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Tradable Credits for Congestion Management: support/reject?

Proefschrift

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Preface

I AM A DOCTOR – Ross Geller

Who could think that a Phoebe would turn into a Ross? Well not me ;)! I've never perceived my PhD journey as a long road, but definitely as a winding one. Especially in the first year: I couldn't see how, when, and if I would reach the end. As the road became clearer, I enjoyed and appreciated the PhD journey, increasingly. Now I see doing a PhD as a true privilege and consider it the most luxurious job, in which the main purpose is personal growth. Luckily the PhD journey was never a lonely one, as there were many people who helped and supported me along the way.

I want to thank my supervisors who have kept this whole process together and without whom, finishing this thesis would not have been possible. Eric, thanks for all the effort and time you have spent on my work, over and over again. Your preference for simplicity has shaped my own style. Your eye for detail was sometimes comforting and sometimes confronting, but it was always valuable. I much relied on your in-depth knowledge about statistics, but also your interest in, and enthusiasm for qualitative research has helped me in conducting this research. Also, I value how our bond of trust has developed over the last four years. I've always felt understood, safe, and heard in your presence. Jan Anne, thanks for being my supervisor, motivational coach, loyal co-attendant at *borrels*, and general partner-in-crime. You've not only guided me with my research, but you also gave me opportunities to develop myself in educational activities. Thanks a lot for your daily invasions of my office, your enthusiasm, and your sense of perspective. It is probably naïve, but I hope to always have a 'Jan Anne' around me in my further career. Bert, you were the one who brought me back to academia when you asked me to take on this position. Thanks for putting so much trust in my abilities and allowing me to make mistakes, which provided me with room to grow. It came as no surprise to me that you recently won the *Leermeester* award. It is amazing how you always see research opportunities. Your youthful enthusiasm for transportation research is contagious, your positive attitude is uplifting, and the loyalty you have towards your students and colleagues is admirable.

Furthermore, I want to thank all the (anonymous) researchers who have read and reviewed my work or otherwise helped me to improve this thesis. I especially want to thank the members of the assessment committee, consisting of prof. Cees van Beers, prof. Marjan Hagenzieker, prof. Dick Ettema and prof. Erik Verhoef, for their time and effort.

I would like to express extra gratitude to Erik Verhoef, who is the leader of the multi-disciplinary consortium which this thesis is part of. I very much appreciate all the time and effort you've spent on the consortium and its members. You've handled this delicate topic with so much care, which shows that you are not only an excellent scientist, but also a great manager. I also want to thank the rest of the U-SMILE consortium. Paul Koster, thanks for your enthusiasm and help with the stated choice experiment. Hadewijch and Ellen, thanks for all the support in these four years. Devi, Nadja, and Boudewijn, it was great to have you as my allies in the consortium.

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The TLO section welcomed me four years ago and I would like to thank all its members, especially Fanchao and Kartika for all the office chats, Andreia for all the (attempts to take) sport classes, and Bing for all the adventures, talks, and care. We have some catching up to do after the lock down. Maarten and Niek for all the laughs about the eye candy and the food baby, respectively. And Betty and Ellen, for always helping and arranging everything so well. I would also like to thank all the students who have helped me with my thesis by taking part in the focus groups, or by reviewing literature. Special thanks to Chris van Langevelde-van Bergen, the co-author of chapter 5. I enjoyed our weekly meetings in which you impressed me with your talents and kindness. I appreciate your great contribution to this thesis very much.

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Tenslotte wil ik mijn familie bedanken. Papa, mama, hoewel de paden die ik heb gekozen jullie onbekend zijn, heb ik me altijd gesteund gevoeld in mijn beslissingen. Maureen en Nori, dank dat jullie grappenmakers er altijd zijn. Door jullie weet ik wat belangrijk is. Maurice, de clichés zijn waar: jij bent mijn rots, mijn *Rachel*. Dank voor je eeuwige rust, zorg en vertrouwen in mij.

