

ACCEPTABILITY OF TRADABLE MOBILITY CREDITS IN THE METROPOLITAN REGION OF AMSTERDAM

“What a monstrous regulation !”

“It seems like a good idea to me, and I hope my answers will have some influence on it. ”

Anonymous 05/26

“What dystopian nonsense this is, emission credits that can be sold or bought. And then the government decides if I can go somewhere by public transport or if I’m allowed to drive? Or do I have to cycle or walk everywhere by force? Orwellian totalitarianism, totally absurd.”

Anonymous 05/26

“Live and let live. Everyone wants freedom, for some it’s the car, for others public transport. There shouldn’t be a system behind it, let alone a digital one.”

Anonymous 05/26

“ Interesting goals to make people aware of various possibilities. ”

Anonymous 05/26

ACCEPTABILITY OF TRADABLE MOBILITY CREDITS IN THE METROPOLITAN REGION OF AMSTERDAM

”WHAT A MONSTROUS REGULATION!”

by

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PREFACE

When I started my studies at the Graduate School of Civil, Environmental, and Urban Engineering in Lyon in 2022, I knew I was interested in transportation and climate policies, but I had no idea I would end up completing my studies here at TU Delft. The choice to move to the Netherlands was highly motivated by, first, the willingness to experience university life, which is quite different from French engineering schools, and to learn more about the bike infrastructure and car-restrictive neighborhoods. Some (or most) of my friends consider I can have strong opinions when it comes to imagining transport policies that could reduce GHG emissions, specifically the air travel and individual car ones. Thus, I am happy I found a subject I really enjoyed working on, as I believe it is societally relevant and relatable to many people.

This thesis is a result of six years of personal, academic and professional development and half a year of hard work with great supervision. I would like to thank Kuldeep and Maarten for their consistent, detailed feedback and input throughout the project, as well as for their incredible positivity. I also want to thank Gonçalo, my chair, for supervising this project and securing funding from the Metacaze Project (Grant number: 101139678). Overall, the enthusiasm of my supervisory team, given the topic's complexity and controversial nature, and their critical yet well-formulated advice were of great help.

Writing a thesis is not an easy task, thanks to everyone who has supported me, directly or indirectly, I have managed to fulfill it. I want to thank everyone who has been there for me in the past years, with specific shout-outs to my colleagues from the Thesis Rooms!

Juliette Massot,
17 August 2026

ABSTRACT

The transportation sector is a major source of greenhouse gas emissions in Europe, with road transport being the largest contributor. To achieve low-carbon urban mobility, restrictive Travel Demand Management (TDM) measures, such as Tradable Mobility Credits (TMCs), are essential. TMCs aim to internalize transport externalities by allocating free credits to users, which are consumed based on travel behaviour. However, their public acceptability, particularly how scheme design influences perceptions of fairness, effectiveness, and freedom, remains understudied.

This study addresses this gap by conducting a rating experiment with 803 respondents from the Metropolitan Region of Amsterdam (MRA). Using Structural Equation Modeling (SEM), we analyze how TMC scheme characteristics: credit allocation, users of credits, transferability/validity of credits, and trading market regulations affect acceptability, mediated by perceptions of fairness, effectiveness, and freedom. We also examine the role of individual characteristics (sociodemographics and travel behaviour) and attitudinal factors in shaping these perceptions and acceptability.

Results show that accessibility-based credit allocation and inclusive user eligibility enhance perceived fairness and acceptability, while credit expiration reduces them. Environmental responsibility, emerges as a strong predictor of acceptability, followed by perceived fairness and effectiveness. Individual characteristics, such as age and public transport subscription, also play a significant role, with older individuals and those without PT subscriptions exhibiting lower acceptability.

This study empirically validates the influence of TMC design characteristics, attitudinal, and individual factors on public acceptability. Findings suggest policymakers should prioritize fairness and awareness campaigns to improve TMC acceptability while addressing concerns about personal freedom and equity.

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INTRODUCTION

1.1. CONTEXT

People have always been on the move, whether for work, leisure, or other reasons. Over the centuries, through industrial revolutions, both transportation modes and their infrastructures have evolved, becoming more accessible and enabling people to cover ever-longer distances in less time. However, these benefits come with negative impacts on biodiversity and human health (Rodrigue, JP., 2017). The transportation sector is the largest source of greenhouse gas (GHG) emissions in Europe and one of the few sectors where emissions have not decreased, with road transport accounting for the highest proportion (Earl, 2024). In 2023, GHG emissions from road traffic in the Netherlands were 4% higher than in 2022, reaching 25.7 Mt of CO₂-eq despite the increase in electric vehicle sales. Passenger cars accounted for 58% of the road traffic emissions (de Haas et al., 2025). To reduce the negative externalities of transportation, particularly those caused by individual cars, such as traffic congestion, air pollution, and the occupation of public space, Transport Demand Management (TDM) strategies need to be implemented (Jaramillo et al., 2022). These strategies are often categorised in two groups: pull and push measures. Pull measures include strategies that promote sustainable travel and make it attractive. While push measures are applied to change people's behaviour by explicitly making their current behaviour more difficult. Given the need for immediate emission reductions (Jaramillo et al., 2022), push (or restrictive) measures are seen as indispensable to achieve low carbon mobility (Jaramillo et al., 2022; Thaller et al., 2023).

1.2. PROBLEM DEFINITION

Notable push measures, designed to reduce congestion and air and noise pollution, are road and congestion pricing. For these measures, road users traveling in a specific area are levied a fee, effectively paying for the externalities they impose on society. Cities such as Singapore, London, Milan, and Stockholm have implemented congestion pricing to reduce the negative externalities of road transport. In all four cities, traffic and its related emissions have decreased, illustrating the effectiveness of such instrument (Li & Robusté, 2021). However, these schemes are yet to be widely implemented, with one of the main obstacle being public acceptance. Several reasons explain their low acceptability. For instance, these measures can create inequalities for populations living in different urban areas, depending on their level of access to public transport or non-motorised infrastructure. Moreover, low-income road users are directly disadvantaged compared to high-income users, especially if the revenues generated by these schemes are not reinvested to improve access to public transportation (Li & Robusté, 2021).

A solution to tackle the issues raised by congestion and road pricing is Tradable Mobility Credits (TMC) (Li & Robusté, 2021; Provoost et al., 2023; Wadud, 2011). TMCs are a novel travel demand management (TDM) instrument not yet implemented. According to most researchers and experts in the transportation field, the concept of TMC is technically possible to implement, but some of its characteristics can be seen as challenging, as they could reduce public support for such a measure (Hamm et al., 2025; Krabbenborg et al., 2021b). Several concepts of TMC exist, following a similar structure to the polluter pay principle. TMC schemes aim to internalise the external costs of transports based on its specific intensity. With a TMC scheme, travellers consume credits according to their use of the transport system. After receiving an initial free allocation of mobility credits, travellers use them when travelling and can also trade them with other users in a dedicated marketplace. The resulting market mechanism ensures that credits flow towards heavy users, while light users, or those who use more sustainable alternatives, can benefit from the scheme by selling their surplus credits (Provoost et al., 2023). Figure 1.1 provides a visual explanation of a TMC scheme, highlighting its main stakeholders.

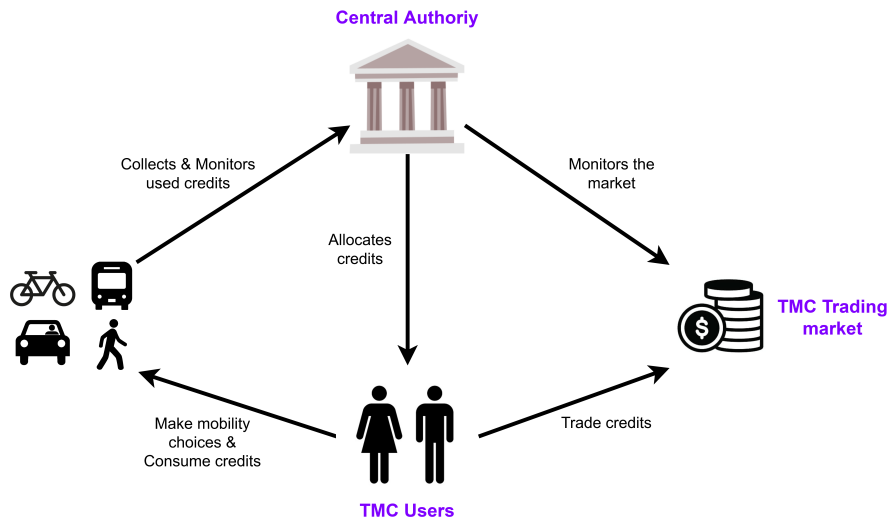


Figure 1.1: TMC global scheme

Different characteristics of TMC schemes can address some of the issues associated with road and congestion pricing. For example, an initial free allocation of credits enhances the political acceptability of the scheme (Wadud, 2011) as users with lower externalities can potentially earn money by selling their unused credits. The scheme can also be designed to be budget-neutral, with monetary transfers occurring only between users (Li & Robusté, 2021; Wadud, 2011), meaning that the government or the authority in charge only plays a regulatory role. Another advantage of such an instrument is its transparency: users can directly access information about their transport use and related externalities, creating incentives to use sustainable transports. With a TMC scheme, users can be nudged by comparing their individual environmental performance with that of others (Servatius et al., 2022). Still, having a limited amount of credits to perform trips can be seen as an infringement on one's freedom of movement (Krabbenborg et al., 2021b). Moreover, such an instrument would require tracking of individual travel behaviour, which could raise privacy and security-related concerns (Provoost et al., 2023).

TMCs can be regarded as a challenging instrument to implement. Their introduction in urban areas would help reduce transport externalities, addressing some of the equity concerns raised by other pricing policies (Li & Robusté, 2021; Provoost et al., 2023; Wadud, 2011), but they rely on the collection of private data and possibly limit people's travel. Implementing such a scheme is technically and economically feasible; however, it requires strong public support (Dogterom et al., 2018a; Krabbenborg et al., 2021a). Moreover, defining eligible

users, trading rules, and credit allocation mechanisms remains challenging (Albano et al., 2025; Hamm et al., 2022; Lessan & Fu, 2022; Wadud, 2011).

1.3. IDENTIFICATION OF KNOWLEDGE GAP

TMCs remain a largely theoretical concept, with only two real-world experiments (Brands et al., 2021; Geng et al., 2023). Research on the topic has mostly focused on specific designs, and user and market equilibrium (Dogterom et al., 2017; Lessan & Fu, 2022). The literature concerning public acceptability of TMCs remains scarce, with most studies defining different TMC schemes to achieve different purposes (Albano et al., 2025; Dogterom et al., 2017; Hamm et al., 2022).

Dogterom et al. (2018a) investigated the acceptability of a kilometre-based Tradable Driving Credit (TDC) scheme for car commuters in the Netherlands and China, with only 22% of Dutch participants finding TDC acceptable.

Krabbenborg et al. (2021b) explored Dutch public support for Tradable Peak Credits (TPC), highlighting the importance and influence of different scheme design characteristics. Cui et al. (2024) and Tian et al. (2024) also examined the acceptability of a TPC scheme in Beijing without specifying its characteristics.

More recently, Hamm et al. (2025) discussed the effectiveness of implementing a TMC scheme, called the Mobility Coin system, in Munich, mostly focusing on the distributional aspect of the scheme: how are credits allocated to users.

While the distributional aspect of TMC is regarded as crucial, most existing schemes assume uniform credit allocation and focus on car users as eligible recipients (Cui et al., 2024; Dogterom et al., 2018a; Krabbenborg et al., 2021b; Tian et al., 2024). Moreover, empirical studies focusing on the influence TMC schemes characteristics on public acceptability remain sparse. Specifically, there is a gap in understanding how scheme characteristics influence perceptions, that in turn shape acceptability of TMCs. Moreover, studies examining the interaction between perceptions and acceptability with other individual factors, such as socio-demographics, travel behaviour and attitudes remains limited. Although some studies (Cui et al., 2024; Hamm et al., 2025; Krabbenborg et al., 2021b) have begun to explore these dimensions, they often isolate specific aspects of TMCs or focus on narrow contexts.

1.4. RESEARCH QUESTION AND SUB-RESEARCH QUESTIONS

As argued previously, the combined influence of: scheme characteristics and individual characteristics and attitudes, on perceptions of TMC schemes and acceptability remains underexplored. Yet, the presence of sufficient public acceptability plays an essential role in the implementation of restrictive transport policies such as TMCs. Therefore, this study will investigate the effect of different factors on the acceptability of TMC schemes. The main research question of this study is as follow:

What scheme design characteristics and individual characteristics influence the perceptions and public acceptability of Tradable Mobility Credits (TMC) ?

To answer, the main research question, the following research questions will be addressed:

1. What design characteristics of TMC schemes emerge as key from the literature?
2. According to the literature, which factors are the most influential in shaping the acceptability of TMC schemes?
3. How do different TMC scheme characteristics influence the perceived fairness, freedom, and effectiveness of such an instrument?

4. How do these perceptions mediate the relationship between TMC scheme characteristics and acceptability?
5. To what extent do factors such as attitudes, sociodemographics, and travel behavior variables influence the acceptability of TMCs?
6. Which characteristics of TMC schemes are most critical for the future design of such an instrument?

1.5. GEOGRAPHICAL SCOPE

It is assumed that TMCs would most likely be implemented in a large city, as congestion problems, as well as air and noise pollution, are worst in urban areas. Moreover, cities could reduce some of the transport negative externalities, specifically transport-related fuel consumption, by introducing a combination of TDM measures and less car-dependent transport infrastructure (Jaramillo et al., 2022). For this thesis, participants were sampled from the Metropolitan Region of Amsterdam (MRA) in the Netherlands.

The Metropolitan Region of Amsterdam (MRA) is the city region around the municipality of Amsterdam and is home to nearly 2,500,000 inhabitants (Metropoolregio Amsterdam, n.d.). It encompasses the city of Amsterdam as well as 36 municipalities within the two provinces of North Holland and Flevoland. The MRA can be divided into seven areas: Amsterdam, Zuid-Kennemerland, Almere-Lelystad, Amstelland-Meerlanden, IJmond, Zaanstreek-Waterland, Gooi en Vechtstreek (see Figure 1.2). Amsterdam is the capital and the largest city of the Netherlands. The city in itself has a population of almost 950,000 (Gemeente Amsterdam, 2024). The municipality of Amsterdam is divided into seven districts: Center, New West, North, East, West, South and Southeast.

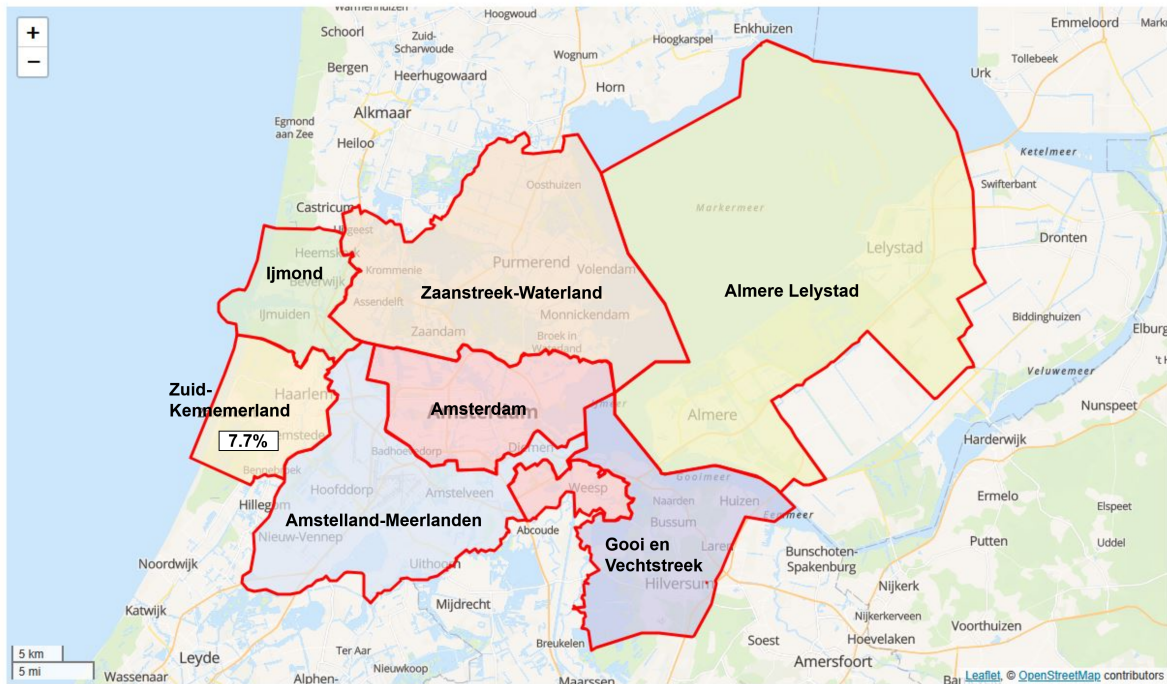


Figure 1.2: Map of the Metropolitan Region of Amsterdam (Metropool Regio Amsterdam, 2026)

1.6. THESIS OUTLINE

Chapter 2 reviews existing research on TMCs, identifying their scheme design characteristics and the factors influencing their acceptability. Chapter 3 presents the conceptualisation of the causal model, describing the three categories of factors affecting acceptability and the hypothesized causal relationships between them. Chapter 4 outlines the methodology, including the survey design with the rating experiment and the analytical methods used in this study. Chapter 5 presents the survey results, while Chapter 6 presents the estimated model. Next, Chapter 7 identifies key characteristics of TMC schemes for future implementation. Finally, Chapters 8 and 9 conclude the study by drawing conclusions, discussing scientific and practical limitations, and offering recommendations for future research.

Table 1.1 provides an overview of the methods employed to answer each of the research questions.

RQ: What scheme design characteristics and individual characteristics influence the perceptions and public acceptability of Tradable Mobility Credits (TMCs)?

Sub research questions:	Method(s)
1. What design characteristics of TMC schemes emerge as key from the literature ?	Literature review
2. According to the literature, which factors are the most influential in shaping the acceptability of TMC schemes ?	Literature review
3. How do different TMC schemes characteristics influence the perceived fairness, freedom and effectiveness of such an instrument ?	General findings, SEM
4. How does these perceptions mediate the relationship between TMC schemes characteristics and acceptability ?	Literature review, SEM
5. To what extent factors such as attitudes, sociodemographics and travel behaviour variables influence acceptability of TMCs ?	General findings, Literature review, EFA, SEM
6. Which characteristics of TMC schemes are most critical for the future design of such an instrument?	General findings, Literature review, SEM

Table 1.1: Research questions and methods

Purple box

Provides the answer to a sub research question.

Red box

Provides a summary of an important section and key insights that need to be remembered.

Blue box

Description of TMC schemes (mostly used in the literature review Chapter 2).

2

LITERATURE REVIEW

2.1. CHARACTERISTICS OF TMC SCHEMES

In a study published in 2013, Fan and Jiang were the first to provide a comparative summary of different tradable permits (TMP) and credit schemes (TMC) for mobility, evaluating them with respect to three key aspects: delineation (how permits are measured and their validity), initial endowment (how permits are allocated to eligible users), and implementation (how permits are collected, verified, and traded). In TMC schemes, users receive a set number of credits, which are deducted as they use transport infrastructure. These credits can be traded, enabling a market-driven allocation. In contrast, TMP schemes require users to acquire permits to use specific roads or links in advance, often aiming to cap demand to match network capacity. Unlike credits, permits are finite, as they are designed to prevent travel demand from exceeding capacity, thereby eliminating traffic congestion (Lessan & Fu, 2022). Permit-based schemes are beyond the scope of this study. Fan and Jiang emphasise that the success of TMPs and TMCs is highly dependent on design characteristics, technological feasibility, and public support. Moreover, they argue that these schemes should be tailored to specific policy goals and local conditions. More recently, Lessan and Fu (2022) also reviewed the state-of-the-art in TMPs and TMCs. From their analysis, they demonstrated that TMC schemes are promising tools for sustainable mobility management. However, they emphasised that scheme characteristics must be carefully designed to avoid equity and fairness issues (Lessan & Fu, 2022).

Design characteristics of TMCs were recently described in a study by Provoost et al. (2023). TMC schemes are defined using a three-dimensional framework, similar to that proposed by Fan and Jiang (2013). This framework includes: an ownership dimension (how credits are held, recorded, and allocated); a transfer dimension (how credits are exchanged between users); a consumption dimension: how credits are spent by users.

2.1.1. OWNERSHIP DIMENSION

CREDIT ALLOCATION

Different allocation strategies have been explored in previous studies. The most common approach is uniform allocation: all users receive the same amount of credits at the beginning of the validity period. While this approach would likely lead to higher trading activity and market liquidity, since users would need to trade to meet their travel needs (Provoost et al., 2023; Servatius et al., 2023), it may be unfair to low-income users or those with high driving demand (Hamm et al., 2022; Krabbenborg et al., 2021b; Li & Robusté, 2021). An alternative approach is a demand-based or origin-destination (O-D) specific distribution, where credits are allocated according to historical or expected travel demand. This method could enhance the scheme's effectiveness and efficiency (Fan & Jiang, 2013; Lessan & Fu, 2022; Li & Robusté, 2025). Focusing on mobility permits (TMP),

Candia and Verhoef (2022) showed that it was preferable to allocate permits taking into account the spatial setting to optimise the impacts of the scheme, as the market distortion is spatially differentiated. Another approach is allocating credit based on income: people with lower income would get more credits than people with high income, to reduce inequalities among users. A different approach is to base the initial allocation of credits on accessibility: giving more credits to individuals living in areas with fewer transport options. Millonig et al. (2022) as well as Hamm et al. (2022) also argue that the initial allocation of credits should be a combination of accessibility and socio-economic factors. Apart from uniform allocation, more sophisticated allocation strategies implies that the authority will need to gather more individual and personal data which could raise privacy concerns. Moreover, the public opinion on allocation strategies is heterogeneous. In a study focusing on Tradable Peak Credits (TPC), Krabbenborg et al. (2021a) showed that people prefer a uniform distribution of credits compared to an income based one. In contrast, results from Hamm et al. (2025) show that most participants of their survey support a non-uniform credit allocation.

CREDIT ALLOCATION FREQUENCY

The credit allocation frequency is often unspecified in the literature. According to various authors, this feature of a TMC scheme could influence travelers' mobility and market behaviour (Albano et al., 2025; Servatius et al., 2023). A monthly distribution might encourage users to plan trips in advance to avoid running out of credits when needed. When specified, monthly distribution is the most common credit allocation frequency in the literature. Krabbenborg et al. (2021b) explored both weekly and monthly allocation methods in their study with monthly allocation being the preferred one. In a field experiment involving parking credits, participants were receiving credits at the beginning of each week (Brands et al., 2021) and could trade them during the entire week (5 working days). In another study, Chen et al. (2023) adopted a continuous time approach wherein credits are provided at a certain rate over the entire day. While a shorter interval may create more administrative hassle, requiring users to trade credits daily, it could also increase effectiveness, as authorities could adjust the system's cap more frequently. In 2010, Bristow et al. (2010) studied Personal Carbon Trading (PCT), a scheme requiring participants to use carbon permits for purchasing and consuming energy. For this scheme, not only focusing on mobility, the authors choose a yearly allocation of permits.

USERS OF THE CREDITS

Li and Robusté (2025) evaluated the advantages and disadvantages of different user definitions, considering equity, effectiveness, and cost. They identified six types of eligible recipients for a TMC scheme: vehicles, vehicle owners, drivers, workers, taxpayers and adult residents. According to the researchers, if the goal is to reduce car use, driver-based allocation offers the most balanced approach in terms of equity, effectiveness, and cost. Still, focusing only on car drivers, would exclude other road users, using sustainable transportation modes, from enjoying the benefits of such a system. The authors recommend against limiting eligibility to only workers or only taxpayers, as this could significantly reduce the scheme's acceptability, given that many other transport infrastructure users also contribute to transport externalities. Allocating credits to the entire adult population of an area provides the highest level of vertical equity since all users are treated equally. However, this approach may disadvantage users with high driving demands under a uniform allocation system. Authors suggest that future research could build on their findings to explore how user selection influences market behaviour, equilibrium outcomes, and the long-term effectiveness and acceptability of a TMC scheme. However, most studies focusing on the acceptability of TMC schemes have been using a car drivers for TMCs user as identified in the Table B.1 in Appendix B.

2.1.2. TRANSFER DIMENSION

CREDIT VALIDITY

The literature mentions various validity periods for credits. In their study on public support for Credit-Based Congestion Pricing (CBCP), Kockelman and Kalmanje (2005) proposed that credits could not be carried over from one period to the next; instead, users would receive cash for any remaining travel credits at the end of each period. Servatius et al. (2022) defined the Mobility Coin system, in which users can monetise their remaining credits by selling them to the agency in charge or spending them on transport-related investment projects. In another study, Servatius et al. (2023) suggested that setting an expiry date for credits would increase trading activity among users, thereby enhancing market liquidity. Chen et al. (2023) also argue that an expiry date would also spur speculation. In the study on PCT (Bristow et al., 2010), the authors proposed a permit lifespan of either one or five years, allowing credits to be transferred from a period to another.

MARKET REGULATION

Researchers and experts on the topic disagree when looking at possible market regulation for credit trading. The market regulation aspect of a TMC scheme is an important point as a limitation of credit purchases could be seen as an interference with the right to move (Hamm et al., 2022). However a lack of limitation could also lead to over-buying credits, creating a lack of possible market liquidity as the volume of trades would not be large enough (Servatius et al., 2023). Provoost et al. (2023) and Servatius et al. (2023) suggest implementing transaction fees to combat excessive speculation: it would discourage users from trading unless they actually need credits for their mobility needs. In their study on TMC market design, Chen et al. (2023) argue that credit purchase should be limited to prevent undesired speculation. They suggest that travelers should only be able to buy credits when they wish to travel and are short of credits. In their field experiment, Brands et al. (2021) and Geng et al. (2023), defined a system in which users could not buy more credits from the platform than they could use themselves to avoid undesirable speculation.

2.1.3. CONSUMPTION DIMENSION

CREDIT MEASUREMENT UNIT

Defining the measurement unit in a TMC scheme involves specifying what the credits represent or entitle users within the system (Hamm et al., 2025). First, the charging mechanism can either be uniform: credits are consumed at a fixed rate, independent of travel behaviour, or, based on different parameters: spatial, temporal, modal or personal. In the spatial dimension, credits can be charged based on usage within a specific area (Dogterom et al., 2018a) or per road segment (Cui et al., 2024; Krabbenborg et al., 2021b; Tian et al., 2024). For the temporal dimension, credit charges can be static: remaining fixed over time (Dogterom et al., 2018a), or dynamic: varying according to the time of day, week, or other circumstances (Kockelman & Kalmanje, 2005). In the modal dimension, credit charges can also depend on the mode of transport used (Servatius et al., 2022). According to Provoost et al. (2023), a mode-dependent charging mechanism offers policymakers and authorities greater flexibility to influence travel behaviour. The measurement unit for TMCs can vary depending on the scheme's objectives. A common approach is to quantify credits by vehicle-kilometres travelled, as in the study by Dogterom et al. (2018a), which is considered relatively straightforward to implement (Hamm et al., 2025). Alternatively, credits can be expressed in terms of CO₂ emissions (Servatius et al., 2022). Still, calculating per-capita CO₂ emissions for a trip requires accounting for multiple factors, such as trip duration, speed, vehicle emission specifications, and vehicle occupancy.

REGISTRATION OF CONSUMPTION

How credit consumption is registered is often not specified in details in studies focusing on TMC scheme design and acceptability. According to Provoost et al. (2023), as the charging system becomes more refined, they

require more precise tracking of individual travel behaviour. This raises privacy and security concerns which would affect public support for such an instrument. To charge travelers based on their actual travel behaviour, data about their trips must be recorded. For area-based schemes, trip data could be registered using automatic number-plate recognition. However, this approach would require expensive road-side infrastructure and may become inefficient when high granularity is required. An alternative approach would be GPS tracking at the vehicle level (e.g., via onboard devices) or the individual level (e.g., via smartphones). While, accessing data via a smartphone could provide more flexibility and details across different modes of transport it also involves collecting privacy-sensitive data. For public transport, an alternative method to smartphone use could involve the use of public transport smart cards (Provoost et al., 2023).

2.2. ACCEPTABILITY OF TRADABLE MOBILITY CREDIT SCHEMES

Several studies have examined the acceptability and public perception of TMCs. Most of these studies explore different schemes across various geographical regions, employing diverse methods to evaluate their acceptability. Table B.1 in Appendix B provides an overview of their design characteristics using an adapted framework from Provoost et al. (2023).

One of the earliest studies in this field was conducted by Kockelman and Kalmanje (2005), who evaluated the acceptability of a Credit-Based Congestion Pricing (CBCP) scheme. In their scheme, credits were allowances used to pay tolls. Unlike the TMC definition proposed by Provoost et al. (2023), their scheme did not allow users to trade credits. In their experiment, a survey of Austin residents revealed that 25% of participants supported the scheme. Privacy concerns were found to be less significant compared to other factors, such as equity. The survey results also indicated that travel experiences, individual characteristics, and household attributes were key determinants of acceptability. Additionally, higher-income respondents tended to view the CBCP more favourably than others.

Credit-Based Congestion Pricing (CBCP)

Drivers receive a monthly allowance of monetary travel credits, to use on the roads. Time- and link-varying prices recognize variable demands and their associated negative externalities. Drivers do not pay money "out of pocket" unless they exceed their allowance. Drivers spending less than their limit can use the credits later or exchange them for cash. Budgets would be only be allocated to registered vehicle owners, with no more than one budget allowance per person. Cashing out or accumulating credits will not be an option (Kockelman & Kalmanje, 2005).

2.2.1. ACCEPTABILITY OF TRADABLE DRIVING CREDITS (TDC)

Tradable Driving Credits (TDC)

The government allocates driving credits to combat congestion. Individual car drivers would receive a budget that contains a certain number of kilometers. Car drivers can drive these kilometers without paying an additional fee and buy additional credits in a market (Dogterom et al., 2018a).

More recently, Dogterom et al. (2018a) evaluated the acceptability of Tradable Driving Credits (TDC) in the Amsterdam region and Beijing. Authors used a survey with a choice experiment to investigate the acceptability of TDC and changes in car use behaviour among car commuters. Participants were asked to report their car trips and were presented with different TDC scenarios, each featuring varying levels of free credits and credit values to simulate surplus or shortage situations.

Analysing the data from both countries, the authors found that acceptability of the scheme was higher in Beijing (67%) compared to the Netherlands (22%). The acceptability level in the Netherlands was similar to that identified by Kockelman and Kalmanje (2005) in Austin. According to Dogterom et al. (2018a), this difference can be attributed to higher congestion levels in Beijing and the presence of existing restrictive TDM policies. In both countries, perceived effectiveness in reducing congestion and perceived fairness emerged as the dominant predictors of TDC acceptability. Additionally, in both urban areas, higher-income individuals found TDC more acceptable, aligning with the findings of Kockelman and Kalmanje (2005).

Focusing on the Netherlands, the results of the stated preference experiment suggested that the magnitude of the reduction in car use was influenced by working hours, car dependency, and residential density (Dogterom et al., 2018b). However, the study did not explore psychological factors, such as social norms and trust in government, which could further influence acceptability.

2.2.2. ACCEPTABILITY OF TRADABLE PEAK CREDITS (TPC)

Tradable Peak Credits (TPC)

The credits are distributed free of charge and people can use these credits to drive in peak hours. The number of available credits depends on the capacity of the area. The government administers the system. Driving a car during peak hours (Monday to Friday, 07:00–09:15 and 16:00–18:15) costs a peak credit on all highways and provincial roads in a specific urban area. Credits are not needed outside of the urban area and outside peak hours. If people have more credits than they need, they can sell them to people who want more credits using an online trading platform. Users cannot buy more credits from the platform than they can use themselves. When people register their car, the credits will be automatically redeemed from their ‘credit budget’ when they use the road(s) during peak hours. People who have not registered their car (e.g. visitors) can buy credits for single-use for a number of days (online or at a gas station) (Krabbenborg et al., 2021b).

Krabbenborg et al. (2021b) examined public support for TPC in the Netherlands, focusing on how scheme design, personal characteristics, and attitudes influence acceptability. Participants evaluated different Tradable Peak Credits (TPC) schemes, which varied across four key characteristics: eligibility for free credits, distribution principle, credit allocation interval and credit price fluctuation. The results revealed that support for the schemes ranged from 32% to 52%, depending on the design, which is higher than the levels reported by Kockelman and Kalmanje (2005) and Dogterom et al. (2018a). The most supported scheme distributed credits monthly and equally to residents and employees who own cars, with credit prices fluctuating daily. The least supported scheme allocated credits weekly, prioritised lower-income users, and featured prices that fluctuated every minute. The authors highlighted that preferences for different credit allocations were highly heterogeneous, warranting further exploration. Their findings also underscored the importance of attitudinal variables, such as expected effectiveness, perceived infringement on freedom, and perceived fairness, in explaining support, consistent with the results of Dogterom et al. (2018a).

In 2024, Cui et al. and Tian et al. investigated the acceptability of TPC in China, employing different theoretical frameworks: the Theory of Planned Behaviour (TPB) and the Norm Activation Model (NAM), respectively. Cui et al. examined the relationships between TPB components: attitudes toward the behaviour, subjective norms, and perceived behavioural control, and their influence on acceptance and behavioural intention. Using Latent Profile Analysis (LPA), they categorised participants into distinct groups based on their attitudes toward TPC. Their findings confirmed that subjective norms and attitudes toward TPC significantly impact acceptance, alongside perceived effectiveness and equity. The LPA results revealed that the weak rejection group was the largest (44.3%), with younger individuals and those from urban areas more likely to support

TPC, while low-income individuals and car owners were more inclined to reject it. In their study, Tian et al. (2024) explored the relationships between NAM components: awareness of consequences, ascription of responsibility, and personal norms and their effects on perceived effectiveness, attitudes, and behavioural intentions. Their results indicated that personal norms were a strong predictor of positive attitudes toward TPC. Consistent with previous research, they found that TPC was more likely to be accepted if individuals perceived it as effective and fair, particularly when credit distribution was tailored.

2.2.3. ACCEPTABILITY OF MOBILITY COINS

Recently, researchers from the University of Munich developed a TMC scheme called the MobilityCoin system, which introduces a novel feature: users can earn additional credits from bike trips (Servatius et al., 2022). Unlike previous schemes, a dynamic price is assigned to each transport mode, based on factors such as distance, emissions, current traffic conditions, and space occupancy.

Mobility coins

Every citizen over 18 years old receives, at no charge, a monthly mobility budget consisting of Mobility-Coins. With this budget, users pay for the negative effects of their daily trips. The operational costs of a mode (fueling, maintenance, tickets, etc.) are paid independently of the mobility budget. An average mobility budget will cover the price of the negative effects of a daily round trip by public transport in the city area. Car trips are more expensive than public transport trips, for example, due to more space requirements and generated emissions. For bike rides, it is possible to earn a small amount of extra coins. As a pedestrian, it is not possible to earn coins as this would require digital tracking of all pedestrian trips. If users do not use their entire budget, they can sell their coins and earn money. Conversely, if their mobility budget is exhausted (e.g., due to frequent car trips), they have the option to purchase additional coins on the market platform (Servatius et al., 2022).

The feasibility and acceptance of the TMC scheme were evaluated through interviews with experts from various fields (Hamm et al., 2022). While the scheme was generally well received, interviewees identified data privacy concerns (due to GPS tracking) and user effort as the most critical barriers to social acceptance. Experts recommended regional-to-national-level enrolment, as restricting the system to city borders would exclude commuter flows and fail to account for all external costs. They also emphasised the importance of the budget allocation function, proposing three key parameters for credit allocation: degree of mobility impairment, accessibility, location of work and residence.

A large-scale stated-preference experiment conducted in Munich examined trade-offs between travel time, internal and external travel costs, and other level-of-service attributes within the MobilityCoin system. The results demonstrated that the TMC scheme led to a 5–10% reduction in car use, with the most significant shifts occurring for work and education trips (Álvarez-Ossorio Martínez et al., 2025). In addition to analysing traveler behaviour under the TMC, Hamm et al. (2025) used the survey to assess public support for different credit allocation strategies. Their findings revealed that nearly 70% of respondents preferred a non-uniform allocation of credits, prioritising factors such as mobility impairment, care work responsibilities, and accessibility. Looking at sociodemographic characteristics, their results showed that opposition was marginally higher with increasing age, while women as well as participants with higher education were slightly more supportive of non-uniform budgets. Moreover, they identified a clear relationship between support for TMC and participants who are frequent public transport and bike users, as well as low support from participants with high car use levels. In addition to individual attributes, having a strong climate change awareness was positively related to higher support for non-uniform allocation.

2.2.4. REAL-WORLD EXPERIMENTS

The first real implementation of a restrictive instrument close to TMC were conducted in the Netherlands and China. In the Dutch case, Brands et al. (2021) carried out an 8-week experiment involving 65 employees from a company in The Hague. The study used Tradable Parking Permits (TPP) to allocate scarce parking resources.

Tradable Parking Permits (TPP)

Every participant receives a trading budget at the beginning of the week. The number of P coins a participant receives is based on the number of working days defined in its contract and can vary from 0 to 2. The permit trading market is designed to reduce the number of parking movements, thus the total number of permits distributed per week was brought to 80% of the parking demand to encourage trading. Participants could trade their P coins within a developed application at the then current P coin price, which varied over time depending on scarcity conditions (Brands et al., 2021).

The results indicated that active participants adjusted their behaviour in response to the scheme: participants who were actively trading permits reacted by parking 15% less. Both active and passive participants perceived the Pcoins system as fairer and more functional than traditional parking allocation methods. However, the participants were highly educated employees of a single organisation, not representative of the general public.

In China, Geng et al. (2023) conducted a 2-week field experiment with 91 students in Beijing, using tradable permits for rush-hour breakfasts, similar to TPC. Their findings revealed that factors such as residential location, class schedules, and flexibility in departure time influenced how participants responded to the scheme. The authors suggested that future studies should explore whether specific permit allocation methods could further enhance effectiveness. Additionally, participants' decisions were significantly shaped by their initial permit allocation, underscoring the importance of this scheme characteristic. Overall, 79% of participants viewed the scheme as fair and expressed willingness to accept a permanent TPC system.

Both experiments provide evidence that tradable credits or permits can effectively reduce congestion in a fair and flexible manner and incentivise users to change their travel behaviour.

1. What design characteristics of TMC schemes emerge as key from the literature ?

The literature on TMC schemes highlights three design dimensions: ownership, transfer, and consumption. Within the ownership dimension, the initial free credit allocation is a critical characteristic as well as the definition of eligible user. As both can directly impact trading market liquidity, administrative burden and equity. The transfer dimension focuses on how credits are exchanged and managed over time. Credits can be designed to expire, encouraging trading between user. Credits can also be transferred or monetised at the end of the month nudging individuals' travel behaviour but possibly introducing speculative behaviour. Debates are centered on whether to impose limitations or transaction fees on credit purchases or allowing a completely free market. The consumption dimension, focuses on how credits are held and measured. The measurement unit of credits can take multiple forms, from only kilometer based, to peak-hour based or vehicle emission based. Each approach offers different levels of targeting but they also vary in terms of complexity and data requirements raising privacy concerns.

3

CONCEPTUALISATION

This section outlines three categories of factors influencing the acceptability of TMC schemes: scheme characteristics, sociodemographic and travel behaviour characteristics, and attitudes. It then presents the hypotheses on causal relations between each of these factors and acceptability and the conceptual model designed to address them.

3.1. FACTORS INFLUENCING ACCEPTABILITY OF TMC SCHEMES

3.1.1. SCHEME DESIGN CHARACTERISTICS

The characteristics of TMC schemes play a role in shaping public acceptability. Variations in TMC scheme characteristics directly influence how users perceive and respond to them (Brands et al., 2021; Geng et al., 2023; Krabbenborg et al., 2021b; Provoost et al., 2023). Credit allocation strategies influence the fairness and effectiveness of a TMC scheme: uniform allocation may enhance market liquidity but can disadvantage low-income or high-demand users (Hamm et al., 2025; Krabbenborg et al., 2021a). Conversely, non-uniform allocation strategies can address equity issues but raise privacy concerns due to the need for detailed personal data (Cui et al., 2024; Millonig et al., 2022). Studies reveal conflicting preferences: while Krabbenborg et al. (2021b) found support for uniform distribution, Hamm et al. (2025) observed a preference for non-uniform allocation, highlighting the need to align design with user expectations.

The frequency and validity of credit allocation also matter. Options like credit monetisation or transferability can affect user behaviour and market dynamics. Moreover, market regulation, such as purchase limits or transaction fees, can prevent speculation but may restrict mobility freedom (Servatius et al., 2023). Defining eligible recipients is another critical factor, as excluding certain groups may reduce support (Krabbenborg et al., 2021a; Li & Robusté, 2025). Thus, to explore the acceptability of TMC schemes, four key attributes have been identified: credit allocation, credit recipients, credit transferability/validity, and market regulation.

The different credit units identified in the study by Provoost et al. (2023) were not explored in the rest of the study, as a TMC scheme is designed to reduce transport negative externalities, the credit consumption unit is fixed to the negative effects of trips similarly to what was done by Hamm et al. (2025). Moreover, as most studies on TMC define a one month period, this scheme characteristics was also fixed for this study resulting in the following TMC scheme:

Global Tradable Mobility Credits scheme

- Every month, the government would allocate a certain number of free mobility credits to each individual living in a specific urban area. These credits would be used to pay for the negative effects of their trips, such as congestion, air and noise pollution, and space occupation.
- Car trips require more mobility credits than public transport trips due to more space occupation and generated emissions. Active modes like walking and cycling do not require spending any credits.
- If users do not use all their mobility credits, they can sell their surplus on a trading platform to earn money. Conversely, if they exhaust their credits before the end of the month, they can purchase additional credits to continue travelling.
- The credit price on the platform is determined by demand and supply.

3.1.2. SOCIO-DEMOGRAPHIC AND MOBILITY BEHAVIOUR CHARACTERISTICS

Acceptability of TMC is influenced by socio-demographic factors (e.g., age, income, urban/rural residence) and mobility behaviour (e.g., car dependency, travel frequency, trip purpose). Early studies (Dogterom et al., 2018a; Kockelman & Kalmanje, 2005) showed that higher-income individuals and urban residents tend to support TMC more, while low-income and car-dependent groups are often more resistant. Mobility behaviour, such as working hours, car dependency, and residential density shapes how individuals respond to TMC schemes (Dogterom et al., 2018b; Krabbenborg et al., 2021b). In studies by Cui et al. (2024) and Tian et al. (2024), younger, urban individuals were more supportive, whereas car owners and low-income groups were more likely to reject TMC. In recent experiments conducted in the Netherlands and China, participants' acceptance of tradable schemes was influenced by their residential location and travel flexibility (Brands et al., 2021; Geng et al., 2023). Thus, including socio-demographic and mobility behaviour variables is crucial for studying the acceptability of TMC, as they help explain differences in public support.

Not focusing specifically on TMCs, Moeinaddini et al. (2026) showed that socio-demographic and travel behaviour characteristics influenced attitudes and perceptions of the TDM policy packages (cordon and parking pricing). Their results indicate that households with higher car values as well as older commuters perceived TDM policies as restrictive to their freedom. Moreover, their results also showed that gender could influence the perceived fairness of TDM policies, with female respondents being more likely to perceive these policies as unfair, as they could be more likely to face safety concerns or logistical challenges when using public transportation. Moreover, when studying the link between public knowledge, attitudes, and acceptance of transportation policies, focusing on the vehicle license auction policy in Shanghai, the results of Li and Zhao (2019) indicated that individual characteristics such as education level, household location, and income influence perceived equity of the policy.

3.1.3. ATTITUDINAL FACTORS

People's attitudes have more explanatory power than the individual characteristics described above in explaining support for travel demand management measures like TMC schemes (Cui et al., 2024; Eriksson et al., 2006; Krabbenborg et al., 2021b; Li & Zhao, 2019; Moeinaddini et al., 2026). Literature shows that users are more likely to support TMC schemes that they perceive as fair, such as those with equitable credit allocation (Dogterom et al., 2018a; Krabbenborg et al., 2021b). Perceived effectiveness also matters: schemes seen as capable of reducing congestion or improving mobility gain higher acceptance (Cui et al., 2024; Dogterom et al., 2018b). Meanwhile, freedom, as the ability to choose travel modes without excessive restrictions, is also a critical factor (Moeinaddini et al., 2026; Sun et al., 2016). Literature focusing on the public acceptability of transport policies have showed that fairness, effectiveness and freedom are strong predictors of acceptability.

Public acceptance of transport policies can also be influenced by more general attitudes, distinct from perceptions of the instrument itself (Li & Zhao, 2019). Attitudes such as trust in the government, environmental concern, technology adoption, general car attitudes, and political ideology have been shown in prior literature to influence transport policy acceptance.

One of the goal of implementing a TMC scheme is to reduce individual car use as the more car-based trips a user makes, the more credits he would have to use. Thus exploring individuals' attitudes toward cars is relevant in this context. In fact, Hamm et al. (2025) showed that car users were less supportive of TMC schemes. Similarly, Cui et al. (2024) also demonstrated that car owners and those frequently driving were more likely to reject a TMC scheme.

Acceptability is higher when people have greater problem awareness (Eriksson et al., 2006). In their study, Sun et al. (2016) concluded that problem awareness would improve the public acceptance of a congestion pricing policy in Beijing. Moreover, Li and Zhao (2019) also demonstrate that when people increase their knowledge, they will focus less on individual burden and develop more positive attitudes toward a policy. Cui et al. (2024) suggested exploring the influence of environmental concern on the acceptance of TMC, as one of the main reason for implementing such a scheme is to reduce the negative externalities of transportation on the environment.

