Master's thesis

NTNU
Norwegian University of Science and Technology
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Department of Architecture and Planning

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User acceptance of geofencing and ITS for urban traffic management of automobiles: a socio-technical perspective

Master's thesis in Physical Planning
Supervisor: Fitwi Wolday
Co-supervisor: Yngve Karl Frøyen

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Abstract

In the context of transitioning to sustainability in the transport sector, addressing the well-established system of automobility and its deeply ingrained practices is of great importance. With this transition in mind, the objective of this master thesis is to investigate user acceptance of geofencing and Intelligent Transport Systems (ITS) for urban traffic management within the realm of automobility. These technologies are considered significant components in facilitating the shift towards sustainable urban mobility. The research aims to understand user attitudes, concerns, and perceptions regarding the potential for and barriers to implementing geofencing and ITS technology, as well as identifying factors that influence users' intentions to change behavior, adopt, and utilize these technologies.

The thesis specifically focuses on two application areas of the technology: distance-based road pricing through geofence-enabled low-emission zones and speed control zones. The relevance of these use cases, in the context of sustainable transitions, lies in their potential to impact car practices by reducing emissions and improving urban air quality. The study is firmly grounded in the context of sustainable transitions in urban mobility, considering socio-technical aspects and adopting a multi-level perspective to conceptualize and gain a comprehensive understanding of the automobility socio-technical system and the role of user acceptance and behavior within its transition lock-in mechanisms.

The literature review first examines the state-of-the-art research projects, by highlighting the significance of these technologies for urban traffic management, followed by the theoretical framework of Sustainable Transitions (ST), thereunder Socio-technical Transitions (STT) and Multi-Level Perspective (MLP). An analytical framework of user acceptance is presented to serve as the knowledge foundation for analyzing empirical data from the GeoSUM and GeoFlow projects.

The method of this study primarily adopts a quantitative research approach, utilizing descriptive statistics, exploratory factor analysis (EFA), and Spearman's rank correlation (SRC) as analytical tools. EFA is used to assess the validity and reliability of the survey as a measurement instrument, while SRC is employed to explore associations between different variables in the data. The characteristics of the empirical data and its collection process are also discussed, with descriptive statistics providing insights into these characteristics.

The results of the data analysis show satisfying values from the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity (BTS) tests of the measurement instruments, followed by a detailed display of survey results and correlation analysis between the survey variables of GeoSUM and GeoFlow, as well as their relationship with participants' behavioral intention. The findings shed light on users' various attitudes, concerns, and preferences regarding the use of geofencing and ITS technology for traffic management. Before the results are concluded a remark on the limitations of the study, such as the sample used for the survey, invalidity of variables used for measurements of psychological constructs, and the data analysis method.

The conclusion of the analysis indicates a moderate and mixed degree of user acceptance, as well as barriers and facilitators in the general users' attitudes, effort expectancy, performance perceptions, privacy concerns, and price evaluation regarding a successful implementation of geofencing and ITS technology in urban traffic management. Variables within the factors attitudes, privacy concerns, performance expectations, and price value, were found to correlate with individuals' behavioral intention to adopt and utilize the system. Factors such as valuing technology, concern for pollution, trust in authorities, and perception of system performance influenced users' intentions.

While the study highlights favorable attitudes towards the system's fairness, adaptability, and potential to improve traffic management, it also identifies challenges related to pricing levels, perceived lack of savings, and privacy concerns. Addressing these barriers through improved pricing structures, clearer cost benefits, and robust data protection measures can enhance user acceptance and increase the likelihood of successful implementation. The findings emphasize the importance of considering non-monetary aspects, such as fairness and user-friendliness, in evaluating the acceptance and adoption of geofencing and ITS technology. The results can inform policymakers, transportation planners, and industry stakeholders in designing effective interventions and policies that promote sustainable urban mobility and enhance the overall user experience.

Sammendrag

I konteksten med overgangen til bærekraft innen transportsektoren er det av stor betydning å ta tak i det etablerte systemet med automobilitet og de dypt forankrede praksisene knyttet til den. Med denne overgangen i tankene er målet med denne masteroppgaven å undersøke brukeraksept av geofencing og Intelligent Transport Systems (ITS) for bytrafikkstyring innenfor rammen av bilbruk. Disse teknologiene anses som betydningsfulle komponenter for å lette overgangen til bærekraftig bymobilitet. Forskningen har som mål å forstå brukernes holdninger, bekymringer og oppfatninger angående potensialet for og barrierene for implementering av geofencing- og ITS-teknologi, samt identifisere faktorer som påvirker brukernes intensjoner om å endre atferd, ta i bruk og utnytte disse teknologiene.

Oppgaven fokuserer spesifikt på to bruksområder for teknologien: distansebasert veiprising gjennom geofence-aktiverte lavutslippssoner og fartskontrollsoner. Relevansen av disse bruksområdene, i sammenheng med bærekraftige overganger, ligger i deres potensial til å påvirke bilbruk ved å redusere utslipp og forbedre luftkvaliteten i byene. Studien er forankret i sammenhengen med bærekraftige overganger innen bymobilitet, og tar hensyn til sosiotekniske aspekter og bruker en flernivåperspektiv for å konseptualisere og oppnå en helhetlig forståelse av det sosiotekniske systemet for bilbruk og rollen til brukeraksept og atferd i mekanismene for låsing av overgangen.

Litteraturgjennomgangen undersøker først forskningsprosjekter på fremtidig teknologi, ved å belyse betydningen av disse teknologiene for bytrafikkstyring, etterfulgt av det teoretiske rammeverket for bærekraftige overganger (ST), herunder sosiotekniske overganger (STT) og flernivåperspektiv (MLP). Et analytisk rammeverk for brukeraksept presenteres som kunnskapsgrunnlaget for analyse av empiriske data fra GeoSUM- og GeoFlow-prosjektene.

Metoden for denne studien benytter primært en kvantitativ forskningsmetode, og bruker deskriptive statistikker, utforskende faktoranalyse (EFA) og Spearman's rank-korrelasjon (SRC) som analytiske verktøy. EFA brukes for å vurdere gyldigheten og påliteligheten til undersøkelsen som måleinstrument, mens SRC brukes for å utforske sammenhenger mellom ulike variabler i dataene. Egenskapene til de empiriske dataene og innsamlingsprosessen diskuteres også, og deskriptive statistikker gir innsikt i disse egenskapene.

Resultatene fra dataanalysen viser tilfredsstillende verdier fra Kaiser-Meyer-Olkin (KMO) og Bartletts sfærisitetstest (BTS) av måleinstrumentene, etterfulgt av en detaljert presentasjon av undersøkelsesresultatene og korrelasjonsanalyse mellom undersøkelsesvariablene for GeoSUM

og GeoFlow, samt deres forhold til deltakernes atferdsintensjon. Funnene belyser brukernes ulike holdninger, bekymringer og preferanser angående bruk av geofencing- og ITS-teknologi for trafikkstyring. Før resultatene konkluderes, påpekes begrensninger ved studien, for eksempel fra utvalget som ble brukt i undersøkelsen, ugyldighet av variabler brukt for måling av psykologiske konstruksjoner og dataanalysemetoden.

Konklusjonen av analysen indikerer moderat til sterk brukeraksept, samt barrierer og faktorer som fremmer generelle brukerholdninger, forventninger om innsats, prestasjonsoppfatninger, personvernbekymringer og prisevaluering angående en vellykket implementering av geofencing- og ITS-teknologi i bytrafikkstyring. Variabler innenfor faktorene holdninger, personvernbekymringer, forventninger til ytelse og prisverdi ble funnet å korrelere med enkeltpersoners atferdsintensjon for å ta i bruk og utnytte systemet. Faktorer som vurdering av teknologi, bekymring for forurensning, tillit til myndigheter og oppfatning av systemets ytelse, påvirket brukernes intensjoner.

Mens studien fremhever positive holdninger til systemets rettferdighet, tilpasningsdyktighet og potensial for å forbedre trafikkstyring, identifiserer den også utfordringer knyttet til prisnivåer, oppfattet mangel på besparelser og personvernbekymringer. Å håndtere disse barrierene gjennom forbedrede prissettingsstrukturer, tydeligere kostnadsfordeler og robuste personvernforanstaltninger kan øke brukeraksepten og øke sannsynligheten for vellykket implementering. Funnene understreker betydningen av å vurdere ikke-økonomiske aspekter, som rettferdighet og brukervennlighet, ved evalueringen av aksept og bruk av geofencing- og ITS-teknologi. Resultatene kan informere beslutningstakere, transportplanleggere og interessenter i bransjen om å utforme effektive tiltak og politikker som fremmer bærekraftig bymobilitet og forbedrer den generelle brukeropplevelsen.

Forord

Jeg vil først få si takk til mine veiledere, hovedveileder Fitwi Wolday og biveileder Yngve Frøyen, for deres gode innspill gjennom semesteret.

Videre vil jeg rette en takk til avdelingen for mobilitet hos SINTEF, som har delt dataene fra prosjektene GeoSUM og GeoFlow, og spesielt Petter Arnesen som gjorde det mulig og for å være en hjelpsom kontaktperson.

I dette prosjektet endret jeg temaet i løpet av semesteret, som gjorde det enda viktigere å ha god og rask kontakt med SINTEF.

Olve Nes Kløvning

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Abbreviations

ADAS	Advanced Driver-Assistance System
AVTAM	Autonomous Vehicles Technology Acceptance Model
BTS	Bartlett's Test of Sphericity
CTAM	Car Technology Acceptance Research Model
EFA	Exploratory Factor Analysis
EV	Electric Vehicle
FA	Factor Analysis
GDPR	The General Data Protection Regulation
GPS	Global Positioning System
ITS	Intelligent Transport Systems
KMO	Kaiser-Meyer-Olkin
MLP	Multi-Level Perspective
NLP	Natural Language Processing
PSP	Perceived system performance
SAE	The Society of Automotive Engineers
SNM	Strategic Niche Management
SRC	Spearman’s Rank Correlations
SSB	Statistisk Sentralbyrå
ST	Sustainable Transitions
STRN	Sustainable Transitions Research Network
STT	Socio-technical Transition
TAM	Technology Acceptance Model
TIS	Technological Innovation System approach
TM	Transition Management
TOD	Transit-Oriented Development
UTAUT	The Unified Theory of Acceptance and Use of Technology

1 Introduction

1.1 Research objectives

This thesis focusses on user acceptance of geofencing and Intelligent Transport Systems (ITS) for urban traffic management of automobility. The concept and application of geofencing and ITS has been gaining more relevance in mobility management and transportation flow. This surge in interest was partially spurred by sustainability goals, which is demanding new innovative ways of controlling traffic and reduce automobile dependency.

Within the broader ITS application area, the thesis will focus on a niche specifically adapted to address sustainable transitions in urban mobility. Testament to the significance of understanding the potentials for and barriers to transitions, research on understanding and governing transitions to sustainability has expanded considerably geographically and through topics the last ten years (Köhler, Geels et al. 2019). A transition in transport and mobility, especially in urban environments, is considered as being highly impactful in most of people's everyday life. As such it is prudent to understand how people react to it and people propensity to accept and adapt to new changes (Miskolczi, Földes et al. 2021). For the purpose of this thesis, urban mobility's sustainable transition (ST) is understood as a socio-technical transition (STT), which looks at the co-evolution of social, technological, institutional and economic changes (Patterson, Schulz et al. 2016).

Regarding potentials for and barriers to a transition in automobility, the primary research objective of this thesis is to enhance our understanding of user acceptance tendencies toward urban traffic management interventions employing geofencing and ITS technology in automobiles. To achieve this objective, the following overarching research question will be addressed, along with its corresponding sub-questions:

Main RQ: To what degree is user acceptance observed regarding distance-based road pricing in low-emission zones, and speed control zone, when employed by geofencing and Intelligent Transportation Systems (ITS) technology in private cars?

Answering this research question forms the fundamental perspective of the research objective, which is to identify user acceptance levels concerning the implementation of geofencing and ITS technology in traffic management. By investigating user attitudes and perceptions towards geofencing and ITS, the study aims to provide valuable insights into the feasibility and effectiveness of these interventions in promoting sustainable and efficient automobility.

Sub RQ#1: What are the potential barriers and facilitators of the general users' attitudes, effort expectancy, performance perceptions, and privacy concerns and price evaluation in a successful implementation of geofencing and ITS technology for urban traffic management?

This sub-question investigates users' direct thoughts, tendencies and perceptions relating to the use of geofencing and ITS technology in the context of traffic management. It aims to gather insights into users' firsthand encounters and expectations of these technologies, their perceived benefits, challenges encountered, and anticipated outcomes. By understanding users' thoughts, expectations, and concerns, researchers can gain valuable insights into the real-world implications and potential effectiveness of geofencing and ITS technology in traffic management scenarios.

Sub RQ#2: Which factors positively or negatively correlates to individuals' behavioral intention to change behavior, adopt, and utilize geofencing and ITS technology?

This sub-question explores more directly the factors that influence users' willingness and intention to adopt and actively engage with geofencing and ITS technology. It seeks to identify the key drivers that encourage users to embrace these technologies, more specifically relating to attitudes, privacy concerns, performance perceptions, price value, and effort expectancy. By identifying the factors that contribute to a behavioral intention, researchers can provide insights into strategies and interventions that can foster higher acceptance and adoption rates of geofencing and ITS technology among users. Behavioral intention refers to an individual's personal tendency or preparedness to engage in a specific behavior, and particularly in relation to using a specific technology or system (Venkatesh, Thong et al. 2012).

By addressing these research questions, this thesis aims to contribute to the body of knowledge surrounding user acceptance of geofencing and ITS technology for urban traffic management. The findings can inform policymakers, transportation planners, and industry stakeholders in designing effective interventions and policies that promote sustainable urban mobility and enhance the overall user experience.

To assist in the research objective, quantitative survey data from the projects GeoSUM and GeoFlow initiated by SINTEF will be utilized. The main objective with these projects was testing geofencing and ITS systems for traffic management. The equipment of this technology, as well as the use cases of differentiated road pricing/low-emission zones, and speed control zones, are investigated in this thesis. Further introductory information about the projects is given in section 1.3 and further information on the pilot project setup and data collection are given in section 3.2.

1.2 Pursuit of sustainability in urban mobility

The broad pursuit of achieving sustainability is a major challenge in the world. There are countless of strategies and plans that aims for it. In Europe, there is the EU 2030 Climate Action Plan that has set a target to reduce greenhouse gas emissions to at least 55% below the levels of 1990. Another is the European Green Deal with the goal of 90% emission reduction in the transport sector by 2050 (EU-Comission 2019). In Norway there are plans to contribute to this, such as the Climate Action Plan that aims for the country to being climate neutral by 2030 (Climate Action Plan 2021-2030).

Transport sector accounts for approximately 25% of Europe's greenhouse gas emissions, and is also the primary contributor to local urban air pollution (EU-Comission 2020). As urban areas are one of the most important focus areas in this debate, there are many different emerging approaches of transforming various parts of the complex urban transport. In the field of urban planning, there is a paradigm shift that focus on the integrated urban mobility concept and accessibility instead of focusing on just the transport itself, like making compact cities and mixed land use types as ways to increase accessibility for the citizens. This reduces the need for transportation altogether (UN-Habitat). Various other interventions include emission reduction through improvement in vehicle technology such as affordable electrification of vehicles, while some methods include nurturing and rewarding sustainable mobility behaviors transport choices through e.g. policy and technology transitions (Loorbach and Rotmans 2006, Requia, Mohamed et al. 2018). These different approaches will likely interact in the transition to sustainability, and urban traffic management is an tool that can support this transition (Elzen, Geels et al. 2004).

To address the sustainability challenge in urban mobility, the utilization of geofencing and Intelligent Transportation Systems (ITS) can play a significant role in enacting urban mobility regulations and promoting new travel behaviors within urban environments. Cities, being the primary hotspots of daily mobility and energy consumption, contribute to over half of the world's emissions (UN-Habitat 2021). Moreover, cities serve as natural hubs for policy experimentation and planning, with local city governments being more engaged with citizens and their activities compared to national governments (Bulkeley 2010, Bulkeley, Castán Broto et al. 2011).

Geofencing has been around since the 1990s (Oßenbrügge and Leonardi 1995, Chen, Provart et al. 1997). It has been used in everything from location-based marketing to animal tracking and disaster management mitigation (Hakim, Renaldi et al. 2022, de Mel, Seneweera et al. 2023, Garcia 2023). This broad applicability is possible because it uses a general technology as global positioning system (GPS) to define geographic boundaries, where a device linked to it can receive and send information based on its position relative to this boundary (Rahate 2016). Intelligent transport systems (ITS) are argued to have been around for two decades, which is comprehensive systems that integrates broad range of vehicle sensing, control, communication, and electronics. In a review of ITS by Zear, Singh et al. (2016), they define ITS as "the set of applications which are advanced and aim to apply intelligent information and communication technologies in order to provide services for transport and traffic management". This is essentially the technology that enables functionalities in the vehicle and the communication between vehicle and an external network (Singh and Gupta 2015, EU-Comission 2020). Figure 1 shows a simple illustration of the interaction of these technologies, were the geofence is the virtual zone and ITS is what handles the information and sends it to and outside of the vehicle to communicate (Arnesen, Seter et al. 2020).

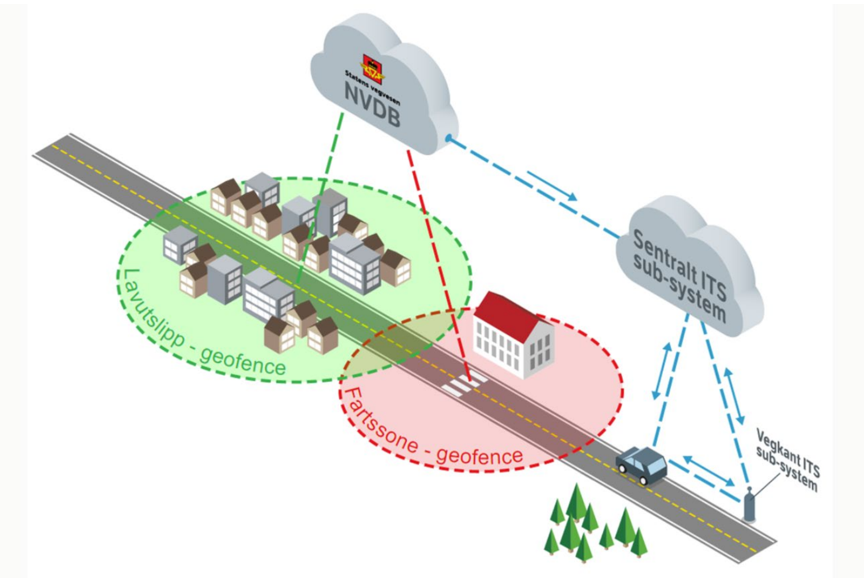

Figure 1 Utilization of geofencing and ITS in urban traffic management (Arnesen 2018)

In a study by Kuss and Nicholas (2022), they find that local city governments led over 75% of successful urban innovations aimed at reducing car usage, where the innovations that have been particularly effective, include measures such as congestion charges, parking and traffic controls, and restricted traffic zones. In the last decade or so, geofencing has been one among many technical solutions, which various city-regions have resorted to in order to contain excess demand in transport and limit private car use. In a report by Hansen, Arnesen et al. (2021), they found projects between 2005 and 2021 that either fully implemented geofences into urban mobility or pilot project experiments. They find examples of cities that integrate geofencing with shared micromobility, such as e-scooters and e-bikes (Moran, Laa et al. 2020, Wanganoo, Shukla et al. 2022). Among other things, they are looking to fix misuse of the micromobility by regulating speed and parking, and being able to quickly communicate between the responsible authority and the users (Nikiforiadis, Martín et al. 2023).

Geofencing and ITS also find application in the realm of freight and logistics, where they are utilized for managing low emission zones for freight vehicles and facilitating route planning for freight drivers (Leonardi, Allen et al. 2015, von Roth 2016). Ongoing projects, such as the NordicWay2 2020 initiative in the City of Gothenburg, explore the implementation of geofencing in private cars and dynamic environmental zones (Innamaa, Kulmala et al. 2020).

ITS are also being deployed independently from the use of geofencing, examples are the millions of cars already equipped with an on-board navigation system that are able to consider real-time traffic while driving (EU-Comission 2020). It has been found in a considerably amount of research projects that ITS can be utilized to improve traffic safety through vehicle control systems, traffic signals and detection systems (Zulkarnain and Putri 2021). Additionally, in newer years, it has been researched in the context of reducing environmental impact, from e.g., greenhouse gas and urban pollution, through increased traffic flow and less congestions (Luo, Barth et al. 2018, Yang, Peng et al. 2020).

In essence, the implementation of geofencing and ITS for automobility can function as instruments for local governments to enforce policies that enable more environmentally friendly travel behavior and safety in the traffic. However, to successfully integrate it into the everyday urban mobility system, there are many additional elements to consider as part of its implementation. As part of these considerations, user acceptance plays a vital role in in adoption of geofencing and ITS in the context of automobility.

1.3 Pilot projects GeoSUM and GeoFlow

The data utilized in this thesis is obtained from twin projects, GeoSUM and GeoFlow, which were conducted between 2018 and 2022. Both projects collected data from recruited participants using surveys, GeoSUM (2018-2021) and GeoFlow (2020-2022), and were aimed at capturing respondents attitudes, expectations, feedback and reactions on driving with equipment implementing geofencing and ITS in their cars (Arnesen, Seter et al. 2020, Arnesen, Moscoso et al. 2022)

GeoSUM was launched by SINTEF in 2018, in a collaboration between The Norwegian Public Roads Administration, Volvo, Q-Free and NTNU. It researches the use of geofencing in combination with intelligent transport systems (ITS) for cars in traffic, to increase safety and environmental benefits. The project has been conducting pilot experiments in Trondheim and Oslo to explore two different applications of geofencing technology. The first set of use cases involved defining speed rule for a designated area, such as vehicle speed limits in the vicinity of schools. The second set of use cases involved creating low-emission zones through geofences, where vehicles were subject to distance-based road pricing to establish more equitable road pricing. This project finished in 2021. (Arnesen, Seter et al. 2020)

The GeoFlow project started afterwards in 2020 and was conducted by SINTEF, together with Q-FREE and The Norwegian Public Roads Administration. The project is a continuation of the use case with differentiated road pricing in low-emission zones done in GeoSUM. The pilot experiment focus on road pricing as an alternative to tolling for car users, with a slightly different system setup compared to the GeoSUM, but still using geofencing and ITS technology. This experiment was only conducted in Trondheim, and finished in 2022. (Arnesen, Moscoso et al. 2022)

Section 3.2 presents the data collection and more details of the projects more extensively.

1.4 Thesis structure

Under the introduction chapter, the research area was delimited, research questions presented and background information pertaining to the research topic laid out. A brief description of the pilot projects GeoSUM and GeoFlow, the source of empirical data used to answer the research questions at hand, concludes the introduction section.

Chapter two presents the literature review, which consist of three parts: State-of-the-art, presenting the latest and relevant research looking at geofencing and ITS for traffic management; theoretical framework, which widely puts urban mobility in the concept of sustainable transitions, thereunder socio-technical transitions and multi-level perspective to conceptualize the automobile socio-technical system; and analytical framework, that seeks to bring an understanding of relevant user acceptance factors and how it relates to behavioral intentio and use behavior of individuals.

Chapter three presents methodology followed by description of empirical data. Quantitative method is discussed as the main approach to data analysis, and more specifically exploratory factor analysis (EFA) to determine validity and reliability of the surveys, and correlation analysis to look closer at correlation between the variables and what correlates to behavioral intention.

Chapter four discusses the analysis results, first of the EFA, and then of the survey responses including the variables correlating the most with behavioral intention through SRC.

Chapter six concludes the thesis and evaluates the results' potential to answer the research questions.

2 Literature review

This section presents the literature review of geofencing and ITS technology for urban mobility and automobility, as well as surrounding topics of relevance. The first part lays out the state-of-the-art of research on geofencing and ITS in the context of urban mobility. The second part will then situate urban mobility and automobility in the theoretical framework of Sustainable Transitions (ST), thereunder Socio-technical Transitions (STT) and Multi-Level Perspective (MLP). The last part will present research through the analytical framework of user acceptance as the knowledge foundation of analyzing empirical data from GeoSUM and GeoFlow.

2.1 State-of-the-art

As mentioned in the introduction, geofencing and ITS has over the last decade been in an increasingly number of projects focusing on urban traffic management. Parts of these is covered in a comprehensive review of geofencing's possible adoption areas for urban traffic management conducted by Hansen, Arnesen et al. (2021). They found in this review, use cases that have been introduced to urban mobility, such as in shared micro-mobility and freight and logistics, and pilot experiments in geofencing, similar to GeoSUM and GeoFlow.

Many of the positive effects of using virtual zones can be found in evaluations of various projects in public transport, freight and micromobility, such as Smartfusion, Civitas Eccentric, NordicWay2, ElectriCity (Leonardi, Allen et al. 2015, ElectriCity 2019, LOTS-Group 2019, Innamaa, Kulmala et al. 2020). In Smartfusion, the aim was to develop smart urban freight solutions, where geofencing was one the of the main technologies in several trial cases, in Italy, Berlin and UK. They measured considerably less CO2 emissions in areas where urban low-emission zones forced hybrid freight vehicles to switch over to electricity (Leonardi, Allen et al. 2015). In Civitas Eccentric, the aim was to test experimental solutions and alternatives for urban mobility in Stockholm. Here they measured significant reductions in CO2 emissions when using plug-in hybrid electric vehicles for night-time freight transportation in combination with low-emission zones (LOTS-Group 2019). In NordicWay2, the aim was to assess feasibility of ITS, including a few geofencing services in the Nordic countries, and found that geofencing can enable dynamic environmental zones, in-vehicle speed limits and traffic ahead warnings, which then can reduce emissions through reduction in congestion and improved urban mobility. In a ElectriCity project, they found that using geofencing for zero-emission and low speed zones in the bus routes led to bus drivers having less stress as an effect of increased automation and less CO2 emissions in the sensitive areas along the road (ElectriCity 2019).

These projects collectively highlight the common understanding of geofencing as a means to create virtual zones for regulatory purposes. Similarly, research on shared micro-mobility, such as e-scooters and e-bikes, has demonstrated the usefulness of geofencing in applying regulations for their usage in urban areas (Prencipe, Colovic et al. 2022). Examples of these regulations include geofence planning, speed limits and no-parking zones (Liazos, Iliopoulou et al. 2022, Nikiforiadis, Martín et al. 2023). However, as presented by Hansen, Arnesen et al. (2021), a problem with this is often that the public sectors are not involvement in the regulatory work; limited to the companies in the private sector, and that there is no guarantee of spatial equality and focus on socio-economic benefits (Moran 2021).

Despite the wide array of geofencing applications, its use for urban traffic management in automobility are limited. Other than GeoSUM and GeoFlow, the most notable research has been done in the NordicWay2 project, were they studied and piloted usage areas for ITS in vehicles, and in some cases including geofencing in private cars. Including in this project, user acceptance was explored specifically regarding ITS technology, through conducting surveys on citizens, excluding the specific cases of geofencing. Among the key findings were that participants usually considered warnings on accident, obstacle, or traffic ahead to be the most useful information content while driving. There is also a high willingness to use ITS, but rather on main roads and highways over urban streets and on longer trips rather than in tight schedules. This suggests the fact that this technology is not favorable in everyday busy morning rush. The likely reasons for this could be that people would feel more distracted by the technology in those situations (Innamaa, Kulmala et al. 2020).

GeoSence is an ongoing project initiated by Joint Programme Initiative (JPI) Urban Europe, funded by the European Union's Horizon 2020 program. It brings together project partners from Germany, Norway, Sweden, and the UK, to elaborate on solutions in urban traffic management, and to create a possible framework that can integrate geofencing into urban mobility. This includes making strategic implementation guidelines and legal and governance framework, measuring, and evaluating impacts of pilot projects, and understanding user acceptance of the technology for various use cases. However, this project has not been concluded yet, as it is planned to finish in 2024. (GeoSence 2020)

The program "Geofencing" is another research and innovation program initiated and supported by the Swedish Transport Administration. Its primary objective is to foster collaboration among various stakeholders in society, business, and academia to collectively develop solutions that advance the utilization of geofencing in transportation system management. However, research findings, especially regarding user acceptance, is limited. (CLOSER 2021)

Despite the growing interest and application of geofencing in various domains of urban traffic management, there is currently overall a limited existing research literature specific to user acceptance for its use cases in distance-based road pricing and speed limit zones. This suggests that research in this particular area is relatively new and still in its early stages. The implementation of geofencing for distance-based road pricing in low-emission zones, in addition geofencing-enabled speed limit zones, presents a significant knowledge gap.

2.2 Theoretical framework

To develop a holistic perspective of geofencing and intelligent transport systems (ITS) in urban mobility, this chapter introduces the theoretical framework that serves as a reference for exploring related topics of transitions. The theoretical section contextualizes urban mobility and automobility within the broader frameworks of Sustainable Transitions (ST), specifically Socio-Technical Transitions (STT), and Multi-Level Perspectives (MLP). These frameworks will help at conceptualizing the automobile system, as well as its different components, including the importance of user practices and social aspects. It ends with looking at behaviorlock-in mechanisms of socio-technical transitions and research gap.

2.2.1 Sustainable transition in urban mobility

Because of all the fundamental sustainability challenges we face in several domains, there has been many attempts at creating a full picture on how to understand, govern and realize sustainable transitions (Falcone 2014, Turnheim, Berkhout et al. 2015). The comprehensive definition of sustainable transitions (ST) consists of many different elements that interplay. Some of them which are adapted from Köhler, Geels et al. (2019)'s description, are outlined in the following paragraphs.

Transitions take several decades to fully mature, which are several reasons for. One is that it takes a long time to downsize and destabilize existing systems. This is essentially trying to overcome the incumbent actors in the systems. Because of this, it's also difficult to introduce new radical "green" innovations and practices. With this *long-term process* in mind, it is important to see how new radical niches can coexist in destabilizing systems.

Transitions are *multi-actor processes* performed by a variety of groups, such as politics, academia, industry, households and citizens, who all have their own resources, strategies and interests. This means that transitions have a high degree of *multi-dimensionality and co-evolution*, that consist of socio-technical systems with multiple elements and changes in e.g., culture, markets, technologies, user practices, infrastructure, policies, industry, supply and distribution chains.

There is a close relationship between *stability and change* in ST research. On the one hand, we have the entrenched systems around petrol automobiles, intensive agriculture, coal/gas-fired power plants etc. On the other hand, there are green innovations and practices trying to diffuse into the socio-technical systems. Understanding this relationship is important to visualize the whole transition. Because of this relationship, there is also a lot of *open-endedness and uncertainty* in transitions. The multiple promising initiatives and innovations in all domains, makes it difficult to predict which of these will succeed. This means the future is open-ended with many possible transition pathways, where uncertainty can be magnified by non-linear innovation, political and cultural processes.

The conception of sustainability is greatly *contested*, which often leads to *disagreement* between different societal groups and actors about the most preferable pathway for a sustainable transition. Sustainability is also a public good, which makes it difficult for private actors to choose where the direction of the transition is going. The public policy must therefore play a fundamental role in the directionality of the transitions, through regulations, subsidies, taxes, innovation policies and standards. This requires a normative narrative for the transitions.

The starting point of a sustainable transition in urban mobility is often considered as the established system of automobility, which is deeply embedded in many of people's lifestyles (Dudley, Kemp et al. 2020). In Norway, we can also see this lifestyle by the high share of car usage in trips in the last National Travel Survey 2018/2019, where it was found that 53% share of daily trips are done with cars. Also, 85% of the participants for the survey belong to a household with at least one car (Berit Grue, Iratxe Landa-Mata et al. 2021). Furthermore, of the total amount of passenger car kilometers driven in Norway in 2022, 63,7% was fossil fuel cars (SSB 2023). The scientific community widely agrees that the private car-based urban mobility models have an unsustainable impact on urban environmental quality, health and economy (Ezquiaga and Barros 2023). Efforts of impacting a sustainable transition for urban mobility must involve automobiles, and by many, this is understood as a long-term process that involves a variety of groups, stability and change, and disagreements; much like the characteristics of a sustainable transition (Loorbach and Rotmans 2006).

The reason automobility is prominent is the past development of urban mobility planning and transport planning. The beginning of modern development in urban mobility and transport seemingly arrived around 150 years ago, when urban expansion pushed many cities beyond a walkable radius. This is around the 1880s, when the first mass public transit systems allowed middle-class people to move around, followed by bicycles that did the same for the working class in the early 20th century (Schipper, Emanuel et al. 2020). However, it was car-oriented urban planning in the 20th century that offered people luxurious flexibility of private cars and that fundamentally redefined streets we know today, also in places where cars were not prevalent (Freund and Martin 1993, Schipper 2008). Streets were redesigned for speed rather than walking, with an example such as New York, where Robert Moses became the face of car-focused development in cities (Caro 1974). This trend accelerated after World War II, first in many of Europe's bombed-out cities and later in cities across the globe, from Johannesburg to Brasilia and Chandigarh. Planners welcomed the principles of high modernist car design, which aimed to create car-based, suburban living quarters connected to central business districts through radial car roads (Schipper 2008).

2.2.2 Socio-technical approach

Viewing the sustainable transition of urban mobility through the socio-technical transition perspective offers a valuable approach for understanding the complex social and technical dynamics of it (Canitez 2019). This approach was first used to understand transitions in the field of innovation studies, to understand the impact of innovation in transitions (Geels 2019). When using this perspective, one can study the transitions of whole socio-technical systems. Siddiqi (2017), describes such a system as:

> "Sociotechnical systems – for example, telecommunication networks, electric grids, large-scale manufacturing systems – are interacting ensembles of engineered artifacts embedded in society, linked with economies, and connected with ecology. Such systems have been analyzed through the lenses of sustainability […], carrying influence in the literatures of technology innovation, product design, infrastructure planning, and service delivery. Sustainability concerns along the environmental and financial dimensions have motivated focus on waste and emissions reduction, new technology development, and greening of industrial ecosystems." (Siddiqi 2017)

The approach of socio-technical transition is different from technological transitions in that it accounts for changes, in e.g. institutional structures and user practices, which are non-technical innovations (Geels and Schot 2010, Rocco 2015). Although geofencing and ITS are technological innovations, using them for urban traffic management, such as low-emission zones, distance-based road pricing and speed control zones, requires it to interacting with other components, such as social phenomenon, cultural aspects and user behavior of automobility.

Figure 2 is an interpretation and graphical representation of the socio-technical system of automobility based on Geels (2002)'s configuration, highlighting its key components and their interactions. The diagram illustrates the complex network of elements encompassing the automobile system, including but not limited to infrastructure, vehicle design, user behavior, policy frameworks, and supporting technologies. Each component within the system has a complementary relationship with others, which collectively shapes the functioning of the overall socio-technical system of automobility.

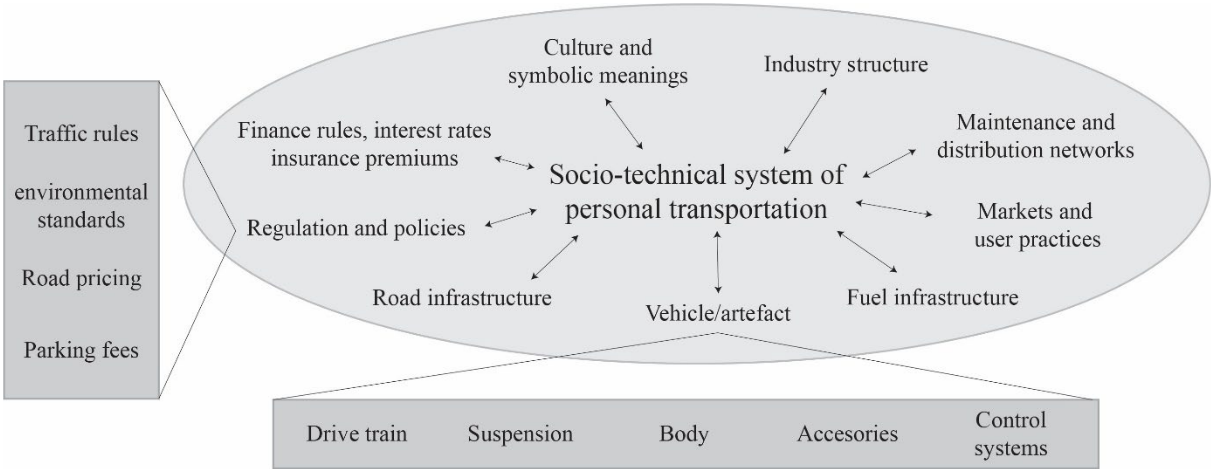

Figure 2 Socio-technical system of personal transportation (Adapted from Geels (2002), p. 1258, «Elements from the sociotechnical configuration in transportation").

As proposed by Geels (2002)'s configuration of elements, the automobility system has been entrenched and sustained by a complex interplay of social and technological elements, which have fostered further development of a road-centric infrastructure and various supporting factors. These encompass not only travel behavior and petroleum supplies but also user practices, car ownership patterns, land use configurations, and a network of industrial processes that favor fossil-fueled vehicles (Gauer, Axsen et al. 2022).