Lizet Krabbenborg

Delft, november 2020

Content

Introduction

1.1 Background and aim

Most people agree that congestion is a problem that should be abated, as it threatens the accessibility and liveability of urban areas. However, agreement on how to abate growing levels of car use and the associated environmental and economic damage is quite rare. Expansion on the supply-side (the road capacity) can alleviate congestion but is typically very expensive, not always spatially compatible, and creates room for more car use and emissions. Congestion can also be reduced through measures on the demand-side, encouraging car users to avoid peak hours or to decrease their overall car use. Many transportation researchers, and in particular transportation economists, advocate congestion pricing as an efficient measure to manage car use and reduce its negative effects. The idea of implementing a tax that would correct the negative external costs of car use started a century ago (Knight, 1924; Pigou, 1920) and led to a large body of academic literature and policy documents about road pricing, demonstrating its economic advantages. After decades of research, road pricing policies became reality in a few cities worldwide, including Singapore (in 1998), London (in 2003) and Stockholm (in 2006), demonstrating the technical functionality and positive effects on congestion. Despite the strong theoretical arguments, foreign success stories, and an increase in car-use-related problems, suggestions to implement road pricing typically lead to fierce public debate with many opponents. Since not only technical feasibility and economic benefits, but also public and political support are required for an innovation to become feasible (Feitelson & Salomon, 2004), implemented road pricing schemes are still a rare phenomenon worldwide.

Because of the longstanding issues with public opposition, a substantive share of the literature on road pricing focused on understanding people's support, revealing a large set of relevant variables (see Schade and Schlag (2003) for an overview). All kinds of scheme design characteristics, socio-demographic variables, mobility habits, general beliefs and attitudes, and attitudes towards the policy play a role. The public is divided about road pricing, but recurring reasons raised by opponents include their disbelief in the effectiveness of the policy: 'paying to be stuck in traffic', distrust in the government's use of the revenues: 'it is just another way to raise more taxes', the belief that the policy treats them or others unfairly: 'poor people and blue-collar workers cannot afford it', and the assessment that it will personally hurt them, financially: 'I already pay enough for car use'. Frequent car users, in particular, tend to be negative towards congestion pricing, since it impacts them more than the average citizen (Jaensirisak, Wardman, & May, 2005).

The concept of tradable credits is a drastically different and rather unconventional policy idea for congestion management that can address the above concerns, potentially. The concept can be worked out in many different scheme designs, but in essence it concerns a market-based tool that treats road access during peak hours as a scarce resource. The operator (e.g. the government) decides how many units (e.g. cars) can use the resource (e.g. the road during peak hours) and translates this into individual rights ('credits') for road access. These credits are allocated among the people who can use the credits to access the road during a specified time of day, or they can trade them on a market where the price for a credit is determined by demand and supply. Thus, while the government controls the charge level in a congestion charging scheme, in a tradable credit scheme the government controls the total number of cars which, potentially, makes it very effective. Furthermore, tradable credits do not generate a revenue flow to the government, as the money stays within the group of scheme users. Thus, it may be that people would not consider it to be a form of taxation. Moreover, equity issues can be addressed by freely distributing the credits in a way that meets concerns about fairness. The idea of applying tradable credits to congestion management is more than 20 years old (Verhoef, Nijkamp, & Rietveld, 1997b), but the concept was generally seen as a theoretical approach rather than a serious policy option and did not get much research attention in the first decade that followed. 75% of the 110 documents about tradable credits in transportation research from the period 1997-2020 was published over the last eight years[1]. A possible explanation for this upsurge in literature may be due to the technological developments in online trading and automated vehicle detection, for example, which make the concept of tradable credits more realistic – at least in terms of technical feasibility and system costs.

Most studies on tradable credits for mobility management focus on theoretical explorations, (optimal) scheme design, and behavioural effects (for reviews on these topics, see Dogterom, Ettema, & Dijst, 2017; Fan & Jiang, 2013; Grant-Muller & Xu, 2014, respectively). Whether tradable credits for congestion management is truly a concept that gets more support from the public compared to conventional congestion charging, and hence is a more feasible policy option, is largely unknown. Therefore, **this thesis aims to add to existing knowledge by exploring the feasibility of tradable credits for congestion management, in terms of public support, in particular. From here on we refer to these as Tradable Peak Credits (TPC)**. Knowledge about who supports (or rejects) TPC, and the reasons why, can help policymakers in designing policy schemes and policy processes that have more support, and hence, are more feasible.