Since TMC can be seen as an innovative high-tech instrument, including technology adoption as an attitude is relevant, as the use of TMC requires familiarity with trip routing and planning platforms, as well as online payments. In a study focusing on the drivers and barriers in adopting Maas (Mobility as a Service), also an innovative concept, van 't Veer et al. (2023) demonstrated that individuals' familiarity with smartphone use, mobile payments and planning apps was positively related to their intention to use Maas.

Moreover, since TMC schemes are defined and managed by the government, trust in the government has a significant impact on the public support of such an instrument as demonstrated by Krabbenborg et al. (2021b).

Additionally, the acceptability of transport policy instruments that limit or reduce mobility is shaped by political context (Aasen & Sælen, 2022; Syrda, 2025). In a study exploring predictors of opposition to road tolls among the Norwegian public, Aasen and Sælen (2022) showed that left-right ideology was positively related to opposing road tolls. In another study, focusing on political ideologies as drivers of public transport infrastructure support, Syrda (2025) demonstrated that individuals with right-leaning political ideology were more likely to oppose public transport investments. (Syrda, 2025) focused on the economic aspects of transport projects, the author defined a specific scale to measure left-right ideology. Given that TMC can be viewed as both an economic instrument and a TDM tool, including political ideology to explore its acceptability is important.

RQ2. According to the literature, which factors are the most influential in shaping the acceptability of TMC schemes ?

From the literature review, three categories of factors were identified: scheme design characteristics; sociodemographic and travel behavior characteristics; and attitudinal variables, such as perceived fairness, effectiveness, and freedom, as well as more general attitudes like car enthusiasm, environmental concern, trust in the government, technology adoption, and political views.

3.2. CONCEPTUAL MODEL

The following conceptual model was designed as presented in Figure 3.1. Hence, it is assumed that TMC scheme design characteristics (attributes) influence perceptions of TMC scheme, and that in turn these perceptions influence the overall acceptability of TMC. Moreover, other variables such as socio-demographics,

travel and mobility characteristics and general attitudes are assumed to also have a direct effect on perceptions and acceptability of TMC.

Hypothesis number	Key hypothesis	Section
H1	TMC design characteristics influence perceptions of TMC schemes	3.1.1, 3.1.3
H2	Perceived fairness, effectiveness, and freedom mediate the relationship between acceptability and TMC schemes characteristics	3.1.3
H3	General attitudes influence the acceptability of TMC schemes	3.1.3
H4	General attitudes influence perceptions of TMC schemes	3.1.3
H5	Individual characteristics (sociodemographics and travel behaviour) influence TMCs acceptability	3.1.2
H6	Individual characteristics (sociodemographics and travel behaviour) influence perceptions of TMC schemes	3.1.2
H7	Individual characteristics (sociodemographics and travel behaviour) influence general attitudes	3.1.2

Table 3.1: Hypotheses Overview

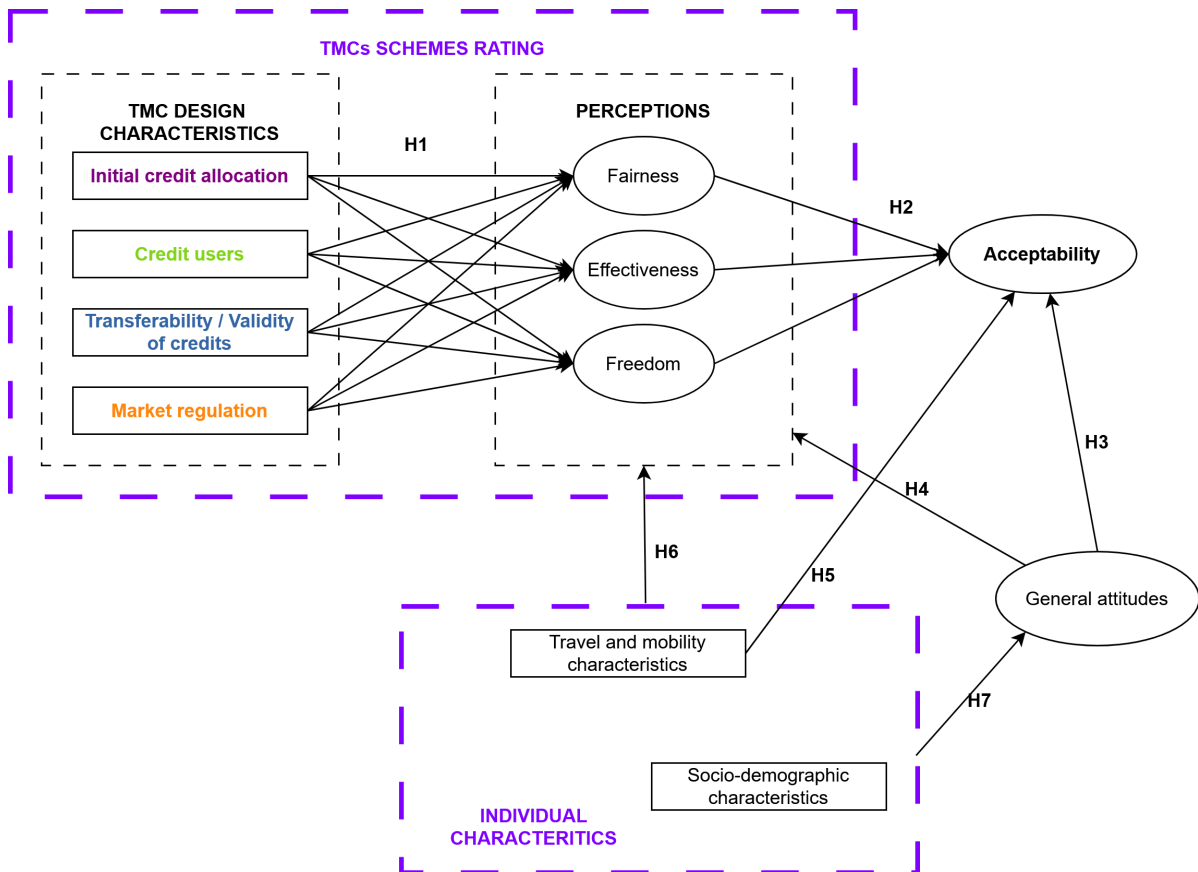


Figure 3.1: Conceptual model

4

METHODOLOGY

This chapter provides the methods that were used to explore factors influencing the acceptability of TMCs. The acceptability of TMCs is explored by estimating a structural equation model that specifies how different TMC scheme characteristics are perceived in terms of fairness, effectiveness, and freedom, and how these perceptions, in turn, influence acceptability. The model also takes into account how individual characteristics and general attitudes influence these perceptions and the acceptability of TMCs. Data to estimate this model was obtained by conducting a survey that included a rating experiment of TMC schemes.

4.1. SURVEY DESIGN

4.1.1. CONSTRUCTION OF THE RATING EXPERIMENT

SALIENT ATTRIBUTES AND THEIR LEVELS

From the literature review the following four attributes as well as their levels were identified.

Characteristics	Description	Levels
Initial Credit Allocation	How the mobility credits are distributed to users at the beginning of each month.	Uniform, Origin-Destination (O-D) specific, income based, Accessibility levels based
Users	Who is eligible or best suited to receive and use mobility credits.	Vehicle Owners / Drivers, Employed people, All residents
Transferability / Validity of credits	What happens to unused credits at the end of a month.	Credits expire, Transfer of credits, Monetisation of credits
Trading Market Regulation	Rules defined by the authority in charge that governs how credits can be bought and sold.	Limitation of credits purchase, Progressive increase of credit price, No limitations

Table 4.1: Scheme design characteristics (attributes) and their levels

COMBINING TMC CHARACTERISTICS INTO SCHEMES

All possible combinations of characteristic levels would result in a full factorial design of $4^4 = 256$ TMC schemes. To reduce the total number of schemes, fractional factorial designs can be used. To ensure that attribute level balance is satisfied, orthogonal designs can be used to select subsets in a structured way. Orthogonal designs satisfy attribute level balance and ensure that all parameters are independently estimable: the attribute levels for each attribute column in the design are uncorrelated (ChoiceMetrics, 2024). In this study, no interaction

effects between characteristics (attributes) are assumed: the characteristics are not correlated within a scheme. It is assumed that the effect of each TMC scheme characteristic is independent of the levels of other characteristics. These designs can be constructed using basic plans (BPs), which are orthogonal fractional factorial designs constructed by mathematicians. A first BP of 16 rows was identified that allowed for attributes with different numbers of levels. However, this BP did not ensure attribute level balance for all attributes. Thus, the Ngene software (version 1.4) was used to generate the appropriate BP. Moreover, the software was also used to block the schemes to limit the number of schemes presented to each respondent and avoid survey fatigue. Each block is not orthogonal by itself, and only the combination of all blocks is orthogonal (ChoiceMetrics, 2024). Ngene created the schemes and blocks, ensuring that all characteristics were equally represented to maintain orthogonality. Ngene created a fractional factorial design of 36 schemes that were blocked into 9 blocks of four schemes

TMC SCHEME 1

Initial credit allocation	Income based the number of credits varies according to a person's income level (e.g., lower-income individuals may receive more credits)	
Users	All Residents people over 18 living in the urban area	
Transferability / Validity of credits	Monetisation of credits unused credits can be converted into money at the end of the month	
Trading Market regulation	Progressive increase of credit price the cost of buying extra credits increases with each purchase: the more credits you buy the more you pay	

Figure 4.1: Exemple of a TMC scheme included in the survey

CHOICE OF MEASUREMENT TASK

Since the goal of this study is not to determine whether one scheme design is preferred over another, but rather to assess the strength of preference for a scheme, a rating task is preferred to a choice task (Molin & Marchau, 2004). Similarly to what was done by Clark et al. (2021) when studying the role of attitudes in perceptions of bicycle facilities, for each TMC scheme, respondents had to choose the most appropriate response for each of the three perceptions on a 5-point Likert scale (see 4.2). Additionally, respondents had to rate the acceptability of each scheme using the same scale.

Variables	Questions
	(-2 = strongly disagree, -1 = disagree, 0 = unsure, 1 = agree, 2 = strongly agree)
Perceived fairness	This scheme is fair to me
Perceived effectiveness	This scheme would effectively reduce congestion and air and noise pollution
Perceived freedom	This scheme limits my freedom to choose my travel mode
Acceptability	I feel positive about the implementation of this scheme

Table 4.2: Statements to measure perceptions and acceptability

Note: The score for freedom was reversed (from negative to positive) to keep consistency with the other items

Every scheme was described by the four statements above (Table 4.2). Participants had to place a slider to express their agreement. The scale ranged from Strongly Disagree (-2) to Strongly Agree (+2). The slider had a custom start position at Neutral (0). The results for perceived freedom were reversed to improve the coherence with the rest of the perceptions as it was the only statement formulated negatively.

4.1.2. SURVEY STRUCTURE

The survey consists of multiple sections. First participants had to report their sociodemographic attributes: gender, age, country of origin, work or study status, living situation, monthly disposable household income, residential location (which part of the Amsterdam Metropolitan Area AND if Amsterdam, which district). Then participants had to answer some questions regarding their attitudes using a five-level Likert scale.

Afterwards, the survey included a short introduction to TMCs schemes and to the rating experiment. Following these descriptions, participants were randomly assigned a block with four different TMC schemes. For each scheme, they were asked to rate the schemes based on its perceived fairness, effectiveness and infringement to freedom as well as acceptability (see Table 4.2).

After, the rating experiment, participants were asked another wave of questions regarding their attitudes (see Table E.1 in Appendix E). Following that, participants had to provide information about their travel behaviour and mobility habits: availability of a driving license, car ownership, public transport subscription, frequency of use of different transport modes (car, bike, public transportation), main mode of transportation (walking, bicycle/electric bike, public transport, carpooling, individual car) for different purpose (work, errands, leisure), accessibility of public transport within 5 minutes walking distance from home, number of teleworking days per week and flexible work arrangements.

Lastly participants had the option to leave a comment at the end of the survey (some of them are provided in the last section of Appendix D).

The complete survey (only including one block of TMC schemes) can be find in Appendix C.

4.1.3. DATA COLLECTION

TMC would most likely be implemented in a large city, as congestion problems, as well as air and noise pollution, are worst in urban areas. For this study, participants were sampled from the Metropolitan Region of Amsterdam (MRA) in the Netherlands. Panel Clix and TGM were hired to collect responses using their online panel. The data collection span over two month (May and June 2026). Only individuals aged 18 and older living in the MRA were invited to participate. Several steps were taken to clean the survey data and check for inconsistencies (removing duplicates, incomplete responses, no participation consent). Answers shorter than 2.5 minutes were also removed. Moreover, respondents that answered *Other* or *Prefer not to say* for their

gender and ones that selected the *Prefer not to say* option regarding their household income were removed from the sample.

4.2. FACTOR ANALYSIS

After collecting data, the data analysis starts. However, it does not begin with SEM, first a factor analysis needs to be conducted.

Factor analysis is a method for modeling and measuring latent variables. Latent variables are variables that cannot be directly measured as they are not directly observable. Attitudes are latent, they require multiple observable indicators. The indicator variables to some extent measure the same variance, and the latent variable represents this common variance in the indicator variables. The part of the variance the indicators do not share with other indicators is considered measurement error. Factor analysis is a method that can be used to understand the structure of a set of latent and observed variables. It is also used to reduce the data set to a feasible size while keeping as much of the original information (Kline, 2016). There are two types of factor analysis: confirmatory factor analysis (CFA) and exploratory factor analysis (EFA). Both methods are based on the common factor model which partitions standardized indicator variances (Kline, 2016).

4.2.1. CONFIRMATORY FACTOR ANALYSIS

CFA is a Structural Equation Model (SEM) that only includes a measurement model: they are no causal relationships between latent variables. CFA tests the relationship between observed variables (indicators) and their underlying latent construct. Based on prior knowledge, the researcher is able to specify which measured variable is associated to which latent variable. In CFA, the variables are only able to load on the factor that was theoretically identified in prior analysis (Kline, 2016). The number of indicators is reduced by eliminating those with factor loadings that are not significant ($p\text{-value} < 0.05$) and that are less than $|0.5|$. The aim of CFA, is to establish to what extent the model fits the data.

4.2.2. EXPLORATORY FACTOR ANALYSIS

On the opposite, EFA does not require a priori specification of the number of factors. This approach enables to have all measured variables that can be related to every possible latent variables. For EFA the shared variance is estimated by the communalities. Communality is the variance of observed variables by the overarching factor. The factoring technique used in EFA determines how many factors should be extracted from the complete dataset. Different techniques can be used with Principal Axis Factoring (PAF) and Maximum Likelihood (ML) Method being the most used ones (Schreiber, 2021).

The determination of the number of factors is done using three measures: the Kaiser rule, a scree plot and a minimum of 3 acceptable factor loadings per factor (Schreiber, 2021). The scree plot shows a plot of eigenvalues and factor numbers. The shape of the plot is used to determine the optimum number of factors by visualising an isolate elbow. Lastly, it is recommended to have at least 3 items per factor which all have a loading greater than $|0.40|$.

After determining the number of factors, factor rotation is used to interpret them, by calculating the loading of the variable on each factor. Overall, most variables have high loadings on the most important factor and small loadings on the other factor. There are two types of rotations, orthogonal and oblique rotations. Orthogonal rotations assume that the factors are not correlated while oblique rotations assume that the factors do correlate (Schreiber, 2021).

After determining the number of factors, the next step is to determine which variables belong to which factor. This is checked using three criteria: the factor loading, the cross-loading and the communality. According to

Field (2009), a factor loading of > 0.3 is acceptable. Furthermore, cross-loadings are important to decide upon which variables should be linked to a factor. Cross-loading are high loadings of a variable with more than one factor. There should be as low cross-loadings as possible.

4.2.3. RELIABILITY OF THE FACTOR

When the amount of factors have been decided on, the reliability of the factors must be measured in order to check the consistency of the measures. This is done by measuring the reliability using Cronbach's Alpha (Molin, 2005). A high value of Cronbach's Alpha tells if the items of each factor are coherent within the factor. A Cronbach's Alpha higher than 0.60 is acceptable for exploratory research.

4.3. STRUCTURAL EQUATION MODELING

Structural equation modeling (SEM) is a modeling technique used to test and evaluate complex relationships between variables. SEM combines two statistical methods: confirmatory factor analysis (CFA) and path analysis. Results of the CFA can be used to reduce the number of variables in the model. If, the underlying structure of the latent variables is not clearly identified, Exploratory Factor Analysis (EFA) can be performed (see section 4.2.2). Path analysis, by contrast, identifies causal relationships among variables based on a series of linked regression equations (provided in Appendix G). The SEM technique allows one to break down the correlations between variables into direct and indirect causal effects (Abu-Bader & Jones, 2025). Figure 4.2 provides an overview of the causal relationships between variables of the model. In line with the conceptual model (see Figure 3.1) the perceptions are hypothesized to mediate the effects of TMCs scheme characteristics on acceptability. Attitudes are hypothesized to influence perceptions and acceptability. Individual characteristics are hypothesized to influence attitudes, perceptions and acceptability.

4.3.1. MODEL SPECIFICATION AND IDENTIFICATION

The final model is rather complex and includes many different variables that are observed or latent (see Table G.2).

The acceptability variable is modeled as a function of individual characteristics, attitudes, and perceptions:

$$\text{Acceptability} = \beta_0 + \sum_{k=1}^K \beta_{1k} \cdot I_k + \sum_{i=1}^I \beta_{2i} \cdot A_i + \sum_{j=1}^J \beta_{3j} \cdot P_j + \epsilon$$

- β_0 : Intercept for the acceptability equation.
- β_{1k} : Coefficient for the k -th individual characteristic.
- I_k : Individual characteristics.
- K : Total number of individual characteristics.
- β_{2i} : Coefficient for the i -th attitude.
- A_i : Attitude variables.
- I : Total number of attitude variables.
- β_{3j} : Coefficient for the j -th perception.
- P_j : Perception variables.
- J : Total number of perception variables.
- ϵ : Error term (residual) for the acceptability equation.

The number of latent variables (A_i) can be reduced by performing CFA or EFA, in order to have the latent variables measured by one single indicator which is the sum scores of the indicators (Molin & Marchau, 2004). The reliability of the summated scale is given by the Cronbach's alpha (see section 4.2.3). Its reliability, that can be regarded as the proportion true variance captured by the scale, is determined by calculating the Cronbach alpha (section 4.2.3). $1 - \text{Cronbach's alpha}$ is an indication of the proportion measurement error of the scale and is fixed in the SEM model.

The measurement error for each summated scale is calculated as:

$$\text{Variance of the measurement error} = \text{Scale Variance} \times (1 - \text{Cronbach's Alpha})$$

This represents the unreliability of the single indicator (summated scale) used to measure the latent construct in the SEM model.

Each of the latent constructs (A_i) are dependent variables as they are assumed to be influenced by other variables (see Figure 4.2). The attitude variables are modeled as a function of individual characteristics. Moreover, they are endogenous thus they have error terms. These represent the unexplained variance in the latent constructs. The error terms of attitude variables are allowed to freely correlate with one another since they are at the same level of causal order as well as the ones of the perception variables (double-headed arrow in Figure 4.2).

In addition, perceptions and acceptability that are identified as observed variables as they are measured with only one indicator also have error terms that represent their unexplained variance. It reflects the measurement error and residual variance that is not explained by the model. The error terms of the perception variables are allowed to freely correlate (double-headed arrow in Figure 4.2). The perception variables are modeled as a function of individual characteristics, TMC characteristics, and attitudes.

On the other hand, individual characteristics (socio-demographic and travel behaviour) are exogenous variables: they are independent of other variables and are assumed to be measured without measurement error. They do not have any error terms. The sociodemographic characteristics as well as the travel behaviour characteristics correlate with one another (double-headed arrow in Figure 4.2).

As SEM relies on linear relationships between variables, categorical variables such as TMC characteristics were converted in numerical format using effect coding (Molin & Marchau, 2004). For a categorical variable with m levels, $m-1$ dummy variables are created. The correlation between TMC characteristics were included in the model but as TMC schemes were designed to be orthogonal for the rating experiment (see section 4.1.1), correlations between different characteristics are null (or close to 0). Thus all covariance between the attributes of different TMCs characteristics were fixed to 0, while the ones between attributes for the same characteristics were fixed to 0.333 (for two attributes) and 0.248 (for three attributes), similarly to what was done in the study by Molin (2005). Moreover, TMC characteristics variables do not correlate with other variables of the model.

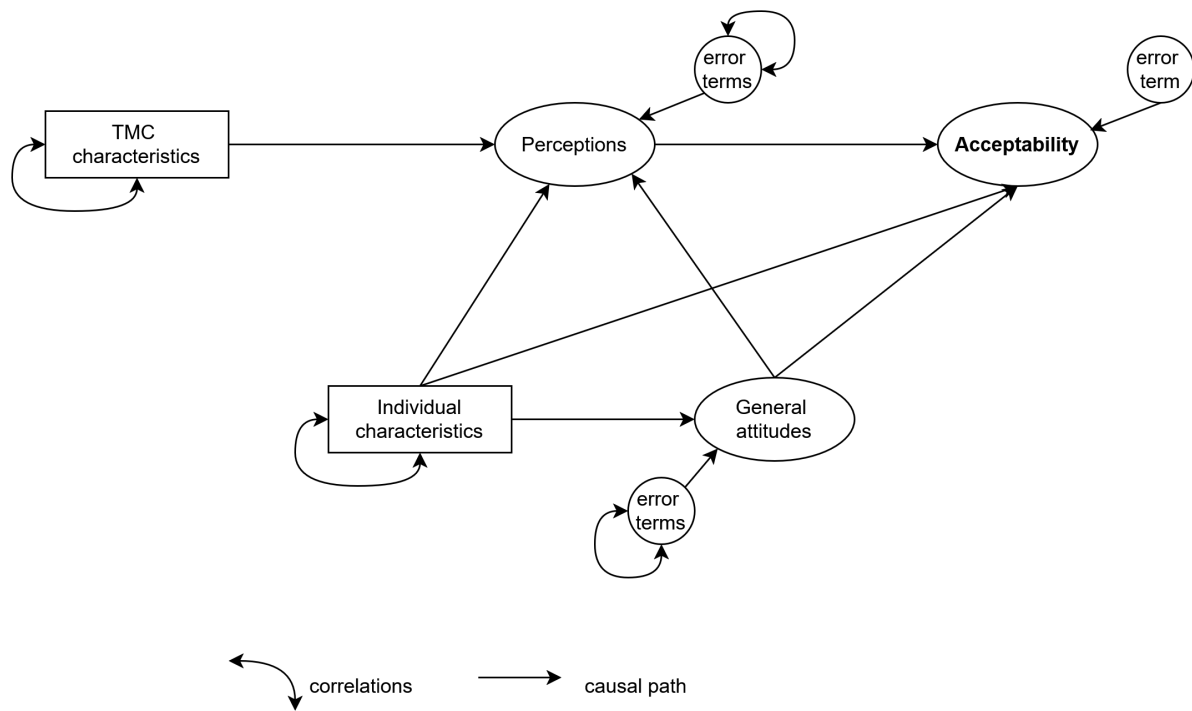


Figure 4.2: Assumed causal order

Variables	Description
TMC schemes characteristics	effect coded; exogenous
Individual characteristics I_k	nominal, ordinal or binary; observed; exogenous
Attitudes A_i	ordinal (summated scale); latent; endogenous,
Perceptions P_j	ordinal; observed; endogenous
Acceptability	ordinal; observed; endogenous

Table 4.3: Scheme design characteristics (attributes) and their levels

4.3.2. PARAMETER ESTIMATION

A SEM software is used to estimate coefficients (β) for paths running from variables in the model (see figure 3.1). The Maximum Likelihood (ML) estimation is selected to estimate all the model parameters simultaneously. When using ML, the parameter estimates are the ones that maximise the likelihood that the data is the one that would be observed in the population (Kline, 2016). In the rating experiment, perceptions and acceptability are dependent variables. The path coefficients estimated for this part of the overall model should indicate how TMC schemes characteristics influence perceived fairness, freedom, effectiveness, and acceptability. SEM is also used to determine the path coefficients between perceptions and acceptability with attitudes and socio-demographic and travel behaviour variables (Figure 3.1). In addition to the causal paths, the correlations between variables and their error terms are also estimated by the model.

4.3.3. MODEL FIT

Model fit is an important step when conducting SEM as it determines the reproducibility of the data. The model is evaluated by checking its performance using different quantitative indices. Multiple fit indices exist, however it is not necessary to include every one of them. As emphasized by Tomarken and Waller (2005), fit

indices have different properties, they are sensitive to many factors, such as data distribution, missing data, model size and sample size. Hooper et al. (2008) advice for including the following indicators:

- **Chi-squared test (CMIN):** indicates the magnitude of covariance between the observed and expected covariance matrix. The test will show a non-significant result if the model is a good fit ($p > 0.05$) supporting the null hypothesis that the covariance matrices are not significantly different.
- **Standardized Root mean square residual (SRMR):** refers to the square root of the difference between residuals of the sample and hypothesised covariance matrixes. Lower values than .08 are considered acceptable levels.
- **Goodness of fit index (GFI):** indicates how well the theoretical model represents the actual data. It calculates the proportion of variance in the observed covariance matrix that is accounted for by the estimated covariance matrix. Values closer to 1 represent a good fit.
- **Comparative fit index (CFI):** assumes that all latent variables are uncorrelated and compares the sample covariance matrix with this null model. Values closer to 1 represent a good fit.
- **Root mean square error of approximation (RMSEA):** analyses the inconsistency between the hypothesized structural model with optimal parameter estimates and the population covariance matrix. Values lower than .06 are considered acceptable.

4.3.4. MODEL MODIFICATION

The initial model starts by drawing all paths between each variable according to the conceptual model defined in chapter 3 and illustrated by Figure 3.1. After estimating the initial model, the model is adapted by possibly removing all paths that did not turn out to be statistically significant. To obtain a parsimonious model, insignificant direct effects can be deleted in a stepwise fashion through a process of backward elimination. All correlations between error terms and exogenous variables are retained (even when insignificant) to ensure proper statistical control (Molin, 2005). In addition, the Modification Indices (MI) are also checked as they may give suggestions on how to improve the model. The MI of a path that is not estimated provides an estimate of how much the Chi-square value will decrease if the path is added.

4.3.5. ASSUMPTIONS IN SEM

To ensure accurate results, SEM requires the achievement of the underlying assumptions, violations of these can impact estimates and model fit. Abu-Bader and Jones (2025) provide a complete list of them in their paper. Critical assumptions that are worth mentioning are linearity, normality and multicollinearity. Linearity refers to the fact that the endogenous (dependent) and the exogenous (predictor) variables should have a linear relationship. Multicollinearity occurs when exogenous variables have high intercorrelations. Normality refers to the fact that all the observations must be draw from a continuous or multivariate normal population (Fan et al., 2016).

4.3.6. LIMITATIONS INHERENT TO STRUCTURAL EQUATION MODELING TECHNIQUE

Although SEM is widely used and praised it has also been criticized for its intrinsic limitations that could alter the quality of results. This section will only reflect on relevant limitations that might hindered the quality of the results.

ML estimation in SEM assumes that the observed variables follow a normal distribution and that relation between variables are linear. The perceptions and acceptability are measured using ordinal Likert scales which can lead to non-normality. ML estimation could underestimates or overestimates the true variability in the data. As a result the standard errors can be biased. Underestimated standard errors could result in spurious

significant paths while overestimated ones could mask true effects between variables. Additionally, non-linear relationships are not captured by SEM, potentially omitting some dynamics between variables. Relations between ordinal variables and dependent ones may be non-linear, for example acceptability might increase with age up to a point and then plateau or decrease.

Another limitation of SEM is the inaccuracy of the rule of thumbs method for most fit indices that are used to evaluate the goodness of a model. Here the fit indices suggest an excellent fit which may be partly due to overfitting since the model is highly complex. Overfitting can lead to poor generalization.

In addition, nominal variables with multiple categories were recoded into binary variables for ease of modeling (see Appendix G for detailed information). Binary recoding collapses multiple categories into two groups, discarding nuanced information between the original levels. Variables that are recoded, can be not mutually exclusive making the interpretation complex and violating the multicollinearity assumptions of SEM which can compromise the validity of the model's estimates.

5

SURVEY RESULTS

In this section, the results and outcomes of the survey are described. First, the sample's sociodemographics and travel behaviour are reviewed, followed by a description of the respondents' answers to the different attitudes statements. Next, the ratings of the different TMC attributes are discussed.

In total, 1472 people opened the survey. The first cleaning steps (removing duplicates, incomplete responses, no participation consent, fast respondent) resulted in a valid sample size of 891 respondents. Respondents that answered *Other* or *Prefer not to say* for their gender (4 respondents, 0.02% of the valid sample) and ones that selected the *Prefer not to say* option regarding their household income (85 respondents, 9.5% of the valid sample) were removed from the sample. This resulted in a final sample size of $N = 803$ respondents. Each respondent rated four different TMC profiles, yielding $4 \times 891 = 3212$ ratings in the experiment. The average time spent on the survey was 12.6 minutes, while the median is 6.2 minutes.

5.1. SOCIO-DEMOGRAPHIC CHARACTERISTICS

The sample's socio-demographics are compared with the Dutch population in order to determine whether the sample is representative of the total population. The data was retrieved from CBS Statline. The Dutch population is used as a proxy to the one of the MRA. More than 14% of the Dutch population lives in the MRA which is the country's most robust economic region (Metropoolregio Amsterdam, n.d.).

Females and people in the age categories (55–79) are slightly overrepresented in the sample, with retired people accounting for 15% of the sample. Compared to the population, people not coming from the Netherlands are underrepresented, as they represent only 5.7% of the sample, with 3.0% coming from Europe and 2.8% from outside Europe (the zone of origin for respondents from outside Europe is provided in Appendix D). Looking at household composition, single individuals without children are slightly underrepresented in the sample, while couples with children are overrepresented. Highly educated people (those with an HBO degree or higher) are overrepresented in the sample. They represent 45% of the sample, while they only represent 36% of the Dutch population.

Variables	Items	Sample	Population
Gender	Male	44.80%	49.80%
	Female	55.20%	50.20%
			CBS (2025a)
Age	18–24	7.80%	10.92%
	25–34	18.70%	16.28%
	35–44	17.60%	15.23%
	45–54	17.10%	15.21%
	55–64	19.30%	16.88%
	65–79	19.20%	19.13%
	80	0.40%	6.35%
			CBS (2025f)
Origin	The Netherlands	94.20%	83.30%
	Europe	3.00%	16.70%
	Non-Europe	2.70%	–
			CBS (2025b)
Education	Primary education, VMBO, MBO 1	15.90%	26.00%
	Higher general secondary education, VWO, MBO 2-3-4	37.90%	37.00%
	HBO	21.50%	
	Bachelor's degree	11.10%	36.00%
	Master's degree	12.50%	
	PhD	1.10%	
			CBS (2024b)
Household composition	Single without children	32.90%	40.10%
	Single with children	9.00%	7.43%
	Couple with children	30.30%	24.09%
	Couple without children	24.30%	27.79%
	Other	3.60%	0.58%
			CBS (2025b)
Employment status	Employed full-time	46.20%	34.83%
	Employed part-time	20.20%	28.82%
	Self-Employed	6.60%	–
	Unemployed	3.70%	2.17%
	Student	2.90%	–
	Retired	15.40%	12.34%
	Other	5.00%	20.84%
			CBS (2025e)

Table 5.1: Sociodemographic characteristics of the sample compared to the Dutch population

Income Range	Percentage
Less than €2,000	17.60%
€2,000–€3,500	33.30%
€3,500–€6,000	35.50%
€6,000–€8,000	8.50%
€8,000–€10,000	2.40%
More than €10,000	2.90%

Table 5.2: Sample's Monthly Disposable Income

Income Range	Percentage
Less than €10,000	2.76%
€10,000 – €20,000	6.23%
€20,000 – €30,000	15.25%
€30,000 – €40,000	15.97%
€40,000 – €50,000	12.44%
€50,000 – €100,000	36.63%
More than €100,000	10.72%

Table 5.3: Dutch Population Yearly Disposable Income

Table 5.2 shows the sample's monthly household disposable income, while Table 5.3 presents the yearly disposable income for Dutch households (CBS, 2025a). Almost 18% of the sample reported a monthly disposable income of less than €2,000 (€24,000 per year), compared to less than 10% of Dutch households with a yearly disposable income below €20,000. This indicates a slight overrepresentation of lower-income individuals in the sample. Almost half of the sample reported a monthly household income of more than €3,500 (€42,000 per year), which is less than in the Dutch population: almost 60% of Dutch households have a yearly disposable income above €40,000. Every monthly income category is represented, with respondents earning between €2,000 and €6,000 (€24,000 and €72,000 per year) accounting for almost 70% of the sample.

Figure 5.1 provides the geographical repartition of the sample within the MRA. 41% of the sample is from the city of Amsterdam (the distribution of the sample within Amsterdam is provided in Appendix D). The province Almere-Lelystad is slightly overpresented, representing 20% of the sample while recent data from CBS indicated that that province only represents 12% of the MRA population. Moreover, there is an underrepresentation for the province of Amstelland-Meerlanden: 5% of the sample while they represent 14% of the MRA population.

Province	Sample	MRA population
Amsterdam	41.00%	34.70%
Almere-Lelystad	20.00%	11.70%
Amstelland-Meerlanden	4.90%	14.15%
IJmond	6.10%	6.49%
Gooi en Vechtstreek	9.00%	10.29%
Zaanstreek-Waterland	11.70%	13.50%
Zuid-Kennemerland	7.30%	9.17%
MRApop		

Table 5.4: Comparison of the sample's geographical repartition and the MRA population

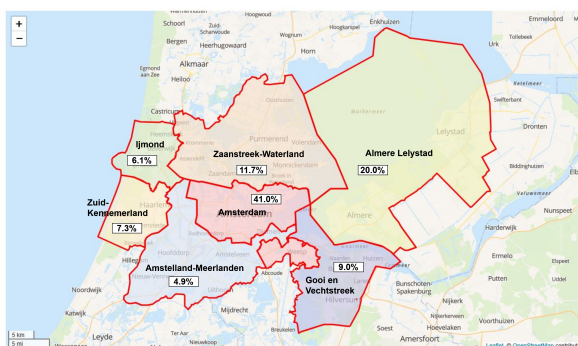


Figure 5.1: Sample's geographical distribution within the MRA

5.2. TRAVEL BEHAVIOUR AND INDIVIDUAL MOBILITY CHARACTERISTICS OF THE SAMPLE

The travel and mobility behaviour of the sample is analysed in the following section and compared to the population also using data from CBS. First, it can be observed that the sample is quite car oriented compared to the Dutch population (see Table 5.5). More than 85% of the sample has a driving license and 75% of the sample owns an individual car while it's only 39% of the population (CBS, 2026). If TMCs were to be applied, having the choice to commute or not, would directly impact ones credit budget. Thus the work flexibility dimension was included in the survey. As can be seen in Table 5.5 half of the respondents do not have work flexibility.

Regarding mobility habits (see Figure 5.2), 40% of the sample uses a car as the main mode to commute, while 26% of the sample bikes to work and 26% uses PT. Recent data from CBS (CBS, 2024a) also show that the use of car for daily commutes and attending education represents almost 45% of the trips in the Netherlands and 35% in Nord-Holland (NH), biking accounts for almost 40% of the trips in NH, and PT accounts for 17% in NH (see Table D.3 in Appendix D). The sample presents an overrepresentation of individuals using PT to commute and an underrepresentation of individuals biking to work or to attend education.

Variables	Items	Sample	Population
Driving licence	Yes	85.40%	64.82%
	No	14.60%	35.18%
CBS (2026)			
Car ownership	Yes	74.80%	38.85%
	No	25.20%	61.15%
CBS (2026)			
PT subscription	Yes	38.70%	–
	No	61.30%	–
PT accessibility (PT stop within 5 minutes walking distance from home)	Yes	79.20%	–
	No	20.00%	–
	idk	0.80%	–
Work flexibility	Yes	40.00%	–
	No	55.50%	–
	idk	4.50%	–
Teleworking (days/week)	0	62.80%	–
	1	8.50%	–
	2	10.60%	–
	3	9.20%	–
	4	4.70%	–
	5	4.40%	–

Table 5.5: Travel and Mobility Behaviour Characteristics of Survey Participants

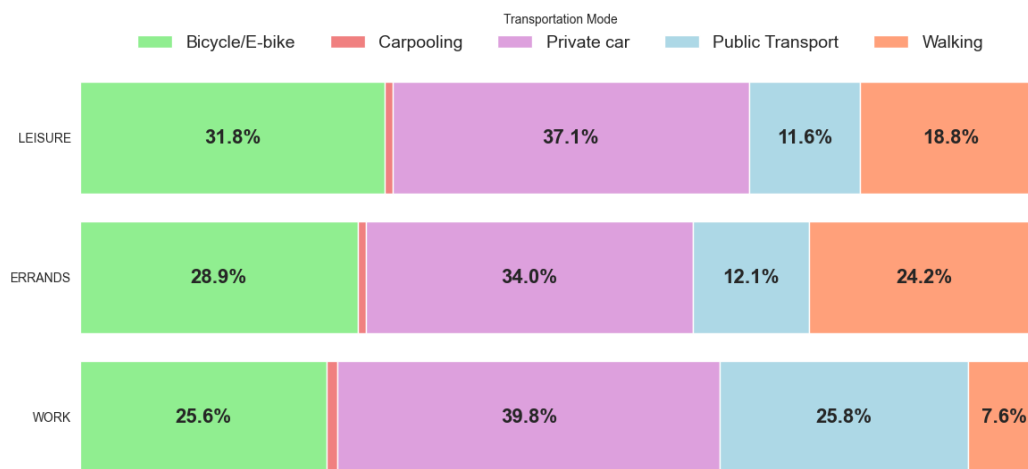


Figure 5.2: Samples' current travel behaviour per travel purpose

Looking at the main mode of transport for leisure (first horizontal bar in Figure 5.2), it is clear that the number of individuals using active modes (walking and cycling) is higher than for commuting to work or school. 19% of the sample walks and 32% of the sample uses the bike for leisure purposes. When looking at the Dutch population, walking is also more important for leisure purposes and accounts for 37% of the trips in the country and 40% in NH. On the other hand, the use of PT in the sample (12%) and among the Dutch population (3% in NL and 5% in NH) is not important for leisure purposes. Once again, the car is the most used transport for leisure among the sample: more than a third of the sample, which is similar to the overall population (33%) but higher compared to NH (27.5%).

For main errands, similar to leisure, active modes account for more than half of the sample, which is also representative of the Dutch population (48.70%). Once again, PT remains the least used transport option for main errands in the sample (12%) but is still overrepresented in the sample compared to the population (less than 3% for both NL and NH). Once again, the car is the main mode of transportation used among the individuals of the sample (34%) but is still an underrepresentation of the population's usage (48.70%).

The difference between the sample and the population in terms of car underrepresentation can be explained by the fact that the sample is only from the MRA: a highly urbanized region of the Netherlands. More than three quarters of the sample have a PT stop within 5 minutes walking distance from their home (78.5%, see Table 5.5).

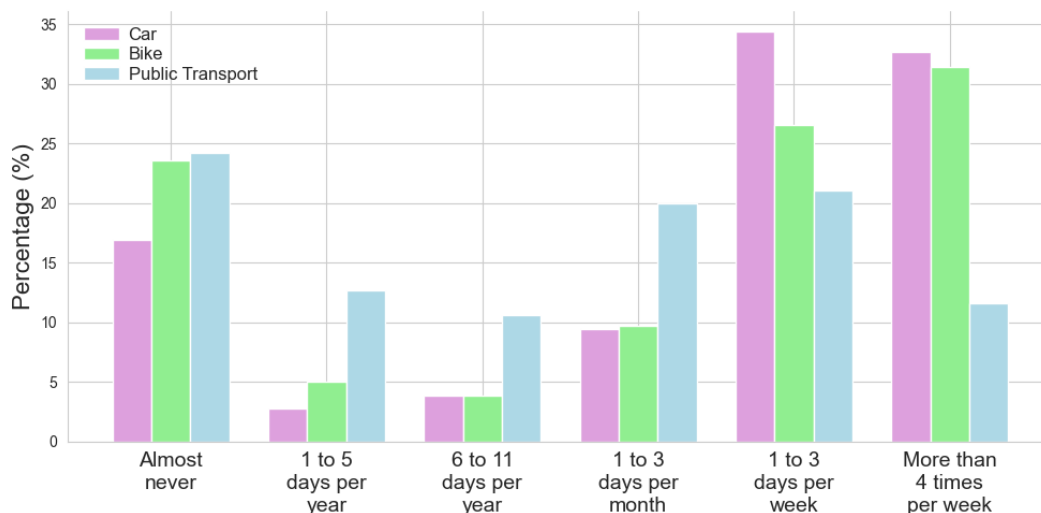


Figure 5.3: Transport use frequency among the sample

Figure 5.3 illustrates the frequency of transport use in the sample (the tables can be found in Appendix D). A third of the sample uses the car more than 4 times per week, and another third of the sample uses the car 1 to 3 days per week, and only 17% of the sample never uses it. These results are in line with other travel characteristics of the sample: 85% of the sample possess a driving license and three quarter of the sample owns an individual car (Table 5.5). Looking at bike use frequency, almost a third of the sample uses it more than 4 times per week, and 24% of the sample never uses it. Regarding PT, as illustrated by the answers reported in Figure 5.2, only 12% of the sample uses it more than 4 times per week, and almost a quarter of the sample (24%) never uses it. These results are in line with the travel characteristics of the sample, as 61.5% of the sample does not own a PT subscription.

Main takeaways from the sample characteristics

Although the sample is somehow skewed in some respects, all main sociodemographic groups are well represented. When it comes to travel behaviour characteristics, there is a slight overrepresentation of car users. However, the sample is suitable to gain first insights into the acceptability of TMC schemes and how it relates to these individual characteristics.

5.3. GENERAL ATTITUDES OF PARTICIPANTS

Part of the survey consisted of a few questions that asked respondents to indicate the extent to which they agreed with statements related to different attitudes. These were five-point Likert scale questions, ranging from "Totally disagree" (-2) to "Totally agree" (+2). The statements were designed to gather information about five attitudes: car enthusiasm, trust in the government, environmental concern, political views, and technology adoption. An overview of each attitude is provided in the following sections. For all the figures, the x-axis represents percentages.

5.3.1. CAR ENTHUSIASM

Regarding car enthusiasm, participants generally value cars for their advantages over other transports (70% of the sample) and the freedom they provide (75% of the sample). There is less consensus on whether they are indispensable, half of the sample says they could not manage without a car and almost a quarter is neutral. These results are in line with the travel behaviour characteristics identified in the survey. Most of respondents have a driving license (85%) and own an individual car.

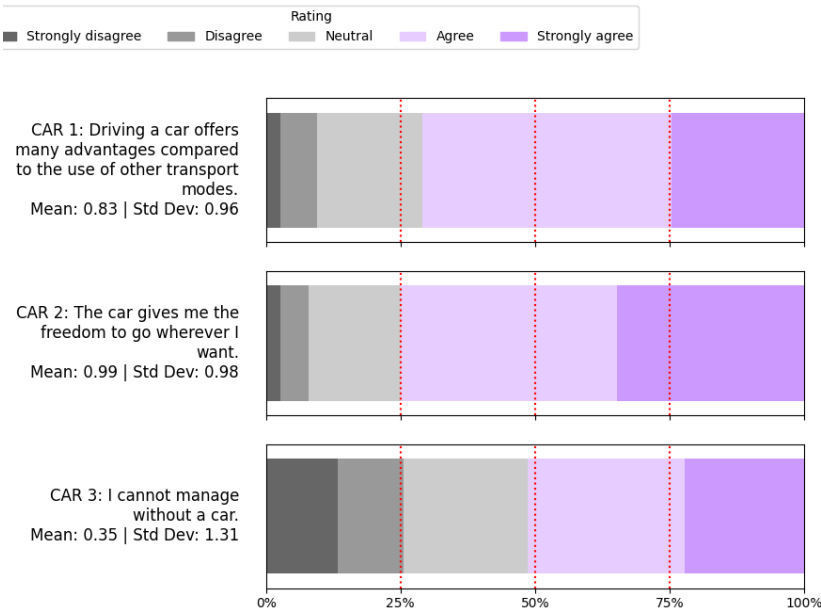


Figure 5.4: Distribution of answers to the statements regarding car enthusiasm

5.3.2. TRUST IN THE GOVERNMENT

Participants show low trust in the government's ability to implement a TMC scheme. Almost a quarter of the sample believes that the government is not capable of implementing a TMC scheme. However, respondents to the survey show more trust in the government when it comes to implementing policies reducing transport emissions, but a large part of the sample stays neutral.

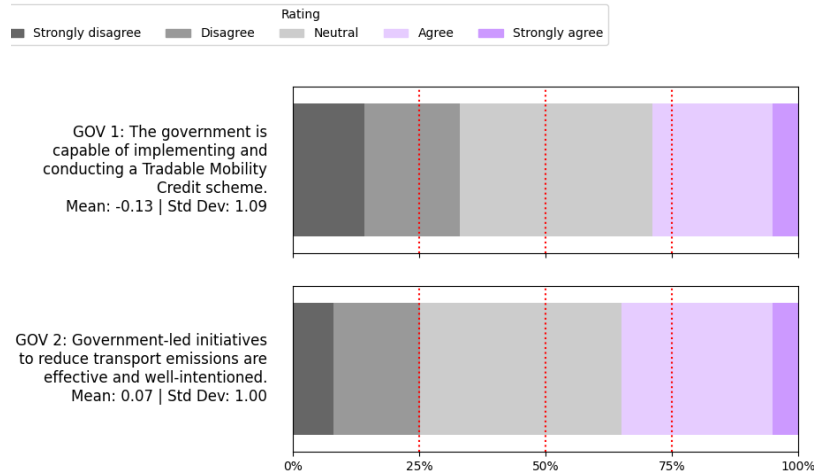


Figure 5.5: Distribution of answers to the statements regarding trust in the government

5.3.3. ENVIRONMENT CONCERN

Moreover, participants show moderate concern for the environment. Around 25% of the sample disagrees to the fact that their individual use of transport has an impact on the environment (ENV_1). Moreover, almost a quarter of the sample disagrees with the statement regarding their individual role in protecting the environment. Still, more than half of them are committed to living a more environmentally friendly lifestyle.