The automobility system has historically relied on deeply ingrained social practices and rituals such as road trips, commuting, and car clubs. Over time, the dominance of car-centric infrastructure and suburbanization has significantly influenced and shaped cultural norms, patterns of social interactions, and societal behaviors (Sovacool and Axsen 2018).

Automobiles have also come to symbolize social status, personal freedom, and individuality, acting as vehicles for self-expression and reflecting personal preferences, values, and aspirations (Moeckli and Lee 2007). From a political-economic perspective, transportation policies, infrastructure development initiatives, emission standards, and safety regulations wield substantial influence over the automotive industry and consumer behavior (Mattioli, Roberts et al. 2020).

2.2.3 Multi-level perspective

There are four prominent theories that aims at conceptualizing socio-technical transitions: the Multi-Level Perspective (MLP), Technological Innovation System approach (TIS), Transition Management (TM), and Strategic Niche Management (SNM) (Köhler, Geels et al. 2019). This thesis will use a multi-level perspective (MLP) on the socio-technical transition (Geels 2019). This theoretical model is largely used when looking at the long-term changes in systems and innovation in technical and social conditions (Elzen and Wieczorek 2005). The Multi-Level Perspective (MLP) is developed primarily by Frank W. Geels, which highlights the connection between three levels of analysis in a system: landscape, socio-technical regime, and niche.

The *landscape level* represents the broader socio-technical, economic, and cultural context in which transitions occur. This level includes factors such as demographics, social norms, resource availability, and geopolitical factors that shape the potential for technological change. Changes at this level can influence the direction and speed of technological transitions. Example of issues impacting most regimes around the world today would be climate change and urbanization. (Geels 2002)

The *regime level* represents the dominant set of rules, institutions, and practices that shape the existing socio-technological system. This level includes factors such as dominant actors, regulatory frameworks, and technical standards that can either facilitate or constrain the emergence and diffusion of new technologies. Changes at this level can create opportunities or barriers for niche innovations to gain traction and challenge the existing regime. (Geels 2010)

The *niche level* represents the space for experimentation and innovation outside the dominant regime. This level includes new technologies, practices, and business models that are not yet fully developed or integrated into the existing regime. Niche innovations may emerge in response to changes in the landscape or as a result of deliberate experimentation by niche actors. Over time, successful niche innovations may gain momentum and influence the direction of socio-technological transition, eventually challenging the existing regime. (Geels 2014)

Figure 3 illustrates the three levels of the multi-level perspective of automobility. At the core is the socio-technical system, expressed as the regime of automobility, which encompasses a dominant set of rules, institutions, and practices, along with various other components. Surrounding the regime are the depicted niches, which represent the innovative initiatives attempting to enter and transform the established regime. These niches include technologies like geofencing and battery electric vehicles, user practices exemplified by car sharing, and conceptual ideas such as vehicle on demand.

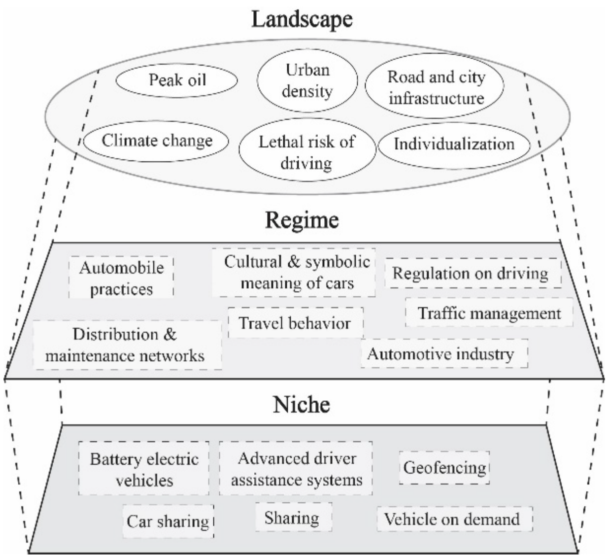

Figure 3 Illustration of landscape, regime and niches of automobility (adapted from Fraedrich, Beiker et al. (2015), p. 3 “multi-level-perspective on automobility).

It is essential to clarify that the different levels within this framework are not intended to be definitive descriptions of objective reality, but rather analytical and heuristic tools that aid in our understanding of the complex interactions and transformations within the sociotechnical system of automobility, as proposed by (Geels 2002). By adopting a multi-level perspective, we can delve into the various dimensions and interconnections that shape the transition of automobility. This approach allows us to analyze the intricate relationships between technological developments, social practices, cultural meanings, institutional arrangements, and economic factors that contribute to the stability or transformation of the sociotechnical system.

An example illustrating the interplay between the MLP levels is the implementation of a road tolling system in Norwegian cities as a niche for financing and managing urban traffic. The road tolls and road pricing was to serve as local taxing methods for financing transportation infrastructure projects by local governments; now, toll revenues contribute significantly to further road development, accounting for 20-30 percent of the overall funds allocated for road/transport funding in Norway (Welde, Bråthen et al. 2020). The implementation additionally introduced noticeable change in travel behavior in the Oslo/Akershus region from 1989 to 1990, indicating a reconfiguration of the automobile system when the first tolling scheme was introduced in Oslo. It is estimated to have reduced car travel by approximately 5-10% in its initial years of operation, affecting trip frequencies, mode choice, destination choice, and route choice (Ramjerdi 1995). In this example, road tolls function as part of the urban mobility regime in major Norwegian cities, prompting subsequent adjustments in travel behavior and automobile practices (Dudley, Kemp et al. 2020). Until today, many conclude that the introduction of road tolls to several Norwegian cities has significantly increased purchase and use of EVs, due to their long exemption from the road toll charges (Aasness and Odeck 2015). This interplay can be considered as an important component in a socio-technical transition of the automobility system in Norway.

Similarly, for geofencing and ITS, the MLP approach provides a relevant framework for understanding its diffusion in the context urban traffic management. The potentials of its ability to enact regulation and encourage specific behaviors through zones introduces new methods in traffic management for city governments as key actors in the regime (Hansen, Arnesen et al. 2021).

2.2.4 Lock-in mechanisms

Understanding the conditions and components of transitions, as well as the successful diffusion of niche innovations into the socio-technical regime, can be accomplished through the concept of lock-in mechanisms. Lock-in mechanisms refer to the specific features within transitions that facilitate the establishment of a socio-technical regime, while also indicating the conditions necessary for one regime to shift to another, thus establishing a new regime (Klitkou, Bolwig et al. 2015). It uses the multi-level concepts of MLP, influenced by the interplay between the landscape, regime, and niches (Geels and Schot 2007). Geels (2019) identifies three main lock-in mechanisms: *techno-economic, socio-cognitive*, and *institutional and political* lock-in.

Techno-economic lock-in mechanisms is viewed as rooted investments in competencies, factories, and infrastructures, creating vested interests that resist transitional changes. Additionally, existing technologies benefit from economies of larger scale and years of accumulated knowledge, resulting in cost advantages and higher performance.

Socio-cognitive lock-in mechanisms are when actors within these systems develop established routines and shared mindsets that limit their awareness of external developments. Moreover, there is a formation of "social capital" through alignments among social groups, while user practices and lifestyles become organized around specific technologies, such as car-dependent mobility behavior.

Institutional and political lock-in mechanisms is based on regulations, standards, and policy networks that favor incumbent actors, creating an uneven playing field. Vested interests exploit their access to policy networks to hinder radical innovation by diluting regulatory changes.

The lock-in features described is affiliated with the current urban mobility and automobility regime, which encompasses various components such as established car technologies, user practices, lifestyles, traffic regulations, the oil industry, and infrastructures. These aspects contribute to the persistence and resistance to change within the system. Therefore, when looking at potential barriers and facilitators regarding the introduction of a specific niche, it is essential understand and address these lock-in mechanisms. With regard to understanding and address the these, researchers have recognized the importance of technology acceptance and behavioral changes, which looks at the socio-cognitive lock-in mechanisms (Steg, Perlaviciute et al. 2015, Markard, Geels et al. 2020).

However, a discussed shortcoming of relying only on the MLP, is its inability analyze the micro-level aspects of the transition, such as individual level socio-cognitive change (Southerton and Watson 2015). In respect to this, psychology has emerged as a valuable field in studying the influence of technology acceptance and behavioral changes amidst transition pathways (Bögel and Upham 2018, Turnheim and Sovacool 2020, Van Rijnsoever and Leendertse 2020). In their article, Bögel and Upham (2018) emphasize the role of individuals as carriers of practices and highlight that individuals are not independent entities but are influenced by sociotechnical transitions. They argue for a closer examination of individual-level processes, particularly in the context of consumption and technology acceptance.

Similarly, Van Rijnsoever and Leendertse (2020) underline the importance of combining technological innovation with behavioral changes among users, especially when focusing on strategies to achieve transitions by leveraging niche systems. This implies that technological advancements alone may not be sufficient to drive transitions alone, and efforts should also be directed towards shaping user behavior and promoting acceptance of niche innovations. By considering the interplay between technological innovation, user behavior, and individual-level processes, research aim at understanding the dynamics of technology acceptance and behavioral for designing effective interventions and promoting sustainable sociotechnical transitions.

2.2.5 Research gap

As discussed in the state-of-the-art there is currently a limited existing research literature specific to user acceptance for the geofencing and ITS use cases in distance-based road pricing and speed limit zones. This suggests that research in this particular area is relatively new and still in its early stages and presents a significant knowledge gap. Furthermore, while studies have explored the lock-in mechanisms associated with sociotechnical transitions in urban mobility and automobility regimes, there is a lack of research focusing on the micro-level aspects of the transition, particularly individual-level socio-cognitive change and technology acceptance. Psychology and individual-level processes have emerged as valuable fields to understand the influence of technology acceptance and behavioral changes in sociotechnical transitions, highlighting the need for closer examination of individual-level processes and their interaction with technological innovation. Integrating these perspectives could provide insights for designing effective interventions and promoting sustainable sociotechnical transitions in the context of geofencing and ITS in urban traffic management, among other things. The focus of this thesis is therefore directed at the micro-level processes at individual level.

Despite the growing emphasis on sustainable transportation alternatives, many individuals still prefer using their cars due to hedonic reasons, the desire for flexibility, and the ability to regulate their personal mobility needs (Schuitema, Anable et al. 2013). However, the way people interact with their vehicles based on these preferences can pose challenges to the acceptance of new mobility initiatives and interventions. The context of individuals attitudes, privacy concerns, performance perceptions, price value and effort expectancy within a transition of the socio-technical regime of automobility will be addressed.

By delving into the user acceptance of geofencing and ITS-enabled road pricing, this research aims to understand the factors that influence user acceptance and can in this context provide valuable insights for policymakers, researchers, and practitioners aiming to promote sustainable urban mobility while addressing the concerns and needs of car-dependent individuals.

2.3 Analytical framework

This section presents the analytical framework, which focuses on user acceptance and behavior models Unified Theory of Acceptance and Use of Technology (UTAUT) and Car Technology Acceptance Model (CTAM), and their relevance in understanding the factors that influence behavior and user acceptance regarding geofencing and ITS for automobility. Through the analytical framework, we explore the key determinants that can shape users' acceptance and adoption of these technologies. By examining and discussing these factors, we aim to provide valuable insights into what factors may function as barriers or facilitators to the user acceptance of geofencing and ITS.

2.3.1 Theory of user acceptance and use of technology

To identify individuals' acceptance and behavior as hurdles or enablers in a socio-technical transition, various factors come into play. These factors are formed by the nature of personalities, attitudes, habit, motivation, cultural influence, safety considerations, social influence, self-efficacy, ease of use, and usefulness, among many others (Davis and Davis 1989, Meade and Islam 2006, Roberts, Flin et al. 2021). There has been a range of theories and research models used to understand accurate linkages between these factors over many decades, such as the Theory of Reasoned Action (1975), Social Cognitive Theory (1986), Technology Acceptance Model (1989), Theory of Planned Behavior (1991), which have been modified and elaborated on in several iterations (Fishbein and Ajzen 1975, Bandura 1986, Davis and Davis 1989, Ajzen 1991, Venkatesh and Bala 2008). Research in these areas brings its roots mainly from information technology, psychology and sociology (Venkatesh, Morris et al. 2003).

A unified theory made by Venkatesh, Thong et al. (2012), called the Unified Theory of Acceptance and Use of Technology (UTAUT), considers all of the factors that are found to be direct determinants to technology acceptance, which has resulted in a research model that this thesis will utilize as its main framework to research the user acceptance and use of geofencing in private cars. A simplified model of UTAUT is depicted in figure 4. The model was created based on empirical comparisons of user reactions and acceptance rates of technological interventions in various domains such as entertainment, telecom services, banking, and public administration (Venkatesh, Morris et al. 2003). Comparisons conducted by researchers suggest that UTAUT, with its inclusion of a wide range of factors, provides a higher level of explanatory power for understanding the acceptance of new technologies, compared to the other mentioned models (Osswald, Wurhofer et al. 2012).

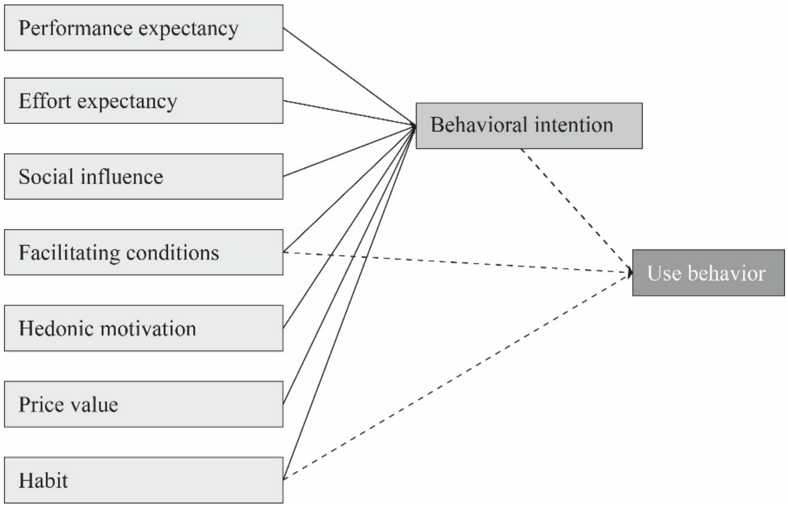

Figure 4 Factors impacting acceptance and use behavior of new technology innovations (adapted from Venkatesh, Thong et al. (2012), p. 160, "Research Model: UTAUT2").

This analytical framework establishes a theory between the factors, behavioral intention, and an individual's use behavior. Behavioral intention refers to an individual's personal tendency or preparedness to engage in a specific behavior, and particularly in relation to using a specific technology or system (Venkatesh, Thong et al. 2012). Brookes (2023) refers to it as the motivational factors that influence a given behavior where the stronger the intention to perform the behavior, the more likely the behavior will be performed. In the UTAUT model, multiple factors are found to shape the behavioral intention, including the individual's performance and effort expectancy towards the technology, hedonic motivation, facilitating conditions, habits, price value and social influence. It plays a pivotal role in predicting actual use behavior.

Use behavior pertains to the use, involvement, or performance of an individual when utilizing a technology or system, and represents the observable actions and behaviors demonstrated by the user in relation to the technology. In the UTAUT model, use behavior is considered an outcome variable that is influenced by factors like behavioral intention, facilitating conditions (such as the availability of necessary resources or support), and individual characteristics (Venkatesh, Thong et al. 2012). Since the empirical data utilized in this study is not based on observed use behavior, but rather on self-report measurements, in the form of surveys, the measure of user acceptance will be conducted through measurements of behavioral intention. This is discussed further in section 3.1, where quantitative method is presented.

The factors shaping behavioral intention will be considered as being psychological constructs in this thesis. Psychological constructs are seen as essential in psychological research and theory-building, since they provide a framework for understanding and predicting human behavior and experiences. The factors in the UTAUT model function in the same way, which is to understand and predict use behavior. Furthermore, psychological constructs represent the concepts or collective of variables that are used to describe, explain, and understand human thoughts, feelings, attitudes, beliefs, and various behaviors. The variables are usually based on observed behaviors, self-report measurements, or other indicators, with examples being personality traits, cognitive processes, emotional states, and social attitudes (Walford, Tucker et al. 2010). By using measurement instruments, such as surveys, a psychological construct can be measured through a battery of variables, ultimately shaping the construct.

In the work and the discourse of the UTAUT, the factors are primarily developed from the user acceptance of technology used in organizational job situations, such as in the situation of information technology adoption (Venkatesh, Morris et al. 2003). However, they are made from a broad number of technology interventions, which bring potentially useful perspectives to geofencing and ITS user acceptance. To further extend review of research on acceptance and usage of in-car technology, we need to consider other models with other relevant use behavior determinants.

2.3.2 User Acceptance models for automobility technology innovations

Previous studies have examined the acceptance and use behavior of innovations in the field of automobility, employing technology acceptance theories and models (Osswald, Wurhofer et al. 2012, Koul and Eydgahi 2018). These studies often consider factors that are incorporated within the UTAUT research model, including habit, price value, social influence, hedonic motivation, attitude, and performance expectancy. However, the focus of research in this area is more centered on the specific context of drivers' interactions with the technology, giving prominence to spontaneous and instinctive reactions and emotions such as safety, anxiety, and privacy concerns (Curtale, Liao et al. 2021).

In the work of Osswald, Wurhofer et al. (2012), they consider such constructs as potentially influential as barriers of technology acceptance, and propose the Car Technology Acceptance Research Model (CTAM). A simplified version of this model is shown in Figure 5. The original model also incorporates the factors developed in the UTAUT model.

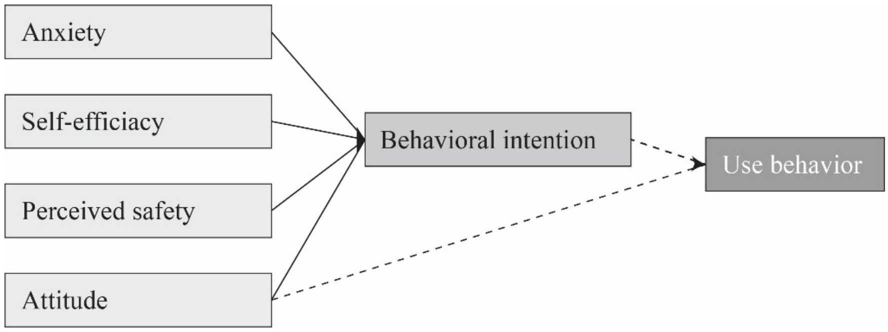

Figure 5 Illustrative model for car technology acceptance (Adapted version of the Car technology Acceptance Research Model (CTAM) by Osswald, Wurhofer et al. (2012), p. 6, “Car Technology Acceptance Research Model”).

The CTAM shares a similar structure with the UTAUT, as it considers the direct influence of factors embodying psychological constructs on behavioral intention and use behavior. However, CTAM specifically focuses on the context of in-car technology and incorporates a distinct set of variables, namely anxiety, self-efficacy, perceived safety, and attitude. Their research aims to enable early in-car technology acceptance assessment in the development process. It is suggested that for estimating perceived ease of use (important variables in effort expectancy), direct hands-on experience with a working prototype is beneficial, while for predicting perceived usefulness, providing information about system functionality is sufficient (Osswald, Wurhofer et al. 2012).

In addition to CTAM, there are other models that explore acceptance factors across a wider range of transport modes and variables. For example, in a study by Herrenkind, Brendel et al. (2019), aimed to investigate the acceptance of autonomous electric buses, they found more key factors that could also be useful for analysis of acceptance of similar technologies in automobiles. These factors are divided within the main categories, individual differences, social impacts, and system characteristics. The individual factors are trust, desire to exert control, privacy concerns, ecological awareness; the social impacts are image and subjective norm; the system characteristics are perceived enjoyment, relative advantage, and price evaluation.

Another research model created by Seuwou, Chrysoulas et al. (2020) focuses on autonomous vehicle technology acceptance, which brings forward the same factors as mentioned in the former models. Analysis of this model was conducted using correlation analysis, reliability analysis, and regression analysis, and concluded that it demonstrated considerable explanatory and predictive power of behavioral intention. Similarly, a model developed by Seuwou, Banissi et al. (2016) concluded with a significant explanatory power of user acceptance same factor through in-depth research, doing interviews with psychologists, sociologists, and computer scientists, and on existing empirically findings across these fields.

There is shown to be a substantial body of empirical evidence supporting the relationship between several factors and behavioral intention and use behavior for in-car technologies concerning higher levels of automation, such as advanced driver-assistance systems (ADAS). These factors, which have demonstrated strong associations, include hedonic motivation, facilitating conditions, habits, price value, social influence, anxiety, self-efficacy, perceived safety, and attitude.

2.3.3 Utilizing the user acceptance models' factors

The analysis method of this thesis aims to utilize the factors presented in the user acceptance models to categorize the data variables obtained from the surveys conducted in GeoSUM and GeoFlow. This categorization process is integrated to the analysis method discussed in section 3.1. The primary objective with this is to be able to shape the psychological construct based on the variables in the surveys, then analyze the correlations between each variable representing a factor and the participants' behavioral intention. This will be further discussed in method section. Due to the limited range of variables in the surveys, not all factors can be included and thoroughly investigated. In the subsequent subsections, we will delve into the factors which had sufficient variables, with their associated research and their relevance to user acceptance of technologies. These factors are displayed within a model structure resembling UTAUT and CTAM, in figure 6.

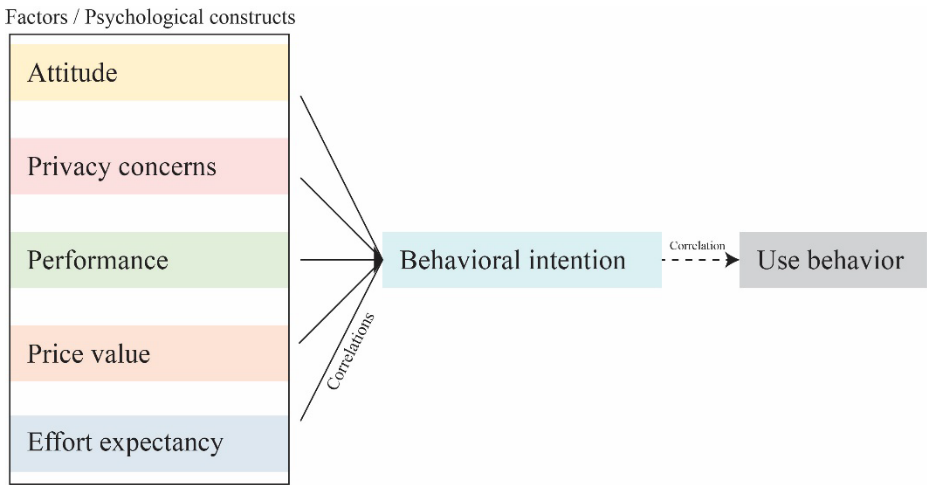

Figure 6 Factors impacting behavioral intention of intervention users.

Attitude

Attitudes have been found to play a significant role in determining the success of technology and innovation adoption. Patel (2007) conducted a review study on the topic, highlighting the importance of attitudes in understanding people's willingness to adopt advanced driving systems. According to the empirical findings of Van, Choocharukul et al. (2014), it was observed that attitude towards cars and public transportation significantly impacts behavioral intention, particularly in the context of commuting choice. Studies focusing on autonomous vehicles, such as those by Schoettle and Sivak (2014) and Liljamo, Liimatainen et al. (2018), have extensively explored attitudes towards this technology. Schoettle and Sivak (2014) surveyed individuals in various countries, including China, India, Japan, UK, Australia, and the USA, and found a generally positive initial opinion and high expectations of self-driving vehicles. Similarly, Liljamo, Liimatainen et al. (2018) conducted a survey in Finland and observed a predominantly positive attitude towards autonomous vehicles. Attitude can be defined in different ways, such as Fishbein and Ajzen (1975) definition of attitude toward behavior as an individual's evaluative affect or positive and negative feelings about performing a target behavior. Osswald, Wurhofer et al. (2012) emphasize that attitude towards using technology is an individual's affective reaction to using a technology, which can be influenced by external factors like an individual's opinion on sustainability and speed limits. Both definitions guide the assessment of attitude as a factor in this context.

Privacy concerns

Privacy security and preferences in the architecture of ITS has opened up for research opportunities (Hahn, Munir et al. 2019). In light of user acceptance, "privacy can be described as the extent to which a person cares about the security of personal data" (Herrenkind, Brendel et al. 2019). Huang (2022) found in their study's result, indicate that privacy concerns, especially considering trust, is a key to adoption and behavioral intention to use Mobility-as-a-Service's (MaaS). In a study conducted by (Eklund, Dou et al. 2016), they look at location privacy acceptance of transport-based location-aware mobile application, where the findings indicate that respondents highly value privacy. However, this did not necessarily imply that they refrain from providing personal information. Walter and Abendroth (2020)'s study found that the perception of privacy plays a significant role in the affective evaluation of connected services in the context of increasingly connected vehicles. Consequently, they concluded that providers of connected vehicular services should prioritize enhancing users' perceived control over their information while minimizing their perception of privacy risks.

In a study conducted by Islami, Fischer-Hübner et al. (2022) it was discovered that user privacy preferences concerning ITS can vary based on cultural perspectives. For instance, when interviewing subjects from South Africa, a predominant trend was their tendency to exhibit mistrust towards the government or any other entities they perceived as potential data exploiters (Islami, Fischer-Hübner et al. 2021). Conversely, interviews with Swedish subjects revealed a notably higher level of trust in governmental data processing. Understanding these variations in privacy preferences is crucial for the development and implementation of ITS. It underscores the need for tailored privacy frameworks and communication strategies that address the concerns and expectations of users from different cultural backgrounds. These are examples of different perspectives on privacy concerns, which will be used to guide the analysis of the privacy concerns together with the definition proposed by Herrenkind, Brendel et al. (2019).

Performance

Performance can be understood in different ways. In this study, it will be understood as *perceived system performance* (PSP) and *performance expectancy*. Performance expectancy refers to the extent to which an individual perceives that utilizing the system will assist them in achieving improvements in their performance (Davis, Bagozzi et al. 1989). You can also think of it as the degree to which using an innovation is being better than using its forerunner (Moore and Benbasat 1991). For example, when contemplating the adoption of a new advanced driver-assistance system (ADAS) in their vehicle, users would assess the performance expectancy by considering how the system can contribute to their driving effectiveness, efficiency, and overall experience. They would gauge whether the ADAS can assist them in avoiding accidents, navigating challenging road conditions, or simplifying parking maneuvers compared to traditional driving methods. If they believe that the new technology will indeed enhance their performance and provide substantial benefits, their level of performance expectancy will be high. Understanding performance expectancy is crucial for the acceptance and adoption of automotive innovations. When users perceive a high level of performance expectancy, they are more likely to embrace and integrate the new automotive technology into their driving routines. Conversely, if users perceive low performance expectancy, they may exhibit resistance or reluctance to adopt the innovation (Sovacool 2017).

Perceived system performance can be understood as the "degree to which a person believes that a system is reliable and responsive during a normal course of operations", as proposed by Liu and Ma (2006). They found that system reliability was critical in regard do explaining satisfaction levels within the field of e-service, which have the potential to impact the user acceptance in this study.

Price value

The relationship between *price value*, user acceptance and adoption of new technology is well-established and can be understood in various ways. Early scholars examining consumer acceptance of electric vehicles (EVs) identified the initial price and operating cost as influential factors in the likelihood of individuals purchasing EVs (Calfee 1985). EVs has long been a niche intervention trying to establish in the socio-technical regime of automobility (Miskolczi, Földes et al. 2021). External factors such as oil prices, which impact the use of fossil-fuel powered vehicles, also heavily influence consumer acceptance of EVs (Diamond 2009). Moreover, policy-induced prices imposed by local governments, like road tolls, have been important in changing people's opinions and encouraging them towards greener transportation options (Uskokovic 2022). Although these examples may not be directly linked to the introduction of new technology, they highlight the extent to which people are willing to alter their behavioral intentions and acceptance due to changes in price. Additionally, in a study on autonomous cars by Schoettle and Sivak (2014), it was found that the majority of survey respondents exhibited a negative inclination towards paying extra for adopting equipment related to self-driving vehicles.

Effort expectancy

Effort expectancy can be defined as the expectance of the level of ease of using a technology (Chua, Rezaei et al. 2018). In Osswald, Wurhofer et al. (2012) they mention, "Especially in the car it is of intrinsic importance to quickly be able to perform a task while driving without lasting periods of trial and error. As secondary tasks can affect the driving performance, it is mandatory that a system is easy to use, and that the system input and output is clearly to understand". As geofencing and ITS and their use cases for low-emission zones, road pricing and speed assistance is interactive by nature, through interface and practice, they can also cause distractions while driving. Nordhoff, Louw et al. (2020) have researched user acceptance of conditionally automated vehicles (SAE Level 3) through effort expectancy, especially as it "represents a paradigm shift for drivers in terms of their relationship with the driving task". The same can be said about the situation of road pricing, low-emission zones and speed control/assistance. Lastly, a study conducted by Fleury, Tom et al. (2017) found through structural equation model that the effort expectancy (in the form of ease of use), is a critical factor influencing behavioral intentions towards corporate carsharing.

3 Method and data

This section provides a detailed presentation of the data utilized as well as the methodology employed in the studying of user acceptance.

The methodological strand adhered to in this thesis is primarily quantitative in nature. The specific analytical tools employed include descriptive statistics, exploratory factor analysis (EFA), and Spearman's rank correlation (SRC). Exploratory factor analysis (EFA) has been conducted to assess the validity and reliability of the survey as a measurement instrument. Spearman's Rank Correlation (SRC) have been employed to delve deeper into the associations between different the variables in the data. The collection process of the empirical data is discussed lastly, where descriptive Statistics have been utilized to gain deeper insights into the characteristics of the data.

3.1 Quantitative method

The purpose of studying user acceptance of geofencing and ITS in automobile is about understanding the fundamentals of potential barriers to acceptance in the context of a sustainable transition in urban mobility. A Quantitative method is well-suited for this purpose, as it is an extensive tool aiming to untangle complex multifactor webs of relationships to arrive at generalizable sound conclusions about the target group (Ilovan and Iulia 2017). When studying large population, it is crucial to include diverse groups with varying socioeconomic statuses, ages, cultures, and so on, while avoiding overrepresentation that could skew the statistical balance. By incorporating different cohorts into the data, quantitative research can identify various patterns based on variables such as age, income, and gender (Pham 2018).

However, despite its ability to reveal valuable information, quantitative methodologies have limitations when it comes to extensively interpreting the underlying needs and reasons behind each research subject's responses (Xie and Kim 2022). As such, a frequently discussed limitation of quantitative research is the lack of flexibility and exploration (Queirós, Faria et al. 2017). The key method of conducting this methodology is not asking research subjects why they are behaving a certain way, but to understand this through statistical patterns in the quantitative data. As it is quantitative, it is also characterized by using numeric values to measure the subjects' answers. A short description by England (2021), rounds up this, "Quantitative research uses methods that seek to explain phenomena by collecting numerical data, which are then analyzed mathematically, typically by statistics. With quantitative approaches, the data produced are always numerical; if there are no numbers, then the methods are not quantitative." (England 2021).

The discussion of whether qualitative and quantitative research should be applied is highly argued in the fields of psychology and sociology, which is relevant to this thesis as it applies quantitative measurement and analysis of psychological constructs. In Walford, Tucker et al. (2010), they engage in a discussion on the importance of measurement in these sciences, which has sparked a two-sided debate. As some advocates emphasize its necessity, particularly qualitative researchers raise concerns about its feasibility and relevance. Critics argue that the intricate nature of human actions, influenced by subtle meanings and motivations, cannot be easily quantified. They stress that social phenomena are dynamic, context-dependent, and intricately connected through language and discourse. These unique characteristics make traditional measurement methods appear insufficient in capturing the multifaceted nature of social realities.

However, the authors themselves argue for the importance of recognizing the essential role of typologies and quantitative dimensions in everyday language. These categories and dimensions are employed to describe various events or individuals, and researchers strive to transform these informal frameworks into more systematic and rigorous constructs in scientific endeavors. They highlight the significance of establishing connections between concepts and evidence to effectively categorize objects or position them on a scale. (Walford, Tucker et al. 2010). Strauss and Smith (2009), further discuss this by highlighting that the primary challenge in measuring constructs lies in relying on reliable criteria and establishing a robust knowledge base to validate these measures. Without a strong foundation of knowledge, it becomes difficult to ascertain the validity of measures and draw conclusions about their significance in psychological processes.

The quantitative analysis in this thesis relies on the analytical framework of user acceptance models as its knowledge foundation. This framework enables the proper analysis of variables obtained from the survey data collected in the GeoSUM and GeoFlow projects. These models have been developed by exploring the underlying psychological constructs, which help in understanding the psychological and social factors influencing individuals' acceptance and use of technology (Momani 2020). It acknowledges the significance of individuals' attitudes, beliefs, and behaviors in the successful adoption and utilization of technological innovations. It is based on empirical evidence gathered in the field of user technology acceptance, which offer a greater level of validity for researching this thesis' topic (Lee, Kozar et al. 2003).

The arguments supporting the choice of quantitative research methods to address the research questions are twofold: first, the generalizability of patterns within psychology constructs and user acceptance, and second, the existence of well-established user acceptance models that provide a strong knowledge foundation. These arguments have guided the selection of analysis methods presented in the subsequent sections 3.1.1 and 3.1.2.

As part of utilizing the knowledge foundation established in the analytical framework, the relevant variables in the GeoSUM and GeoFlow surveys were reorganized to align with the factors that influence behavioral intention (as discussed in section 2.3.3). This reordering process was carried out using Microsoft Excel, employing a color-coding system to associate each variable with a specific factor. The original surveys' variables can be found in Appendix A, while the complete restructured arrangement of the measured variables of GeoSUM and GeoFlow is available in Appendix B. The variables in the GeoSUM and GeoFlow surveys were categorized into the following factors: attitude, privacy concerns, performance, effort expectancy (only GeoSUM), and price value. The variables that didn't correspond with any of the factors were discarded from further analysis. Figure 7 presents a subset of the GeoSUM survey variables that correspond to the "Attitude" factor.

Attitude	
Attitude - car	
1-5 Likert scale, Strongly disagree - Strongly agree	The car is just a means of transportation for me
	Driving pleasure is an important part of driving for me
	I would rather have a fully electric car if the selection, range, and price met my requirements better.
Attitude - hybrid	
1-5 Likert scale, No importance - Great importance	The car automatically switches to fossil fuel (without the battery being depleted of electricity).
	The car is out of electricity.
	I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc.
	I choose to save the battery for other parts of the route I'm driving on.
Attitude – technology	
1-5 Likert scale, Strongly disagree - Strongly agree	I am interested in testing out new technology.
	I think it is important to drive a car with the latest technology.
	I believe that technology will be among the most important tools to prevent human-induced climate change.
	I believe that technology in the transportation sector will minimize deaths and serious injuries in traffic.
Attitude – low-emission zone	
1-5 Likert scale, Strongly disagree - Strongly agree	Human-induced climate change is the most important societal challenge we face.
	Local pollution is a major problem in the city I live in.
	I am conscious of where and when the car is running on electric power.
	I try to use information from the car to drive as much as possible on electricity.
Attitude – speed	
1-5 Likert scale, Strongly disagree - Strongly agree	I think breaking the speed limit is a big problem for traffic safety
	I think the speed limits in Norway should be higher than they are today
	I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is
	I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)

Figure 7 Variables fitting the factor «attitude» of user acceptance models.

The "Attitude" factor consists of variables that measure participants' attitudes towards car use, hybrid vehicle functions (when they are switching to electricity), technology in general, low-emission zones, and car speed in traffic. The "Privacy concerns" factor includes variables that assess participants' thoughts on GPS tracking, general privacy preferences, and their trust in data handling. Under the "Performance" factor, issues relating performance expectations of technology, speed control zones, low-emission zones, as well as direct feedback on the technical performance of the equipment are assessed. The "Effort expectancy" factor comprises variables that measure participants' perceived ease of use and the level of stress experienced when using the technology. Lastly, the "Price value" factor includes variables that reflect participants' views on their willingness to pay, potential cost reductions for driving, and perceptions of fairness in paying for distance traveled compared to toll booth systems currently in place. In the GeoFlow survey, relevant variables are organized within the factors: Attitude, Privacy concerns, Performance (expectancy), and Price value, as shown in table 1.

User acceptance factor	Survey variables
Attitude	Attitude - car
	Attitude - hybrid
	Attitude – technology
	Attitude – low-emission zone
	Attitude – speed
Privacy concerns	Privacy concerns/preferences
	GPS Tracking
Performance	Performance: technical equipment
	Expectation: technology
	Expectance: Speed control zone
	Expectance: Low emission zone
Effort expectancy	Ease of use
	Ease of use 2
	Switch to electricity
Price value	Additional cost: willingness to pay for
	Switch if lower charges

Table 1 GeoSUM survey variables rearranged to user acceptance factors.

