



A good share of respondents expressed interest in using audio or video streaming, including via paid contracts. A relatively large number of people confirmed that they already had subscriptions or were interested in subscriptions (Figure 8). Video is most popular, followed by audio streaming. Renting a temporary lodging via Airbnb is third most popular, with 10% of Dutch adults stating they had done this during the past 12 months, and another 15% expressing interest in doing this. People were much less interested in using other mobility-related services. More than 80% of respondents said they never used such rental, sharing or leasing services, nor were they interested in them. Despite enjoying strong growth in recent years, private leasing and car sharing were only used by 2.7 and 1.2% of respondents, respectively. Shared bikes and alternative taxi services are relatively popular mobility solutions, however: 6% of Dutch adults used these services during the past 12 months. The limited use of 'shared mobility' aligns with the findings of other studies (ITS Australia, 2018; Kamargianni et al., 2015).

Figure 8 Participation in the platform economy



We found virtually no correlation between using music streaming or video services (Spotify, iTunes, Netflix, Videoland, Kijk) and using shared mobility in the form of car sharing, bike sharing or alternative taxi services (see also Chapter 2); on a scale from 0 to 1, the correlation coefficients varied between 0.21 and 0.37. However, the relationship between Airbnb and shared mobility was slightly different: we found a correlation of 0.60 between use of or interest in Airbnb and the use of or interest in alternative taxi services. Some 3% of Dutch adults said they had used both services in the past year, while 65% said they had not used either service and were not interested in using them.

We found a greater overlap between the renting of lodgings and vehicles than between the use of audio or video streaming and renting vehicles. Renting lodgings and vehicles involves a physical experience. Moreover, such rentals rarely transpire anonymously: usually one needs to know who is renting the car or lodging. When devising the MPI, we ultimately omitted the statements about music and video services, as there was no link between online streaming and new mobility.

We used the following statements for the **Rent or Share** indicator (Appendix 2):

- Two statements about the importance of ownership and freedom of choice;
- One question about the use of Airbnb;
- Four questions about renting or sharing mobility.

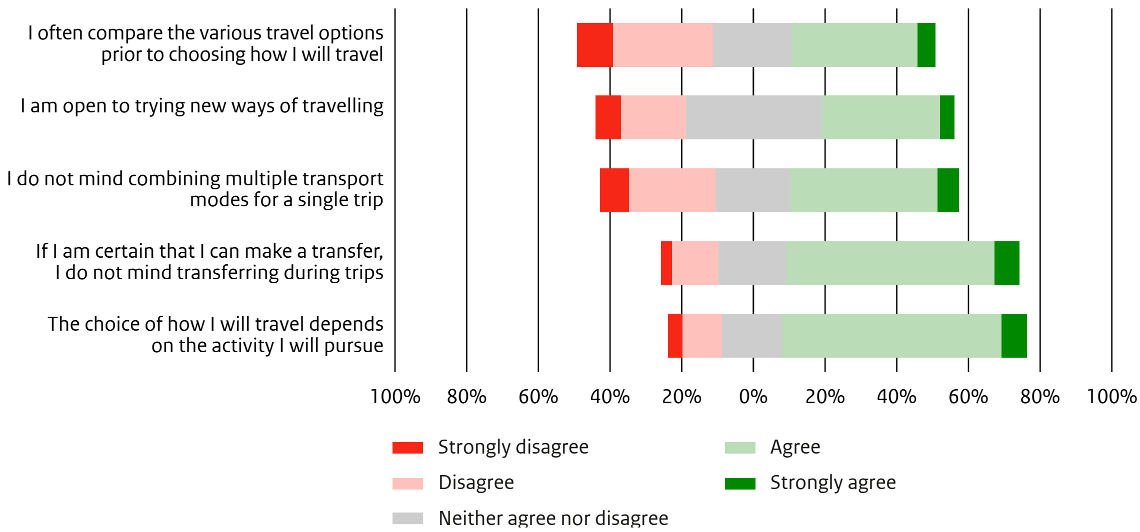
4.3 Varied transport modes: a multimodal mindset?

A multimodal mindset refers to the extent to which a person chooses to use a variety of transport solutions when travelling, and the extent to which they are open to new solutions. A variety of transport modes can be used within a single trip: people can travel via multiple modalities to their destinations, such as travelling by bike, train and then taxi to reach a business meeting. Variation also means using different transport modes within a certain period of time, examples of which would include using multiple transport modes or multiple variations of a particular transport mode (bicycle, e-bike, tandem, cargo bike, folding bike) during a period of one month. Alonso-González et al. (2017) found that people with multimodal travel patterns, using multiple transport modes during a single week, are more likely to use MaaS. This act of combining modes within a single trip is called intermodality or a multimodal trip, and combining them within a certain time period is called multimodal travel behaviour or a multimodal travel pattern (Oostendorp & Gebhardt, 2018). We examine both types.

Approximately one in three Dutch adults confirmed that they were open to trying new ways of travelling (Figure 9); however, compared to other statements, the respondents were the most measured in their responses: 38% said they neither agreed nor disagreed with that statement, although their reservedness here seemingly stemmed from how the statement was formulated, as it perhaps lacked clarity.

More than two out of every three Dutch adults said how they choose to travel depends on the activity they will pursue (Figure 9), thereby indicating that their choices vary according to distance, destination and purpose. Far fewer people said that they actively compared the various travel options before departing.

Figure 9 Statements about the trip differentiation



The respondents were asked about the situations in which they used online travel and route information, with one option being 'to determine which transport mode I will use'. Twelve percent of respondents said the transport mode they chose to use was due to online travel and route information. All other uses of online travel or route information scored higher.

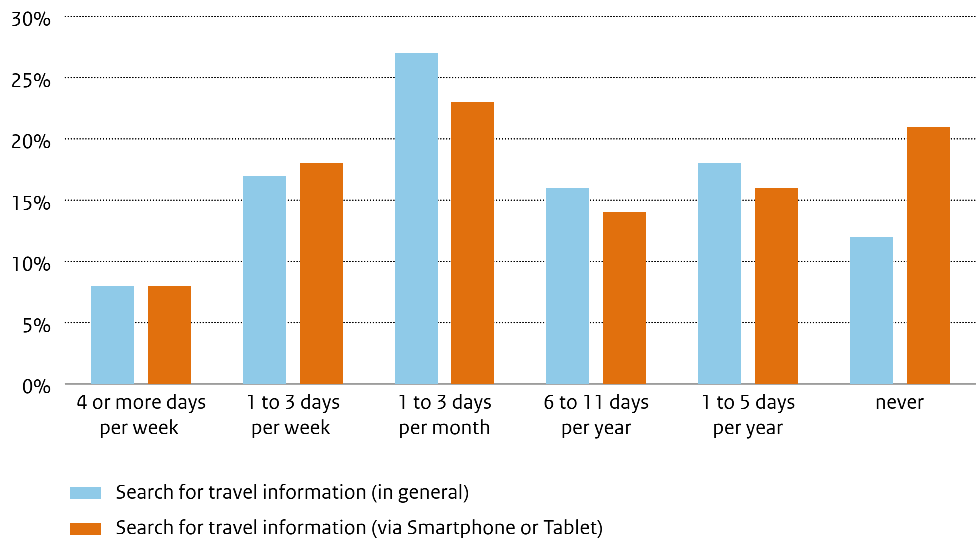
Given these insights, we can cautiously conclude that many people do vary their transport modes, and they do not choose the same transport mode for all their activities. However, this does not necessarily mean that they actively compare travel options prior to departure, and it certainly does not mean that online travel and route information play main roles here.

We used the following statements for the **Multimodal** indicator (Appendix 2):
- One statement about the use of information for determining the choice of transport mode;
- Five statements about variation in ways of travelling.

4.4 Need for travel information

Some 47% of Dutch adults stated that they rarely (less than once a month) used travel information, including traffic information or public transport departure times. Of this slight minority of the Dutch population, we observed that 26% never used travel information, 39% used it less than once every two months, and the remaining 35% used it less than once a month. Conversely, 8% of the Dutch population indicated that they used travel information daily (Figure 10).

Figure 10 Frequency of searching for travel information



For the people who use travel information and have access to smartphones or tablets, these devices are key conduits for compiling information. The frequency of using travel information and the frequency of searching for travel information via smartphones closely correspond: the correlation coefficient is 0.86. Eighty-nine percent of the people who use travel information at least four days per week also use it via smartphones or tablets at least four days per week.

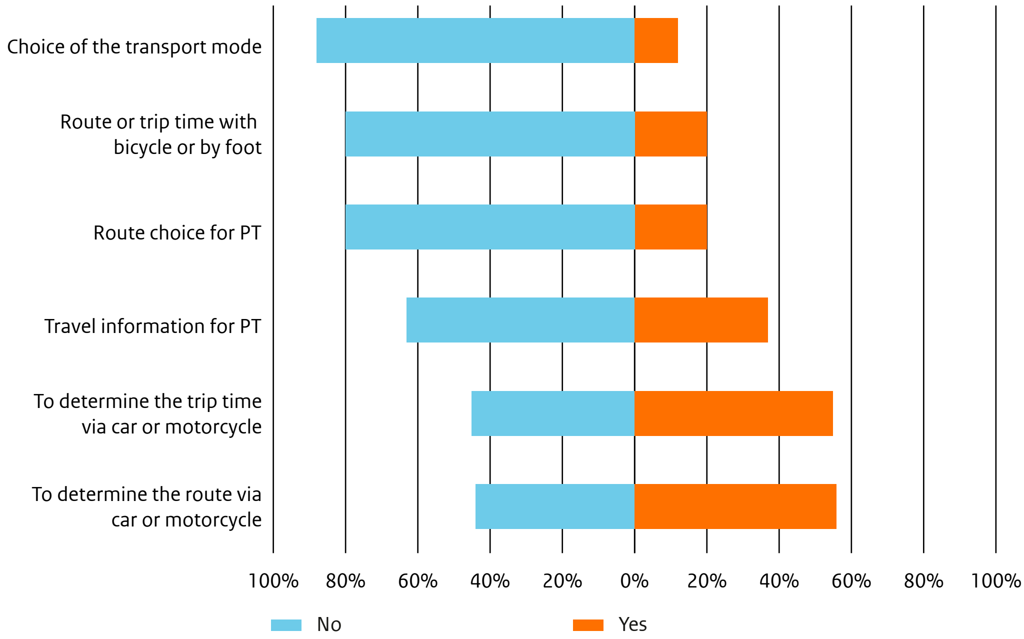
Car and motorcycle route information is by far the most popular of all online travel information (Figure 11), with 56% of Dutch adults stating that they used route information to determine their routes, and 54% indicating that they used route planners to get information about trip times, roadworks, possible delays due to traffic congestion, and alternative routes.