[1] This is based on a search in Scopus, on July 17, 2020. With the search string: (TITLE-ABS-KEY (tradable OR tradeable OR marketable) AND TITLE-ABS-KEY (credits OR permits) AND TITLE-ABS-KEY (congestion OR traffic OR (road AND transport)))

Before the conceptualization and research set-up is discussed (1.4), the following sections will first provide background information on tradable credits (1.2) and summarize the knowledge gap in current literature (1.3).

1.2 Tradable Credits

1.2.1 Dealing with externalities

The concept of tradable credits is based on a different economic principle than conventional road pricing. In the 20th century, two approaches to deal with externalities such as road congestion arose: the Pigouvian (Pigou, 1920) and the Coasean (Coase, 1960). In a Pigouvian approach, externalities are seen as market failure that should be corrected for through government interventions. The externalities should be internalized by taxes in which a Pigouvian tax is equal to the marginal external costs. Coase shed a different light on the problem and argued that externalities exist because the property rights over public goods are ill-defined. In other words, it is not the market that fails, but the way it is set up. Dales (1968) built upon Coase's work and explicitly proposed market-based tools by means of tradable property rights. A property right represents the right to use the resource. He argues that if property rights over the use of a resource existed, people would bargain with each other about their use of the resources and in this way achieve the optimal distribution of resources with the lowest social costs, assuming that transaction costs are absent. It would be the market that determined the value of a resource, rather than the regulator, as it is with Pigouvian taxes. Those who value using a right less, have an incentive to sell them to someone who values it more. Both the seller and the buyer benefit from the trade. Montgomery (1972) continued the work and provided theoretical underpinnings by showing that a market with tradable property rights is cost-effective, regardless of how the credits are distributed.

Although the Pigouvian approach of putting a tax on externalities is the dominant approach in many policy fields, the number of policies and studies inspired by the Coasean approach has increased and led to a substantive set of (ideas for) tradable property rights. In this thesis, the concept is referred to as 'tradable credits', but in the literature such systems have also been given names like transferable permits, (personal) quota, cap-and-trade, and tradable property rights.

1.2.2 Tradable credit schemes

Tradable credits can be implemented at the level of industries and firms, or the level of individuals - the end users. The number of tradable credit schemes implemented at the level of firms has rapidly increased over the years. The traditional command-and-control measures often failed to sufficiently protect the value of the resources (Tietenberg, 2003), and this, in combination with the theoretical advantages of cap-and-trade systems, explains this growth. Different tradable credit schemes have been applied to reduce water pollution, regulate logging and forestry, encourage renewable energy, or manage fishery, for example (see Sovacool, 2011). The EU Emission Trading Scheme for greenhouse gasses, in which over 11,000 factories and other installations from 31 countries participate (European Commission, 2015), is probably the best-known example. At the level of citizens, no real-world examples of tradable credit systems exist yet, but ideas for 'personal quota', or 'individual tradable budgets' started in the 1990's. Literature on personal tradable credits can be divided into two streams: tradable credits for environmental purposes, and tradable credits for mobility management.

The idea of placing a cap on citizens' energy use can be traced back to the work of Fleming (1997). He argued that these policies are more durable and efficient than policies at the level of suppliers because ultimately, it is the behaviour of the end users (individuals or households) that cause the production of emissions. The idea received more attention in the UK around 2006-2008, as the government had ambitious carbon reduction goals and asked for an investigation of personal carbon trading (PCT) as potential policy. This led to a set of pre-feasibility (policy) studies on PCT which are summarised in a report from the government's Department for Environment, Food & Rural Affairs (Defra, 2008). They acknowledge that PCT is an interesting way to engage citizens, but conclude that the policy is ahead of its time in terms of public acceptability and technological options to reduce the costs. Meanwhile, academic interest in the topic continued and researchers have kept on working on these challenges and questions raised by Defra (e.g. Al-Guthmy & Yan, 2020; Capstick & Lewis, 2010; Fawcett & Parag, 2010; IPPR, 2009; Niemeier et al., 2008; Seyfang, Lorenzoni, & Nye, 2009; Woerdman & Bolderdijk, 2017).