The "Attitude" factor consists of variables that measure attitudes towards technology use, the existing toll rings, fairness of toll rings, and differentiated road pricing. Under the "Privacy concerns" factor, variables measure concerns and preferences for GPS tracking, privacy preferences, and personal data handling. The "Performance" factor includes variables that measure performance expectancy of road pricing, as well as perceptions of technical performance. The "Price value" factor contains variables that measure participants' views on prices, willingness to pay, and fairness of rush hour and non-rush hour pricing.

User acceptance factor	Survey variables
Attitude	Attitude - technology
	Attiude - toll ring
	Attitude - toll - fair
	Attitude - road pricing
Privacy concerns	Privacy concerns/preference
	GPS Tracking
	Handling of personal data
Performance	Performance expectance road pricing
	Performance - technical
	Performance - road pricing
Price value	Road price preference
	Price fairness
	Choice - private car - after cost increase
	Extent to pay for other uses

Table 2 GeoFlow survey variables rearranged to user acceptance factors.

The variables included within each factor are intended to measure the overall psychological constructs (factors) of the participants. The correlations between the variables within each factor will serve to understand the constructs. It is important to note that the data, originally intended for a simpler analysis using descriptive statistics, introduces inherent inaccuracies and limitations in comprehending the underlying constructs. Therefore, it is essential to consider these limitations when interpreting the findings derived from the rearranged variables in relation to the behavioral intention and user acceptance models. Also, each project was composed of different groups of participants, which means the variables can’t be analyzed across the two surveys.

As mentioned in the analytical framework (section 2.3.3), this rearrangement process resulted in a model structure with five prominent factors that are possible to research: Attitude, privacy concerns, performance (expectancy), price value and effort expectancy. The model structure uses the same analytical view as the UTAUT model and CTAM (discussed in section 2.3) and is depicted in figure 8.

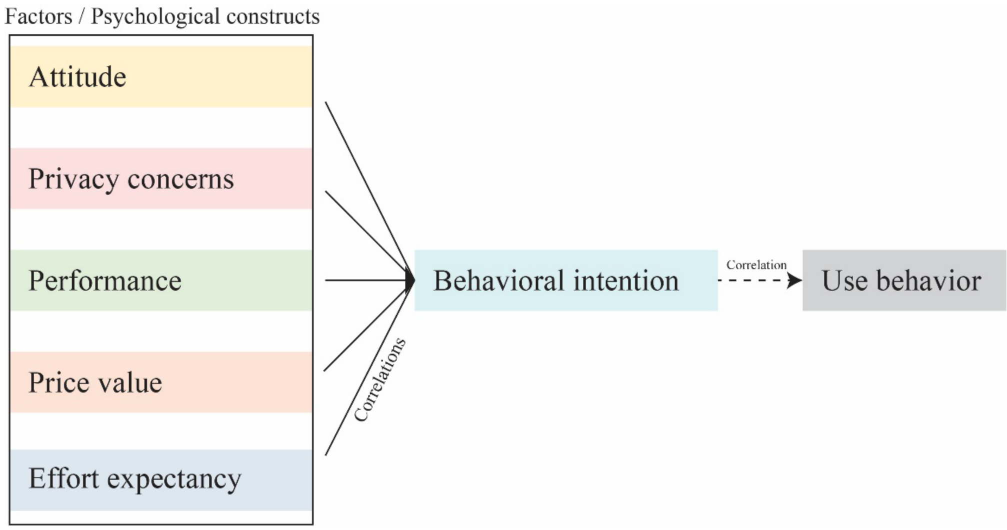

Figure 8 This thesis' model of factors influencing behavioral intention.

As the analytical approach is the same as UTAUT and CTAM, it is considering external factors that influence behavioral intention. Behavioral intention refers to an individual's personal tendency or preparedness to engage in a specific behavior. It is often assessed through empirically evidence-based variables such as "I intend to use the technology," "I have a positive attitude towards the technology," "I am willing to change my behavior," or "I believe others would change their behavior" (Fishman, Lushin et al. 2020). Therefore, the behavioral intention of participants will be measured through specific key questions/variables provided in the post-pilot surveys, given in table 3.

Survey	**Variables**
GeoSUM 5-point Likert scale, To no extent - To a great extent	Q1 - As a hybrid car driver, I would be positive about differentiated charges for different fuel types within geofence zones.
	Q2 - As a hybrid car driver, I would drive more on electricity than I usually do if differentiated charges within geofence zones were implemented.
	Q3 - If there was a requirement for all car drivers (not just hybrid car drivers) to use geofence zones for differentiated charges, I believe that most people would be positive about it.
	Q4 - If there was a requirement for all car drivers to use geofence zones for differentiated charges, I believe that most hybrid car drivers would drive on electricity within low-emission zones.
GeoFlow 5-point Likert scale, from very unlikely – very likely	Q1 - You would change your driving behavior if road pricing were to be introduced? 5-point Likert scale, from very unlikely – very likely
	Q2 - The majority of drivers would be positive about it
	Q3 - Most drivers would change their driving habits

Table 3 Survey variables used to measure behavioral intention.

It can be argued that these variables don't measure the same construct (behavioral intention) and are invalid to be compared with each other (such as reflecting on others behavior). This will be considered when evaluating and concluding the correlations. Another backside with the GeoSUM variables is that there were no variables accurately focusing on behavioral intention to use the speed control perspective of the system. This means the behavioral intention will only be directly related to the low-emission zone/road pricing.

3.1.1 Reliability and validity of the surveys

To fully conclude the reliability and validity of the analysis, and important aspect is internal reliability of the measuring instrument and the sample used for analysis. The inherent properties of quantitative methods, such as objectivity, measurability and countability, tend to make them more scientifically credible than those that cannot measure (Lakshman, Sinha et al. 2000). However, to conclude the reliability and validity of the GeoSUM and GeoFlow surveys as a measuring instrument of psychological constructs, it should also be backed up by the appropriate analysis. Reliability can be described as the consistency of a measure, where responses are approximately the same every time a variable is measured. This can also be viewed as a statistical measure of how reproducible a survey's data is (Litwin and Fink 1995). The validity is also an important aspect of quantitative research, which is defined as to which degree a concept is accurately measured (Roberta and Alison 2015).

The first examination of the survey data was through *descriptive statistics*. Descriptive statistics is an analysis method that summarizes main characteristics of quantitative data, through visualization, indexes, frequencies and so on (Cooksey 2020). This uncover limitations of the analysis, and whether the data is valid to appropriately answer the research questions. The descriptive statistics of the surveys' data will be presented in the section discussing the process of data collection, in section 3.2.

The second method of ensuring validity and reliability is *Factor Analysis* (FA). Factor analysis is a statistical method used frequently in psychology to analyze the underlying factor of a set of observed variables/psychological constructs, such as attitude and personality. It is also used to see if an research instrument, such as a survey, more likely have actually measured the right constructs (Arokodare 2020). The method itself is statistically finding correlations and relationships between multiple variables, an instance being a battery of variables from a survey (Fabrigar and Wegener 2012, Tavakol and Wetzel 2020). The literature concerning this research method extensively documents a strong relationship between construct validity and factor analysis, which makes this method known for providing valuable evidence related to test content and internal structure, which are essential components of construct validity (Tavakol and Wetzel 2020). Construct validity means the overall accuracy of the construct measured.

The focus of this thesis is to explore the surveys responses, to see if there are any user acceptance patterns in the field of geofencing and ITS for automobility. The factor analysis will function to support this and evaluate validity and reliability of the survey. *Exploratory factor analysis* (EFA) was therefore chosen as part of data analysis method.

In order to conduct the exploratory factor analysis, IBM SPSS Statistics was used to find the essential coefficients that was used to examine the construct validities and the overall internal survey structure. This consist of conducting the *Kaiser-Meyer-Olkin (KMO)* test & *Bartlett's Test of Sphericity* (BTS). Bartlett's Test of Sphericity (BTS) specifically is conducted to assess whether the correlation coefficients in a dataset deviate significantly from zero. In other words, it calculates the probability of finding significant correlations among variables within the correlation matrix, which can be considered as a fundamental requirement for conducting factor analysis (Gorsuch 1973). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy is employed as a diagnostic test to evaluate the suitability of conducting factor analysis on a given dataset. Its purpose is to assess whether the data exhibits sufficient patterns and relationships among variables to warrant the application of factor analysis (Kaiser 1974). If there proved to be a sufficient number of correlations and adequacy of factor analysis in the data, the survey variables were subject extended examination of correlations. It's usually concluded that the coefficient of KMO must be at least over 0,500 (indicating moderate number of correlations) for the set of variables to be seen as adequate and reliable for a further analysis of correlations (Hair 1995).

3.1.2 Correlation analysis

After conducting the KMO (Kaiser-Meyer-Olkin) and BTS (Bartlett's test of sphericity) tests to examine the surveys, the next step involved examining the variables through Spearman's rank correlations. *Spearman's rank correlation* (SRC), is a non-parametric correlation test commonly used in quantitative analysis methods to assess the relationship between variables and sets of data (Dodge 2008). SRC measures the strength and direction of the monotonic relationship between two variables. Monotonicity is the extent in which the value of one variable increases, the value of the other variable either consistently increases or decreases (Colding and Minicozzi 2013). An illustration depicting monotonicity between two variables can be found in figure 9.

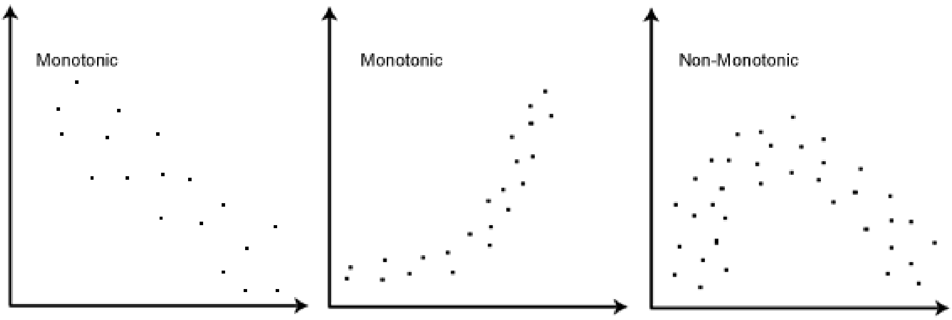

Figure 9 Decreasing (left side) and increasing (middle) monotonic variable relationship, and non-monotonic (right side) relationship of variables (source: Statistics (2023))

Non-parametric tests are suitable for analyzing ordinal and categorical datasets, while parametric tests like the *t-test* are typically used for interval or ratio data. This distinction is favorable because non-parametric tests provide more reliable analysis for non-normally distributed data, whereas parametric tests are more likely to reject a false null hypothesis assuming normal data distribution (Vickers 2005, Sheskin 2011)

In this thesis, a non-parametric test was deemed appropriate because the data collection method primarily relied on surveys utilizing ordinal scales, which often exhibited skewness in the distribution of responses. By utilizing SRC, the analysis considered the monotonic relationship between variables rather than assuming a linear relationship. This approach accounts for the specific characteristics and distribution patterns of the data collected through the surveys. Applying non-parametric tests, such as SRC, was seen as crucial to ensuring accurate and valid analysis in the thesis. It allowed for a more comprehensive exploration of the relationships between variables, considering the specific nature of the data collected. By using appropriate statistical techniques tailored to the data type, the research aimed to provide reliable insights and draw meaningful conclusions regarding the relationships among the variables under investigation.

The correlation between variables is presented as coefficients that express the level of correlation, which goes from -1.000 (negative correlation) to +1.000 (positive correlation). Negative correlation is when a variable decrease - the other variable increases. With a perfect positive correlation (+1.000), they would both be strongly agreeing (Dancey and Reidy 2020). The following intervals, as suggested by Dancey and Reidy (2020) will be used as appointed reference when discussing correlation coefficients:

Spearman's rank correlation coefficient	Correlation
±1.000 - ±0.700	very strong
±0,699 - ±0,400	strong
±0,399 - ±0,300	moderate
±0,299 - ±0,200	weak
±0,199 - 0	negligible

Table 4 Strength of correlation coefficient values (source: Dancey and Reidy (2020))

The primary purpose of this analysis method is to be able to conclude statistically if the variables in the survey are associated to their behavioral intention of using the technology. Examining which variables are connected to the behavioral intention of the participants will also function as the indicator for intention to use the system, and thereunder user acceptance. In the results section, correlations between variables will be presented either as "r = x, p > x", or with "moderately/strongly/very strongly correlated". where the r-value is the correlation coefficient, and the p-value represents the percent level of significance, which is the probability of observing a correlation as extreme as the one calculated in your data, assuming the null hypothesis is true (i.e., assuming there is no true correlation in the population). A commonly used threshold of p-value is 5% percent level of significance, $p > 0.05$, although this depends on the analyzed sample (Wasserstein, Schirm et al. 2019).

Correlation analysis serves another purpose, which is to gain a comprehensive understanding of the correlations between variables within the factors and the intercorrelations across the factors. The variables represent the questions asked in the surveys. Examining their correlations can unveil associations between specific perceptions, attitudes, and experiences. Figure 10 provides an illustration of how correlation analysis is used to analyze the relationships between variables.

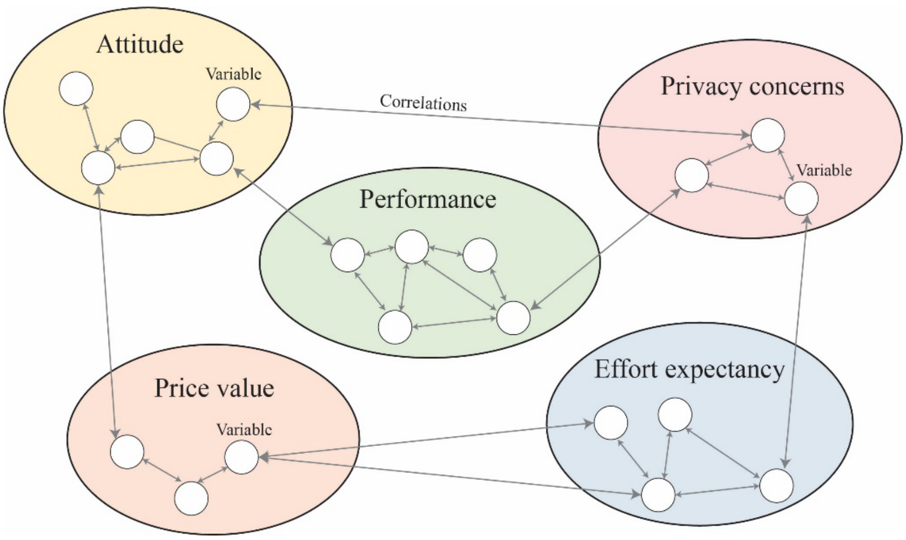

Figure 10 Illustration: use of correlation analysis between variables.

It’s crucial to keep in mind that correlation coefficients don’t show causal relationships, which is whether one variable change in response to the other. In other words, there is not attempt to establish one variable as dependent and one as independent (Gogtay and Thatte 2017). Therefore, a limitation of this analysis method is the incapability to understand why two variables correlate.

3.2 Data

The empirical data used in this thesis is derived from the pilot projects GeoSUM and GeoFlow. This section will provide a comprehensive overview of the data collection process employed in these projects and explore the potential limitations that may impact the ability to address the research questions effectively.

In each project, the data collection itself was done through web-based surveys before and after the pilot periods. The pre-pilot survey had general questions about the participant, like age, gender, car model, education and work, and attitudes towards technology, car usage and environmental issues. The post-pilot survey had more specific question about the experiences, satisfaction, usefulness, and usability of the retrofitted equipment in the car. The participants could mostly only respond through a Likert scale (disagree - agree, to no extent – to great extent, positive - negative), either from 1-5, 1-7 or 1-10 All the survey variables are shown in appendix A.

3.2.1 GeoSUM

The primary objective of the GeoSUM pilot project was to conduct experimental tests on geofencing and ITS in car traffic. Following an initial phase of iterations, the project finalized the pilot design, which encompassed the development of car equipment, recruitment plan, data collection procedures, geofencing zone definition, and a project timeline (Arnesen, Seter et al. 2020). The information presented in this subsection is derived from the project report authored by Arnesen, Seter et al. (2020).

Equipment

To enable geofencing and ITS capabilities in the cars, new retrofitted equipment was utilized. This equipment consisted of a Samsung Galaxy A10 smartphone connected to an OBD II dongle via Bluetooth. The smartphone was securely installed beside the dashboard screen and continuously charged using a 12V USB Charge adapter. Q-Free developed an application that served as an interface for the test subjects. Figure 11 displays the pictures of these three devices.

Figure 11 Equipment used for GeoSUM pilot project (left: Dongle, middle: all equipments, right: smartphone setup). (GeoSUM project report, figure 26, p. 47).

Recruitment

The recruitment was done in Oslo and Trondheim, through publishing information about the project and geofencing technology through media, and additionally through internal channels in SINTEF, the Norwegian Public Roads Administration and Q-Free. Each invited car owner could registerer 2 users for the pilot. This resulted in a total of 46 registered different hybrid vehicles shown in Table 5, with 80 registered participants. Only plug-in hybrid cars could participate in this project.

	Total	Mercedes	Mitsubishi	Volvo	Volkswagen
Oslo	18	0	6	11	1
Trondheim	28	2	14	9	3
Total	46	2	20	20	4

Table 5 Registered cars in Oslo and Trondheim for GeoSUM (source: project report).

The test subjects would receive more information about the data collection and aim of the project after signing up. During the pilot period, the project team provided support service for the drivers, through e.g., answering calls, emails, and running an online Q&A website.

Geofencing zones and use cases

The geofencing zones and their use cases were designed before the pilot, which included low emission zones and school zones. The low-emission zones for Trondheim and Oslo are depicted in figure 12. Low emission zones were defined with 3 levels in Oslo and 2 levels in Trondheim, were they each defined which fees would be charged for the drivers using fossil fuel. The fees are calculated per km driven in the zone. This pricing scheme is shown in Table 6. School zones were defined with a radius 150 m around all schools in Trondheim and Oslo.

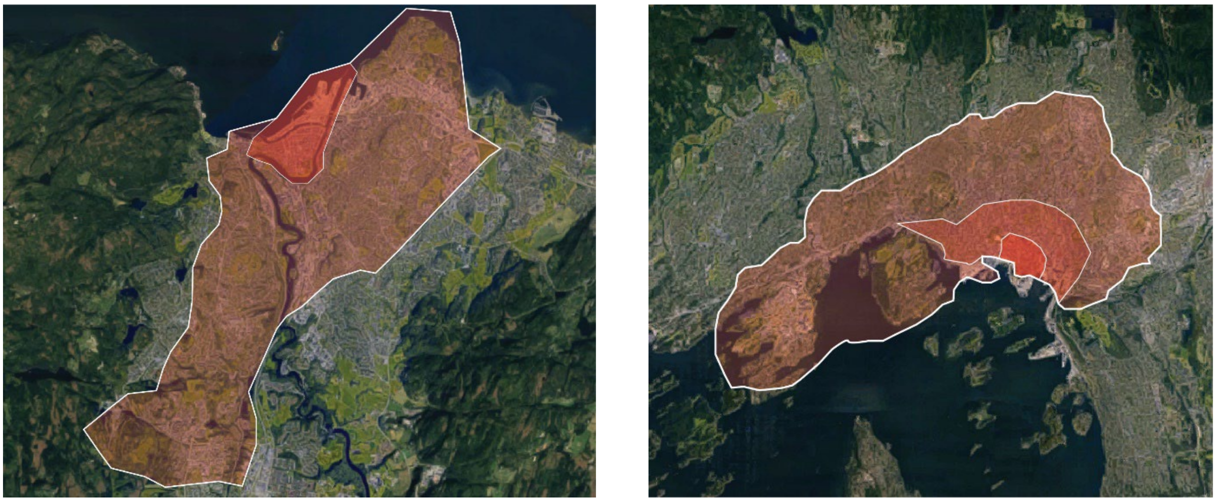

Figure 12 Geofence-enabled Low-emission zone in GeoSUM project for Trondheim and Oslo.

	Oslo	Trondheim
Inner zone	6 NOK/km	6 NOK/km
Middle zone	4 NOK /km	-
Outer zone	2 NOK/km	3 NOK/km

Table 6 Pricing schemes for inner, middle, and outer low emission zones (source: GeoSUM project report).

The geofencing zones had four use cases, where the first and second are related to the low emission zones, while the third and fourth are related to the school zones. The first of use case was having participants driving with fossil fuel pay fees for emissions. As the driver is in the zone, they receive a message informing about the geofence zone and the fee. The vehicle owner is charged upon leaving the geofence zone.

The second use case involved hybrid vehicles having to change to electric mode when approaching a geofencing zone. The ITS application would inform the driver about the zone and to change the vehicle's energy source from a mix of fossil fuel and electricity to pure electricity upon entering the zone.

The third use case involved a vehicle approaching a geofencing zone with regulations on vehicle speed due to vulnerable users. The driver would receive a message about the zone and the speed limit. Upon entering the zone, the vehicle's maximum speed was automatically reduced to 30 km/h.

The fourth use case involved a vehicle approaching a geofencing zone with access regulations on vehicle speed due to vulnerable users. The driver receives a message about the zone and the speed limit. Upon entering the zone, an audio-visual warning was triggered whenever the vehicle speed exceeds 30 km/h.

The pilot period started from the equipment installation and lasted 8 weeks. In the first two weeks of pilot testing, there was no display on the drivers' user interface, and was purely a period for collecting information from the trips to be evaluated and analyzed. In the remaining 6 weeks, the displayed showed information about the low emission- and school zones to the drivers. Examples of these displays is shown in figure 13.

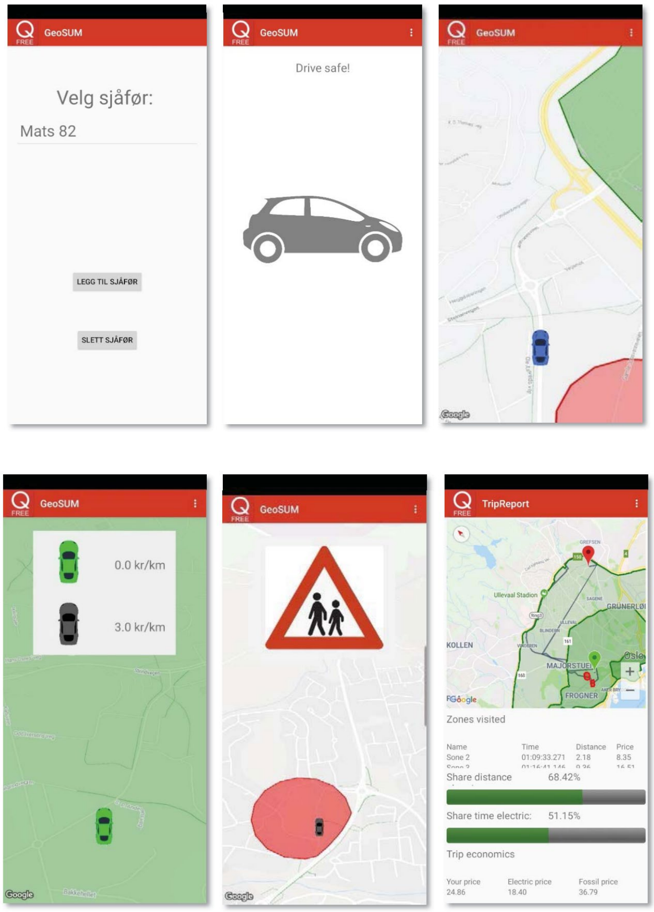

Figure 13 Examples of displays on smartphone shown to the drivers (GeoSUM project report, figure 30, p. 50).

3.2.2 GeoFlow

This section provides a thorough description of the process of data collection in GeoFlow. Similar to GeoSUM, a project report made for GeoFlow will be source for the material writing in this subsection (Arnesen, Moscoso et al. 2022).

Car installation equipment

The equipment installed in the cars consisted of 3 modules, namely, processing unit, antenna, and a smartphone, which visually looked similar to the GeoSUM pilot. The smartphone was put beside the dashboard facing the driver and had an application with Wi-Fi connection to the processing unit, and was free to use or not, as it was used only to display information, such as the zones, prices, and route planning to the driver. The smartphone didn't need to be connected for the antenna and processing unit to do all the functional parts of the pilot experiment. The antenna was a small device that could be put inside the car at the corner of the windshield. The setup is shown in figure 14.

Figure 14 Equipment used for GeoFlow pilot project (left: smartphone setup, middle: antenna, right: processing unit). (Source: GeoFlow project report, figure 1, p. 6).

The functional parts of the antenna and processing unit made it possible to gather and analyze the trips and prices from driving in the geofencing zones. They adopted two ways of handling the data in this pilot, which were baxsed on the thick client and thin client logic. Thick client is a client-server architecture, where most resources for treating the data are installed locally, so that it doesn't need to be distributed over a network. Thin clients on the other hand, use a server-based environment to run the treatment and analysis of the data (Spacey 2016). This is relevant for drivers in the pilot because they are being questioned on their attitude towards data handling. Additionally, they recorded toll data as the cars were crossing them, so they could compare the costs between road pricing and tolling.

Road pricing and zones

The use case of geofence and ITS in this project was similar to what they did in GeoSUM, which was having participants driving with fossil fuel pay fees for emissions. To provide users with a pricing comparison, the project team decided to focus on a pricing regime where toll costs for participants would be on average equal to the piloted road pricing system. The aim was to shift toll costs to distance-based payments, without incorporating other external costs such as environmental, noise, and road use charges. An important reason for this is that it would incentivize and make it easier to research the user's behavior with no external factors. The project team calculated a road price that would likely result in the same total cost for multiple users as the toll ring they currently use. The payment zone for the pilot was defined in figure 15, with zone boundaries located at existing toll stations where available. A difference to the GeoSUM project is that its only one pricing level but would only vary depending on the time of day (rush/no-rush). The participants were under the pilot period for 3 months, which is considerably longer than the GeoSUM project.

Figure 15 GeoFlow geofencing zone.

Recruitment of participants

Several measures were taken to recruit participants for the pilot. Initially, media coverage was created through TV and newspapers to generate interest in the project. The registration information was included in several written articles, allowing people to sign up via email. Additionally, a promotional video for recruitment was created and distributed on websites, newsletters, and networks associated with the State Road Administration, SINTEF, and Q-Free. To recruit a representative sample, many questions were asked during registration, like age, gender, car model, car type, number of regular car users, company car ownership, education level, interest in testing new technology, importance of driving a car with the latest technology, frequency of rush-hour commuters, and household income. After recruiting through media and networks, an initial data analysis was conducted, which revealed that the sample was uneven with regards to age and gender. It was therefore asked to recruit more younger women through phone interviews, but only a handful of users were recruited this way. In this project, instead of experimenting with road pricing hybrid cars only, they wanted to try it on a broader audience of fossil fuel, hybrid, and zero-emission cars.

3.3 Descriptive statistics

The descriptive statistics presented in this section were produced by analyzing the data obtained from SINTEF using IBM SPSS Statistics and Excel. With statistical measures such as mean values, standard deviation and skewness, this section will provide valuable insights, and uncover inherent limitations when it comes to capturing generalized tendencies of user acceptance.

3.3.1 GeoSUM

The GeoSUM dataset consisted of responses from 57 participants, encompassing a range of ages, genders, professions, education levels, and car brands. The overall statistics of ages, gender and car brands are shown in table 7. The average age of the participants was calculated to be 48.2 years, with a standard deviation of 9.67 years. The average number of years with driver license was 28.7 with a standard deviation of 9.97, which means the average age when they got it was, in average, 19.5 years. The age range within the dataset spanned from the youngest participant at 31 years old to the oldest participant at 63 years old. Approximately two-thirds of the total participants identified as men, while the remaining one-third identified as women. The most represented car brands among the participants were Volvo and Mitsubishi, as presented in the table 7.

Variable	Mean		Standard deviation	
Age	48,2		9,67	
Years with driver licence	28,7		9,97	
Age when receiveing licence	19,5		-	
	Men		**Women**	
Gender	2/3		1/3	
	Volvo	**Mitsubishi**	**Volkswagen**	**Mercedes**
Car brands	40,4%	43,9%	12,3%	3,5%

Table 7 Mean value and standard deviation of GeoSUM participants' ages, years with driver license, and age when receiveing license.

In figure 16, we can see the participants' ages split by gender in a population pyramid. This shows the overall gender and age skewness.

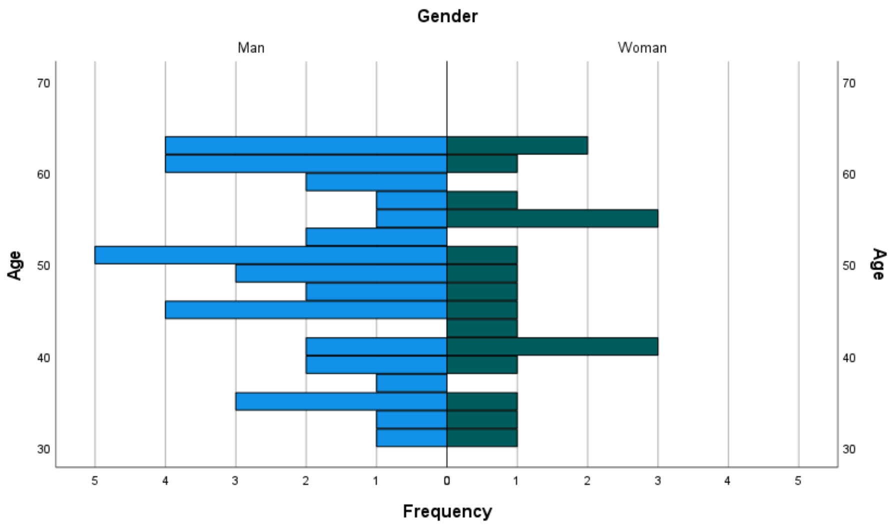

Figure 16 Population pyramid for participants' ages split by gender in GeoSUM survey.

Distribution of education and occupations are shown in figure 17. Most participants (60%) had completed at least 4 years or more years of college/university education. The distribution of education levels also included 3 years or less of college/university, doctoral degrees, upper secondary school, and primary and lower secondary school, in descending order of representation. Among the participants, 53% had a professional/academic occupation equivalent to a higher degree (4 years or more of college/university education), and 21% were managers. Other occupations were also represented, but in smaller proportions.

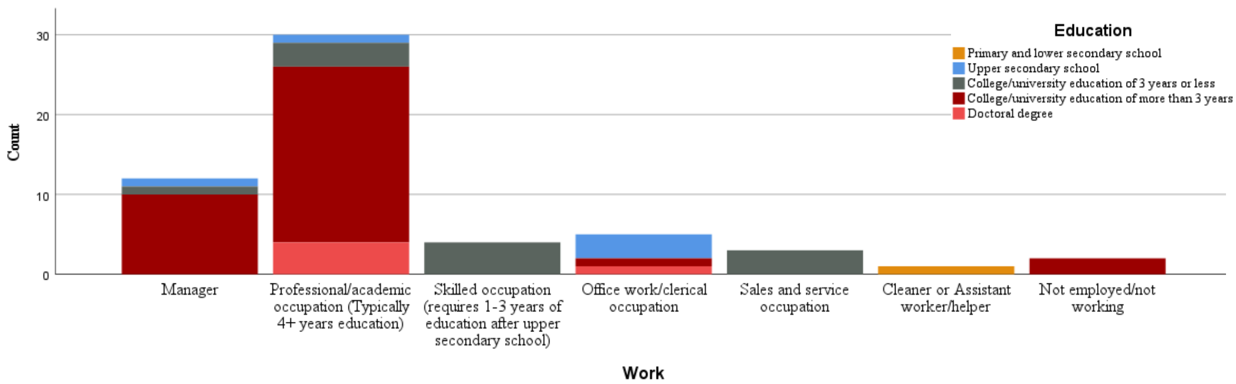

Figure 17 Bar chart for participants workplace and their education.

In the context of researching generalizable patterns of user acceptance, this dataset is influenced by skewness in age, daily occupations, driver license acquirement ages and car brands. As the lowest and highest age is 31 and 63 years with slightly more older people, there is likely none or very few students or retired within this age range, which we can confirm by looking at the daily occupations of the participants. Majority of them were working at a professional/academic job or as a manager, and very few in other occupations. This is not able to reflect a large share of the population who realistically works in many different occupations. The skewness might have come from the recruitment method, which was partly based through internal channels in SINTEF, the Norwegian Public Roads Administration and Q-Free. Most of them also got the driver license when they were 18-19 years, except for a few. The car brands are mainly Mitsubishi and Volvo and influences the analysis with a lack of car variety, since cars brands have different functions settings when driving.

3.3.2 GeoFlow

The GeoFlow survey consisted of 94 participants, showcasing similarities to the GeoSUM survey. Table 8 presents the mean values and standard deviation of various ages, gender distribution, and percentages of car types. The average age of the participants is 46.9 years, with a standard deviation of 13.73 years, while average years of driving license was 28.4 with a standard deviation of 13.28. This means most of the participants have taken the license at the average age of 18,5 years. The age range spans from the youngest participant at 21 years old to the oldest participant at 77 years old. In GeoFlow there was a combination of different types of cars with different car fuels; 54% used gasoline car fuel, 15% used plug-in hybrid cars, and 31% used zero-emission cars. Furthermore, the survey's gender distribution reveals that approximately two-thirds of the participants are men, while one-third are women, as presented in the table.

Variables	**Mean**		**Standard deviation**
Age	46,9		13,73
Years with driver license	28,4		13,28
Age when receiveing license	18,5		-
	Men		**Women**
Gender	2/3		1/3
	Gasoline/diesel	**Hybrid**	**Zero-emission vehicle**
Car type	54,3%	14,9%	30,9%

Table 8 Mean value and standard deviation of GeoFlow participants' ages, years with driver license, and age when receiving license.

The distribution of ages and gender is visually depicted in the population pyramid, in figure 18 below, providing a clear overview of skewness within the sample.

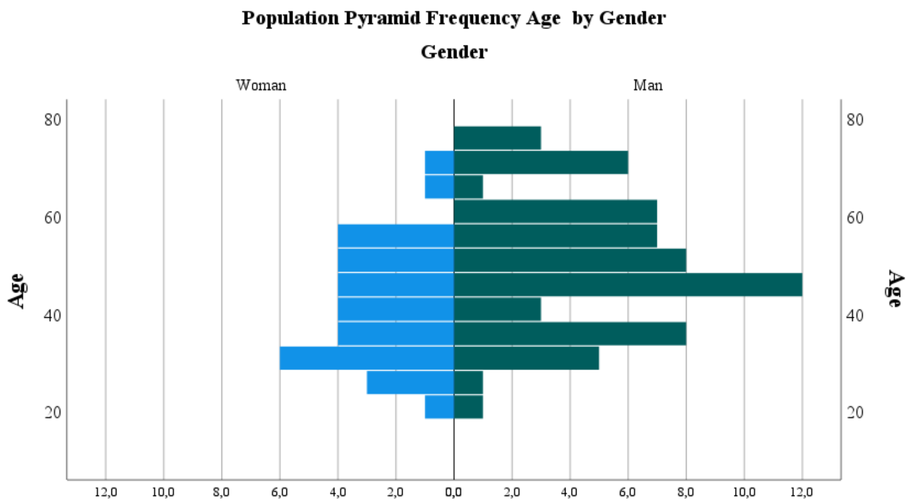

Figure 18 Age distribution of participants for GeoFlow survey.

Most of the participants had completed a college/university degree of at least 4–5-year duration, while the second largest group was college/university degree of 3 years or less. There were many people in an income generating workplace, but in contrary to GeoSUM, the surveys here had no way of differentiating participants' workplaces. Both the distribution of education and occupation is shown in Table 9.

Variables	**Upper secondary**	**College/university - 3 years or less**	**College/university - 3 years or more**	**Doctoral degree**
Education	17,0%	24,5%	48,9%	9,6%
	Income-generating work	**Retired**	**Student**	**Other**
Occupation	79,8%	9,6%	6,4%	4,6%

Table 9 Distribution of educations and occupations of the GeoFlow participants.

As a dataset to be analyzed for researching user acceptance, it is overall showing varied level of skewness in gender, age, car type, driver license acquirement ages and daily occupation. The range of ages is larger than in GeoSUM, which is the reflected in their daily occupations. However, the number of middle-aged men is a major cohort in this data, while the number of students and retired is both under 10 participants each. The number of older women between 60-77 years old is also considerably lower than that of the same cohort of older men. In the surveys of GeoFlow, they didn't distinguish the different types of jobs the participants had. The skewness of the different car fuel types can impact the data significantly as differentiated road pricing is a directed especially at these different fuel types.

4 Results and discussion

This section presents the results provided by the data analysis. It first introduces shortly the results of the Kaiser-Meyer-Olkin (KMO) & Bartlett's Test of Sphericity (BTS) tests, followed by an in-depth display of survey results and the correlation analysis of the GeoSUM and GeoFlow survey variables and between the variables and behavioral intention of the participants.