People who use public transport travel information are particularly interested in information about trip times, delays and (current) departure times, with 37% of Dutch adults stating that they occasionally requested such information (Figure 11), and 20% stating that they also used public transport travel information to determine what routes to take via public transport.

Using route information for trips by bicycle, scooter or on foot is less popular: only 20% of Dutch adults searched for such information online (Figure 11), but this could be due to the fact that these transport modes have limited range and people use them locally, where they reside and are generally familiar with the surroundings.

From the perspective of MaaS, and particularly its multimodal character, the most interesting statement in our questionnaire was about the use of trip information to determine transport modes: some 12% of respondents said they currently used online travel information to determine the transport modes they would use (Figure 11), and this was the lowest score of all the possible uses. Exploring possible transport modes (via online information) was also relatively unpopular, scoring poorly in absolute terms. At present, seven out of eight Dutch adults do not use online travel or route information to inform themselves about the most suitable transport modes, and this situation prevails despite MaaS being hailed as the ideal method for comparing transport modes. Approximately 8% of the people in our sample indicated that they were not informed in any way by online travel or route information.

Figure 11 Use of online travel and route information



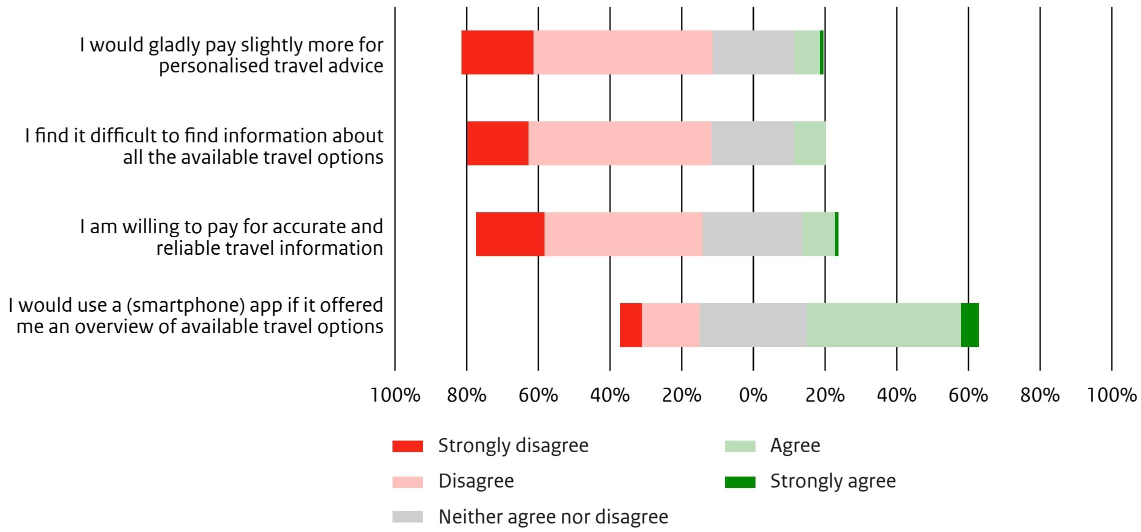
As noted, maps are extremely popular tablet and smartphone apps: 64% of all Dutch adults, and 73% of Dutch adults who own smartphones or tablets, installed a map app, like GoogleMaps or Maps.Me. Such high percentages are perhaps also due to the fact that map apps are pre-installed on many devices prior to purchase. Android devices routinely come with Google apps as standard. Notably, only 41% of Dutch adults had navigation software installed on their smartphones or tablets, but many map apps can also be used for navigation.

Approximately 38% of Dutch adults, or 5.3 million people, have one or more public transport travel info apps installed on their smartphones or tablets. These apps include 9292, NS Xtra, OVinfo and various regional apps for bus, tram or metro (GVB, HTM, etc.). This data roughly corresponds to the number of downloads tracked via Google Play and the App Store.

Statements about travel information elicited predominantly negative responses (Figure 12). Regarding the statements 'I am willing to pay for accurate and reliable travel information', and 'I would gladly pay slightly more for personalised travel advice', we note that less than 1% of people 'strongly agree' and 8% 'agree', meaning that less than 10% of Dutch adults are willing to pay for personalised or accurate travel information. That many people already have access to reams of free information via existing travel apps, as noted above, could play a role here. A third statement revealed that less than 10% of Dutch adults had difficulty finding their desired information; however, owing to inconsistent answers, we had to omit this statement when devising the Travel Information indicator.

People responded very differently to the statement 'I would use a (smartphone) app if it offered me an overview of available travel options' (Figure 12), with approximately 50% of Dutch adults responding positively, stating they (strongly) agreed with that statement. Only 22% responded negatively. Of all the statements in the questionnaire, this statement came closest to the MaaS potential, as a deeper analysis of the findings revealed (Appendix 2).

Figure 12 Four statements about travel information



We used the following statements for the **Travel Information** indicator (Appendix 2):

- Three statements about the need for travel information;
- The frequency distribution of the use of travel information in general (not specifically online).

5 The profile of people likely to adopt MaaS

The people most likely to use MaaS are young, active and healthy, they use public transport, enjoy travelling and have an above-average income and education level. This group scored the highest on all four indicators. The laggards – those who will only use MaaS much later or never – are generally senior citizens who rarely take trips or never fly, have lower income or education levels and do not use public transport. This study does not conclude whether such people will never or only latterly use MaaS, as we have not assessed the total market potential.

We discussed the MaaS Potential Index's (MPI) four indicators in detail in the previous chapter. In this chapter we link these indicators to people's background characteristics. We tested many characteristics for possible relevance, using Lasso regression analysis, a machine-learning technique for selecting the most relevant variables. Here the focus is on a shortlist of the most relevant characteristics. This chapter details the key insights derived from this analysis. Additional background information is found in Appendix 3.

5.1 The key characteristics of groups most likely to use MaaS

The most important background characteristics are age group, frequency of public transport use, frequency of (private) air travel, education level, and environmental concern (Table 1), as derived from an analysis of explained variance (Appendix 3). These are followed by factors that include frequency of travel, urban density, ownership of folding bikes or speed pedelecs, and personal income. Other relevant but less important factors include gender, motorcycle ownership, health status and frequency of bicycle use.

Table 1 Top 10 most important variables

Rank	Variabele	Rank	Variabele
1	Age group	6	Frequency of travel
2	Frequency of public transport use	7	Urban density
3	Frequency of air travel (private)	8	Folding bike ownership
4	Education level	9	Speed pedelec ownership
5	Environmental concern	10	Personal income

The relative importance of a category, such as age group, still says nothing about the direction the effect will take. Young people may be more likely to use MaaS than older people, or vice versa. Moreover, among the indicators, effects (in theory) can also be contradictory; for example, the group of young people can have a positive coefficient for one indicator and a negative one for another. A category or variable is important when it significantly contributes to capture the variance of the depended variables. This might be because it impacts everyone to some extent or because a small group of people exhibited an extreme effect. Below we detail how the variables relate to the indicators, and more importantly, we also discuss the direction of the effects.

Age group is the most relevant variable in the explanatory model. MaaS's early adopters will mainly be young adults. We should reiterate, however, that our study is limited to adults (aged 18 and older); consequently, we cannot comment on those younger than 18 years of age. Young adults in particular are above-averagely interested in new technology; they are also above-average in their use of travel information and more open to current forms of renting or sharing. The impact of age on the *Multimodal* indicator is limited and erratic (non-linear): the 18 to 25 age group scores about as well as those aged 55 to 75. The 25 to 55 age group scores relatively poorly on this indicator, while people aged 75+ score even worse. What this reveals is that young adults do not necessarily want to travel in more varied ways. Age emerged as the most useful characteristic, because significant differences exist between people of different age groups and because everyone participates, as everyone has a birthdate. Compared to variables like gender or car ownership, the age groups are relatively more detailed and dispersed.

Figure 13: The importance of age for the MPI, illustrated by comparing a person aged 21 to a person aged 60.

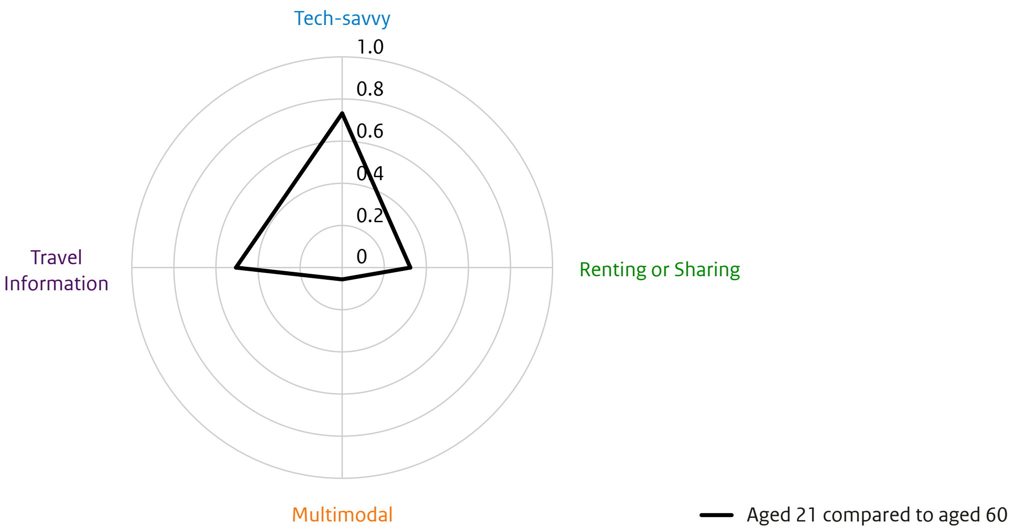
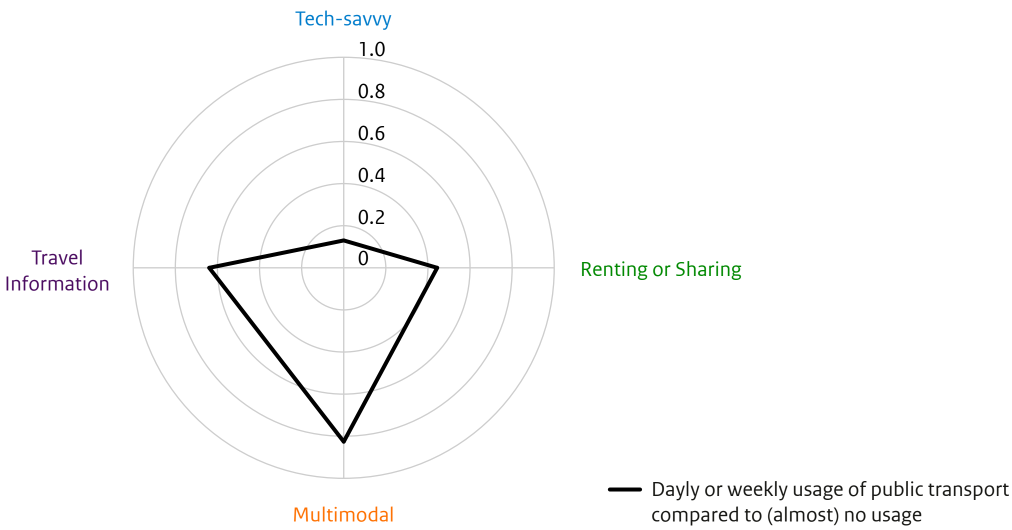