Ideas to use the cap-and-trade principle to manage car use developed in the same period. In transportation research, the tradable credit schemes are more diverse since they can serve multiple policy aims. Some of the mobility schemes discussed aim for emission reduction in the first place, just like PCT. Goddard (1997) proposed tradable driving day rights (TDDR) as a way to efficiently mitigate the emission problems in Mexico City. He argues TDDR is a more flexible and efficient tool than the restricting license plate policies and a more politically feasible tool than environmental taxes. Verhoef et al. (1997b), Raux and Marlot (2005), and Aziz, Ukkusuri, and Romero (2015) proposed schemes in which credits are needed to buy fuel, in order to abate car emissions. Other schemes focus on restricting overall car use in terms of vehicle miles (or kilometres) travelled (Dogterom, 2017; Xu & Grant-Muller, 2016; Yang & Wang, 2011). Schemes that focus on congestion reduction at specific locations and times were explored by Verhoef et al. (1997b), Buitelaar, van der Heijden, and Argiolu (2007), and Akamatsu (2007). Also Kockelman and Kalmanje (2005) and Bagloee and Sarvi (2017) worked on schemes as an alternative to congestion pricing, but they thought of schemes in which the trading component is substituted by a personal budget. More recently, tradable parking credits have also been topic of study (Brands, Verhoef, Knockaert, & Koster, 2020).

1.2.3 Tradable credits versus conventional charges in mobility management

Tradable credit schemes do not only differ from each other in which policy aims they serve, but also in other aspects, such as the definition of the 'traders', the proposed credit allocation, the spatial scope of the scheme, trading rules, such as the validity of the credits, and so on (see Fan and Jiang (2013) and Santos, Behrendt, Maconi, Shirvani, and Teytelboym (2010) for overviews of scheme design characteristics). Nonetheless, the following general advantages and disadvantages are subscribed to tradable credit schemes and have been studied in existing literature.

Advocates of tradable credit schemes argue that the approach is potentially effective, efficient and fair. Hence, it is expected that tradable credit schemes can count on stronger support compared to equivalent tax schemes. Effectiveness relates to the degree to which a scheme is successful in achieving the desired outcome, whereas efficiency relates to the extent that a system can achieve maximum outcome, with minimum wasted costs. In the case of tradable credits, the effectiveness is theoretically very high due to the firm limit on the resource - the 'cap'. The regulator of the scheme has direct control over the number of credits and therewith the total use of the resource, which can be seen as a major advantage according to Cropper and Oates (1992). A tax scheme, on the other hand, cannot necessarily guarantee that the desired outcome will be achieved. For a Pigouvian tax scheme to be fully effective, full knowledge is required about the price elasticity structures of road users. In practice, these price elasticity structures are not well known beforehand, which leads to suboptimal prices. Tradable credits are also cost-efficient in theory because the goal is reached through a market in which demand and supply determine the price of a credit. In other words, the person who attaches the highest value to using the road, will buy the credit from the person who attaches the least value to the resource. The effectiveness and efficiency of tradable credit schemes are being studied and compared to pricing schemes with optimization and mathematical programming approaches (e.g. Chen, Li, Lam, & Choi, 2016; Gao & Hu, 2015; Gao, Sun, Wu, Liu, & Chen, 2018; Han & Cheng, 2016; Liu, Yang, Yin, & Zhang, 2014). Later, empirical behavioural studies also followed which demonstrated that people indeed react to the price signals in a rational way and behave as anticipated in the models, which suggest a substantial reduction in car use (Brands et al., 2020; Dogterom, Ettema, & Dijst, 2018).