4.1 Kaiser-Meyer-Olkin (KMO) & Bartlett's Test of Sphericity (BTS)

First a reliability and validity test of the survey data was carried out by running KMO and BTS tests. The results of the KMO and BTS tests show that the survey questions and their behavioral constructs have varied extent of correlations within each other. It is likely that most of the variables are reflecting consistent and reliable responses from the participants, although it is noticeable that parts of the surveys have not been designed to properly measure behavioral constructs in accurate ways, as there is often only one question (instead of a battery of questions) measuring a behavioral construct. A KMO of 0,500 and a 1 percent level of significance for BTS are used as thresholds. The test results under KMO = 0,500 and BTS > .01 will be highlighted with red text.

4.1.1 GeoSUM

Results for the GeoSUM variables within user acceptance factors are shown in table 10.

User acceptance factor	Survey variables	KMO	BTS
Attitude	Attitude - car	0.590	< .001
	Attitude - hybrid		
	Attitude – tech		
	Attitude – low-emission zone		
	Attitude – speed		
Privacy concerns	Privacy concerns/preferences	0.564	< .001
	GPS Tracking		
Performance	Performance: technical equipment	0.623	< .001
	Expectation: technology	0.576	< .001
	Expectance: Speed control zone		
	Expectance: Low emission zone		
Effort expectancy	Ease of use	0.799	< .001
	Ease of use 2		
	Switch to electricity	0.570	< .001
Price value	Additional cost: willingness to pay for	0.529	< .001
	Switch if lower charges		
Behavioral intention	Likeliness to change practice	0.666	.006

Table 10 Results: KMO and BTS test – GeoSUM.

All of the KMO and BTS test results exceeded the minimum thresholds of KMO > 0.500 and BTS > 0.01. These results indicate that there are significant correlations among the constructs measured in this survey, which justifies conducting further correlation analysis. Among the constructs, the "effort expectancy" factor exhibited the highest KMO coefficient of 0.799, indicating strong intercorrelations among the variables within this factor. On the other hand, the "price value" factor had the lowest KMO coefficient of 0.529, which suggests relatively weaker intercorrelations among the variables within this factor.

4.1.2 GeoFlow

Results for GeoSUM variables withing user acceptance factors are shown in table 11.

User acceptance factor	Survey variables	KMO	BTS
Attitude	Attitude - technology	0,450	<.001
	Attiude - toll ring		
	Attitude - toll - fair		
	Attitude - road pricing		
Privacy concerns	Privacy concerns/preference	0.826	< .001
	Processing		
	Handling of personal data		
Performance	Performance expectance road pricing	0.551	< .001
	Performance - technical	0.914	< .001
	Performance - road pricing	0.797	< .001
Price value	Road price preference	0.648	< .001
	Habit vs. price value		
	Choice - private car - after cost increase		
	Extent to pay for other uses		
Behavioral intention	Behavioral intention	0,517	<.001
	Behavioral intention 2		

Table 11 Results: KMO and BTS test – GeoFlow.

The test results of the GeoFlow survey reveal that the attitude factor variables within GeoFlow are characterized by a low KMO score and exhibit relatively fewer correlations in the correlation matrix. However, upon closer examination of the correlation matrix for attitudes, a few correlations emerge that warrant further investigation for additional analysis. It is important to note that these correlations cannot be considered entirely reliable and valid due to the limited number of measured variables within the same construct. Other variables show test result values exceeding the desired threshold, which warrants further correlation analysis. The construct of privacy concerns and certain performance measures has the highest KMO score and will be regarded as the most accurate construct measurements.

Overall, the results of both the GeoSUM and GeoFlow surveys indicate mostly acceptable KMO and BTS values. However, the results vary across a range of KMO scores from approximately 0.500 to 0.900, suggesting significant disparities in the reliability of the construct measurements in both surveys.

4.2 Survey results and correlation analysis

This section presents the survey results and correlation analysis, divided into two subsections: one focusing on the GeoSUM variables and another on the GeoFlow variables. Within each subsection, the survey variables and their responses are presented, along with the correlations between these variables. This is to understand the general responses from the participants in relation to different variables. Furthermore, the variables that exhibit the strongest correlation with the behavioral intention are discussed at the end of each subsection. Along the results, they will be discussed in regard what role they might have as potential barriers or facilitators to user acceptance, and what implications they have for the implementation of geofencing and ITS for urban traffic management. There are many results related to spearman's rank correlation (SRC) and associated correlation matrixes, which are shown in Appendix C1 for GeoSUM variables and Appendix C2 for GeoFlow variables.

4.2.1 GeoSUM variables

Attitude

In the surveys, the assessment of individuals' attitudes towards the technology and its applications was conducted by examining their positive and negative feelings and evaluations related to engaging in the desired behavior, as proposed by Fishbein and Ajzen (1975). In the context of the transition to electric vehicles and increased automation in the realm of automobility, the GeoSUM study focused on two primary target behaviors: driving in low-emission zones with electricity/road pricing and driving with active speed control and/or warning alerts. There is also measured attitudes that are relevant in the topic and that might impact their behavioral intention to use system.

First off, a large majority (86%) of the participants agreed or strongly agreed to rather have a fully electric car if selection, range, and price is to their preference; 56% agreed or strongly agreed to that the car was just a transport mode, and 23% agreed or strongly agreed to that the pleasure of driving quickly is important. Other percentages are shown in figure 19. The responses were analyzed using spearman's rank correlation, and showed a strong negative correlation that the more you agree on “driving quickly”, the less you agree to “Car only a transport mode for me” ($r = -.522$, $p < .001$).

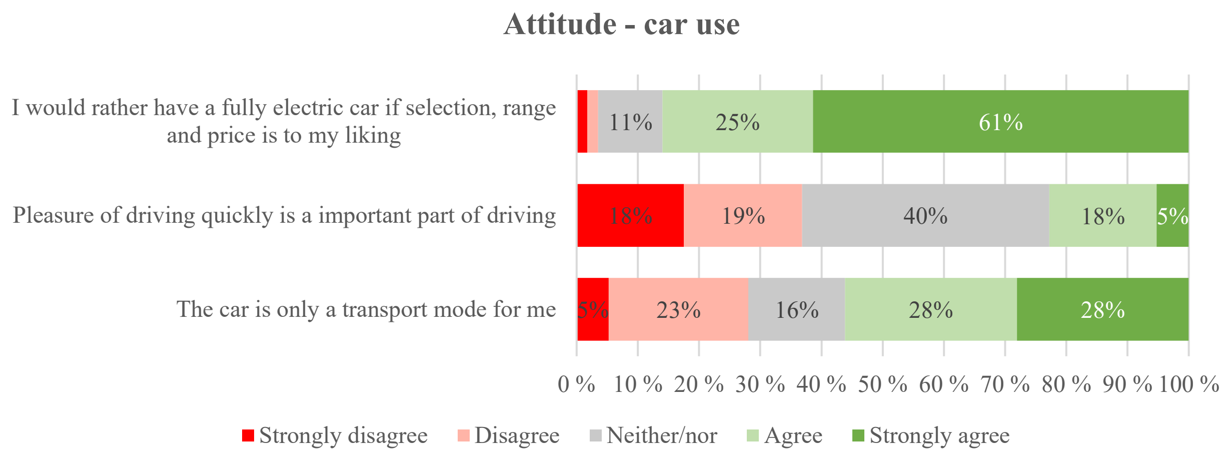

Figure 19 Results - Attitude - car use.

When participants were asked about the factors that lead them to switch to fossil fuel while driving, a significant majority (92%) agreed or strongly agreed that they were compelled to make this switch due to the complete discharge of electricity. This finding is illustrated in figure 20, which visually represents the participants' responses. Additionally, a slight majority of participants expressed that their cars automatically transition from electricity to fossil fuel. Interestingly, most participants indicated that they did not actively choose to change the fuel type themselves, neither to conserve battery for later use nor to achieve quicker acceleration and higher speeds. There showed no correlation of significance between any of these variables, which was checked using spearman’s rho. As most of the participants doesn’t seem to actively change their fuel type, the low-emission zones may be experienced as stressful or too much of a burden. The variables “choose to drive on fossil fuel to achieve higher speed” and “pleasure of driving quickly” correlated strongly ($r = 0.592$, $p > .001$).

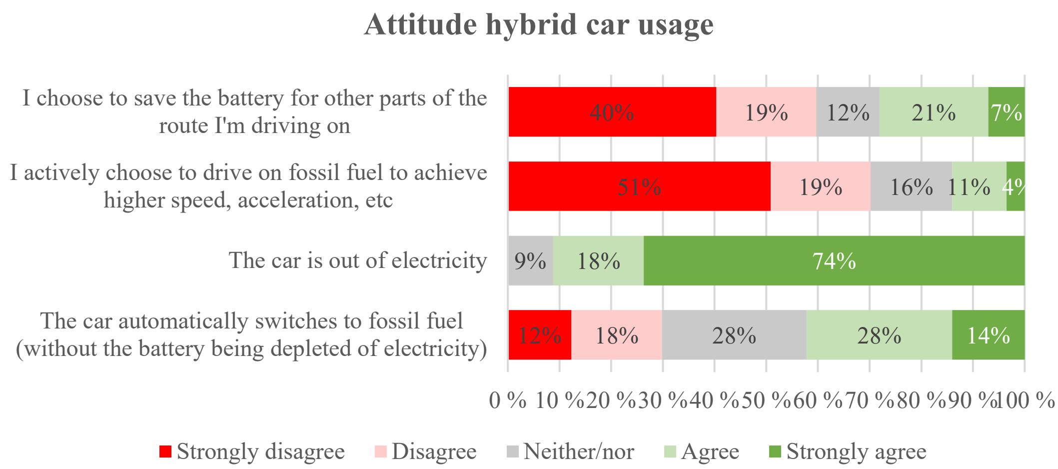

Figure 20 Results - Attitude – hybrid.

To comprehensively measure and understand participants' attitudes, it is crucial to consider their perspectives on climate change, pollution, and speed limits/speed breaking. A significant majority of participants (82%) agree or strongly agree that human-induced climate change represents the most significant societal challenge we currently face. However, when it comes to local pollution, opinions are more divided, with approximately 41% agreeing or strongly agreeing that it is a major problem. Moreover, most participants responded that they are conscious of the usage of electricity in their vehicles, as well as the utilization of information provided by their cars to optimize electric driving. Figure 21 illustrates the variables related to this aspect. Notably, a strong correlation exists between the first two questions ($r = .563$, $p < 0.001$), indicating that participants who are conscious of when and where they are driving on electricity are more likely to agree that they actively utilize the information provided by their cars to optimize electric driving. However, those responses don’t correlate with any responses given in figure 20, which suggest that the knowledge of when the car is on electricity doesn’t make the drivers actively swap between this and fossil fuel.

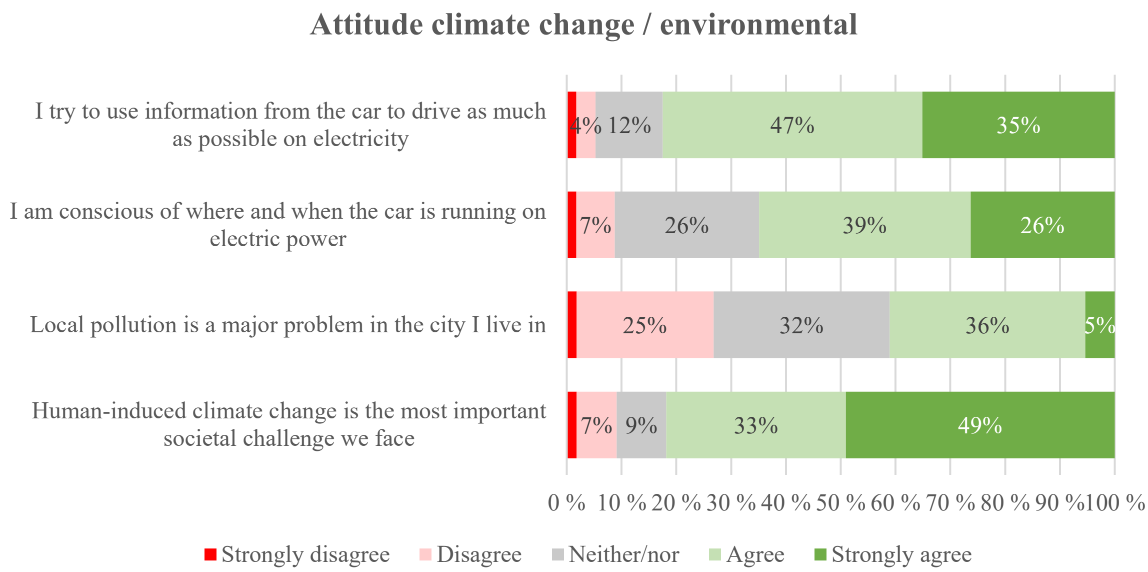

Figure 21 Results - Attitude - low-emission.

Close to a third of the participants (30%) agree or strongly agree to that they believe it's irresponsible to drive over the speed limit, regardless of what the speed limit is, while a third responded neither/nor and disagree, 38% and 33%, respectively. The percentages are similar for those who think the speed limits in Norway should be higher than today (37% agree/strongly agree, 32% neither/nor, 32% disagree/strongly disagree). Even though participants have opposing responses on these questions, majority still believe breaking the speed limit is a big problem for traffic safety. These responses are shown in figure 22. There are strong correlations between the three last variables shown here: negative correlation between "I believe it's irresponsible" and "wanting higher speed limits" with $r = -.431$, $p < .001$, positive correlation between "I believe it's irresponsible" and "traffic safety" with $r = .602$, $p < .001$ and negative correlation between "wanting higher speed limits" – "traffic safety" with $r = -.523$, $p < .001$. These correlations indicate significant relationships between participants' attitudes towards driving over the speed limit, their opinions on current speed limits, and their perception of speed limit violations as a traffic safety concern.

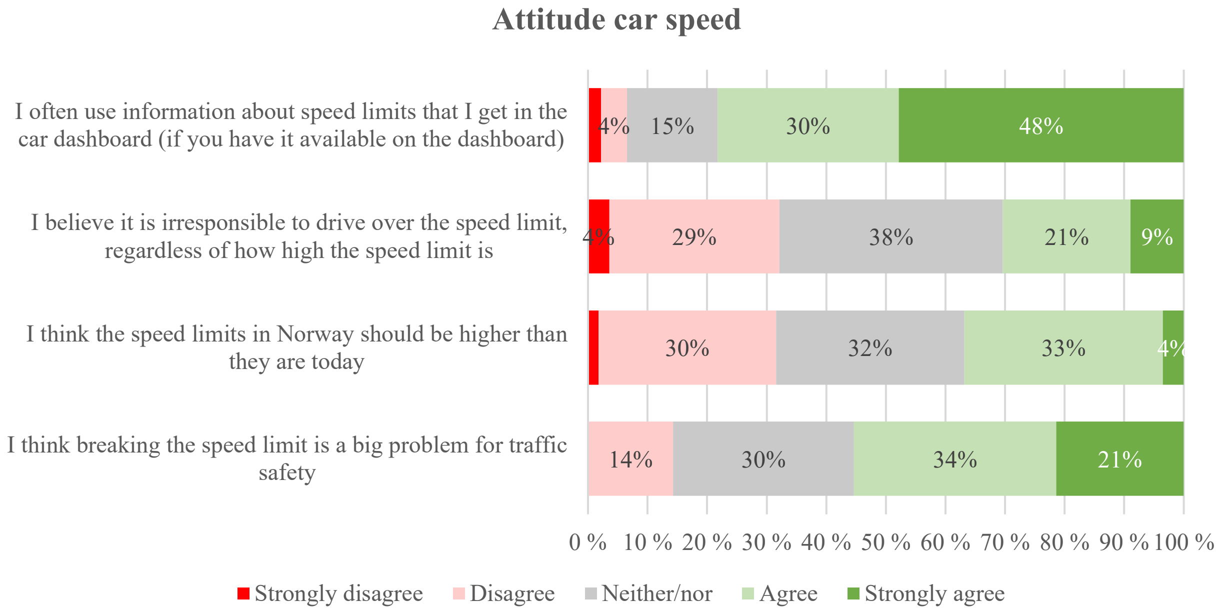

Figure 22 Results - Attitude - car speed.

These results reveal three distinct attitudinal variables that may function as a barrier to a transition in automobility, with regards to the geofencing use cases. The first one is that participants aren't choosing when to drive on electricity, such as saving electricity for more sensitive and polluted areas. When they stop using electricity, it is because they run out of charge. This suggest that hybrid car users might show resistance when introducing measures that force them to change. Secondly, there were mixed perception of local pollution, were many downplayed its importance as a major problem in the city. The impact of this attitude requires further exploration to comprehend its implications fully, as it may have a minimal effect considering the relatively good air quality conditions in Nordic cities (Åström, Geels et al. 2022). Thirdly, the results revealed significant variations in participants' attitudes towards speed limits. These attitudes correlated with their perception of irresponsibility and traffic safety. Consequently, if drivers are compelled to change their speed during automated driving, these pre-existing attitudes may act as a barrier to the acceptance and adoption of automation technologies, such as the speed control zones in GeoSUM.

On the other hand, the participants' overall positive attitude towards changing their car type presents a promising aspect of the transition. A large majority showed willingness to switch to electric cars if certain factors like selection, price, and range aligned with their preferences. This can be considered a favorable attitude toward willingness to transition to electrified transportation, which is a important aspect of the sustainable transition in automobility.

Privacy concerns

As presented earlier in section 2.3.3, “privacy can be described as the extent to which a person cares about the security of personal data” (Herrenkind, Brendel et al. 2019). The participants were asked 6 main questions about their privacy preferences in the pre-pilot survey, shown in figure 23.

Majority of participants were familiar with the Norway’s personal data privacy legislation. However, there was no association between participants responding agree to this and the other questions related to privacy concerns. There was a moderate negative correlation between participants concern of personal data being misused and their trust in companies and authorities (r = -.347, p = .008 for authorities, and r = -.341, p = .009 for private companies). Participants showed more trust to the authorities than to private companies to safeguard their privacy, however there was a strong correlation between these variables (r = .641, p=.001). Most are also agreeing or strongly agreeing to registration of personal travel data if it contributes to them being offered better services, and if it contributes to a fairer toll system. These have a strong association (r = .694, p=.001). This can be seen in raw data which reveals that those who chose to agree or strongly agreed to first one usually answered agree or strongly agree to the other.

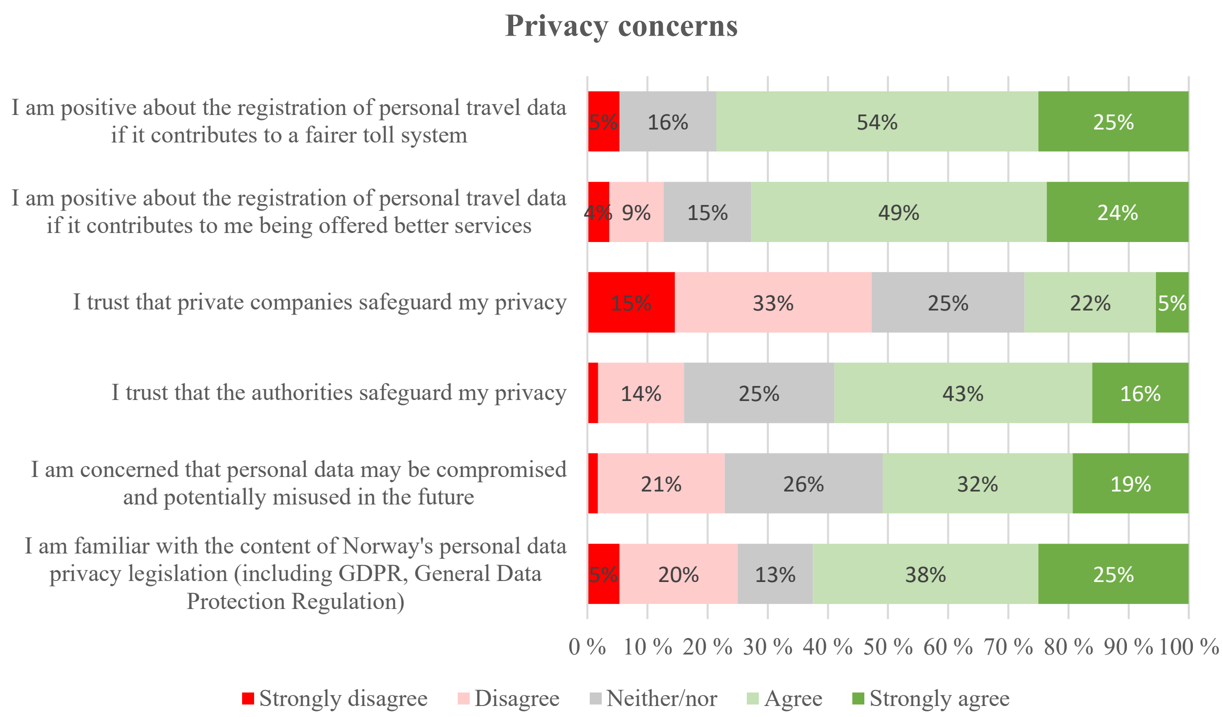

Figure 23 Results - Privacy concerns.

Variables concerning GPS tracking is shown in figure 24. The participants showed the most positive responses (83%) to GPS position being processes locally in the car before it is sent off to a neutral third party. Those processes include local calculation and a creation of a short summary before it is sent. 32% of responses was toward positive side to GPS position being processed by a neutral third party themselves. Responses to GPS position being used to inform, guide, and control traffic were 64% on the positive side. There is a strong association between the "GPS position processed by a third party" and "GPS position used to inform, guide and control traffic", with r = .586 and p < .001.

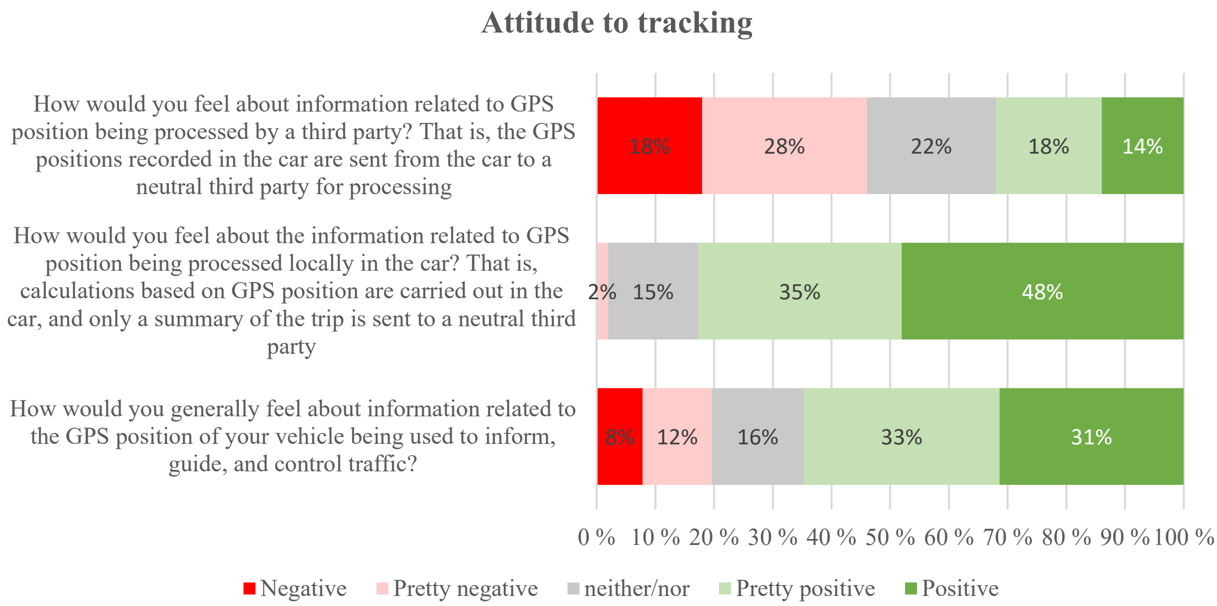

Figure 24 Results - GPS Tracking.

Privacy concerns play a significant role in the architecture of Intelligent Transportation Systems (ITS) in private vehicles. These concerns can introduce barriers and restrictions to the functioning of ITS, particularly in the context of achieving a sustainable transition in urban mobility. This is compounded by the constant integration of new dependencies on critical materials and the need for robust cybersecurity measures (Kivimaa, Brisbois et al. 2022).

Firstly, these results indicates that participants showed a mostly favorable attitude towards sharing their personal travel data. However, a significantly higher proportion expressed a preference for authorities safeguarding their data. Secondly, participants would be more positive with local data processing within the car, which advocates local data processing in the architecture of the ITS system.

Performance

The performance factor will be evaluated based on two dimensions: technical performance and performance expectancy. In this context, performance expectancy refers to the extent to which individuals perceive that using the system will help them achieve performance improvements, as well as to what the participants expect of the performance of the technology (Davis, Bagozzi et al. 1989, Moore and Benbasat 1991). In GeoSUM, there are several ways of looking at its performance; the low-emission zones and road pricing which was intended to change the existing tolling system and create better conditions for environmentally friendly car user practice; and speed assistance system for safer traffic conditions and more automated control of car speeds in school zones.

The variables related to performance expectancy, as depicted in figure 25, suggest a predominantly positive outlook to some perceptions of the technology. The majority of participants (79% and 84%) expressed favorable expectations regarding the reliability of the technology and its ability to enhance their awareness of emissions, respectively. However, a relatively lower proportion of respondents (58% agree or strongly agree) showed positive responses regarding their anticipated awareness of speed limits. The "reliable" and local emission" variables displayed strong association ($r = .418$, $p > .001$). These variables are not related to the performance of the driving capabilities of the driver; rather, it indicates extent of general positiveness to the technology and what the participants are expecting of changes as result of the technology.

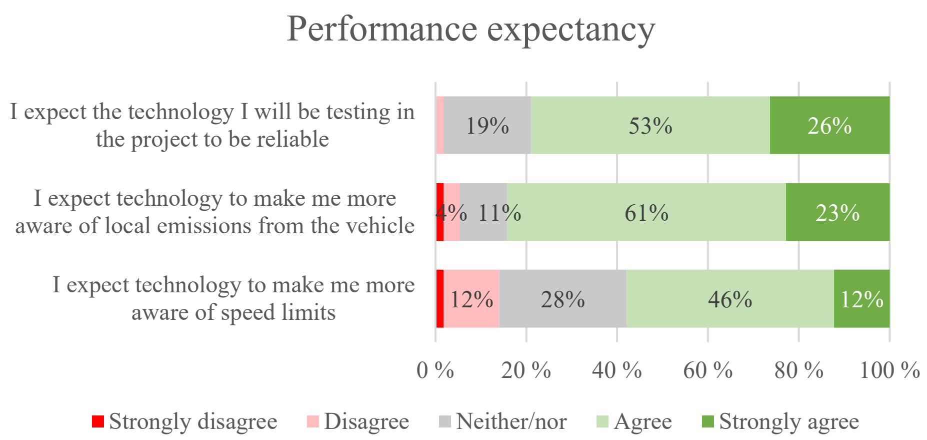

Figure 25 Results - performance expectancy

In the post-survey, the participants were asked again about the performance. Of the total amount of responses, most agreed or strongly agreed to that the system would help them drive more environmentally friendly within the defined low-emission zones, as well as to the whole city traffic being more environmentally friendly if everyone had this system installed in their vehicles. This is shown in figure 26. Furthermore, majority was positive to the speed assistance system as a way to create safer traffic, however it was significantly more participants who perceived that the system didn't help themselves specifically to drive within the speed limits and safer, but if everyone in the traffic had it. Also, there was around half amount of people who strongly agreed to the extent of the speed assistance system's performance, compared to the environmentally focused use cases. “Traffic safety” and “helped to stay within speed limit” strongly correlated (r = .429, p > .001), and “make city traffic more environmentally friendly” and “helped drive more environmentally friendly within low-emission zone” strongly correlated (r = .533, p > .001).

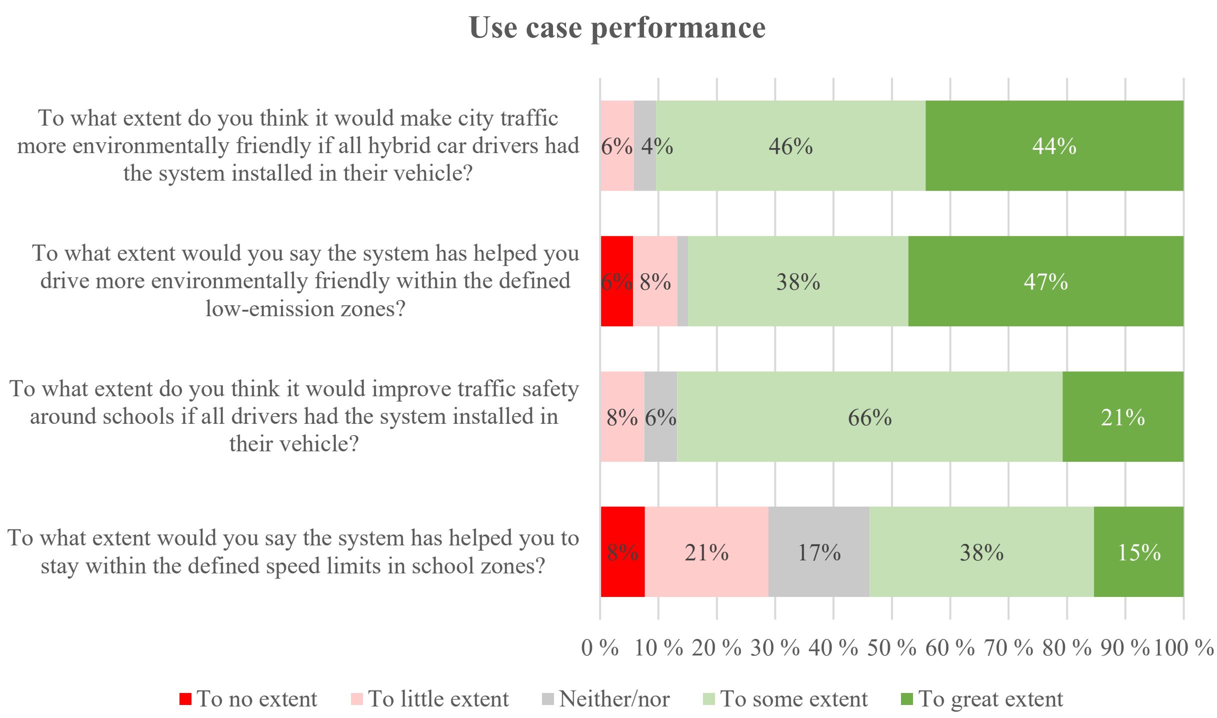

Figure 26 Results - Performance use case.

Technical performance can in this situation be regarded as perceived system performance (PSP), which refers to the degree to which a person believes that a system is reliable and responsive during its standard course of operations (Liu and Ma 2006). The responses regarding technical performance, show that most of the participants often had problems on the equipment startup, either because of no contact with dongle or phone not starting. However, problems seemed to have ceased after start-up problems, with very few cases of unexpected shutdowns, or the equipment losing GPS signal. The variables regarding technical performances is shown in figure 27. There is low degree and number of correlations between these variables, which means that none of these technical flaws relates to another.

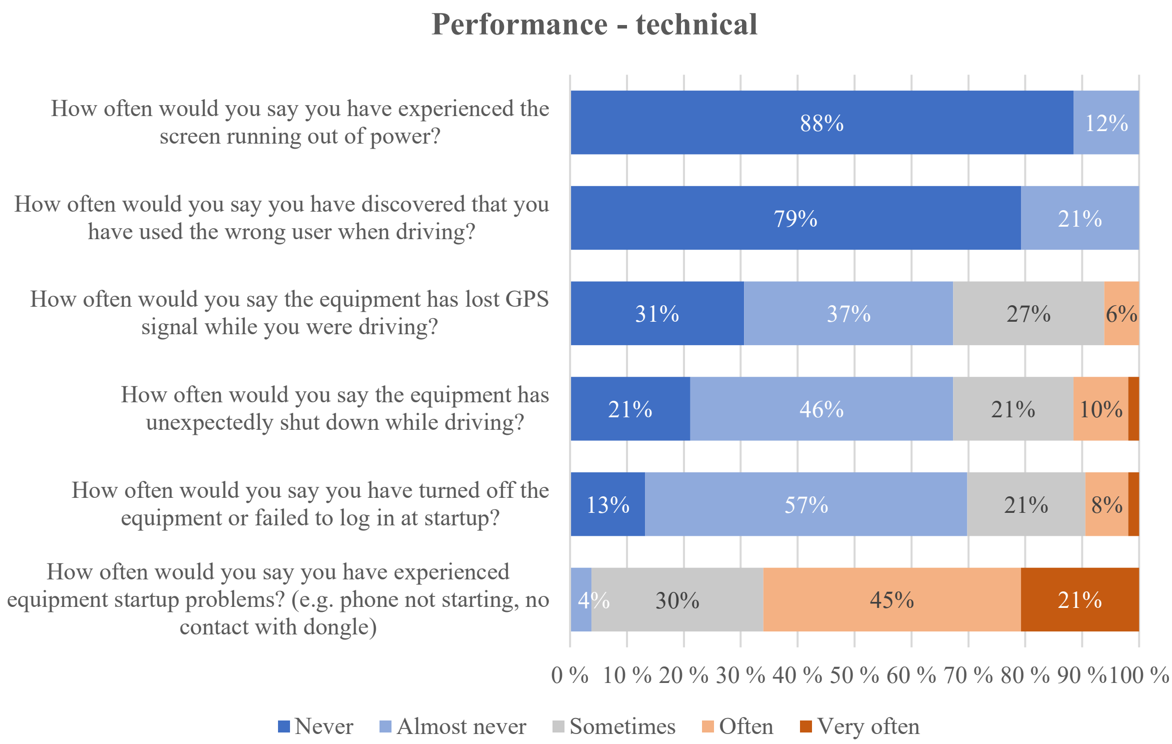

Figure 27 Results - Performance – technical.

As suggested by the UTAUT model, performance expectancy plays a notable role in shaping the behavioral intention of technology users. In the context of a socio-technical transition in automobility, it is important to assess the extent to which individuals perceive the technology as beneficial and capable of enhancing their performance, although it can be argued that not all the performance measures here are not directly related to the drivers themselves. The positive expectations regarding the benefits and potential advantages for traffic of the technology can be considered to have a positive influence on its adoption.

The feedback on the technical performance suggest that the equipment was not fully functioning in the start-up processes. This indicates that further improvements and refinements are required in the design of the equipment and technology before considering a larger scale adoption. If the system is not properly designed for implementation, user acceptance might drop considerably.

Price value

Price value can be expressed by various perspectives, as described in section 2.3.3, and is characterized by whether the value of a technology or practice is worth the price of adopting and utilizing it. In the GeoSUM survey, participants were asked to what extent they were willing to pay for a system with an interface in the car, such as in the pilot experiment, and detailed information on trips and statistics. The responses were split with 45% and 57% to no extent, 13% and 10% neither/nor, and 41% and 33% to great extent to having to pay for both situations, shown in figure 28. SRC shows that there is a strong association between the responses (r = .580, p = .001). There is therefore a high probability that participants responded the same on both questions.

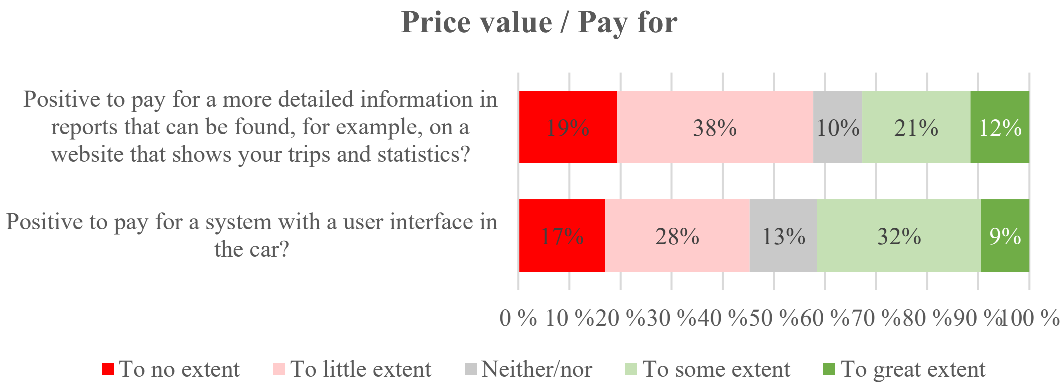

Figure 28 Results - Price value.

As discussed in the analytical framework, individuals' price evaluation of an innovation greatly impacts its use behavior and user acceptance. Since these results indicate a considerable number of negative responses towards paying for additional information and interface, it can be implied that making these elements a requirement would have a harmful effect on the adoption of the system. Therefore, it is recommended that the use of these additional elements should not be mandatory to ensure better user acceptance and adoption of the system. However, the additional prices are not explicitly given, which leaves room for interpretation and uncertainty.

Effort expectancy

Effort expectancy was measured through the level of ease and effort expressed by the participants. In the post-pilot survey, a large majority of participants answered that they found it easy and comfortable to use the system. This can be seen in the figure 29 below, which shows participants' answers given in a Likert scale. Most of the questions showed SRC ranging from moderate to very strong association with each other ($.350 < r < .785 \mid 51 < n < 53 \mid r < .001$). The questions related to how frustrating and distracting the interface was (with the highest number of disagrees in red) had a negative correlation with all the other questions, and positive between themselves. However, from looking at the raw data, there was shown no pattern in those who answered negatively. It was independent from variables such as car brand, age, or gender.