Figure 13 and the other spider plots in this chapter illustrate the differences between the two groups of coefficients for the four indicators of the MPI (see Appendix 3 for the coefficients). At issue then is the relative position: how is a group of Dutch people positioned relative to another group, with the other differences between the groups already corrected for. For the age-based comparisons, corrections were made to account for differences in income and public transport use, for example. To simplify the interpretation, we selected the group and reference group in a manner that ensured the differences were positive. Because the underlying variables were already standardised and normalised (Appendix 2), we could properly compare the scores of the individual indicators.

The frequency of public transport use (bus, tram, metro and train) is seemingly crucial to the MPI's total score (Figure 14). Indeed, for two of the four indicators, frequency of **public transport** use is the most important variable. There is a particularly stark contrast between using and not using public transport, while a much smaller difference exists between people who travel via public transport a few times per month or at least once per week. In the MPI, public transport passengers primarily scored on the need for travel information. Positive correlation also exists between frequency of public transport use and the *Rent or Share* or *Travel Information* indicators. Moreover, there is a limited yet slightly positive correlation to interest in new technology. Approximately 15% of Dutch adults use the public transport system weekly, while 38% rarely or never use the bus, tram, train or metro.

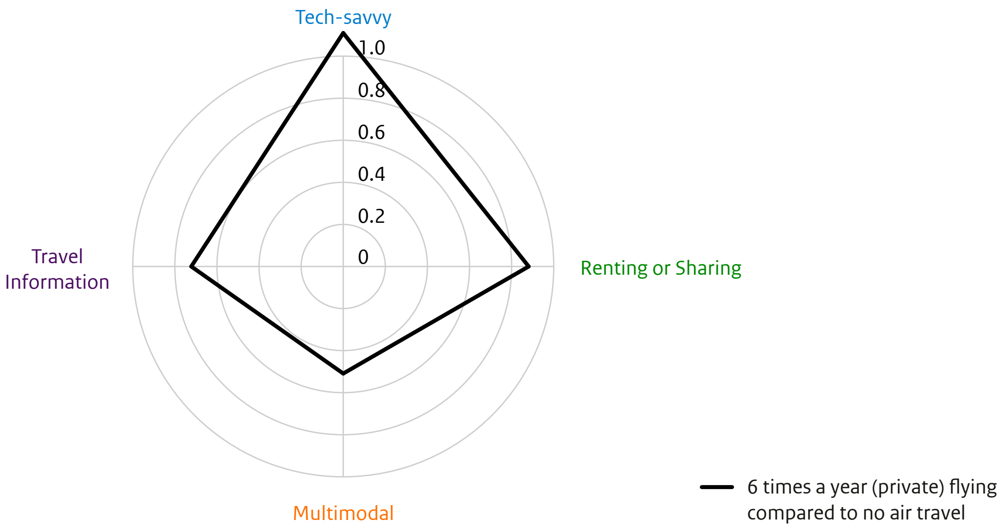
Figure 14 The importance of public transport use for the MPI



The number of flights a person took in the past 12 months for private reasons ranked third on the MPI's list of most relevant variables. According to the regression analysis, frequent flyers have a greater need for travel information, are better at engaging with the platform economy, have stronger preferences for technology-driven innovations, and score positively on the *Multimodal* indicator. The frequency of air travel, as well as public transport use, is skewed among the Dutch population (Zijlstra & Huibregtse, 2018). In our sample, 42% of Dutch adults took at least one roundtrip private flight during the past year. Slightly more than 6% took three of more private flights during the same period, while approximately 0.4% flew six times or more.

Air travel and public transport use have more in common than one would expect. Both are by definition intermodal, as these transport modes virtually never travel door-to-door – additional transport modes are needed for that. Moreover, both of these main transport modes are types of collective transport: a person shares a vehicle with one or more passengers, and both modes operate according to timetables. Consequently, public transport use and air travel are positively associated: people who frequently use public transport also fly more frequently (Zijlstra et al., 2017). With air travel – perhaps even more so than with public transport – people want to explore a destination, via rented cars, rented bikes or public transport, and it is precisely the fact of not having one's own vehicle at the destination that could determine the MaaS potential.

Figure 15 The importance of air travel for the MPI



As for **education level**, the higher the education level, the higher the potential use of MaaS. People with high education levels (Bachelor, Master, PhD) scored particularly high on the MPI for new types of sharing and the need for travel information. However, education level also has a significantly positive effect on the other two indicators. Thirty-six percent of Dutch adults have a high level of education.

Regarding **concern for the environment**, we observe a distinct trend: the higher the concern, the higher the MPI score. All indicators play roles here. There are sharp differences between those who are indifferent to the environment (10%) and those who are neutral (37%), and between those who are concerned about the environment (47%) and those who are highly concerned (6%). The effect is greatest on the *Multimodal* indicator. In short, people who are above-averagely concerned about the environment are above-averagely interested in the range of available transport modes. The weakest effect was on the Tech-savvy indicator.

It is difficult to reconcile the established link between environmental concern and the MPI's four indicators with the previous observation that people who fly frequently also score high on the MPI. There is, however, no correlation between the two explanatory factors: people highly concerned about the environment do not fly more frequently, and they also do not fly less frequently.

5.2 Other characteristics of the groups most likely to adopt MaaS

The frequency with which a person travels for leisure purposes (visiting amusement parks, restaurants, etc.) is a good indication of above-average MaaS potential, while, conversely, people who rarely or never take excursions score poorly, especially on the need for travel information. The group stating that they (virtually) never travel clearly scored the worst on the MPI, with this group represented by 3% of the people in our sample. The group that takes a leisure trip at least once per year but less than once per month also scored poorly on all four indicators: at 46%, this was a large group in our sample.

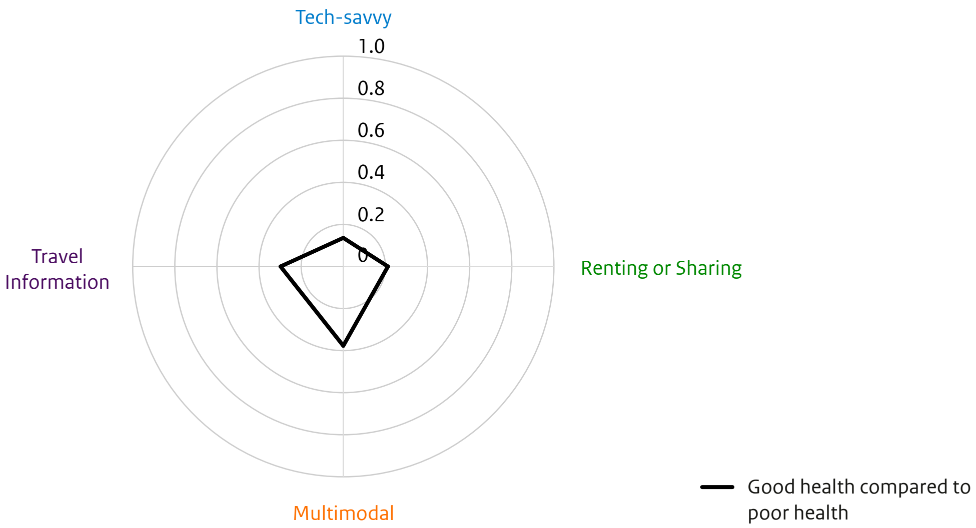
Various socio-economic characteristics are also seemingly important. As previously noted, the age category is vital. Education level is also crucial. Moreover, a positive correlation exists between higher personal incomes and the MPI. We mainly observed a connection between income and the *Travel Information* and *Multimodal* indicators. Gender is of some importance as well: men scored slightly higher than women on all MPI dimensions, and especially on questions pertaining to interest in new (technological) products or services, and the need for travel information. We also examined seven different possible household compositions, although this variable was not included in the final models, as we observed no clear correspondence to high or low MPI scores.

High urban density – expressed in the number of addresses per square-kilometre – positively correlates with all MPI indicators, meaning that as urban density increases, so too does the likelihood of a person adopting MaaS. This increase differed per indicator. We found the strongest connection to the *Tech-savvy* indicator and the weakest to *Multimodal*. The other two indicators were very similar to each other and scored in between the two aforementioned indicators. The strongest effect occurred for low urban density. A detailed study of the effects of urban density yielded little new information. The absolute effects of urban density were modest. This variable is especially important because every person's residential area has a certain urban density, and hence this variable applies to everyone in our sample.

Owning a folding bike, speed pedelec or motorcycle positively impacts MPI scores, with the importance of these variables decreasing sequentially. Folding bicycles had a slightly positive impact on all indicators, but with a negligible impact on *Tech-savvy*. A total of 52 people in our sample owned folding bicycles. Speed pedelec ownership had an extreme impact on three of the four indicators; however, only four people in our sample owned speed pedelecs. Motorcycle ownership (n = 49) had slightly positive scores on all MPI indicators, but with a negligible impact on the *Multimodal* indicator.