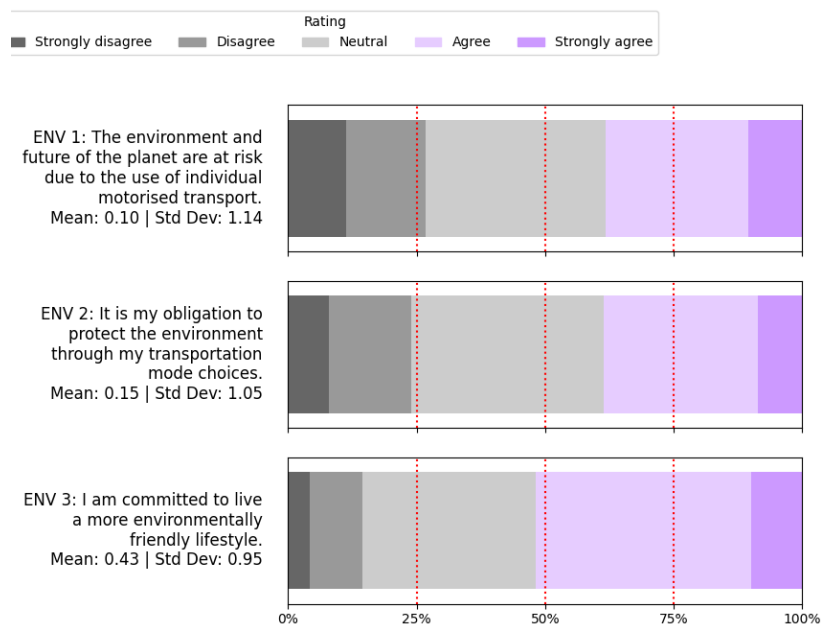


Figure 5.6: Distribution of answers to the statements regarding environment concern

5.3.4. POLITICAL VIEWS

Looking at the political views of the participants, most support government intervention for social welfare. Almost half of the sample agrees that the government should redistribute revenues (POL_1) and more than half of the respondents also agrees that the government should guarantee everyone a decent standard of living (POL_2). While most of the sample oppose excessive regulation and government presence. There is a strong consensus that government interventions are sufficient (POL_4).

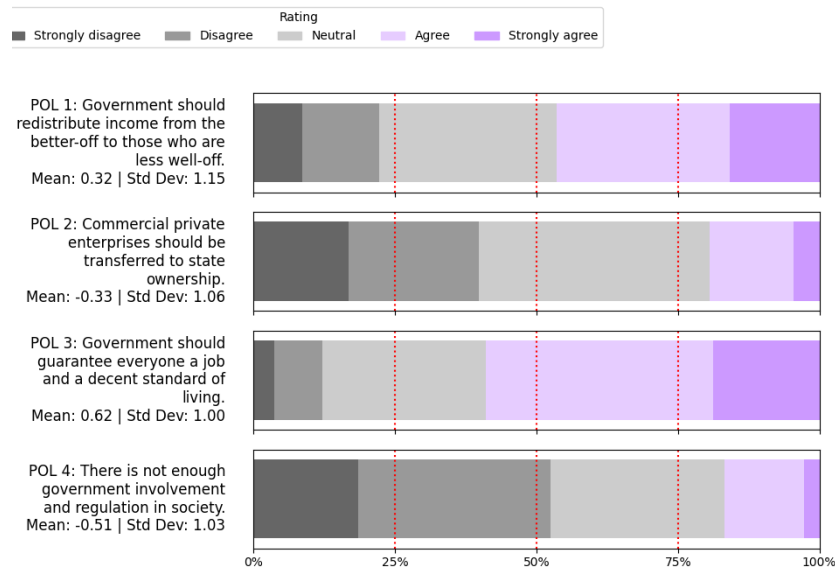


Figure 5.7: Distribution of answers to the statements regarding political views

5.3.5. TECHNOLOGY ADOPTION

Lastly, most participants (more than 75%) are familiar with using smartphones and making online payments (TECH_1 and TECH_3). Half of them rely on GPS tracking apps in their daily life (TECH_2). Moreover, half of the sample would be confident in managing tradable mobility credits via their smartphone (TECH_4).

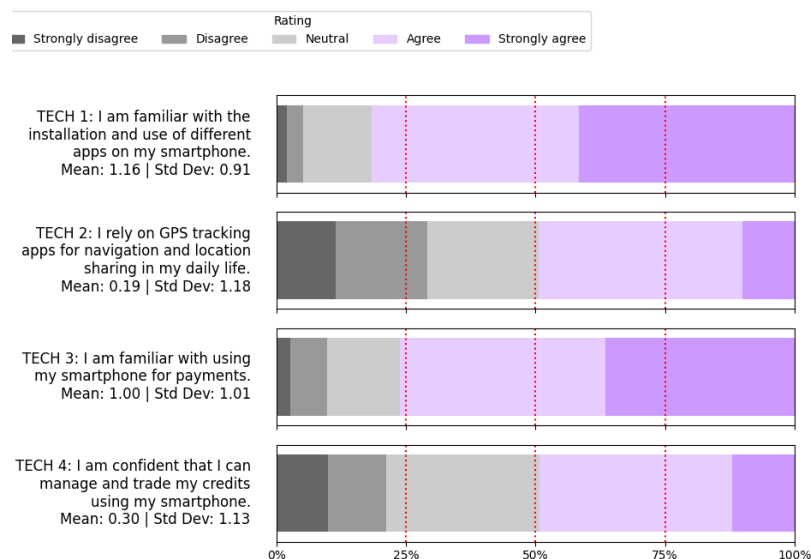


Figure 5.8: Distribution of answers to the statements regarding technology adoption

General attitudes of the respondents

Participants present mixed opinions regarding each of the statements, with most standard deviations being close to 1. There are no statements on which participants strongly disagree or agree. These first descriptive results provide a first image of the sample. They are familiar with the use of new technology and are car enthusiasts, which is in line with their travel characteristics. They are committed to having a more environment-friendly lifestyle but not regarding their individual mobility behaviour. They do not trust the government in implementing effective instruments, such as TMCs, to reduce transport emissions. They strongly agree that there is too much involvement of the government in society. However they do support government interventions that are for social welfare.

5.4. RATING OF TMC SCHEMES

The most important part of the survey consisted of a rating experiment in which participants were randomly presented with four TMC schemes. For each scheme, respondents were asked to indicate the extent to which they agreed with each of the statements associated with a perception (fairness, effectiveness, freedom) and one for acceptability. These were five-point Likert scale questions, ranging from "Totally disagree" (-2) to "Totally agree" (+2). The following section presents the ratings of the schemes, with each section focusing on a different TMC scheme characteristic. Appendix F provides horizontal bar plots showing the distribution of answers to each of the statements.

The blocks were evenly distributed among participants to ensure equal representation in the dataset. Since part of the survey data had to be cleaned, the distribution of the blocks and the TMC scheme characteristics is almost even as well as the presentation of every TMC characteristics level (see Tables F.1a and F.1 in Appendix F).

5.4.1. RATINGS OF TMCs ALLOCATION STRATEGIES

(a) Fairness				(b) Effectiveness			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme is fair to me	Uniform	-0.003	1.139	This scheme would effectively reduce air and noise pollution	Uniform	0.061	1.128
	OD	-0.014	1.190		OD	0.045	1.166
	Income	-0.011	1.162		Income	0	1.114
	Accessibility	0.073	1.177		Accessibility	0.097	1.136
(c) Freedom				(d) Acceptability			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme does not limit my freedom to choose my travel mode	Uniform	-0.483	1.147	I feel positive about the implementation of this scheme	Uniform	-0.235	1.186
	OD	-0.529	1.134		OD	-0.278	1.216
	Income	-0.438	1.150		Income	-0.239	1.191
	Accessibility	-0.550	1.117		Accessibility	-0.171	1.222

Table 5.6: Rating of perceptions regarding different initial credit allocation strategies

From the Table 5.6, one can see that there are no strong differences in the ratings between the TMCs allocation attributes. All attributes have relatively high negative means for perceived freedom and acceptability, meaning that participants perceive the attributes of the allocation dimension negatively in regard to perceived freedom and acceptability. Looking at perceived fairness, only one attribute has a positive mean, the *accessibility-based* allocation strategy. Moreover, all attributes have positive means for perceived effectiveness, with *accessibility*

and *uniform* based allocation having the highest. Looking at perceived freedom, *accessibility* and *OD-based* allocations have the highest negative means. However, when looking at acceptability, the *accessibility-based* allocation is the one with the lowest negative mean. From those first ratings, it appears that no TMCs allocation strategy is acceptable. However, *accessibility based* allocation is the best-perceived strategy in terms of fairness and effectiveness. While having the *OD-based* is the least best-perceived strategy.

5.4.2. RATINGS OF TMCs ELIGIBLE USERS

(a) Fairness				(b) Effectiveness			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme is fair to me	Vehicle owner/-driver	0.007	1.145	This scheme would effectively reduce air and noise pollution	Vehicle owner/-driver	0.073	1.149
	Employed	-0.096	1.190		Employed	-0.005	1.150
	Residents	0.123	1.158		Residents	0.072	1.108
(c) Freedom				(d) Acceptability			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme does not limit my freedom to choose my travel mode	Vehicle owner/-driver	-0.538	1.138	I feel positive about the implementation of this scheme	Vehicle owner/-driver	-0.229	1.196
	Employed	-0.519	1.146		Employed	-0.302	1.210
	Residents	-0.443	1.127		Residents	-0.163	1.204

Table 5.7: Rating of perceptions regarding credit recipients

There are more contrast between attributes of the user dimension. Looking at perceived fairness and effectiveness, only having *Employed user* presents a negative mean. *All residents* has the highest mean for perceived fairness which makes sense since a TMC would be implemented in an entire urban area in which every resident uses the transport infrastructure. *Vehicle owner/driver* and *all residents* have almost the same positive mean in regard to perceived effectiveness, meaning that respondents agree that those two user definition would be effective in reducing transport externalities but there are no strong differences in which one is perceived as most effective. Similarly to the allocation characteristics, all the means are negative for perceived freedom and acceptability. *Vehicle owner/driver* has the highest negative mean while *all residents* the lowest, meaning that more people consider that having only *car user/driver* as TMC user has a stronger infringement on freedom than having *all residents*. However, when looking at acceptability having only *employed people* as user has the highest negative mean while having *all residents* has the lowest. From these first ratings, it appears that having only *employed people* as TMC user is the most critical user category while the *resident* one is the most favorable definition for all perceptions and acceptability.

5.4.3. RATINGS OF TMCs TRANSFERABILITY AND VALIDITY

(a) Fairness				(b) Effectiveness			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme is fair to me	Invalidation	-0.106	1.178	This scheme would effectively reduce air and noise pollution	Invalidation	-0.018	1.162
	Transfer	0.071	1.156		Transfer	0.005	1.123
	Monetisation	0.074	1.159		Monetisation	0.134	1.119
(c) Freedom				(d) Acceptability			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme does not limit my freedom to choose my travel mode	Invalidation	-0.544	1.133	I feel positive about the implementation of this scheme	Invalidation	-0.317	1.200
	Transfer	-0.487	1.125		Transfer	-0.200	1.210
	Monetisation	-0.468	1.154		Monetisation	-0.173	1.198

Table 5.8: Rating of perceptions regarding transfer of credits

As can be seen, in the Tables 5.8, there is one attribute of the transfer dimension that has negative means across all perceptions and acceptability: *invalidation* (expiration) of credits at the end of the month. For perceived fairness, *transfer* and *monetisation* of credits have similar means while for perceived effectiveness, *monetisation* has a higher positive mean than the *transfer* one. All attributes score negatively for perceived freedom and acceptability with *credit invalidation* having the highest mean and *monetisation* the lowest. Thus, *monetisation* of credits performs best across all perceptions and acceptability while their *invalidation* is the least favored. *Transfer* of credits is a middle ground, performing better than *invalidation* but not as well as *monetisation*.

5.4.4. RATINGS OF TMCs TRADING MARKET REGULATIONS

(a) Fairness				(b) Effectiveness			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme is fair to me	Limitation	-0.009	1.162	This scheme would effectively reduce air and noise pollution	Limitation	0.037	1.138
	Increase	0.014	1.174		Increase	0.064	1.146
	No	0.034	1.167		No	0.052	1.125
(c) Freedom				(d) Acceptability			
Statement	Attribute	Mean	Std Dev	Statement	Attribute	Mean	Std Dev
This scheme does not limit my freedom to choose my travel mode	Limitation	-0.504	1.147	I feel positive about the implementation of this scheme	Limitation	-0.247	1.210
	Increase	-0.504	1.136		Increase	-0.252	1.197
	No	-0.492	1.130		No	-0.193	1.204

Table 5.9: Rating of perceptions regarding trading market regulation

There are no strong difference in the ratings between TMC market regulation attributes as can be seen in the tables 5.8. *Limiting* the purchase of credits is the only attribute with a negative mean regarding perceived fairness. All attributes have positive means for the perceived effectiveness. Similarly to the previous TMC schemes characteristics, perceived freedom and acceptability present negative means for all the different trading market regulation attribute.

5.4.5. OVERALL RATING OF TMC SCHEMES

Results of the survey indicate that TMC schemes are not widely perceived as acceptable instruments. Only 34% of the respondents would support implementing such a system, while 23% are neutral and the remaining 43% are opposed. (Figure 5.9). The acceptability found in this study is similar to the one measured for Tradable Peak Credits (TPC) in China (Cui et al., 2024) and in the Netherlands (Krabbenborg et al., 2021b). However, the public support for TMC schemes observed here is higher than that for Tradable Driving Credits (TDC), which recorded a support level of 22% in the Netherlands (Dogterom et al., 2018a). A significant concern is the perceived restriction on freedom, with more than half of the respondents viewing TMC schemes as limiting their autonomy in travel mode selection. However, nearly 50% of the sample demonstrates a more favorable perception of the fairness and effectiveness of TMCs. These preliminary results suggest that while TMC schemes are considered fair and effective, they are simultaneously perceived as a substantial infringement on individual freedom.

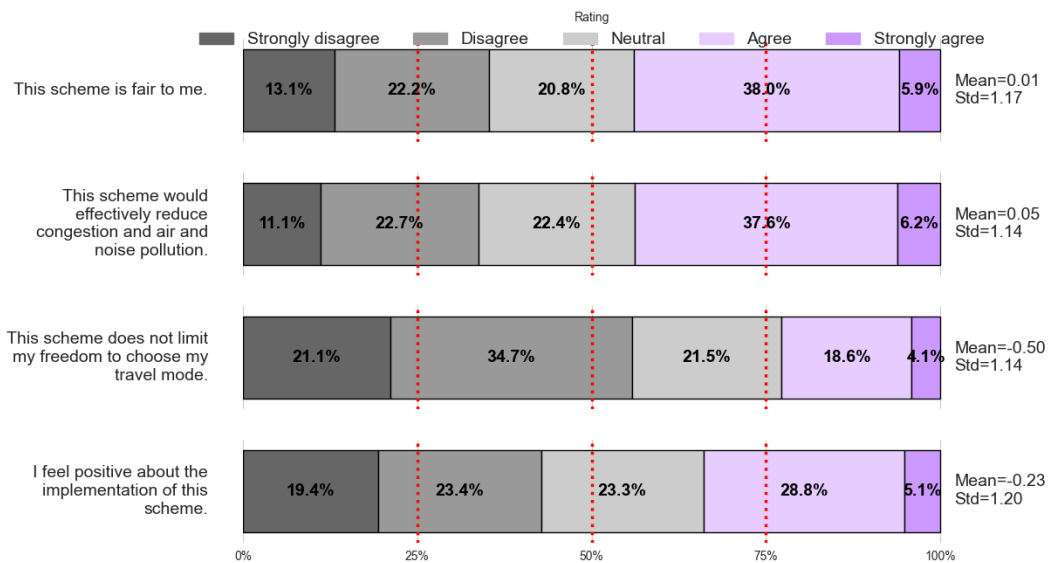


Figure 5.9: Overall distribution of answers to the statements regarding TMC schemes (-2 = strongly disagree, -1 = disagree, 0 = unsure, 1 = agree, 2 = strongly agree)

Rating results of the TMC characteristics

Looking at the different TMC allocation strategies, the accessibility and income ones have the least negative perceptions and acceptability, while the OD strategy is the least favored. Having only residents as TMC users also scores best in terms of perceptions and acceptability, while having only employed people as users is the opposite. Regarding transferability and validity of credits, monetisation is the most favorable option, while regulation and invalidation of the credits are the least. The different trading market regulations do not present very contrasted results, but having no regulation is the least unacceptable. Overall, individuals perceive TMC schemes as an infringement on their freedom, with more individuals not feeling positive about their future implementation.

The survey results do not clearly show which TMC characteristics are perceived as fair, effective, or acceptable. To better understand these relationships, Structural Equation Modeling (SEM) will be used. This method will reveal the underlying factors influencing acceptability, providing deeper insights than direct comparisons alone.

6

MODEL ESTIMATION RESULTS

This section first provides the results of the factor analysis that was performed to check the reliability of the five attitudes defined in Chapter 3. They were measured using a 5-point Likert scale, distribution of the answers and descriptive results are provided in previous section of Chapter 5 and Appendix E. After the structure of the attitudinal variable is clearly defined, the main results of the SEM model are presented.

6.1. EXPLORATORY FACTOR ANALYSIS RESULTS

Before estimating the postulated model defined in Chapter 3 (see figure 3.1), factor analysis was performed to understand the structure of the latent attitude variables and check the reliability of the latent construct.

Results of the CFA (see Appendix E) suggested a different structure of the five attitudes defined in Chapter 3. Moreover, the reliability of the factors using CFA was too low (see Appendix E). This could be because the attitudes were defined using literature from various transport policy papers as the concept of TMCs is new and as not been fully explored (the items for each attitude are described at the start of Appendix E).

Thus, 16 attitudinal indicators were analysed performing EFA (more information in Section E.3 of Appendix E). The extraction method of Principal Axis Factoring (PAF) was used combined with the Promax rotation technique. A simple structure of four factors was identified (see the scree plot in Appendix E). Table 6.1 provides the factor loadings after rotation.

As can be observed in Table 6.1, *POL_2*, *POL_4*, *TECH_2* and *TECH_4* present low loadings ($<|0.4|$). Moreover, *TECH_2* has a higher loading on *factor 1* which includes the trust in the government and the environment concern indicators. *POL_4* and *TECH_2* present their higher loadings for factor 2 which includes indicators related to car enthusiasm. As can be observed in Table 6.1, items from environmental concern and trust in the government present high loadings for the same factor (*factor 1*). Moreover, without accounting for the items *TECH_2*, *TECH_4* and *POL_4*, the structure of *factor 2,3* and *4* is the same as in the conceptual model, with technology adoption only having two items.

Factor 1 is a combination of the trust in the government and environment concern indicators. The combination of these items form a new factor: environmental responsibility, accounting for individual and the government responsibility regarding the impact of transportation on the environment. In order to check the internal consistency of the factors, a Cronbach's Alpha test was conducted. The reliability analysis resulted in four latent constructs with Cronbach Alpha > 0.5 , presented in Table 6.2. Even if *POL_2* presents a relatively low loading on *factor 4* 6.1, the reliability test conducted on SPSS suggested including it as it resulted in a higher Cronbach Alpha.

Items	1	2	3	4
CAR_2	0.038	0.759	0.099	0.002
ENV_2	0.749	-0.019	0.007	-0.015
CAR_1	0.055	0.739	0.018	-0.038
CAR_3	-0.070	0.736	-0.176	0.084
GOV_2	0.730	0.104	-0.077	-0.037
TECH_1	-0.050	-0.034	0.713	0.036
POL_1	0.012	-0.104	0.025	0.707
TECH_3	0.033	0.063	0.696	-0.017
ENV_1	0.618	-0.123	-0.056	0.093
POL_3	-0.047	0.143	0.113	0.550
ENV_3	0.547	0.059	0.115	-0.057
GOV_1	0.476	0.012	-0.067	0.128
POL_2	0.148	0.052	-0.155	0.378
POL_4	0.287	-0.358	-0.104	-0.077
TECH_4	0.347	-0.145	0.275	0.055
TECH_2	0.282	0.325	0.143	-0.039

Table 6.1: Results of EFA

Factor	Items	Scale Variance	Cronbach Alpha	Variance of the measurement error
2	CAR_1	7.319	0.758	1.771
	CAR_2			
	CAR_3			
1	ENV_1	13.974	0.762	3.326
	ENV_2			
	ENV_3			
	GOV_1			
	GOV_2			
4	POL_1	5.448	0.553	2.435
	POL_2			
	POL_3			
3	TECH_1	2.687	0.650	0.940
	TECH_3			

Table 6.2: Cronbach Alpha results

Attitude variables included in the model

After executing an EFA, four reliable factors were made up: environment responsibility (*ENV_1*, *ENV_2*, *ENV_3*, *GOV_1*, *GOV_2*), technology familiarity (*TECH_1*, *TECH_3*), car enthusiasm (*CAR_1*, *CAR_2*, *CAR_3*) and support for social policies (*POL_1*, *POL_2*, *POL_3*). Environment responsibility, relates to support for individual and government-led environmental action. These factors will serve as input for the SEM model.

As can be seen in Table 6.1, *Factor 1* and *2* have good reliability (Cronbach Alpha > 0.7) indicating that the latent constructs environmental responsibility and car enthusiasm are well-measured by their respective summated scales. The summated scale for *factor 4* indicates less reliability compared to the other variables, however it will still be included in the SEM model.

Each latent construct identified in EFA (*Factor 1,2,3,4*) is only measured by a single indicator variable in the SEM model. Those single indicators are a summated scale of the items. Each of these single indicator variables have error terms that are fixed in the SEM model. They represent the unreliability of the single indicators used to measure the latent constructs. These measurement error are determined using the Cronbach Alpha of the summated scales reported in Table 6.2. The proportion measurement error of the scale is given by $(1 - \text{Cronbach's alpha})$. Multiplying the proportion measurement error with the variance of the scale, the variance of the error component is obtained. This result is used to fix the measurement error of the single indicator in AMOS.

6.2. SEM RESULTS

AMOS SPSS software was used to estimate the postulated model defined in Chapter 3 (see Figure 3.1) and simplified in Figure 6.1. The model estimates path coefficients between:

- TMCs characteristics and perceptions (see section 6.2.1)
- Perceptions and acceptability (see section 6.2.1)
- Individual characteristics and attitudes (see section 6.2.2)

- Attitudes and perceptions (see section 6.2.4)
- Attitudes and acceptability (see section 6.2.4)
- Individual characteristics and perceptions (see section 6.2.3)
- Individual characteristics and acceptability (see section 6.2.3)

The final model turned out to fit the data very well as can be seen in Table 6.3.

Fit Index	Chi-square	Degrees of Freedom	Probability Level (p)	SRMR	RMSEA	GFI	CFI
Value	198.06	234	0.957	0.0097	0.000	0.996	1.000

Table 6.3: Model Fit Indices

The Chi-square test indicates that the model fits the data: $p > 0.005$, meaning that there are no significant differences between the observed and estimated covariances matrices. A SRMR below the 0.08 threshold indicates a very good fit for the residual covariance matrix. A RMSEA of 0 also implies that there is no discrepancy between the observed and estimated covariance matrices. Moreover, both CFI and GFI have values close or equal to 1 indicating that the model explains most of the variance in the observed data. Thus, the model is considered as valid and the model's outputs can be analyzed and interpreted.

Since the model is rather complex and includes a lot of variables, different parts of the model will be presented in the following subsections, as depicted in Figure 6.1, before presenting the overall model .

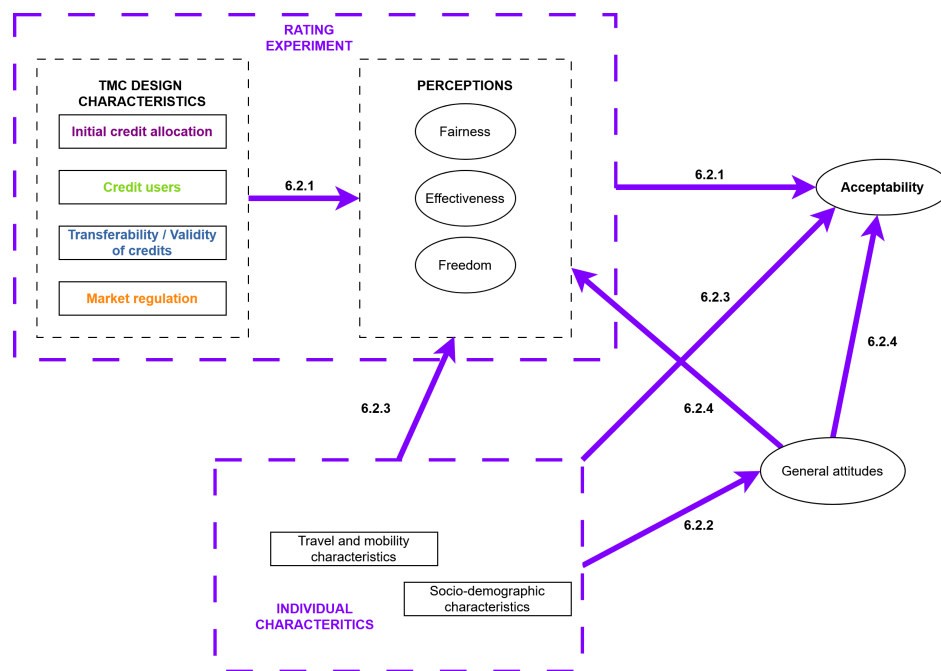


Figure 6.1: Simplified SEM with related sections

In order to make every coefficients of the model comparable and interpretable, the coefficients were standardized: transformed into a scale-free metric (mean = 0 and standard deviation (sd) = 1) in SPSS AMOS.

6.2.1. EFFECTS OF SCHEME CHARACTERISTICS ON PERCEPTIONS AND ACCEPTABILITY

AMOS was used to estimate the coefficients from the indicator variables (TMC scheme characteristics) to each of the three perceptions, as well as from these perceptions to acceptability. Table 6.4, presents the standardized direct effects of TMCs scheme characteristics on perceptions and their standardized total effect on acceptability. The significant effects ($p < 0.1$) are highlighted in bold.

TMC characteristics		Direct effects on			Total effects on
		Fairness	Effectiveness	Freedom	Acceptability
Allocation	Uniform	-0.014	0.001	0.01	-0.004
	Income	-0.01	-0.032*	0.037*	-0.008
	OD	-0.012	0	-0.022	-0.007
	Accessibility	0.036**	0.031*	-0.025	0.019
Users	Residents	0.079***	0.015	0.043**	0.039
	Vehicle owner/driver	-0.008	0.009	-0.030	-0.004
	Employed	-0.071***	-0.024	-0.013	-0.035
Transferability / Validity	Expiration	-0.077***	-0.015	-0.025	-0.036
	Transfer	0.046**	-0.029	0.008	0.012
	Monetisation	0.031*	0.044**	0.017	0.024
Trading market	Limitation	-0.006	-0.002	0.001	-0.003
	Price increase	-0.005	0.002	-0.008	-0.002
	No limitations	0.011	0	0.007	0.005
	Direct effects on acceptability	0.393***	0.229***	0.096***	

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 6.4: Effects (standardized regression weights) of TMCs scheme characteristics on perceptions and acceptability

DIRECT EFFECTS OF TMCs SCHEME CHARACTERISTICS ON PERCEPTIONS

Regarding TMC allocation strategies, not all attributes have significant effects on the perceived fairness of the scheme. The accessibility-based allocation has a significant positive effect on perceived fairness, while uniform and OD-based allocations negatively affect it. Individuals without access to PT need to use the car for their trips resulting in high credit consumption and quick shortage compare to individuals living close to PT services. Since TMC schemes are instruments that directly influence the costs of trips depending the transport mode use, it makes sense that perceived fairness is higher for accessibility-based allocation and lower for the uniform one. The accessibility-based allocation also has a significant positive effect on perceived effectiveness, whereas the income-based allocation has a significant negative effect. If people living in already well connected neighborhoods have a lower amount of credits than people living in neighborhoods with poor public connections, a TMC scheme with an accessibility-based allocation should make them use active modes or PT, reducing their negative transport externalities. Meanwhile, the income-based allocation has a significant positive effect on perceived freedom, while accessibility and OD-based allocations have non-significant negative effects. A credit allocation based on income would result in distributing more credits to individuals with lower incomes. Here, freedom is associated to the capacity of choosing a travel mode. Individuals with higher incomes are more likely to buy more credits if they exceed their budget: they should always be able to choose their travel mode and it would be the same for people with lower incomes if they get more credits initially. The signs of the attributes for each of the coefficients are in line with the means of the ratings described in section 5.4 in the previous Chapter.

When examining different TMC user groups, having all residents as eligible user has a significant positive effect on the perceived fairness and freedom of the scheme. In contrast, limiting eligibility to only employed people has a significant negative effect on perceived fairness. TMC schemes are supposed to be implemented in an entire urban area, thus including only a certain segment of the population decreases fairness as all people living in the same urban area produce negative externalities when travelling. None of the different user definitions have significant effects on the perceived effectiveness of the scheme, which is surprising as the higher the number of user the higher the impact of the scheme on negative transport externalities would be. Additionally, restricting eligibility to only vehicle owners or drivers does not yield any statistically significant effects on perceptions, though the regression weight for perceived freedom is relatively high (and negative). Having only car owners/drivers as user would have a direct impact on their possibility to choose travel modes as a TMC scheme would directly nudge them to choose a different transportation mode. These results are in line with means of the scheme ratings. Having all residents as TMCs user had positive means and lower negative means compared to only employed users (see section 5.4).

For the transferability (or validity) dimension of TMC schemes, credit expiration (invalidation) at the end of the month has a significant negative effect on perceived fairness, while the ability to transfer or monetise credits has a significant positive effect. If a user has a lot of credits remaining at the end of the month it means that he has been using PT or active modes for most of his trip, thus his negative transport externalities are low. While it is probably the opposite for a user that just has a few credits left. Thus having the credits expiring at the end of the month instead of them being monetised or transferred creates an important imbalance between the two users in favor of the one with higher negative transport externalities. For perceived effectiveness, only the monetisation of TMCs at the end of the month has a significant and positive effect. In fact, being able to monetise credits had the end of the month, would nudge individuals to change their travel behaviour in order to reduce their air and noise pollution or congestion as they would be able to win money since the credits are allocated for free at the beginning of the month. None of the transferability characteristics have a significant effect on perceived freedom. Credit expiration has a negative effect, while transfer and monetisation of credits have a positive effect. These results are also in line with the means of the ratings provided in section 5.4. Monetisation performed best across all perceptions and acceptability while invalidation appeared as the least favored.

Regarding the trading market dimension, none of the TMC characteristics have significant positive or negative effects on any of the perceptions. Trading market regulation can be more complex and abstract to understand. Moreover, it is more likely that individuals first focus on the credits they have and later on what they can possibly do with them.

RQ3. How do different TMC schemes characteristics influence the perceived fairness, effectiveness and freedom of such an instrument ?

Income and accessibility allocation strategies both significantly influence the perceived effectiveness of TMC schemes, as well as perceived freedom and fairness, respectively. Defining only residents or employed individuals as TMC users influences the perceived fairness of the schemes. Furthermore, limiting eligibility to only residents increases the perceived freedom of the scheme. All credit transferability options influence the perceived fairness of the scheme, and monetisation of credits also influences the perceived effectiveness. None of the trading market regulations influence the perceptions of TMC schemes.

These initial results support the first hypothesis (H1): *TMC design characteristics influence perceptions of TMC schemes.*

MEDIATION EFFECTS OF PERCEPTIONS ON TMCs ACCEPTABILITY

As explained in Chapter 3, perceptions were assumed to mediate the effects of TMC schemes' characteristics on acceptability. The initial model started by drawing all paths between variables including direct paths from each of the TMC characteristics to acceptability. After estimating the initial model, these paths were removed as they were not statistically significant. The modification indices did not indicate any direct path to be added between TMC scheme characteristics and acceptability. Thus, TMC characteristics do not have any direct effects on acceptability.

At the bottom of Table 6.4, it can be seen that the direct effects of the three perceptions on acceptability are significant ($p < 0.001$). Perceived fairness (0.393) has the strongest effect on acceptability, followed by effectiveness (0.229) and freedom (0.096).

All the allocation strategies have minor negative effects on acceptability, except for the accessibility-based one, which would increase the acceptability of the scheme. Looking at the user dimension, two user definitions have strong opposite effects on acceptability. Having only residents as TMC user would increase the acceptability while on the other hand, having only employed people as users would decrease the acceptability of the tool. As explained above, every citizen of a urban area is using the transport infrastructure, resulting in negative externalities. Limiting the scheme to only a segment of the residents has a negative effect on all perceptions thus a negative effect on acceptability. The same opposition effect of TMC attributes can be identified for the transferability dimension. Credits invalidation would decrease acceptability while on the other hand credit monetisation would increase it.

Looking in more details at the total effects of TMC attributes on acceptability, only four attributes present relatively high loadings: all residents and employed for the user dimension and expiration and monetisation for the transferability/validity dimension. The attributes related to the allocation dimension have less impact on acceptability due to the mediation effect of the perceptions. The positive and significant effect of accessibility allocation on perceived fairness and effectiveness are decreased by the negative effect of perceived freedom resulting in a relatively minor influence on acceptability. Similarly, for income based allocation, the positive significant effect of the perceived freedom is suppressed by negative significant effect of the perceived fairness of this allocation strategy resulting in a minor negative acceptability.

RQ4. How does these perceptions mediate the relationship between TMC schemes characteristics and acceptability ?

TMC characteristics do not have direct effects on acceptability. Their effects are mediated by the perceptions.

Looking at the total effects of the different allocation strategies on acceptability, the user and transfer dimensions appear to have the most effect on acceptability, while the effects of different allocation strategies are mediated by the perceptions resulting in less effect on acceptability. Moreover, the trading market regulation dimension does not have any effect on acceptability of TMCs.

These first results support the second hypothesis (H2): *Perceived fairness, effectiveness, and freedom mediate the relationship between acceptability and TMC schemes' characteristics.*

6.2.2. DIRECT EFFECTS OF SOCIODEMOGRAPHIC AND TRAVEL BEHAVIOUR CHARACTERISTICS ON ATTITUDES

AMOS was used to estimate the coefficients from the sociodemographic and travel behaviour variables to each of the four attitudes described in section 6.1. These coefficients are presented in Table 6.5. The significant ($p < 0.1$) effects are highlighted in bold. It can be observed that most sociodemographic and travel related

characteristics have a significant effect on the four attitudes.

	Direct effects on			
	Support for social policies (Lpol)	Technological familiarity (Ltech)	Environmental responsibility (Lenv_gov)	Car enthusiasm (Lcar)
Sociodemographic				
Gender (female)	0.008	0.016	0.092***	0
Age	-0.098**	0.164***	-0.001	0.004
Income level	-0.19***	0.065**	0.1***	-0.038**
Household (with child)	0.095***	0	0.068**	-0.017
Educational level	-0.149***	0.042*	0.051**	-0.114***
Origin (outside NL)	-0.009	-0.063**	-0.014	-0.042**
MRA (not Amsterdam resident)	-0.122***	-0.045**	-0.109***	0.113***
Retired (no)	-0.106**	0.08**	-0.055	-0.03
Student (no)	0.046	-0.201***	0.065**	-0.045**
Employed (no)	0.106**	-0.102**	0.079**	-0.049*
Travel behaviour				
Car ownership (no)	-0.017	-0.042	0.059**	-0.498***
PT subscription (no)	-0.203***	0.036	-0.203***	0.149***
Car use (less than 4 times per week)	-0.032	-0.093***	0.042*	-0.216***
Bike use (less than 4 times per week)	-0.043*	-0.066**	-0.106***	0.098***
PT use (less than 4 times per week)	0.046*	-0.021	-0.015	-0.025
Work flexibility (no)	-0.04	-0.066**	-0.137**	-0.037**
PT accessibility (no)	-0.056**	-0.028	-0.033*	0.035**

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$.

Table 6.5: Direct effects (standardized regression weights) of sociodemographic and travel behaviour characteristics on attitudes

Regarding car enthusiasm, people who do not live in Amsterdam and have a low education level have higher car enthusiasm. The same applies to people who own a car and use it frequently. Moreover, the positive signs of path loadings for bike use and PT subscription indicates that infrequent bike users and respondents without a PT subscription also have higher car enthusiasm.

Support for individual and government-led environmental action is higher among female, household with children, higher income and individuals living in Amsterdam. Moreover, people without any PT subscription and those who do not bike frequently are associated with lower environmental responsibility as well as ones with lower work flexibility. Moreover, non-employed individuals show higher support in regard to environmental responsibility than employed individuals.

Looking at technology familiarity, it appears that older individuals and ones with higher income are more familiar with technology. Moreover, higher education also increases familiarity while non-employed individuals have lower technological familiarity than employed ones. For travel behaviour characteristics, less frequent car and bike use reduces familiarity with technology as well as having less work flexibility.

Lastly, a higher income level is associated with lower support for social policies as well as a higher level of education. Moreover, people who are not from Amsterdam also show lower political support. On the other hand, household composition also has a significant effect on political support for social policies: having children increases support, as well as not being employed. PT subscription is the only variable among the travel

behaviour one that has a very significant effect on political support: not having a PT subscription strongly reduces support for social policies. Moreover, low PT accessibility as well as less frequent bike use also reduces support.

Direct effects of individual characteristics on attitudes

These first results support the seventh hypothesis (H7): *Individual characteristics influence general attitudes*. PT subscription as well as living location (outside of Amsterdam or not) are recurring strong predictors across all attitudes except technological familiarity. Overall sociodemographics variables have more effect than travel behaviour ones on support for social policies and technology familiarity. While almost all travel behaviour characteristics have a significant effect on car enthusiasm. Non employed individuals (unemployed, students, retired and other) are more supportive of social policies and express more environment responsibility compared to employed individuals. Moreover, they are less familiar with technology and enthusiastic about cars.

6.2.3. EFFECTS OF SOCIODEMOGRAPHIC AND TRAVEL BEHAVIOUR CHARACTERISTICS ON PERCEPTIONS AND ACCEPTABILITY

This section presents the path loadings from the sociodemographic and travel behaviour variables to the three perceptions and acceptability. The significant ($p < 0.1$) effects are highlighted in bold in Table 6.6.

	Direct effects on				Total Effect on
	Fairness	Effectiveness	Freedom	Acceptability	Acceptability
Sociodemographic Variables					
Gender (female)	-0.016	0.006	0.016	-0.002	0.038
Age	-0.132***	-0.132***	-0.008	-0.053***	-0.169
Income level	0.015	-0.02	-0.011	0.049**	0.071
Household (with child)	0.014	0.038**	-0.017	-0.027**	0.032
Educational level	-0.024	-0.04**	-0.042**	-0.035**	-0.044
Origin (outside NL)	-0.019	0.023	-0.005	0.008	0.010
MRA (not Amsterdam resident)	-0.019	0.022	-0.044**	-0.029**	-0.11
Retired (no)	-0.064**	-0.118***	-0.101**	0.003	-0.106
Student (no)	0.018	0.01	0.018	0.034**	0.113
Employed (no)	-0.005	-0.046*	-0.064**	0.013	0.064
Travel behaviour Characteristics					
Car ownership (no)	-0.051**	-0.045*	-0.117***	-0.044**	0.001
PT subscription (no)	-0.044**	-0.022	0.049**	-0.04**	-0.202
Car use (less than 4 times per week)	-0.008	-0.032*	-0.045**	0	0.037
Bike use (less than 4 times per week)	0.011	0.007	0.048**	0.031**	-0.018
PT use (less than 4 times per week)	0.015	0.009	0.019	-0.002	0.012
Work flexibility (no)	-0.032*	0.002	0.012	0.013	-0.056
PT access (no)	-0.004	0.027*	-0.02	-0.004	-0.025

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$; the reference level of the binary variables are in brackets

Table 6.6: Direct and total effects of sociodemographic and travel behaviour characteristics on perceptions and acceptability

DIRECT EFFECTS OF SOCIODEMOGRAPHIC AND TRAVEL BEHAVIOUR CHARACTERISTICS ON PERCEPTIONS AND ACCEPTABILITY

First, it can be seen that gender, origin, as well as PT use, work flexibility, and PT accessibility have non-significant or very little significant effects on perceptions and acceptability.

Only two sociodemographic variables have a significant effect on perceived fairness: age and living occupation. Perceived fairness and effectiveness decrease with age. Looking at the perceived infringement on freedom, age

is not significant anymore. Perceived freedom also decreases for non-employed individuals. Moreover, living outside of Amsterdam also reduces perceived freedom. Looking at the direct effects on acceptability, age and education level are associated with low acceptability: the higher the age and the higher the education level is the lower the acceptability. While households with high income and without children rate acceptability higher.

There are fewer travel behaviour characteristics that have significant effects on perceptions. Some of them have counter-intuitive signs. Here, non car owners perceive TMC as less fair, effective, acceptable and more infringing their personal freedom. On the other hand, individuals who bike less find that TMC increases their freedom and they find it more acceptable. Individuals without a PT subscription perceive TMC as less fair but they feel it increases their freedom.

Direct effects of individual characteristics on perceptions and acceptability

Age is the most consistent negative predictor across fairness, effectiveness and acceptability. The higher the age is the lower the perceptions and the acceptability is. Not having a PT subscription as well as not having a car reduces the perceived fairness, effectiveness and acceptability of the scheme. However, not having a car strongly reduces the perceived freedom of the scheme while not having a PT subscription increases it.

These first results support the fifth and sixth hypothesis (H5-6): *Individual characteristics influence perceptions and acceptability.*

TOTAL EFFECTS OF SOCIODEMOGRAPHIC AND TRAVEL BEHAVIOUR CHARACTERISTICS ON ACCEPTABILITY

As illustrated in Figure 6.1, individual characteristics directly influence acceptability but also influence attitudes and perceptions that in turn influence acceptability. Thus mediation effects need to be taken into account.

First, age has the highest effect on acceptability as can be seen in the last column of Table 6.6. Older individuals find the scheme less acceptable than younger ones. In contrast, households with higher income and with children are associated with higher total acceptability. People living outside of Amsterdam and ones with higher education are associated with lower acceptability. Looking at travel behaviour characteristics, individuals without a PT subscription have a low acceptability score as well as individuals that do not have work flexible arrangements. Moreover, car ownership, which had significant path loadings for every perceptions and (direct) effect on acceptability has no total effect on acceptability, illustrating the possible mediation effect of attitudes and perceptions. Non-employed individuals perceive TMC as less effective and more restrictive on their freedom, but the total effect on acceptability is positive, also illustrating the possible mediation effect of attitudes and perceptions.

RQ5. To what extent factors such as sociodemographics and travel behaviour variables influence acceptability of TMCs ?

Lack of PT subscription has the largest negative effect on acceptability which makes sense as a TMC instrument is made to make individual car trips more expensive than ones with PT. Amsterdam residents have higher acceptability than the rest of individuals living in MRA likely due to better public and active modes infrastructure. Non employed individuals also have higher acceptability.

These first results support the fifth and sixth hypothesis (H5-6): *Individual characteristics influence perceptions and acceptability.*

6.2.4. EFFECTS OF ATTITUDES ON PERCEPTIONS AND ACCEPTABILITY

This section presents the path loadings from the attitudes to the perceptions and acceptability as well as the total effects of attitudes on acceptability. The significant ($p < 0.1$) effects are highlighted in bold in Table 6.7. Most attitudes have a significant effect on each of the perceptions and acceptability.

	Direct effects on				Total Direct Effect on Acceptability
	Fairness	Effectiveness	Freedom	Acceptability	
Support for social policies (Lpol)	0.095**	-0.063*	0.043	0.094***	0.121
Technological familiarity (Ltech)	-0.086***	-0.08***	0.144***	-0.087***	-0.125
Environmental responsibility (Lenv_gov)	0.398***	0.647***	0.066*	0.172***	0.483
Car enthusiasm (Lcar)	-0.096**	-0.025	-0.411***	-0.027	-0.110

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 6.7: Direct effects (standardized regression weights) of attitudes on perceptions and acceptability

DIRECT EFFECT OF ATTITUDES ON PERCEPTIONS AND ACCEPTABILITY

Environmental responsibility has a strong, significant positive effect on the perceived fairness of TMC schemes. Moreover, higher support for social policies is also associated with perceiving TMCs as fairer. In contrast, higher technological familiarity and higher car enthusiasm are associated with a lower perception of TMC fairness. Environmental responsibility also has a strong positive effect on the perceived effectiveness of the scheme. However, greater familiarity with technology is associated with a negative effect on the perceived effectiveness of the scheme as well as higher support for social policies. Looking at the perceived freedom of the scheme, environmental responsibility is less significant this time. Technological familiarity is associated with an increase in perceived freedom. However, car enthusiasm has a strong negative effect on the perceived freedom of the scheme.

Direct effects of attitudes on perceptions and acceptability

Focusing on acceptability, all attitudes except car enthusiasm have a significant direct effect. Environmental responsibility has the strongest positive effect. Moreover, higher support for social policies also directly increases acceptability. In contrast, higher technological familiarity decreases acceptability of the scheme. These results support the third and fourth hypothesis (H3-4): *Attitudes influence perceptions and acceptability.*

MEDIATION EFFECTS OF PERCEPTIONS BETWEEN ATTITUDES AND ACCEPTABILITY

When comparing the last two columns of Table 6.7, it can be observed that the total direct effects of the attitudes on acceptability are higher than the direct ones, suggesting that perceptions play a mediative role between attitudes and acceptability. The mediation effect of the perceptions is particularly important between environmental responsibility (Lenv_gov) and acceptability: the indirect effect is 0.311 (total effect - direct effect): 64% of its effect is mediated by the perceptions. The same applies to car enthusiasm (Lcar), where 75% of its effect is mediated by perceptions.