A scheme is considered to be fair when it meets a normative standard of fairness. Concerns about fairness in connection to road pricing usually relate to the distribution of costs and benefits, because people are afraid that a road pricing scheme hurts certain groups, disproportionally. A tradable credit scheme has the characteristic that its cost-efficiency is not affected by the credit distribution (Montgomery, 1972). This provides the operator with the option to reach a certain desired distributional outcome in a very flexible manner. For example, operators can give a larger share of credits to people with a lower income, or to those with a critical profession if that meets the normative standard. In that way, a tradable credit scheme can directly address the public's concerns about equity. More importantly, by distributing the initial credits for free, instead of selling them via an auction, the flow of money stays within the group of users and does not flow towards the operator (usually the government). Thus, it may be that the public would not consider tradable credits to be a form of taxation. Different credit allocation strategies and their impact on social welfare have been analysed (Wadud, 2011; Wadud, Noland, & Graham, 2008) and optimisation models showed that tradable credit schemes are more suitable for obtaining more equitable and progressive distributional outcomes (Di Wu, Yin, Lawphongpanich, & Yang, 2012). Also, some empirical studies on whether people really perceive personal tradable credits as a fairer and/or acceptable policy have been done. See Figure 1 for an overview of the schemes studied, which is also used in Chapter 1. Studies on personal carbon trading (PCT) showed positive results with support levels ranging around 40% (Wallace, Irvine, Wright, & Fleming, 2010), reaching up to 80% depending on the exact scheme design (Bristow, Wardman, Zanni, & Chintakayala, 2010). Support for tradable carbon permits is higher than support for an equivalent carbon tax, in these studies. However, support for tradable credits in mobility management may be lower since people in a carbon trading scheme have more options to reduce their carbon emissions, other than changing travel behaviour. Regarding tradable credits that aim to reduce overall kilometres driven by car, Dogterom, Bao, Xu, and Ettema (2018) found that 22% of Dutch car users and 67% of Beijing car users find a tradable kilometre credit scheme (TDC) acceptable. Whereas Harwatt, Tight, Bristow, and Gühnemann (2011) found in an interview study that people are considerably more supportive towards a tradable carbon scheme for car use than to an equivalent fuel price increase. Kockelman and Kalmanje (2005) measured public support for a (non-tradable) scheme (CBCP) that focuses on congestion reduction, and they found that 25% of respondents in Texas is supportive of the system, which they consider to be a substantial number given the total unfamiliarity of the system. These studies on support for credit schemes for mobility management show diverse results. This is not that surprising since support may heavily depend on the exact scheme design, as Bristow et al. (2010) showed in their study on carbon trading. In particular, the way in which the credits are distributed is expected to affect support since it directly influences the distribution of costs and benefits. The type of credit distribution that citizens prefer for credits in mobility management has not been thoroughly studied yet, although Vanoutrive and Zijlstra (2018) did an interesting survey by confronting transportation professionals with dilemmas on the question of: 'who has the (most) right to travel during peak hours?'. They report that many of the respondents found it difficult to answer these questions.

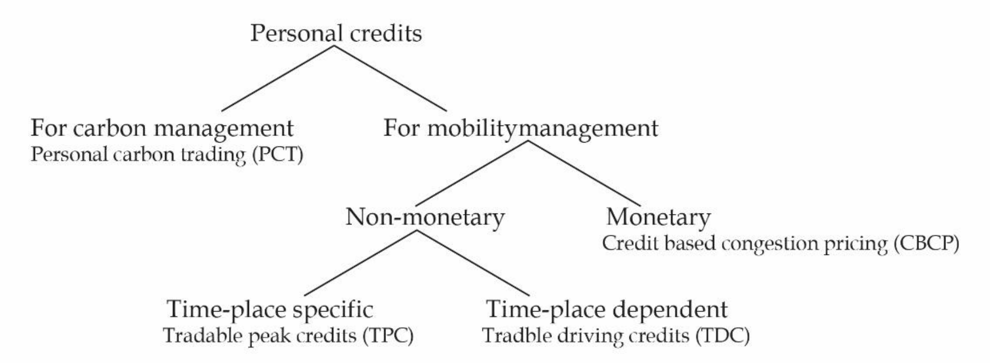

Figure 1 An overview of personal tradable credits that have been empirically studied in the light of public support