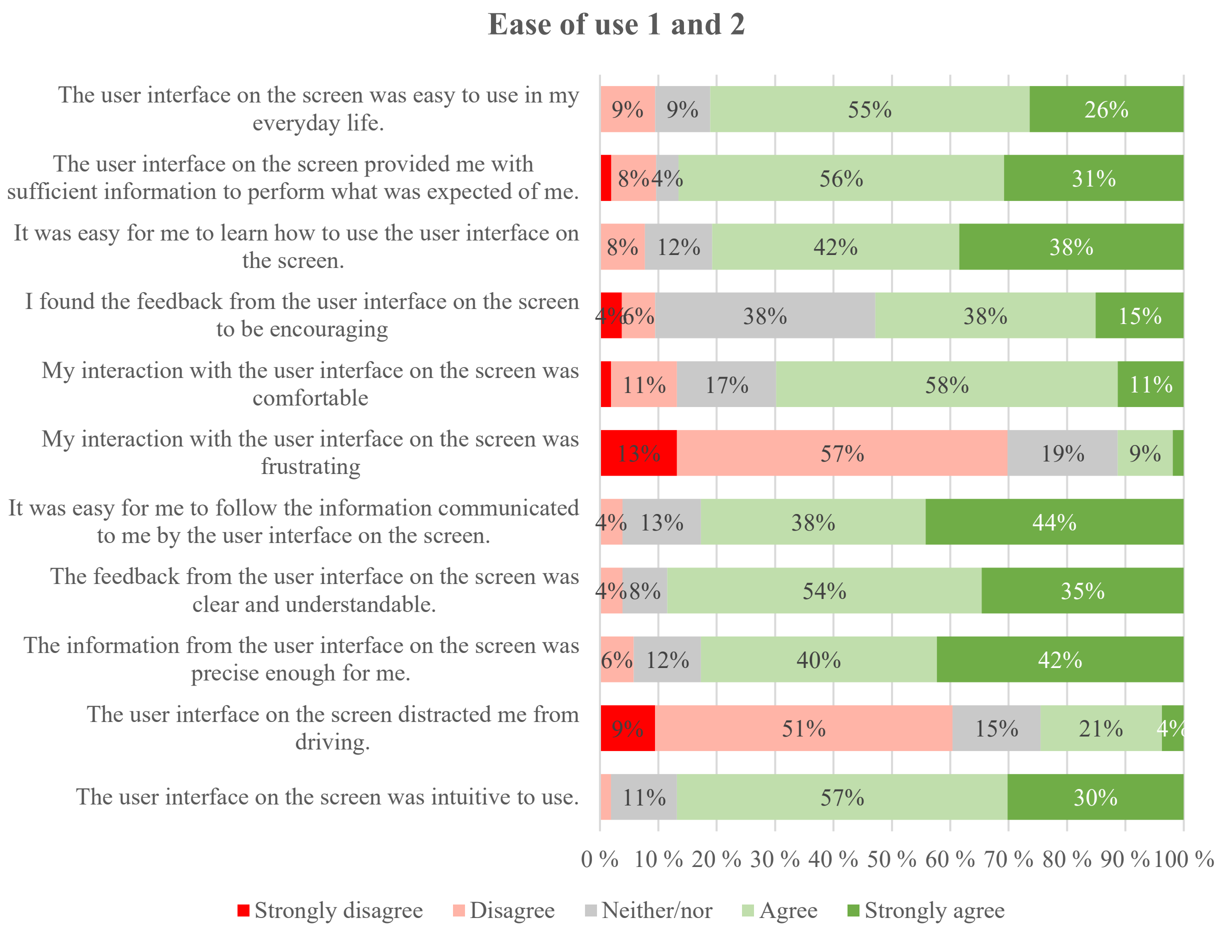

Figure 29 Results - Ease of use.

Another way of measurement was through the extent of physical and mental effort of the participants regarding the switch between fuel types in the low-emission zones. These measurements are shown in figure 30. Majority answered that they didn't feel any pressure or use much of their capacity either mentally or physically. Those who answered negatively was too few and showed no common reliable patterns that could explain why they felt this way. The answers were all associated with each other, ranging from ($.344 < r < 666$, $p < 0{,}019$). Participants often responded the same in all questions, except for the first question.

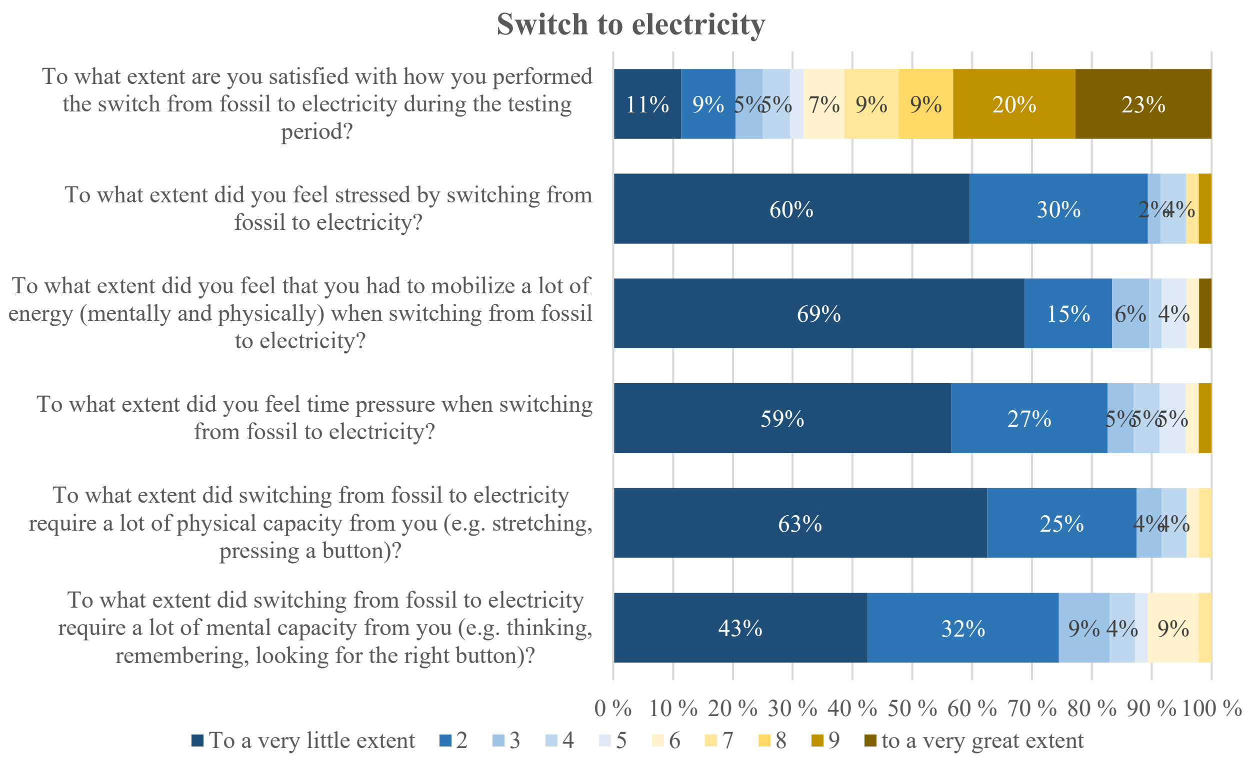

Figure 30 Results – Switch to electricity.

The overall assessment of these results indicates that ITS and geofencing, along with the associated equipment used in the pilot, were perceived as mentally and physically easy to use by the participants. This finding suggests that participants did not experience stress when required to change fuel types while driving, especially since most of them were not actively engaging in such behavior previously. If this system were to be adopted for traffic management on a larger scale it is likely that individuals within similar cohorts would have a similar experience. This is advantageous for the technology interventions that introduce new functions to vehicles but require additional attention from the driver. This factor will not be seen as a barrier regarding this specific use case.

Behavioral intention

The results of the variables measuring behavioral intention is shown in figure 31, and will be used to indicate the actual extent of user acceptance among the participants. Looking at the responses, there was generally shown a great extent of positive intention toward using the differentiated pricing and the low-emission zones. Participants expressed the least positive responses regarding their belief that all drivers (not just hybrid drivers) would be positive to differentiated road pricing, even though they were themselves positive to it. As it is specifically mentioned "(not only hybrid drivers)" in the question, but it might also be because they think that drivers using other fuel types won't be positive to it. There showed no significant difference between responses of ages, genders, or car brand.

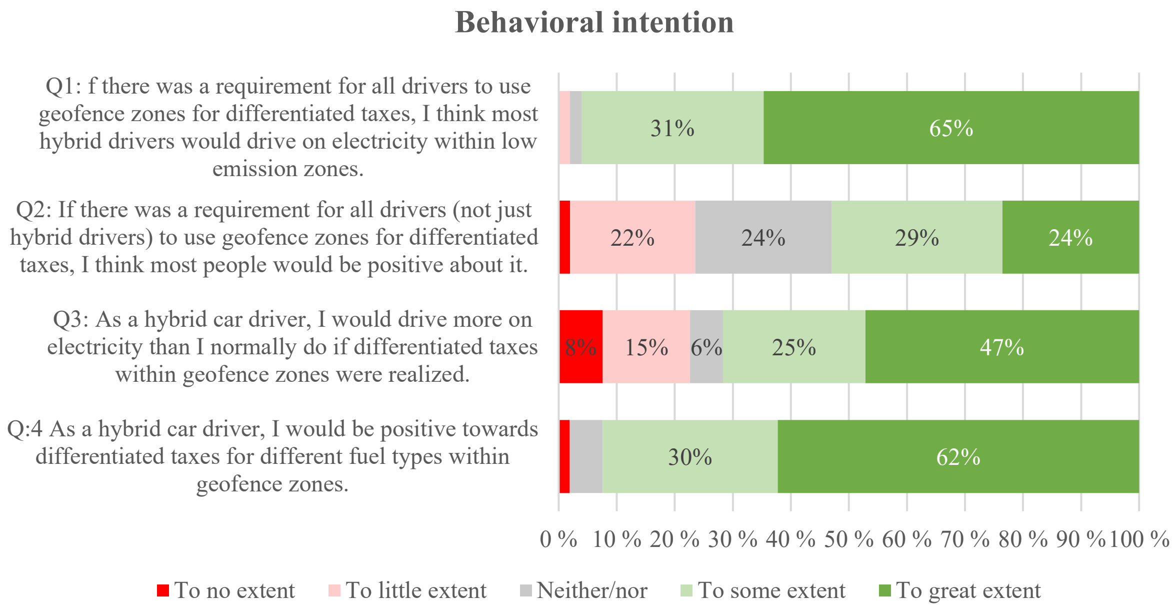

Figure 31 Results - behavioral intention of GeoSUM participants.

Correlations with behavioral intention

The correlation analysis reveals varying degrees of correlation between the variables of the user acceptance factors and behavioral intention to use system. Table 12 below presents the variables organized within the factors. The table displays the correlation coefficients indicating the strength of association between each variable and behavioral intention (indicated as Q1, Q2, Q3 and Q4). The blank cells in the table indicate a negligible correlation (> 0,200) coefficient between the variable and behavioral intention, while green and yellow fields show positive and negative correlations, respectively. The degrees of correlation in the table are adapted from Dancey and Reidy (2020), as discussed in section 3.1.2. It must be noted that the most correlated variables are also argued based on their correlation consistency among several of the variables measuring behavioral intention.

Factor	Variables	Behavioral intention			
		Q 1	Q 2	Q 3	Q 4
Attitude	Pleasure of driving quickly is a important part of driving	-0,273			-0,471
	I think it is important to drive a car with the latest technology	0,309	0,273	0,288	
	Local pollution is a major problem in the city I live in	0,320	0,283		0,295
	I think the speed limits in Norway should be higher than they are today	-0,374			-0,613
Privacy concerns	I trust that the authorities safeguard my privacy	0,507	0,213	0,314	0,287
	How would you feel about information related to GPS position being processed by a third party? That is, the GPS positions recorded in the car are sent from the car to a neutral third party for processing	0,323	0,413	0,304	
	How would you generally feel about information related to the GPS position of your vehicle being used to inform, guide, and control traffic?	0,217		0,298	
Performance	I expect technology to make me more aware of local emissions from the vehicle	0,246	0,354		
	To what extent would you say the system has helped you to stay within the defined speed limits in school zones?	0,256	0,313	0,555	
	To what extent do you think it would improve traffic safety around schools if all drivers had the system installed in their vehicle?		0,350		0,313
	To what extent would you say the system has helped you drive more environmentally friendly within the defined low-emission zones?	0,286	0,515		
	To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicle?	0,524	0,488	0,412	
Price value	To what extent do you consider it likely that in your everyday life you would switch to electricity within low-emission zones if it would result in lower fees?		0,239		0,345
	Positive to pay for a system with a user interface in the car?		0,463	0,225	

Degree of correlation				
	Weak	Moderate	Strong	Very strong
Positive	+	+	+	+
Negative	-	-	-	-

Table 12 GeoSUM - Most correlated variables to behavioral intention (Significant, $p < 0.01$).

In terms of the attitude of the participants, there was shown varying degrees of correlation to the behavioral intention to use the system. The first one being "the pleasure of driving quickly is important" (negatively correlated with Q1 and Q4). This indicates that individuals who prioritize speed often had a lower desire towards adopting the system. The second was "it's important to drive with the latest technology" (positively correlated with Q1, Q2 and Q3), which may imply that those who value technological advancements in the car are more likely to have a positive behavioral intention towards the system. The third is "local pollution is a major problem" (positively correlated with Q1, Q2 and Q4), which suggests that individuals who are concerned about pollution are more inclined to support the system. Lastly, it is "the speed limits in Norway should be higher than they are today" (negatively correlated with Q1 and Q4), suggesting that individuals who advocate for higher speed limits have a less intention to use the system offered in GeoSUM.

Within the factor of privacy concerns, certain variables displayed notable correlations with behavioral intention. These variables included: "trust that the authorities safeguard your safety" (positively correlated with all), indicating strongly that individuals who have faith in the authorities' ability to protect their safety are more likely to exhibit positive behavioral intention; "positive to GPS positions being processed by a neutral third party" (positively correlated with Q1, Q2 and Q3), suggesting that individuals who perceive a neutral third party handling GPS data positively are more likely to support the system; and "positive to GPS position being used to inform, guide, and control traffic" (positively correlated with Q1 and Q2), indicating that individuals who view GPS data usage as beneficial for traffic management are more likely to have a positive behavioral intention.

Within the factor of performance, many variables demonstrated varying degrees of correlation with behavioral intention. The first one is "I expect that the technology will make me more aware of local emissions from the vehicle" (positively correlated with Q1 and Q2). This implies that individuals who anticipated increased awareness of emissions are more likely to support the system. The second is "To what extent would you say the system has helped you to stay within the defined speed limits in school zones?" (positively correlated with Q1, Q2 and Q3), which indicates that individuals who perceived the system's effectiveness in adhering to speed limits in school zones are more likely to have a positive behavioral intention. The third variable is "To what extent do you think it would improve traffic safety around schools if all drivers had the system installed in their vehicle?" (positively correlated with Q2 and Q4), suggesting that individuals who believe widespread adoption of the system would enhance traffic safety around schools are more likely to support it. The fourth is "To what extent would you say the system has helped you drive more environmentally friendly within the defined low-emission zones?" (positively correlated with Q1 and Q2). This indicates that individuals who perceive the system's role in promoting environmentally friendly driving within low-emission zones are more likely to have a positive behavioral intention. The last variable "To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicle?" (positively correlated with Q1, Q2 and Q3), is suggesting that individuals who believe the system's installation in hybrid cars would contribute to environmentally friendly city traffic are more likely to support it.

In the factor of price value, two variables exhibited positive correlations with behavioral intention. The variables were: "To what extent do you consider it likely that in your everyday life you would switch to electricity within low-emission zones if it would result in lower fees?"

(with Q2 and Q4) and "Positive to pay for a system with a user interface in the car?" (with Q2 and Q3). Individuals who expressed a higher likelihood of switching to electricity within low-emission zones due to reduced fees and those who showed a positive inclination towards paying for a system with a user interface in the car were more likely to have a positive behavioral intention.

4.2.2 GeoFlow variables

Attitude

The GeoFlow project implemented geofencing and Intelligent Transportation Systems (ITS) to introduce a new road pricing system through low-emission zones. The primary focus is therefore on measuring participants' attitudes towards transitioning from the existing road tolling system to the newly introduced technology-driven road pricing system.

In the pre-pilot survey, the results show that 65% of participants was positive/very positive in their immediate attitudes to the use of the proposed road pricing system, compared to 31% positive/strongly positive attitude towards the existing road tolling system in Trondheim. 24% of participants was negative/very negative while 44% was neither/nor to existing road toll. This is displayed in figure 32. The responses for attitudes on existing toll system was found to have a moderate correlation with both the other responses ($r = .374$, $p < .001$). This indicate that the participants had moderate similarities in both their answers, such as either choosing negative, neutral, or positive on both variables. However, as they are moderate there is still significance difference between the variables.

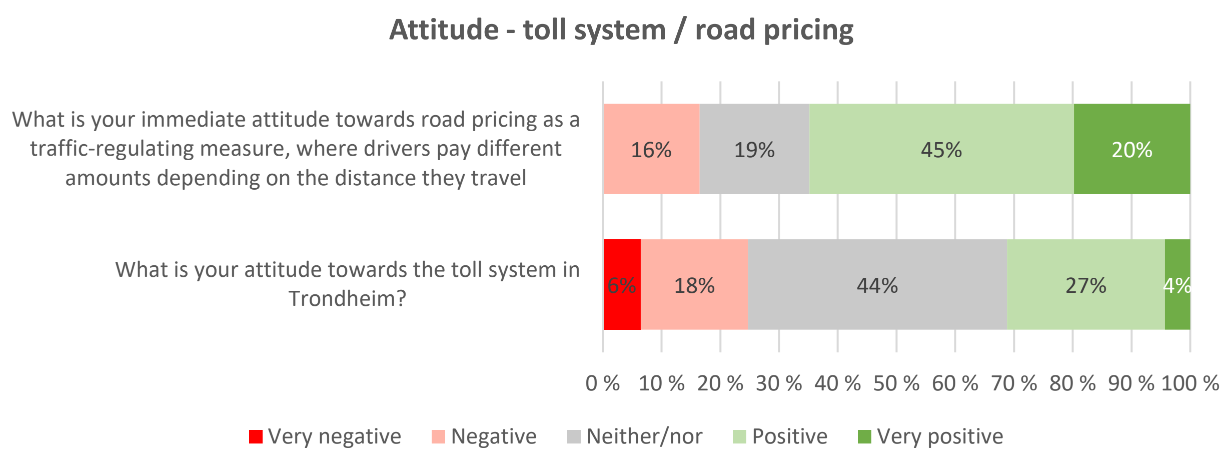

Figure 32 Results - Attitude - toll system - road pricing.

Participants were asked to express their opinion on whether zero-emission vehicles should be subject to the same fees as other vehicles. Most respondents expressed agreement with this, with 31% agreeing and an additional 27% strongly agreeing that zero-emission vehicles should pay the same fees. This distribution of responses is depicted in figure 33.

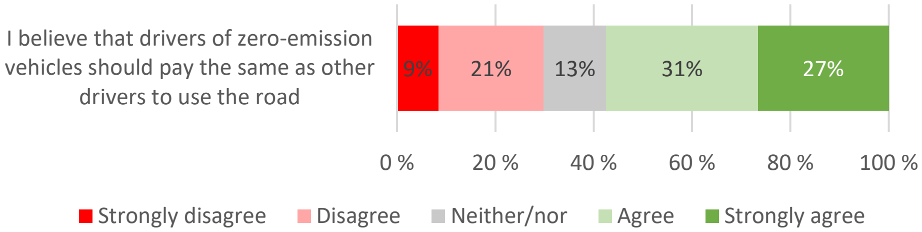

Figure 33 Results - Pay same.

It must be noted that the majority's belief in non-differentiated pricing, is influenced by the number of gasoline/diesel and hybrid car drivers in the data. The clustered bar chart in figure 34 shows a clear difference between the responses of fossil fuel/hybrid drivers and the zero-emission vehicle (EV) drivers. These finding suggests that a significant proportion of participants driving fossil fuel and hybrid have the belief that zero-emission vehicles should not receive preferential treatment in terms of fees. Instead, they likely support a fair and equitable system where all vehicles, regardless of their emission levels, are subject to the same charges. This perspective may stem from a desire for equal treatment and from a recognition that maintaining infrastructure and funding services require contributions from all vehicle owners.

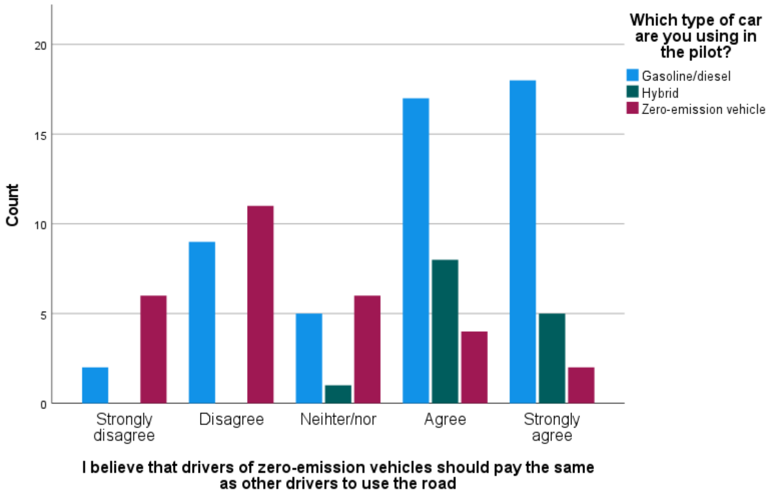

Figure 34 Results - Pay same - Bar cluster.

Among the participants, there is mostly a one-sided positive attitude towards trying out new technology, shown in figure 35, which might influence the data. On the importance of driving the latest technology in the car, the participants responded 19% negative/strongly negative, 44% neither/nor and 38% positive/strongly positive. These two variables exhibited moderate correlation ($r = 378$, $p > .001$).

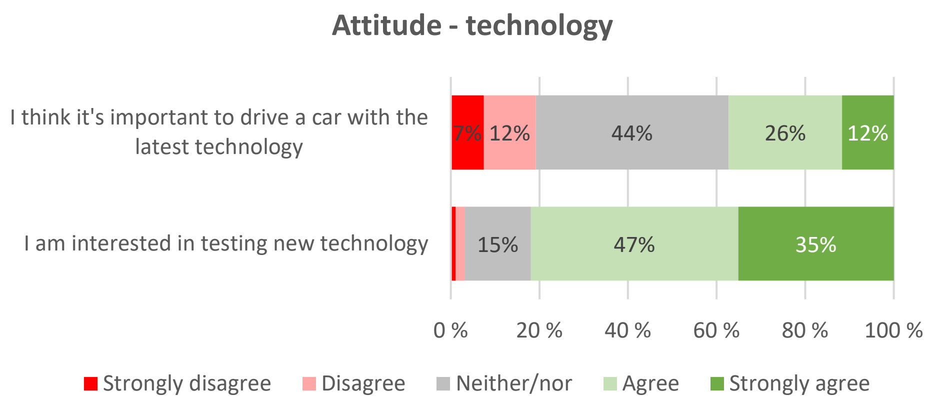

Figure 35 Results - Attitude – technology.

The findings concerning attitudinal variables reveal potential barriers or facilitators for the successful implementation of differentiated road pricing. One significant variable is the divergent belief on whether zero-emission vehicles should be subject to the same pricing in low-emission zones. This can pose as a potential barrier, as one of the road pricing's primary objectives is to incentivize the use of zero-emission vehicles as a favorable behavior in the transition towards sustainable urban mobility.

A significant facilitator for the transition is the positive attitude towards the road pricing system in comparison to the existing road toll system. This favorable attitude towards the new system is considered crucial as it reflects the desired behavior (although, not confirmed by correlations to behavioral intention) and serves as a key dimension in comprehending participants' attitudes towards the geofencing-enabled road pricing system. Interest in technology may also impact the extent of acceptance to new technology.

Privacy concerns

When looking at the participants' position on privacy concerns, the general trend is very positive to personal data sharing. The responses for this are shown below in figure 36, which is from the before-pilot survey. Firstly, there were similarities between participants' trust in government and third party; 55% and 18% agree and strongly agree to trust in the government to safeguard their privacy, while 55% and 9% agree or strongly agree to trust on third parties. There was a strong correlation between them ($r = .625$, $p < .001$) suggesting that people who have confidence in the government's privacy protection measures are more likely to extend that trust to third parties (This could also be true the other way). Secondly, the participants were largely positive to registration of personal travel data if it offers a fairer road toll system overall and better services to themselves, however, there was no other specification of who it's being shared to and what personal travel data. A significant portion (41% and 9%) of responses disagreed and strongly disagreed to that they are worried personal data will be misused in the future. This variable showed strong negative correlations with the others mentioned above, while all other mentioned variables showed strong positive correlation with each other. However, variable "Familiarity with Norwegian privacy legislation" didn't show any notable correlation with other variables.

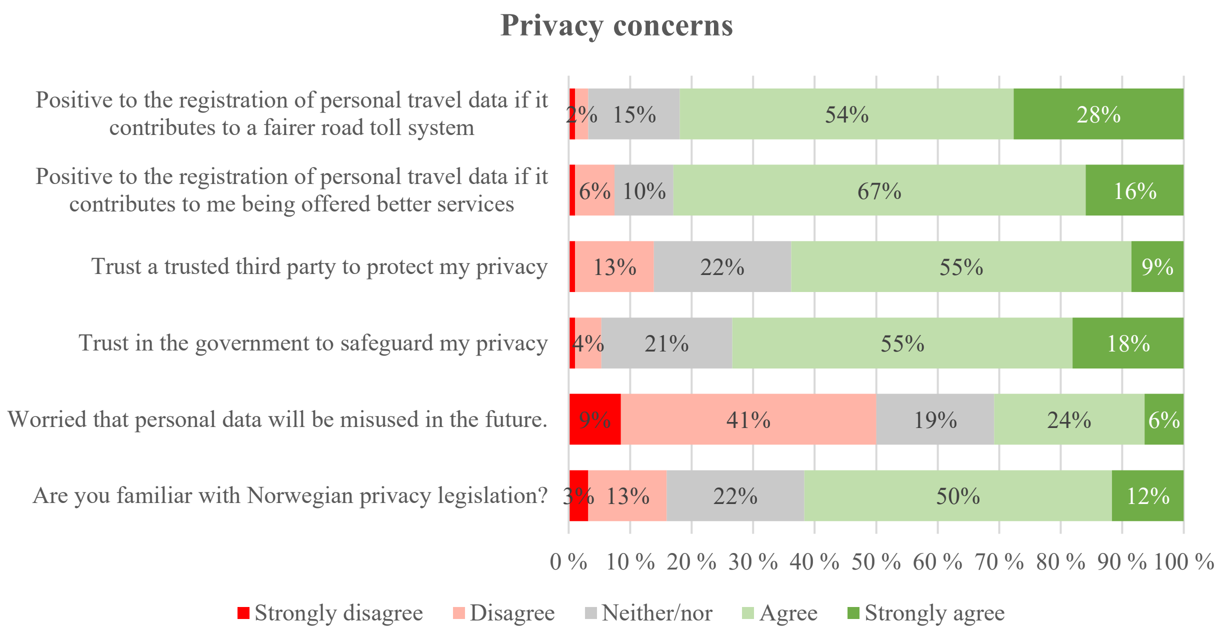

Figure 36 Results - privacy concern.

Like in the GeoSUM survey, there were more positive responses to GPS data being processed in the car before it is sent to a neutral third party compared to being processes by a neutral third party themselves. This is shown in figure 37. Further in this part of the survey, the participants responded positively once more to personal travel data being recorded if it contributes to a fairer toll system and better services being offered to themselves, although it was slightly less positive than responses in the before-pilot survey; these responses showed moderate to very strong correlation among each other in the SRC correlation matrix. Notably, the variable "GPS position processed locally only in the car" correlated (moderate to strongly) with all variables where participants expressed positiveness to personal data being recorded.

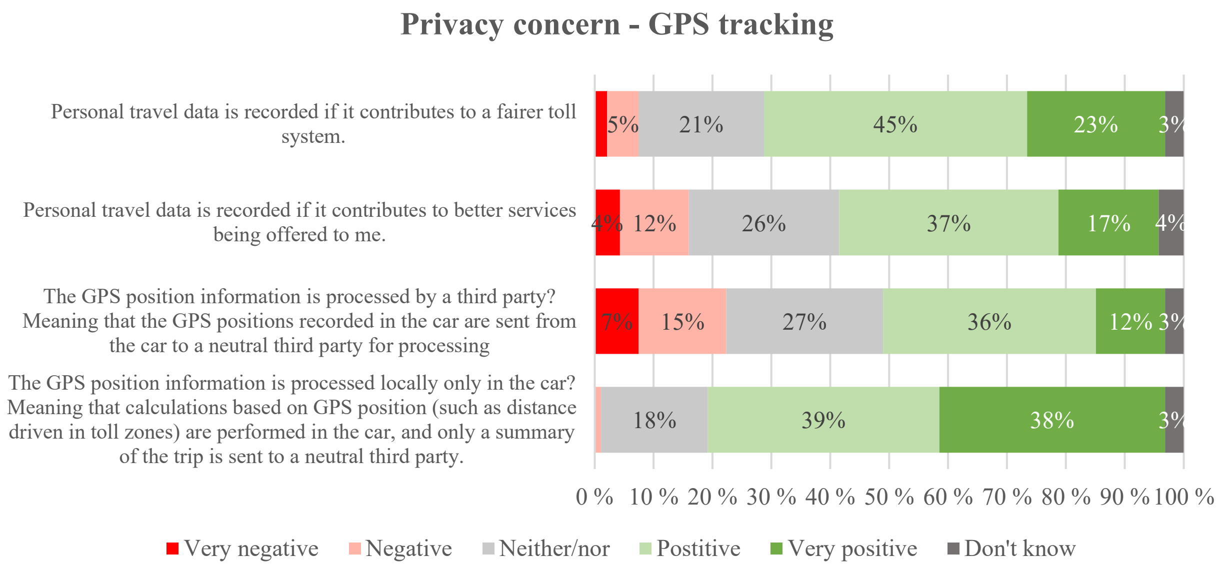

Figure 37 Results - privacy concerns 2.

In general, the trend regarding data sharing and GPS Tracking is positive, and the trust in authorities and third parties is high. However, there are many individuals with concerns about the misuse of the personal data in the future. Among the privacy concerns, this is the variable with most prevalent number of negative responses. Also, GPS position being recorded and processes only in the car might be an important precondition for travel personal data being recorded if it contributes to better services and fairer toll system, as indicated by correlations.

In comparison to the GeoSUM results, the trust is seemingly much higher for third parties/private companies, which might suggest a difference in measure or inaccurate measures. It is worth noting that the GeoSUM survey referred to "private companies," while the GeoFlow survey used the term "trusted third party." This discrepancy in wording can lead to different interpretations among participants, potentially influencing their responses.

Performance

The performance factor will be evaluated based on the two dimensions: performance expectancy and technical performance. Performance expectancy will be regarded as to what extent individuals perceive that using the system will help them achieve performance improvements, and what the participants expect of the performance of the technology (Davis, Bagozzi et al. 1989). Here, this is assessed by considering participants' beliefs about the system's potential to lower costs, increase awareness of the environmental impact of transportation, make it fairer, and reliability of the system.

Many expressed positive and neutral expectations throughout these variables. The highest expectation, with 93% agree or strongly agree, was for the reliability of the technology, while the lowest expectation, with 37% agree or strongly agree, was for lower cost in the testing. The results are shown in figure 38. SRC showed a strong correlation, $r = .616$, $p < .001$, between expectance of lower cost in testing and lower cost in future implementation, and a weak negative correlation, $r = -.294$, $p < .001$, between expectance of “lower cost in testing” and “more aware of environmental impact”.

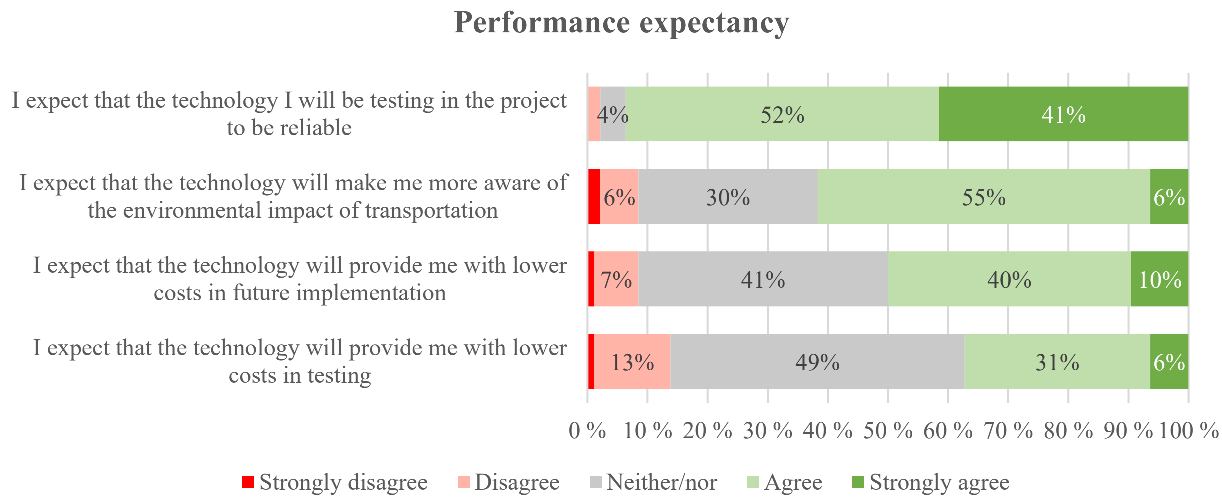

Figure 38 Results - Performance expectancy - Road pricing.

The survey asked participants about various questions on technical performance of the equipment and technology, shown in figure 39. The state of the technical performance of the system and its associated equipment can impact what behavioral intention the participant develop towards using the system, as proposed by Liu and Ma (2006).

In average, around half of participants didn’t know how often or if the equipment was having technical difficulties. However, many participants who were aware responded often never or almost never. This might indicate that many of the participants wasn’t paying full attention to the equipment, as most of the time driving goes to watching the road. There was only 20% who didn’t know if there was startup problem, which happens before the driving starts. This also means a higher share of the participants experienced more problems on startup. SRC revealed that all the variables moderately and strongly correlated with each other, suggesting that many of the participants responded similarly on all variables. The results of both GeoSUM and GeoFlow suggests that the weak point of the technical performance might be the startup processes and the bluetooth connection between the dongle and the car system.

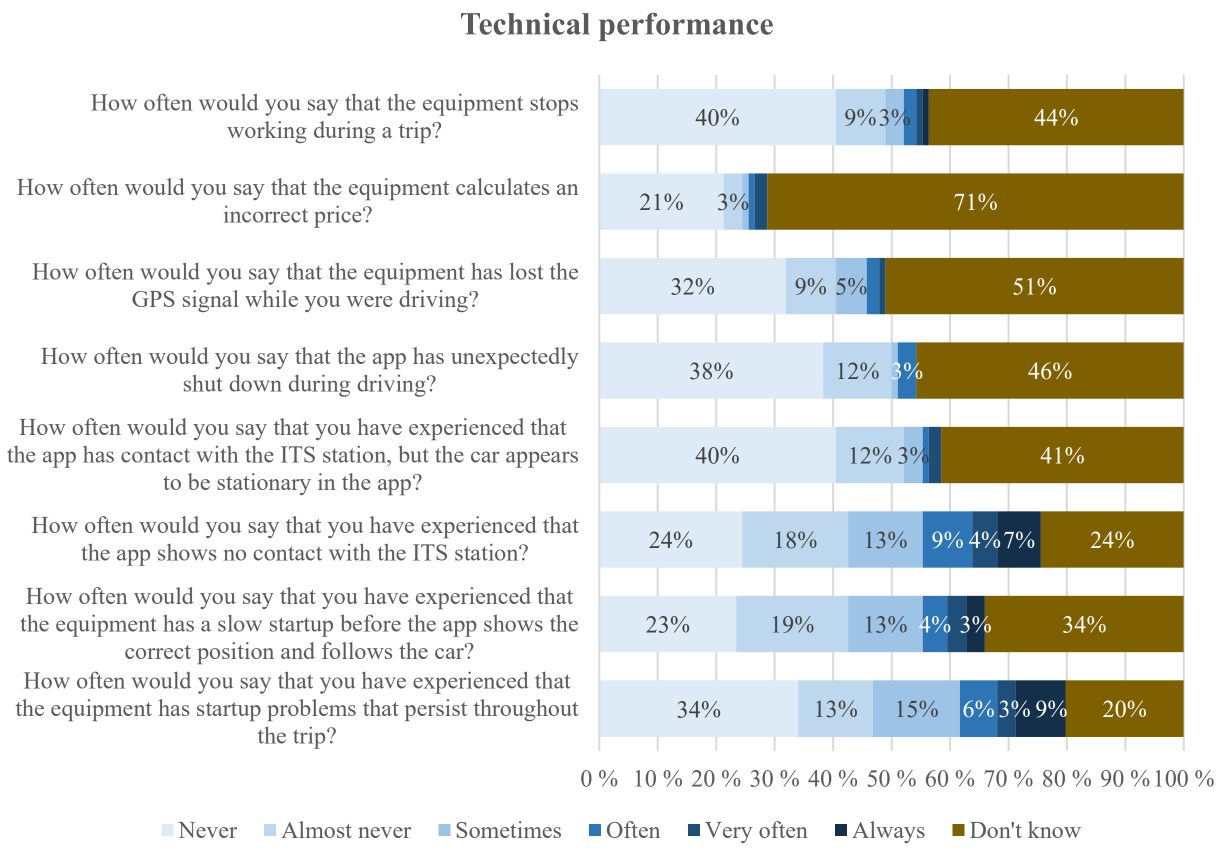

Figure 39 Results - Technical performance.