RQ5. To what extent factors such as attitudes influence acceptability of TMCs ?

Perceptions are significantly influenced by attitudes. Environment responsibility present strong positive direct effects on the perceived fairness and effectiveness of the scheme. On the other hand, car enthusiasm is the only attitude with a strong negative direct effect on the perceived freedom of the scheme. All these perceptions act as mediators between attitudes and acceptability.

6.2.5. FULL MODEL

Figure 6.2 presents the estimated significant paths and their standardized coefficients that denote their direct effects. For ease of presentation, the summated scales of the latent variables and all the error terms are left out of the figure as well as the correlation arrows. Positive effects are highlighted in green and negative ones in purple. Moreover, significant direct paths between individual characteristics and attitudes were removed as they are not the main focus of this study. Table 6.9 provides the standardized total effects, the last column shows the overall impact of each variable on acceptability.

As illustrated by Figure 6.2 and the findings from the previous section, seven TMC attributes directly influence perceptions. Looking at the influence of TMC characteristics on acceptability (first rows in Table 6.9) it can be seen that most of the TMC attributes have minor effects on TMC acceptability compared to individual characteristics or attitudes. Krabbenborg et al. (2021b) had similar results in their study on public support of TPC: personal factors including sociodemographic variables, attitudes and perceptions were more influencing factors compared to scheme characteristics.

Attributes from the transferability dimension present relatively high loadings compared to others: monetisation of mobility credits would increase acceptability while invalidation of credits would decrease acceptability. The importance of those two attributes can be explained by the fact that they have significant effects on perceptions. Moreover, the user dimension of the TMC scheme also presents opposing attributes with high loadings. Having all residents as eligible user increases the acceptability of the scheme while having only employed people decreases its acceptability. These results are in line with the analysis provided by Li and Robusté (2025) on TMC user definition, as having all residents as user provides the highest level of vertical equity. If the TMC scheme is implemented in an urban area, having all the user of the transport infrastructure, thus all the residents enhance the fairness of the instrument thus its acceptability. In their field experiment, Brands et al. (2021) and Geng et al. (2023) showed that having specific segment of users (employed individuals or students) for specific context (office or university) did not yield in negative support of TMCs. Looking at the allocation dimension, the accessibility based one is the only strategy with a relatively high total effect and is also the only positive one. This result is in line with the study conducted by Hamm et al. (2025), in which public support for non-uniform allocation of credits was high. While it contradicts the result of Krabbenborg et al. (2021b) for which a uniform allocation of credits (only used for peak hours) was preferred.

Regarding sociodemographic characteristics in Table 6.9, two variables have high total effects: age and living location (excluding being retired or a student). The higher the age the less acceptable the TMC scheme, in line with results from Cui et al. (2024) where younger individuals were more likely to support TPC. Moreover, people who are not employed have a higher overall acceptability compare to employed ones. People living outside of Amsterdam have lower acceptability. Cui et al. (2024) also showed that individuals from urban areas were more likely to support TPC schemes. For the travel behaviour characteristics, not having a PT subscription strongly reduces acceptability, this effect was also identified by Hamm et al. (2025). As can be seen car ownership does not have a total effect on acceptability. This is due to the mediation effect of perceptions. Not owning a car increases the perceived freedom of the scheme, but the effect of freedom on acceptability is much smaller compare to the ones of fairness and effectiveness (bottom rows of the Table 6.9), thus these effects cancel out,

resulting in no total direct effect on acceptability.

Focusing on attitudes, environment responsibility is the one with the highest effect: higher environmental responsibility leads to higher acceptability. Hamm et al. (2025) also identified climate change awareness has a strong positive predictor of public support. Focusing on congestion pricing, Sun et al. (2016) had the same result. As expected, higher support for social policies also leads to higher acceptability of TMCs. Those results make sense as a TMC instrument is made to reduce the impact of transport emissions on the environment in a fair way based on the polluter pay principle. On the other hand higher familiarity with technology and higher car enthusiasm leads to lower acceptability. The negative effect of car enthusiasm makes sense as a TMC scheme is made to reduce individual car use. All studies mentioned in the literature review (see Chapter 2) identified car ownership and frequent car use as strong predictor of non public support. These variables are strong predictors of car enthusiasm as can be seen in Table 6.9. However the negative effect of technology familiarity is hard to interpret. One would have assumed that being familiar with technology would have positively influence acceptability since TMC would be operationalised via a specific online platform.

Finally, all perceptions positively affect acceptability. Similarly to Krabbenborg et al. (2021b), fairness and perceived effectiveness have the most influence on acceptability for TMCs, also in line with results from Cui et al. (2024).

	Lpol	Ltech	Lenv_gov	Lcar	Fairness	Effectiveness	Freedom	Acceptability
% R^2	0.148	0.081	0.157	0.515	0.293	0.396	0.136	0.61

Table 6.8: Explained variance (R^2)

The R^2 (explained variance) for the attitudes, perceptions and acceptability are presented in the last row of Table 6.9. Looking at attitudes, we can see that most variance for policy support, technology familiarity and environmental responsibility remain unexplained by their predictors (individual characteristics). Moreover, the variance of the error terms also explain that attitude such as environmental responsibility is not fully explained by the model (see Appendix G). This means that the estimated model is not very successful in reproducing these individual attitudes. On the other hand, more than 50% of the variance in car enthusiasm is explained by the model. Perceptions show moderate explanatory power: only 14% of the variance in perceived freedom is explained and 30% for perceived fairness. The estimated model is not very successful in explaining these individual perceptions. Perceived effectiveness has the highest explanatory power with 40% of its variance explained by the predictors defined in the model. Lastly but most importantly, 61% of the variance in acceptability is explained by the model. Thus the three different types of predictors: individual characteristics, attitudes and perceptions have a strong explanatory power for acceptability.

Predictors of acceptability

The model demonstrated an exceptional fit to the data (key fit indices in Table 6.3). Results of the SEM confirms that acceptability of TMCs is primarily driven by perceptions of fairness and effectiveness, which are shaped by scheme design characteristics as well as and individual characteristics. While TMC characteristics only have indirect effects via perceptions, other individual characteristics such as environment responsibility and support for social policies but also age, living location and having a PT subscription exert strong direct influence on acceptability. Attitudinal factors exert the strongest influence on acceptability likely because they are endogenous to it. Attitudes defined in this model are not only predictors of acceptability but can also be shaped by the same underlying factors that influence acceptability itself. The model explains 61% of the variance in acceptability, highlighting its robustness, though limitations like non-linearity and overfitting warrant caution in interpretation.

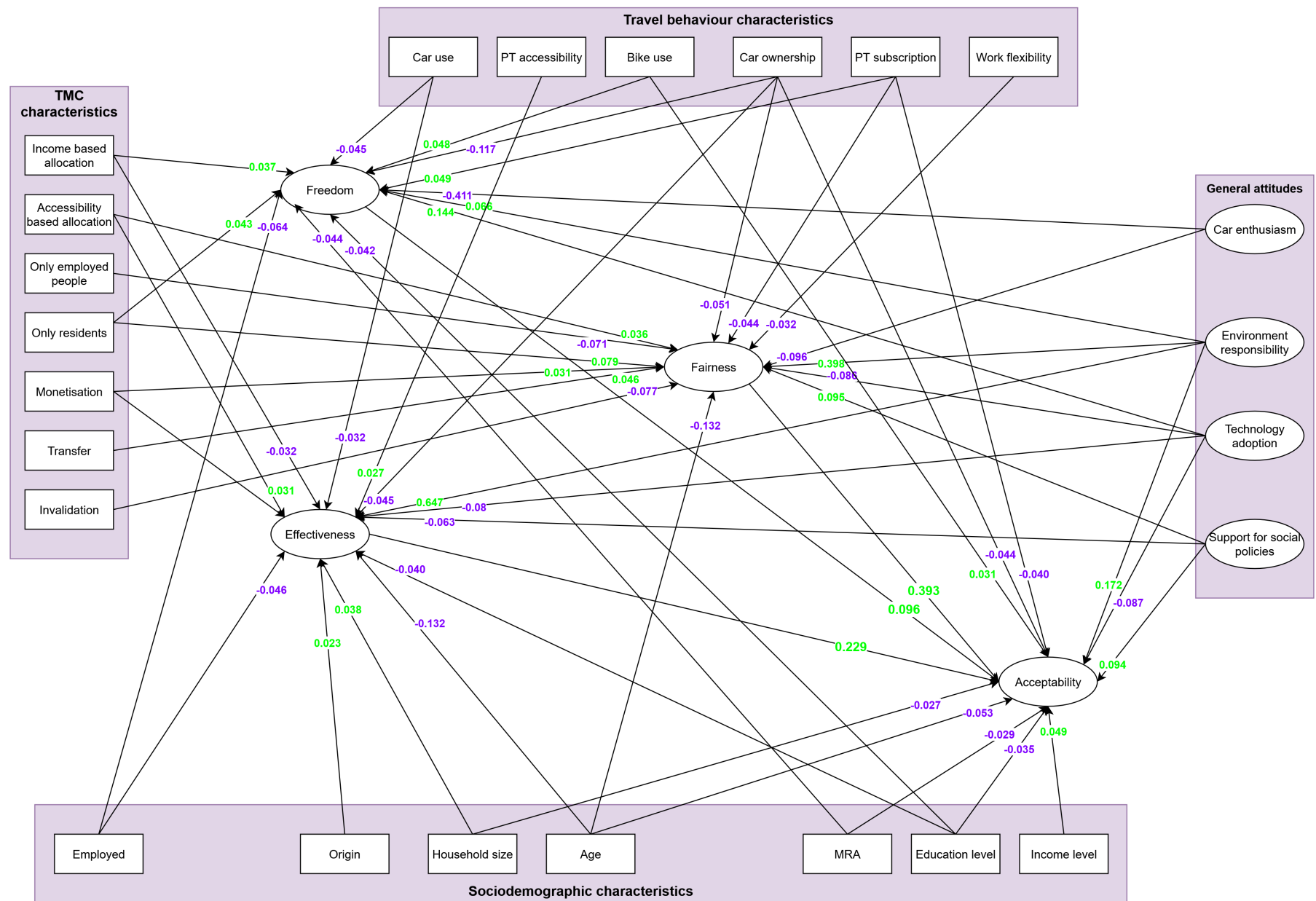


Figure 6.2: Simplified estimated structural model

		Total effects							
		Lpol	Ltech	Lenv_gov	Lcar	Fairness	Effectiveness	Freedom	Acceptability
Trading market regulation	Price increase					-0.005	0.002	-0.008	-0.002
	Limitation					-0.006	-0.002	0.001	-0.003
	No limitations					0.011		0.007	0.005
Transferability / Validity	Monetisation					0.031	0.044	0.017	0.024
	Transfer					0.046	-0.029	0.008	0.012
	Invalidation					-0.077	-0.015	-0.025	-0.036
Users	Employed					-0.071	-0.024	-0.013	-0.034
	Vehicle					-0.008	0.009	-0.03	-0.004
	Residents					0.079	0.015	0.043	0.038
Allocation	Accessibility					0.036	0.031	-0.025	0.019
	Income					-0.01	-0.032	0.037	-0.008
	OD					-0.012		-0.022	-0.007
	Uniform					-0.014	0.001	0.01	-0.004
Sociodemographic variables	Gender (female)	0.008	0.016	0.092		0.02	0.064	0.025	0.038
	Age	-0.098	0.164	-0.001	0.004	-0.157	-0.14	0.01	-0.169
	Income level	-0.19	0.065	0.1	-0.038	0.035	0.052	0.013	0.071
	Household (with children)	0.095		0.068	-0.017	0.052	0.076	-0.001	0.032
	Educational level	-0.149	0.042	0.051	-0.114	-0.011	0.002	0.007	-0.044
	Origin (outside NL)	-0.009	-0.063	-0.014	-0.042	-0.016	0.021	0.002	0.01
	MRA (not Amsterdam residents)	-0.122	-0.045	-0.109	0.113	-0.081	-0.04	-0.11	-0.11
	Retired (no)	-0.106	0.08	-0.055	-0.03	-0.1	-0.153	-0.085	-0.106
	Student (no)	0.046	-0.201	0.065	-0.045	0.07	0.066	0.013	0.113
Travel behaviour variables	Employed (no)	0.106	-0.102	0.079	-0.049	0.051	0.008	-0.049	0.064
	Car ownership (no)	-0.017	-0.042	0.059	-0.498	0.022	0.01	0.085	0.001
	PT subscription (no)	-0.203	0.036	-0.203	0.149	-0.161	-0.147	-0.029	-0.202
	Car use (less than 4 times per week)	-0.032	-0.093	0.042	-0.216	0.034	0.01	0.032	0.037
	Bike use (less than 4 times per week)	-0.043	-0.066	-0.106	0.098	-0.04	-0.056	-0.011	-0.018
	PT use (less than 4 times per week)	0.046	-0.021	-0.015	-0.025	0.018	-0.001	0.027	0.012
	Work flexibility (no)	-0.04	-0.066	-0.137	-0.037	-0.082	-0.078	0.008	-0.056
Attitudes	PT accessibility (no)	-0.056	-0.028	-0.033	0.035	-0.023	0.01	-0.043	-0.025
	Support for social policies (Lpol)					0.095	-0.063	0.043	0.121
	Technological familiarity (Ltech)					-0.086	-0.08	0.144	-0.125
	Environmental responsibility (Lenv_gov)					0.398	0.647	0.066	0.483
Perceptions	Car enthusiasm (Lcar)					-0.096	-0.025	-0.411	-0.11
	Freedom								0.096
	Effectiveness								0.229
	Fairness								0.393

Table 6.9: Total standardized direct effects

KEY FEATURES OF TMC SCHEMES FOR FUTURE IMPLEMENTATION

This chapter briefly explores the design of Tradable Mobility Credits (TMC) schemes, by analyzing the positive and negative effects of various TMC features provided in Table 6.9. Qualitative insights from some respondents also provide valuable information for design of future TMC schemes.

7.1. DESIGNING TMC SCHEMES

The most acceptable TMC scheme, is a combination of TMC characteristics that have the highest positive effect on acceptability (coefficients in Table 6.9), while the worse one is a combination of the highest negative effects. The most acceptable TMC scheme as well as the worse one are described in the following figures.

Initial credit allocation	Accessibility based the number of credits depends on the availability of public transport options in a person's area
Users	All Residents people over 18 living in the urban area
Transferability / Validity of credits	Monetisation of credits unused credits can be converted into money at the end of the month
Trading Market regulation	No limitations there are no restrictions on buying or selling credits: users can trade them freely

Figure 7.1: Most acceptable TMC scheme

While the accessibility-based allocation would allow more equity as well as having all residents of an urban area part of the TMC scheme, one can see that monetisation of credits combined with no trading market regulation

could lead to a complex situation that could exacerbate inequalities between users. With this scheme, high-income users and users familiar with trading could possibly earn more money, assuming that high-income users would be less sensitive to buying extra credits on the platform. Given that high-income groups disproportionately contribute to climate change (Schöngart et al., 2025), this combination of scheme characteristics could diminish the polluter-pay principle partially embodied by TMCs. However, similarly to the scheme that was designed by Servatius et al. (2022) in which monetisation of credits is allowed, policymakers should ensure that TMC users can only invest that money in transport projects. A similar approach is also recommended by Millonig et al. (2022). They suggest that mobility credits could be transformed in credits that could only be used in public transport. Moreover, the monetisation of credits is one of the few characteristics of a TMC scheme that can directly transform it into a reward system for individuals with minimal negative transport externalities (Servatius et al., 2022).

Initial credit allocation	Income based the number of credits varies according to a person's income level (e.g., lower-income individuals may receive more credits)
Users	Only employed people who are working in the urban area (credits would only be used for commuting trips)
Transferability / Validity of credits	Invalidation unused credits that have not been traded on the platform are destroyed at the end of each month: they can not be used for the next month
Trading Market regulation	Limitations user cannot buy unlimited additional credits: they have to respect a certain limit

Figure 7.2: Least acceptable TMC scheme

Given that in our specific study TMC schemes would be implemented in an urban area, having only a specific segment of the population as user (employed people) would lead to low public support as it would enhance inequalities between non-employed and employed user who are both having negative transport externalities on the environment. Looking at the transfer dimension, even if invalidating credits at the end of the month would spur speculation 2023 it is highly perceived as unfair and infringing on ones freedom as well as being only able to buy a limited amount of credits. However, having those two characteristics of the transfer dimension would allow policymakers to reach their targets in reduction in emissions from the transport sector.

Those first two schemes illustrate the complexity of TMCs. Given that they are still radical innovations, they have to be tested in specific situations like the experiments done by Brands et al. (2021) and Geng et al. (2023) on longer periods so that their characteristics can be fine tuned. Thus, before defining trading regulations or validity periods for credits, policy makers should first identify specific locations in urban areas in which TMC could be implemented. These specific locations should be directly linked to a specific type of user in order to have an acceptable TMC scheme. Given that acceptability decreases with age, universities could serve as ideal pilot locations, as they are supposed to be key places where societal change processes are developed (Esteban Ibáñez et al., 2020). Moreover, implementing TMC schemes on a small scale would reduce administrative

burden and allow the development of effective communication and secured tracking tools to measure GHG emissions of individual trips. Additionally, survey results indicated that most respondents were familiar with the use of smartphones for making online payments and relied on GPS tracking apps for travel. Furthermore, half of the respondents expressed confidence in their ability to manage and trade credits. Therefore, policy makers should leverage this existing technological familiarity to facilitate the adoption of TMC schemes.

7.2. QUALITATIVE INSIGHTS FROM RESPONDENTS

This section presents an analysis of a selection of specific open-ended comments (53) provided by respondents at the conclusion of the survey. The comments reveal a strong consensus among respondents: while most demonstrated a clear understanding of TMC schemes, they expressed opposition to a possible implementation. The comments highlighted several recurring themes, including concerns about equity, practicality, and critics of the existing public transport infrastructure.

The majority of comments (from 21 respondents) reflected strong opposition to the concept of TMCs. Respondents perceived the schemes as unfair, impractical, or even dystopian:

- *Live and let live. Everyone wants freedom, for some it's the car, for others public transport. There shouldn't be a system behind it, let alone a digital one.*
- *If you make people who work and need cars pay extra for credits, and let unemployed people who sit on their lazy asses at home with a beer can sell their unused credits and get rewarded for staying home, then we're really missing the point.*
- *What dystopian nonsense this is, emission credits that can be sold or bought. And then the government decides if I can go somewhere by public transport or if I'm allowed to drive? Or do I have to cycle or walk everywhere by force? Orwellian totalitarianism, totally absurd.*
- *Far too complicated and prone to fraud.*
- *The global use of private jets has been rising for years. Shell, other oil companies, Tata Steel, etc., have no intention of becoming sustainable. It's an illusion to think you can place the environmental crisis on the shoulders of citizens.*

However these strong criticism show that they have understood TMC schemes. Moreover, these comments highlight possible limitations of the TMC schemes, with some individuals taking advantage of a possible monetisation of credits. As explained by Provoost et al. (2023) monetisation of credits could lead to speculative behaviours that would hinder the efficiency of TMCs. Another important critic of TMCs is due to the fact that this system would only apply to individuals, while some could consider that the impacts of the climate crisis is due to bigger companies.

Moreover, a significant portion of the comments (from 12 respondents) emphasized the lack of consideration for people with disabilities in the survey's description of TMC schemes. Respondents with disabilities stressed their reliance on cars due to physical limitations, arguing that such schemes would exacerbate inequality if their needs were not explicitly addressed: *The whole idea creates inequality between people who depend on a car (e.g., due to physical limitations) and those who can choose another option.*

Another point of contention was the current state of public transportation, which at least 12 respondents deemed explicitly unreliable, expensive, or inaccessible. Several comments criticized the impracticality of shifting to PT under existing conditions *As long as public transport is unreliable, trips keep getting canceled, and I can't get to work by public transport, I won't use the ridiculously expensive public transport..* Another respondent argued for simplification and cost reduction as prerequisites for any TMC implementation: *Don't make it so*

complicated. It only creates more work for agencies that are already understaffed. Make public transport cheaper!!! Then everyone can choose their own mode of transport..

Several respondents highlighted the possible incompatibility of TMC schemes with certain professions, particularly those requiring physical presence or frequent travel. For example, healthcare workers, who often must use private vehicles to visit patients or commute between facilities, expressed strong objections. One respondent noted: *I can't possibly work from home because I work in healthcare and deal with patients.* Additionally, concerns were raised about workers in industries without remote work options, who already face higher transportation costs. A respondent elaborated: *For many workers, it's not possible to work from home. They often still depend on their own car or expensive public transport. Not everyone can cycle. Their costs are then much higher than office workers, who often have a higher salary and the option to work from home. That's unfair..*

Moreover, some respondents also showed frustration as the description of the TMC scheme was very broad and did not provide detailed information about electric cars: *Since I drive an electric car, which I charge using solar panels and a battery, I think people in similar situations shouldn't need TMCs..*

RQ6. Which characteristics of TMC schemes are most critical for the future design of such an instrument?

The most acceptable Tradable Mobility Credits (TMC) scheme should have an accessibility-based allocation to ensure equity among all TMC users. Moreover, this strategy must be combined with considerations for individuals with disabilities and particular professions. The importance of these parameters were also highlighted by the research conducted by Hamm et al. (2025). Monetisation of credits is another critical feature, as it would reward sustainable mobility choices. This characteristic would need to be combined to strong regulation to avoid speculative behaviours.

DISCUSSION AND IMPLICATION

This chapter wrap-ups and reflects on the work accomplished in this study. First it provides an answer to the main research question. It later highlights the strengths and limitations of this study and then discusses its societal and practical implications.

What scheme design characteristics and individual characteristics influence the perceptions and public acceptability of Tradable Mobility Credits (TMC) ?

TMC characteristics indirectly shape acceptability through perceived fairness, effectiveness, and freedom, with fairness as the most influential mediator. Accessibility-based allocation enhances fairness, effectiveness, and acceptability, while an income-based allocation slightly reduces acceptability due to its mixed effects on perceptions. Uniform and OD-based allocations show negligible impact. Including all residents as eligible users strongly boosts acceptability by improving fairness and freedom, whereas restricting eligibility to employed individuals decreases acceptability given its negative impact on fairness. Credit monetisation positively influences acceptability through fairness and effectiveness, but credit expiration undermines it mostly by diminishing fairness. Trading market regulations have no notable effects on perceptions nor on its acceptability.

Next to TMC schemes characteristics, attitudes, sociodemographics, and travel behavior also affect the acceptability of TMC schemes, with attitudes being the most influential. Environmental responsibility has the strongest positive impact, while technological familiarity and car enthusiasm reduce acceptability. Perceived fairness, effectiveness, and freedom act as mediators, reinforcing or weakening the influence of individual traits. Environmental responsibility increases acceptability both directly and by enhancing fairness and effectiveness, whereas car enthusiasm lowers it by reducing perceived freedom. Among sociodemographics, age consistently predicts lower acceptability, with older individuals showing less support. Location also matters: Amsterdam residents, likely due to better public transport, exhibit higher acceptability than those in the broader MRA or with higher incomes. Non-employed individuals also show greater support, possibly due to fewer travel constraints. In fact, lack of a public transport subscription most strongly reduces acceptability, while inflexible work arrangements lower support. Surprisingly, car ownership has no net effect, as its negative impact on perceived freedom is balanced by minor positive effects on fairness and effectiveness.

8.1. STRENGTHS AND LIMITATIONS

First, this research innovates by clearly identifying and categorizing TMC characteristics across the distinct dimensions proposed by Provoost et al. (2023) and Fan and Jiang (2013). While earlier studies often focused

on the ownership dimension with uniform credit allocation and car drivers as main user; this study is one of the first attempt to understand the effect of multiple different TMC schemes characteristics on acceptability and not only the credit allocation one. This study empirically demonstrates that the transfer dimension when designing TMC schemes is all the more important.

Moreover, this study innovates methodologically by employing a rating experiment rather than a stated choice experiments commonly used in prior research (Dogterom et al., 2018a; Krabbenborg et al., 2021b). While stated choice experiments focus on the preference between TMC schemes, the rating experiment allows respondents to evaluate the strength of their preference for each TMC schemes across multiple dimensions. This approach enables better granularity as every TMC scheme was disaggregated to isolate and analyse the effects of each TMC scheme characteristics independently. This study employed orthogonal designs when constructing the TMC schemes and blocks, which assumes that the effect of each TMC scheme characteristics (Allocation, User, Transferability, Trading regulations) are independent of the levels of others. However, this assumption may not hold in reality. Orthogonality simplifies the reality, potentially overlooking nuanced relationships that could impact perceptions and ultimately acceptability.

The rating experiment in the survey required participants to evaluate four TMC schemes each defined by four attributes with multiple levels. Given the complexity of TMCs (average completion time of 12.6 minutes) participants may have experienced cognitive overload or survey fatigue. This could have led participants to choosing the first acceptable option rather than carefully considering each response. Additionally, the sequential presentation of the schemes may have introduced order effects, with first schemes receiving more careful attention than later ones. Moreover, the use of a neutral midpoint for the 5-point Likert scale may have encouraged non-committal responses, reducing the sensitivity of the measurements.

However, this study advances the scientific understanding of TMC acceptability by empirically validating and refining theoretical frameworks that explain their public support. While prior research (Dogterom et al., 2018a; Hamm et al., 2025; Krabbenborg et al., 2021b) has identified perceived fairness, effectiveness, freedom has key predictors of acceptability of TMCs, this one provides more granularity by testing the effect of TMC scheme characteristics on each of these perceptions and how in turn these perceptions mediate the relationships between TMC scheme design and acceptability. Each perceptions (fairness, effectiveness, freedom) were measured using only one item. This approach was decided to reduce survey length and complexity. However, it introduces reliability concerns, as single-item measures are prone to random error and may not fully capture the perception. Participants may have interpreted the items differently. The same goes with acceptability as it was measured using a single indicator *"I feel positive about the implementation of this scheme"*.

Finally, this study also refines attitudinal constructs that shape TMC acceptability addressing a gap in the literature where attitudes are often treated as isolated variables. The Confirmatory Factor Analysis (CFA) failed to confirm the expected structure of the five attitudes that were identified in the literature: car enthusiasm, trust in the government, environmental concern, political views and technological adoption. This discrepancy could be due to the fact that TMC are quite a recent research topic, thus the attitudinal items were adapted from diverse transport policy studies rather than a unified theoretical framework. Through Exploratory Factor Analysis (EFA) combined with SEM, the study identifies environmental responsibility, a combined construct of trust in government and environmental concern as the strongest attitudinal predictor of acceptability. Results of this study demonstrates that institutional trust, pro-environmental attitudes as well as support for social policies are intertwined in shaping acceptability of TMCs. This extends the work of Hamm et al. (2025) and Cui et al. (2024) and confirms the theoretical framework of Eriksson et al. (2006) who highlighted the role of problem awareness and policy beliefs in shaping public support for Travel Demand Management measures.

8.2. SOCIETAL AND PRACTICAL IMPLICATIONS

Understanding the public acceptability of a measure such as TMC is of first importance for its possible future implementation. The following section provides recommendations for policy makers based on the results of this study.

8.2.1. FOCUSING ON FAIRNESS

Perceived fairness emerged as the most significant predictor of acceptability. In the field of transportation, fairness can be summarized as "everyone should have unhindered travel speed on the transportation network of their choice" (Rode, 2023). To ensure the fairness of travel demand management policies, such as TMCs, accessibility, defined as the capacity to access places, must be prioritized (Hamm et al., 2025; Rode, 2023). The strong negative influence of residential location, work flexibility, and PT subscription on perceived fairness and acceptability underscores the need to combine TMCs with pull transport policies, such as making public transport cheaper and more accessible. This need for an improved transport system is also reflected by the survey responses (see Section 7.2). Implementing a TMC scheme in a metropolitan area with significant disparities in PT offerings across districts would directly create strong imbalances among users. Therefore, defining a credit allocation system based on accessibility appears to be the best strategy, as it accounts for the actual state of the transport infrastructure. In addition to accessibility, policymakers should also incorporate work flexibility and disabilities as parameters in the allocation function to further ensure equity.

8.2.2. RAISING AWARENESS

Next to fairness, problem awareness (environmental responsibility) also emerged as a strong predictor of acceptability. The effects of the climate crisis on daily life are becoming more visible with the rise in GHG emissions. There is a pressing need to drastically reduce these emissions by implementing strong policy instruments such as TMCs, which would enable reductions in demand for transport services and car dependency (Jaramillo et al., 2022). Survey results revealed that more than half of the sample identified as car enthusiasts, and the car was the most used transport mode for work, errands, or leisure in the Metropolitan Region of Amsterdam, despite the region's reputation for having a well-developed public transport infrastructure. Furthermore, respondents demonstrated only moderate concern for the environment: a quarter of them disagreed with the idea that their individual transport use impacts the environment or that they have a role in protecting it. As research highlights, well-informed individuals are the most motivated to change their behavior (Eriksson et al., 2006; Li & Zhao, 2019; Sun et al., 2016). According Li and Zhao (2019), when people gain a deeper understanding of a policy, they focus less on its individual burdens and develop more positive attitudes toward it. A critical first step before implementing a TMC scheme would be effective government communication that explains the rationale behind TMCs and emphasizes their social benefits. This is particularly important because TMCs directly impact individuals' fundamental right to travel. While almost half of the respondents perceived TMCs as fair and effective, more than half viewed them as an infringement on their individual freedom. Nonetheless, half of the respondents expressed a commitment to adopting a more environmentally friendly lifestyle. Therefore, policymakers need to design convincing communication campaigns to first raise awareness of resource-intense travel behaviour, the provision of travel alternatives and then comprehension of the tool among the urban population. Moreover, policy makers should accentuate the rewarding dimension of TMC schemes as individuals with minimal negative transport negative externalities would directly benefit from it.

Policy recommendations

To maximize acceptability, policymakers should prioritise accessibility-based credit allocation and include all residents of the urban areas to ensure fairness, as these characteristics emerged as the strongest positive predictors of acceptability. Conversely, schemes that restrict eligibility to specific groups (e.g., employed individuals) or impose credit expiration risk exacerbating inequalities and reducing public support. To address potential inequities, monetisation of credits should be regulated by restricting credit earnings to investments in public transport or sustainable mobility projects. Most importantly, a TMC scheme can only be combined with "pull" measures, such as improving public transport affordability and accessibility, particularly in areas with disparities in transport infrastructure. Before large-scale implementation, small-scale pilot programs should be conducted in targeted urban zones to fine-tune scheme characteristics, reduce administrative burdens, and develop secure tracking tools for measuring GHG emissions. These pilots should take place in already well-developed urban areas with efficient public transport systems. Additionally, they could be implemented in environments where individuals are already committed to changing their travel behaviors, such as sustainability-focused companies, universities or government institutions. Finally, communication campaigns must play a central role: they should first raise awareness about the environmental impacts of resource-intensive travel behaviours and the availability of alternatives. The rationale and social benefits of TMCs, should be clearly explained in a later phase leveraging the population's existing familiarity with digital tools to foster comprehension and acceptance.

9

CONCLUSION

The aim of this study was to explore public acceptability of Tradable Mobility Credit (TMC) schemes as a travel demand management (TDM) instrument for reducing negative transport externalities. Acceptability is influenced by TMC scheme characteristics, but also by individual attitudes, as well as socio-demographic and travel behaviour characteristics. In our conceptual model, we proposed for the first time to explore the direct relationships between different TMC scheme characteristics, perceptions and individual characteristics. To that end, a survey (N=803), including a rating experiment, was distributed to individuals living in the Metropolitan Region of Amsterdam (MRA). In the rating experiment, TMC schemes were varied based on the TMC scheme design dimensions identified in the literature: credit allocation, user definition, validity/transferability of credits and trading market regulations. A structural equation model (SEM) was then estimated to examine the relationships between TMC scheme characteristics, attitudes, individual characteristics and acceptability.

The results indicate that only 35% of the respondents would support implementing such a system, while 23% are neutral and the remaining 42% are opposed. The acceptability found in this study is similar to the one measured for Tradable Peak Credits (TPC) in China (Cui et al., 2024) and in the Netherlands (Krabbenborg et al., 2021b). However, the public support for TMC schemes observed here is higher than that for Tradable Driving Credits (TDC), which recorded a support level of 22% in the Netherlands (Dogterom et al., 2018a). Notably, almost half of the respondents perceive TMC schemes as fair and effective. Yet, more than half perceive it as an infringement on personal freedom.

TMC scheme characteristics do not directly influence acceptability. Their effects are mediated by perceived fairness, effectiveness and freedom. Three design characteristics emerged as key: credit allocation, user definition and validity of credits. Acceptability of a TMC scheme would be higher if the credits were distributed to all residents of the urban area rather than only to road users; credits are allocated based on accessibility and not uniformly; credits are not invalidated at the end of the month but are monetised.

SEM results indicate that attitudes and perceptions are stronger predictors of acceptability than sociodemographic or travel behaviour characteristics, aligning with earlier TDM acceptability studies (Krabbenborg et al., 2021b; Li & Zhao, 2019; Moeinaddini et al., 2026; Sun et al., 2016). Environment responsibility has the strongest effect on acceptability, followed by perceived fairness and effectiveness. The importance of these constructs highlights the need for effective communication on the rationale and benefits of TMCs.

Among socio-demographic variables, age stands out as the most consistent negative predictor of acceptability, with older individuals exhibiting lower support for TMC schemes. Living location also plays a significant role: residents of Amsterdam show higher acceptability compared to those in the broader Metropolitan Region of Amsterdam (MRA). In terms of travel behaviour, the lack of a public transport (PT) subscription has

the strongest negative effect on acceptability. Work flexibility also influences acceptability, with those lacking flexible work arrangements showing lower support. The importance of these characteristics is further highlighted by comments from survey respondents, who cited the lack of public transport options and their high costs as reasons for their strong disapproval of TMCs implementation. These results highlight that a TMC scheme should be implemented in an urban area with an effective and accessible public transport system.

These results need to be interpreted with some caution, as this is one of the first quantitative study regarding public support of TMC schemes. To advance the understanding of TMC schemes, future research should address the limitations of this study while building on its findings. Future studies could explore potential interactions by including interaction terms, such as Initial Credit Allocation $\times$ Users, as additional predictors in the SEM model. Thus, one could assess whether the effect of one attribute on perceptions depends on the level of another attribute, providing deeper insights into how combinations of characteristics shape acceptability. While this approach is not as robust as designing an experiment with explicit interaction effects, it could provide preliminary insights into potential interactions using this dataset.

Another valuable avenue for future research using this dataset would be to apply Latent Class Regression Analysis (LCRA) to identify heterogeneous subgroups within the population based on their attitudes, perceptions, and individual characteristics. Unlike traditional subgroup analyses, LCRA would allow researchers to uncover unobserved heterogeneity within the population. This approach would complement the current study's focus and highlight tailored strategies for policy design and communication.

Finally, the need for strong TDM measures to reduce negative transport externalities requires the earliest possible implementation of pilot programs. Additionally, future studies should focus on the cost of implementing such systems and the development of their technical components. In fact, implementing TMC schemes requires collecting sensitive data, most likely via GPS tracking, which could be perceived as a significant barrier by the public. Thus, there is a need for clear communication about TMC schemes, emphasizing their rewarding dimension and fairness.

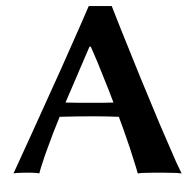
REFERENCES

- Aasen, M., & Sælen, H. (2022). Right-wing populism and climate policies: Explaining opposition to road tolls in Norway. *Transportation Research Part D: Transport and Environment*, 105, 103222. <https://doi.org/10.1016/j.trd.2022.103222>
- Abu-Bader, S., & Jones, T. V. (2025). Structural equation modeling: Principles, assumptions, and practical application using spss amos. *International Journal of Quantitative and Qualitative Research Methods*, 13(1), 12–31. <https://doi.org/10.37745/ijqqr.13/vol13n11231>
- Albano, G., Mattas, K., Mourtzouchou, A., Seshadri, R., Nahmias-Biran, B., Azevedo, C. L., & Ciuffo, B. (2025). Tradable credit scheme for mobility management: State of the art and comparison of theoretical and experimental research. *Transportation Research Interdisciplinary Perspectives*, 33, 101611. <https://doi.org/10.1016/j.trip.2025.101611>
- Álvarez-Ossorio Martínez, S., Schatzman, T., Loder, A., Axhausen, K. W., & Bogenberger, K. (2025). Mode choice behavior in a tradable mobility credit scheme: A stated-preference experiment. *Transportation Research Part A: Policy and Practice*, 199, 104570. <https://doi.org/10.1016/j.tra.2025.104570>
- Brands, D., Verhoef, E., & Knockaert, J. (2021). Pcoins for parking: A field experiment with tradable mobility permits. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.3819842>
- Bristow, A. L., Wardman, M., Zanni, A. M., & Chintakayala, P. K. (2010). Public acceptability of personal carbon trading and carbon tax. *Ecological Economics*, 69(9), 1824–1837. <https://doi.org/10.1016/j.ecolecon.2010.04.021>
- Candia, D., & Verhoef, E. T. (2022). Tradable mobility permits in a monocentric city with pre-existing labor taxation: A general equilibrium perspective. *Transportation Research Part B: Methodological*, 163, 145–165. <https://doi.org/10.1016/j.trb.2022.07.002>
- CBS. (2024a). Figures: Mobility; per person, modes of travel, purposes of travel and regions [Accessed: 2026-06-28]. *Statistics Netherlands (CBS)*. <https://www.cbs.nl/en-gb/figures/detail/84710ENG>
- CBS. (2024b). The netherlands in numbers 2024: Level of education [Accessed: 2026-06-10]. <https://longreads.cbs.nl/the-netherlands-in-numbers-2024/what-is-the-level-of-education-in-the-netherlands/>
- CBS. (2025a). Household income [Accessed: 2026-06-10]. <https://opendata.cbs.nl/#/CBS/nl/dataset/83932NED/table?ts=1652104416359>
- CBS. (2025b). Population by origin [Accessed: 2026-06-10]. <https://www.cbs.nl/en-GB/visualisations/dashboard-population/origin>
- CBS. (2026). Number of driving licence holders and car owners on the rise [Accessed: 2026-06-10]. <https://www.cbs.nl/en-gb/news/2026/07/number-of-driving-licence-holders-and-car-owners-on-the-rise>
- CBS. (2025a). Dashboard: Men and women in the netherlands [Accessed: 2026-06-10]. <https://www.cbs.nl/en-gb/visualisations/dashboard-population/men-and-women>
- CBS. (2025b). Household composition [Accessed: 2026-06-10]. <https://opendata.cbs.nl/#/CBS/en/dataset/82905ENG/table?ts=1781078774000>
- CBS. (2025e). Labour participation [Accessed: 2026-06-10]. <https://opendata.cbs.nl/#/CBS/en/dataset/85264ENG/table?searchKeywords=labour%20participation>
- CBS. (2025f). Population by age [Accessed: 2026-06-10]. <https://opendata.cbs.nl/#/CBS/nl/dataset/7461BEV/table?fromstatweb>
- Chen, S., Seshadri, R., Azevedo, C. L., Akkinapally, A. P., Liu, R., Araldo, A., Jiang, Y., & Ben-Akiva, M. E. (2023). Market design for tradable mobility credits. *Transportation Research Part C: Emerging Technologies*, 151, 104121. <https://doi.org/10.1016/j.trc.2023.104121>
- ChoiceMetrics. (2024). *The cutting edge in experimental design* [Ngene 1.4 User Manual]. ChoiceMetrics.

- Clark, C., Mokhtarian, P. L., Circella, G., & Watkins, K. (2021). The role of attitudes in perceptions of bicycle facilities: A latent-class regression approach. *Transportation Research Part F: Traffic Psychology and Behaviour*, 77, 129–148. <https://doi.org/10.1016/j.trf.2020.12.006>
- Cui, S., Tian, L., Xu, Y., & Wang, Y. (2024). Measuring acceptance of tradable credit scheme and its effect on behavioral intention through theory of planned behavior. *Transport Policy*, 150, 174–188. <https://doi.org/10.1016/j.tranpol.2024.03.009>
- de Haas, M., Visser, J., Jonkeren, O., Moorman, S., Romijn, G., & Faber, R. (2025). Key mobility figures 2024 [Accessed: 2026-04-09]. <https://english.kimnet.nl/documents/2025/03/04/key-mobility-figures-2024>
- Dogterom, N., Bao, Y., Xu, M., & Ettema, D. (2018a). Acceptability of a tradable driving credit scheme in the netherlands and beijing. *Case Studies on Transport Policy*, 6(4), 499–509. <https://doi.org/10.1016/j.cstp.2018.06.003>
- Dogterom, N., Ettema, D., & Dijst, M. (2017). Tradable credits for managing car travel: A review of empirical research and relevant behavioural approaches. *Transport Reviews*, 37(3), 322–343. <https://doi.org/10.1080/01441647.2016.1245219>
- Dogterom, N., Ettema, D., & Dijst, M. (2018b). Behavioural effects of a tradable driving credit scheme: Results of an online stated adaptation experiment in the netherlands. *Transportation Research Part A: Policy and Practice*, 107, 52–64. <https://doi.org/10.1016/j.tra.2017.11.004>
- Earl, T. (2024). State of european transport 2024 [Retrieved December 9, 2025]. <https://www.transportenvironment.org/state-of-european-transport/state-of-transport>
- Eriksson, L., Garvill, J., & Nordlund, A.-M. (2006). Acceptability of travel demand management measures: The importance of problem awareness, personal norm, freedom, and fairness. *Journal of Environmental Psychology*, 26(1), 15–26. <https://doi.org/10.1016/j.jenvp.2006.05.003>
- Esteban Ibáñez, M., Musitu Ferrer, D., Amador Muñoz, L. V., Claros, F. M., & Olmedo Ruiz, F. J. (2020). University as change manager of attitudes towards environment (the importance of environmental education). *Sustainability*, 12(11), 4568. <https://doi.org/10.3390/su12114568>
- Fan, W., & Jiang, X. (2013). Tradable mobility permits in roadway capacity allocation: Review and appraisal. *Transport Policy*, 30, 132–142. <https://doi.org/10.1016/j.tranpol.2013.09.002>
- Fan, Y., Chen, J., Shirkey, G., & John, R. (2016). Applications of structural equation modeling (sem) in ecological research: An updated review [PDF]. *Ecological Processes*. <https://doi.org/10.1186/s13717-016-0063-3>
- Gemeente Amsterdam. (2024). Bevolking in cijfers 2024 [Accessed: 2026-07-13].
- Geng, K., Brands, D. K., Verhoef, E. T., & Wang, Y. (2023). The impact of tradable rush hour permits on peak demand: Evidence from an on-campus field experiment. *Transportation Research Part D: Transport and Environment*, 120, 103775. <https://doi.org/10.1016/j.trd.2023.103775>
- Hamm, L., Weikl, S., Loder, A., Bogenberger, K., Schatzmann, T., & Axhausen, K. (2022, November). Mobilitycoins—first empirical findings on the user-oriented system design for tradable credit schemes. <https://doi.org/10.3929/ethz-b-000573828>
- Hamm, L. S., Álvarez-Ossorio Martínez, S., Loder, A., & Bogenberger, K. (2025). Who gets what? a user perspective on initial credit allocation in tradable mobility credit schemes. *Transport Policy*, 164, 118–129. <https://doi.org/10.1016/j.tranpol.2025.01.032>
- Hooper, D., Coughlan, J., & Mullen, M. (2008). Structural equation modeling: Guidelines for determining model fit [Retrieved 21 April 2026]. https://www.researchgate.net/publication/254742561_Structural_Equation_Modeling_Guidelines_for_Determining_Model_Fit
- Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O., Kajino, T., Lee, D., Nugroho, S., Ou, X., Hammer Strømman, A., & Whitehead, J. (2022). Transport. In P. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, & J. Malley (Eds.), *Climate change 2022: Mitigation of climate change. contribution*

- of working group iii to the sixth assessment report of the intergovernmental panel on climate change. Cambridge University Press. <https://doi.org/10.1017/9781009157926.012>
- Kline, R. B. (2016). *Principles and practice of structural equation modeling*. Guilford Press.
- Kockelman, K. M., & Kalmanje, S. (2005). Credit-based congestion pricing: A policy proposal and the public's response. *Transportation Research Part A: Policy and Practice*, 39(7), 671–690. <https://doi.org/10.1016/j.tra.2005.02.014>
- Krabbenborg, L., Molin, E., Annema, J. A., & van Wee, B. (2021a). Exploring the feasibility of tradable credits for congestion management. *Transportation Planning and Technology*, 44(3), 246–261. <https://doi.org/10.1080/03081060.2021.1883226>
- Krabbenborg, L., van Langevelde-van Bergen, C., & Molin, E. (2021b). Public support for tradable peak credit schemes. *Transportation Research Part A: Policy and Practice*, 145, 243–259. <https://doi.org/10.1016/j.tra.2021.01.014>
- Lessan, J., & Fu, L. (2022). Credit- and permit-based travel demand management state-of-the-art methodological advances. *Transportmetrica A: Transport Science*, 18(1), 5–28. <https://doi.org/10.1080/23249935.2019.1692963>
- Li, M., & Zhao, J. (2019). Gaining acceptance by informing the people? public knowledge, attitudes, and acceptance of transportation policies. *Journal of Planning Education and Research*, 39(2), 166–183. <https://doi.org/10.1177/0739456X17732623>
- Li, S., & Robusté, F. (2021). From urban congestion pricing to tradable mobility credits: A review [XIV Conference on Transport Engineering, CIT2021]. *Transportation Research Procedia*, 58, 670–677. <https://doi.org/10.1016/j.trpro.2021.11.088>
- Li, S., & Robusté, F. (2025). Tradable mobility credit schemes: Suitable users and their management. *Transportation Planning and Technology*, 1–21. <https://doi.org/10.1080/03081060.2025.2550726>
- Metropool Regio Amsterdam. (2026). Interactieve kaart [Accessed: 2026-07-03]. <https://www.metropoolregioamsterdam.nl/interactieve-kaart/>
- Metropoolregio Amsterdam. (n.d.). About MRA [Accessed: 2026-07-13].
- Millonig, A., Rudloff, C., Richter, G., Lorenz, F., & Peer, S. (2022). Fair mobility budgets: A concept for achieving climate neutrality and transport equity. *Transportation Research Part D: Transport and Environment*, 103, 103165. <https://doi.org/10.1016/j.trd.2021.103165>
- Moeinaddini, A., Habibian, M., Zou, Y., Zhang, T., & Li, L. (2026). Assessing acceptability of push-pull TDM policy packages: Integrating objective and subjective factors via hybrid choice modeling. *Transportation Research Part A: Policy and Practice*, 204, 104808. <https://doi.org/10.1016/j.tra.2025.104808>
- Molin, E. J. E., & Marchau, V. A. W. J. (2004). User perceptions and preferences of advanced driver assistance systems. *Transportation Research Record*, 1886(1), 119–125. <https://doi.org/10.3141/1886-15>
- Molin, E. (2005). Causal analysis of hydrogen acceptance. *Transportation Research Record*, 1941, 115–121. <https://doi.org/10.3141/1941-14>
- Provoost, J., Cats, O., & Hoogendoorn, S. (2023). Design and classification of tradable mobility credit schemes. *Transport Policy*, 136, 59–69. <https://doi.org/10.1016/j.tranpol.2023.03.010>
- Rode, P. (2023). Fairness and the sufficiency turn in urban transport. *Journal of City Climate Policy and Economy*, 2(1), 37–54. <https://doi.org/10.3138/jccpe-2023-0006>
- Rodrigue, J.P. (2017, December). Transportation and the environment [Accessed: Monday 17th August, 2026]. <https://transportgeography.org/contents/chapter4/transportation-and-environment/>
- Schöngart, S., Nicholls, Z., Hoffmann, R., Pelz, S., & Schleussner, C.-F. (2025). High-income groups disproportionately contribute to climate extremes worldwide. *Nature Climate Change*, 15(6), 627–633. <https://doi.org/10.1038/s41558-025-02325-x>

- Schreiber, J. B. (2021). Issues and recommendations for exploratory factor analysis and principal component analysis. *Research in Social and Administrative Pharmacy*, 17(5), 1004–1011. <https://doi.org/10.1016/j.sapharm.2020.07.027>
- Servatius, P., Hamm, L., Loder, A., & Bogenberger, K. (2022). Conceptualizing an individual full-trip tradable credit scheme for multi-modal demand and supply management: The mobilitycoin system. *Frontiers in Future Transportation*, 3. <https://doi.org/10.3389/ffutr.2022.914496>
- Servatius, P., Loder, A., Provoost, J., Balzer, L., Cats, O., Leclercq, L., Hoogendoorn, S., & Bogenberger, K. (2023). Trading activity and market liquidity in tradable mobility credit schemes. *Transportation Research Interdisciplinary Perspectives*, 22, 100970. <https://doi.org/10.1016/j.trip.2023.100970>
- Sun, X., Feng, S., & Lu, J. (2016). Psychological factors influencing the public acceptability of congestion pricing in China. *Transportation Research Part F: Traffic Psychology and Behaviour*, 41, 104–112. <https://doi.org/10.1016/j.trf.2016.06.015>
- Syrda, J. (2025). Sharing the road: Political ideologies and political party preference as drivers of public transport infrastructure support. *Global Environmental Change*, 92, 103012. <https://doi.org/10.1016/j.gloenvcha.2025.103012>
- Thaller, A., FleiB, E., Brohmer, H., Köstenbaumer, D., Posch, A., & Athenstaedt, U. (2023). When perceived fairness and acceptance go hand in hand—drivers of regulatory and economic policies for low-carbon mobility. *PLOS Climate*. <https://doi.org/10.1371/journal.pclm.0000157>
- Tian, L., Cui, S., Huang, H., Xu, Y., & Wang, Y. (2024). How the norm activation model explains the individuals' response to tradable credit schemes and reducing car use. *Transport Policy*, 155, 208–223. <https://doi.org/10.1016/j.tranpol.2024.06.016>
- Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: Strengths, limitations, and misconceptions. *Annual Review of Clinical Psychology*, 1(1), 31–65. <https://doi.org/10.1146/annurev.clinpsy.1.102803.144239>
- van 't Veer, R., Annema, J. A., Araghi, Y., Homem de Almeida Correia, G., & van Wee, B. (2023). Mobility-as-a-service (maas): A latent class cluster analysis to identify dutch vehicle owners' use intention. *Transportation Research Part A: Policy and Practice*, 169, 103608. <https://doi.org/10.1016/j.tra.2023.103608>
- Wadud, Z. (2011). Personal tradable carbon permits for road transport: Why, why not and who wins? *Transportation Research Part A: Policy and Practice*, 45(10), 1052–1065. <https://doi.org/10.1016/j.tra.2010.03.002>



SCIENTIFIC PAPER

Acceptability of Tradable Mobility Credits in the Metropolitan Region of Amsterdam

Abstract

The transportation sector is a major source of greenhouse gas emissions in Europe, with road transport being the largest contributor. To achieve low-carbon urban mobility, restrictive Travel Demand Management (TDM) measures, such as Tradable Mobility Credits (TMCs), are essential. TMCs aim to internalize transport externalities by allocating free credits to users, which are consumed based on travel behaviour. However, their public acceptability, particularly how scheme design influences perceptions of fairness, effectiveness, and freedom, remains understudied.