Finally, the current, self-reported state of a person's health is a good indicator of MaaS potential, and hence deserves to be discussed separately here. People who stated that they were in fair or poor health scored below average on the four MPI indicators, with negative scores on the need for travel information and the diversity of travel options pillars. More than 15% of the people in our sample stated that they were in fair (14%) or poor (3%) health. Good health therefore increases the likelihood of a person using MaaS (Figure 16).

Figure 16 The importance of the self-reported health status for the MPI score



5.3 The profile of promising groups in other studies

Our findings largely align with other studies in terms of the personal characteristics of MaaS's most promising groups. We did find some discrepancies, however. In this section we compare our findings to those of other researchers.

That interest in MaaS will primarily come from young people was also found by Sytsma and Stulen (2018), Caiati et al. (2018), and Jittrapirom et al. (2018). Other innovations in the transport field have high expectations for young people as well (Planing, 2014); however, according to Rogers (2003), the diffusion of innovation theory is ambivalent in this regard. Age does not seem to be of great importance to the diffusion of new ideas generally, and consequently our findings differ on this point. Age is certainly crucial for MaaS potential.

The literature in the field of innovations does systematically reveal that people of higher socio-economic status are the first to embrace new concepts, which corresponds to higher education and/or income levels, both of which are ranked in our 'Top 10 most important variables'. Studies by Alonso-González et al. (2017) and ITS Australia (2018) found positive correlations between MaaS potential and education or income levels.

Various studies concluded that current public transport use is a good indication of above-average MaaS potential (Alonso-González et al., 2017; Jittrapirom et al., 2018). In choice experiments, the most popular MaaS bundles were those that included public transport (Ho et al., 2018; Matyas & Kamargianni, 2018b). This is why some people call the public transport system the 'backbone of MaaS' (Karlsson et al., 2017; UITP, 2016).

The most promising groups in our study were comprised of avid travellers, as exhibited by their frequent flights and trips for social-recreational purposes, and other studies had similar findings (ITS Australia, 2018). Rogers (2003) noted the importance of cosmopolitan lifestyles and open-mindedness among the true early adopters. People who are keen to embrace new concepts are active in social circles beyond their immediate society. Although other MaaS-related studies do not reach the same conclusion, we should not automatically doubt the veracity of our finding; rather, it is more likely that our research has successfully expanded the existing knowledge base.

There is a positive association between adopting MaaS and having a higher awareness of environmental issues, as based on the expectations of others (Karlsson et al., 2017; Sochor et al., 2015a; Sytsma and Stulen, 2018). However, at present, there is a lack of empirical data to support this point. The literature pertaining to car sharing clearly establishes a link between car sharing and a greater awareness of environmental issues (Dias et al., 2017; Efthymiou et al., 2013; van Paassen, 2018).

We found no relevant literature about ownership of folding bicycles or speed pedelecs. One qualification here is that bicycles are a typically Dutch phenomenon, and people in other countries are likely to be less interested in special types of bikes, like speed pedelecs.

We ultimately found support for our research findings in the international literature focused on MaaS, sharing concepts, and the adoption of innovations. Conversely, in other studies, we also discovered certain aspects that were of little or no importance to our analysis; for example, Sytsma and Stulen (2018) suggest that people who place high value on positional goods, like expensive cars, are less likely to adopt MaaS, and also note that a residential area's parking regime could be a possible indicator. Neither of those aspects resonate in our study. Many researchers stressed the importance of urban areas as fertile breeding grounds for MaaS, and they often did so from the perspective of the transport services offered, such as public transport, sharing concepts and so forth. In our study, urbanity had a limited direct impact on the interest in MaaS.

5.4 Household dynamics

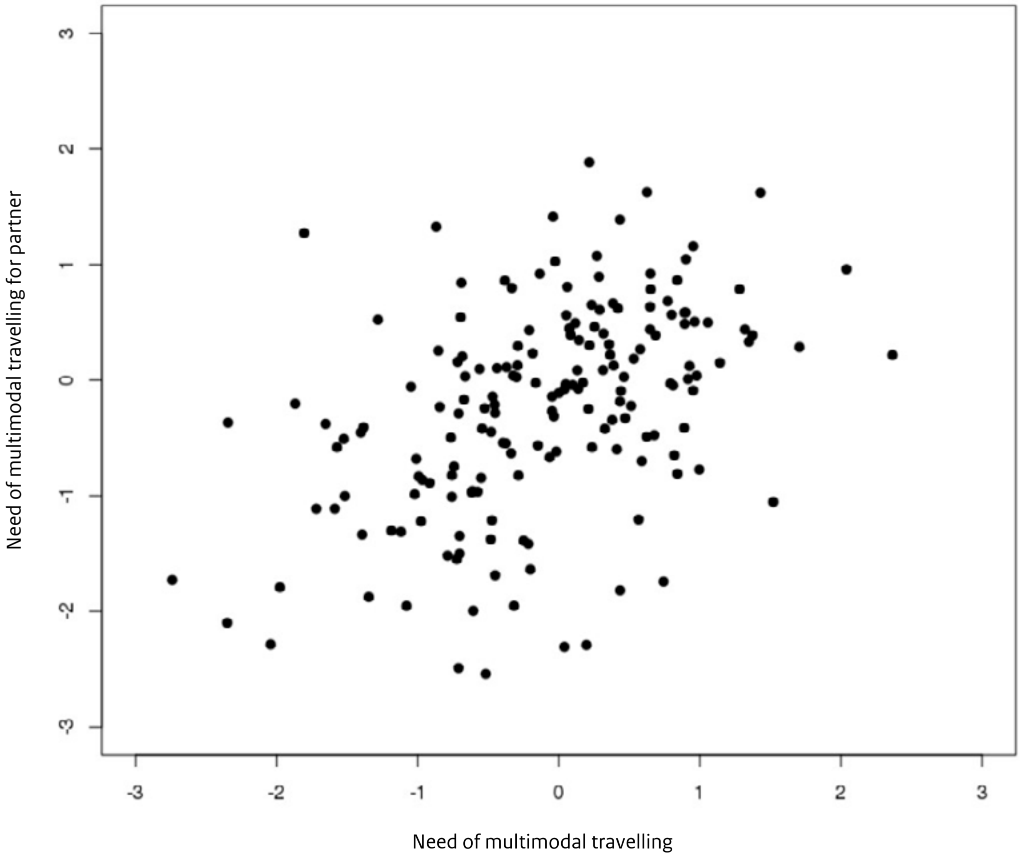
MaaS use will likely impact household budgets. In choice experiments, MaaS bundles cost from €25 to €300 per month (Caiati, 2018; Ho et al., 2018; Matyas and Kamargianni, 2018a; Ratilainen, 2017). Whim Unlimited costs €500 per month (https://whimapp.com/monthly-plans/). Various companies are currently devising comprehensive offers for the entire household. Moreover, MaaS is routinely presented as a substitute for private car ownership (Jittrapirom et al., 2017), which is frequently the largest household expense after rent/mortgage payments. In short, MaaS could have far-reaching consequences beyond that of the individual and encompassing the entire household (see also Ho et al., 2018). We therefore conclude this chapter with a brief discussion of household dynamics.

In our sample we identified 175 partners sharing a single household. Collectively, these couples accounted for 350 observations from a total of 1,547. The correlation coefficient of MPI scores between partners ranged from 0.42 to 0.45 across the four MPI indicators. The differences between partners were largest for the *Tech-savvy* indicator and smallest for the *Rent or Share* indicator. Such differences must not be overestimated, however, as we primarily observed consistent situations.

The correlation between the scores of two random individuals on a single MPI indicator is effectively zero, as we are dealing with standard normally distributed indicators. The score for a perfect overlap between two people would approach one. In other words, the partners' indicators are much more closely aligned than would be expected from a random couple, but the scores are certainly not equal.

Some discrepancy can be expected, because, as previously observed, differences exist between men and women, for instance, and virtually all the couples in our sample set are heterosexual couples. Nevertheless, couples do often have numerous key explanatory factors in common: they are often close in age (our various partners had an average age difference of 3.5 years), reside in the same area, and likely take (flight) vacations or trips together. If we solely examine the known and modelled background variables, as discussed in section 5.1 and section 5.2, the correlation between partners is 0.75 on average.

Figure 17 Scores of partners on one indicator in the MPI



The differences among partners in terms of MaaS potential are not easily explained. For possible explanations we turned to household composition, household size, household income, and more, but none of those factors offered any guidance. Some couples are more alike than others, but we were unable to find a good predictor of this, which perhaps presents an opportunity for additional research.

6 Conclusions and discussion

In this study, KiM aims to identify those groups within the Dutch population that are most likely to use Mobility-as-a-Service (MaaS). We approached this task from the perspective of the relative differences existing on the demand side, namely, between the wants, needs and behaviour of groups in Dutch society. We did not account for MaaS's total supply side market share and organisation. By gaining a better understanding of the groups most likely to adopt MaaS, we can also perhaps better understand MaaS's eventual impacts on the transport system. Moreover, this approach also allows us to target actions toward certain groups that may lag behind in adopting MaaS.

Because MaaS is still in its nascent stage, we could not directly gauge the interest in the platform: the vast majority of people are unaware that MaaS even exists. Consequently, we studied MaaS's fundamental elements: it is a new digital multimodal mobility platform in which renting and sharing concepts in particular occupy key positions, as translated into the MaaS Potential Index's four indicators: *Tech-savvy, Renting or Sharing, Multimodal,* and *Travel Information* (see section 6.1).

In this research study we relied on the Netherlands Mobility Panel (MPN), which is KiM's multi-year study of mobility in the Netherlands. The MPN provided us with a wealth of information about the respondents' current travel behaviour, vehicle ownership rates, places of residence and socio-economic characteristics. A special questionnaire – distributed among a large number of MPN participants – fed the MaaS Potential Index with relevant information. The resulting data set was cleaned and weighted to ensure a good representation of Dutch adults.

6.1 Key insights

Key insights into the four MaaS indicators are presented below.

Tech-savvy – The average Dutch person seemingly prefers new technological tools. Smartphones and tablets are in great demand, as is the corresponding use of such devices. Young people, men and avid travellers are primarily interested in new tech-driven products and services. Higher education levels and degrees of urbanisation are also seemingly important for this indicator.