On the other hand, tradable credit schemes also have characteristics that are potential disadvantages compared to a Pigouvian congestion charge. First of all, a tradable credit scheme is rather complex in its set-up and monitoring since it needs an (online) market where people can buy and sell their credits. This may lead to higher administration and monitoring costs compared to an equivalent congestion charge. Also, the transaction costs for the users (the time and 'effort' needed for trading) are seen as a potential risk (Wadud, 2011; Woerdman & Bolderdijk, 2017). In the past, real world applications of tradable credit schemes at a level of companies had rather high costs associated with monitoring and credit trading (Sovacool, 2011). If the costs are, indeed, considerably higher, it negates the cost-efficiency of the tradable credit policy. Nevertheless, (future) technological advancements in online trading mechanisms and automated vehicle detection, for example, may considerably lower these costs. Furthermore, many of the real-world applications of schemes for firms also showed a rather higher volatility of the credit price, as unexpected changes in weather, for example, prompted a steep drop in sulphur dioxide credit prices (Sovacool, 2011). In the case of tradable credits for mobility management, volatile prices may weaken public support since people have a strong preference for simple price signals when it comes to road pricing (Bonsall, Shires, Maule, Matthews, & Beale, 2007), and this may lead to less rational and efficient trading behaviour. However, an explorative empirical experiment with tradable parking credits showed that credit prices stayed within the expected boundaries of 2-3 Euros, and participants traded in a rational manner (Brands et al., 2020). Lastly, Sovacool (2011) warns that, as with all policy proposals, tradable credit schemes can become less efficient due to political compromises in system design. In road pricing policies there is usually a balance to be found between public support and efficiency. Generally, more efficient schemes are more complex and differentiated, whereas people prefer simpler schemes. If tradable credit schemes for mobility management have to be simplified to gain support, to an extent that its efficient properties are undermined, the motivation to implement the concept no longer holds.

1.3 Knowledge gaps

As the previous section showed, the attention paid to tradable credits as an alternative for congestion management has steadily grown, especially in the last decade. The general reasons for researchers to study tradable credits lie in the notion that tradable credits schemes are efficient schemes that have the potential to address the equity concerns associated with regular congestion charging, and hence they can count on more public support. The effectiveness, efficiency and equity impacts of tradable credit schemes have been studied to some extent. The first studies analysed the concept in a theoretical way. Later, studies followed that used programming and optimization approaches to study the schemes and their impacts on traffic flows from a mathematical perspective. More recently, empirical studies have followed that have shown that people behave under a tradable scheme in an expected way. For literature overviews on scheme designs, theoretical reflections and behavioural studies, see Dogterom et al., 2017; Fan & Jiang, 2013; Grant-Muller & Xu, 2014, respectively.

However, the literature on public support for tradable credits for congestion management still remains remarkably scarce. The few studies on support for related tradable credit schemes showed rather diverse results and these may not hold for tradable credits for congestion management specifically. Thus, whether the concept can really count on more support among the public, and hence is more feasible compared to conventional pricing instruments, is still rather unclear. The studies in mobility management focused on the support for a fixed scheme design, while support may heavily depend on the exact scheme design as Bristow et al. (2010) showed with carbon trading schemes. The distribution of the credits, in particular, is theorized in the literature as an important feature that can be used to influence and improve support. However, public preferences for scheme designs and credit distributions and their influence on support have not been studied empirically. Furthermore, studies on support for tradable credits for mobility management, and of road pricing in general, often focus on variables. These studies measure the support for a certain scheme, express support on an aggregated level, and include all kinds of socio-economic and attitudinal variables in a model to explain the relation between this and the support (e.g. Börjesson, Hamilton, Näsman, & Papaix, 2015; Kim, Schmöcker, Fujii, & Noland, 2013; Sun, Feng, & Lu, 2016). This variable-based approach gives valuable insights into the role of different factors, but it also entails the risk of missing out information about the heterogeneity of the public. Indeed, when it comes to instruments like road pricing, the public is typically very heterogeneous in its opinions, attitudes and feelings. Especially when comparing support for different instruments (conventional road pricing versus tradable credits), it makes sense to try to understand which (categories of) people reject TPC but accept road pricing (or vice versa), and for what reasons. Also, the studies on tradable credits in mobility management studied support in a quantitative way using surveys and conventional road pricing literature to select the variables to be measured in the survey. It is indeed likely that many of these variables, such as perceived fairness and infringement on freedom, that play a role in road pricing support, also play a role in TPC support. However, it may also be that different kinds of factors, attitudes and feelings play a role when it comes to TPC. A more open approach that explores whether new variables play a role regarding TPC support seems to be missing. Lastly, public support is an important requisite for a policy to be feasible, but it is not sufficient for a policy to become feasible. The feasibility of tradable credit schemes for mobility management has been theoretically analysed by mainly economists in a small string of literature and some potential problems for implementation of such a policy have been identified. A broader view on the feasibility of TPC, also with insights from different perspectives, including psychological and behavioural perspectives, seems to be missing.