This study addresses this gap by conducting a rating experiment with 803 respondents from the Metropolitan Region of Amsterdam (MRA). Using Structural Equation Modeling (SEM), we analyze how TMC scheme characteristics: credit allocation, users of credits, transferability/validity of credits, and trading market regulations affect acceptability, mediated by perceptions of fairness, effectiveness, and freedom. We also examine the role of individual characteristics (sociodemographics and travel behaviour) and attitudinal factors in shaping these perceptions and acceptability.

Results show that accessibility-based credit allocation and inclusive user eligibility enhance perceived fairness and acceptability, while credit expiration reduces them. Environmental responsibility, emerges as a strong predictor of acceptability, followed by perceived fairness and effectiveness. Individual characteristics, such as age and public transport subscription, also play a significant role, with older individuals and those without PT subscriptions exhibiting lower acceptability.

This study empirically validates the influence of TMC design characteristics, attitudinal, and individual factors on public acceptability. Findings suggest policymakers should prioritize fairness and awareness campaigns to improve TMC acceptability while addressing concerns about personal freedom and equity.

Keywords: acceptability, fairness, tradable mobility credits, factor analysis, structural equation model

1. Introduction

The transportation sector is the largest source of greenhouse gas (GHG) emissions in Europe and one of the few sectors where emissions have not decreased, with road transport accounting for the highest proportion (Earl, 2024). In 2023, GHG emissions from road traffic in the Netherlands were 4% higher than in 2022 despite the increase in electric vehicle sales. Passenger cars accounted for 58% of these emissions (de Haas et al., 2025). To reduce the negative externalities of transportation, particularly those caused by individual cars, such as traffic congestion, air pollution, and the occupation of public space, Transport Demand Management (TDM) strategies need to be implemented. Given the need for immediate emission reductions, restrictive measures could be an effective tool to achieve low carbon mobility (Thaller et al., 2023; Jaramillo et al., 2022). These strategies, combined to less car-dependent transport infrastructure could reduce the negative externalities of transport in urban environments (Jaramillo et al., 2022)

An innovative strategy to reduce the negative externalities of transports are Tradable Mobility Credits (TMC) schemes (Li and Robusté, 2021; Provoost et al., 2023; Wadud, 2011). TMCs are novel TDM instruments not yet implemented but gaining more attention from researchers and urban designers. Several concepts of TMCs exist, following a similar structure to the polluter pay principle. TMC schemes aim to internalise the external costs of transports based on their specific intensity. With a TMC scheme, travellers consume credits according to their use of the transport system. After receiving an initial free allocation of credits, travellers use them when travelling and can also trade them with other users in a dedicated marketplace. The resulting market mechanism ensures that credits flow towards heavy users, while light users, those who use more sustainable alternatives, can benefit from the scheme by selling their surplus credits (Provoost et al., 2023).

Different characteristics of TMC schemes address some of the equity concerns raised by other pricing policies. An initial free allocation of credits could enhance the political acceptability of the scheme (Wadud, 2011) as users with lower externalities can potentially earn money by selling their unused credits. Moreover, TMC schemes can be designed to be budget-neutral, with monetary transfers occurring only between users (Li and Robusté, 2021; Wadud, 2011), the authority in charge only plays a regulatory role. Another advantage is its transparency: users can directly access information about their transport use

1 and related externalities, creating direct incentives to use sustainable transports (Servatius
2 et al., 2022). However, having a limited amount of credits to perform trips can be seen as
3 an infringement to one's freedom of movement (Krabbenborg et al., 2021a) and different
4 credit distribution strategies can lead to equity issues. Besides, TMCs would require track-
5 ing of individual travel behaviour, which could raise privacy and security-related concerns
6 (Provoost et al., 2023). Even if their implementation is technically feasible, TMCs remain
7 a largely theoretical concept, with only two real-world experiments (Geng et al., 2023;
8 Brands et al., 2021). Their design is challenging as defining eligible users, trading rules,
9 and credit allocation mechanism largely influence their acceptability.

10 Research on the topic has mostly focused on specific designs, and user and market
11 equilibrium (Lessan and Fu, 2022; Dogterom et al., 2017). Empirical studies focusing
12 on the influence of different TMC schemes characteristics on public acceptability remain
13 sparse. Although some studies have begun to explore these dimensions, they often isolate
14 specific design characteristics of TMCs. Specifically, there is a gap in understanding how
15 scheme characteristics influence perceptions, such as fairness, freedom, and effectiveness
16 that in turn shape acceptability of TMCs. Moreover, the interaction between perceptions
17 and acceptability, as well as other individual factors, such as socio-demographics, travel
18 behaviour and attitudes remains limited. Yet, sufficient public acceptability plays an es-
19 sential role in the implementation of restrictive transport policies such as TMCs.

20 This raises the following question:

21 **What scheme design characteristics and individual characteristics influence the**
22 **perceptions and public acceptability of Tradable Mobility Credits (TMC) ?**

23 In this paper, we examine the effect of different factors on the acceptability of TMC
24 schemes by first providing an overview of their current design characteristics and building
25 a framework to measure their acceptability. In this work, we introduce a survey, including
26 a rating experiment, to individuals from the Metropolitan Region of Amsterdam (MRA).
27 Structural Equation Modeling (SEM) has been applied to simultaneously estimate how
28 TMC scheme design characteristics are perceived in terms of fairness, effectiveness, and
29 freedom and how these perceptions affect acceptability. This study also examines effects
30 of individual and attitudinal factors on perceptions and acceptability.

31 The remainder of this paper is structured as follows. Section 2 reviews the literature

1 on TMC scheme design and describes the three categories of factors that may affect ac-
2 ceptability. Next, section 3 provides the conceptual model used in this study and describes
3 the survey design, rating experiment and data collection process. Section 4 presents the
4 modelling framework used in the analysis. Section 5 reports and discusses the empirical
5 findings. Section 6 elaborates on the implications for TMC design and outlines directions
6 for policy makers. Finally, Section 7 concludes the paper.

7 **2. Literature Review**

8 This section reviews the literature that informs the analytical approach adopted in this
9 study and begins by discussing the design dimensions of TMC schemes. It then outlines
10 three categories of factors influencing public support for restrictive TDM measures such as
11 TMCs: sociodemographic and travel behaviour variables, attitudinal variables, and scheme
12 design characteristics. Finally, it presents the hypotheses on causal relations between these
13 factors and acceptability, as well as the conceptual model designed to explore them.

14 *2.1. TMC scheme design*

15 TMC schemes can be defined using a three-dimensional framework proposed by Provoost
16 et al. (2023). This framework includes: an ownership dimension (how credits are held,
17 recorded, and allocated); a transfer dimension (how credits are exchanged between users);
18 a consumption dimension: how credits are spent by users.

19 *2.1.1. Ownership dimension*

20 *Credit allocation.*

21 Different allocation strategies have been explored in previous studies. The most common
22 approach is uniform allocation: all users receive the same amount of credits at the begin-
23 ning of the validity period. While this approach would likely lead to higher trading activity
24 and market liquidity, since users would need to trade to meet their travel needs (Servatius
25 et al., 2023; Provoost et al., 2023), it may be unfair to low-income users or those with high
26 driving demand (Hamm et al., 2022; Krabbenborg et al., 2021a; Li and Robusté, 2021). An
27 alternative approach is a demand-based or origin-destination (O-D) specific distribution,
28 where credits are allocated according to historical or expected travel demand. This method
29 could enhance the scheme's effectiveness and efficiency (Lessan and Fu, 2022; Fan and

1 Jiang, 2013; Li and Robusté, 2025). Another approach is allocating credit based on in-
2 come: people with lower income would get more credits than people with high income,
3 to reduce inequalities among users. A different approach is to base the initial allocation
4 of credits on accessibility: giving more credits to individuals living in areas with fewer
5 transport options. Millonig et al. (2022) and Hamm et al. (2022) also argue that the initial
6 allocation of credits should be a combination of accessibility and socio-economic factors.
7 However, allocation strategies that are more sophisticated than the uniform one require the
8 authority in charge to gather more individual and personal data raising privacy concerns.

9 Credit allocation frequency.

10 The credit allocation frequency is often unspecified in the literature. According to vari-
11 ous authors, this feature of a TMC scheme could influence travelers' mobility and market
12 behaviour (Albano et al., 2025; Servatius et al., 2023). A monthly distribution might en-
13 courage users to plan trips in advance to avoid running out of credits when needed. When
14 specified, monthly distribution is the most common credit allocation frequency in the liter-
15 ature. Krabbenborg et al. (2021a) explored both weekly and monthly allocation methods
16 in their study with monthly allocation being the preferred one. In a field experiment in-
17 volving parking credits, participants were receiving credits at the beginning of each week
18 (Brands et al., 2021) and could trade them during the entire week (5 working days). In
19 another study, Chen et al. (2023) adopted a continuous time approach wherein credits are
20 provided at a certain rate over the entire day. While a shorter interval may create more
21 administrative hassle, requiring users to trade credits daily, it could also increase effective-
22 ness, as authorities could adjust the system's cap more frequently. In 2010, Bristow et al.
23 (2010) studied Personal Carbon Trading (PCT), a scheme requiring participants to use car-
24 bon permits for purchasing and consuming energy. For this scheme, not only focusing on
25 mobility, the authors choose a yearly allocation of permits.

26 Credit users.

27 Li and Robusté (2025) evaluated the advantages and disadvantages of different user def-
28 initions, considering equity, effectiveness, and cost. They identified six types of eligible
29 recipients for a TMC scheme: vehicles, vehicle owners, drivers, workers, taxpayers and
30 adult residents. According to the researchers, if the goal is to reduce car use, driver-based
31 allocation offers the most balanced approach in terms of equity, effectiveness, and cost.

1 Still, focusing only on car drivers, would exclude other road users, using sustainable trans-
2 portation modes, from enjoying the benefits of such a system. The authors recommend
3 against limiting eligibility to only workers or only taxpayers, as this could significantly
4 reduce the scheme's acceptability, given that many other transport infrastructure users also
5 contribute to transport externalities. Allocating credits to the entire adult population of an
6 area provides the highest level of vertical equity since all users are treated equally. How-
7 ever, this approach may disadvantage users with high driving demands under a uniform
8 allocation system. Most studies focusing on the acceptability of TMC schemes have been
9 using car drivers for TMCs user.

10 *2.1.2. Transfer dimension*

11 *Credit validity.*

12 The literature mentions various validity periods for credits. In their study on public support
13 for Credit-Based Congestion Pricing (CBCP), Kockelman and Kalmanje (2005) proposed
14 that credits could not be carried over from one period to the next; instead, users would re-
15 ceive cash for any remaining travel credits at the end of each period. Servatius et al. (2022)
16 defined the Mobility Coin system, in which users can monetise their remaining credits by
17 selling them to the agency in charge or spending them on transport-related investment
18 projects. The possible monetisation of credits is an important characteristic of TMCs. In
19 opposition to congestion pricing, individuals not using a car for their trips could directly
20 benefit from TMC schemes, emphasizing their reward mechanism. In another study, Ser-
21 vatius et al. (2023) suggested that setting an expiry date for credits would increase trading
22 activity among users, thereby enhancing market liquidity. Chen et al. (2023) also argue
23 that an expiry date would also spur speculation. In the study on PCT (Bristow et al.,
24 2010), the authors proposed a permit lifespan of either one or five years, allowing credits
25 to be transferred from a period to another. The possibility of transferring credits between
26 periods would enable users to plan future trips requiring a significant number of credits.

27 *Market regulation.*

28 Researchers and experts on the topic disagree when looking at possible market regulation
29 for credit trading. The market regulation aspect of a TMC scheme is an important point
30 as a limitation of credit purchases could be seen as an interference with the right to move
31 (Hamm et al., 2022). However a lack of limitation could also lead to over-buying credits,

1 creating a lack of possible market liquidity as the volume of trades would not be large
2 enough (Servatius et al., 2023). Provoost et al. (2023) and Servatius et al. (2023) suggest
3 implementing transaction fees to combat excessive speculation: it would discourage users
4 from trading unless they actually need credits for their mobility needs. In their study on
5 TMC market design, Chen et al. (2023) argue that credit purchase should be limited to
6 prevent undesired speculation. They suggest that travelers should only be able to buy
7 credits when they wish to travel and are short of credits. In their field experiment, Brands
8 et al. (2021) and Geng et al. (2023), defined a system in which users could not buy more
9 credits from the platform than they could use themselves, to avoid undesirable speculation.

10 *2.1.3. Consumption dimension*

11 *Credit measurement unit*

12 Defining the measurement unit in a TMC scheme involves specifying what the credits
13 represent or entitle users within the system (Hamm et al., 2025). First, the charging mech-
14 anism can either be uniform: credits are consumed at a fixed rate, independent of travel
15 behaviour, or, based on different parameters: spatial, temporal, modal or personal. In the
16 spatial dimension, credits can be charged based on usage within a specific area (Dogterom
17 et al., 2018a) or per road segment (Krabbenborg et al., 2021a; Cui et al., 2024; Tian et al.,
18 2024). For the temporal dimension, credit charges can be static: remaining fixed over
19 time (Dogterom et al., 2018a), or dynamic: varying according to the time of day, week,
20 or other circumstances (Kockelman and Kalmanje, 2005). In the modal dimension, credit
21 charges can also depend on the mode of transport used (Servatius et al., 2022). Accord-
22 ing to Provoost et al. (2023), a mode-dependent charging mechanism offers policymakers
23 and authorities greater flexibility to influence travel behaviour. The measurement unit for
24 TMCs can vary depending on the scheme’s objectives. A common approach is to quantify
25 credits by vehicle-kilometres travelled, as in the study by Dogterom et al. (2018a), which
26 is considered relatively straightforward to implement (Hamm et al., 2025). Alternatively,
27 credits can be expressed in terms of CO₂ emissions (Servatius et al., 2022). Still, calcu-
28 lating per-capita CO₂ emissions for a trip requires accounting for multiple factors, such as
29 trip duration, speed, vehicle emission specifications, and vehicle occupancy.

Registration of consumption.

How credit consumption is registered is often not specified in details in studies focusing on TMC scheme acceptability. According to Provoost et al. (2023), as the charging system becomes more refined, it requires more precise tracking of individual travel behaviour. This raises privacy and security concerns which would affect public support for such an instrument. To charge travelers based on their actual travel behaviour, data about their trips must be recorded. For area-based schemes, trip data could be registered using automatic number-plate recognition. However, this approach would require expensive road-side infrastructure and may become inefficient when high granularity is required. An alternative approach would be GPS tracking at the vehicle level (e.g., via onboard devices) or the individual level (e.g., via smartphones). While, accessing data via a smartphone could provide more flexibility and details across different modes of transport it also involves collecting privacy-sensitive data. For public transport, an alternative method to smartphone use could involve the use of public transport smart cards (Provoost et al., 2023).

2.2. Factors influencing acceptability

2.2.1. Scheme design characteristics

The characteristics of TMCs play a role in shaping public acceptability. Variations in scheme characteristics directly influence how users perceive and respond to them (Krabbenborg et al., 2021a; Provoost et al., 2023; Brands et al., 2021; Geng et al., 2023). Credit allocation strategies influence the fairness and effectiveness of a TMC scheme: uniform allocation may enhance market liquidity but can disadvantage low-income or high-demand users (Krabbenborg et al., 2021b; Hamm et al., 2025). Conversely, non-uniform allocation strategies can address equity issues but raise privacy concerns due to the need for detailed personal data (Millonig et al., 2022; Cui et al., 2024). The frequency and validity of credit allocation also matter. Options like credit monetisation or transferability can affect user behaviour and market dynamics. Moreover, market regulation, such as purchase limits or transaction fees, can prevent speculation but may restrict mobility freedom (Servatius et al., 2023). Defining eligible recipients is another critical factor, as excluding certain groups may reduce support (Krabbenborg et al., 2021b; Li and Robusté, 2025). Thus, to explore the acceptability of TMC schemes, four key characteristics have been identified: credit allocation, credit recipients, credit transferability/validity, and market

1 regulation (see Table 1). The different credit units identified in the study by Provoost et al.
2 (2023) were not explored in the rest of the study, as a TMC scheme is designed to reduce
3 transport negative externalities, the credit consumption unit is fixed to the negative effects
4 of trips similarly to what was done by Hamm et al. (2025). Moreover, as most studies on
5 TMC define a one month period, this characteristics was also fixed for this study.

6 2.2.2. *Sociodemographic and mobility behaviour characteristics*

7 Acceptability of TMCs is influenced by sociodemographic factors (e.g., age, income,
8 urban/rural residence) and mobility behaviour (e.g., car dependency, travel frequency, trip
9 purpose). Early studies (Kockelman and Kalmanje, 2005; Dogterom et al., 2018a) showed
10 that higher-income individuals and urban residents tend to support TMC more, while low-
11 income and car-dependent groups are often more resistant. Mobility behaviour, such as
12 working hours, car dependency, and residential density shapes how individuals respond
13 to TMC schemes (Dogterom et al., 2018b; Krabbenborg et al., 2021a). In studies by Cui
14 et al. (2024) and Tian et al. (2024), younger, urban individuals were more supportive,
15 whereas car owners and low-income groups were more likely to reject TMC. In recent
16 experiments conducted in the Netherlands and China, participants' acceptance of tradable
17 schemes was influenced by their residential location and travel flexibility (Brands et al.,
18 2021; Geng et al., 2023). Thus, including socio-demographic and mobility behaviour vari-
19 ables is crucial for studying the acceptability of TMC, as they help explain differences in
20 public support. Not focusing specifically on TMCs, Moeinaddini et al. (2026) showed that
21 socio-demographic and travel behaviour characteristics influenced attitudes and percep-
22 tions of TDM policy packages (cordon and parking pricing). Their results indicated that
23 households with higher car values as well as older commuters perceived TDM policies as
24 restrictive to their freedom. Moreover, their results also showed that gender could influ-
25 ence the perceived fairness of TDM policies, with female respondents being more likely
26 to perceive these policies as unfair, as they could be more likely to face safety concerns
27 or logistical challenges when using public transportation. Moreover, when studying the
28 relations between public knowledge, attitudes, and acceptance of transportation policies,
29 focusing on the vehicle license auction policy in Shanghai, the results of Li and Zhao
30 (2019) indicated that individual characteristics such as education level, household loca-
31 tion, and income influence perceived equity of the policy.

2.2.3. Attitudinal factors

People's attitudes have more explanatory power than the individual characteristics described above in explaining support for TDM instruments like TMC schemes (Krabbenborg et al., 2021a; Cui et al., 2024; Moeinaddini et al., 2026; Li and Zhao, 2019; Eriksson et al., 2006). Literature shows that users are more likely to support TMC schemes that they perceive as fair, such as those with equitable credit allocation (Dogterom et al., 2018a; Krabbenborg et al., 2021a). Perceived effectiveness also matters: schemes seen as capable of reducing congestion or improving mobility gain higher acceptance (Dogterom et al., 2018b; Cui et al., 2024). Meanwhile, freedom, as the ability to choose travel modes without excessive restrictions, is also a critical factor (Moeinaddini et al., 2026; Sun et al., 2016). Literature focusing on the public acceptability of transport policies have showed that fairness, effectiveness and freedom are strong predictors of acceptability.

Public acceptance of transport policies can also be influenced by more general attitudes, distinct from perceptions of the instrument itself (Li and Zhao, 2019). Attitudes such as trust in the government, environmental concern, technology adoption, general car attitudes, and political ideology have been shown in prior literature to influence transport policy acceptance (Eriksson et al., 2006; Sun et al., 2016).

One of the goal of implementing a TMC scheme is to reduce individual car use as the more car-based trips a user makes, the more credits he would have to use. Thus exploring individuals' attitudes toward cars is relevant in this context. In fact, Hamm et al. (2025) showed that car users were less supportive of TMC schemes. Similarly, Cui et al. (2024) also demonstrated that car owners and those frequently driving were more likely to reject a TMC scheme.

Acceptability can be higher when people have greater problem awareness (Eriksson et al., 2006). In their study, Sun et al. (2016) concluded that problem awareness would improve the public acceptance of a congestion pricing policy in Beijing. Focusing on cordon and parking policies, Moeinaddini et al. (2026) showed that pro-environmental attitudes had a negative effect on the acceptability of such TDM measures. The authors suggest that individuals concerned about environmental issues do not perceive pricing schemes as effective unless they are paired with sustainable alternatives. Cui et al. (2024) suggested exploring the influence of environmental concern on the acceptance of TMC, as one of the main reason for implementing such a scheme is to reduce the negative externalities of

1 transportation on the environment.

2 Since TMC can be seen as an innovative high-tech instrument, including technology adop-
3 tion as an attitude is relevant, as the use of TMC requires familiarity with trip routing and
4 planning platforms, as well as online payments. In a study focusing on the drivers and bar-
5 riers in adopting Maas (Mobility as a Service), also an innovative concept, van 't Veer et al.
6 (2023) demonstrated that individuals' familiarity with smartphone use, mobile payments
7 and planning apps was positively related to their intention to use Maas.

8 Moreover, since TMC schemes are defined and managed by the government, trust in the
9 government has a significant impact on the public support of such an instrument as demon-
10 strated by Krabbenborg et al. (2021a).

11 Additionally, the acceptability of transport policy instruments that limit or reduce mobility
12 is shaped by political context (Syrda, 2025; Aasen and Sælen, 2022). In a study explor-
13 ing predictors of opposition to road tolls among the Norwegian public, Aasen and Sælen
14 (2022) showed that left-right ideology was positively related to opposing road tolls. In
15 another study, focusing on political ideologies and political party preference as drivers of
16 public transport infrastructure support, Syrda (2025) demonstrated that individuals with
17 right-leaning political ideology were more likely to oppose public transport investments.
18 Syrda (2025) focused on the economic aspects of transport projects, defining a specific
19 scale to measure left-right ideology. Given that TMC can be viewed as both an economic
20 instrument and a TDM tool, including political ideology to explore its acceptability is
21 important.

22 Based on the gaps and insights identified in the literature, this study aims to address
23 the following objectives:

- 24 • To investigate how different TMC scheme characteristics shape perceptions of fair-
25 ness, freedom, and effectiveness.
- 26 • To analyze the mediating role of these perceptions in the relationship between TMC
27 scheme characteristics and acceptability.
- 28 • To assess the influence of attitudes (car enthusiasm, trust in the government, environ-
29 mental concern, political views, and technology adoption), sociodemographic factors,
30 and travel behaviour variables on the acceptability of TMCs.
- 31 • To identify the most critical TMC scheme characteristics for informing the future
32 design of such instruments.

3. Conceptual model and survey design

3.1. Conceptual model

Building on the literature review, the following conceptual model (Figure 1) was designed to explore the relationships between these factors. It is assumed that scheme design characteristics influence perceptions of TMCs, and that these perceptions, in turn, mediate the overall acceptability of TMC. Additionally, sociodemographics, travel and mobility characteristics, and general attitudes are hypothesized to directly and indirectly affect both perceptions and acceptability. This model will be estimated using Structural Equation Modeling (SEM) to test the proposed hypotheses.

- TMC design characteristics influence perceptions of TMC schemes (H1)
- Perceived fairness, effectiveness, and freedom mediate the relationship between acceptability and TMC schemes characteristics (H2)
- General attitudes influence perceptions (H4) and the acceptability (H3) of TMC schemes
- Individual characteristics (sociodemographics and travel behaviour) influence attitudes (H7), perceptions (H6) and TMC schemes acceptability (H5)

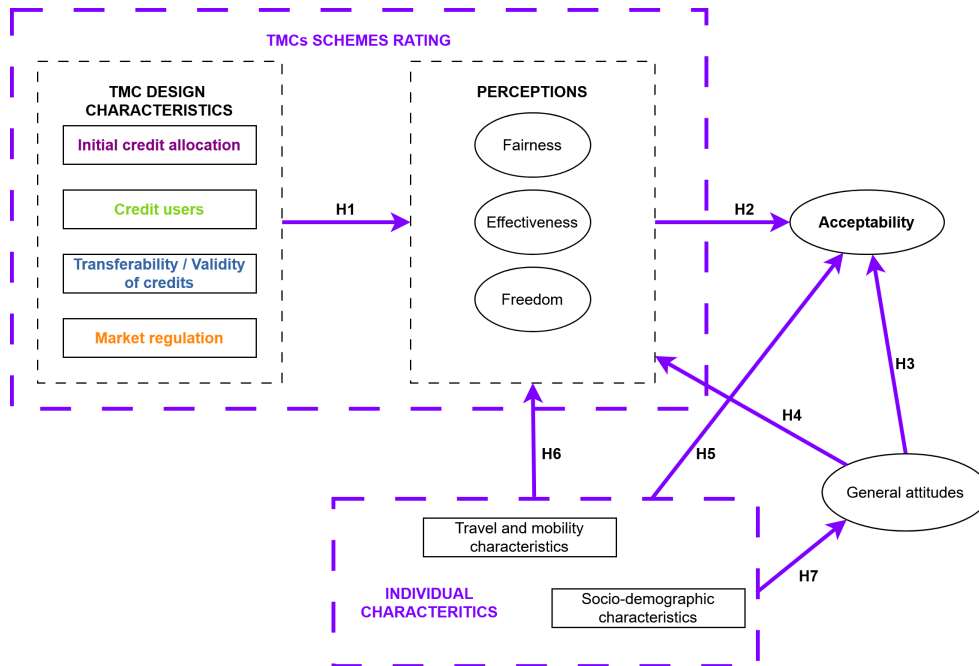


Figure 1: Conceptual model

3.2. Construction of the rating experiment

Salient characteristics and their levels.

From the literature review four characteristics as well as their levels were identified. Their description is given in Table 1.

Characteristics	Description	Levels
Initial Credit Allocation	How mobility credits are distributed to users at the start of each month.	• Uniform • Origin-Destination (O-D) specific • Income-based • Accessibility-based
Users	Who is eligible to receive and use mobility credits.	• Vehicle owners/drivers • Employed people • In-age residents
Transferability / Validity	What happens to unused credits at the end of a month.	• Credits expire • Transfer of credits • monetisation of credits
Trading Market Regulation	Rules governing how credits can be bought/sold.	• Limitation of credits purchase • Progressive increase of credit price • No limitations

Table 1: Scheme design characteristics and their levels

Combining TMC characteristics into schemes.

All possible combinations of characteristic levels would result in a full factorial design of $4^4 = 256$ TMC schemes. To reduce the total number of schemes, fractional factorial designs can be used. To ensure that attribute level balance is satisfied, orthogonal designs can be used to select subsets in a structured way. Orthogonal designs satisfy attribute level balance and ensure that all parameters are independently estimable: the attribute levels for each attribute column in the design are uncorrelated (ChoiceMetrics, 2024). In this study, no interaction effects between characteristics (attributes) are assumed: the characteristics are not correlated within a scheme. It is assumed that the effect of each TMC scheme characteristic is independent of the levels of other characteristics. These designs can be constructed using basic plans (BPs), which are orthogonal fractional factorial designs constructed by mathematicians. A first BP of 16 rows was identified that allowed for

1 attributes with different numbers of levels. However, this BP did not ensure attribute level
 2 balance for all attributes. Thus, the Ngene software (version 1.4) was used to generate the
 3 appropriate BP. Moreover, the software was also used to block the schemes to limit the
 4 number of schemes presented to each respondent and avoid survey fatigue. Each block is
 5 not orthogonal by itself, and only the combination of all blocks is orthogonal (ChoiceMet-
 6 rics, 2024). Ngene created the schemes and blocks, ensuring that all characteristics were
 7 equally represented to maintain orthogonality. Ngene created a fractional factorial design
 8 of 36 schemes that were blocked into 9 blocks of four schemes.

9 Choice of measurement task.

10 Since the goal of this study is not to determine whether one scheme design is preferred
 11 over another, but rather to assess the strength of preference for a scheme, a rating task
 12 is preferred to a choice task (Molin and Marchau, 2004). Similarly to what was done by
 13 Clark et al. (2021) when studying the role of attitudes in perceptions of bicycle facilities,
 14 respondents had to choose the most appropriate response for each of the three perceptions,
 15 on a 5-point Likert scale for each TMC scheme (-2 = strongly disagree, -1 = disagree, 0 =
 16 unsure, 1 = agree, 2 = strongly agree; see Table 2). Additionally, respondents had to rate
 17 the acceptability of each scheme using the same scale. The score for freedom was reversed
 18 (from negative to positive) to keep consistency with the other items when modelling.

Variables	Questions
Perceived fairness	This scheme is fair to me
Perceived effectiveness	This scheme would effectively reduce congestion and air and noise pollution
Perceived freedom	This scheme limits my freedom to choose my travel mode
Acceptability	I feel positive about the implementation of this scheme

Table 2: Statements to measure perceptions and acceptability

3.3. Survey structure

The survey consists of multiple sections. First participants had to report their sociodemographic attributes: gender, age, country of origin, work or study status, living situation, monthly disposable household income, residential location (which part of the Amsterdam Metropolitan Area AND if Amsterdam, which district). Then participants had to answer some questions regarding their attitudes using a five-level Likert scale (see Table 2).

Afterwards, the survey included a short introduction to TMCs schemes and to the rating experiment. Following these descriptions, participants were randomly assigned a block with four different TMC schemes. For each scheme, they were asked to rate the schemes based on its perceived fairness, effectiveness and infringement to freedom as well as acceptability (see Table 2).

After, the rating experiment, participants were asked another wave of questions regarding their attitudes (see Table 6). Following that, participants had to provide information about their travel behaviour and mobility habits: availability of a driving license, car ownership, public transport subscription, frequency of use of different transport modes (car, bike, public transportation), main mode of transportation (walking, bicycle/electric bike, public transport, carpooling, individual car) for different purpose (work, errands, leisure), accessibility of public transport within 5 minutes walking distance from home, number of teleworking days per week and flexible work arrangements.

Lastly participants had the option to leave a comment at the end of the survey.

3.4. Data collection

TMC would most likely be implemented in a large city, as congestion problems, as well as air and noise pollution, are worst in urban areas. For this study, participants were sampled from the Metropolitan Region of Amsterdam (MRA) in the Netherlands. Panel Clix and TGM were hired to collect responses using their online panel. The data collection span over two month (May and June 2026). Only individuals aged 18 and older living in the MRA were invited to participate. Several steps were taken to clean the survey data and check for inconsistencies (removing duplicates, incomplete responses, no participation consent). Answers shorter than 2.5 minutes were also removed. Moreover, respondents that answered *Other* or *Prefer not to say* for their gender and ones that selected the *Prefer*

1 *not to say* option regarding their household income were removed from the sample. This
2 resulted in a final sample size of $N = 803$ respondents.

3 **4. Methodology**

4 The acceptability of TMCs is explored by estimating a structural equation model
5 (SEM) that specifies how different TMC scheme characteristics are perceived in terms
6 of fairness, effectiveness, and freedom, and how these perceptions, in turn, influence ac-
7 ceptability. The model also takes into account the effects of individual characteristics and
8 general attitudes on these perceptions and the acceptability of TMCs. To capture the atti-
9 tudinal factors, which are latent constructs that cannot be directly observed, factor analysis
10 is employed.

11 *4.1. Structural Equation Modeling*

12 Structural equation modeling (SEM) is a modeling technique used to test and eval-
13 uate complex relationships between variables. SEM combines two statistical methods:
14 confirmatory factor analysis (CFA) and path analysis. Path analysis, identifies causal re-
15 lationships among variables based on a series of linked regression equations. The SEM
16 technique allows one to break down the correlations between variables into direct and
17 indirect causal effects (Abu-Bader and Jones, 2025).

18 *4.1.1. Model specification and identification*

19 The number of latent variables can be reduced by performing CFA or EFA, in order
20 to have the latent variables measured by one single indicator which is the sum scores
21 of the indicators (Molin and Marchau, 2004). The reliability of the summated scale is
22 given by the Conbrach's alpha. $1 - \text{Cronbach's alpha}$ is an indication of the proportion
23 measurement error of the scale and is fixed in the SEM model. Each of the latent constructs
24 (attitudes) are dependent variables as they are assumed to be influenced by other variables
25 (see Figure 1). They are endogenous thus they have error terms. In addition, perceptions
26 and acceptability that are identified as observed variables as they are measured with only
27 one indicator also have error terms that represent their unexplained variance. On the other
28 hand, individual characteristics (socio-demographic and travel behaviour) are exogenous
29 variables: they are independent of other variables and are assumed to be measured without

1 measurement error. The sociodemographic characteristics as well as the travel behaviour
2 characteristics correlate with one another. As SEM relies on linear relationships between
3 variables, categorical variables such as TMC characteristics were converted in numerical
4 format using effect coding. The correlation between TMC characteristics were included in
5 the model but as TMC schemes were designed to be orthogonal for the rating experiment,
6 correlations between different characteristics are null (or close to 0). Thus all covariance
7 between the characteristics of different TMC schemes were fixed to 0, while the ones
8 between levels for the same characteristics were fixed to 0.333 (for two attributes) and
9 0.248 (for three attributes), similarly to what was done in the study by Molin (2005).
10 TMC characteristics variables do not correlate with other variables of the model.

Variables	Description
TMC schemes characteristics	effect coded; exogenous
Individual characteristics	ordinal or binary; observed; exogenous
Attitudes	ordinal (summated scale); latent; endogenous
Perceptions	ordinal; observed; endogenous
Acceptability	ordinal; observed; endogenous

Table 3: SEM variables

11 4.1.2. *Parameter estimation*

12 A SEM software estimates path coefficients (see figure 1). All model parameters are
13 estimated simultaneously using Maximum Likelihood (ML) which maximises the likeli-
14 hood of observing the population data (Kline, 2016). The model also estimates correlations
15 between variables and their error terms.

16 4.1.3. *Model fit*

17 Model fit is an important step when conducting SEM as it determines the reproducibil-
18 ity of the data. The model is evaluated by checking its performance using different quan-
19 titative indices. Multiple fit indices exist, however it is not necessary to include every one
20 of them. As emphasized by Tomarken and Waller (2005), fit indices have different proper-
21 ties, they are sensitive to many factors, such as data distribution, missing data, model size

1 and sample size. Hooper et al. (2008) advice for including the following indicators: Chi-
2 squared test (CMIN), Standardized Root mean square residual (SRMR), Goodness of fit
3 index (GFI), Comparative fit index (CFI) and the Root mean square error of approximation
4 (RMSEA).

5 4.1.4. Model modification

6 The initial model starts by drawing all paths between each variables according to the
7 conceptual model defined in section 3.1 and illustrated by Figure 1. After estimating the
8 initial model, the model is adapted by possibly removing all paths that did not turn out to be
9 statistically significant. To obtain a parsimonious model, insignificant direct effects can be
10 deleted in a stepwise fashion through a process of backward elimination. All correlations
11 between error terms and exogenous variables are retained (even when insignificant) to
12 ensure proper statistical control (Molin, 2005). In addition, the Modification Indices (MI)
13 are also checked as they may give suggestions on how to improve the model. The MI of
14 a path that is not estimated provides an estimate of how much the Chi-square value will
15 decrease if the path is added.

16 5. Results

17 In this section, results and outcomes of the survey and the model are presented. The
18 first subsection outlines descriptive statistics of the sample. The second subsection pro-
19 vides the results of the factor analysis that was performed to check the reliability of the
20 attitudinal factors. The third subsection presents the effects of TMC characteristics on
21 acceptability. The final subsection presents the full model.

22 5.1. Result 1: Descriptive statistics

23 In total, 1472 people opened the survey. The first cleaning steps (removing duplicates,
24 incomplete responses, no participation consent, fast respondent) resulted in a valid sample
25 size of 891 respondents. Respondents that answered *Other* or *Prefer not to say* for their
26 gender (4 respondents, 0.02% of the valid sample) and ones that selected the *Prefer not to*
27 *say* option regarding their household income (85 respondents, 9.5% of the valid sample)
28 were removed from the sample, as the income variable was treated as ordinal in the SEM
29 model. This resulted in a final sample size of $N = 803$ respondents. Each respondent

1 rated four different TMC profiles, yielding $4 \times 891 = 3212$ ratings in the experiment. The
2 average time spent on the survey was 12.6 minutes, while the median is 6.2 minutes.

3 *5.1.1. Sociodemographic characteristics of the sample*

4 The sample's socio-demographics are compared with the Dutch population, which is
5 used as a proxy to the one of the MRA. More than 14% of the Dutch population lives
6 in the MRA which is the country's most robust economic region (Metropoolregio
7 Amsterdam, n.d.). The data was retrieved from CBS Statline.

8 The sample slightly overrepresents females and individuals aged 55–79, with retired
9 individuals comprising 15% of participants (Table 4). Non-Dutch individuals are un-
10 derrepresented, constituting only 5.7% of the sample. Single individuals without chil-
11 dren are underrepresented, while couples with children are overrepresented. Highly ed-
12 ucated participants (HBO degree or higher) account for 45% of the sample, compared
13 to 36% in the Dutch population. Income distribution shows a slight overrepresentation
14 of lower-income individuals, with 18% reporting a monthly disposable income below
15 €2,000 (€24,000 annually). Nearly 70% of respondents earn between €2,000 and €6,000
16 monthly (€24,000–€72,000 annually; see Table A.15 and Table A.16 in Appendix A).
17 Geographically, 41% of the sample resides in Amsterdam. Almere-Lelystad is overrepre-
18 sented (20% vs. 12% in the MRA population), while Amstelland-Meerlanden is underrep-
19 resented (5% vs. 14% ; see Figure A.6 in Appendix A).

Variables	Items	Sample	Population
Gender CBS (2025a)	Male	44.80%	49.80%
	Female	55.20%	50.20%
Age CBS (2025g)	18–24	7.80%	10.92%
	25–34	18.70%	16.28%
	35–44	17.60%	15.23%
	45–54	17.10%	15.21%
	55–64	19.30%	16.88%
	65–79	19.20%	19.13%
	80	0.40%	6.35%
Origin CBS (2025)	The Netherlands	94.20%	83.30%
	Europe	3.00%	16.70%
	Non-Europe	2.70%	–
Education CBS (2024b)	Primary education, VMBO, MBO 1	15.90%	26.00%
	Higher general secondary education, VWO, MBO 2-3-4	37.90%	37.00%
	HBO	21.50%	36.00%
	Bachelor's degree	11.10%	
	Master's degree	12.50%	
	PhD	1.10%	
Household composition CBS (2025b)	Single without children	32.90%	40.10%
	Single with children	9.00%	7.43%
	Couple with children	30.30%	24.09%
	Couple without children	24.30%	27.79%
	Other	3.60%	0.58%
Employment status CBS (2025f)	Employed full-time	46.20%	34.83%
	Employed part-time	20.20%	28.82%
	Self-Employed	6.60%	–
	Unemployed	3.70%	2.17%
	Student	2.90%	–
	Retired	15.40%	12.34%
	Other	5.00%	20.84%

Table 4: Sociodemographic characteristics of the sample compared to the Dutch population

1 5.1.2. Travel and mobility characteristics of the sample

Variables	Items	Sample	Population
Driving license CBS (2026)	Yes	85.40%	64.82%
	No	14.60%	35.18%
Car ownership CBS (2026)	Yes	74.80%	38.85%
	No	25.20%	61.15%
PT subscription	Yes	38.70%	—
	No	61.30%	—
PT accessibility	Yes	79.20%	—
	No	20.00%	—
	idk	0.80%	—
Work flexibility	Yes	40.00%	—
	No	55.50%	—
	idk	4.50%	—

Table 5: Mobility characteristics of the sample compared to the Dutch population

2 The sample exhibits a high prevalence of driving license ownership (85.40%) and car
3 ownership (74.80%), exceeding Dutch population figures (see Table 5). Public transport
4 (PT) accessibility is high, with 79.20% of respondents having a PT stop within a 5-minute
5 walk. Work flexibility is limited, as 55.50% of the sample report no flexibility. For com-
6 muting (Figure 2), 40% of the sample primarily uses cars, while 26% bike and 26% use
7 PT. Compared to national data, the sample overrepresents PT users and underrepresents
8 cyclists (see Table 5 in Appendix A). For leisure, active modes (walking and cycling) dom-
9 inate, aligning with Dutch trends, while PT remains underused (Figure 2). Active modes
10 account for over half of errand trips, mirroring national trends (48.70%). PT remains the
11 least used option (Figure 2). Two-thirds of the sample use cars weekly, with only 17%
12 never using them; PT usage is low (see Figure A.7 in Appendix A): almost a quarter of the
13 respondents never use them, consistent with 61.5% of the sample lacking a PT subscription
14 (see Table 5).