Renting or Sharing – At present there is limited interest in renting or sharing mobility. Over the past 12 months only a small percentage of Dutch adults actively used car sharing, private leasing or Uber, and only a slightly larger percentage expressed interest in such types of mobility. Moreover, there is a tenuous connection to the use of audio or video streaming; in other words, using Spotify is not a good indicator for the use of MaaS. As for renting or sharing, young people, frequent public transport users and higher educated people account for most of the potential. Above-average concern for the environment also positively correlates to the *Renting or Sharing* indicator.

Multimodal – Multimodal travel is one of the pillars of MaaS. Many of MaaS's key players expect that people will make better decisions regarding transport modes because the MaaS platform provides an overview of available travel options. Moreover, great emphasis is placed on a smooth, seamless travel experience, thereby rendering intermodal or trip chain trips more attractive. Every trip chain is a multimodal trip. Research reveals that the extent to which a person currently uses public transport is a good indication of how likely that person is to have a multimodal mindset; this emerged when we linked the MPI to people's background characteristics. Above-average concern for the environment and frequent bicycle use are also good indications of multimodal travel behaviour or of a need for multimodal travel.

Travel Information – Approximately 92% of Dutch adults indicated that they used online travel or route information. Route information for car trips was the most frequently mentioned application. Only one in eight Dutch people used online information to select the most suitable transport mode, making this the least popular application we measured. Frequent public transport use, young age, high education levels and frequent (private) air travel are all good predictors of an above-average need for travel information. The need for travel information is seemingly a good intermediary between the other three indicators; of the four indicators, this indicator therefore constitutes the best approach for gauging interest in MaaS.

Based on the four indicators combined, we conclude that the people most likely to embrace MaaS are healthy young adults who have a high socio-economic status and frequently use public transport. Conversely, the least likely group consists of elderly people who have limited mobility and poorer health, lower income and education levels, and who reside in more remote areas.

As outlined, the most promising groups correspond in various respects to the overall image derived from the diffusion of innovations literature. The early adopters generally come from the higher socio-economic classes and have high income and education levels. Early adopters are often open-minded or cosmopolitan in outlook; however, the supposition that these are primarily young people is not supported in all other studies on innovation diffusion. The emergence of avid travellers and public transport users as the most likely MaaS users has much to do with the fact that MaaS is a multimodal mobility platform. Moreover, other studies of MaaS's promising groups also found one or more of those characteristics.

6.2 Focal points

It is highly likely that the profile of early adopters will differ from that of the majority or laggards. Our indicators revealed a sharp contrast between these groups. The idea that the personal characteristics of early adopters and laggards differ from one another is also supported by the findings of marketing and innovation literature.

This insight has far-reaching implications for MaaS's potential impacts on the transport system. The behaviour of the initial users cannot be extrapolated to the entire population. It may well be that the initial users start using public transport less, precisely because one of MaaS's most promising groups consists of people who already frequently use public transport. If the use of MaaS results in the early adopters using public transport less frequently, this does not necessarily mean that public transport use will further decrease when more people adopt MaaS.

Our research provides no firm estimate of MaaS's overall market potential. Based on current literature about the situation in the Netherlands, we foresee a bandwidth potential of 0 to 30% of the total population. Should the total number of users lag behind, the personal characteristics will become increasingly blurred and the profile of the early adopters will largely correspond to that of the majority or laggards. Conversely, we can expect the greatest possible diversity to emerge if the entire population accepts and uses MaaS. The diversity among MaaS users would then reflect the heterogeneity of the Dutch population.

Our findings pertaining to MaaS's most promising groups are certainly not set in stone. The main question is what will emerge from 'autonomous' development. It is possible that other groups will be quicker to embrace MaaS, which, firstly, could be due to the fact that the MaaS 'product' is not yet sufficiently developed. Consequently, in this study, we could not directly gauge people's interest in MaaS. We instead examined the platform's key characteristics. In practice the focal points could lie elsewhere, whereby a different type of platform could also emerge, with other groups leading the way, and this could involve other services besides mobility, or the omission of the exact services that appeal to the most promising groups, or extensive telephone support for passengers.

Secondly, the possibility always exists that the parties involved will control how the diffusion of a new technology unfolds (Rogers, 2003). The less promising groups could be reached sooner by means of specific marketing efforts, such as targeted communications via social media or at certain locations, thereby reaching people with certain profiles. Information about the use of MaaS can lower barriers to adoption. Price differentiation or temporary discounts for certain groups are also conceivable. Flanking measures, such as discouraging private ownership of cars or bicycles, could also impact the adoption rate and composition of the user group.

This study's research sample was comprised of Dutch people aged 18 and older, with a particular focus on their households. We implicitly assumed that citizens or consumers will be responsible for MaaS's diffusion in the Netherlands, although this is not necessarily the case. We could also have focused on governments, employers, self-employed entrepreneurs or other parties. A completely different picture will emerge if the government encourages or imposes the use of a MaaS app. Moreover, it is also highly conceivable that employers will actively engage with MaaS and compel their employees to use a certain MaaS app for business travel. MaaS's potential would then be much less dependent on citizens or consumers generally, and much more dependent on the approach of a few relevant parties.

6.3 Additional research

To conclude this study, we cite a few knowledge gaps uncovered during the course of our research and requiring additional research:

- MaaS's potential users are the focal point of our current research. The supply of transport services remains undeveloped. In addition to this research, it would be prudent to take a closer look at the business cases of MaaS service providers, to see in what areas, for which types of trips and to what extent their transport services can be developed.
- A logical follow-up step to this research is to further explore MaaS's potential scope in the Netherlands, as we could then determine whether it will be the group of early adopters or larger numbers of Dutch people who will ultimately embrace MaaS. All current studies are informed with a high degree of uncertainty. Moreover, the estimates of several studies are biased, as the samples were drawn from (highly) urbanised areas.
- Now that we have determined who belongs to the most promising MaaS groups, we can also turn our attention to questions such as where and when MaaS will be welcomed as a solution or supplement for certain travel needs, because, ultimately, it remains unclear whether MaaS will be used for all trips. For example, people are unlikely to use MaaS to find the best travel options for familiar routes or short and routine trips.
- According to various insiders and trend watchers, MaaS has the potential to (radically) change transport systems. But such potential can only ever be realised if there is sufficient space in the system and if the system is sufficiently equipped for such an evolution. From this perspective, it seems pertinent to thoroughly consider the various transition paths, as well as the possible implications for governments, companies and people.
- The MPI was carefully compiled based on four indicators, as derived from various statements and questions. Based on statistical analyses, the MPI is seemingly plausible. However, this does not imply that other compilations or indicators are implausible. Some of the statements used could have been formulated more sharply. Additional research could focus on honing the MPI.
- Dutch adults are the primary focus of this study. We did give some attention to households, as we also concluded that MaaS could have far-reaching consequences for households, yet our findings in this regard are largely unsatisfactory. We see that partners within the same household share certain similarities, but they are certainly not fully aligned. It is difficult to explain the differences between partners in a single household. A follow-up study focusing on such couples could provide greater insights into MaaS's opportunities on this level.

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Appendices

Appendix I: Data collection via questionnaire in the Netherlands Mobility Panel

We devised a questionnaire for setting up and supporting the MaaS Potential Index (MPI). The questionnaire was distributed among participants in the Netherlands Mobility Panel (MPN), thereby allowing us to link the scores on the MPI to the background characteristics and travel behaviour of individuals.

Candidates had to be at least 18 years of age and have completed the MPN survey of Wave 5 (Autumn 2017). Moreover, the gross sample had to be representative for contemporary Dutch society; the criteria we used to achieve this were gender, age group, education level, household size, and geographic region. A correct balance was sought for each of the criteria. Invitations to complete the questionnaire were sent via email to 2,150 candidates. The questionnaire was to be completed online (CAWI).

In this appendix we provide a condensed and simplified version of our questionnaire, in the sense that we omitted certain questions and sections, as those elements were used in another study and included in the questionnaire for practical reasons. We simplified matters further by not replicating the questionnaires' original design and layout, nor did we show the distribution across the blocks, the randomisation, and the criteria for displaying the question (dependence). This allowed us to reduce the original 17-page questionnaire to just the few pages below, thereby greatly enhancing its readability.

A total of 1,621 people completed the questionnaire, with the resulting data carefully cleaned and checked to control for inferior respondents, for which we used the following criteria: speeding (too rapid completion rate, answering too quickly), non-differentiation (straight downward lines in matrix questions), inconsistent answers, and the quality of responses in MPN's Wave 5. A penalty point was awarded for each 'violation'; respondents with three or more penalty points were eliminated.

Owing to this selective response behaviour and cleansing process, the final file is unrepresentative of the aforementioned criteria. Consequently, we calculated the weighting factors and corrected the final sample. The weights were calculated based on the aforementioned criteria: age group, gender, Nielsen-region, education level, and household size.

Introduction

Welcome to the travel and transport questionnaire. We are conducting this research on behalf of the KiM Netherlands Institute for Transport Policy Analysis. It should take approximately 12 minutes to complete this questionnaire. Thank you in advance for your participation.

Do you have a cell phone and/or smartphone?

Multiple answers allowed

- O Yes, cell phone (only for calls)
- O Yes, smartphone (for calls and internet)
- O No

Do you have a tablet? (for example, an iPad)

- O Yes
- O No

Via which device and network do you connect to the internet?

Please indicate all options below.

Tablet/iPad:

- O via Wi-Fi
- O via 3G/4G/data bundle

Smartphone:

- O via Wi-Fi
- O via 3G/4G/data bundle

Which internet connection do you use the most for your tablet?

Please indicate all options below.

- O Always or usually via Wi-Fi
- O Always or usually via mobile data bundle (3G/4G)
- O Varies between Wi-Fi and data bundle (3G/4G)
- O None of thes

Which internet connection do you use the most for your smartphone?

Please indicate all options below.

- O Always or usually via Wi-Fi
- O Always or usually via mobile data bundle (3G/4G)
- O Varies between Wi-Fi and data bundle (3G/4G)
- O None of these

How often do you use your smartphone and/or tablet for...