The participants' experience with various performance aspects of the road pricing system was evaluated using the variables represented in figure 40. In terms of the impact of the technology and the road pricing scheme, it was found that 34% of the participants felt more aware of their driving habits, while 40% did not experience a significant increase in their level of awareness. Notably, despite a considerable proportion of participants not achieving monetary savings (as discussed section of correlation results for price value variables), a majority of participants (69%) still perceived the road pricing system as fairer, to some extent or to a large extent, compared to the existing scheme. Furthermore, most participants believed that the tax system itself would be fairer if all drivers were equipped with the road pricing system in their vehicles.

Additionally, the majority of participants exhibited a positive attitude towards the technology, viewing it as a means to enhance traffic management in cities if universally implemented. This positive attitude was reflected in their perception of the technology's potential benefits and its contribution to improving overall traffic conditions.

The correlation analysis revealed that the majority of variables exhibited moderate, strong, and very strong correlations with each other, indicating interrelationships among participants' experiences and perceptions of the performance of the road pricing system. The variables related to fairness demonstrated particularly strong or very strong correlations with each other, which enhances the reliability of this measure. Additionally, the variables assessing the extent of "user-friendliness compared to the existing system" and "improvement of traffic management" exhibited moderate to strong correlations with the fairness variables.

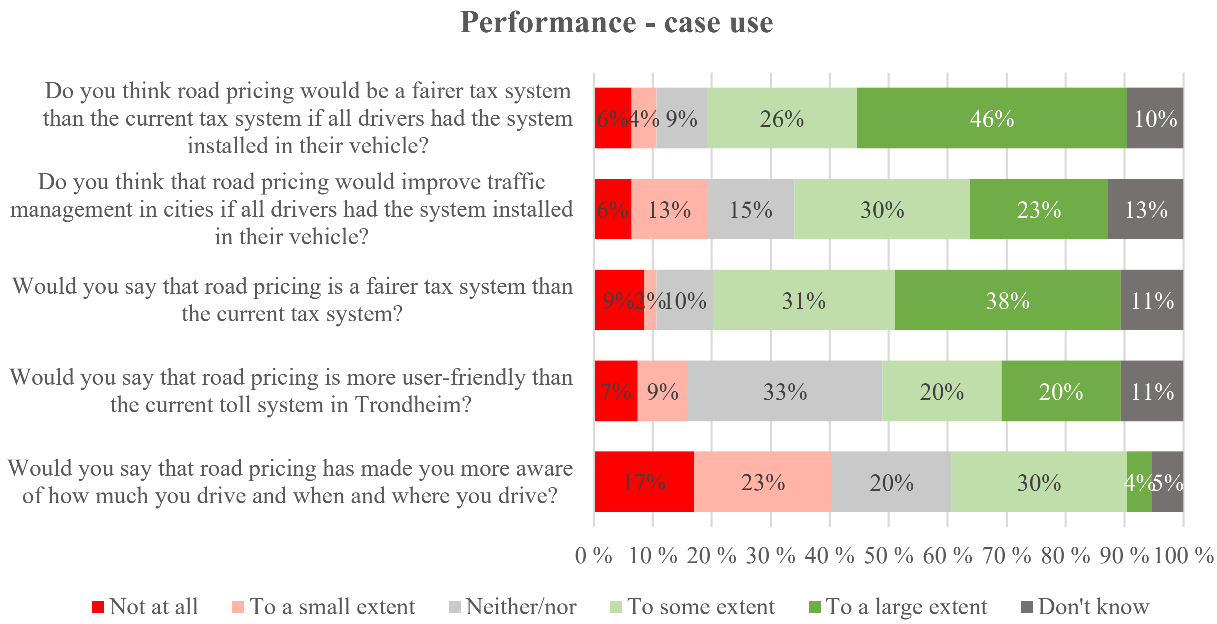

Figure 40 Results - Performance of road pricing.

These findings provide valuable insights into participants' performance expectancy, experience with technical performance and road pricing performance (such as improved fairness, traffic management improvement, more user-friendly). The expectancy of the participants was influenced by that they weren't sure what to expect of lower costs, hence the number of neutral responses on these variables were high.

Despite some participants not realizing significant cost savings (as shown within the "price value" results, in Figure 41), the majority still recognized the system's fairness and its potential to improve traffic management. These results highlight the importance of considering various factors beyond monetary savings when evaluating the success and acceptance of a road pricing system. However, the consequence of high fairness and user-friendliness is not fully understood through these results, as it is not telling completely how individuals relate to this.

Price value

As highlighted in section 2.3.3, the acceptance rate among users tends to increase when a technology or innovation offers greater price value. This analytical view can be applied when looking at the price value of a new taxing system, such as the ways it can decrease costs.

Responses shown in figure 41, tells that the most participants slightly agreed before the pilot, that the technology would decrease driving costs. However, after completing the pilot project, the majority responded that road pricing didn't help them save any money at all (32%) or to a little extent (16%). Clustering the answers by car type (hybrid/gasoline/zero-emission vehicles) didn't show any clear difference in responses, which means it doesn't depend on car type.

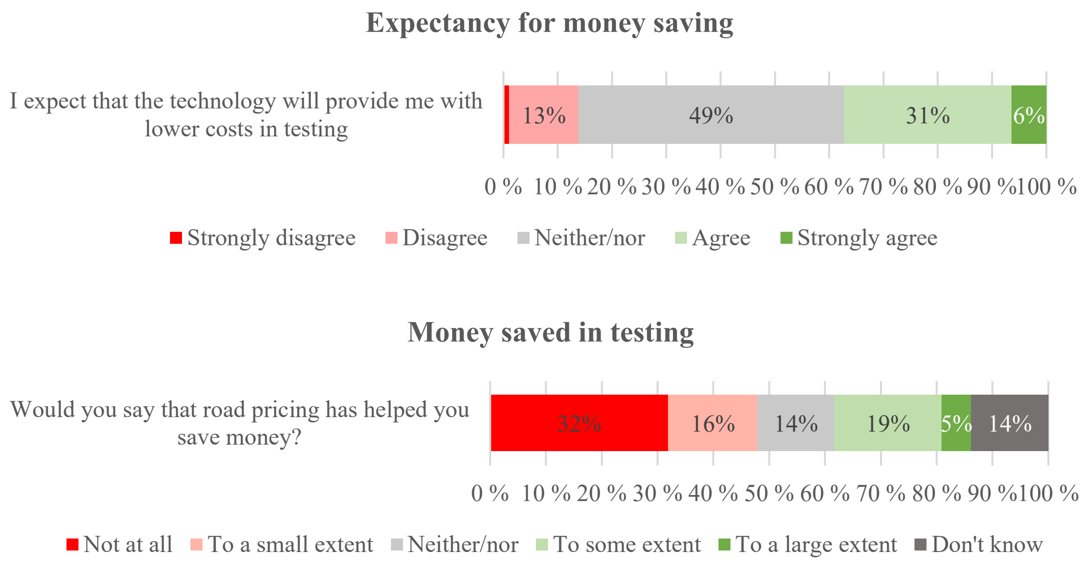

Figure 41 Results - Price value - money saving.

Despite the high belief of fairness of the system, expressed in the results of performance, the specific road pricing taxes that were introduced in the pilot project was considered as unfair by most of the participants. Regarding the charge of 3 kr. per kilometer outside rush hours, 48% disagree and 18% agree, while for the charge of 4 kr. per kilometer during rush hour, 35% disagree and 23% agree on. Notably, these two charges exhibited a strong positive correlation with each other ($r = .693$, $p < .001$).

However, in regard to the varying prices in respect to traffic load, the participants held a different perspective. A considerable portion (80%) agreed or strongly agreed to that it should vary depending on the fluctuation of traffic load. This variable also correlates with both the former mentioned variables (shown in figure 42), $r = .580$ and $r = .376$, and suggest a strong association between the different perspective of perceived fair prices.

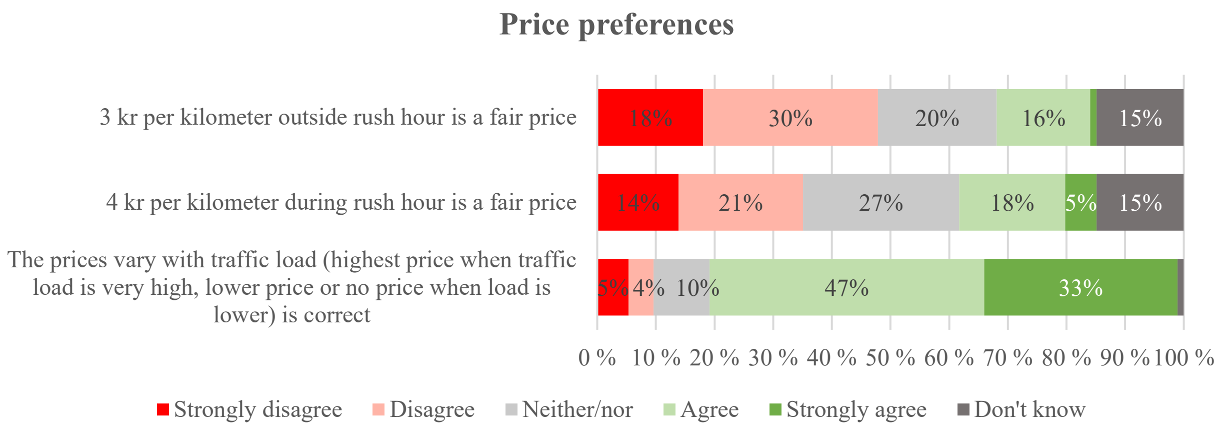

Figure 42 Results - Price preferences.

As there was mostly a high share of agreement to the pricing scheme varying with traffic load, most (52%) participants also found that the rush-hour pricing was fairer in the pilot than in the current toll system. Also, 46% and 27% responded likely and very likely that paying for distance driven in the test was fairer than paying at toll booths like today. All the questions asking whether the road pricing scheme was fair, and if it was fairer than the current toll system, had mostly strong or very strong positive correlating responses.

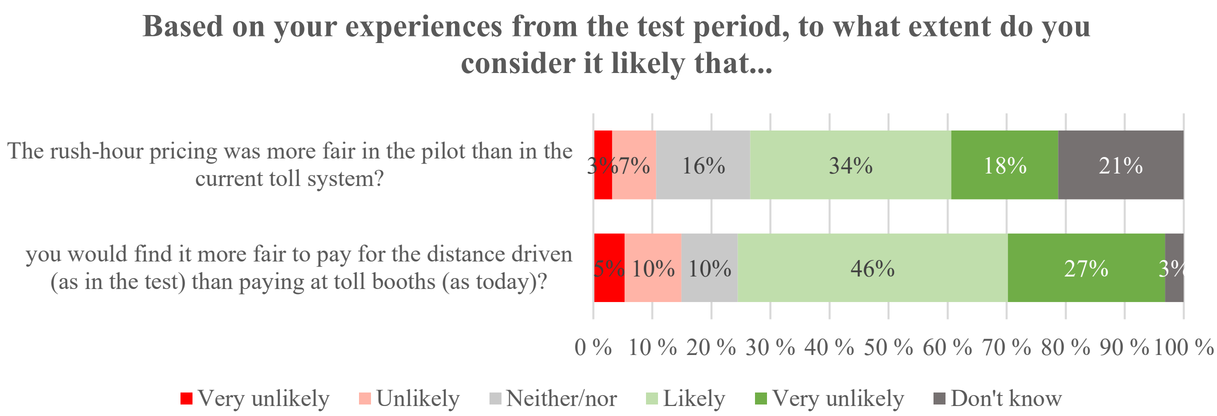

Figure 43 Results - price value – Fairness.

In the post-pilot survey, it was expressed by majority of participants, a significant interest in utilizing payment systems for various additional services, shown in figure 44. These were: paying for services such as emergency information (e.g., tunnel fires, traffic accidents), parking fees, and real-time updates on traffic congestion and roadworks. These additional elements would seem to provide new arguments for individuals to adopt the technology and incorporate it into their daily routines. By offering a diverse range of functionalities, the technology becomes more appealing and relevant to users' needs, ultimately increasing its attractiveness and potential for widespread user acceptance and adoption. These variables correlated moderately and strongly with each other.

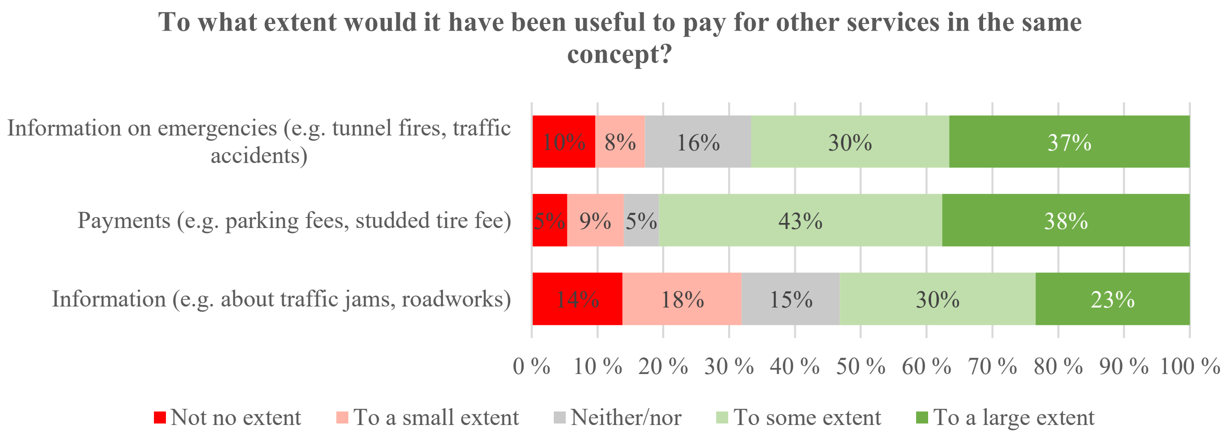

Figure 44 Results - Price value - Pay for other services.

Among these results, the most notable potential barrier to the acceptance of the new pricing system is the perceived lack of savings. Participants initially had the expectation that the new road pricing system would decrease driving costs. However, after completing the pilot project, the majority responded that road pricing didn't help them save money or only to a little extent. Also, the prices of 3 and 4 kr. are perceived as too high for many participants, suggesting a need to address the pricing levels for a potential future large-scale adoption.

On the other hand, the overall favorable responses regarding the fairness of the new system can potentially function as a facilitator of the user acceptance, depending on how much weight this assigns to the individuals' intention to use. Moreover, their favorable responses to the geofencing enabled system's ability to incorporate the fluctuating traffic congestion can influence this positively. Lastly, the high willingness to pay for additional information using this concept is another facilitator, indicating a general intention to use such a system.

In summary, while the perceived lack of savings and concerns about pricing levels pose potential barriers, the positive responses regarding fairness, the system's adaptability to traffic congestion, and the willingness to pay for additional services indicate potential facilitators for user acceptance and adoption of the new pricing system.

Behavioral intention

The measured variables assessing the participants' behavioral intention in GeoFlow reveal a diverse range of responses, as shown in figure 45. There was roughly a third responding either positively, neutral, or negative to all three variables, which shows a great difference between the participants overall assessment of distance-based road pricing in the GeoFlow pilot. The responses for variables "most drivers would change their driving habits" and "you would change driving behavior" correlates strongly with each other (r = .673, p < .001). This suggests that the participants believe others would have the same perception as them.

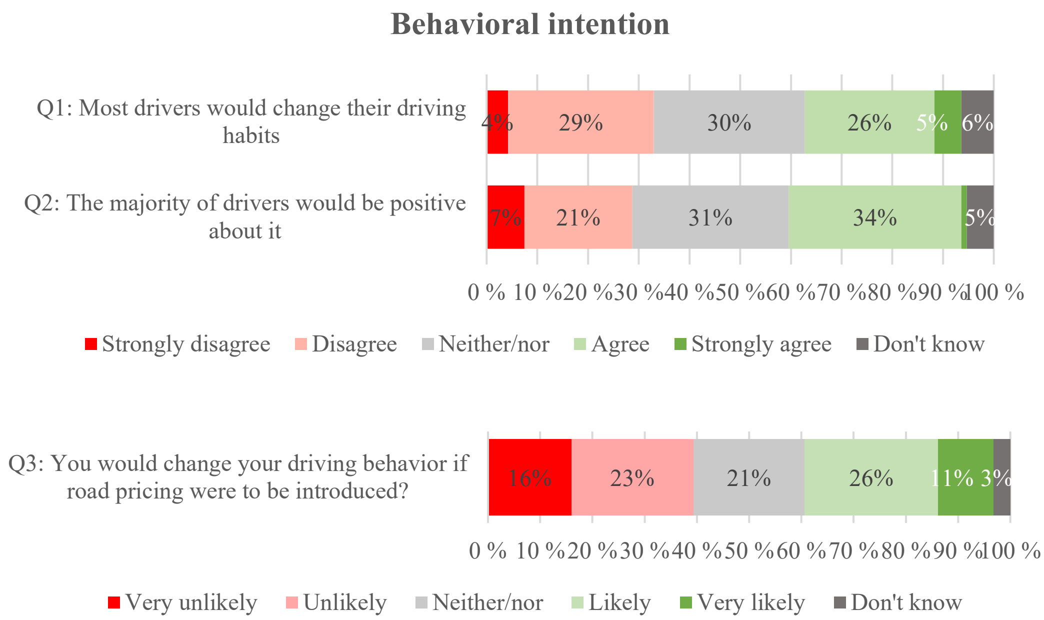

Figure 45 Results - Behavioral intention of GeoFlow participants.

There showed no significant difference between various ages and genders, however, the different car type drivers showed significantly different answers the "you would change driving behavior", shown in figure 46. The hybrid vehicle drivers responded that they more likely would change their driving behavior, while fossil-fuel drivers were least likely.

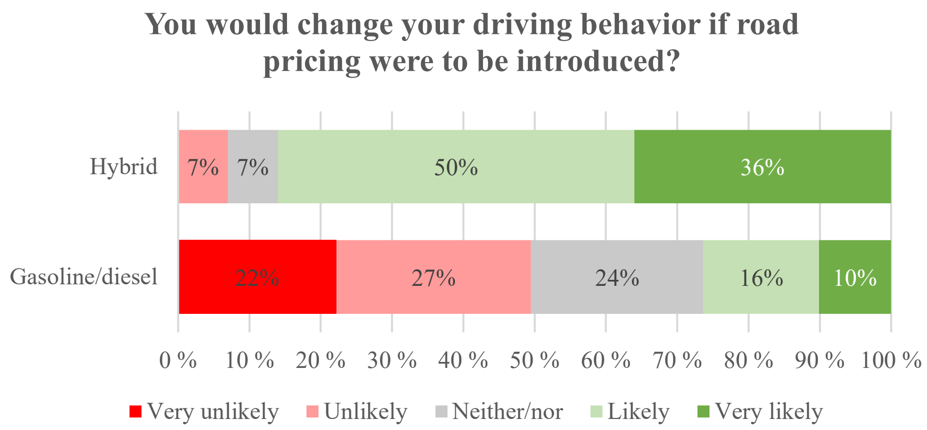

Figure 46 Driving behavior clustered by car type.

A speculation for this reason might be that hybrid vehicles would only have to switch their fuel type when they enter a low-emission zone to save money, while fully fossil-fuel driven cars would have to do comprehensive changes like changing the driving route, take shorter routes or other similar measures. However, this cannot be confirmed from this analysis alone.

Correlations with behavioral intention

Table 13 illustrates the correlations between variables and behavioral intention, with varying degrees of strength. The green fields represent the correlation coefficient between the variables and the behavioral intention. The intervals of weak, moderate, strong and very strong degrees of correlation are adapted from Dancey and Reidy (2020), as discussed in section 3.1.2. Like the results obtained with GeoSUM variables, the variables that exhibit the highest correlations are identified based on their consistent correlation patterns across multiple of the variables measuring behavioral intention.

Factor	Variables	Behavioral intention		
		Q 1	Q 2	Q 3
Attitude	I think it's important to drive a car with the latest technology	0,201		0,380
Performance	Do you think that road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?	0,570	0,345	0,460
	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?	0,339	0,400	0,208
Price value	Would you say that road pricing has helped you save money?	0,233	0,330	0,297
	The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	0,453	0,285	0,346
	4 kr per kilometer during rush hour is a fair price	0,509		0,270
	3 kr per kilometer outside rush hour is a fair price	0,326	0,297	
	you would find it more fair to pay for the distance driven (as in the test) than paying at toll booths (as today)?	0,414	0,351	0,226
	The rush-hour pricing was more fair in the pilot than in the current toll system?	0,441	0,371	

Degree of correlation				
	Weak	Moderate	Strong	Very strong
Positive	+	+	+	+
Negative	-	-	-	-

Table 13 Results - correlation matrix for behavioral intention and other variables

Within the factor of attitude, the only variable that exhibited correlation with the variables measuring behavioral intention was "I think it's important to drive a car with the latest technology," with a positive correlation with Q1 and Q2. This suggests, similarly to the results of correlations in GeoSUM, that individuals who value having the latest technology in their cars are more likely to have a positive behavioral intention.

Within the factor of performance, two variables consistently displayed correlation with all the variables measuring behavioral intention. The first variable is "Do you think that road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?" (positively correlating), and the second one is "Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?" (positively correlating). Both the variables were measured by the extent of agreement from the participants. Based on these results, participants who view road pricing as advantageous for traffic management and as a more equitable substitute for the current tax system are inclined to have a favorable behavioral intention.

In the factor of price value, several variables demonstrated significant correlations with behavioral intention. These variables demonstrated different aspects related to road pricing and its impact on individuals' financial considerations. The variables and the associated direction of correlation is as follows: "Would you say that road pricing has helped you save money?" (positively correlating with all variables), "The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct" (positively correlating with all variables), "4 kr per kilometer during rush hour is a fair price" (positively correlating), "4 kr per kilometer during rush hour is a fair price" (positively correlating with Q1 and Q3), "3 kr per kilometer outside rush hour is a fair price" (positively correlating with Q1 and Q2), "you would find it more fair to pay for the distance driven (as in the test) than paying at toll booths (as today)?" (positively correlating with all variables), and "The rush-hour pricing was more fair in the pilot than in the current toll system?" (positively correlating with Q1 and Q2). The outlook of these results indicates a strong probability that the individuals who perceived road pricing as a cost-saving measure and view the pricing structure as fair are more likely to exhibit a positive behavioral intention.

4.3 Limitations and future work

> “Study limitations represent weaknesses within a research design that may influence outcomes and conclusions of the research. Researchers have an obligation to the academic community to present complete and honest limitations of a presented study” - (Ross and Bibler Zaidi 2019)

This section will sum up the limitations of this study, which includes the aspects from the pilot experiments, characteristics of the obtained data, and the data analysis methods utilized.

First off, the projects were conducted in Oslo and Trondheim (GeoFlow only in Trondheim) and consists most likely of Norwegians (although this isn’t backed up by evidence), which affects the results and conclusion with cultural variables. Each project is also using a different set of equipment when conducting the pilot, making it difficult to compare the results. Furthermore, there is a period of time between measurements of the pre-pilot surveys and post-pilot survey, which is a aspect that inherently might influence the data sample (Gogtay and Thatte 2017).

The descriptive statistics revealed key attributes of the data that can potentially impact the generalizability of the findings. Firstly, the data primarily consisted of a high percentage of middle-aged men, with a limited representation of retired individuals and students. Additionally, there was a low prevalence of women across all age groups in both surveys, as well as a limited variety of daily occupations, with a notable skewness in the distribution of car types in the GeoFlow pilot projects (GeoSUM only had hybrid vehicles). Future research would need to address these discrepancies in a future study.

The surveys' (GeoSUM and GeoFlow) measurements were assessed for validity and reliability using the KMO (Kaiser-Meyer-Olkin) and BTS (Bartlett's test of sphericity) tests. These tests revealed significant correlations ($p < .001$) in each factor, indicating a high level of reliability and validity based on statistical probability. However, in order to accurately conduct factor analysis and compare psychological constructs, it is crucial to design surveys that precisely measure these factors using appropriate variables and a comprehensive set of variables, measuring the same psychological construct.

The main objective of factor analysis (FA) is to reduce a set of variables and identify underlying constructs (Tavakol and Wetzel 2020). In this context, the surveys employed may not have accurately measured the same variables using a comprehensive set of variables, which limits the robustness of the data analysis. It is possible that the KMO and BTS result values were influenced by random correlations between themselves, as they are related to each other to some extent. This could explain why certain factors, such as attitude, performance expectancy, and effort expectancy in GeoSUM, as well as behavioral intention and certain aspects of performance in GeoFlow, received relatively low (but acceptable) KMO values. Considering this, similar future work should include conducting a survey specifically designed for measurements of the psychological constructs.

An additional limitation in the data analysis concerns the use of correlation analysis. As discussed in section 3.1.2, it is important to note that correlation analysis does not establish causality between variables, it rather examines the degree of association between them. This difference has implications for the analysis conducted in this thesis, especially regarding the interpretation of behavioral intention and its relationship with the other factors and variables. In other words, while the factors examined in this study may show a statistically significant correlation with behavioral intention, it does not necessarily mean that they are the sole determinants or causative factors influencing behavioral intention. Therefore, when interpreting the findings of this analysis, it is important to recognize that the factors considered can only be seen as associated with behavioral intention rather than directly causing it. This limitation highlights the need for further research and a more comprehensive understanding of the underlying mechanisms and causal relationships that contribute to behavioral intention in the context of this study.

To overcome this limitation, future research could explore additional methodologies, such as experimental designs or longitudinal studies, to investigate causality and gain a deeper understanding of the factors that influence behavioral intention. By employing a more comprehensive approach, researchers can uncover the subtle relationships and contributing factors that go beyond simple associations, which ultimately enhances our understanding of factors impacting behavioral intention and thereunder user acceptance/behavior.

Lastly, before conclusion: The difficulties of using the available variables in the surveys for the data analysis, proved it difficult to conclude it properly and soundly in terms of psychological constructs. The data set utilized in this thesis fits well for a more comprehensive use of descriptive statistics as a data analysis tool (with variables age, gender, car ownership, typical driving distance, car brand, years of driver license, etc.), to research external factors to user acceptance. In hindsight, more time should have gone to looking at this type of data analysis, seeing as the variables in the survey have varying quality at measuring psychological features of the participants. This is a possible future work and research opportunity using the same data sample.

5 Conclusions

The overall outlook of the results indicates a moderate to user acceptance based on mixed and positive behavioral intentions towards the system. Variations in responses were observed between participants in the GeoSUM and GeoFlow projects. GeoSUM participants showed higher levels of behavioral intention compared to GeoFlow participants, with hybrid drivers displaying a greater likelihood of behavioral change compared to fossil-fuel drivers. One plausible reason for the difference is that car type heavily influenced results of GeoFlow, where hybrid drivers showed more likeliness for behavioral change with the technology compared to fossil-fuel drivers.

Several variables within each factor were found to correlate in different degrees with individuals' behavioral intention to change behavior, adopt and utilize the system. However, the effort expectancy factor didn't show any correlation with behavioral intention among the GeoSUM variables. This suggest that it wasn't directly associated in terms of the statistical analysis conducted in this thesis, but this doesn't mean it should be completely discarded as a potential factor, as the GeoSUM survey responses to the variables within the effort expectancy factor were significantly positive. Forward, the specific findings and its implications will be discussed simultaneously. The analysis of users' attitudes, effort expectancy, performance perceptions, privacy concerns, and price evaluation revealed important factors influencing the successful implementation of geofencing and ITS technology.

The conclusions drawn from the **GeoSUM** study indicate several important findings. Firstly, participants expressed a preference for fully electric cars if they meet their criteria in terms of selection, range, and price. This suggests that there is a positive attitude towards driving on 100% electricity among hybrid car users, given the right conditions. However, the specific criteria and magnitude of these conditions remain unclear and require further investigation.

The study observed significant variations in participants' attitudes towards speed limits. These attitudes were strongly associated with perceptions of irresponsibility and traffic safety. Such pre-existing attitudes may act as barriers to the acceptance and adoption of automation technologies, particularly speed control zones in geofenced areas. Addressing these attitudes and concerns will be crucial in successfully implementing such technologies. Participants' attitudes favoring speed had a strong negative correlation with positiveness to the technology.

Regarding privacy concerns, most participants exhibited a favorable attitude towards sharing their personal travel data. However, a significant majority expressed a stronger preference for authorities to safeguard their data compared to private companies. Additionally, participants showed a stronger preference for local data processing within the car, suggesting that incorporating local data processing capabilities into the Intelligent Transportation System (ITS) architecture can alleviate privacy concerns and enhance user acceptance.

In regard to performance perceptions, participants expressed positive expectations regarding the benefits and advantages of the geofencing and ITS. This factor was also containing the most variables that correlated positively to behavioral intention to use system. This outlook is likely to have a favorable impact on the adoption of the technology, as users anticipate improved performance and outcomes, particularly in terms of increased awareness on emissions and the reliability of the technology. However, it was indicated by variables concerning the technical performance, that the equipment used in the study was not fully functional at start-up. This emphasizes the need for further improvements and refinements of the equipment's start-up processes and technology design before considering larger-scale adoption. Ensuring properly designed and functional systems is essential to maintain user acceptance.

Lastly, the study revealed negative responses from participants regarding paying for additional information and interface. Making these elements mandatory would have a harmful effect on the adoption of the system. Providing users with flexibility in choosing whether to utilize these additional features can enhance user acceptance and adoption of the system. However, the study did not provide explicit information about the specific prices associated with these additional elements, creating interpretation and uncertainty regarding their potential impact on user behavior. Further research or clarification is needed to address this aspect and provide more concrete insights into the pricing dynamics and their influence on user behavior.

The findings from the **GeoFlow** study offer valuable insights into participants' attitudes and perceptions. Firstly, there is a divergence in beliefs between fossil-fuel/hybrid drivers and zero-emission car drivers regarding whether zero-emission vehicles should be subject to the same pricing in the low-emission zones. This divergence poses a potential barrier to the successful implementation of road pricing. However, if different fuel types were to be charged equally, it would impair the purpose of road pricing in promoting behavior changes and encouraging individuals to choose zero-emission vehicles.

On a positive note, participants exhibited in advance a favorable attitude towards the road pricing system compared to the existing road toll system. This positive perception of the new system is considered crucial, as it serves as a key dimension in understanding participants' attitudes towards the geofencing-enabled road pricing system. This positive attitude can act as a facilitator for the transition towards sustainable urban mobility.

Regarding privacy concerns, participants generally showed positive responses towards sharing their personal data and demonstrated a high level of trust in both authorities and third parties. However, concerns about the potential misuse of personal data in the future stood out as the variable with the highest number of negative responses. This highlights the continued importance of addressing these concerns and implementing robust safeguards to protect personal data. Ensuring user acceptance and trust in the Intelligent Transportation System (ITS) architecture relies on addressing privacy concerns effectively.

Participants' performance expectancy was influenced by their uncertainty about the expected lower costs associated with the road pricing system. This resulted in a significant number of neutral responses regarding variables related to cost savings. While some participants did not experience significant cost savings, the majority still recognized the system's fairness and its potential to improve traffic management. The fairness of the distance-based was found to correlate strongly the behavioral intention. These findings emphasize the need to consider factors beyond monetary savings when evaluating the success and acceptance of a road pricing system. Non-monetary aspects such as fairness and traffic management improvement play a crucial role in shaping participants' attitudes and acceptance of the technology. However, it is important to note that the study did not fully explore the specific details of how individuals relate to these aspects, warranting further investigation.

One notable potential barrier to the acceptance of the new pricing system is the perceived lack of savings. Participants initially had neutral or positive expectations that the system would decrease driving costs. However, after completing the pilot project, the majority responded that the road pricing system didn't help them save money or only resulted in minimal savings. This indicates the need to address the pricing levels to ensure that participants perceive tangible cost benefits for a potential future large-scale adoption.

Despite the perceived lack of savings and concerns about pricing levels, the overall favorable responses regarding fairness, adaptability to traffic congestion, and willingness to pay for additional services indicate potential facilitators for user acceptance and adoption of the new pricing system. Addressing pricing concerns and ensuring clear cost benefits for users will be crucial in improving acceptance and increasing the likelihood of successful implementation.

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Appendix

A Original pilot project surveys

A1 GeoFlow survey before pilot

A_0: What is the registration number of the vehicle you are using in the pilot?

A: What is your gender?

B: What is your age?

C: What is your highest completed education?

D: What is your main daily occupation?

E: How many years have you had a driver's license for a car?

F: Approximately how many kilometers do you drive in a year? (Tip: Think about the annual mileage you have stated on your car insurance.)

H: If you have work or school/studies, how would you describe your work hours/attendance time?

I: Has the COVID-19 pandemic caused you to use the car more or less than before the pandemic? (due to working from home, reduced use of public transportation)

I_1: What type of car are you using in the pilot?

I_2: Is the car being used for business purposes in the pilot? (Taxi, driving school, work vehicle, etc.)

I_3: You indicated in the previous question that you used the car for business purposes. Can you indicate what type of business?

J: Indicate how much you agree or disagree with the following statements:

I am interested in testing new technology

I think it's important to drive a car with the latest technology

L_0: What is your attitude toward the toll ring in Trondheim?

L_1: You have indicated that you are negative about the toll ring in Trondheim. What do you think are the negative aspects of the toll ring? You can check several options.

Expensive/costs me too much

Motorists pay enough taxes and fees

Unfair system
Expensive toll collection system □
Harmful to downtown Trondheim
Finances other measures than road construction □
Surveillance problem □
Other reasons: Open

L_2: You have indicated that you are positive about the toll ring in Trondheim. What do you think are the positive aspects of the toll ring? You can check several options.

Extra fees for using a car in downtown areas
Fewer cars in downtown areas
Encourages more use of public transport
Practical toll collection system
Finances road construction
Finances public transport, safety, and environmental measures
Other reasons: Open

M: In your opinion, how fair is the toll system in Trondheim, as it operates today (with regard to price, location, and number of collection stations)?

N: What is your immediate attitude towards road pricing as a traffic regulation tool as described here?

P: Indicate how much you agree or disagree with the following statements:

I am well aware of the content of Norway's privacy legislation (including GDPR, General Data Protection Regulation).
I am concerned that personal data may be compromised and could be misused in the future.
I trust that the authorities protect my privacy.
I trust that a trusted third party protects my privacy.
I am positive about the registration of personal travel data if it helps me to receive better services.
I am positive about the registration of personal travel data if it contributes to a fairer toll system.

Q: What is your position on GPS location information being processed only locally in the car? This means that calculations based on GPS position (such as distance driven in zones) are carried out in the car, and only a summary of the trip is sent for billing.

R: What is your position on GPS location information being processed only by a third party? This means that the GPS positions recorded in the car are sent from the car to a neutral third party for processing and billing.

S: Indicate how much you agree or disagree with the following statements regarding road pricing technology:

I expect the technology to give me lower costs (toll fees) in the test.
I expect the technology to give me lower costs in future implementation.
I expect the technology to make me more aware of the environmental impact of transportation.
I expect the technology I will test in the project to be reliable.

I believe that drivers of zero-emission vehicles should pay on an equal footing with other drivers to use the road.

A2 GeoFlow survey post-pilot

Label2: In this section, you will get some technical questions.

To what extent have you actively used the information in the app?

Did you use the information more actively at the beginning of the period?

Label3: How often would you say that you have experienced the following equipment issues during a trip? (e.g. the app on the phone not starting, no contact with the ITS station - i.e., red dot on the app - and similar).

Have you experienced that the equipment had start-up problems that persisted throughout the trip?

Have you experienced that the equipment has slow start-up before the app shows the correct position and follows the car?

Have you experienced that the app shows no contact with the ITS station (red dot on the app)?

Have you experienced that the app has contact with the ITS station (green dot on the app), but the car is stationary in the app?

Has the app unexpectedly shut down during a trip?

Has the equipment lost GPS signal while you were driving?

Has the equipment calculated an incorrect price?

Has the equipment stopped working during a trip (i.e., the equipment worked at startup)?

Label4: Do you have any other comments on the technical equipment?