In short, academic proof of the theoretical advantages and disadvantages, the cost-efficiency, optimal scheme design, and behavioural responses of tradable credits for congestion management is expanding. But whether Tradable Peak Credits (TPC) really is a concept that is more accepted by the wider public, and hence is a more feasible instrument than conventional charging schemes, remains largely unknown.

1.4 Research set-up

The main aim is split into five sub-questions. First an initial conceptual framework is presented in 1.4.1. The sub-questions and the main methods that were used to answer the sub-questions are summarized in section 1.4.2. More details about the methods are provided in the individual chapters. Lastly, the context in which this research takes place in described in 1.4.3.

1.4.1 Conceptualization

This thesis is approached from a conceptual framework that is based upon the political-economic framework of Feitelson and Salomon (2004), inspired by the work of Vonk Noordegraaf, Annema, and van de Riet (2012), supplemented with existing road pricing literature, and adjusted to the situation of tradable credits for congestion management.

Feitelson and Salomon (2004) explain that before an innovation can be adopted in practice, it needs to work, i.e. it needs to be technically feasible. Also, the economic benefits need to exceed the economic costs, which is referred to as economic feasibility. But economic and technical feasibility are not sufficient, as the innovation also needs to be supported by sufficient politicians and the public. An innovation can be considered ‘socially feasible’ when a majority of the public is likely to support the innovation. In the case of road pricing, public support is related to all different kinds of factors. First of all, the scheme design itself can influence support (Schuitema & Steg, 2008; Ubbels & Verhoef, 2006). Secondly, all kinds of individual factors have been shown to play a role. These can be distinguished in socio-economic variables such as income and residential variables (Jaensirisak et al., 2005; Rienstra, Rietveld, & Verhoef, 1999), mobility habits, such as the frequency of car use (Gaunt, Rye, & Allen, 2007), general beliefs and attitudes, such as environmental concerns (Schuitema, Steg, & van Kruining, 2011) and trust in the government (Eliasson, 2016), and evaluations of the policy, such as expected effectiveness and perceived fairness (Gärling, Jakobsson, Loukopoulos, & Fujii, 2008; Jaensirisak et al., 2005; Schade & Schlag, 2003a). Thirdly, external variables can play a role. Public perceptions are influenced by the ‘sanctioned discourse’, which is the set of dominant ideologies of what the media and elite see as acceptable (Ardıç, Annema, & van Wee, 2013). Also, geographical, institutional and cultural variables relate to public support. Many road pricing studies focus on Western countries and therefore, do not usually explicitly study these variables. More recently, empirical studies in Asian countries show that road pricing support can differ substantially from Western countries, which confirms the importance of contextual variables (Dogterom, Bao et al., 2018; Liu, Lucas, & Marsden, 2019). Also, experience with previous, or similar, policies can influence preferences. In turn, political support heavily depends on public support in democratic countries, since politicians take their (future) voters' preferences into account. But, as Feitelson and Salomon explain, politicians can also be influenced by interest groups and lobby groups as they need their support. In the case of road pricing in the Netherlands, the interest group representing car users (ANWB) has been an influential stakeholder in the non-implementation of the policy (Smaal, 2012).