1. ... searching for information
2. ... social media
3. ... other purposes

Answer options:

- O 1 or more times per hour
- O a couple of times per day
- O a few times per week
- O a couple of times per month
- O rarely or never

You use your smartphone and/or tablet...

1. ... for booking or reserving products or services (for ex. tickets)
2. ... for paying for products or services (for ex. tickets)
3. ... as proof of payment (for ex. with QR-code)

Answer options:

- O Yes, regularly
- O Yes, sometimes
- O No, but I would not find this a problem
- O No, I would not like this

To what extent do you agree or disagree with the following statements?

Statements:

1. I try new services, like Netflix or Uber, before my friends or family members.
2. I often buy the latest products, such as a smartphone, even if they are expensive.
3. My family and friends often ask me for advice about new products and services.
4. I am enthusiastic about the possibilities afforded by new technology.
5. I buy new products, like the latest 3D TV, before my friends or family members do.
6. I am open to trying new ways of travelling.

Answer options:

- O Strongly disagree
- O Disagree
- O Neither agree nor disagree
- O Agree
- O Strongly agree

To what extent do you agree or disagree with the following statements?

Statements:

1. The choice of how I will travel depends on the activity I will pursue.
2. I would prefer to have the choice between different types of cars, such as a small city car or luxurious SUV.
3. I would like to use an electric bike occasionally.
4. I often compare the various travel options prior to choosing how I will travel.
5. A life without having my own car is unimaginable.
6. I would like to enjoy the convenience of a car but without having to own my own car.
7. I do not mind combining multiple transport modes for a single trip, such as a bike and the train.
8. I do not like to sit in the same vehicle with strangers.

Answer options:

- O Strongly disagree
- O Disagree
- O Neither agree nor disagree
- O Agree
- O Strongly agree

Can you please indicate the extent to which you use the options below? And if you do not use them, can you indicate the extent to which you are interested or not interested?

1. I have a subscription to Spotify or iTunes.
2. I have a subscription to Netflix, Videoland or Kijk.
3. In the past 12 months I have booked a room or apartment/house via Airbnb
4. In the past 12 months I have used car sharing, like Greenwheels or Snappcar.
5. In the past 12 months I have used an alternative taxi service, like Uber or ViaVan.
6. In the past 12 months I have used bike sharing, like PT-bike, FlickBike or MoBike.
7. I use a car via private leasing.
8. I use a lease car via my job or company.

Answer options:

- O Yes
- O No, but interested
- O No, not interested
- O Unknown

How often do you search for information about your trip?

For example, traffic information or public transport departure times

- O 4 or more days per week
- O 1 to 3 days per week
- O 1 to 3 days per month
- O 6 to 11 days per year
- O 1 to 5 days per year
- O never

How often do you search for information about your trip via smartphone and/or tablet?
For example, traffic information or public transport departure times
- O 4 or more days per week
- O 1 to 3 days per week
- O 1 to 3 days per month
- O 6 to 11 days per year
- O 1 to 5 days per year
- O never

In what situations do you use online travel or route information or navigation systems?
Multiple answers allowed
- O To determine which transport mode I will use.
- O To receive information about my trip time, traffic congestion or accidents if I travel by car or motorcycle.
- O To determine which route I will take by car or motorcycle.
- O To get information about public transport timetables, trip times and delays.
- O To determine what route I will take via public transport.
- O To determine my route and trip time by bicycle, scooter or walking.
- O I never use online travel and route information.

Which trip and route information apps do you have on your smartphone and/or tablet?
Multiple answers allowed
- O Apps for maps, such as GoogleMaps or Maps.Me.
- O Apps for navigation, such as TomTom or GoogleMaps.
- O Apps for public transport, such as NS Xtra or OV9292.
- O Apps for bicycle use, such as Fietsrouteplanner.
- O Apps for parking, such as Parkmobile.
- O I do not have travel apps op my smartphone/tablet.

To what extent do you agree or disagree with the following statements?
Statements:
1. I would use a (smartphone) app if it offered me an overview of available travel options.
2. I am willing to pay for accurate and reliable travel information.
3. I find it difficult to find information about all the available travel options.
4. I would gladly pay slightly more for personalised travel advice.

Answer options:
- O Strongly disagree
- O Disagree
- O Neither agree nor disagree
- O Agree
- O Strongly agree

To what extent do you agree or disagree with the following statements?

Statements:

1. Before going to a restaurant, I always make a reservation to ensure I have a table.
2. I gladly pay slightly more for the security offered by roadside assistance.
3. Before I start using a new device, I always read the instruction manual first.
4. I prefer to buy magazines individually than to commit to a subscription.
5. If I am certain that I can make a transfer, I do not mind transferring during trips.
6. I like not having to think about what route I will take when travelling to a new destination.
7. When I go on vacation, I prefer to make all the arrangements myself.
8. I would gladly pay slightly more to have my groceries delivered to my home.

Answer options:

- O Strongly disagree
- O Disagree
- O Neither agree nor disagree
- O Agree
- O Strongly agree

The following statements pertain to the activities that you engage in with your family members.

Statements:

To what extent do you agree or disagree with the following statements?

1. In my house I usually make the decisions about purchasing new products.
2. In my house we usually decide together where we will go on vacation.
3. When we travel somewhere together, I am usually the driver.
4. I usually plan the trip and route when we travel somewhere together.

Answer options:

- O Strongly disagree
- O Disagree
- O Neither agree nor disagree
- O Agree
- O Strongly agree
- O Not applicable

Appendix II: Development of the MaaS Potential Index via confirmatory factor analysis

In this appendix we describe the research method and development of the MaaS Potential Index (MPI), including the total concept, four indicators, overview of statements per indicator, the method used, model fit and findings.

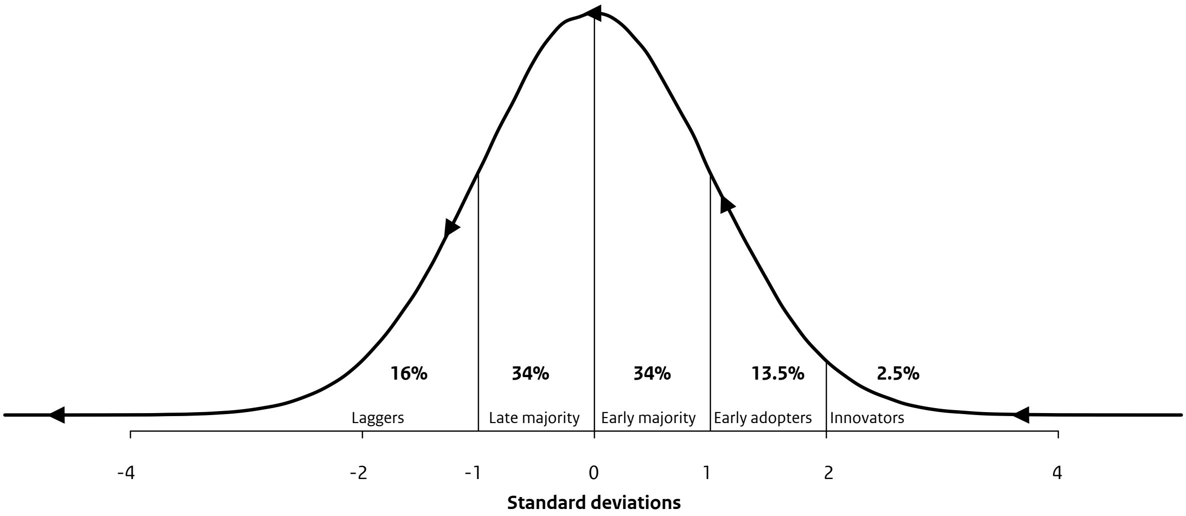
The MaaS Potential Index is comprised of four separate indicators, namely: *Tech-savvy, Rent or Share, Multimodal,* and *Travel Information*. Originally, during the research initiation stage, the idea was to develop one indicator capable of capturing the potential to use MaaS. However, further analysis of the collected data revealed that we lost much information when using only one index: for example, a person who is tech-savvy does not necessarily have a multimodal mindset, according to the responses in our questionnaire, and consequently we decided not to combine the four indicators in one. Moreover, we initially thought to include 'carefree' as a fifth indicator and part of the index; however, the statements pertaining to 'carefree' proved to be insufficiently interrelated and unuseful for constructing the indicator.

Each of the four indicators is based on responses to various statements and questions. Confirmatory Factor Analysis (CFA) was used to transform the resulting information – derived from a special questionnaire completed by MPN participants (Appendix 1) – into an indicator. Unlike exploratory factor analysis, CFA begins with a pre-imposed model, and must then demonstrate whether the available data also supports this conceptual model with the assumed relationships. There is no automatic search for the best fitting distribution. To conduct the CFA, we used the 'lavaan' package in 'R' (Rosseel et al., 2017).

All indicators were standardised and normalised in the CFA. By normalisation we mean that the various variables were coherently transformed into a standardised normal distribution in the familiar clock shape. This distribution is largely inspired by statistically desirable characteristics; society itself however is not necessarily normally distributed. By standardisation we mean that in this case the variables are transformed in such a way that the final variable has an average of zero and standard deviation of one. Because the latent variables are underpinned by binary and ordinal variables, and because we work with weighting factors, in actuality the distributions are only approximately standard normal.

The normal distribution coincides nicely with the curve as devised by Rogers for the diffusion of new products and services in the market (Rogers, 1962; 2003). According to Rogers, the 'innovators' will embrace a new product in the start-up stage, but only with a 2.5% share. The 'early adopters' will follow in a second stage with a 13.5% share of the total. And in the next two stages come the 'early majority' and 'late majority', and finally the small group of 'laggards' (Figure 1-appx.2).

Figure 1-appx.2 The standard normal distribution in relation to Rogers' diffusion of innovations theory



If full market penetration occurs in the Netherlands, we can make a one-to-one translation to our standard normal distribution. In the regression analysis above, the people with a combined effect above 2 are the innovators. Those with an effect of between 1 and 2 are the early adopters. When the effect is above 1, this denotes a fairly exclusive club of around 16% of the highest-potential people. When the effect is -1, this denotes the 16% of the population with the least potential.