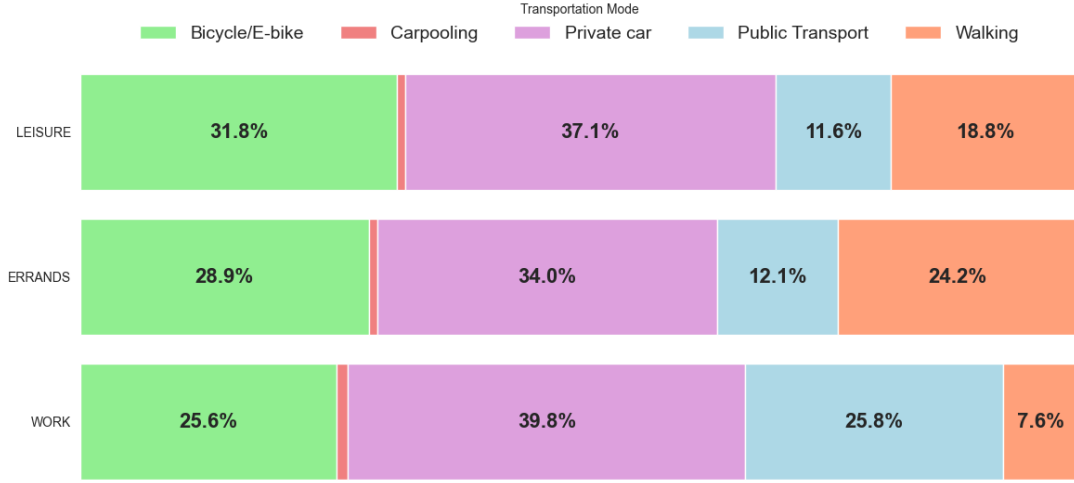


Figure 2: Samples' current travel behaviour per travel purpose

The sample represents a diverse range of socio-demographic (gender, age, origin, education, household, employment) and travel (car ownership, PT access, commuting modes) characteristics. All categories are well represented.

5.1.3. Rating of TMC schemes

In the rating experiment respondents had to indicate the extent to which they agreed with statements related to different perceptions (see Table 2). These were five-point Likert scale questions, ranging from "Totally disagree" (-2) to "Totally agree" (+2).

Results of the survey indicate that TMC schemes are not widely perceived as acceptable instruments. Only 34% of the respondents would support implementing such a system, while 23% are neutral and the remaining 43% are opposed. (Figure 3). The acceptability found in this study is similar to the one measured for Tradable Peak Credits (TPC) in China (Cui et al., 2024) and in the Netherlands (Krabbenborg et al., 2021a). However, the public support for TMC schemes observed here is higher than that for Tradable Driving Credits (TDC), which recorded a support level of 22% in the Netherlands (Dogterom et al., 2018a). A significant concern is the perceived restriction on freedom, with more than half of the respondents viewing TMC schemes as limiting their autonomy in travel

1 mode selection. However, nearly 50% of the sample demonstrates a more favorable per-
 2 ception of the fairness and effectiveness of TMCs. These preliminary results suggest that
 3 while TMC schemes are considered fair and effective, they are simultaneously perceived
 4 as a substantial infringement on individual freedom.

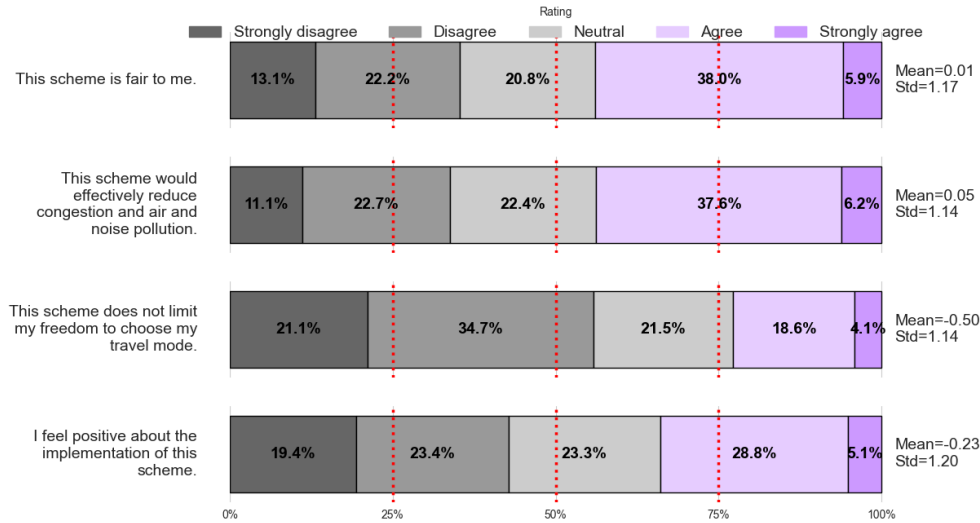


Figure 3: Overall distribution of answers to the perception and acceptability statements regarding TMC schemes

5 An analysis of the different TMC allocation strategies (not presented in this document)
 6 reveals that accessibility- and income-based approaches elicit the least negative percep-
 7 tions and highest acceptability, similar to results from Hamm et al. (2025), whereas the
 8 origin-destination (OD) strategy is the least favored. Restricting TMC usage to residents
 9 yields the most positive perceptions and acceptability, similarly to results from Krabben-
 10 borg et al. (2021a); while limiting usage to employed individuals produces the opposite ef-
 11 fect. Regarding credit transferability and validity, monetisation emerges as the most favor-
 12 able option, whereas regulatory constraints and credit invalidation are the least accepted.
 13 The evaluation of trading market regulations does not reveal substantial differences; how-
 14 ever, the absence of regulation is the more acceptable among the options considered.

1 5.2. Result 2: Factor analysis result

2 Part of the survey consisted of a few questions that asked respondents to indicate the
3 extent to which they agreed with statements related to different attitudes (see Table 6).
4 These were five-point Likert scale questions, ranging from "Totally disagree" (-2) to "To-
5 tally agree" (+2). The statements were designed to gather information about five attitudes:
6 car enthusiasm, trust in the government, environmental concern, political views, and tech-
7 nology adoption.

Dimension	Item	Question	Mean	Standard Dev
Car enthusiasm	CAR_1	Driving a car offers many advantages compared to the use of other transport modes.	0.83	0.967
	CAR_2	The car gives me the freedom to go wherever I want.	0.99	0.983
	CAR_3	I cannot manage without a car.	0.34	1.312
Trust in the government	GOV_1	The government is capable of implementing and conducting a Tradable Mobility Credit scheme.	-0.11	1.094
	GOV_2	Government-led initiatives to reduce transport emissions are effective and well-intentioned.	0.09	0.994
Environment concern	ENV_1	The environment and future of the planet are at risk due to the use of individual motorised transport.	0.12	1.129
	ENV_2	It is my obligation to protect the environment through my transportation mode choices.	0.16	1.039
	ENV_3	I am committed to live a more environmentally friendly lifestyle.	0.42	0.955

Table 6: Distribution of statements regarding general attitudes 1

8 Participants present mixed opinions regarding each of the statements, with most stan-
9 dard deviations being close to 1. There are no statements on which participants strongly
10 disagree or agree. These first descriptive results provide a first image of the sample. They
11 are familiar with the use of new technology and are car enthusiasts, in line with their travel
12 characteristics. They are committed to having a more environment-friendly lifestyle but

Dimension	Item	Question	Mean	Standard Dev
Political views	POL_1	Government should redistribute income from the better-off to those who are less well-off.	0.35	1.156
	POL_2	Commercial private enterprises should be transferred to state ownership.	-0.30	1.063
	POL_3	Government should guarantee everyone a job and a decent standard of living.	0.63	0.988
	POL_4	There is not enough government involvement and regulation in society.	-0.51	1.031
Technology readiness	TECH_1	I am familiar with the installation and use of different apps on my smartphone.	1.18	0.880
	TECH_2	I rely on GPS tracking apps for navigation and location sharing in my daily life.	0.22	1.185
	TECH_3	I am familiar with using my smartphone for payments.	1.00	1.019
	TECH_4	I am confident that I can manage and trade my credits using my smartphone.	0.34	1.121

Table 7: Distribution of statements regarding general attitudes 2

1 not regarding their individual mobility behaviour. They do not trust the government in
2 implementing effective instruments, such as TMCs, to reduce transport emissions. They
3 strongly agree that there is too much involvement of the government in society. However
4 they do support government interventions that are for social welfare.

5 5.2.1. Exploratory Factor Analysis

6 Before estimating the model defined in Section 3.1 (see Figure 1), a factor analysis
7 was conducted to reduce the number of items for each latent construct and assess their
8 reliability. The results of the confirmatory factor analysis (CFA) suggested an alternative
9 structure for the five attitudes defined in Section 3.1. This discrepancy may stem from the
10 fact that the attitudes were derived from literature across various transport policy papers,
11 as the concept of TMCs is novel and has not been fully explored.

12 The 16 attitudinal indicators 6 were analysed performing EFA. The extraction method
13 of Principal Axis Factoring (PAF) was used combined with the Promax rotation technique.
14 A simple structure of four factors was identified. *POL_4*, *TECH_2* and *TECH_4* present

low loadings ($<|0.4|$, see Table B.19 in Appendix B) and were removed. As can be observed in Table 8, items from environmental concern and trust in the government present high loadings for the same factor (factor 1). Without accounting for the items *TECH_2*, *TECH_4* and *POL_4*, the structure of factor 2,3 and 4 is the same as defined in Section 3.1, with technology adoption only having two items. Factor 1 is a combination of the trust in the government and environment concern indicators. The combination of these items form a new factor: environmental responsibility, accounting for individual and the government responsibility regarding the impact of transportation on the environment. In order to check the internal consistency of the factors, a Cronbach's Alpha test was conducted. The reliability analysis resulted in four latent constructs with Cronbach Alpha > 0.5 , presented in Table 8.

Factor	Item	Factor Loading	Scale Variance	Cronbach Alpha	Variance of the measurement error
2	CAR_1	0.739	7.319	0.758	1.771
	CAR_2	0.759			
	CAR_3	0.736			
1	ENV_1	0.618	13.974	0.762	3.326
	ENV_2	0.749			
	ENV_3	0.547			
	GOV_1	0.476			
	GOV_2	0.730			
3	POL_1	0.707	5.448	0.553	2.435
	POL_2	0.378			
	POL_3	0.550			
4	TECH_1	0.713	2.687	0.650	0.940
	TECH_3	0.696			

Table 8: Cronbach Alpha results

As can be seen in Table 8, Factor 1 and 2 have good reliability (Cronbach Alpha > 0.7) indicating that the latent constructs environmental responsibility and car enthusiasm are well-measured by their respective indicators. The scale for factor 4 indicates less reliability compared to the other ones. Each latent construct identified in EFA (*Factor*

1 1,2,3,4) is only measured by a single indicator variable in the SEM model. Those single
 2 indicators are a summated scale of the items. Each of these single indicator variables
 3 have error terms that are fixed in the SEM model. They represent the unreliability of
 4 the single indicators used to measure the latent constructs. These measurement error are
 5 determined using the Cronbach Alpha of the summated scales reported in Table 8. The
 6 proportion measurement error of the scale is given by $(1 - \text{Cronbach's alpha})$. Multiplying
 7 the proportion measurement error with the variance of the scale, the variance of the error
 8 component is obtained. This result is used to fix the measurement error of the single
 9 indicator in AMOS.

10 5.3. Result 3: Model estimation results

11 AMOS SPSS software was used to estimate the postulated model defined in section
 12 3.1 (see Figure 1). The model estimates path coefficients between:

- 13 • TMCs characteristics and perceptions
- 14 • Perceptions and acceptability
- 15 • Individual characteristics and attitudes
- 16 • Attitudes and perceptions
- 17 • Attitudes and acceptability
- 18 • Individual characteristics and perceptions
- 19 • Individual characteristics and acceptability

20 The last four groups of effects can be found in Appendix C.

21 The final model turned out to fit the data very well as can be seen in Table 9.

Fit Index	Chi-square	df	p-value	SRMR	RMSEA	GFI	CFI
Value	198.06	234	0.957	0.0097	0.000	0.996	1.000

Table 9: Model Fit Indices

22 The Chi-square test indicates that the model fits the data ($p > 0.05$) meaning that there
 23 are no significant differences between the observed and estimated covariances matrices.
 24 A SRMR below the 0.08 threshold indicates a very good fit for the residual covariance
 25 matrix. A RMSEA of 0 also implies that there is no discrepancy between the observed and
 26 estimated covariance matrices. Moreover, both CFI and GFI have values close or equal to

1 1 indicating that the model explains most of the variance in the observed data. Thus, the
2 model is considered as valid and the model's outputs can be analyzed and interpreted.

3 The initial model started by drawing all paths between variables including direct paths
4 from each of the TMC characteristics to acceptability. After estimating the initial model,
5 these paths were removed as they were not statistically significant. The modification in-
6 dices did not indicate any direct path to be added between TMC scheme characteristics and
7 acceptability. Thus, TMC characteristics do not have any direct effects on acceptability;
8 perceptions mediate the effects of TMC schemes' characteristics on acceptability.
9 In order to make every coefficients of the model comparable and interpretable, the coef-
10 ficients were standardized: transformed into a scale-free metric (mean = 0 and standard
11 deviation (sd) = 1) in SPSS AMOS.

12 5.3.1. Effects of TMC scheme characteristics on perceptions

13 AMOS was used to estimate the coefficients from the indicator variables (TMC scheme
14 characteristics) to each of the three perceptions, as well as from these perceptions to ac-
15 ceptability. Table 10, 11, 12 and 13, present the standardized direct effects of TMCs
16 scheme characteristics on perceptions. The significant effects ($p < 0.1$) are highlighted in
17 bold. The total effects on acceptability are provided in Table 14 in Section 5.3.2.

18 Credit allocation strategy

TMC Characteristics	Fairness	Effectiveness	Freedom
Uniform	-0.014	0.001	0.01
Income	-0.01	-0.032*	0.037*
OD	-0.012	0	-0.022
Accessibility	0.036**	0.031*	-0.025

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 10: Effects of allocation strategies on perceptions

19 Regarding TMC allocation strategies, not all attributes have significant effects on the
20 perceived fairness of the scheme. The accessibility-based allocation has a significant pos-
21 itive effect on perceived fairness, while uniform and OD-based allocations negatively af-
22 fect it. Individuals without access to PT need to use the car for their trips resulting in high

1 credit consumption and quick shortage compare to individuals living close to PT services.
2 Since TMC schemes are instruments that directly influence the costs of trips depending
3 the transport mode use, it makes sense that perceived fairness is higher for accessibility-
4 based allocation and lower for the uniform one. The accessibility-based allocation also
5 has a significant positive effect on perceived effectiveness, whereas the income-based al-
6 location has a significant negative effect. If people living in already well connected neigh-
7 borhoods have a lower amount of credits than people living in neighborhoods with poor
8 public connections, a TMC scheme with an accessibility-based allocation should make
9 them use active modes or PT, reducing their negative transport externalities. Meanwhile,
10 the income-based allocation has a significant positive effect on perceived freedom, while
11 accessibility and OD-based allocations have non-significant negative effects. A credit allo-
12 cation based on income would result in distributing more credits to individuals with lower
13 incomes. Here, freedom is associated to the capacity of choosing a travel mode. Individ-
14 uals with higher incomes are more likely to buy more credits if they exceed their budget:
15 they should always be able to choose their travel mode and it would be the same for people
16 with lower incomes if they get more credits initially.

17 Credit users.

TMC Characteristics	Fairness	Effectiveness	Freedom
Residents	0.079***	0.015	0.043**
Vehicle owner/driver	-0.008	0.009	-0.030
Employed	-0.071***	-0.024	-0.013

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 11: Effects of user definitions on perceptions

18 When examining different TMC user groups, having all residents as eligible user has a
19 significant positive effect on the perceived fairness and freedom of the scheme. In contrast,
20 limiting eligibility to only employed people has a significant negative effect on perceived
21 fairness. TMC schemes are supposed to be implemented in an entire urban area, thus in-
22 cluding only a certain segment of the population decreases fairness as all people living in

the same urban area produce negative externalities when moving. None of the different user definitions have significant effects on the perceived effectiveness of the scheme, which is surprising as the higher the number of user the higher the impact of the scheme on negative transport externalities should be. Additionally, restricting eligibility to only vehicle owners or drivers does not yield any statistically significant effects on perceptions, though the regression weight for perceived freedom is relatively high (and negative). Having only car owners/drivers as user would have a direct impact on their possibility to choose travel modes as a TMC scheme would directly nudge them to choose a different transportation mode.

Credit validity.

TMC Characteristics	Fairness	Effectiveness	Freedom
Expiration	-0.077***	-0.015	-0.025
Transfer	0.046**	-0.029	0.008
Monetisation	0.031*	0.044**	0.017

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 12: Effects of transferability/validity of credits on perceptions

For the transferability (or validity) dimension of TMC schemes, credit expiration (invalidation) at the end of the month has a significant negative effect on perceived fairness, while the ability to transfer or monetise credits has a significant positive effect. If a user has a lot of credits remaining at the end of the month it means that he has been using PT or active modes for most of his trip, thus his negative transport externalities are low. While it's the opposite for a user that just has a few credits left. Thus having the credits expiring at the end of the month instead of them being monetised or transferred creates an important imbalance between the two users in favor of the one with higher negative transport externalities. For perceived effectiveness, only the monetisation of TMCs at the end of the month has a significant and positive effect. In fact, being able to monetise credits at the end of the month, would nudge individuals to change their travel behaviour in order to reduce their air and noise pollution or congestion as they would be able to win money since the credits are allocated for free at the beginning of the month. None of the transferability

1 characteristics have a significant effect on perceived freedom. Credit expiration has a neg-
2 ative effect, while transfer and monetisation of credits have a positive effect. Monetisation
3 performed best across all perceptions while invalidation appeared as the least favored.
4 Market regulation.

TMC Characteristics	Fairness	Effectiveness	Freedom
Limitation	-0.006	-0.002	0.001
Price increase	-0.005	0.002	-0.008
No limitations	0.011	0	0.007

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table 13: Effects of trading market regulation on perceptions

5 Regarding the trading market dimension, none of the TMC characteristics have signif-
6 icant positive or negative effects on any of the perceptions. Trading market regulation can
7 be more complex and abstract to understand. Moreover, it is more likely that individuals
8 first focus on the credits they have and later on what they can possibly do with them.

9 5.3.2. Full model

10 Table 14 provides the standardized total effects for all the variables included in the
11 model, the last column shows the overall impact of each variable on acceptability.

		Total effects							
Variables		Lpol	Ltech	Lenv_gov	Lcar	Fairness	Effectiveness	Freedom	Acceptability
Trading market	Price increase					-0.005	0.002	-0.008	-0.002
	Limitation					-0.006	-0.002	0.001	-0.003
Regulation	No limitations					0.011		0.007	0.005
	Monetisation					0.031	0.044	0.017	0.024
Transferability / Validity	Transfer					0.046	-0.029	0.008	0.012
	Invalidation					-0.077	-0.015	-0.025	-0.036
Users	Employed					-0.071	-0.024	-0.013	-0.034
	Vehicle					-0.008	0.009	-0.03	-0.004
	Residents					0.079	0.015	0.043	0.038
	Accessibility					0.036	0.031	-0.025	0.019
Allocation	Income					-0.01	-0.032	0.037	-0.008
	OD					-0.012		-0.022	-0.007
	Uniform					-0.014	0.001	0.01	-0.004
Socio-demographic	Gender (female)	0.008	0.016	0.092		0.02	0.064	0.025	0.038
	Age	-0.098	0.164	-0.001	0.004	-0.157	-0.14	0.01	-0.169
	Income level	-0.19	0.065	0.1	-0.038	0.035	0.052	0.013	0.071
	Household (with children)	0.095		0.068	-0.017	0.052	0.076	-0.001	0.032
	Educational level	-0.149	0.042	0.051	-0.114	-0.011	0.002	0.007	-0.044
	Origin (outside NL)	-0.009	-0.063	-0.014	-0.042	-0.016	0.021	0.002	0.01
	MRA (not Amsterdam residents)	-0.122	-0.045	-0.109	0.113	-0.081	-0.04	-0.11	-0.11
	Retired (no)	-0.106	0.08	-0.055	-0.03	-0.1	-0.153	-0.085	-0.106
	Student (no)	0.046	-0.201	0.065	-0.045	0.07	0.066	0.013	0.113
	Employed (no)	0.106	-0.102	0.079	-0.049	0.051	0.008	-0.049	0.064
Travel behaviour	Car ownership (no)	-0.017	-0.042	0.059	-0.498	0.022	0.01	0.085	0.001
	PT subscription (no)	-0.203	0.036	-0.203	0.149	-0.161	-0.147	-0.029	-0.202
	Car use (less than 4 times per week)	-0.032	-0.093	0.042	-0.216	0.034	0.01	0.032	0.037
	Bike use (less than 4 times per week)	-0.043	-0.066	-0.106	0.098	-0.04	-0.056	-0.011	-0.018
	PT use (less than 4 times per week)	0.046	-0.021	-0.015	-0.025	0.018	-0.001	0.027	0.012
	Work flexibility (no)	-0.04	-0.066	-0.137	-0.037	-0.082	-0.078	0.008	-0.056
	PT accessibility (no)	-0.056	-0.028	-0.033	0.035	-0.023	0.01	-0.043	-0.025
Attitudes	Support for social policies (Lpol)					0.095	-0.063	0.043	0.121
	Technological familiarity (Ltech)					-0.086	-0.08	0.144	-0.125
	Environmental responsibility (Lenv_gov)					0.398	0.647	0.066	0.483
	Car enthusiasm (Lcar)					-0.096	-0.025	-0.411	-0.11
Perceptions	Freedom								0.096
	Effectiveness								0.229
	Fairness								0.393
	% explained variance	0.148	0.081	0.157	0.515	0.293	0.396	0.136	0.61

Table 14: Total standardized direct effects

1 Effect of scheme characteristics.

2 TMC characteristics do not have any direct effects on acceptability; perceptions me-
3 diate the effects of TMC schemes' characteristics on acceptability. Attributes from the
4 transferability dimension present relatively high loadings compared to others: monetisa-
5 tion of mobility credits would increase acceptability while invalidation of credits would
6 decrease acceptability. The importance of those two attributes can be explained by the
7 fact that they have significant effects on perceptions. Moreover, the user dimension of the
8 TMC scheme also presents opposing attributes with high loadings. Having all residents as
9 eligible user increases the acceptability of the scheme while having only employed people
10 decreases its acceptability. These results are in line with the analysis provided by Li and
11 Robusté (2025) on TMC user definition as having all residents as user provides the highest
12 level of vertical equity. If the TMC scheme is implemented in an urban area, having all the
13 user of the transport infrastructure, enhance the fairness of the instrument thus its accept-
14 ability. In their field experiment, Brands et al. (2021) and Geng et al. (2023) showed that
15 having specific segment of users (employed individuals or students) for specific context
16 (office or university) did not yield in negative support of TMCs. Looking at the allocation
17 dimension, the accessibility based one is the only strategy with a relatively high total ef-
18 fect on acceptability and is also the only positive one. This result is in line with the study
19 conducted by Hamm et al. (2025), in which public support for non-uniform allocation of
20 credits was high. While it contradicts the result of Krabbenborg et al. (2021a) for which a
21 uniform allocation of credits (only used for peak hours) was preferred.

22 Effect of sociodemographic and travel behaviour characteristics

23 Regarding sociodemographic characteristics in Table 14, two variables have high to-
24 tal effects: age and living location (excluding being retired or a student, see Appendix
25 Appendix C). The higher the age the less acceptable the TMC scheme, in line with re-
26 sults from Cui et al. (2024) where younger individuals were more likely to support TPC.
27 Moreover, people who are not employed have a higher overall acceptability compare to
28 employed ones. People living outside of Amsterdam have lower acceptability. Dogterom
29 et al. (2018a) and Cui et al. (2024) also showed that individuals from urban areas were
30 more likely to support TMC schemes. For the travel behaviour characteristics, not having
31 a PT subscription strongly reduces acceptability also identified by Hamm et al. (2025). As
32 can be seen car ownership does not have a total effect on acceptability. This is due to the

1 mediation effect of perceptions. Not owning a car increases the perceived freedom of the
2 scheme, but the effect of freedom on acceptability is much smaller compare to the ones
3 of fairness and effectiveness (bottom rows of the Table 14), thus these effects cancel out,
4 resulting in no total direct effect on acceptability.

5 Effects of attitudinal factors.

6 Focusing on attitudes, environment responsibility is the one with the highest effect:
7 higher environmental responsibility leads to higher acceptability. Hamm et al. (2025) also
8 identified climate change awareness has a strong positive predictor of public support. Fo-
9 cusing on congestion pricing, Sun et al. (2016) had the same result. As expected, higher
10 support for social policies also leads to higher acceptability of TMCs. Those results make
11 sense as a TMC instrument is made to reduce the impact of transport emissions on the
12 environment in a fair way, based on the polluter pay principle. On the other hand higher
13 familiarity with technology and higher car enthusiasm leads to lower acceptability. The
14 negative effect of car enthusiasm makes sense as a TMC scheme is made to reduce indi-
15 vidual car use. All studies mentioned in the literature review (see Chapter 2) identified car
16 ownership and frequent car use as strong predictor of non public support. These variables
17 are strong predictors of car enthusiasm as can be seen in Table 14. However the negative
18 effect of technology familiarity is hard to interpret. One would have assumed that being
19 familiar with technology would have positively influence acceptability since TMC would
20 be operationalised via a specific online platform.

21 The R^2 (explained variance) for the attitudes, perceptions and acceptability are pre-
22 sented in the last row of Table 14. Looking at attitudes, we can see that most variance
23 for policy support, technology familiarity and environmental responsibility remain un-
24 explained by their predictors (individual characteristics). This means that the estimated
25 model is not very successful in reproducing these individual attitudes. On the other hand,
26 more than 50% of the variance in car enthusiasm is explained by the model. Perceptions
27 show moderate explanatory power: only 14% of the variance in perceived freedom is ex-
28 plained and 30% for perceived fairness. The estimated model is not very successful in ex-
29 plaining these individual perceptions. Perceived effectiveness has the highest explanatory
30 power with 40% of its variance explained by the predictors defined in the model. Lastly
31 but most importantly, 61% of the variance in acceptability is explained by the model. Thus
32 the three different types of predictors: individual characteristics, attitudes and perceptions

1 have a strong explanatory power for acceptability.

2 The model demonstrated an exceptional fit to the data, as evidenced by key fit in-
3 dices in Table 9. Results of the SEM confirms that acceptability of TMCs is primarily
4 driven by perceptions of fairness and effectiveness, which are shaped by scheme design
5 characteristics as well as and individual traits: attitudes as well as socio-demographic and
6 travel behaviour characteristics. While TMC characteristics only have indirect effects via
7 perceptions, other individual characteristics such as environment responsibility and sup-
8 port social policies but also age, living location and having a PT subscription exert strong
9 direct influence on acceptability. Attitudinal factors exert the strongest influence on ac-
10 ceptability likely because they are endogenous to it. Attitudes defined in this model are
11 not only predictors of acceptability but can also be shaped by the same underlying factors
12 that influence acceptability itself.

13 **6. Discussion and policy implications**

14 This chapter wrap-ups and reflects on the work accomplished in this study. First it
15 discusses design of future TMC schemes based on results of the SEM model. Then it
16 highlights the strengths and limitations of this study and then discusses its societal and
17 practical implications.

18 *6.1. Designing TMC schemes*

19 The most acceptable TMC scheme, is a combination of TMC characteristics that have
20 the highest positive effect on acceptability (coefficients in Table 14), while the worse one
21 is a combination of the highest negative effects. The most acceptable TMC scheme (Figure
22 4) as well as the worse (Figure 5) one are described in the following figures.

Initial credit allocation	Accessibility based the number of credits depends on the availability of public transport options in a person's area more credits if public transportation is not available
Users	All Residents people over 18 living in the urban area
Transferability / Validity of credits	Monetisation of credits unused credits can be converted into money at the end of the month
Trading Market regulation	No limitations there are no restrictions on buying or selling credits: users can trade them freely

Figure 4: Most acceptable TMC scheme

Initial credit allocation	Income based the number of credits varies according to a person's income level (e.g., lower-income individuals may receive more credits)
Users	Only employed people who are working in the urban area (credits would only be used for commuting trips)
Transferability / Validity of credits	Invalidation unused credits that have not been traded on the platform are destroyed at the end of each month: they can not be used for the next month
Trading Market regulation	Limitations user cannot buy unlimited additional credits: they have to respect a certain limit

Figure 5: Least acceptable TMC scheme

While the accessibility-based allocation would allow more equity as well as having all residents of an urban area part of the TMC scheme, one can see that monetisation of credits combined with no trading market regulation could lead to a complex situation that could exacerbate inequalities between users. With this scheme, high-income users and users familiar with trading could possibly earn more money, assuming that high-income users would be less sensitive to buying extra credits on the platform. Given that high-income groups disproportionately contribute to climate change (Schöngart et al., 2025), this combination of scheme characteristics could diminish the polluter-pay principle partially embodied by TMCs. However, similarly to the scheme that was designed by Servatius et al. (2022) in which monetisation of credits is allowed, policymakers should ensure that TMC users can only invest that money in transport projects. A similar approach is also recommended by Millionig et al. (2022). They suggest that mobility credits could be transformed in credits that could only be used in public transport.

Given that in our specific study TMC schemes would be implemented in an urban area, having only a specific segment of the population as user (employed people) would lead to low public support as it would enhance inequalities between non-employed and employed user who are both having negative transport externalities on the environment. Looking at the transfer dimension, even if invalidating credits at the end of the month would spur speculation Servatius et al. (2023) it is highly perceived as unfair and infringing on ones freedom as well as being only able to buy a limited amount of credits. However, having those two characteristics of the transfer dimension would allow policymakers to reach their targets in reduction in emissions from the transport sector.

1 Those first two schemes illustrate the complexity of TMCs. Given that they are still
2 radical innovations, they have to be tested in specific situations like the experiments done
3 by Brands et al. (2021) and Geng et al. (2023) on longer periods so that their characteristics
4 can be fine tuned. Thus, before defining trading regulations or validity periods for credits,
5 policy makers should first identify specific locations in urban areas in which TMC could be
6 implemented. These specific locations should be directly linked to a specific type of user
7 in order to have an acceptable TMC scheme. Moreover, implementing TMC schemes on
8 a small scale would reduce administrative burden and allow the development of effective
9 communication and secured tracking tools to measure GHG emissions of individual trips.
10 Additionally, survey results indicated that most respondents were familiar with the use of
11 smartphones for making online payments and relied on GPS tracking apps for travel. Fur-
12 thermore, half of the respondents expressed confidence in their ability to manage and trade
13 credits. Therefore, policy makers should leverage this existing technological familiarity to
14 facilitate the adoption of TMC schemes.

15 *6.2. Societal and practical implications*

16 *6.2.1. Focusing on fairness*

17 Perceived fairness emerged as one of the strongest predictor of TMC acceptability. In
18 transportation, fairness is often defined as ensuring unhindered travel speed on the network
19 of one's choice (Rode, 2023). To achieve fairness in TMCs, accessibility as in the capacity
20 to reach destinations, must be prioritized (Rode, 2023; Hamm et al., 2025). The negative
21 influence of residential location, work flexibility, and public transport (PT) subscriptions
22 on perceived fairness and acceptability highlights the need to integrate TMCs with pull
23 policies, such as improving PT affordability and accessibility (see Section Appendix A in
24 Appendix). Implementing TMCs in metropolitan areas with unequal PT provision could
25 exacerbate inequities. Thus, a credit allocation system based on accessibility, also in-
26 cluding individual parameters such as work flexibility and disabilities, would best address
27 existing transport infrastructure disparities among TMCs users.

28 *6.2.2. Raising awareness*

29 Problem awareness, particularly environmental responsibility, emerged as another strong
30 predictor of TMC acceptability. With rising GHG emissions and visible climate impacts,

1 there is an urgent need for robust policy instruments like TMCs to reduce transport de-
2 mand and car dependency (Jaramillo et al., 2022). Survey results revealed that over half of
3 respondents identified as car enthusiasts, with cars being the primary mode for work, er-
4 rands, and leisure in the Amsterdam Metropolitan Region, despite its strong public trans-
5 port network. Additionally, environmental concern was only moderate: 25% disagreed
6 that their transport choices impacted the environment or that they had a role in address-
7 ing it. Research indicates that well-informed individuals are more motivated to change
8 their behaviour (Sun et al., 2016; Eriksson et al., 2006; Li and Zhao, 2019). As Li and
9 Zhao (2019) notes, deeper policy understanding shifts focus from individual burdens to
10 broader social benefits. Given that TMCs affect the fundamental right to travel, effec-
11 tive government communication is critical to explain their rationale and social advantages.
12 While nearly half of respondents viewed TMCs as fair and effective, over half perceived
13 them as an infringement on personal freedom. Yet, half expressed willingness to adopt
14 greener lifestyles. Thus, policymakers must design persuasive communication campaigns
15 to first raise awareness of resource-intensive travel behaviours and alternatives, then foster
16 comprehension of TMCs among urban populations.

17 *6.3. Strength and limitations*

18 This research innovates by categorizing TMC characteristics across the dimensions
19 proposed by Provoost et al. (2023) and Fan and Jiang (2013). Unlike prior studies focusing
20 on ownership and uniform credit allocation, this study empirically assesses how different
21 TMC scheme characteristics affect acceptability.

22 Methodologically, a rating experiment was used instead of stated choice experiments
23 (Dogterom et al., 2018a; Krabbenborg et al., 2021a). While stated choice experiments
24 assess preferences between schemes, the rating approach allows respondents to evalu-
25 ate the strength of their preference for each scheme across multiple dimensions, offering
26 finer granularity. However, the use of orthogonal designs assumes independence between
27 characteristics, potentially oversimplifying reality by ignoring potential interactions (see
28 Section 6.1).

29 The rating experiment required participants to evaluate four TMC schemes, each de-
30 fined by four attributes with multiple levels. Due to complexity of the survey, participants
31 may have experienced cognitive overload or survey fatigue, leading to less thoughtful re-

sponses. Additionally, order effects and the inclusion of a neutral midpoint in the 5-point Likert scale may have reduced measurement sensitivity.

This study advances the understanding of TMC acceptability by empirically validating and refining theoretical frameworks. While prior research (Dogterom et al., 2018a; Krabbenborg et al., 2021a; Hamm et al., 2025) identified fairness, effectiveness, and freedom as key predictors, this work provides greater granularity by testing how TMC scheme characteristics influence these perceptions and mediate the relationship between scheme design and acceptability. However, single-item measures for each perception and acceptability may introduce reliability concerns.

Finally, this study refines attitudinal constructs shaping TMC acceptability. While CFA failed to confirm the expected five-factor structure, EFA combined with SEM identified environmental responsibility as the strongest attitudinal predictor of acceptability. These findings extend prior work (Hamm et al., 2025; Cui et al., 2024) and align with Eriksson et al. (2006), confirming that institutional trust, pro-environmental attitudes, and support for social policies are intertwined in shaping Travel Demand Management measures acceptability.

7. Conclusions

This study addressed the research question: What scheme design characteristics and individual characteristics influence the perceptions and public acceptability of Tradable Mobility Credits (TMCs)? A rating experiment with a sample of 803 respondents from the Metropolitan Region of Amsterdam was conducted to analyze how TMC scheme characteristics—credit allocation, user definition, transferability/validity, and trading market regulations—affect acceptability, mediated by perceptions of fairness, effectiveness, and freedom. Only 35% of respondents supported TMC implementation, similar to levels observed for Tradable Peak Credits (TPC) in China and the Netherlands (Cui et al., 2024; Krabbenborg et al., 2021a), but higher than for Tradable Driving Credits (TDC) in the Netherlands (22%) (Dogterom et al., 2018a). While nearly half perceived TMCs as fair and effective, over half viewed them as an infringement on personal freedom.

TMC characteristics do not directly influence acceptability; their effects are mediated by perceptions. Accessibility-based credit allocation enhances perceived fairness and effectiveness, whereas uniform or origin-destination (OD) allocations reduce fairness. In-

cluding all residents as users increases fairness and acceptability, while limiting eligibility to employed individuals reduces fairness. Monetisation of credits improves acceptability, whereas credit expiration reduces fairness and freedom.

Attitudes and perceptions are stronger predictors of acceptability than socio-demographic or travel behaviour characteristics. Environmental responsibility, a combined construct of trust in government and environmental concern, emerged as the strongest attitudinal predictor, followed by perceived fairness and effectiveness. Among socio-demographic factors, age negatively predicts acceptability, with older individuals showing lower support. Residents of Amsterdam exhibit higher acceptability than those in the broader MRA, and the lack of a PT subscription strongly reduces acceptability.

This study is among the first to quantitatively assess TMC acceptability, but its findings should be interpreted with caution. The use of orthogonal designs assumes independence between TMC characteristics, potentially oversimplifying reality. The rating experiment may have introduced cognitive overload or order effects, and single-item measures for perceptions and acceptability may limit reliability.

Future studies could explore potential interactions by including interaction terms such as Initial Credit Allocation $\times$ Users as additional predictors in the SEM model. Thus, one could assess whether the effect of one attribute on perceptions depends on the level of another attribute; providing deeper insights into how combinations of characteristics shape acceptability. Another valuable avenue for future research using this dataset would be to apply Latent Class Regression Analysis (LCRA) to identify heterogeneous subgroups within the population based on their attitudes, perceptions and individual characteristics. Unlike traditional subgroup analyses, LCRA would allow researchers to uncover unobserved heterogeneity within the population. This approach would complement the current study's focus and highlight tailored strategies for policy design and communication.

To enhance TMC acceptability, policymakers should prioritize fairness by designing credit allocation systems based on accessibility, incorporating parameters like work flexibility and disabilities. Raising awareness through communication campaigns is critical; these campaigns should highlight the social benefits of TMCs, their rewarding dimension if credits can be monetized, and address concerns about personal freedom. Additionally, integrating pull policies, such as improving public transport affordability and accessibility, can mitigate inequities.

1 Appendix A. Additional description of the sample

2 Table A.17 compares the sample's monthly household disposable income with the
3 yearly disposable income of Dutch households (CBS, 2025e).

Sample's disposable monthly income		Dutch population yearly disposable income	
Less than €2,000	17.60%	Less than €10,000	2.76%
€2,000–€3,500	33.30%	€10,000 – €20,000	6.23%
€3,500–€6,000	35.50%	€20,000 – €30,000	15.25%
€6,000–€8,000	8.50%	€30,000 – €40,000	15.97%
€8,000–€10,000	2.40%	€40,000 – €50,000	12.44%
More than €10,000	2.90%	€50,000 – €100,000	36.63%
		More than €100,000	10.72%

Table A.15: Sample's monthly disposable income

Table A.16: Dutch population's yearly disposable income

Table A.17: Comparison of disposable income: Sample vs. Dutch population

4 Data for the Dutch population (and NH) was retrieved from CBS (CBS, 2024a). Not
5 all travel motives from CBS were used to make the comparison. For work, the category
6 *travel to/from work, (non)-daily commute* and attending *education/course* were summed
7 together. For leisure, the categories *leisure, sports* and *Touring/Walking* were summed. For
8 errands, the categories *Shopping, groceries, funshopping* and *Services/care* were summed.

	Main work			Main leisure			Main errands		
	Sample	NL	NH	Sample	NL	NH	Sample	NL	NH
Walking	7.60%	8.64%	9.43%	18.80%	37.23%	39.56%	24.20%	19.57%	26.43%
Bicycle/E-bike	25.63%	37.27%	39.15%	31.80%	26.28%	27.84%	28.90%	29.13%	33.04%
Public Transport	25.78%	10.45%	16.98%	11.60%	2.92%	5.13%	12.10%	2.60%	2.20%
Carpooling	1.19%	–	–	0.70%	–	–	0.90%	–	–
Private car	39.79%	43.64%	34.43%	37.10%	33.58%	27.47%	34.00%	48.70%	38.33%

Table A.18: Comparing transport mode distribution by trip purpose between the sample and the Dutch population

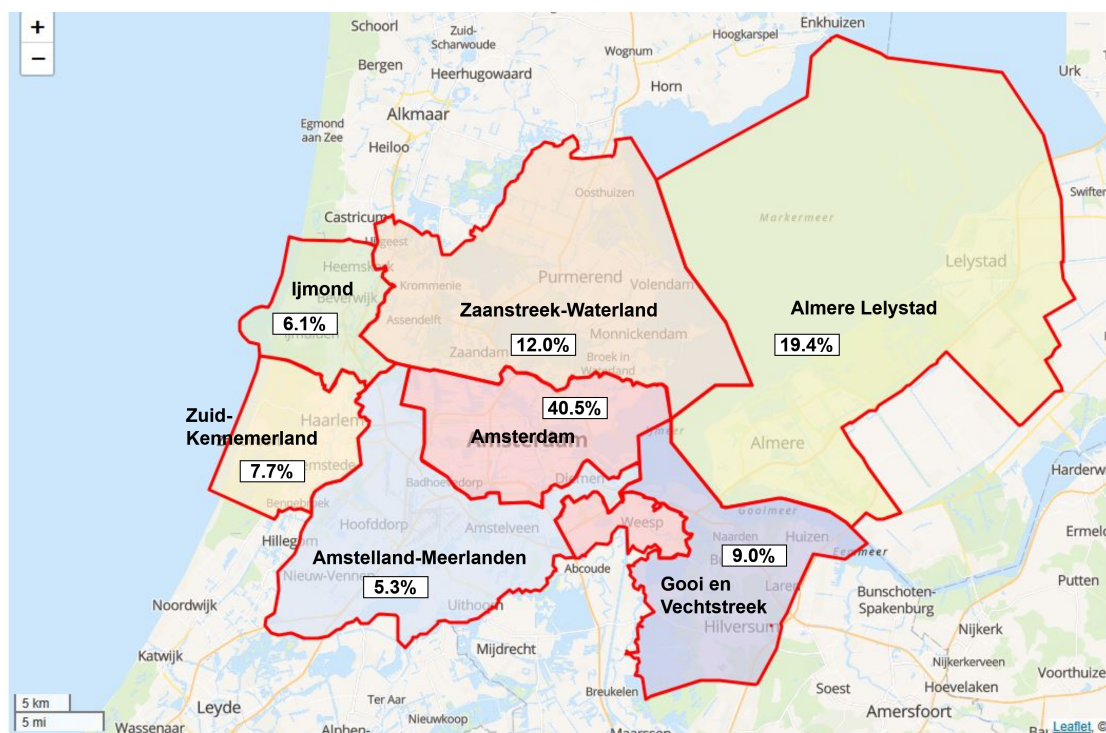


Figure A.6: Geographical distribution of the sample

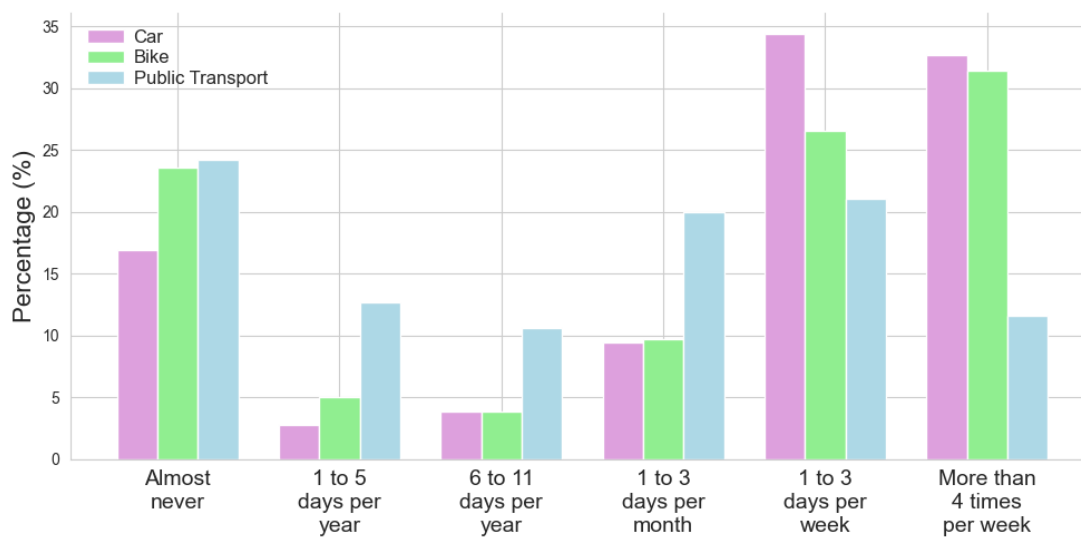


Figure A.7: Sample's main transport use

1 Appendix A.1. Comments from respondents

2 This section provides a short analysis of comments left by some respondents at the end
3 of the survey. These showed that most of the respondents understood the concept of TMC
4 schemes and that they are strongly against it. An important part of the comments focused
5 on individuals with disabilities as this user specificity was not mentioned in the survey
6 when describing the scheme. Respondents with disabilities reported their strong reliance
7 on individual car making a TMC scheme unfair if these were not taken into account: *The*
8 *whole idea creates inequality between people who depend on a car (e.g., due to physical*
9 *limitations) and those who can choose another option.*

10 Moreover, a respondent pointed the importance of work flexibility if TMC would be
11 implemented: *For many workers, it's not possible to work from home. They often still*
12 *depend on their own car or expensive public transport. Not everyone can cycle. Their*
13 *costs are then much higher than office workers, who often have a higher salary and the*
14 *option to work from home. That's unfair..* A respondent also highlighted the issue with
15 individuals working in healthcare as they are bound to travel a lot with an individual car
16 for their job: *I can't possibly work from home because I work in healthcare and deal with*
17 *patients.*

18 Many of the comments were complaints about the actual lack and price of PT services
19 making the scheme unfair to most respondents: *As long as public transport is unreliable,*
20 *trips keep getting canceled, and I can't get to work by public transport, I won't use the*
21 *ridiculously expensive public transport., Don't make it so complicated. It only creates*
22 *more work for agencies that are already understaffed. Make public transport cheaper!!!*
23 *Then everyone can choose their own mode of transport.*

24 Moreover, some respondents also showed frustration as the description of the TMC
25 scheme was very broad and did not provide detailed information about electric cars: *Since*
26 *I drive an electric car, which I charge using solar panels and a battery, I think people in*
27 *similar situations shouldn't need TMCs.*

28 Most comments from respondents showed their strong opposition to TMC:

- 29 • *This regulation sounds fine for someone who doesn't need a car. For someone who*
30 *works and needs a car to be mobile, this is absurd and completely unfeasible. Make*
31 *public transport free!!! Many people would leave their cars at home.*
32 • *Live and let live. Everyone wants freedom, for some it's the car, for others public*

- 1 *transport. There shouldn't be a system behind it, let alone a digital one.*
- 2 • *If you make people who work and need cars pay extra for credits, and let unemployed*
- 3 *people who sit on their lazy asses at home with a beer can sell their unused credits*
- 4 *and get rewarded for staying home, then we're really missing the point.*
- 5 • *What dystopian nonsense this is, emission credits that can be sold or bought. And*
- 6 *then the government decides if I can go somewhere by public transport or if I'm*
- 7 *allowed to drive? Or do I have to cycle or walk everywhere by force? Orwellian*
- 8 *totalitarianism, totally absurd.*
- 9 • *Far too complicated and prone to fraud.*

10 **Appendix B. Results of the Exploratory Factor Analysis**

11 The 16 attitudinal indicators were analysed performing EFA. The Kaiser-Meyer-Olkin

12 (KMO) values computed in SPSS indicated that EFA was suitable for our dataset (0.795).