Label5: As part of the pilot project, we are investigating people's attitudes to different methods of handling personal data. This will typically be location data (GPS traces). There are two main alternatives for the treatment of personal data for road pricing. In one alternative, all personal data in the car is processed. In the other alternative, personal data is sent to a trusted third party for processing.

How would you feel about:

The information related to GPS position being processed locally only in the car? I.e., calculations based on GPS position (such as distance traveled in zones) are carried out in the car, and only a summary of the trip is sent on to a neutral third party.

Information related to GPS position being processed by a third party? I.e., the GPS positions recorded in the car are sent from the car to a neutral third party for processing.

Personal travel data being recorded if it contributes to me being offered better services.

Personal travel data being recorded if it contributes to a fairer road pricing system.

Label6: In this section, you will get some questions about the benefits of road pricing.

To what extent...

Would you say that road pricing has helped you save money?

Would you say that road pricing has given you greater awareness of how much you drive and when and where you drive?
Would you say that road pricing is more user-friendly than the current toll system in Trondheim?
Would you say that road pricing is a fairer tax system than the current tax system?
Do you think road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?
Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?

Label7: In this section, you will get some questions about your attitude to price if road pricing were to be permanently introduced. Indicate how much you agree or disagree with the following statements.
If road pricing were to be introduced permanently, and with a pricing system like we have in GeoFlow, do you think...

It is appropriate for prices to vary with traffic volume (highest price when traffic volume is very high, lower price or no price when volume is lower)
4 NOK per kilometer during rush hour is a fair price.
3 NOK per kilometer outside rush hour is a fair price.

Label8 If road pricing were to turn out to be more expensive for you than the current solution, to what extent are the following factors important for you to continue using your private car?

Lack of environmentally friendly transportation options
Flexibility and availability
Personal economy
Travel time
Experience of safety
Experience of comfort

Label9 With the experience gained during the test period, to what extent do you consider it likely that...

You would find it fairer to pay for the distance driven (as in the test) than to pay at toll booths (as today)?
Rush hour pricing was fairer in the pilot than in today's toll system?
You would change your driving pattern if road pricing were to be implemented?

Label10 In this section, you will be asked some questions about your opinion if all car drivers were to use road pricing. Please indicate whether you agree or disagree with the following statements.
If there were a requirement for all car drivers to use road pricing, I believe that...

Most drivers would be positive about it.
Most drivers would change their driving pattern.

Label11 In this section, you will be asked some questions about your travel habits.

Have you changed anything about your travel habits as a result of participating in GeoFlow?

Label12 If you answered yes, what change has been most common?

Driving earlier than before
Driving later than before
Changing the driving route
Driving less than before
Don't know
Other: [Open]

Label13 In this section, you will be asked some questions about other uses of road pricing. To support sustainability, to what extent do you believe the following conditions will be more affected by using a road pricing system?

Awareness of travel habits (less driving to limit costs and/or emissions)
Increased use of more sustainable modes of transportation (e.g., public transportation, cycling, etc.)

Label14 To what extent would it be useful to pay for other services in the same concept?

Information (e.g., about traffic congestion, roadwork)
Payment (e.g., parking, studded tire fee)
Information about emergency situations (e.g., tunnel fire, traffic accidents)

Label16 How would you rate the different technical solutions for a permanent solution in your car if road pricing were to be introduced?

A system with a voluntary user interface in the car (as in the test)
A system without the possibility of a user interface in the car (such as in the test but without the possibility of connection with a phone), but where one could go to an app or website afterwards to see...
A system with an integrated user interface in the car (such as in the test with an included fixed screen connected to the equipment).
A system integrated in the car (for example, through an app on the center console).

Label15: Do you have any other comments about the concept you have tested in the project?

A3 GeoSUM survey before pilot

Gender:

Male
Female

Age:

Please enter your age here:

What is your highest level of education?

Primary school
High school
College/university, 3 years or less
College/university, 4 years or more
Doctorate

What is your occupation?

Manager
Academic profession (profession that normally requires education from university or college, minimum 4 years completed)
College profession (profession that requires 1-3 years of education after high school)
Office job
Sales and service profession
Primary industry
Craftsman
Process and machine operator, transporter
Cleaner, assistant worker
Not employed
If none of the categories apply, please specify your occupation here: Open

How many years have you had a driver's license for a car?
Number of years:

What brand of car are you participating in this project with?
Volvo
Mitsubishi
Volkswagen
BMW
Audi
Mercedes

Approximately how many kilometers does your/their hybrid car drive in one year? Tip: Think about what you/they have stated as the annual mileage on the car insurance.
Less than 5000 km
Between 5000 and 8000 km
Between 8000 km and 12,000 km
Between 12,000 and 20,000 km
Over 20,000 km
Don't know

Ownership What type of ownership do you/they have on the hybrid car?
Privately owned car
Private leasing
Company car
Other type of ownership

How important were these factors when you/they chose this particular car? Rank them using the scale.
Price of the car at purchase
Operating costs of the car
That the car is environmentally friendly
High engine performance
High safety
Size of the car
Many available driver support systems
Car brand

How often do you/they charge the car during an average week?

Less than once a week
About once a week
Several times a week
Daily
Several times a day

How often do you/they fill up gasoline/diesel on average during this time of year (fall)? Think about an average period.

Once a week or more
Every other week
Once a month
Less than once a month

What percentage of the time do you estimate that you drive on electric power during this time of year (fall)?

10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Please indicate in which percentage:

When the car is fully charged, approximately how long trips have you experienced being able to drive without running out of electricity?

Less than 10 km
Between 10 and 20 km
Between 20 and 30 km
Over 30 km
Never or very rarely experienced running out of electricity
Don't know

Attitude - car: How much do you agree or disagree with the following statements related to cars:

The car is just a means of transportation for me.
Driving pleasure is an important part of driving for me.
I would rather have a fully electric car if the selection, range, and price met my requirements better.

Attitude - hybrid: When you are driving fossil fuel with your hybrid car, what is the most important factors for this choice?

The car automatically switches to fossil fuel (without the battery being depleted of electricity).
The car is out of electricity.
I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc.
I choose to save the battery for other parts of the route I'm driving on.

Attitude – tech: How much do you disagree or agree with these statements?

I am interested in testing out new technology.
I think it is important to drive a car with the latest technology.
I believe that technology will be among the most important tools to prevent human-induced climate change.

I believe that technology in the transportation sector will minimize deaths and serious injuries in traffic.

Attitude – low-emission zone: How much do you disagree or agree with the following statements regarding low emission zones?

Human-induced climate change is the most important societal challenge we face.
Local pollution is a major problem in the city I live in.
I am conscious of where and when the car is running on electric power.
I try to use information from the car to drive as much as possible on electricity.

Attitude – speed: How much do you disagree or agree with the following statements regarding speed control zones?

I think breaking the speed limit is a big problem for traffic safety.
I think the speed limits in Norway should be higher than they are today.
I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is.
I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)

Privacy concerns/preferences: How much do you disagree or agree with the following statements regarding privacy?

I am familiar with the content of Norway's personal data privacy legislation (including GDPR, General Data Protection Regulation)
I am concerned that personal data may be compromised and potentially misused in the future.
I trust that the authorities safeguard my privacy.
I trust that private companies safeguard my privacy.
I am positive about the registration of personal travel data if it contributes to me being offered better services.
I am positive about the registration of personal travel data if it contributes to a fairer toll system.

Expectations: How much do you disagree or agree with the following statements regarding the technology of the experiment?

I expect technology to make me more aware of speed limits.
I expect technology to make me more aware of local emissions from the vehicle.
I expect the technology I will be testing in the project to be reliable.

A4 GeoSUM survey post-pilot

1 Please state the user number that you used when operating the Geosum equipment, three digits.
User number:

First, some questions related to how you have experienced the technical equipment (phone + dongle) functioning during the test period.

How often would you say that you have experienced that the equipment has had startup problems? (e.g. phone doesn't start, no contact with dongle)?
How often would you say that you have turned off the equipment or failed to log in at startup?
How often would you say that the equipment has unexpectedly terminated while running?
How often would you say that the equipment has lost GPS signal while you were driving?
How often would you say that you have discovered that you have used the wrong user when driving?
How often would you say that you have experienced that the screen has run out of power?

Do you have any other comments you would like to add related to how the technical equipment has functioned? (not mandatory)
Open

You will now be asked some questions related to the user interface on the screen. Based on when the equipment was functioning. How much do you agree or disagree with the following statements:

The user interface on the screen was intuitive to use.
The user interface on the screen distracted me from driving.
The information from the user interface on the screen was precise enough for me.
The feedback from the user interface on the screen was clear and understandable.
It was easy for me to follow the information communicated to me by the user interface on the screen.

You will now be asked some questions related to the user interface on the screen. Based on when the equipment was functioning. How much do you agree or disagree with the following statements:

My interaction with the user interface on the screen was frustrating.
My interaction with the user interface on the screen was comfortable.
I thought the feedback from the user interface on the screen was encouraging.
It was easy for me to learn how to use the user interface on the screen.
The user interface on the screen provided me with sufficient information to perform what was expected of me.
The user interface on the screen was easy to use in my everyday life.

You will now be presented with some statements related to how useful the geofence school zone is in helping drivers to keep within the speed limit in these particularly vulnerable areas.

To what extent would you say that the system has helped you to keep within the speed limits within the defined school zones?
To what extent do you think it would improve road safety around schools if all drivers had the system installed in their vehicles?

You will now be presented with some statements related to how useful the geofence low emissions zone is in helping drivers to drive environmentally friendly in dedicated areas, such as city centers.

To what extent would you say that the system has helped you to drive more environmentally friendly within the defined low emissions zones?

To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicles?

During testing of the geofence low emissions zones, part of the function was linked to switching from fossil fuel to electricity within the low emissions zones in order not to reduce the prize pool. You will now be asked some questions about how laborious you found this process to be during the test period. If you are not able to influence this choice on your car model (for example by driving more calmly or by choosing the fuel mode), answer "don't know" to all questions.

To what extent did the switch from fossil fuel to electricity require a lot of mental capacity from you (e.g. thinking, remembering, finding the right button)?

To what extent did the switch from fossil fuel to electricity require a lot of physical capacity from you (e.g. stretching, pushing a button)?

To what extent did you feel time pressure when switching from fossil fuel to electricity?

To what extent did you feel that you had to mobilize a lot of energy (both mental and physical) when switching from fossil fuel to electricity?

To what extent were you stressed by the switch from fossil fuel to electricity?

To what extent are you satisfied with how you performed the switch from fossil fuel to electricity during the test period?

If you have any comments on how you experienced the workload, feel free to share them here (not mandatory).

Input: Open

In the test, you have tried retrofitted equipment that only has informative functions. With factory-installed equipment in the car, you can get integrated functions that enable the car either to help the driver keep the speed limit or force the driver to keep the speed limit. To what extent do you agree with the following statements?

I would rather have an integrated function in the car where I receive assistance from the car to adjust the speed (e.g. by the car helping you slow down when you enter a zone to remind you of a speed change), but where you as the driver can still override this by pressing harder on the gas pedal.

I would rather have an integrated function where the car forces the speed down when I enter a zone, without me being able to override the speed set by the car.

You will now be asked some questions related to how you would react if the authorities were to use geofencing as a tool to differentiate charges within low-emission zones for different fuel types. You would then, by documenting that you were driving on electricity, receive lower charges within such zones.

As a hybrid car driver, I would be positive about differentiated charges for different fuel types within geofence zones.

As a hybrid car driver, I would drive more on electricity than I usually do if differentiated charges within geofence zones were implemented.

If there was a requirement for all car drivers (not just hybrid car drivers) to use geofence zones for differentiated charges, I believe that most people would be positive about it.

If there was a requirement for all car drivers to use geofence zones for differentiated charges, I believe that most hybrid car drivers would drive on electricity within low-emission zones.

Based on your experiences from the test period, to what extent do you consider it likely that...

...in your everyday life, you would switch to electricity within low-emission zones if it would make you pay lower charges?

...for geofenced low-emission zones, you would find it more fair to pay for the distance driven (as in the test) than to pay at toll plazas (as is done today)?

If the authorities were to introduce differentiated charges within low-emission zones as a measure to control traffic, we need more knowledge about which solutions users would prefer. How would you evaluate the different solutions for feedback to you as a driver as a permanent solution in your car if differentiated charges in low-emission zones were to be introduced?

A system without a user interface in the car (such as an autoPASS tag), which only reports registered information further.

A system without a user interface in the car (such as an autoPASS tag), but where you could access an app or website afterwards to see what information has been registered and forwarded.

A system without a user interface in the car (such as the autoPASS tag), but where you have the ability to connect your own phone to display in real-time the information that you have seen on the screen in the car during the test.

A system with a user interface (like the screen you have tested in this experiment), where you can see what information has been recorded and sent.

To what extent would you be positive about paying an additional cost for...

...a system with a user interface in the car?

...more detailed information in reports that can be found, for example, via a website that shows your trips and statistics?

The use of geofence technology requires a certain degree of tracking of the vehicle associated with GPS position to determine whether one is inside or outside the zone.

How would you generally feel about information related to the GPS position of your vehicle being used to inform, guide, and manage traffic?

How would you feel about information related to GPS position being processed only locally in the car? Meaning that calculations based on GPS position (such as distance driven in zones) are carried out in the car, and only a summary of the trip is sent to a neutral third party.

How would you feel about information related to GPS position being processed by a third party? Meaning that the GPS positions recorded in the car are sent from the car to a neutral third party for processing.

Thank you very much for your participation! Both during the testing period and in the survey. If you have any other feedback besides what has been the focus of the survey, we would love to hear it.

Please enter your feedback here: Open.

B – Reorganized pilot project surveys

B1 - GeoSUM

GeoSUM

Attitude	
Attitude - car	
1-5 Likert scale, Strongly disagree - Strongly agree	The car is just a means of transportation for me
	Driving pleasure is an important part of driving for me
	I would rather have a fully electric car if the selection, range, and price met my requirements better.
Attitude - hybrid	
1-5 Likert scale, No importance - Great importance	The car automatically switches to fossil fuel (without the battery being depleted of electricity).
	The car is out of electricity.
	I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc.
	I choose to save the battery for other parts of the route I'm driving on.
Attitude – tech	
1-5 Likert scale, Strongly disagree - Strongly agree	I am interested in testing out new technology.
	I think it is important to drive a car with the latest technology.
	I believe that technology will be among the most important tools to prevent human-induced climate change.
	I believe that technology in the transportation sector will minimize deaths and serious injuries in traffic.
Attitude – low-emission zone	
1-5 Likert scale, Strongly disagree - Strongly agree	Human-induced climate change is the most important societal challenge we face.
	Local pollution is a major problem in the city I live in.
	I am conscious of where and when the car is running on electric power.
	I try to use information from the car to drive as much as possible on electricity.
Attitude – speed	
1-5 Likert scale, Strongly disagree - Strongly agree	I think breaking the speed limit is a big problem for traffic safety
	I think the speed limits in Norway should be higher than they are today
	I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is
	I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)
Privacy concerns	
Privacy concerns/preferences	
1-5 Likert scale, Strongly disagree - Strongly agree	I am familiar with the content of Norway's personal data privacy legislation (including GDPR, General Data Protection Regulation)
	I am concerned that personal data may be compromised and potentially misused in the future.
	I trust that the authorities safeguard my privacy.
	I trust that private companies safeguard my privacy.
	I am positive about the registration of personal travel data if it contributes to me being offered better services.
	I am positive about the registration of personal travel data if it contributes to a fairer toll system.
GPS Tracking	
1-5 Likert scale, Negative - positive	Extra comment: The use of geofence technology requires a certain degree of tracking of the vehicle associated with GPS position to determine whether one is inside or outside the zone.
	How would you generally feel about information related to the GPS position of your vehicle being used to inform, guide, and manage traffic?
	How would you feel about information related to GPS position being processed only locally in the car? Meaning that calculations based on GPS position (such as distance driven in zones) are carried out in
	How would you feel about information related to GPS position being processed by a third party? Meaning that the GPS positions recorded in the car are sent from the car to a neutral third party for
Performance	
Performance: technical equipment	
1-5 Likert scale, Never - Very often	How often would you say that you have experienced that the equipment has had startup problems? (e.g. phone doesn't start, no contact with dongle)?
	How often would you say that you have turned off the equipment or failed to log in at startup?
	How often would you say that the equipment has unexpectedly terminated while running?
	How often would you say that the equipment has lost GPS signal while you were driving?
	How often would you say that you have discovered that you have used the wrong user when driving?
	How often would you say that you have experienced that the screen has run out of power?
Comment	
	Add comment
Expectations: technology	
1-5 Likert scale, Strongly disagree - Strongly agree	I expect technology to make me more aware of speed limits.
	I expect technology to make me more aware of local emissions from the vehicle.
	I expect the technology I will be testing in the project to be reliable.
Expectance: Speed control zone	
1-5 Likert scale, To no extent - To great extent	To what extent would you say that the system has helped you to keep within the speed limits within the defined school zones?
	To what extent do you think it would improve road safety around schools if all drivers had the system installed in their vehicles?
Expectance: Low emission zone	
1-5 Likert scale, To no extent - To great extent	To what extent would you say that the system has helped you to drive more environmentally friendly within the defined low emissions zones?
	To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicles?

Effort expectancy	
Ease of use 1	
1-5 Likert scale, Strongly disagree - Strongly agree	The user interface on the screen was intuitive to use.
	The user interface on the screen distracted me from driving.
	The information from the user interface on the screen was precise enough for me.
	The feedback from the user interface on the screen was clear and understandable.
	It was easy for me to follow the information communicated to me by the user interface on the screen.
Ease of use 2	
1-5 Likert scale, Strongly disagree - Strongly agree	My interaction with the user interface on the screen was frustrating.
	My interaction with the user interface on the screen was comfortable.
	I thought the feedback from the user interface on the screen was encouraging.
	It was easy for me to learn how to use the user interface on the screen.
	The user interface on the screen provided me with sufficient information to perform what was expected of me.
	The user interface on the screen was easy to use in my everyday life.
Switch to electricity	open for comments
1-10 Likert scale, To very little extent - To very large extent	To what extent did the switch from fossil fuel to electricity require a lot of mental capacity from you (e.g. thinking, remembering, finding the right button)?
	To what extent did the switch from fossil fuel to electricity require a lot of physical capacity from you (e.g. stretching, pushing a button)?
	To what extent did you feel time pressure when switching from fossil fuel to electricity?
	To what extent did you feel that you had to mobilize a lot of energy (both mental and physical) when switching from fossil fuel to electricity?
	To what extent were you stressed by the switch from fossil fuel to electricity?
	To what extent are you satisfied with how you performed the switch from fossil fuel to electricity during the test period?
Price value	
Additional cost: willingness to pay for	
1-5 Likert scale, To no extent - To great extent	...a system with a user interface in the car?
	...more detailed information in reports that can be found, for example, via a website that shows your trips and statistics?
Switch if lower charges	
1-5 Likert scale, Unlikely - Likely	Extra comment: Based on your experiences from the test period, to what extent do you consider it likely that...
	...in your everyday life, you would switch to electricity within low-emission zones if it would make you pay lower charges?
	...for geofenced low-emission zones, you would find it more fair to pay for the distance driven (as in the test) than to pay at toll plazas (as is done today)?
Behavioral intention	
Likeliness to change practice	
1-5 Likert scale, To no extent - To great extent	Extra comment: You will now be asked some questions related to how you would react if the authorities were to use geofencing as a tool to differentiate charges within low-emission zones for different fuel types. You would then, by documenting that you were driving on electricity, receive lower charges within such zones.
	As a hybrid car driver, I would be positive about differentiated charges for different fuel types within geofence zones.
	As a hybrid car driver, I would drive more on electricity than I usually do if differentiated charges within geofence zones were implemented.
	If there was a requirement for all car drivers (not just hybrid car drivers) to use geofence zones for differentiated charges, I believe that most people would be positive about it.
	If there was a requirement for all car drivers to use geofence zones for differentiated charges, I believe that most hybrid car drivers would drive on electricity within low-emission zones.

B2 - GeoFlow

GeoFlow

Attitude

Attitude - tech	
1-5 Likert scale, Strongly disagree - Strongly agree	I am interested in testing new technology
	I think it's important to drive a car with the latest technology
Attiude - toll ring	
1-5 Likert scale, Strongly disagree - Strongly agree	What is your attitude toward the toll ring in Trondheim?
Attitude - toll ring - follow up - negative	
Several alternative	Expensive/costs me too much
	Motorists pay enough taxes and fees
	Unfair system
	Expensive toll collection system
	Harmful to downtown Trondheim
	Finances other measures than road construction
	Surveillance problem
	Other reasons: Open
Attitude - toll ring - follow up - positive	
Several alternative	Extra fees for using a car in downtown areas
	Fewer cars in downtown areas
	Encourages more use of public transport
	Practical toll collection system
	Finances road construction
	Finances public transport, safety, and environmental measures
	Other reasons: Open
Attitude - toll - fair	
1-5 Likert scale, Very unfair - Very fair	In your opinion, how fair is the toll system in Trondheim, as it operates today (with regard to price, location, and number of collection stations)?
Attitude - road pricing	
1-5 Likert scale, Very negative - Very positive	What is your immediate attitude towards road pricing as a traffic regulation tool as described here?

Privacy concerns

Privacy concerns/preference	
1-5 Likert scale, Strongly disagree - Strongly agree	I am well aware of the content of Norway's privacy legislation (including GDPR, General Data Protection Regulation).
	I am concerned that personal data may be compromised and could be misused in the future.
	I trust that the authorities protect my privacy.
	I trust that a trusted third party protects my privacy.
	I am positive about the registration of personal travel data if it helps me to receive better services.
	I am positive about the registration of personal travel data if it contributes to a fairer toll system.
Processing	
1-5 Likert scale, Very negative - Very positive	What is your position on GPS location information being processed only locally in the car? This means that calculations based on GPS position (such as distance driven in zones) are carried out in the car, and only a summary of the trip is sent for billing.
	What is your position on GPS location information being processed only by a third party? This means that the GPS positions recorded in the car are sent from the car to a neutral third party for processing and billing.
Handling of personal data	
1-5 Likert scale, Very negative - Very positive	Extra comment: As part of the pilot project, we are investigating people's attitudes to different methods of handling personal data. This will typically be location data (GPS traces). There are two main alternatives for the treatment of personal data for road pricing. In one alternative, all personal data in the car is processed. In the other alternative, personal data is sent to a trusted third party for processing.
	How would you feel about:
	The information related to GPS position being processed locally only in the car? I.e., calculations based on GPS position (such as distance traveled in zones) are carried out in the car, and only a summary of the trip is sent on to a neutral third party.
	Information related to GPS position being processed by a third party? I.e., the GPS positions recorded in the car are sent from the car to a neutral third party for processing.
	Personal travel data being recorded if it contributes to me being offered better services?
	Personal travel data being recorded if it contributes to a fairer road pricing system?

Performance

Performance expectance road pricing	
1-5 Likert scale, Strongly disagree - Strongly agree	I expect the technology to give me lower costs (toll fees) in the test.
	I expect the technology to give me lower costs in future implementation.
	I expect the technology to make me more aware of the environmental impact of transportation.
	I expect the technology I will test in the project to be reliable.
Performance - technical	
1-5 Likert scale, Never - Always	Have you experienced that the equipment had start-up problems that persisted throughout the trip?
	Have you experienced that the equipment has slow start-up before the app shows the correct position and follows the car?
	Have you experienced that the app shows no contact with the ITS station (red dot on the app)?
	Have you experienced that the app has contact with the ITS station (green dot on the app), but the car is stationary in the app?
	Has the app unexpectedly shut down during a trip?
	Has the equipment lost GPS signal while you were driving?
	Has the equipment calculated an incorrect price?
	Has the equipment stopped working during a trip (i.e., the equipment worked at startup)?
Performance - road pricing	
1-5 Likert scale, To no extent - To great extent	Would you say that road pricing has helped you save money?
	Would you say that road pricing has given you greater awareness of how much you drive and when and where you drive?
	Would you say that road pricing is more user-friendly than the current toll system in Trondheim?
	Would you say that road pricing is a fairer tax system than the current tax system?
	Do you think road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?
	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?

Price value

Road price preference	
1-5 Likert scale, Strongly disagree - Strongly agree	If road pricing were to be introduced permanently, and with a pricing system like we have in GeoFlow, do you think...
	It is appropriate for prices to vary with traffic volume? (highest price when traffic volume is very high, lower price or no price when volume is lower)
	4 NOK per kilometer during rush hour is a fair price?
	3 NOK per kilometer outside rush hour is a fair price?
Habit vs. price value	
1-5 Likert scale, Very unlikely - Very likely	With the experience gained during the test period, to what extent do you consider it likely that...
	You would find it fairer to pay for the distance driven (as in the test) than to pay at toll booths (as today)?
	Rush hour pricing was fairer in the pilot than in today's toll system?
Choice - private car - after cost increase	
1-5 Likert scale, Not important at all - Very important	If road pricing were to turn out to be more expensive for you than the current solution, to what extent are the following factors important for you to continue using your private car?
	Lack of environmentally friendly transportation options
	Flexibility and availability
	Personal economy
	Travel time
	Experience of safety
	Experience of comfort
Extent to pay for other uses	
1-5 Likert scale, To no extent - To great extent	Extra comment: To what extent would it be useful to pay for other services in the same concept?
	Information (e.g., about traffic congestion, roadwork)
	Payment (e.g., parking, studded tire fee)
	Information about emergency situations (e.g., tunnel fire, traffic accidents)

Behavioral intention

Behavioral intention	
1-5 Likert scale, Very unlikely - Very likely	You would change your driving behavior if road pricing were to be introduced?
Behavioral intention 2	
1-5 Likert scale, Very unlikely - Very likely	The majority of drivers would be positive about it
	Most drivers would change their driving habits

C – Spearman's Rank Correlation Analysis Results

C1 GeoSUM - SRC

C1.1 GeoSUM – SRC: Performance – use case

Correlations

			To what extent would you say the system has helped you to stay within the defined speed limits in school zones?	To what extent do you think it would improve traffic safety around schools if all drivers had the system installed in their vehicle?	To what extent would you say the system has helped you drive more environmentally friendly within the defined low-emission zones?	To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicle?
Spearman's rho	To what extent would you say the system has helped you to stay within the defined speed limits in school zones?	Correlation Coefficient	1,000	,429**	,392**	,270
		Sig. (2-tailed)	.	,001	,004	,056
		N	52	52	52	51
	To what extent do you think it would improve traffic safety around schools if all drivers had the system installed in their vehicle?	Correlation Coefficient	,429**	1,000	,250	,121
		Sig. (2-tailed)	,001	.	,071	,391
		N	52	53	53	52
	To what extent would you say the system has helped you drive more environmentally friendly within the defined low-emission zones?	Correlation Coefficient	,392**	,250	1,000	,533**
		Sig. (2-tailed)	,004	,071	.	<,001
		N	52	53	53	52
	To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicle?	Correlation Coefficient	,270	,121	,533**	1,000
		Sig. (2-tailed)	,056	,391	<,001	.
		N	51	52	52	52

**. Correlation is significant at the 0.01 level (2-tailed).

C1.2 – GeoSUM - SRC: Pleasure of driving quickly – Car transport

Correlations

			Pleasure of driving quickly is a important part of driving	The car is only a transport mode for me
Spearman's rho	Pleasure of driving quickly is a important part of driving	Correlation Coefficient	1,000	-,522**
		Sig. (2-tailed)	.	<,001
		N	57	57
	The car is only a transport mode for me	Correlation Coefficient	-,522**	1,000
		Sig. (2-tailed)	<,001	.
		N	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

C1.3 – GeoSUM - SRC: Attitude hybrid car use

Correlations

			The car automatically switches to fossil fuel (without the battery being depleted of electricity)	The car is out of electricity	I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc	I choose to save the battery for other parts of the route I'm driving on
Spearman's rho	The car automatically switches to fossil fuel (without the battery being depleted of electricity)	Correlation Coefficient	1,000	,052	,145	,158
		Sig. (2-tailed)	.	,701	,282	,241
		N	57	57	57	57
	The car is out of electricity	Correlation Coefficient	,052	1,000	-,169	-,034
		Sig. (2-tailed)	,701	.	,208	,803
		N	57	57	57	57
	I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc	Correlation Coefficient	,145	-,169	1,000	,213
		Sig. (2-tailed)	,282	,208	.	,112
		N	57	57	57	57
	I choose to save the battery for other parts of the route I'm driving on	Correlation Coefficient	,158	-,034	,213	1,000
		Sig. (2-tailed)	,241	,803	,112	.
		N	57	57	57	57

C1.4 – GeoSUM - SRC: Attitude climate change / environmental

Correlations

			Human-induced climate change is the most important societal challenge we face	Local pollution is a major problem in the city I live in	I am conscious of where and when the car is running on electric power	I try to use information from the car to drive as much as possible on electricity
Spearman's rho	Human-induced climate change is the most important societal challenge we face	Correlation Coefficient	1,000	,214	-,051	,014
		Sig. (2-tailed)	.	,109	,709	,916
		N	57	57	57	57
	Local pollution is a major problem in the city I live in	Correlation Coefficient	,214	1,000	,219	-,012
		Sig. (2-tailed)	,109	.	,101	,931
		N	57	57	57	57
	I am conscious of where and when the car is running on electric power	Correlation Coefficient	-,051	,219	1,000	,563**
		Sig. (2-tailed)	,709	,101	.	<,001
		N	57	57	57	57
	I try to use information from the car to drive as much as possible on electricity	Correlation Coefficient	,014	-,012	,563**	1,000
		Sig. (2-tailed)	,916	,931	<,001	.
		N	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

C1.5 – GeoSUM - SRC: Attitude - speed

Correlations

			I think breaking the speed limit is a big problem for traffic safety	I think the speed limits in Norway should be higher than they are today	I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is	I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)
Spearman's rho	I think breaking the speed limit is a big problem for traffic safety	Correlation Coefficient	1,000	-,523**	,602**	,077
		Sig. (2-tailed)	.	<,001	<,001	,569
		N	57	57	57	57
	I think the speed limits in Norway should be higher than they are today	Correlation Coefficient	-,523**	1,000	-,431**	-,053
		Sig. (2-tailed)	<,001	.	<,001	,695
		N	57	57	57	57
	I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is	Correlation Coefficient	,602**	-,431**	1,000	-,060
		Sig. (2-tailed)	<,001	<,001	.	,658
		N	57	57	57	57
	I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)	Correlation Coefficient	,077	-,053	-,060	1,000
		Sig. (2-tailed)	,569	,695	,658	.
		N	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

C1.6 – GeoSUM - SRC: Performance expectancy

Correlations

			I expect technology to make me more aware of speed limits	I expect technology to make me more aware of local emissions from the vehicle	I expect the technology I will be testing in the project to be reliable
Spearman's rho	I expect technology to make me more aware of speed limits	Correlation Coefficient	1,000	,418**	,130
		Sig. (2-tailed)	.	,001	,334
		N	57	57	57
	I expect technology to make me more aware of local emissions from the vehicle	Correlation Coefficient	,418**	1,000	,210
		Sig. (2-tailed)	,001	.	,118
		N	57	57	57
	I expect the technology I will be testing in the project to be reliable	Correlation Coefficient	,130	,210	1,000
		Sig. (2-tailed)	,334	,118	.
		N	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

C1.7 – GeoSUM - SRC: Privacy concern

Correlations

			I am familiar with the content of Norway's personal data privacy legislation (including GDPR, General Data Protection Regulation)	I am concerned that personal data may be compromised and potentially misused in the future	I trust that the authorities safeguard my privacy	I trust that private companies safeguard my privacy	I am positive about the registration of personal travel data if it contributes to me being offered better services	I am positive about the registration of personal travel data if it contributes to a fairer toll system
Spearman's rho	I am familiar with the content of Norway's personal data privacy legislation (including GDPR, General Data Protection Regulation)	Correlation Coefficient	1,000	-,051	-,077	,062	,099	,142
		Sig. (2-tailed)	.	,706	,568	,646	,462	,294
		N	57	57	57	57	57	57
	I am concerned that personal data may be compromised and potentially misused in the future	Correlation Coefficient	-,051	1,000	-,347**	-,341**	-,243	-,171
		Sig. (2-tailed)	,706	.	,008	,009	,069	,203
		N	57	57	57	57	57	57
	I trust that the authorities safeguard my privacy	Correlation Coefficient	-,077	-,347**	1,000	,641**	,344**	,249
		Sig. (2-tailed)	,568	,008	.	<,001	,009	,062
		N	57	57	57	57	57	57
	I trust that private companies safeguard my privacy	Correlation Coefficient	,062	-,341**	,641**	1,000	,296*	,045
		Sig. (2-tailed)	,646	,009	<,001	.	,025	,740
		N	57	57	57	57	57	57
	I am positive about the registration of personal travel data if it contributes to me being offered better services	Correlation Coefficient	,099	-,243	,344**	,296*	1,000	,694**
		Sig. (2-tailed)	,462	,069	,009	,025	.	<,001
		N	57	57	57	57	57	57
	I am positive about the registration of personal travel data if it contributes to a fairer toll system	Correlation Coefficient	,142	-,171	,249	,045	,694**	1,000
		Sig. (2-tailed)	,294	,203	,062	,740	<,001	.
		N	57	57	57	57	57	57

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C1.8 – GeoSUM - SRC: Ease of use

Correlations

			To what extent did switching from fossil to electricity require a lot of mental capacity from you (e.g. thinking, remembering, looking for the right button)?	To what extent did switching from fossil to electricity require a lot of physical capacity from you (e.g. stretching, pressing a button)?	To what extent did you feel time pressure when switching from fossil to electricity?	To what extent did you feel that you had to mobilize a lot of energy (mentally and physically) when switching from fossil to electricity?	To what extent did you feel stressed by switching from fossil to electricity?	To what extent are you satisfied with how you performed the switch from fossil to electricity during the testing period?
Spearman's rho	To what extent did switching from fossil to electricity require a lot of mental capacity from you (e.g. thinking, remembering, looking for the right button)?	Correlation Coefficient	1,000	,472**	,344*	,598**	,378**	-,044
		Sig. (2-tailed)	.	<,001	,019	<,001	,009	,778
		N	47	47	46	47	47	43
	To what extent did switching from fossil to electricity require a lot of physical capacity from you (e.g. stretching, pressing a button)?	Correlation Coefficient	,472**	1,000	,642**	,617**	,422**	-,097
		Sig. (2-tailed)	<,001	.	<,001	<,001	,003	,534
		N	47	48	46	48	47	43
	To what extent did you feel time pressure when switching from fossil to electricity?	Correlation Coefficient	,344*	,642**	1,000	,619**	,632**	,170
		Sig. (2-tailed)	,019	<,001	.	<,001	<,001	,281
		N	46	46	46	46	46	42
	To what extent did you feel that you had to mobilize a lot of energy (mentally and physically) when switching from fossil to electricity?	Correlation Coefficient	,598**	,617**	,619**	1,000	,666**	,017
		Sig. (2-tailed)	<,001	<,001	<,001	.	<,001	,911
		N	47	48	46	48	47	43
	To what extent did you feel stressed by switching from fossil to electricity?	Correlation Coefficient	,378**	,422**	,632**	,666**	1,000	-,015
		Sig. (2-tailed)	,009	,003	<,001	<,001	.	,925
		N	47	47	46	47	47	43
	To what extent are you satisfied with how you performed the switch from fossil to electricity during the testing period?	Correlation Coefficient	-,044	-,097	,170	,017	-,015	1,000
		Sig. (2-tailed)	,778	,534	,281	,911	,925	.
		N	43	43	42	43	43	44

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C1.9 – GeoSUM - SRC: Ease of use