In Table 1-appx.2, we present the CFA's findings. Without exception, all coefficients are significantly different, except for zero, which is partly due to the large number of observations (n=1,547). Much more important, however, is that all coefficients are positive, and hence the impact is in the expected direction and constructively contributes to the relevant indicator. The magnitude of the coefficients is partly dependent on the number of levels of the underlying variable's scale and is in itself not always particularly insightful. Comparisons are possible when the underlying variables have the same format, and this for example applies to the Tech-savvy indicator's last six statements, where the statement about trying new products or services sooner than family or friends is the most influential, and the one about trying new ways of travelling the least influential.

Table 1-appx.2 Estimates of the CFA model with corresponding standard error (se.)

Indicator with underlying statements	**Coefficient (sf.)**
Tech-Savvy	
Frequently search for information	0.677 (0.015)***
Frequent use of tablet or smartphone	0.602 (0.018)***
Reserve products or services with tablet or smartphone	0.851 (0.009)***
Purchase products or services with tablet or smartphone	0.864 (0.008)***
Tablet or smartphone as proof of payment	0.713 (0.014)***
Try new products or services before friends or family members	0.778 (0.012)***
Frequently purchase new products, even if expensive	0.741 (0.013)***
Family members or friends ask for advice about new products or services	0.674 (0.014)***
Enthusiastic about new technology	0.602 (0.018)***
Purchase new products sooner than family and friends	0.724 (0.014)***
Open to new ways of travelling	0.422 (0.021)***
Rent or Share	
Would like to switch between different types of cars	0.460 (0.03)***
Would like convenience of car use without owning a car	0.352 (0.027)***
Use car sharing	0.731 (0.019)***
Use bike sharing	0.746 (0.018)***
Use private leasing	0.445 (0.031)***
Use alternative taxi services	0.766 (0.019)***
Use Airbnb	0.665 (0.023)***
Multimodal	
Activity determines way of travelling	0.578 (0.023)***
Compare travel options	0.724 (0.02)***
Combine transport modes	0.713 (0.02)***
Use online information for choosing transport modes	0.557 (0.045)***
Open to new ways of travelling	0.417 (0.022)***
No problem to transfer, if secure	0.563 (0.024)***
Travel Information	
Would use app that provides overview of available transport options	0.663 (0.021)***
Willing to pay for accurate and reliable travel info	0.212 (0.027)***
Would gladly pay for more personalised trip advice	0.149 (0.029)***
Frequently searches for travel information	0.618 (0.023)***

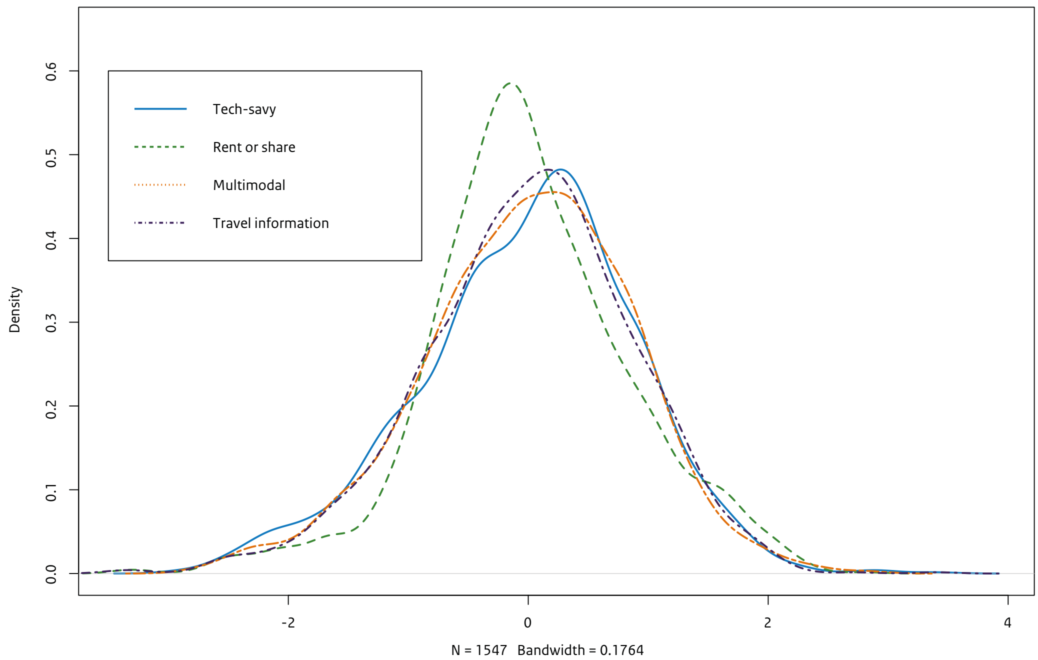
As shown in Table 2-appx.2, the CFA model fit is sufficient (Harrington, 2009). We have a positive number of degrees of freedom. The Chi-square test's p-value is highly significant. The CFI and TLI are on the low side, with the common rule of thumb prescribing a value of 0.950 or higher, which we are just below. Partly due to the many ordinal variables, we require many parameters, which does not benefit the CFI and TLI. Fortunately, the RMSEA and SRMR are well below the common rule of thumb's maximum of 0.10. Ultimately, while there is indeed room for improvement, the findings reveal that our model is plausible.

Table 2-appx.2 Model fit of the CFA

Modelfit		
Observations	1547	
Optimisation method	NLMINB	
Degrees of freedom	351	
	DWLS	**Rule of thumb**
P-value χ^2-test	0.000	0.050
Comparative Fit Index	0.949	0.950
Tucker-Lewis Index	0.943	0.950
RMSEA	0.084	0.100
SRMR	0.076	0.100

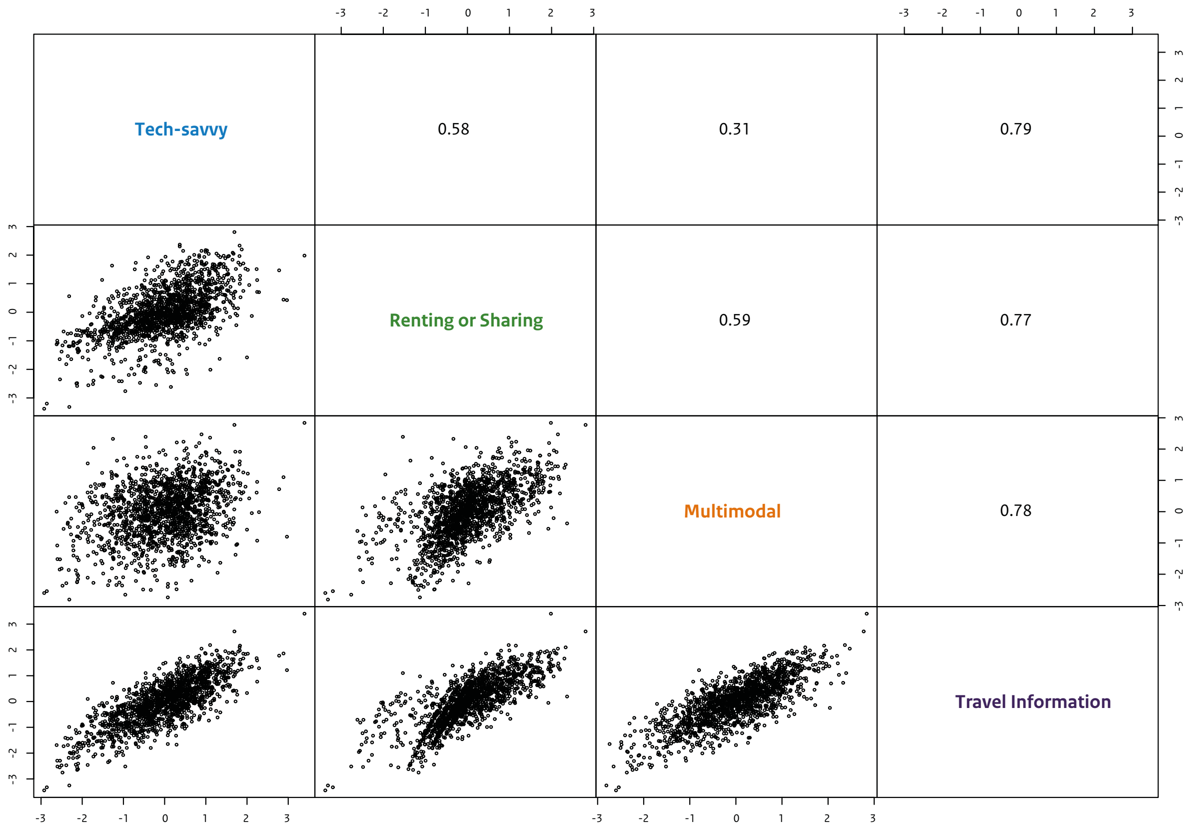
Figure 2-appx.2 depicts the distribution of the four indicators, revealing that the indicators do indeed approach the standard normal distribution. In no case is this distribution perfect. We also observe that the Rent or Share indicator differs from the others, with a peak for the zero, which is due to the skewed distribution occurring during use; many people do not participate in the sharing or platform economy.

Figure 2-appx.2 Distribution of the four indicators of the MaaS Potential Index with the scores on the x-axis



Finally, in Figure 3-appx.2, we present the correlation plot, where the four indicators cross each other. The correlations between the indicators vary considerably but are positive in all cases. The correlation between *Tech-savvy* and *Multimodal* is 0.31. We also observe a point cloud in the figure. The highest correlation is between *Travel Information* on the one side, and *Multimodal* or *Tech-savvy* on the other, with coefficients of 0.78 and 0.79, respectively. The points in the figure have more of a line-shape here. The *Travel Information* indicator has the strongest correlations to all other indicators and is thus seemingly a good intermediary. *Travel Information* also has the strongest correlation to the MaaS Potential Index's overall indicator.

Figure 3-appx.2 Correlation plot of the individual scores for the MaaS Potential Index indicators



Appendix III: Regression analysis

This appendix describes the research approach taken for linking the indicators (Appendix 2) to the personal characteristics, as available in the Netherlands Mobility Panel.

We used a method called *Relaxed Lasso* (Meinshausen, 2007; Hastie et al., 2015) to establish a select and representative list of the background characteristics from people that are most likely to adopt MaaS. We linked these background variables to the MaaS Potential Index (MPI) via a machine-learning technique that, specifically, involved a two-stage approach: first, we performed a multivariate multiple linear regression analysis with a *Least absolute shrinkage and selection operator* (abbreviation: Lasso; Tibshirani, 1996), and then, in the second stage, we used a mixed-effects model to derive the final estimates.