13 The KMO index indicates the proportion of variance in your variables that might be caused

14 by underlying factors. The Bartlett's Test of Sphericity is significant : $p < 0.001$, indicating

15 that the variables are intercorrelated and thus suitable for factor analysis. This test checks

16 whether the correlation matrix is an identity matrix (no correlations between variables)

17 (Schreiber, 2021).

18 The extraction method of Principal Axis Factoring (PAF) was used combined with the

19 Promax rotation technique. PAF uses the original correlation matrix. The factor loadings

20 are use to estimate new communalities and replace the old ones (Schreiber, 2021). From

21 the communalities table, it can be seen that CAR_1, POL_4, ENV_3, TECH_2, GOV_2,

22 CAR_3 have extraction communalities > 0.5 , thus these variables are strongly represented

23 by the factors. However, GOV_1, POL_2, ENV_2, POL_3, TECH_4, CAR_2, ENV_1

24 have extraction communalities < 0.3 . These variables contribute little to the factor struc-

25 ture.

Items	1	2	3	4
CAR_2	0.038	0.759	0.099	0.002
ENV_2	0.749	-0.019	0.007	-0.015
CAR_1	0.055	0.739	0.018	-0.038
CAR_3	-0.070	0.736	-0.176	0.084
GOV_2	0.730	0.104	-0.077	-0.037
TECH_1	-0.050	-0.034	0.713	0.036
POL_1	0.012	-0.104	0.025	0.707
TECH_3	0.033	0.063	0.696	-0.017
ENV_1	0.618	-0.123	-0.056	0.093
POL_3	-0.047	0.143	0.113	0.550
ENV_3	0.547	0.059	0.115	-0.057
GOV_1	0.476	0.012	-0.067	0.128
POL_2	0.148	0.052	-0.155	0.378
POL_4	0.287	-0.358	-0.104	-0.077
TECH_4	0.347	-0.145	0.275	0.055
TECH_2	0.282	0.325	0.143	-0.039

Table B.19: Results of EFA

Variable	Initial	Extraction
CAR_1	0.492	0.611
POL_4	0.486	0.563
ENV_3	0.287	0.545
TECH_2	0.424	0.538
GOV_2	0.406	0.522
CAR_3	0.331	0.521
POL_1	0.428	0.510
TECH_1	0.307	0.485
TECH_3	0.358	0.450
GOV_1	0.205	0.301
POL_2	0.329	0.296
ENV_2	0.276	0.287
POL_3	0.281	0.285
TECH_4	0.257	0.283
CAR_2	0.195	0.214
ENV_1	0.202	0.178

Table B.20: Communalities for variables in EFA

1 Appendix C. SEM results

2 Appendix C.1. SEM variables

3 Table C.21 presents the sociodemographic and travel behaviour variable that were in-
4 cluded in the model. Most of them were recoded in binary variables. Table 3 provides a
5 short description of the other variables included in the model.

Variable	Description
Sociodemographic	
Age	Ordinal (1: 18–24 to 7: 80+, 10 years increment between each category)
Gender	Binary (0: male, 1: female)
Education level	Ordinal (1: primary education to 6: PhD)
Household composition	Binary (0: without children, 1: with children)
Income level	Ordinal (1: less than €2000 to 6: more than €10,000)
Origin	Binary (0: the Netherlands, 1: Europe and Non-Europe)
Being employed	Binary (0: employed full-time, part-time, and self-employed, 1: the rest)
Being a student	Binary (0: student, 1: the rest)
Being retired	Binary (0: retired, 1: the rest)
MRA	Binary (0: Amsterdam, 1: the rest)
Travel behaviour	
Car ownership	Binary (0: yes, 1: no)
PT subscription	Binary (0: yes, 1: no)
Car use frequency	Binary (0: more than 4 times per week, 1: the rest)
Bike use frequency	Binary (0: more than 4 times per week, 1: the rest)
PT use frequency	Binary (0: more than 4 times per week, 1: the rest)
PT accessibility	Binary (0: yes, 1: no, idk)
Work flexibility	Binary (0: yes, 1: no, idk)
TMC characteristics	effect coded

Table C.21: Description of observed exogenous variables

1 The original employment status variable had 7 distinct levels and was recoded into
 2 three binary variables (employed, student, retired). These binary variables are not mutually
 3 exclusive in their recoding. The coefficients for *Employed* represent the effect of not being
 4 in the Employed group (unemployed, student, retired, other) compared to being full time,
 5 part time, self-employed (73% of the sample). The coefficients for *Retired* represent the
 6 effect of not being retired (employed, unemployed, student) compared to being retired
 7 (15% of the sample). While the coefficients for *Student* represent the effect of not being a
 8 student (employed, unemployed, retired) compared to being a student (3% of the sample).

1 *Appendix C.2. Direct effects of sociodemographic and travel behaviour characteristics on*
2 *attitudes*

	Direct effects on				
	Support social (Lpol)	for policies	Technological familiarity (Ltech)	Environmental responsibility (Lenv_gov)	Car enthusiasm (Lcar)
Sociodemographic					
Gender (female)	0.008		0.016	0.092***	0
Age	-0.098**		0.164***	-0.001	0.004
Income level	-0.19***		0.065**	0.1***	-0.038**
Household (with child)	0.095***		0	0.068**	-0.017
Educational level	-0.149***		0.042*	0.051**	-0.114***
Origin (outside NL)	-0.009		-0.063**	-0.014	-0.042**
MRA (not Amsterdam resident)	-0.122***		-0.045**	-0.109***	0.113***
Retired (no)	-0.106**		0.08**	-0.055	-0.03
Student (no)	0.046		-0.201***	0.065**	-0.045**
Employed (no)	0.106**		-0.102**	0.079**	-0.049*
Travel behaviour					
Car ownership (no)	-0.017		-0.042	0.059**	-0.498***
PT subscription (no)	-0.203***		0.036	-0.203***	0.149***
Car use (less than 4 times per week)	-0.032		-0.093***	0.042*	-0.216***
Bike use (less than 4 times per week)	-0.043*		-0.066**	-0.106***	0.098***
PT use (less than 4 times per week)	0.046*		-0.021	-0.015	-0.025
Work flexibility (no)	-0.04		-0.066**	-0.137**	-0.037**
PT accessibility (no)	-0.056**		-0.028	-0.033*	0.035**

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$.

Table C.22: Direct effects (standardized regression weights) of sociodemographic and travel behaviour characteristics on attitudes

1 *Appendix C.3. Effects of sociodemographic and travel behaviour characteristics on per-*
2 *ceptions and acceptability*

	Direct effects on				Total Effect on
	Fairness	Effectiveness	Freedom	Acceptability	Acceptability
Sociodemographic Variables					
Gender (female)	-0.016	0.006	0.016	-0.002	0.038
Age	-0.132***	-0.132***	-0.008	-0.053***	-0.169
Income level	0.015	-0.02	-0.011	0.049**	0.071
Household (with child)	0.014	0.038**	-0.017	-0.027**	0.032
Educational level	-0.024	-0.04**	-0.042**	-0.035**	-0.044
Origin (outside NL)	-0.019	0.023	-0.005	0.008	0.010
MRA (not Amsterdam resident)	-0.019	0.022	-0.044**	-0.029**	-0.11
Retired (no)	-0.064**	-0.118***	-0.101**	0.003	-0.106
Student (no)	0.018	0.01	0.018	0.034**	0.113
Employed (no)	-0.005	-0.046*	-0.064**	0.013	0.064
Travel behaviour Characteristics					
Car ownership (no)	-0.051**	-0.045*	-0.117***	-0.044**	0.001
PT subscription (no)	-0.044**	-0.022	0.049**	-0.04**	-0.202
Car use (less than 4 times per week)	-0.008	-0.032*	-0.045**	0	0.037
Bike use (less than 4 times per week)	0.011	0.007	0.048**	0.031**	-0.018
PT use (less than 4 times per week)	0.015	0.009	0.019	-0.002	0.012
Work flexibility (no)	-0.032*	0.002	0.012	0.013	-0.056
PT access (no)	-0.004	0.027*	-0.02	-0.004	-0.025

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table C.23: Direct and total effects of Sociodemographic and Travel behaviour characteristics on Perceptions and Acceptability

¹ Appendix C.4. Effects of attitudes on perceptions and acceptability

	Direct effects on				Total Direct Effect on
	Fairness	Effectiveness	Freedom	Acceptability	Acceptability
Support for social policies (Lpol)	0.095**	-0.063*	0.043	0.094***	0.121
Technological familiarity (Ltech)	-0.086***	-0.08***	0.144***	-0.087***	-0.125
Environmental responsibility (Lenv_gov)	0.398***	0.647***	0.066*	0.172***	0.483
Car enthusiasm (Lcar)	-0.096**	-0.025	-0.411***	-0.027	-0.110

Note: *** $p < 0.001$, ** $p < 0.05$, * $p < 0.1$

Table C.24: Direct effects (standardized regression weights) of attitudes on perceptions and acceptability

References

- Aasen, M., Sælen, H., 2022. Right-wing populism and climate policies: Explaining opposition to road tolls in Norway. *Transportation Research Part D: Transport and Environment* 105, 103222. URL: <https://doi.org/10.1016/j.trd.2022.103222>, doi:10.1016/j.trd.2022.103222.
- Abu-Bader, S., Jones, T.V., 2025. Structural equation modeling: Principles, assumptions, and practical application using spss amos. *International Journal of Quantitative and Qualitative Research Methods* 13, 12–31. doi:10.37745/ijqrm.13/vol13n11231.
- Albano, G., Mattas, K., Mourtzouchou, A., Seshadri, R., Nahmias-Biran, B., Azevedo, C.L., Ciuffo, B., 2025. Tradable credit scheme for mobility management: State of the art and comparison of theoretical and experimental research. *Transportation Research Interdisciplinary Perspectives* 33, 101611. doi:10.1016/j.trip.2025.101611.
- Brands, D., Verhoef, E., Knockaert, J., 2021. Pcoins for parking: A field experiment with tradable mobility permits. *SSRN Electronic Journal* doi:10.2139/ssrn.3819842.
- Bristow, A.L., Wardman, M., Zanni, A.M., Chintakayala, P.K., 2010. Public acceptability of personal carbon trading and carbon tax. *Ecological Economics* 69, 1824–1837. URL: <https://doi.org/10.1016/j.ecolecon.2010.04.021>, doi:10.1016/j.ecolecon.2010.04.021.
- CBS, 2024a. Figures: Mobility; per person, modes of travel, purposes of travel and regions. URL: <https://www.cbs.nl/en-gb/figures/detail/84710ENG>. accessed: 2026-06-28.
- CBS, 2024b. The netherlands in numbers 2024: Level of education. URL: <https://longreads.cbs.nl/the-netherlands-in-numbers-2024/what-is-the-level-of-education-in-the-netherlands/>. accessed: 2026-06-10.
- CBS, 2025. Population by origin. URL: <https://www.cbs.nl/en-GB/visualisations/dashboard-population/origin>. accessed: 2026-06-10.

- 1 CBS, 2025a. Dashboard: Men and women in the netherlands. URL: <https://www.cbs.nl/en-gb/visualisations/dashboard-population/men-and-women>. accessed: 2026-06-10.
- 2
- 3
- 4 CBS, 2025b. Household composition. URL: <https://opendata.cbs.nl/#/CBS/en/dataset/82905ENG/table?ts=1781078774000>. accessed: 2026-06-10.
- 5
- 6 CBS, 2025e. Household income. URL: <https://opendata.cbs.nl/#/CBS/nl/dataset/83932NED/table?ts=1652104416359>. accessed: 2026-06-10.
- 7
- 8 CBS, 2025f. Labour participation. URL: <https://opendata.cbs.nl/#/CBS/en/dataset/85264ENG/table?searchKeywords=labour%20participation>.
- 9
- 10 accessed: 2026-06-10.
- 11 CBS, 2025g. Population by age. URL: <https://opendata.cbs.nl/#/CBS/nl/dataset/7461BEV/table?fromstatweb>. accessed: 2026-06-10.
- 12
- 13 CBS, 2026. Number of driving licence holders and car owners
- 14 on the rise. URL: <https://www.cbs.nl/en-gb/news/2026/07/number-of-driving-licence-holders-and-car-owners-on-the-rise>. ac-
- 15
- 16 cessed: 2026-06-10.
- 17 Chen, S., Seshadri, R., Azevedo, C.L., Akkinapally, A.P., Liu, R., Araldo, A., Jiang, Y.,
- 18 Ben-Akiva, M.E., 2023. Market design for tradable mobility credits. *Transportation*
- 19 *Research Part C: Emerging Technologies* 151, 104121. doi:10.1016/j.trc.2023.
- 20 104121.
- 21 ChoiceMetrics, 2024. The Cutting Edge in Experimental Design. ChoiceMetrics. Ngene
- 22 1.4 User Manual.
- 23 Clark, C., Mokhtarian, P.L., Circella, G., Watkins, K., 2021. The role of attitudes in
- 24 perceptions of bicycle facilities: A latent-class regression approach. *Transportation*
- 25 *Research Part F: Traffic Psychology and Behaviour* 77, 129–148. URL: <https://doi.org/10.1016/j.trf.2020.12.006>, doi:10.1016/j.trf.2020.12.006.
- 26

- 1 Cui, S., Tian, L., Xu, Y., Wang, Y., 2024. Measuring acceptance of tradable credit scheme
2 and its effect on behavioral intention through theory of planned behavior. *Transport*
3 *Policy* 150, 174–188. doi:10.1016/j.tranpol.2024.03.009.
- 4 Dogterom, N., Bao, Y., Xu, M., Ettema, D., 2018a. Acceptability of a tradable driving
5 credit scheme in the netherlands and beijing. *Case Studies on Transport Policy* 6, 499–
6 509. doi:10.1016/j.cstp.2018.06.003.
- 7 Dogterom, N., Ettema, D., Dijst, M., 2017. Tradable credits for managing car travel: A
8 review of empirical research and relevant behavioural approaches. *Transport Reviews*
9 37, 322–343. URL: <https://doi.org/10.1080/01441647.2016.1245219>, doi:10.
10 1080/01441647.2016.1245219.
- 11 Dogterom, N., Ettema, D., Dijst, M., 2018b. Behavioural effects of a tradable driving
12 credit scheme: Results of an online stated adaptation experiment in the netherlands.
13 *Transportation Research Part A: Policy and Practice* 107, 52–64. doi:10.1016/j.tra.
14 2017.11.004.
- 15 Earl, T., 2024. State of european transport 2024. URL: [https://www.transportenvironment.org/state-of-european-transport/](https://www.transportenvironment.org/state-of-european-transport/state-of-transport)
16 [https://www.transportenvironment.org/state-of-european-transport/](https://www.transportenvironment.org/state-of-european-transport/state-of-transport)
17 state-of-transport. retrieved December 9, 2025.
- 18 Eriksson, L., Garvill, J., Nordlund, A.M., 2006. Acceptability of travel demand manage-
19 ment measures: The importance of problem awareness, personal norm, freedom, and
20 fairness. *Journal of Environmental Psychology* 26, 15–26. URL: [https://doi.org/](https://doi.org/10.1016/j.jenvp.2006.05.003)
21 10.1016/j.jenvp.2006.05.003, doi:10.1016/j.jenvp.2006.05.003.
- 22 Fan, W., Jiang, X., 2013. Tradable mobility permits in roadway capacity allocation: Re-
23 view and appraisal. *Transport Policy* 30, 132–142. doi:10.1016/j.tranpol.2013.
24 09.002.
- 25 Geng, K., Brands, D.K., Verhoef, E.T., Wang, Y., 2023. The impact of tradable rush hour
26 permits on peak demand: Evidence from an on-campus field experiment. *Transportation*
27 *Research Part D: Transport and Environment* 120, 103775. doi:10.1016/j.trd.2023.
28 103775.

- 1 de Haas, M., Visser, J., Jonkeren, O., Moorman, S., Romijn, G., Faber, R., 2025. Key
2 mobility figures 2024. URL: [https://english.kimnet.nl/documents/2025/03/](https://english.kimnet.nl/documents/2025/03/04/key-mobility-figures-2024)
3 04/key-mobility-figures-2024. accessed: 2026-04-09.
- 4 Hamm, L., Weikl, S., Loder, A., Bogenberger, K., Schatzmann, T., Axhausen, K.,
5 2022. Mobilitycoins—first empirical findings on the user-oriented system design for
6 tradable credit schemes. URL: <https://doi.org/10.3929/ethz-b-000573828>,
7 doi:10.3929/ethz-b-000573828.
- 8 Hamm, L.S., Álvarez-Ossorio Martínez, S., Loder, A., Bogenberger, K., 2025. Who gets
9 what? a user perspective on initial credit allocation in tradable mobility credit schemes.
10 Transport Policy 164, 118–129. doi:10.1016/j.tranpol.2025.01.032.
- 11 Hooper, D., Coughlan, J., Mullen, M., 2008. Structural equation modeling: Guidelines
12 for determining model fit. URL: [https://www.researchgate.net/publication/](https://www.researchgate.net/publication/254742561_Structural_Equation_Modeling_Guidelines_for_Determining_Model_Fit)
13 254742561_Structural_Equation_Modeling_Guidelines_for_Determining_
14 Model_Fit. retrieved 21 April 2026.
- 15 Jaramillo, P., Kahn Ribeiro, S., Newman, P., Dhar, S., Diemuodeke, O., Kajino, T., Lee,
16 D., Nugroho, S., Ou, X., Hammer Strømman, A., Whitehead, J., 2022. Transport, in:
17 Shukla, P., Skea, J., Slade, R., Al Khourdajie, A., van Diemen, R., McCollum, D.,
18 Pathak, M., Some, S., Vyas, P., Fradera, R., Belkacemi, M., Hasija, A., Lisboa, G., Luz,
19 S., Malley, J. (Eds.), Climate Change 2022: Mitigation of Climate Change. Contribution
20 of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel
21 on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY,
22 USA. doi:10.1017/9781009157926.012.
- 23 Kline, R.B., 2016. Principles and Practice of Structural Equation Modeling. Methodology
24 in the Social Sciences, Guilford Press.
- 25 Kockelman, K.M., Kalmanje, S., 2005. Credit-based congestion pricing: A policy pro-
26 posal and the public's response. Transportation Research Part A: Policy and Practice
27 39, 671–690. doi:10.1016/j.tra.2005.02.014.

- 1 Krabbenborg, L., van Langevelde-van Bergen, C., Molin, E., 2021a. Public support for
2 tradable peak credit schemes. *Transportation Research Part A: Policy and Practice* 145,
3 243–259. doi:10.1016/j.tra.2021.01.014.
- 4 Krabbenborg, L., Molin, E., Annema, J.A., van Wee, B., 2021b. Exploring the feasibility of tradable credits for congestion management. *Transportation Planning and Technology* 44, 246–261. URL: <https://doi.org/10.1080/03081060.2021.1883226>,
6 doi:10.1080/03081060.2021.1883226.
- 8 Lessan, J., Fu, L., 2022. Credit- and permit-based travel demand management state-of-the-art methodological advances. *Transportmetrica A: Transport Science* 18, 5–28. doi:10.1080/23249935.2019.1692963.
- 11 Li, M., Zhao, J., 2019. Gaining acceptance by informing the people? public knowledge, attitudes, and acceptance of transportation policies. *Journal of Planning Education and Research* 39, 166–183. URL: <https://doi.org/10.1177/0739456X17732623>,
14 doi:10.1177/0739456X17732623.
- 15 Li, S., Robusté, F., 2021. From urban congestion pricing to tradable mobility credits: A review. *Transportation Research Procedia* 58, 670–677. doi:10.1016/j.trpro.2021.11.088. xIV Conference on Transport Engineering, CIT2021.
- 18 Li, S., Robusté, F., 2025. Tradable mobility credit schemes: Suitable users and their management. *Transportation Planning and Technology* , 1–21doi:10.1080/03081060.2025.2550726.
- 21 Metropoolregio Amsterdam, n.d. About MRA. <https://www.metropoolregioamsterdam.nl/about-mra/>. Accessed: 2026-07-13.
- 23 Millonig, A., Rudloff, C., Richter, G., Lorenz, F., Peer, S., 2022. Fair mobility budgets: A concept for achieving climate neutrality and transport equity. *Transportation Research Part D: Transport and Environment* 103, 103165. doi:10.1016/j.trd.2021.103165.
- 26 Moeinaddini, A., Habibian, M., Zou, Y., Zhang, T., Li, L., 2026. Assessing acceptability of push-pull TDM policy packages: Integrating objective and subjective factors via

- 1 hybrid choice modeling. *Transportation Research Part A: Policy and Practice* 204,
2 104808. URL: <https://doi.org/10.1016/j.tra.2025.104808>, doi:10.1016/j.
3 tra.2025.104808.
- 4 Molin, E., 2005. Causal analysis of hydrogen acceptance. *Transportation Research Record*
5 1941, 115–121. doi:10.3141/1941-14.
- 6 Molin, E.J.E., Marchau, V.A.W.J., 2004. User perceptions and preferences of advanced
7 driver assistance systems. *Transportation Research Record* 1886, 119–125. doi:10.
8 3141/1886-15.
- 9 Provoost, J., Cats, O., Hoogendoorn, S., 2023. Design and classification of tradable mo-
10 bility credit schemes. *Transport Policy* 136, 59–69. doi:10.1016/j.tranpol.2023.
11 03.010.
- 12 Rode, P., 2023. Fairness and the sufficiency turn in urban transport. *Journal of City*
13 *Climate Policy and Economy* 2, 37–54. doi:10.3138/jccpe-2023-0006.
- 14 Schreiber, J.B., 2021. Issues and recommendations for exploratory factor analysis and
15 principal component analysis. *Research in Social and Administrative Pharmacy* 17,
16 1004–1011. URL: <https://doi.org/10.1016/j.sapharm.2020.07.027>, doi:10.
17 1016/j.sapharm.2020.07.027.
- 18 Schöngart, S., Nicholls, Z., Hoffmann, R., Pelz, S., Schleussner, C.F., 2025. High-income
19 groups disproportionately contribute to climate extremes worldwide. *Nature Climate*
20 *Change* 15, 627–633. URL: <https://doi.org/10.1038/s41558-025-02325-x>,
21 doi:10.1038/s41558-025-02325-x.
- 22 Servatius, P., Hamm, L., Loder, A., Bogenberger, K., 2022. Conceptualizing an individual
23 full-trip tradable credit scheme for multi-modal demand and supply management: The
24 mobilitycoin system. *Frontiers in Future Transportation* 3. doi:10.3389/ffutr.2022.
25 914496.
- 26 Servatius, P., Loder, A., Provoost, J., Balzer, L., Cats, O., Leclercq, L., Hoogendoorn, S.,
27 Bogenberger, K., 2023. Trading activity and market liquidity in tradable mobility credit

- 1 schemes. *Transportation Research Interdisciplinary Perspectives* 22, 100970. doi:10.
2 1016/j.trip.2023.100970.
- 3 Sun, X., Feng, S., Lu, J., 2016. Psychological factors influencing the public acceptability
4 of congestion pricing in China. *Transportation Research Part F: Traffic Psychology*
5 *and Behaviour* 41, 104–112. URL: [https://doi.org/10.1016/j.trf.2016.06.](https://doi.org/10.1016/j.trf.2016.06.015)
6 015, doi:10.1016/j.trf.2016.06.015.
- 7 Syrda, J., 2025. Sharing the road: Political ideologies and political party preference as
8 drivers of public transport infrastructure support. *Global Environmental Change* 92,
9 103012. URL: <https://doi.org/10.1016/j.gloenvcha.2025.103012>, doi:10.
10 1016/j.gloenvcha.2025.103012.
- 11 Thaller, A., FleiB, E., Brohmer, H., Köstenbaumer, D., Posch, A., Athenstaedt,
12 U., 2023. When perceived fairness and acceptance go hand in hand—drivers
13 of regulatory and economic policies for low-carbon mobility. *PLOS Cli-*
14 *mate* URL: [https://www.researchgate.net/publication/370683317_](https://www.researchgate.net/publication/370683317_When_perceived_fairness_and_acceptance_go_hand_in_hand-Drivers_of_regulatory_and_economic_policies_for_low-carbon_mobility)
15 [When_perceived_fairness_and_acceptance_go_hand_in_hand-Drivers_](https://www.researchgate.net/publication/370683317_When_perceived_fairness_and_acceptance_go_hand_in_hand-Drivers_of_regulatory_and_economic_policies_for_low-carbon_mobility)
16 [of_regulatory_and_economic_policies_for_low-carbon_mobility,](https://www.researchgate.net/publication/370683317_When_perceived_fairness_and_acceptance_go_hand_in_hand-Drivers_of_regulatory_and_economic_policies_for_low-carbon_mobility)
17 doi:10.1371/journal.pclm.0000157.
- 18 Tian, L., Cui, S., Huang, H., Xu, Y., Wang, Y., 2024. How the norm activation model ex-
19 plains the individuals’ response to tradable credit schemes and reducing car use. *Trans-*
20 *port Policy* 155, 208–223. doi:10.1016/j.tranpol.2024.06.016.
- 21 Tomarken, A.J., Waller, N.G., 2005. Structural equation modeling: Strengths, lim-
22 itations, and misconceptions. *Annual Review of Clinical Psychology* 1, 31–65.
23 URL: <https://doi.org/10.1146/annurev.clinpsy.1.102803.144239>, doi:10.
24 1146/annurev.clinpsy.1.102803.144239.
- 25 van ’t Veer, R., Annema, J.A., Araghi, Y., Homem de Almeida Correia, G., van Wee, B.,
26 2023. Mobility-as-a-service (maas): A latent class cluster analysis to identify dutch
27 vehicle owners’ use intention. *Transportation Research Part A: Policy and Practice* 169,
28 103608. URL: <https://doi.org/10.1016/j.tra.2023.103608>, doi:10.1016/j.
29 tra.2023.103608.

¹ Wadud, Z., 2011. Personal tradable carbon permits for road transport: Why, why not
² and who wins? *Transportation Research Part A: Policy and Practice* 45, 1052–
³ 1065. URL: <https://doi.org/10.1016/j.tra.2010.03.002>, doi:10.1016/j.
⁴ tra.2010.03.002.

B

TMC SCHEMES FROM THE LITERATURE

	Reference	Krabbenborg et al. (2021a)	Kockelman & Kalmanje (2005)	Dogterom et al. (2018a)	Cui et al. (2024) ; Tian et al. (2024)	Brands et al. (2021)	Geng et al. (2023)	Servatius et al., 2022	metaCCAZE (2026)
	TMC scheme	Tradable Peak Credits (TPC)	Credit-Based Congestion Pricing (CBCP)	Tradable Driving Credits (TDC)	TPC	Tradable Parking Permits	TPC	Mobility coins	Umix
Ownership dimension	How are credits allocated ?	uniform OR income based OR employment based OR Origin-Destination based	uniform with possible adjustments	demand based	uniform with possible adjustments	number of working days per week	non uniform	non uniform	origin-destination based
	Who are the eligible users ?	car drivers	car drivers	car drivers	car drivers	workers from a specific company	students	all adult residents in Munich	workers in a specific company
	Credit allocation frequency	weekly OR monthly	monthly	not specified	not specified	weekly	weekly	monthly	monthly
Transfer dimension	Transferability/ Validity of credits	not specified	no transfer of credits between month	not specified	not specified	no transfer of credits between weeks	no transfer of credits between weeks	credits can be transferred between month but expire after one year	not specified
	Market regulation	users cannot buy more credits from the platform than they can use themselves	cashing out or accumulating credits is not allowed	not specified	not specified	a participant could not own more permits than the number of working days that remained that week	number of credits capped at the number of remaining morning peaks in the week	not specified	not specified
Consumption dimension	Credit measurement unit	temporal (peak hour) and spatial (main roads): driving during one peak hour = one credit	temporal and spatial	distance based: one kilometer = one credit	temporal (peak hour) and spatial (main roads): driving during one peak hour = one credit	one parking spot during working hours = one credit	one breakfast during peak hour = one credit	externalities of using transports for every trip	externalities of using transports for every trip
	How is consumption registered ?	not specified	using tolls	users need to record their trip	not specified	automatic license plate registration	when buying breakfast	not specified	GPS tracking

Figure B.1: Characteristics of different TMC schemes

C

SURVEY

Information and consent form

Dear participant,

Thank you for taking the time to complete this survey. This survey explores how people perceive an innovative measure aimed at making daily trips more sustainable. To better understand your perspective, we will ask you about:

- Your background: Basic socio-demographic information
- Your travel habits: How you usually travel and for what purpose
- Your attitudes: Your views and preferences regarding transport and society

The survey will take approximately 10 minutes to complete.

Your participation is anonymous. The data will only be used for research purposes. The survey includes a section at the end where you can share any questions or comments you may have.

Do you consent to these terms ?

- ☐ Yes
- ☐ No

Socio-Demographic

How do you identify your gender ?

- ☐ Male
- ☐ Female
- ☐ Other
- ☐ Prefer not to say

Which age group do you belong to ?

- ☐ 18-24
- ☐ 25 - 34
- ☐ 35 - 44
- ☐ 45 - 54
- ☐ 55 - 64
- ☐ 65 - 79
- ☐ 80 +
- ☐ Prefer not to say

What is your country of origin ?

- ☐ the Netherlands
- ☐ Europe
- ☐ Non Europe

Please specify

Non-Europe

What is the highest level of education you have completed ?

- ☐ Primary education, VMBO, MBO 1
- ☐ Higher general secondary education, VWO, MBO 2-3-4
- ☐ HBO
- ☐ Bachelor's degree
- ☐ Master's degree
- ☐ PhD

What is your living situation ?

- ☐ Single without children
- ☐ Single with children
- ☐ Couple with children
- ☐ Couple without children
- ☐ Other

What is your disposable monthly household income ?

- ☐ Less than €2000
- ☐ €2000 - €3500
- ☐ €3500 - €6000
- ☐ €6000 - €8000
- ☐ €8000 - €10000
- ☐ More than €10000
- ☐ Prefer not to say

Which of the following options best describes your current employment status?

- ☐ Employed full-time
- ☐ Employed part-time
- ☐ Self-Employed
- ☐ Unemployed
- ☐ Student
- ☐ Retired
- ☐ Other

In which part of the Amsterdam metropolitan area do you live in ?

- ☐ Amsterdam
- ☐ Almere-Lelystad
- ☐ Amstelland-Meerlanden
- ☐ IJmond
- ☐ Gooi en Vechstreek
- ☐ Zaanstreek-Waterland
- ☐ Zuid-Kennemerland
- ☐ I do not know

In which part of Amsterdam do you live in ?

- ☐ Amsterdam Centrum
- ☐ Amsterdam Zuid
- ☐ Amsterdam West
- ☐ Amsterdam Oost
- ☐ Amsterdam Noord
- ☐ Amsterdam Westpoort
- ☐ Amsterdam Nieuw-West
- ☐ I do not know

General attitudes 1

General attitudes

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
Driving a car offers many advantages compared to the use of other transport modes.	☐	☐	☐	☐	☐
There is too much government involvement and regulation in society.	☐	☐	☐	☐	☐
I am committed to live a more environmentally friendly lifestyle.	☐	☐	☐	☐	☐
I rely on GPS tracking apps for navigation and location sharing in my daily life.	☐	☐	☐	☐	☐
Government-led initiatives to reduce transport emissions are effective and well-intentioned.	☐	☐	☐	☐	☐
Commercial private enterprises should be transferred to state ownership.	☐	☐	☐	☐	☐

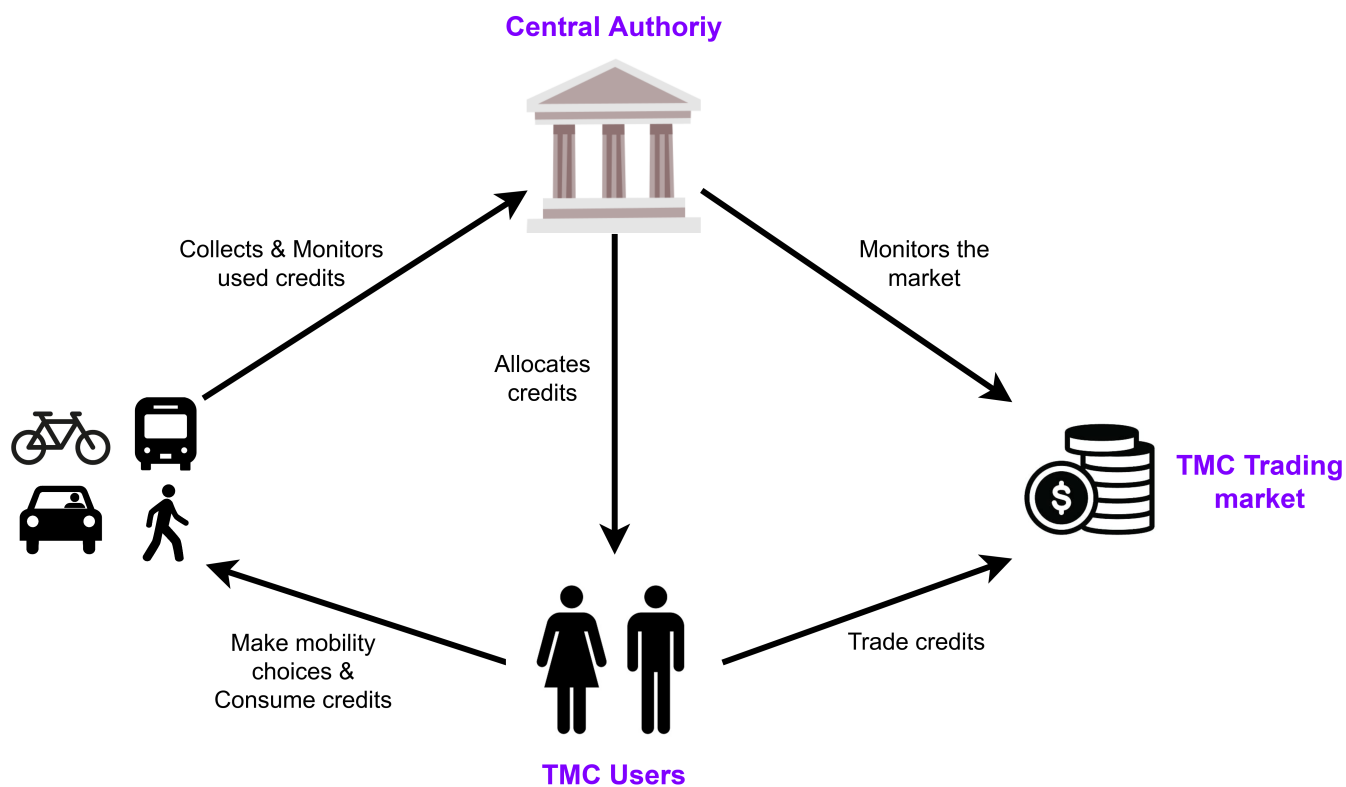
Description of TMC scheme

What are Tradable Mobility Credits (TMC) and how do they work ?

Imagine that **every month**, the government provides each individual a certain number of **free mobility credits**. With these mobility credits, individual **pay for the negative effects of their trips** (congestion, air and noise pollution, space occupation, etc.). Car trips require using more mobility credits than public transport trips. Walking and cycling do not require using mobility credits.

If users do not use all their credits, they **can sell them** on a trading platform and **earn money**. Conversely, if their mobility budget is exhausted before the end of the month, they can **buy additional credits** on the trading platform.

The following figure illustrates the main functioning of a TMC system:



Description of the rating experiment (attributes and their levels)

In the following section, you will be asked to evaluate four different Tradable Mobility Credits (TMC) schemes based on how fair, effective, restrictive to personal freedom, and acceptable you find them. Each scheme varies according to four key characteristics. The table below provides a description of each characteristic. The specific levels will be detailed within the individual schemes.

Characteristics	Definition	Levels
Initial Credit Allocation	How the mobility credits are distributed to users at the beginning of each month.	Uniform 
		Origin-Destination (O-D) 
		Income 
		Accessibility 
Users	Who is eligible or best suited to receive and use mobility credits ?	Vehicle Owners / Drivers 
		Employed people 
		All residents 
Transferability / Validity of credits	What happens to unused credits at the end of a month.	Credits expire 
		Transfer of credits 
		Monetisation of credits 
Trading Market Regulation	Rules defined by the authority in charge that governs how credits can be bought and sold.	Limitation of credits purchase 
		Progressive increase of credit price 
		No limitations 

TMC SCHEME 1

Initial credit allocation	Income based the number of credits varies according to a person's income level (e.g., lower-income individuals may receive more credits)	
Users	All Residents people over 18 living in the urban area	
Transferability / Validity of credits	Monetisation of credits unused credits can be converted into money at the end of the month	
Trading Market regulation	Progressive increase of credit price the cost of buying extra credits increases with each purchase: the more credits you buy the more you pay	

B11 How do you perceive the following scheme ?

Strongly disagree Disagree Neutral Agree Strongly agree
-2 -1 0 1 2

This scheme is fair to me.

This scheme would effectively reduce congestion and air and noise pollution.

This scheme limits my freedom to choose my travel mode.

I feel positive about the implementation of this scheme.

TMC SCHEME 2

Initial credit allocation	Accessibility levels based the number of credits depends on the availability of transportation options in a person's area (e.g., fewer credits if public transport is widely available)	
Users	Vehicle Owners / Drivers people who own or drive vehicles in the urban area: the scheme only applies to people driving an individual or a lease car	
Transferability / Validity of credits	Transfer of credits unused credits can be transferred to the next month: they can be saved for future use (e.g., credits can be saved for a long trip happening in the future)	
Trading Market regulation	Progressive increase of credit price the cost of buying extra credits increases with each purchase: the more credits you buy the more you pay	

B12 How do you perceive the following scheme ?

Strongly disagree Disagree Neutral Agree Strongly agree
-2 -1 0 1 2

This scheme is fair to me.

This scheme would effectively reduce congestion and air and noise pollution.

This scheme limits my freedom to choose my travel mode.

I feel positive about the implementation of this scheme.

TMC SCHEME 3

Initial credit allocation	Uniform everyone receives the same number of credits	
Users	All Residents people over 18 living in the urban area	
Transferability / Validity of credits	Monetisation of credits unused credits can be converted into money at the end of the month	
Trading Market regulation	Limitation of credits purchase user cannot buy unlimited additional credits: they have to respect a certain limit	

B13 How do you perceive the following scheme ?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
	-2	-1	0	1	2	
This scheme is fair to me.						
This scheme would effectively reduce congestion and air and noise pollution.						
This scheme limits my freedom to choose my travel mode.						
I feel positive about the implementation of this scheme.						

TMC SCHEME 4

Initial credit allocation	Uniform everyone receives the same number of credits	
Users	Vehicle Owners / Drivers people who own or drive vehicles in the urban area: the scheme only applies to people driving an individual or a lease car	
Transferability / Validity of credits	Credits expire unused credits that have not been traded on the platform are destroyed at the end of each month: they can not be used the next month	
Trading Market regulation	Limitation of credits purchase user cannot buy unlimited additional credits: they have to respect a certain limit	

B14 How do you perceive the following scheme ?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
	-2	-1	0	1	2	
This scheme is fair to me.						
This scheme would effectively reduce congestion and air and noise pollution.						
This scheme limits my freedom to choose my travel mode.						
I feel positive about the implementation of this scheme.						

General attitudes

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I am familiar with using my smartphone for payments.	☐	☐	☐	☐	☐
It is my obligation to protect the environment through my transportation mode choices.	☐	☐	☐	☐	☐
The government is capable of implementing and conducting a Tradable Mobility Credit scheme.	☐	☐	☐	☐	☐
I am confident that I can manage and trade my credits using my smartphone.	☐	☐	☐	☐	☐
Government should guarantee everyone a job and a decent standard of living.	☐	☐	☐	☐	☐
The car gives me the freedom to go wherever I want.	☐	☐	☐	☐	☐
The environment and future of the planet are at risk due to the use of individual motorised transport.	☐	☐	☐	☐	☐
I am familiar with the installation and use of different apps on my smartphone.	☐	☐	☐	☐	☐
Government should redistribute income from the better-off to those who are less well-off.	☐	☐	☐	☐	☐
I cannot manage without a car.	☐	☐	☐	☐	☐

Travel behaviour and mobility characteristics

Do you have a valid driving licence ?

- ☐ Yes
- ☐ No

Do you own an individual car ?

- ☐ Yes
- ☐ No

Do you have a public transport subscription ?

For example: Studentenreisproduct, NS Flex, RET/HTM/GVB monthly subscription,...

- ☐ Yes
- ☐ No

How often do you use the car ?

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

How often do you use the bike ?

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

How often do you use public transportation ?

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

What is usually your main mode of transportation for commuting ?

Main transportation mode is the mode with which you travel the largest share of the total distance.

- ☐ Walking
- ☐ Bicycle / Electric bike
- ☐ Public Transport
- ☐ Carpooling
- ☐ Private car
- ☐ I do not work/study

What is usually your main mode of transportation for shopping ?

Main transportation mode is the mode with which you travel the largest share of the total distance.

- ☐ Walking
- ☐ Bicycle / Electric bike
- ☐ Public Transport
- ☐ Carpooling
- ☐ Private car

What is usually your main mode of transportation during free time / leisure ?

Main transportation mode is the mode with which you travel the largest share of the total distance.

- ☐ Walking
- ☐ Bicycle / Electric bike
- ☐ Public Transport
- ☐ Carpooling
- ☐ Private car

Do you have any public transport stop (tram/bus/train/metro) within 5 minutes walking distance from your home?

- ☐ Yes
- ☐ No
- ☐ I do not know

Do you currently have access to flexible work arrangements (e.g., remote work, flexible hours, compressed work week)?

- ☐ Yes
- ☐ No
- ☐ Unsure

How many days a week do you work remotely, if any ?

- ☐ 0
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

Comments

Feel free to add any comments

D

SOCIODEMOGRAPHIC AND TRAVEL CHARACTERISTICS OF THE SAMPLE

This chapter provides additional description of the sample.

D.1. SOCIODEMOGRAPHIC

41% of the sample indicated living in Amsterdam, the following table provides more granular information on their living location.

Variables	Items	Entire Sample	MRA = Amsterdam
District in Amsterdam	Centrum	9.20%	22.50%
	Zuid	2.20%	5.50%
	West	6.70%	16.40%
	Oost	8.30%	20.40%
	Noord	5.40%	13.10%
	Westpoort	5.20%	12.80%
	Nieuw-West	0.20%	0.60%
	idk	3.60%	8.80%

Table D.1: Distribution of the sample by district in Amsterdam

Only 2.8% of the sample (25 respondents) had non-European origins.

Variables	Items	Entire Sample	Country of origin = Non-Europe
Non-European regions	Africa	0.40%	13.60%
	North America	0.10%	4.50%
	Central America and Carribean	0.20%	9.10%
	South America	1.00%	36.40%
	Middle East	0.40%	13.60%
	Central Asia	0.00%	0.00%
	South Asia	0.00%	0.00%
	East Asia	0.20%	9.10%
	South-East Asia	0.40%	13.60%
	Oceania	0.00%	0.00%

Table D.2: Distribution of the sample by region for non-European origins

D.2. TRAVEL BEHAVIOUR CHARACTERISTICS OF THE SAMPLE

	Main work			Main leisure			Main errands		
	Sample	NL	NH	Sample	NL	NH	Sample	NL	NH
Walking	7.60%	8.64%	9.43%	18.80%	37.23%	39.56%	24.20%	19.57%	26.43%
Bicycle/E-bike	25.63%	37.27%	39.15%	31.80%	26.28%	27.84%	28.90%	29.13%	33.04%
Public Transport	25.78%	10.45%	16.98%	11.60%	2.92%	5.13%	12.10%	2.60%	2.20%
Carpooling	1.19%	–	–	0.70%	–	–	0.90%	–	–
Private car	39.79%	43.64%	34.43%	37.10%	33.58%	27.47%	34.00%	48.70%	38.33%

Table D.3: Comparing transport mode distribution by trip purpose between the sample and the Dutch population

Data for the Dutch population (and NH) was retrieved from CBS (**cbs2024travelfigure**). Not all travel motives from CBS were used to make the comparison. For work, the category *travel to/from work, (non)-daily commute* and attending *education/course* were summed together. For leisure, the categories *leisure, sports* and *Touring/Walking* were summed. For errands, the categories *Shopping, groceries, funshopping* and *Services/care* were summed.