Correlations

			The user interface on the screen was intuitive to use.	The user interface on the screen distracted me from driving.	The information from the user interface on the screen was precise enough for me.	The feedback from the user interface on the screen was clear and understandable.	It was easy for me to follow the information communicated to me by the user interface on the screen.	My interaction with the user interface on the screen was frustrating	My interaction with the user interface on the screen was comfortable	I found the feedback from the user interface on the screen to be encouraging	It was easy for me to learn how to use the user interface on the screen.	The user interface on the screen provided me with sufficient information to perform what was expected of me.	The user interface on the screen was easy to use in my everyday life.
Spearman's rho	The user interface on the screen was intuitive to use.	Correlation Coefficient	1,000	-,337*	,567**	,486**	,536**	-,391**	,476**	,250	,377**	,493**	,497**
		Sig. (2-tailed)	.	,014	<,001	<,001	<,001	,004	<,001	,071	,006	<,001	<,001
		N	53	53	52	52	52	53	53	53	52	52	53
	The user interface on the screen distracted me from driving.	Correlation Coefficient	-,337*	1,000	-,362**	-,427**	-,213	,452**	-,378**	-,183	-,401**	-,387**	-,484**
		Sig. (2-tailed)	,014	.	,008	,002	,130	<,001	,005	,191	,003	,005	<,001
		N	53	53	52	52	52	53	53	53	52	52	53
	The information from the user interface on the screen was precise enough for me.	Correlation Coefficient	,567**	-,362**	1,000	,489**	,563**	-,361**	,476**	,340*	,538**	,639**	,516**
		Sig. (2-tailed)	<,001	,008	.	<,001	<,001	,008	<,001	,014	<,001	<,001	<,001
		N	52	52	52	51	51	52	52	52	52	51	52
	The feedback from the user interface on the screen was clear and understandable.	Correlation Coefficient	,486**	-,427**	,489**	1,000	,655**	-,299*	,350*	,307*	,290*	,590**	,392**
		Sig. (2-tailed)	<,001	,002	<,001	.	<,001	,031	,011	,027	,039	<,001	,004
		N	52	52	51	52	52	52	52	52	51	52	52
	It was easy for me to follow the information communicated to me by the user interface on the screen.	Correlation Coefficient	,536**	-,213	,563**	,655**	1,000	-,091	,336*	,310*	,436**	,626**	,455**
		Sig. (2-tailed)	<,001	,130	<,001	<,001	.	,520	,015	,025	,001	<,001	<,001
		N	52	52	51	52	52	52	52	52	51	52	52
	My interaction with the user interface on the screen was frustrating	Correlation Coefficient	-,391**	,452**	-,361**	-,299*	-,091	1,000	-,602**	-,073	-,218	-,183	-,375**
		Sig. (2-tailed)	,004	<,001	,008	,031	,520	.	<,001	,602	,120	,194	,006
		N	53	53	52	52	52	53	53	53	52	52	53
	My interaction with the user interface on the screen was comfortable	Correlation Coefficient	,476**	-,378**	,476**	,350*	,336*	-,602**	1,000	,437**	,433**	,491**	,495**
		Sig. (2-tailed)	<,001	,005	<,001	,011	,015	<,001	.	,001	,001	<,001	<,001
		N	53	53	52	52	52	53	53	53	52	52	53
	I found the feedback from the user interface on the screen to be encouraging	Correlation Coefficient	,250	-,183	,340*	,307*	,310*	-,073	,437**	1,000	,334*	,418**	,356**
		Sig. (2-tailed)	,071	,191	,014	,027	,025	,602	,001	.	,015	,002	,009
		N	53	53	52	52	52	53	53	53	52	52	53
	It was easy for me to learn how to use the user interface on the screen.	Correlation Coefficient	,377**	-,401**	,538**	,290*	,436**	-,218	,433**	,334*	1,000	,785**	,596**
		Sig. (2-tailed)	,006	,003	<,001	,039	,001	,120	,001	,015	.	<,001	<,001
		N	52	52	52	51	51	52	52	52	52	51	52
	The user interface on the screen provided me with sufficient information to perform what was expected of me.	Correlation Coefficient	,493**	-,387**	,639**	,590**	,626**	-,183	,491**	,418**	,785**	1,000	,683**
		Sig. (2-tailed)	<,001	,005	<,001	<,001	<,001	,194	<,001	,002	<,001	.	<,001
		N	52	52	51	52	52	52	52	52	51	52	52
	The user interface on the screen was easy to use in my everyday life.	Correlation Coefficient	,497**	-,484**	,516**	,392**	,455**	-,375**	,495**	,356**	,596**	,683**	1,000
		Sig. (2-tailed)	<,001	<,001	<,001	,004	<,001	,006	<,001	,009	<,001	<,001	.
		N	53	53	52	52	52	53	53	53	52	52	53

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

C1.10 – GeoSUM - SRC: Pay for system

Correlations

			Positive to pay for a system with a user interface in the car?	Positive to pay for a more detailed information in reports that can be found, for example, on a website that shows your trips and statistics?
Spearman's rho	Positive to pay for a system with a user interface in the car?	Correlation Coefficient	1,000	,580**
		Sig. (2-tailed)	.	<,001
		N	53	53
	Positive to pay for a more detailed information in reports that can be found, for example, on a website that shows your trips and statistics?	Correlation Coefficient	,580**	1,000
		Sig. (2-tailed)	<,001	.
		N	53	53

**. Correlation is significant at the 0.01 level (2-tailed).

C1.11 – GeoSUM - SRC: Performance - technical

Correlations

			How often would you say you have experienced equipment startup problems? (e. g. phone not starting, no contact with dongle)	How often would you say you have turned off the equipment or failed to log in at startup?	How often would you say the equipment has unexpectedly shut down while driving?	How often would you say the equipment has lost GPS signal while you were driving?	How often would you say you have discovered that you have used the wrong user when driving?	How often would you say you have experienced the screen running out of power?
Spearman's rho	How often would you say you have experienced equipment startup problems? (e.g. phone not starting, no contact with dongle)	Correlation Coefficient	1,000	,124	,229	,192	-,086	,078
		Sig. (2-tailed)	.	,378	,103	,186	,539	,585
		N	53	53	52	49	53	52
	How often would you say you have turned off the equipment or failed to log in at startup?	Correlation Coefficient	,124	1,000	,342*	,235	,149	,180
		Sig. (2-tailed)	,378	.	,013	,105	,287	,202
		N	53	53	52	49	53	52
	How often would you say the equipment has unexpectedly shut down while driving?	Correlation Coefficient	,229	,342*	1,000	,580**	,235	,166
		Sig. (2-tailed)	,103	,013	.	<,001	,093	,245
		N	52	52	52	49	52	51
	How often would you say the equipment has lost GPS signal while you were driving?	Correlation Coefficient	,192	,235	,580**	1,000	,192	-,007
		Sig. (2-tailed)	,186	,105	<,001	.	,186	,961
		N	49	49	49	49	49	48
	How often would you say you have discovered that you have used the wrong user when driving?	Correlation Coefficient	-,086	,149	,235	,192	1,000	,255
		Sig. (2-tailed)	,539	,287	,093	,186	.	,068
		N	53	53	52	49	53	52
	How often would you say you have experienced the screen running out of power?	Correlation Coefficient	,078	,180	,166	-,007	,255	1,000
		Sig. (2-tailed)	,585	,202	,245	,961	,068	.
		N	52	52	51	48	52	52

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

C2 GeoFlow - SRC

C2.1 – GeoFlow - SRC: Attitude - road pricing – toll system

Correlations

			What is your attitude towards the toll system in Trondheim?	How fair do you consider the current toll system in Trondheim, with regards to price, location, and number of toll stations?	What is your immediate attitude towards road pricing as a traffic-regulating measure, where drivers pay different amounts depending on the distance they travel
Spearman's rho	What is your attitude towards the toll system in Trondheim?	Correlation Coefficient	1,000	,317**	,374**
		Sig. (2-tailed)	.	,003	<,001
		N	93	87	91
	How fair do you consider the current toll system in Trondheim, with regards to price, location, and number of toll stations?	Correlation Coefficient	,317**	1,000	,007
		Sig. (2-tailed)	,003	.	,951
		N	87	87	85
	What is your immediate attitude towards road pricing as a traffic-regulating measure, where drivers pay different amounts depending on the distance they travel	Correlation Coefficient	,374**	,007	1,000
		Sig. (2-tailed)	<,001	,951	.
		N	91	85	91

**. Correlation is significant at the 0.01 level (2-tailed).

C2.2 – GeoFlow - SRC: Attitude - Technology

Correlations

			I am interested in testing new technology	I think it's important to drive a car with the latest technology
Spearman's rho	I am interested in testing new technology	Correlation Coefficient	1,000	,378**
		Sig. (2-tailed)	.	<,001
		N	94	94
	I think it's important to drive a car with the latest technology	Correlation Coefficient	,378**	1,000
		Sig. (2-tailed)	<,001	.
		N	94	94

**. Correlation is significant at the 0.01 level (2-tailed).

C2.2 – GeoFlow - SRC: Performance expectance

Correlations

			I expect that the technology will provide me with lower costs in testing	I expect that the technology will provide me with lower costs in future implementatio n	I expect that the technology will make me more aware of the environmental impact of transportation	I expect that the technology I will be testing in the project to be reliable
Spearman's rho	I expect that the technology will provide me with lower costs in testing	Correlation Coefficient	1,000	,616**	-,294**	,120
		Sig. (2-tailed)	.	<,001	,004	,248
		N	94	94	94	94
	I expect that the technology will provide me with lower costs in future implementation	Correlation Coefficient	,616**	1,000	-,179	,214*
		Sig. (2-tailed)	<,001	.	,085	,039
		N	94	94	94	94
	I expect that the technology will make me more aware of the environmental impact of transportation	Correlation Coefficient	-,294**	-,179	1,000	-,061
		Sig. (2-tailed)	,004	,085	.	,557
		N	94	94	94	94
	I expect that the technology I will be testing in the project to be reliable	Correlation Coefficient	,120	,214*	-,061	1,000
		Sig. (2-tailed)	,248	,039	,557	.
		N	94	94	94	94

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C2.3 – GeoFlow - SRC: Performance

Correlations

			How often would you say that you have experienced that the equipment has startup problems that persist throughout the trip?	How often would you say that you have experienced that the app shows no contact with the ITS station?	How often would you say that the app has unexpectedly shut down during driving?	How often would you say that the equipment has lost the GPS signal while you were driving?	How often would you say that the equipment calculates an incorrect price?	How often would you say that you have experienced that the app has contact with the ITS station, but the car appears to be stationary in the app?	How often would you say that you have experienced that the equipment has a slow startup before the app shows the correct position and follows the car?	How often would you say that the equipment stops working during a trip?
Spearman's rho	How often would you say that you have experienced that the equipment has startup problems that persist throughout the trip?	Correlation Coefficient	1,000	,672**	,626**	,593**	,274**	,504**	,656**	,608**
		Sig. (2-tailed)	.	<,001	<,001	<,001	,007	<,001	<,001	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that you have experienced that the app shows no contact with the ITS station?	Correlation Coefficient	,672**	1,000	,703**	,612**	,350**	,633**	,705**	,581**
		Sig. (2-tailed)	<,001	.	<,001	<,001	<,001	<,001	<,001	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that the app has unexpectedly shut down during driving?	Correlation Coefficient	,626**	,703**	1,000	,799**	,396**	,743**	,728**	,763**
		Sig. (2-tailed)	<,001	<,001	.	<,001	<,001	<,001	<,001	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that the equipment has lost the GPS signal while you were driving?	Correlation Coefficient	,593**	,612**	,799**	1,000	,499**	,657**	,651**	,785**
		Sig. (2-tailed)	<,001	<,001	<,001	.	<,001	<,001	<,001	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that the equipment calculates an incorrect price?	Correlation Coefficient	,274**	,350**	,396**	,499**	1,000	,352**	,321**	,483**
		Sig. (2-tailed)	,007	<,001	<,001	<,001	.	<,001	,002	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that you have experienced that the app has contact with the ITS station, but the car appears to be stationary in the app?	Correlation Coefficient	,504**	,633**	,743**	,657**	,352**	1,000	,575**	,590**
		Sig. (2-tailed)	<,001	<,001	<,001	<,001	<,001	.	<,001	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that you have experienced that the equipment has a slow startup before the app shows the correct position and follows the car?	Correlation Coefficient	,656**	,705**	,728**	,651**	,321**	,575**	1,000	,588**
		Sig. (2-tailed)	<,001	<,001	<,001	<,001	,002	<,001	.	<,001
		N	94	94	94	94	94	94	94	94
	How often would you say that the equipment stops working during a trip?	Correlation Coefficient	,608**	,581**	,763**	,785**	,483**	,590**	,588**	1,000
		Sig. (2-tailed)	<,001	<,001	<,001	<,001	<,001	<,001	<,001	.
		N	94	94	94	94	94	94	94	94

**. Correlation is significant at the 0.01 level (2-tailed).

C2.4 – GeoFlow - SRC: Privacy concerns

Correlations

			Are you familiar with Norwegian privacy legislation?	Worried that personal data will be misused in the future.	Trust in the government to safeguard my privacy	Trust a trusted third party to protect my privacy	Positive to the registration of personal travel data if it contributes to me being offered better services	Positive to the registration of personal travel data if it contributes to a fairer road toll system
Spearman's rho	Are you familiar with Norwegian privacy legislation?	Correlation Coefficient	1,000	,217*	-,035	-,091	-,083	-,108
		Sig. (2-tailed)	.	,035	,739	,386	,427	,299
		N	94	94	94	94	94	94
	Worried that personal data will be misused in the future.	Correlation Coefficient	,217*	1,000	-,488**	-,545**	-,470**	-,409**
		Sig. (2-tailed)	,035	.	<,001	<,001	<,001	<,001
		N	94	94	94	94	94	94
	Trust in the government to safeguard my privacy	Correlation Coefficient	-,035	-,488**	1,000	,625**	,487**	,426**
		Sig. (2-tailed)	,739	<,001	.	<,001	<,001	<,001
		N	94	94	94	94	94	94
	Trust a trusted third party to protect my privacy	Correlation Coefficient	-,091	-,545**	,625**	1,000	,576**	,520**
		Sig. (2-tailed)	,386	<,001	<,001	.	<,001	<,001
		N	94	94	94	94	94	94
	Positive to the registration of personal travel data if it contributes to me being offered better services	Correlation Coefficient	-,083	-,470**	,487**	,576**	1,000	,644**
		Sig. (2-tailed)	,427	<,001	<,001	<,001	.	<,001
		N	94	94	94	94	94	94
	Positive to the registration of personal travel data if it contributes to a fairer road toll system	Correlation Coefficient	-,108	-,409**	,426**	,520**	,644**	1,000
		Sig. (2-tailed)	,299	<,001	<,001	<,001	<,001	.
		N	94	94	94	94	94	94

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

C2.5 – GeoFlow - SRC: Privacy concerns 2

Correlations

			The GPS position information is processed locally only in the car? Meaning that calculations based on GPS position (such as distance driven in toll zones) are performed in the car, and only a summary of the trip is sent to a neutral third party.	The GPS position information is processed by a third party? Meaning that the GPS positions recorded in the car are sent from the car to a neutral third party for processing	Personal travel data is recorded if it contributes to better services being offered to me.	Personal travel data is recorded if it contributes to a fairer toll system.	Positive to the registration of personal travel data if it contributes to me being offered better services	Positive to the registration of personal travel data if it contributes to a fairer road toll system
Spearman's rho	The GPS position information is processed locally only in the car? Meaning that calculations based on GPS position (such as distance driven in toll zones) are performed in the car, and only a summary of the trip is sent to a neutral third party.	Correlation Coefficient	1,000	-,023	,129	,072	,085	,183
		Sig. (2-tailed)	.	,826	,233	,504	,426	,083
		N	91	91	88	89	91	91
	The GPS position information is processed by a third party? Meaning that the GPS positions recorded in the car are sent from the car to a neutral third party for processing	Correlation Coefficient	-,023	1,000	,507**	,441**	,336**	,218*
		Sig. (2-tailed)	,826	.	<,001	<,001	,001	,038
		N	91	91	88	89	91	91
	Personal travel data is recorded if it contributes to better services being offered to me.	Correlation Coefficient	,129	,507**	1,000	,763**	,398**	,318**
		Sig. (2-tailed)	,233	<,001	.	<,001	<,001	,002
		N	88	88	90	89	90	90
	Personal travel data is recorded if it contributes to a fairer toll system.	Correlation Coefficient	,072	,441**	,763**	1,000	,444**	,461**
		Sig. (2-tailed)	,504	<,001	<,001	.	<,001	<,001
		N	89	89	89	91	91	91
	Positive to the registration of personal travel data if it contributes to me being offered better services	Correlation Coefficient	,085	,336**	,398**	,444**	1,000	,644**
		Sig. (2-tailed)	,426	,001	<,001	<,001	.	<,001
		N	91	91	90	91	94	94
	Positive to the registration of personal travel data if it contributes to a fairer road toll system	Correlation Coefficient	,183	,218*	,318**	,461**	,644**	1,000
		Sig. (2-tailed)	,083	,038	,002	<,001	<,001	.
		N	91	91	90	91	94	94

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C2.6 – GeoFlow - SRC: Rush hour and traffic load prices

Correlations

			The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	4 kr per kilometer during rush hour is a fair price	3 kr per kilometer outside rush hour is a fair price
Spearman's rho	The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	Correlation Coefficient	1,000	,580**	,376**
		Sig. (2-tailed)	.	<,001	<,001
		N	93	80	80
	4 kr per kilometer during rush hour is a fair price	Correlation Coefficient	,580**	1,000	,693**
		Sig. (2-tailed)	<,001	.	<,001
		N	80	80	80
	3 kr per kilometer outside rush hour is a fair price	Correlation Coefficient	,376**	,693**	1,000
		Sig. (2-tailed)	<,001	<,001	.
		N	80	80	80

**. Correlation is significant at the 0.01 level (2-tailed).

C2.7 – GeoFlow - SRC: Performance – use case - road pricing

Correlations

			Would you say that road pricing has made you more aware of how much you drive and when and where you drive?	Would you say that road pricing is more user-friendly than the current toll system in Trondheim?	Would you say that road pricing is a fairer tax system than the current tax system?	Do you think that road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?
Spearman's rho	Would you say that road pricing has made you more aware of how much you drive and when and where you drive?	Correlation Coefficient	1,000	,102	,221*	,326**	,265*
		Sig. (2-tailed)	.	,356	,045	,003	,016
		N	89	84	83	81	82
	Would you say that road pricing is more user-friendly than the current toll system in Trondheim?	Correlation Coefficient	,102	1,000	,539**	,415**	,567**
		Sig. (2-tailed)	,356	.	<,001	<,001	<,001
		N	84	84	81	78	78
	Would you say that road pricing is a fairer tax system than the current tax system?	Correlation Coefficient	,221*	,539**	1,000	,441**	,798**
		Sig. (2-tailed)	,045	<,001	.	<,001	<,001
		N	83	81	84	77	78
	Do you think that road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?	Correlation Coefficient	,326**	,415**	,441**	1,000	,588**
		Sig. (2-tailed)	,003	<,001	<,001	.	<,001
		N	81	78	77	82	78
	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?	Correlation Coefficient	,265*	,567**	,798**	,588**	1,000
		Sig. (2-tailed)	,016	<,001	<,001	<,001	.
		N	82	78	78	78	85

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

C2.7 – GeoFlow - SRC: Fairness of road pricing compared to existing road tolling

Correlations

			Would you say that road pricing is a fairer tax system than the current tax system?	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?	4 kr per kilometer during rush hour is a fair price	3 kr per kilometer outside rush hour is a fair price	The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	you would find it more fair to pay for the distance driven (as in the test) than paying at toll booths (as today)?	The rush-hour pricing was more fair in the pilot than in the current toll system?
Spearman's rho	Would you say that road pricing is a fairer tax system than the current tax system?	Correlation Coefficient	1,000	,798**	,285*	,376**	,187	,678**	,600**
		Sig. (2-tailed)	.	<,001	,016	,001	,090	<,001	<,001
		N	84	78	71	71	83	82	67
	Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?	Correlation Coefficient	,798**	1,000	,284*	,231*	,210	,684**	,553**
		Sig. (2-tailed)	<,001	.	,015	,049	,056	<,001	<,001
		N	78	85	73	73	84	83	70
	4 kr per kilometer during rush hour is a fair price	Correlation Coefficient	,285*	,284*	1,000	,693**	,580**	,321**	,638**
		Sig. (2-tailed)	,016	,015	.	<,001	<,001	,004	<,001
		N	71	73	80	80	80	78	65
	3 kr per kilometer outside rush hour is a fair price	Correlation Coefficient	,376**	,231*	,693**	1,000	,376**	,267*	,505**
		Sig. (2-tailed)	,001	,049	<,001	.	<,001	,018	<,001
		N	71	73	80	80	80	78	65
	The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	Correlation Coefficient	,187	,210	,580**	,376**	1,000	,217*	,527**
		Sig. (2-tailed)	,090	,056	<,001	<,001	.	,040	<,001
		N	83	84	80	80	93	90	73
	you would find it more fair to pay for the distance driven (as in the test) than paying at toll booths (as today)?	Correlation Coefficient	,678**	,684**	,321**	,267*	,217*	1,000	,676**
		Sig. (2-tailed)	<,001	<,001	,004	,018	,040	.	<,001
		N	82	83	78	78	90	91	74
	The rush-hour pricing was more fair in the pilot than in the current toll system?	Correlation Coefficient	,600**	,553**	,638**	,505**	,527**	,676**	1,000
		Sig. (2-tailed)	<,001	<,001	<,001	<,001	<,001	<,001	.
		N	67	70	65	65	73	74	74

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

C2.8 – GeoFlow - SRC: pay for other extra services

Correlations

			Information (e. g. about traffic jams, roadworks)	Payments (e.g. parking fees, studded tire fee)	Information on emergencies (e.g. tunnel fires, traffic accidents)
Spearman's rho	Information (e.g. about traffic jams, roadworks)	Correlation Coefficient	1,000	,356**	,688**
		Sig. (2-tailed)	.	<,001	<,001
		N	94	93	93
	Payments (e.g. parking fees, studded tire fee)	Correlation Coefficient	,356**	1,000	,328**
		Sig. (2-tailed)	<,001	.	,001
		N	93	93	93
	Information on emergencies (e.g. tunnel fires, traffic accidents)	Correlation Coefficient	,688**	,328**	1,000
		Sig. (2-tailed)	<,001	,001	.
		N	93	93	93

**. Correlation is significant at the 0.01 level (2-tailed).

D - KMO and BTS results

D1 GeoSUM

D1.1 Attitude

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,590
Bartlett's Test of Sphericity	Approx. Chi-Square	640,518
	df	351
	Sig.	<,001

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FACTOR
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D1.2 Privacy concerns

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,564
Bartlett's Test of Sphericity	Approx. Chi-Square	85,565
	df	36

Sig.	<,001

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D1.3 Performance: technical equipment

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,623
Bartlett's Test of Sphericity	Approx. Chi-Square	42,148
	df	15
	Sig.	<,001

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 /METHOD=CORRELATION.
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D1.4 Performance expectancy

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,576
Bartlett's Test of Sphericity	Approx. Chi-Square	67,749
	df	21
	Sig.	<,001

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D1.5 Effort expectancy

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	,799

Bartlett's Test of Sphericity	Approx. Chi-Square	296,801
	df	55
	Sig.	<,001

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D1.7 Price value

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,460
Bartlett's Test of Sphericity	Approx. Chi-Square	17,076
	df	3
	Sig.	<,001

```
FACTOR
 /VARIABLES price1 price2 lowem_use1
 /MISSING LISTWISE
 /ANALYSIS price1 price2 lowem_use1
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /FORMAT SORT
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2 GeoSUM

D2.1 Attitude

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,450
Bartlett's Test of Sphericity	Approx. Chi-Square	49,107
	df	10
	Sig.	<,001

Syntax

```
FACTOR
 /VARIABLES AJN1 AJN2 AL_0N1 AMN1 ANN1
 /MISSING LISTWISE
 /ANALYSIS AJN1 AJN2 AL_0N1 AMN1 ANN1
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2.2 Privacy concerns

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,845
Bartlett's Test of Sphericity	Approx. Chi-Square	386,046
	df	66
	Sig.	<,001

Syntax

```
FACTOR
 /VARIABLES APN1 APN2 APN3 APN4 APN5 APN6 AQN1 ARN1 ALabel5N3 ALabel5N4 ALabel5N1 ALabel5N2
 /MISSING LISTWISE
 /ANALYSIS APN1 APN2 APN3 APN4 APN5 APN6 AQN1 ARN1 ALabel5N3 ALabel5N4 ALabel5N1 ALabel5N2
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2.3 Performance expectance road pricing

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,551
Bartlett's Test of Sphericity	Approx. Chi-Square	58,655
	df	6
	Sig.	<,001

Syntax

```
FACTOR
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 /MISSING LISTWISE
 /ANALYSIS ASN1 ASN2 ASN3 ASN4
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2.4 Technical performance

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,914
Bartlett's Test of Sphericity	Approx. Chi-Square	537,769
	df	28
	Sig.	<,001

```
FACTOR
 /VARIABLES ALabel3N1 ALabel3N2 ALabel3N3 ALabel3N4 ALabel3N5 ALabel3N6 ALabel3N7 ALabel3N8
 /MISSING LISTWISE
 /ANALYSIS ALabel3N1 ALabel3N2 ALabel3N3 ALabel3N4 ALabel3N5 ALabel3N6 ALabel3N7 ALabel3N8
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2.5 Performance - road pricing

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,797
Bartlett's Test of Sphericity	Approx. Chi-Square	186,107
	df	15
	Sig.	<,001

Syntax

```
FACTOR
 /VARIABLES ALabel6N1 ALabel6N2 ALabel6N3 ALabel6N4 ALabel6N5 ALabel6N6
 /MISSING LISTWISE
 /ANALYSIS ALabel6N1 ALabel6N2 ALabel6N3 ALabel6N4 ALabel6N5 ALabel6N6
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

D2.6 Price value

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,648
Bartlett's Test of Sphericity	Approx. Chi-Square	356,249
	df	105
	Sig.	<,001

Syntax

```
FACTOR
 /VARIABLES ALabel7N1 ALabel7N2 ALabel7N3 ALabel9N1 ALabel9N2 ALabel9N3 ALabel8N1 ALabel8N2
  ALabel8N3 ALabel8N4 ALabel8N5 ALabel8N6 ALabel14N1 ALabel14N2 ALabel14N3
 /MISSING LISTWISE
 /ANALYSIS ALabel7N1 ALabel7N2 ALabel7N3 ALabel9N1 ALabel9N2 ALabel9N3 ALabel8N1 ALabel8N2
  ALabel8N3 ALabel8N4 ALabel8N5 ALabel8N6 ALabel14N1 ALabel14N2 ALabel14N3
 /PRINT INITIAL CORRELATION SIG DET KMO EXTRACTION ROTATION
 /CRITERIA MINEIGEN(1) ITERATE(25)
 /EXTRACTION PC
 /CRITERIA ITERATE(25) DELTA(0)
 /ROTATION OBLIMIN
 /METHOD=CORRELATION.
```

E - Correlation matrix for behavioral intention and variables

GeoSUM Correlation matrix for behavioral intention and variables	As a hybrid car driver, I would be positive towards differentiated taxes for different fuel types within geofence zones.	As a hybrid car driver, I would drive more on electricity than I normally do if differentiated taxes within geofence zones were realized.	If there was a requirement for all drivers (not just hybrid drivers) to use geofence zones for differentiated taxes, I think most people would be positive about it.	If there was a requirement for all drivers to use geofence zones for differentiated taxes, I think most hybrid drivers would drive on electricity within low emission zones.
Price of the car at purchase		0,254		
That the car is environmentally friendly	0,392			0,352
High engine performance	-0,465			-0,485
High safety				-0,239
Many available driver assistance systems			0,227	
Car brand			0,535	
In average, how often do you charge your car a week?		-0,355		
How many percentage of your time do you drive on electricity?			-0,249	
When the car is fully charged, around how many kilometers can you drive before its empty?			0,241	-0,233
The car is only a transport mode for me			-0,307	0,287
Pleasure of driving quickly is a important part of driving	-0,273			-0,471
I would rather have a fully electric car if selection, range and price is to my liking			-0,219	
The car automatically switches to fossil fuel (without the battery being depleted of electricity)				
The car is out of electricity		-0,229	-0,291	
I actively choose to drive on fossil fuel to achieve higher speed, acceleration, etc				-0,353
I choose to save the battery for other parts of the route I'm driving on			-0,329	
I am interested in testing out new technology		0,303		
I think it is important to drive a car with the latest technology	0,309	0,273	0,288	
I believe that technology in the transportation sector will minimize deaths and serious injuries in traffic				-0,229
Local pollution is a major problem in the city I live in	0,320	0,283		0,295
I am conscious of where and when the car is running on electric power				0,322
I try to use information from the car to drive as much as possible on electricity				
I think breaking the speed limit is a big problem for traffic safety				0,384
I think the speed limits in Norway should be higher than they are today	-0,374			-0,613
I believe it is irresponsible to drive over the speed limit, regardless of how high the speed limit is				0,329
I often use information about speed limits that I get in the car dashboard (if you have it available on the dashboard)	0,360			
I am familiar with the content of Norway's personal data privacy legislation (including GDPR, General Data Protection Regulation)	-0,339			
I trust that the authorities safeguard my privacy	0,507	0,213	0,314	0,287
I trust that private companies safeguard my privacy	0,223		0,272	
I am positive about the registration of personal travel data if it contributes to me being offered better services			0,348	
I am positive about the registration of personal travel data if it contributes to a fairer toll system			0,219	
I expect technology to make me more aware of speed limits		0,267		

I expect technology to make me more aware of local emissions from the vehicle	0,246	0,354		
I expect the technology I will be testing in the project to be reliable			-0,294	
How often would you say you have experienced equipment startup problems? (e.g. phone not starting, no contact with dongle)	0,235			
How often would you say you have turned off the equipment or failed to log in at startup?			0,224	
How often would you say the equipment has unexpectedly shut down while driving?		0,207	0,218	
How often would you say the equipment has lost GPS signal while you were driving?	0,396		0,516	
How often would you say you have discovered that you have used the wrong user when driving?	-0,286			
How often would you say you have experienced the screen running out of power?	-0,286			
The user interface on the screen was intuitive to use.		0,373		
The user interface on the screen distracted me from driving.		0,347	0,383	
The information from the user interface on the screen was precise enough for me.		0,214		
The feedback from the user interface on the screen was clear and understandable.			-0,223	
It was easy for me to follow the information communicated to me by the user interface on the screen.		0,535		0,250
My interaction with the user interface on the screen was frustrating	0,385	0,344	0,270	
My interaction with the user interface on the screen was comfortable			-0,308	
I found the feedback from the user interface on the screen to be encouraging	0,218		-0,272	
To what extent would you say the system has helped you to stay within the defined speed limits in school zones?	0,256	0,313	0,555	
To what extent do you think it would improve traffic safety around schools if all drivers had the system installed in their vehicle?		0,350		0,313
To what extent would you say the system has helped you drive more environmentally friendly within the defined low-emission zones?	0,286	0,515		
To what extent do you think it would make city traffic more environmentally friendly if all hybrid car drivers had the system installed in their vehicle?	0,524	0,488	0,412	
To what extent did switching from fossil to electricity require a lot of mental capacity from you (e.g. thinking, remembering, looking for the right button)?			-0,285	-0,202
To what extent did switching from fossil to electricity require a lot of physical capacity from you (e.g. stretching, pressing a button)?		0,225	-0,309	
To what extent did you feel time pressure when switching from fossil to electricity?	0,265	0,209		
To what extent did you feel that you had to mobilize a lot of energy (mentally and physically) when switching from fossil to electricity?			-0,352	
I would rather have an integrated function in the car where I receive assistance from the car to adjust my speed (for example, the car helps you slow down when you enter a zone to remind you of a speed change), but where you as the driver can still overri				0,382
I would rather have an integrated function where the car forces me to slow down when I enter a zone, without me being able to override the speed set by the car.			0,344	
As a hybrid car driver, I would be positive towards differentiated taxes for different fuel types within geofence zones.	1,000		0,331	0,378
As a hybrid car driver, I would drive more on electricity than I normally do if differentiated taxes within geofence zones were realized.		1,000	0,229	
If there was a requirement for all drivers (not just hybrid drivers) to use geofence zones for differentiated taxes, I think most people would be positive about it.	0,331	0,229	1,000	
If there was a requirement for all drivers to use geofence zones for differentiated taxes, I think most hybrid drivers would drive on electricity within low emission zones.	0,378			1,000
To what extent do you consider it likely that in your everyday life you would switch to electricity within low-emission zones if it would result in lower fees?		0,239		0,345
To what extent do you consider it likely that for geofenced low-emission zones you would find it more fair to pay for the distance driven (as in the test) rather than paying at toll booths (as today)?				0,520
A system without a user interface in the car (such as the autoPASS tag), and which only reported registered information.	0,340	0,234		
A system without a user interface in the car (such as the autoPASS tag), but where you could go to an app or website afterwards to see what information has been registered and sent on.	0,351			
Positive to pay for a system with a user interface in the car?		0,463	0,225	
Positive to pay for a more detailed information in reports that can be found, for example, on a website that shows your trips and statistics?		0,459	-0,248	
How would you generally feel about information related to the GPS position of your vehicle being used to inform, guide, and control traffic?	0,217		0,298	
How would you feel about the information related to GPS position being processed locally in the car? That is, calculations based on GPS position (such as distance driven in zones) are carried out in the car, and only a summary of the trip is sent to a neu			0,260	
How would you feel about information related to GPS position being processed by a third party? That is, the GPS positions recorded in the car are sent from the car to a neutral third party for processing	0,323	0,413	0,304	

GeoFlow
Correlation matrix for behavioral intention and variables

	You would change your driving behavior if road pricing were to be introduced?	The majority of drivers would be positive about it	Most drivers would change their driving habits
I am interested in testing new technology			0,335
I think it's important to drive a car with the latest technology	0,201		0,380
What is your attitude towards the toll system in Trondheim?	0,414		
How fair do you consider the current toll system in Trondheim, with regards to price, location, and number of toll stations?			
What is your immediate attitude towards road pricing as a traffic-regulating measure, where drivers pay different amounts depending on the distance they travel	0,303		
Are you familiar with Norwegian privacy legislation?			0,459
Worried that personal data will be misused in the future.			
Trust in the government to safeguard my privacy			
Trust a trusted third party to protect my privacy			
Positive to the registration of personal travel data if it contributes to me being offered better services			
Positive to the registration of personal travel data if it contributes to a fairer road toll system			
How do you feel about the information related to GPS position only being processed locally in the car?	0,233		
How do you feel about the information related to GPS position being processed only by a third party?			
I expect that the technology will provide me with lower costs in testing		0,203	
I expect that the technology will provide me with lower costs in future implementation	-0,247		
I expect that the technology will make me more aware of the environmental impact of transportation		-0,201	
I expect that the technology I will be testing in the project to be reliable	-0,200		-0,207
I believe that drivers of zero-emission vehicles should pay the same as other drivers to use the road	0,212		
To what extent have you actively used the information in the app?			
To what extent did you use the information more actively at the beginning of the period?			
How often would you say that you have experienced that the equipment has startup problems that persist throughout the trip?			
How often would you say that you have experienced that the equipment has a slow startup before the app shows the correct position and follows the car?			
How often would you say that you have experienced that the app shows no contact with the ITS station?			
How often would you say that you have experienced that the app has contact with the ITS station, but the car appears to be stationary in the app?			
How often would you say that the app has unexpectedly shut down during driving?	-0,205		
How often would you say that the equipment has lost the GPS signal while you were driving?			

How often would you say that the equipment calculates an incorrect price?			
How often would you say that the equipment stops working during a trip?			
The GPS position information is processed locally only in the car? Meaning that calculations based on GPS position (such as distance driven in toll zones) are performed in the car, and only a summary of the trip is sent to a neutral third party.		0,256	
The GPS position information is processed by a third party? Meaning that the GPS positions recorded in the car are sent from the car to a neutral third party for processing			
Personal travel data is recorded if it contributes to better services being offered to me.		0,275	
Personal travel data is recorded if it contributes to a fairer toll system.		0,205	
Would you say that road pricing has helped you save money?	0,233	0,330	0,297
Would you say that road pricing has made you more aware of how much you drive and when and where you drive?	0,377		
Would you say that road pricing is more user-friendly than the current toll system in Trondheim?		0,235	
Would you say that road pricing is a fairer tax system than the current tax system?		0,362	
Do you think that road pricing would improve traffic management in cities if all drivers had the system installed in their vehicle?	0,570	0,345	0,460
Do you think road pricing would be a fairer tax system than the current tax system if all drivers had the system installed in their vehicle?	0,339	0,400	0,208
The prices vary with traffic load (highest price when traffic load is very high, lower price or no price when load is lower) is correct	0,453	0,285	0,346
4 kr per kilometer during rush hour is a fair price	0,509		0,270
3 kr per kilometer outside rush hour is a fair price	0,326	0,297	
Lack of environmentally friendly transportation options			0,410
Flexibility and availability		0,515	
Personal finance	-0,223		
Travel time		0,319	
Sense of safety			
Sense of comfort	-0,244		-0,283
you would find it more fair to pay for the distance driven (as in the test) than paying at toll booths (as today)?	0,414	0,351	0,226
The rush-hour pricing was more fair in the pilot than in the current toll system?	0,441	0,371	
You would change your driving behavior if road pricing were to be introduced?	1,000	0,258	0,702
The majority of drivers would be positive about it	0,258	1,000	0,247
Most drivers would change their driving habits	0,702	0,247	1,000
Har du/dere endret noe på reisevanene som følge av deltakelsen i GeoFlow?			
Consciousness of travel habits (less driving to limit costs and/or potential emissions)	0,585		0,405
Increased use of more sustainable transport modes (e.g. public transport, cycling, etc.)	0,428		
Information (e.g. about traffic jams, roadworks)	-0,214		
Payments (e.g. parking fees, studded tire fee)			
Information on emergencies (e.g. tunnel fires, traffic accidents)			
A system with a voluntary user interface in the car (as in the test)			
A system without the possibility of a user interface in the car (such as in the test but without the possibility of connecting with a phone), but where you could go into an app or website afterwards to see what information has been registered and transmitted		0,226	
A system with an integrated user interface in the car (such as in the test with a fixed screen attached to the equipment)A system with an integrated user interface in the car (such as in the test with a fixed screen attached to the equipment)	0,321		
A system integrated into the car (e.g. through an app in the center console)	0,500	0,234	0,230

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