The first stage technique is 'multivariate' because we had not one but four dependent variables (Appendix 2). These dependent variables are the MPI's individual building blocks, namely: *Tech-savvy, Renting or Sharing, Multimodal,* and *Travel Information*. Thanks to the confirmatory factor analysis, as described in Appendix 2, we could transform an extensive list of statements into four standard normal distributed indicators (Figure 3-appx.2), thereby making it easier to successfully apply linear regression rather than the more complex non-linear regression techniques.

We had to contend with 'multiple' regressions because of the numerous independent factors. These explanatory variables, or 'features' in the vocabulary of machine-learning, were directly taken or derived from the Netherlands Mobility Panel (MPN) or could be linked to a person via the MPN. In Table 1-appx.3, we provide a list of all independent variables used in the Lasso regression model: the original list contained 45 independent variables, with many of the other variables having already been omitted as irrelevant over the course of previous rounds and based on earlier tests.

Table 1-appx.3 List of categories used in the definitive Lasso regression model

Categories	Categories (continued)	Categories (continued)
Gender	Ownr. car	Concern for environment
Age group	Ownr. hybrid car	Health status
Education level	Ownr. delivery van	Residential population density
Income (gross, personal)	Ownr. motorcycle	Distance to IC train station
Household composition	Ownr. scooter	Distance to exit or entrance HWN
Number of household members	Ownr. moped	Distance to bus stop
Frequency of travel	Ownr. bicycle	Distance to centre of urban area
Frequency of bike use	Ownr. e-bike	
Frequency of PT use	Ownr. motorised scooter	
Number of vehicles	Ownr. speed pedelec	

The Lasso is primarily used to arrive at a selection of relevant explanatory variables (Tibshirani, 1996; Hastie et al., 2015). The most relevant features are selected from a comprehensive list of background characteristics. The other, less relevant background characteristics are equated to zero and can thus be omitted, which, by extension, prevents an 'over-fit' from occurring.

We used the *glmnet* function in the 'glmnet-package' in the statistical platform 'R' to perform the multivariate multiple regression analysis with Lasso (Friedman et al., 2018). This was a fairly straightforward choice: we are unaware of any other software that can do the same. The cut-off point was determined via cross-validation and the norm of one standard error relative to the minimum. At this value, 28 of the 45 independent variables were included in the model.

We used a mixed-effects model per indicator to arrive at the final coefficients in the second stage of the Relaxed Lasso method (Hox, 2010). The mixed-effects model has two main advantages over the Lasso regression model:
- First, in this way, we could account for the fact that we often had multiple observations within a single household. It is important to account for this, because household members are expected to have a certain degree of coordination and interdependence in their travel behaviour. In 1,058 cases these were solo observations. In 207 cases, two respondents were members of the same household, while 24 households had three or more respondents.
- Second, by using these mixed-effects models, it was easier to test the relative importance of a variable with more than one level (categorical or ordinal variables). We did this via an ANOVA test.

The results of the ANOVA tests gave an impression of the variables' added value in the model (Table 2-appx.3). The absolute added value, as well as the relative position in the ranking, is always dependent on the other variables in the model and therefore never absolute. This is based on agreements between variables, as illustrated: there is a positive correlation between the frequency of bus, tram or metro use or the frequency of train use. If we were to include both, they would both become relevant factors in the analysis, but neither would rank among the top three variables, which now includes the general use of public transport (= bus, tram or metro + train). By combining both variables, little information is lost and the degree of freedom saved.

Table 2-appx.3 Relative importance of the variables per mixed-effects model

Position	Tech-savvy	Rent or Share	Multimodal	Travel Information
1	Age group	Age group	PT use	PT use
2	Freq. of travel	PT use	Environmental concern	Age group
3	Air travel (private)	Education level	Bicycle use	Education level
4	Education level	Air travel (private)	Age group	Air travel (private)
5	Gender	Environment concern	Education level	Freq. of travel
6	Urban density	Freq. of travel	Health status	Environment concern
7	Income	Speed pedelec ownr.	Air travel (private)	Income
8	Motorcycle ownr.	Folding bike ownr.	Speed pedelec ownr.	Urban density
9	PT use	Motorcycle ownr.	Folding bike ownr.	Health status
10	Environment concern	Urban density	Income	Gender
11	Folding bike ownr.	Gender	Freq. op pad	Folding bike ownr.
12	Speed pedelec ownr.	Income	Urban density	Motorcycle ownr.
13	Health status	Bicycle use	Motorcycle ownr.	Speed pedelec ownr.
14	Bicycle use	Health status	Gender	Bicycle use

Table 3-appx.3 presents the estimates and significance levels for all four mixed-effects models. Given the large number of stars, many effects are significantly unequal to zero, which is partly owing to the large number of observations and the use of machine-learning techniques (Lasso), with irrelevant categories no longer included in these models. It is important to note that the effects are always relative; that is, the effect is relative to the reference group (ref.).

Table 3-appx.3 Model estimates of four mixed-effects models

Categories	Level	Tech-savvy	Renting or Sharing	Multimodal	Travel Information
Gender	Man	*ref.*	*ref.*	*ref.*	*ref.*
	Women	-0.161***	-0.071*	-0.012	-0.095***
Age group	18 to 24 y/o	*ref.*	*ref.*	*ref.*	*ref.*
	25 to 39 y/o	-0.255***	-0.127	-0.183**	-0.290***
	40 to 54 y/o	-0.422***	-0.206***	-0.146*	-0.378***
	55 to 64 y/o	-0.730***	-0.323***	-0.057	-0.504***
	65 to 74 y/o	-0.901***	-0.496***	-0.037	-0.585***
	75+	-1.392***	-0.837***	-0.443***	-1.131***
Education level	Low	*ref.*	*ref.*	*ref.*	*ref.*
	Medium	0.171***	0.187***	0.160***	0.193***
	High	0.275***	0.420***	0.268***	0.383***
Income	Less than €2,000 p.m.	*ref.*	*ref.*	*ref.*	*ref.*
	€2,000 to €3,000 p.m.	0.114**	0.035	0.045	0.122***
	€3,000 to €4,000 p.m.	0.164**	0.155**	0.133**	0.217***
	€4,000 p.m. or more	0.268*	0.099	0.348***	0.406***
Health status	Good or excellent	*ref.*	*ref.*	*ref.*	*ref.*
	Fair	-0.040	-0.023	-0.158***	-0.096*
	Poor	-0.135	-0.212*	-0.377***	-0.297***
Environmental concern	Unconcerned	*ref.*	*ref.*	*ref.*	*ref.*
	Neutral	0.149**	0.151**	0.270***	0.243***
	Concerned	0.170**	0.165**	0.382***	0.315***
	Very concerned	0.255**	0.423***	0.571***	0.484***
Frequency of trips	1 time per week or more	*ref.*	*ref.*	*ref.*	*ref.*
	1 to 3 days per month	-0.083	-0.077	-0.046	-0.082
	1 to 11 days per year	-0.309***	-0.188***	-0.104	-0.259***
	1 time per year or less	-0.523***	-0.351***	-0.293**	-0.507***
Own a car	No	*ref.*	*ref.*	*ref.*	*ref.*
	Yes	0.231**	0.249**	0.109	0.225**
Own a folding bike	No	*ref.*	*ref.*	*ref.*	*ref.*
	Yes	0.105	0.282***	0.246**	0.228**

Categories	Level	Tech-savvy	Renting or Sharing	Multimodal	Travel Information
Own a speed pedelec	No	*ref.*	*ref.*	*ref.*	*ref.*
	Yes	0.311	0.995***	0.883**	0.748**
Frequency of cycling	1 time per week or more	*ref.*	*ref.*	*ref.*	*ref.*
	1 to 3 days per month	0.072	-0.060	-0.126**	-0.016
	1 to 11 days per year	0.011	-0.116*	-0.340***	-0.154***
	1 time per year or less	0.051	-0.083*	-0.252***	-0.087*
Frequency of PT	1 time per week or more	*ref.*	*ref.*	*ref.*	*ref.*
	1 to 3 days per month	0.030	-0.091	-0.075	-0.068
	1 to 11 days per year	-0.017	-0.183***	-0.314***	-0.248***
	1 time per year or less	-0.136**	-0.446***	-0.824***	-0.642***
Air travel (private)	Never	*ref.*	*ref.*	*ref.*	*ref.*
	1 or 2 trips per year	0.165***	0.219***	0.099**	0.178***
	3 to 5 trips per year	0.402***	0.502***	0.324***	0.452***
	6 trips per year or more	1.112***	0.882***	0.508*	0.723***
Urban density	log(OAD)	0.078***	0.055**	0.033	0.060***
Constant		-0.113	-0.142	-0.006	0.010

*Significance levels: * < 0.05; ** < 0.01; *** < 0.001; ref. is reference level*

The final table presents the goodness-of-fit statistics for the four indicators' mixed-effects models (Table 4-appx.3). All observations are included in all the models; consequently, we are not troubled by missing values. The log-likelihood of an empty simple linear model is given under 'Log-Likelihood (null)'. By indicating that we are dealing with mixed effects, the log-likelihood already moves towards null. The final fit is given on the following line ('Log-likelihood (full)'), where we see that the largest improvement is for the need for *Travel Information*, and the least improvement for *Tech-savvy*. As stated above, we concluded that *Travel Information* acts as an intermediary and is thus the most important indicator. Consequently, it is only logical that the Lasso regression sought and achieved the greatest improvement in that indicator. In all cases, unexplained variance remains, and hence the variable used in the model cannot explain certain differences between people.

Table 4-appx.3 Model fit statistics for all four mixed-effects models

	Tech-savvy	Rent or Share	Multimodal	Travel Information
Observations	1.547	1.547	1.547	1.547
Log-likelihood (null)	-2.124,04	-2.086,46	-2.074,55	-2.081,76
Log-Likelihood (mixed)	-2.048,79	-1.942,49	-1.993,53	-1.992,69
Log-Likelihood (full)	-1.833,66	-1.728,40	-1.739,41	-1.650,78
pseudo-Rho^2	0,14	0,17	0,16	0,21
AIC	3.737,32	3.526,80	3.548,82	3.371,55
BIC	3.924,36	3.713,84	3.735,86	3.558,59

Colophon

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