E

GENERAL ATTITUDES - RESULTS OF CFA AND EFA

E.1. GENERAL ATTITUDES

The following section presents the results of the questions related to attitudes.

Dimension	Item	Question	Mean	Standard Dev
Car	Car_1	Driving a car offers many advantages compared to the use of other transport modes.	0.83	0.967
	Car_2	The car gives me the freedom to go wherever I want.	0.99	0.983
	Car_3	I cannot manage without a car.	0.34	1.312
Trust in the government	Gov_1	The government is capable of implementing and conducting a Tradable Mobility Credit scheme.	-0.11	1.094
	Gov_2	Government-led initiatives to reduce transport emissions are effective and well-intentioned.	0.09	0.994
Environment concern	Env_1	The environment and future of the planet are at risk due to the use of individual motorised transport.	0.12	1.129
	Env_2	It is my obligation to protect the environment through my transportation mode choices.	0.16	1.039
	Env_3	I am committed to live a more environmentally friendly lifestyle.	0.42	0.955
Political views	Pol_1	Government should redistribute income from the better-off to those who are less well-off.	0.35	1.156
	Pol_2	Commercial private enterprises should be transferred to state ownership.	-0.30	1.063
	Pol_3	Government should guarantee everyone a job and a decent standard of living.	0.63	0.988
	Pol_4	There is not enough government involvement and regulation in society.	-0.51	1.031
Technology readiness	Tech_1	I am familiar with the installation and use of different apps on my smartphone.	1.18	0.880
	Tech_2	I rely on GPS tracking apps for navigation and location sharing in my daily life.	0.22	1.185
	Tech_3	I am familiar with using my smartphone for payments.	1.00	1.019
	Tech_4	I am confident that I can manage and trade my credits using my smartphone.	0.34	1.121

Table E.1: Distribution of statements regarding general attitudes

E.2. RESULTS OF THE CONFIRMATORY FACTOR ANALYSIS

CFA was performed using SPSS AMOS to confirm the pre-specified factor structure described in section 3.1.3. Thus, it was assumed that each latent variables (general car attitude, environmental concern, technology adoption, trust in the government and political ideology) load only on their specific factor. A measurement model was defined using the AMOS SPSS software to estimate the factor loadings between each indicator and their latent variable. Table E.2 provides the factor loadings for each construct. The factor loadings for Political Ideology: POL_2, POL_3 and POL_4 as well as the one for Technology adoption TECH_2 and TECH_4 present loadings that are less than [0.5]. Moreover, the results of the model also show that the latent construct trust in the government and environmental concern strongly correlate (0.91), as well as trust in the government and political views (0.66) (see figure E.1).

Moreover, when performing a consistency test using the Cronbach Alpha measure it can be seen that the Cronbach Alpha for three of the latent construct: trust in the government, political views and technology adoption does not meet the widely accepted 0.7 criterion.

These results suggest that a different structure for the latent construct can exist.

Factor	Items	Standardized Loadings	Scale Variance	Cronbach Alpha
Car enthusiasm	CAR_1	0.711	7.319	0.758
	CAR_2	0.828		
	CAR_3	0.654		
Trust in the government	GOV_1	0.534	2.948	0.517
	GOV_2	0.657		
Environment concern	ENV_1	0.702	6.260	0.717
	ENV_2	0.791		
	ENV_3	0.554		
Political views	POL_1	0.703	6.918	0.465
	POL_2	0.446		
	POL_3	0.403		
	POL_4	0.280		
Technology adoption	TECH_1	0.615	7.759	0.564
	TECH_2	0.381		
	TECH_3	0.759		
	TECH_4	0.321		

Table E.2: CFA and Cronbach Alpha results

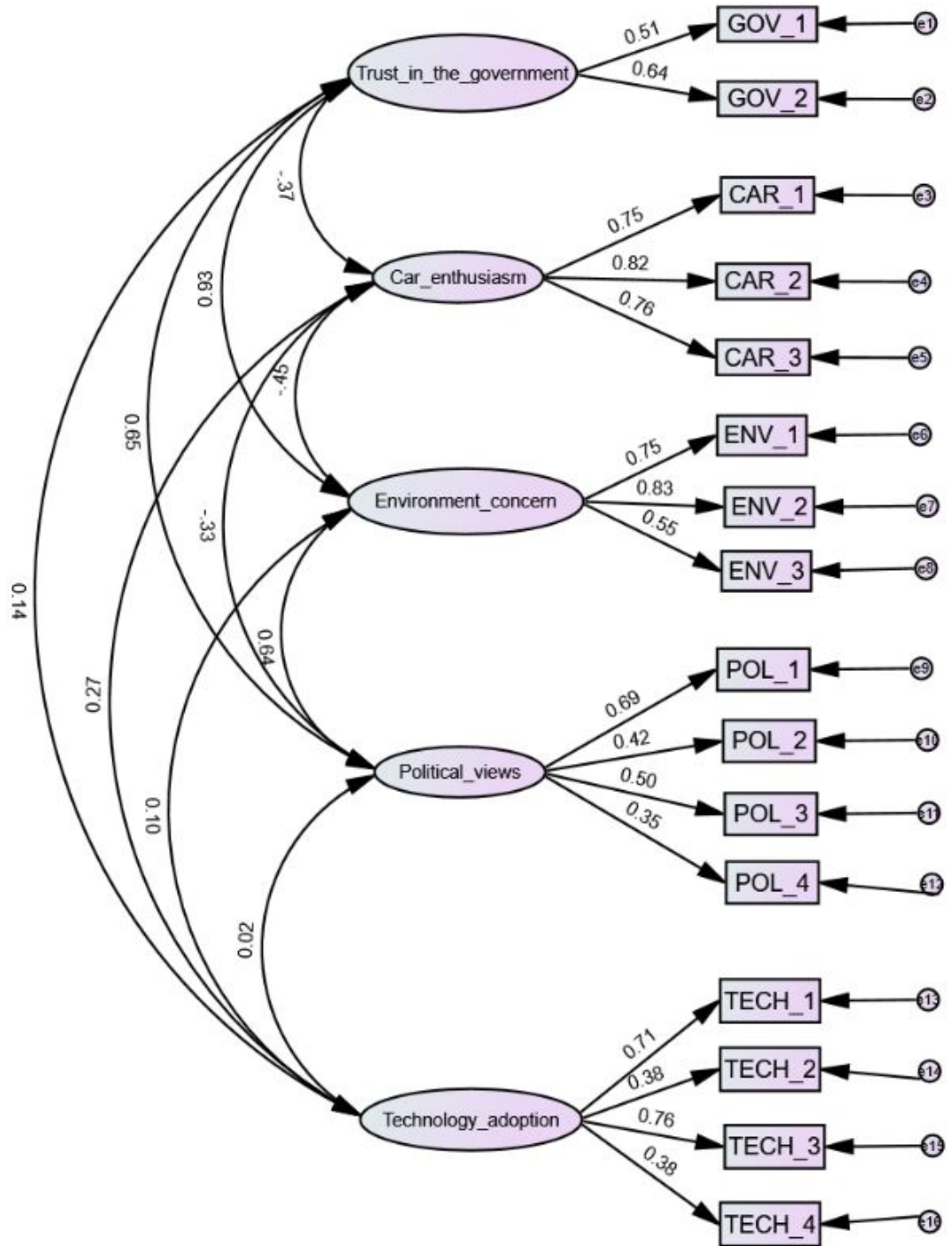


Figure E.1: Results of the CFA using SPSS AMOS

E.3. ADDITIONAL RESULTS OF THE EXPLORATORY FACTOR ANALYSIS

The 16 attitudinal indicators were analysed performing EFA. The Kaiser-Meyer-Olkin (KMO) values computed in SPSS indicated that EFA was suitable for our dataset (0.795). The KMO index indicates the proportion of variance in your variables that might be caused by underlying factors. The Bartlett's Test of Sphericity is significant : $p < 0.001$, indicating that the variables are intercorrelated and thus suitable for factor analysis. This test checks whether the correlation matrix is an identity matrix (no correlations between variables) (Schreiber, 2021).

The extraction method of Principal Axis Factoring (PAF) was used combined with the Promax rotation technique. PAF uses the original correlation matrix. The factor loadings are use to estimate new communalities and replace the old ones (Schreiber, 2021).

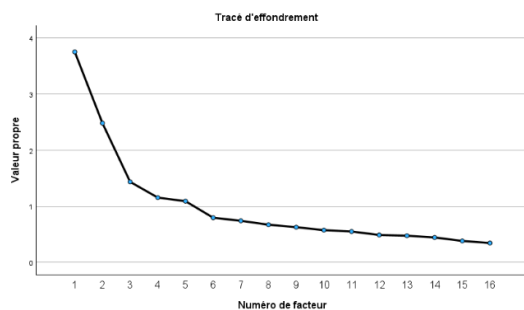


Table E.3: Scree plot of eigenvalues and factor numbers

Variable	Initial	Extraction
CAR_1	0.492	0.611
POL_4	0.486	0.563
ENV_3	0.287	0.545
TECH_2	0.424	0.538
GOV_2	0.406	0.522
CAR_3	0.331	0.521
POL_1	0.428	0.510
TECH_1	0.307	0.485
TECH_3	0.358	0.450
GOV_1	0.205	0.301
POL_2	0.329	0.296
ENV_2	0.276	0.287
POL_3	0.281	0.285
TECH_4	0.257	0.283
CAR_2	0.195	0.214
ENV_1	0.202	0.178

Table E.4: Communalities for variables in EFA

From the communalities table, it can be seen that CAR_1, POL_4, ENV_3, TECH_2, GOV_2, CAR_3 have extraction communalities > 0.5 , thus these variables are strongly represented by the factors. However, GOV_1, POL_2, ENV_2, POL_3, TECH_4, CAR_2, ENV_1 have extraction communalities < 0.3 . These variables contribute little to the factor structure.

The plot E.3 shows that the optimum number of factors is 4.

F

DESCRIPTION OF THE RATINGS OF TMC SCHEMES

F.1. RATING OF THE TMC SCHEMES

(a) Block Frequency and Percentage		
Block	Frequency	Percentage
1	84	10.5
2	94	11.7
3	85	10.6
4	85	10.6
5	90	11.2
6	99	12.3
7	80	10.0
8	97	12.1
9	89	11.1

(b) Frequency and Percentage of TMC Attributes		
TMC character-istics	Attribute	Percentage
Allocation	Uniform	24.4
	OD	24.9
	Income	25.4
	Accessibility	25.3
Recipients	Car own-er/driver	34.0
	Employed	32.4
	Residents	33.7
Transfer	Invalidation	33.5
	Transfer	34.2
	Monetisation	32.2
Regulation	Limitation	34.2
	Increase	32.2
	No	33.6

Table F.1: Block and TMC attribute frequency

Figure F.1 provides the rating legend for the following figures.



Figure F.1: Rating legend

F.1.1. ALLOCATION STRATEGIES

Figure F.2 to F.5 provide a distribution of answers to the rating statements regarding TMC allocation strategies.

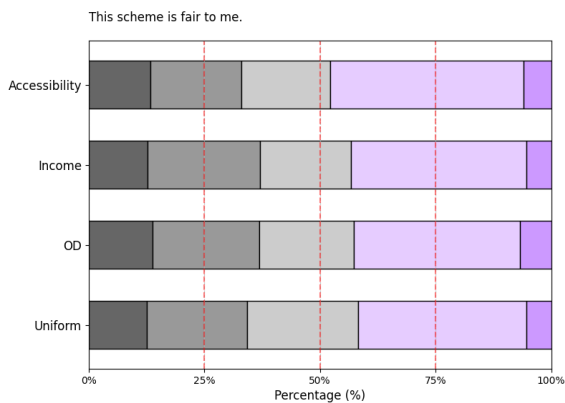


Figure F.2: Perceived fairness

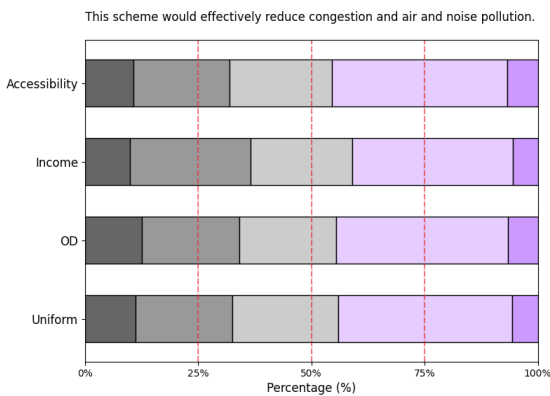


Figure F.3: Perceived effectiveness

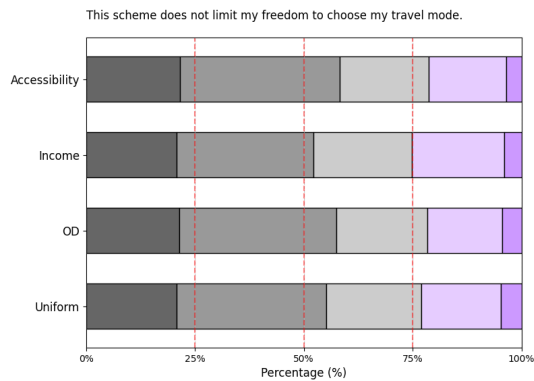


Figure F.4: Perceived freedom

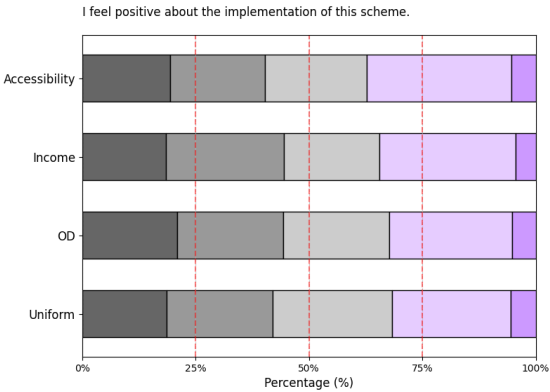


Figure F.5: Acceptability

F.1.2. USER DEFINITIONS

Figure F.6 to F.9 provide a distribution of answers to the rating statements regarding TMC user definition.

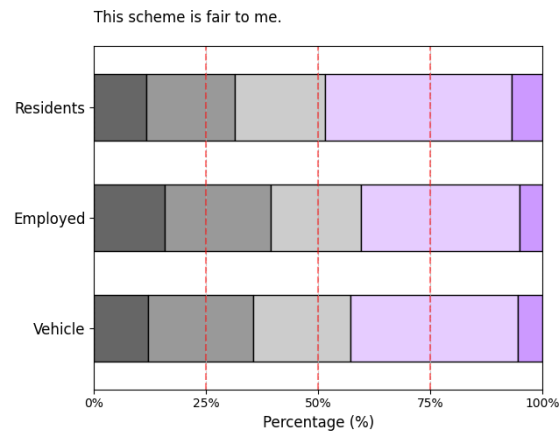


Figure F.6: Perceived fairness

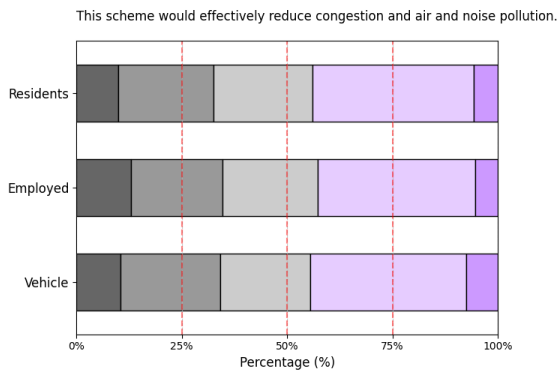


Figure F.7: Perceived effectiveness

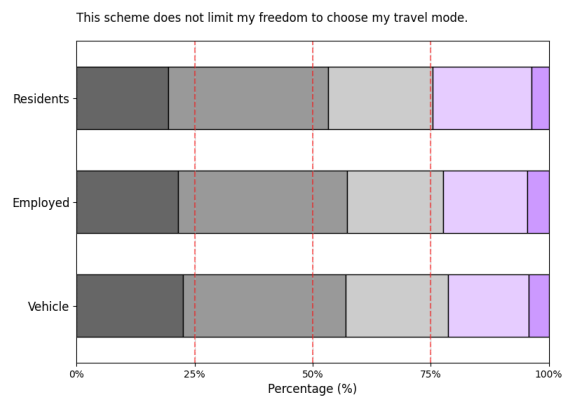


Figure F.8: Perceived freedom

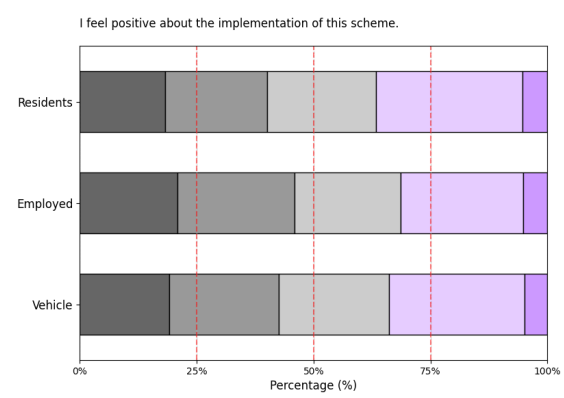


Figure F.9: Acceptability

F.1.3. TRANSFERABILITY AND VALIDITY OF CREDITS

Figure F.10 to F.13 provide a distribution of answers to the rating statements regarding transferability and validity of credits.

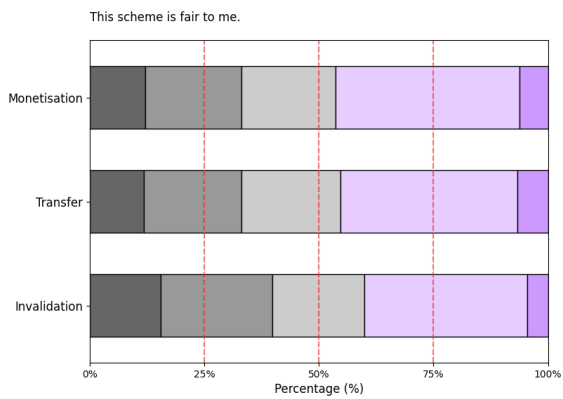


Figure F.10: Perceived fairness

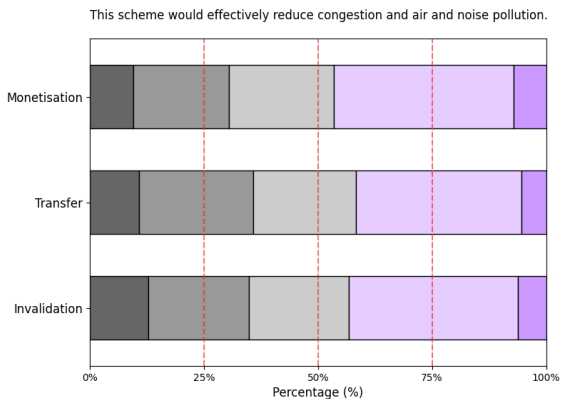


Figure F.11: Perceived effectiveness

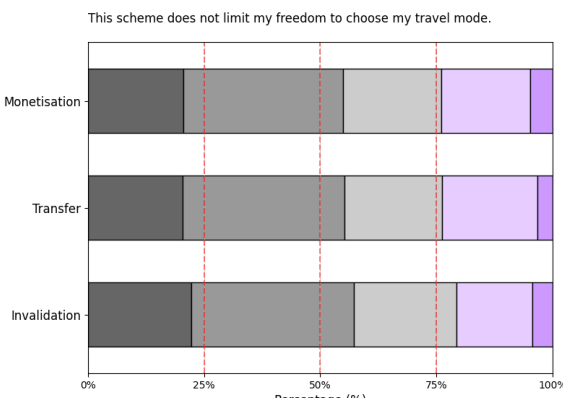


Figure F.12: Perceived freedom

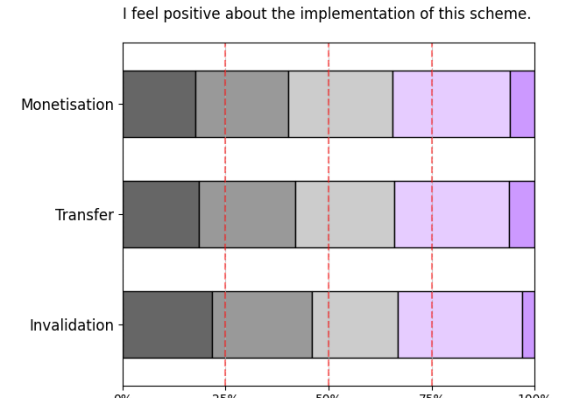


Figure F.13: Acceptability

F.1.4. TRADING MARKET REGULATION

Figure F.14 to F.17 provide a distribution of answers to the rating statements regarding possible trading market regulations.

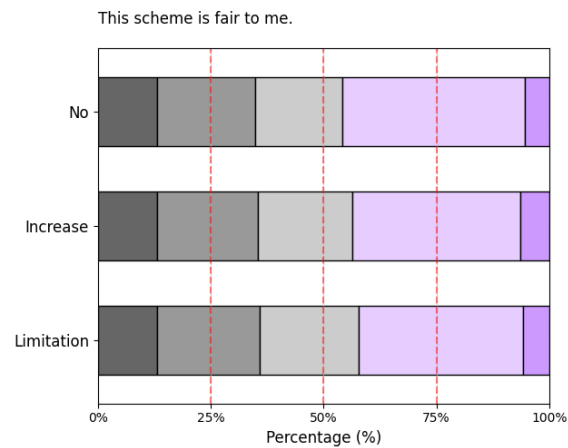


Figure F.14: Perceived fairness

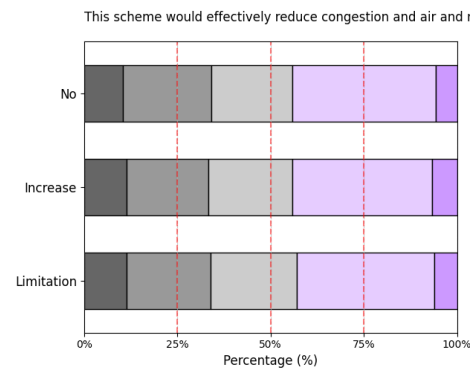


Figure F.15: Perceived effectiveness

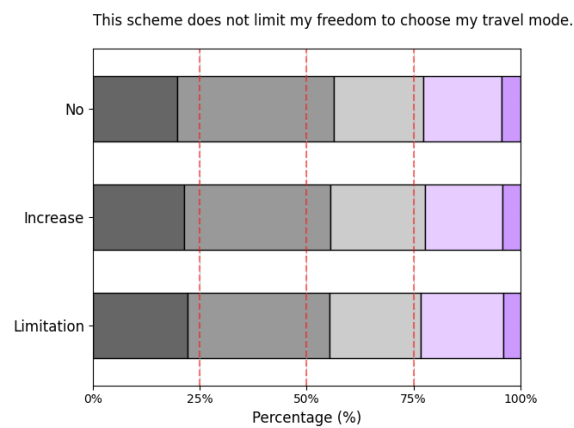


Figure F.16: Perceived freedom

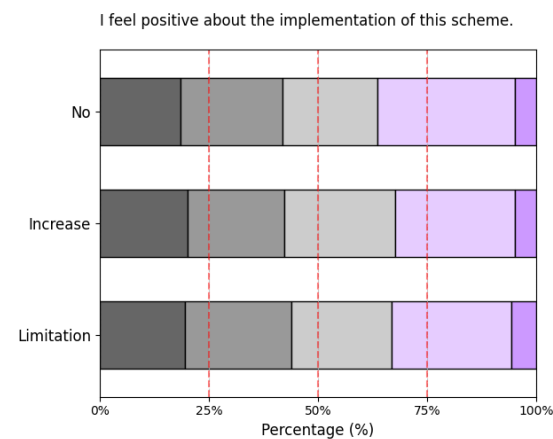


Figure F.17: Acceptability

G

MODEL ESTIMATION USING SPSS AMOS

The following section provides more detailed information on the SEM model and outputs from SPSS AMOS.

G.1. AMOS MODEL

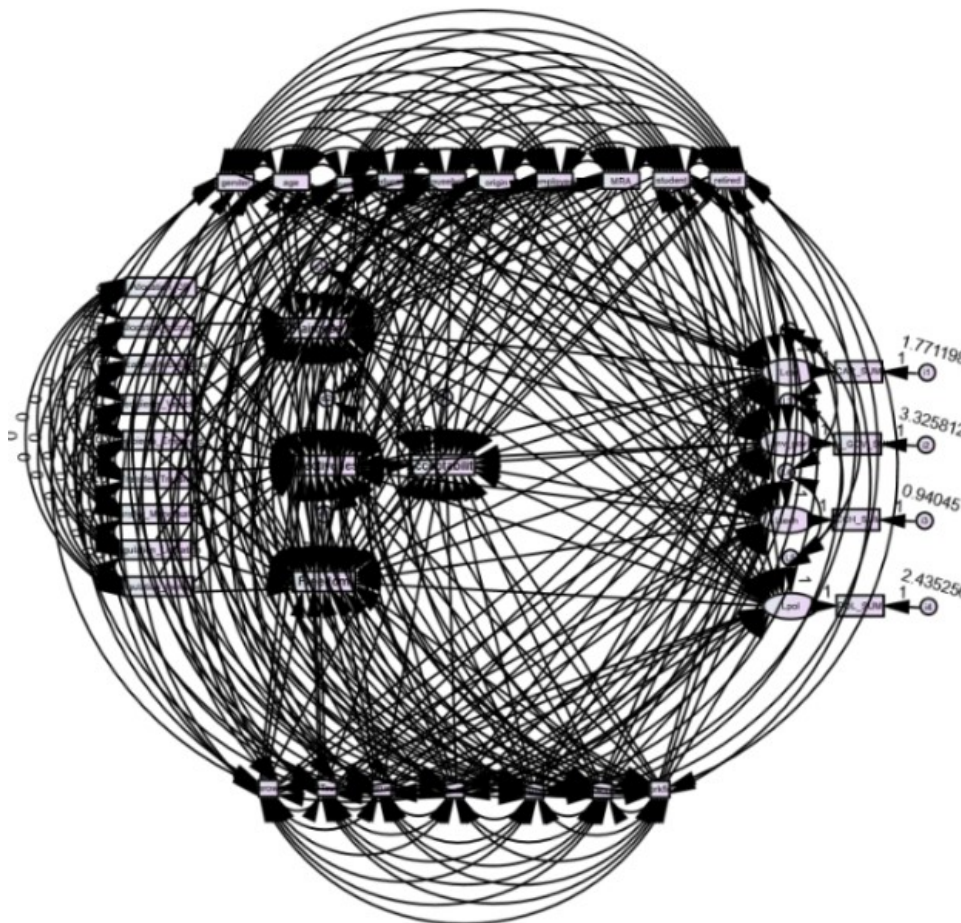


Figure G.1: AMOS model

Figure G.1 represents the final model that was estimated in AMOS. 50 variables (including error terms) were

included in the model. A description of the variables is provided in Table G.1 and G.2. The sociodemographic variables appear at the top of Figure G.1 and the travel behaviour ones at the bottom. They are exogenous (assumed to be independent of others) and do not have any measurement error. The TMC characteristics appear at the left of Figure G.1.

The latent variables for attitudes appear at the right of Figure G.1. Each latent construct identified in EFA (*Lcar*, *Lenv_gov*, *Ltech*, *Lpol*) is only measured by a single indicator variable (respectively *CAR*, *ENV_GOV*, *TECH*, *POL*). Each of these indicator variables have error terms (*i1*, *i2*, *i3*, *i4*) that are fixed in the model. They represent the unreliability of the single indicators used to measure the latent constructs. These measurement error are determined using the Cronbach Alpha of the summated scales. $1 - \text{Cronbach's alpha}$ is an indication of the proportion measurement error of the scale. By multiplying the proportion measurement error with the variance of the sum score (the scale), the variance of the error component of the scale is obtained. The latent construct have error components (*L2*, *L3*, *L4*, *L5*) that correlate as their errors might share variance.

The latent attitude variables (e.g., *Lcar*, *Lenv_gov*, *Lpol*, *Ltech*) are modeled as a function of individual characteristics:

$$\text{Latitude}_i = \beta_0 + \sum_{k=1}^{17} \beta_{1k} \cdot \text{Individual}_k + L_i$$

- Latitude_i : Latent attitude variable.
- β_0 : Intercept for the latent attitude equation.
- β_{1k} : Coefficient for the k -th individual characteristic.
- L_i : Error term (residual) for the latent attitude equation.

Similarly, the three perceptions also have error component (*e1*, *e2*, *e3*) that correlate with one another. These variables are in the middle left part of Figure G.1. Acceptability also has an error term (*e4*). Even if these variables are measured by only one indicator, they are not assumed to be perfectly reliable and have random error.

The perception variables are modeled as a function of individual characteristics, TMC characteristics, and attitudes:

$$\text{Perception}_j = \beta_0 + \sum_{k=1}^{17} \beta_{1k} \cdot \text{Individual}_k + \sum_{m=1}^9 \beta_{2m} \cdot \text{TMC}_m + \sum_{i=1}^4 \beta_{3i} \cdot \text{Attitude}_i + e_j$$

- Perception_j : Perception variable.
- β_0 : Intercept for the perception equation.
- β_{1k} : Coefficient for the k -th individual characteristic.
- Individual_k : Individual characteristics
- β_{2m} : Coefficient for the m -th TMC characteristic.
- TMC_m : TMC characteristics.
- β_{3i} : Coefficient for the i -th attitude.
- Attitude_i : Attitude variables.
- e_j : Error term (residual) for the perception equation.

The acceptability variable is modeled as a function of individual characteristics, attitudes, and perceptions:

$$\text{Acceptability} = \beta_0 + \sum_{k=1}^{17} \beta_{1k} \cdot \text{Individual}_k + \sum_{i=1}^4 \beta_{2i} \cdot \text{Attitude}_i + \sum_{j=1}^3 \beta_{3j} \cdot \text{Perception}_j + e_4$$

- Acceptability: Acceptability variable.
- β_0 : Intercept for the acceptability equation.
- β_{1k} : Coefficient for the k -th individual characteristic.
- Individual_k : Individual characteristics.
- β_{2i} : Coefficient for the i -th attitude.
- Attitude_i : Attitude variables.
- β_{3j} : Coefficient for the j -th perception.
- Perception_j : Perception variables.
- e_4 : Error term (residual) for the acceptability equation.

Variable	Description
Sociodemographic	
Age	Ordinal (1: 18–24 to 7: 80+, 10 years increment between each category)
Gender	Binary (0: male, 1: female)
Education level	Ordinal (1: primary education to 6: PhD)
Household composition	Binary (0: without children, 1: with children)
Income level	Ordinal (1: less than €2000 to 6: more than €10,000)
Origin	Binary (0: the Netherlands, 1: Europe and Non-Europe)
Being employed	Binary (0: employed full-time, part-time, and self-employed, 1: the rest)
Being a student	Binary (0: student, 1: the rest)
Being retired	Binary (0: retired, 1: the rest)
MRA	Binary (0: Amsterdam, 1: the rest)
Travel behaviour	
Car ownership	Binary (0: yes, 1: no)
PT subscription	Binary (0: yes, 1: no)
Car use frequency	Binary (0: more than 4 times per week, 1: the rest)
Bike use frequency	Binary (0: more than 4 times per week, 1: the rest)
PT use frequency	Binary (0: more than 4 times per week, 1: the rest)
PT accessibility	Binary (0: yes, 1: no, idk)
Work flexibility	Binary (0: yes, 1: no, idk)
TMC characteristics	effect coded

Table G.1: Description of observed exogenous variables

Type	Variables	Description
Observed, Endogenous		
	Fairness, effectiveness, freedom, acceptability	Ordinal variables (-2 to +2)
	CAR, ENV_GOV, TECH, POL	Summated ordinal variables
Unobserved, Endogenous		
	Lcar, Lenv_gov, Ltech, Lpol	Latent variables for perceptions
Unobserved, Exogenous		
	e1, e2, e3	Error component of each of the perceptions
	e4	Error component for acceptability
	i1, i2, i3, i4	Error component of the summated scales CAR, ENV_GOV, POL, TECH (fixed in the model)
	L2, L3, L4, L5	Error component of the latent variables (attitudes)

Table G.2: SEM variables and Their Descriptions

G.2. CORRELATIONS BETWEEN VARIABLES IN THE SAMPLE

Table G.3 provides the correlation between all the variables in the model (excluding TMC scheme characteristics). Correlations higher than $|0.3|$ are highlighted in bold. As can be seen in the table most variables do not present strong correlations. The variables Retired, Student and Employed correlate with one another as well as with age and work flexibility. Moreover, the variable employed correlates negatively with income level (-0.3), education level (-0.3) and household composition (-0.3). Positive correlations (0.3) also exist between education level, household composition and income level.

The strong correlation between Retired and Employed (-0.8) and retired and Student (0.4) indicate the high multicollinearity among these variables given that they are not mutually exclusive.

PT subscription positively correlates with PT use and the CAR attitude variable. Car ownership positively correlate with car use (0.4) and negatively with CAR attitude (-0.5). Car use also negatively correlates with CAR attitude (-0.4). Perceived freedom negatively correlates with CAR attitude and positively correlates with Acceptability. Perceived effectiveness positively correlates with perceived fairness (0.6), ENV attitude (0.5) and acceptability (0.6). Perceived fairness also positively correlates with ENV attitudes (0.4) and acceptability (0.7). Moreover the POL attitude (political views) positively correlates with the ENV attitude (0.4) and acceptability (0.3). The ENV attitude negatively correlates with the CAR attitude (-0.3) and positively with acceptability (0.5). Lastly the CAR attitude negatively correlates with acceptability (-0.3).

The negative correlation signs between car use, car ownership and the CAR attitude can look counterintuitive but they are due to the binary coding of the variables. People who do NOT own a car tend to have lower values regarding CAR attitude.

	Retir.	Stud.	Orig.	MRA	Empl.	Inc.	House.	Educ.	Gen.	Age	Car Own.	PT Sub.	Car Use	Bike Use	PT Use	Work Flex	PT Access	Free.	Effect.	Fair.	POL	TECH	ENV GOV	CAR	Accept.
Retired	1.0																								
Student	0.4	1.0																							
Origin	0.0	0.0	1.0																						
MRA	-0.1	0.0	-0.1	1.0																					
Employed	-0.8	-0.3	0.0	0.1	1.0																				
Income	0.1	0.0	0.0	0.0	-0.3	1.0																			
Household	0.3	0.1	0.0	0.0	-0.3	0.3	1.0																		
Education	0.2	-0.1	0.0	-0.1	-0.3	0.3	0.1	1.0																	
Gender	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	1.0																
Age	-0.4	0.3	-0.1	0.1	0.4	-0.1	-0.2	-0.2	-0.1	1.0															
Car Own.	-0.1	-0.2	0.0	-0.2	0.2	-0.3	-0.2	-0.1	0.0	0.0	1.0														
PT Sub.	0.0	0.1	-0.1	0.2	0.1	0.0	0.0	-0.2	0.0	0.2	-0.2	1.0													
Car Use	-0.2	-0.1	0.0	-0.1	0.2	-0.2	-0.2	0.0	0.0	0.1	0.4	-0.2	1.0												
Bike Use	0.0	0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.1	0.0	-0.1	0.1	-0.2	1.0											
PT Use	0.0	0.1	0.0	0.2	0.1	0.1	0.0	0.0	0.0	0.2	-0.2	0.3	-0.1	0.0	1.0										
Work Flex	-0.3	-0.1	-0.1	0.1	0.4	-0.3	-0.2	-0.3	0.0	0.2	0.1	0.2	0.0	0.0	0.1	1.0									
PT Access	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	-0.1	0.0	0.0	0.0	1.0								
Freedom	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.1	0.0	0.0	0.0	-0.1	1.0							
Effect.	0.0	0.0	0.0	-0.1	0.0	0.1	0.1	0.1	0.1	-0.1	0.0	-0.2	0.0	-0.1	-0.1	-0.1	0.0	0.2	1.0						
Fairness	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.1	0.0	-0.1	0.1	-0.2	0.1	0.0	-0.1	-0.1	0.0	0.2	0.6	1.0					
POL SUM	-0.1	0.0	0.0	-0.1	0.1	-0.2	0.0	-0.1	0.0	0.0	0.1	-0.1	0.0	0.0	0.0	0.0	-0.1	0.1	0.2	0.2	1.0				
TECH SUM	0.1	-0.1	-0.1	0.0	-0.1	0.1	0.1	0.1	0.1	0.0	0.0	-0.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0			
ENV GOV	0.0	0.0	0.0	-0.2	0.0	0.1	0.1	0.1	0.1	0.0	0.1	-0.2	0.1	-0.1	-0.1	-0.2	-0.1	0.2	0.5	0.4	0.4	0.1	1.0		
CAR SUM	0.0	0.1	-0.1	0.3	-0.1	0.1	0.1	-0.1	0.0	0.0	-0.5	0.3	-0.4	0.2	0.1	0.0	0.1	-0.3	-0.2	-0.2	-0.1	0.2	-0.3	1.0	
Accept.	0.0	0.0	0.0	-0.2	0.0	0.1	0.0	0.0	0.1	-0.1	0.1	-0.2	0.1	0.0	-0.1	-0.1	-0.1	0.3	0.6	0.7	0.3	-0.1	0.5	-0.3	1.0

Table G.3: Correlations between variables in the sample

G.3. FOCUSING ON THE ERROR TERMS

Correlations between the error terms of the SEM variables defined above provide information about the shared unexplained variance between these variables.

	L2	L3	L4	L5	e1	e2	e3	Error Term	Variance
L2	1.000							L2	2.688
L3	-0.306	1.000						L3	8.96
L4	0.341	0.133	1.000					L4	1.603
L5	-0.084	0.584	0.091	1.000				L5	2.561
e1					1.000			e1	0.961
e2					0.387	1.000		e2	0.778
e3					0.147	0.490	1.000	e3	1.117
								e4	0.565

Figure G.2: Correlations between error terms

Figure G.3: Variances of error terms

Focusing on Table G.2, it can be seen that the strongest positive correlation appears between the error terms of Lenv_gov and Lpol (0.584) suggesting that environmental and policy attitudes are closely linked. The error terms of L_car and Lenv_gov share a moderate negative correlation, they share an inverse unexplained variance that could reflect competing attitudes. There is also a moderate positive correlation between the error terms of Lcar and Ltech.

In Table G.2, it can be seen that correlation between error terms of the perceptions are all positive, suggesting that perceptions may share common unexplained factors. The strongest correlation is between the error term of perceived fairness and effectiveness.

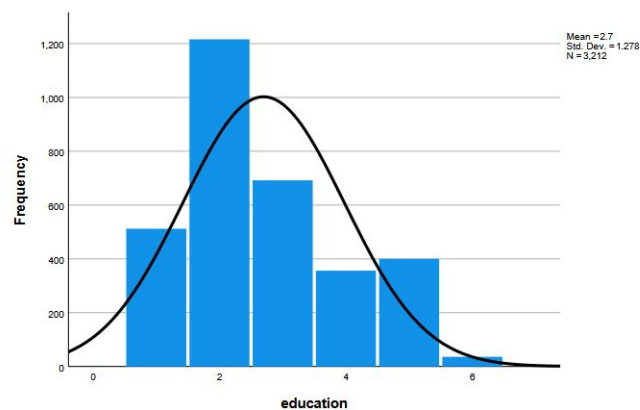
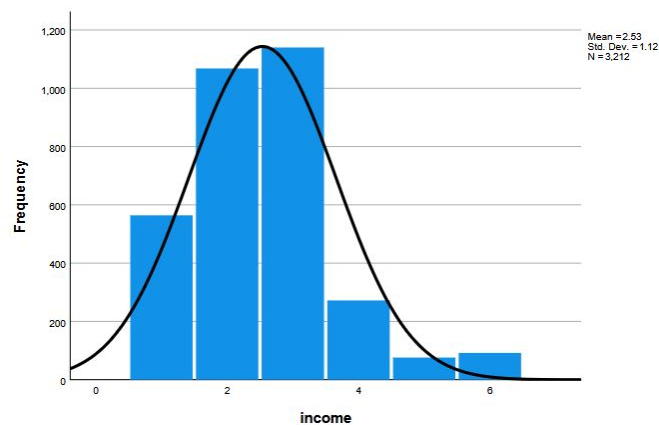
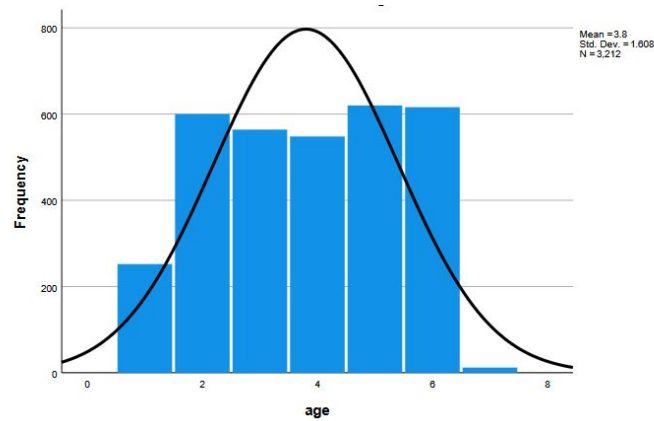
SPSS AMOS also provides the variance of the error terms (see G.3). The variances of L2, L3, L4 and L5 represent the unexplained variance in the latent constructs for the attitudes (Lcar, Lenv_gov, Ltech, Lpol). The highest unexplained variance is for Lenv_gov suggesting that the environmental responsibility is not fully explained by the model. The error variances for the perception variables are relatively low suggesting that these variables

are well explained by the model. Perceived freedom has the highest error variance indicating that it had the most unexplained variance among the perceptions. The error term for acceptability represents its unexplained variance. As it is relatively low it can be deduced that the single indicator for acceptability is fairly reliable.

G.4. SEM VARIABLE DISTRIBUTION

The following are the data distribution histograms of the non binary variables that have been used in the SEM model.

G.4.1. SOCIODEMOGRAPHIC



G.4.2. PERCEPTIONS AND ACCEPTABILITY

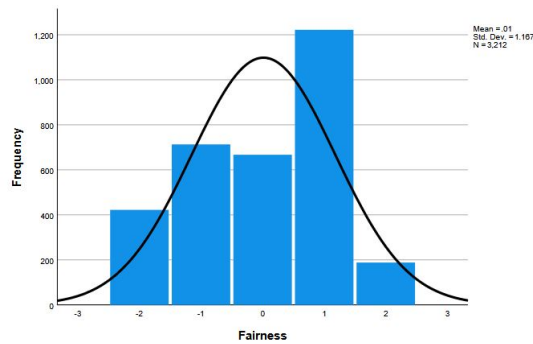


Figure G.4: Fairness

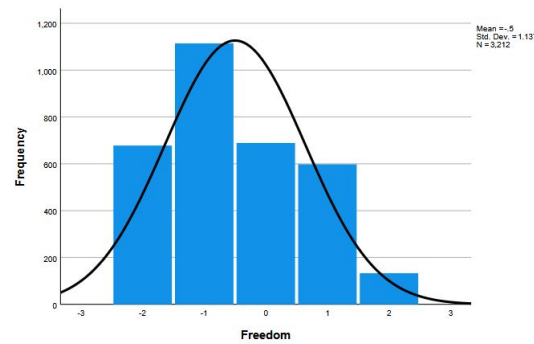


Figure G.5: Freedom

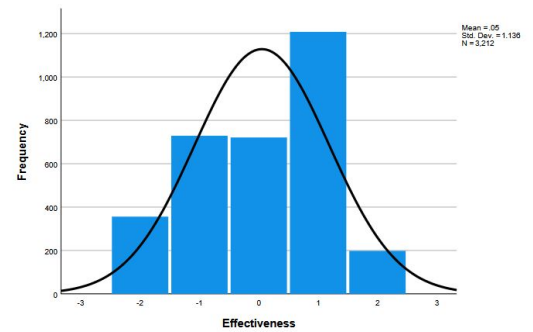


Figure G.6: Effectiveness

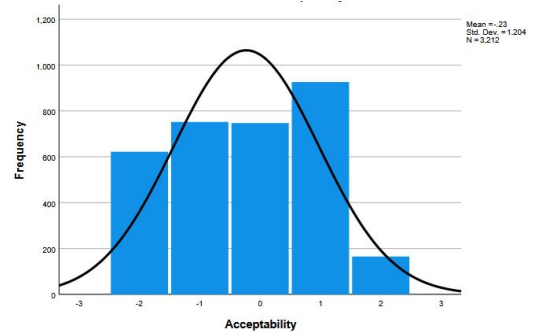
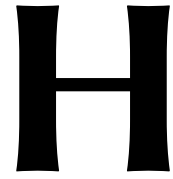


Figure G.7: Acceptability



AI STATEMENT

This thesis was written during the dawn of artificial intelligence (AI). For writing academic research I have used AI. However, I set myself some guidelines and rules at the beginning which I have tried to adhere to throughout the process. First and foremost, AI is a tool. A tool which, I used carefully and efficiently. It allowed me to spend more time on actual research and less on the repetitive tasks.

I used AI for writing code, mainly to clean my survey data, code effect coding of TMC attributes and plot graphs. I also used AI for most of the tasks that involved translating results into LATEXreadable code, mainly for tables. For spelling and grammar checks I put some sections of my thesis and asked AI to summarize my mistakes for me to correct.