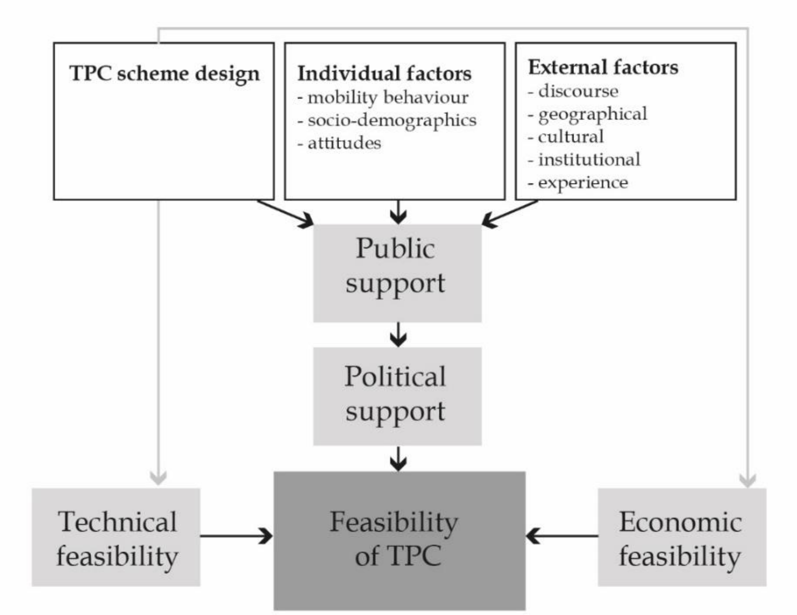

Figure 2 Conceptual framework for studying the feasibility of TPC, particularly public support

The conceptual framework is illustrated in Figure 2. Chapter 2 discusses the feasibility of TPC in more detail, but the main focus of this thesis lies on the upper part of the model about public support. The influence of scheme design and individual factors on public support have been studied. The influence of external factors was not explicitly studied, as this thesis only uses Dutch cases.

1.4.2 Questions and methods

Based on the research aim and the gaps in existing knowledge that have been identified, the following five sub questions were formulated. Figure 3 summarizes the five parts of this study, based on these sub-questions and their main methodology.

To what extent is TPC feasible as a policy instrument and what are the main barriers to implementation according to transportation researchers and policymakers?

As already stated, the feasibility of tradable credits for congestion management has been theoretically analysed in a small collection of studies. By answering this question, a broader view is taken on its feasibility and the main barriers to its implementation, by also taking other things into account, such as from a psychological perspective and from the perspective of public administration. To that end, policymakers and researchers who are well acquainted with road pricing in the Netherlands were interviewed (sample I). These interviewees are expected to be able to quickly understand the rather complex topic of TPC and provide insights into potential barriers to policy implementation. The outcomes of the interviews are compared and supplemented with empirical studies and theories from literature on policy processes.

Which main segments of the public can be identified regarding opinions in the road pricing debate?

By answering this sub question, insights into the great heterogeneity of the public when it comes to opinions, attitudes and feelings regarding road pricing are provided. This is done using Q-methodology, a qualitative-quantitative method. In an online survey (sample II), respondents are asked to rank-order a set of statements from the Dutch road pricing debate. These rank-orderings represent an individual's complete viewpoint about road pricing. By systematically comparing these viewpoints and shared viewpoints, the so-called 'frames' in the Dutch road pricing debate can be identified.

Which factors play a role in citizens' opinion about, attitudes towards, and support for TPC?

As TPC is a new instrument to most people, different variables may play a role regarding support for TPC, compared to support for conventional road pricing. To answer this sub question, focus group meetings with people from the public were organized (sample III). Participants were confronted with a hypothetical city that faces a congestion problem in which two instruments were considered: a peak charge and a TPC scheme. By content analysing the transcriptions, this study gives insights into why people react to TPC in a certain way and how these reactions differ from reactions to a peak charge.

To what extent do citizens support the introduction of a TPC policy, and how is support related to personal characteristics and scheme design characteristics?

By answering this sub question, we find out how many people would actually support the introduction of a TPC scheme, rather than keeping the status quo. Also, the relative importance of personal characteristics (socio-demographic variables, mobility habits and attitudes) and scheme design characteristics to these support levels is analysed. This is done through a stated choice experiment that was held among citizens of the Amsterdam and Utrecht regions (sample IV). Respondents were asked to choose between different TPC scheme designs and the status quo. Different choice models, based on the utility theory (McFadden, 1986), were estimated to reveal the trade-offs made and the relative importance of the (types of) variables. The estimated model was applied to predict the support levels for different TPC schemes.

How is support for TPC different from support for conventional road charging instruments?

The main reason for studying TPC lies in the expectation that tradable credits would be more supported than conventional charging instruments, especially by car users. To answer this sub question, in an online survey (sample IV), respondents were asked about their support for three instruments: TPC, a congestion charge and a kilometre charge. The aggregated support levels for the three instruments were compared. Also, the heterogeneity of the sample was studied using a Latent Class Cluster Analysis (LCCA), revealing which distinct homogeneous clusters of people exist that show similar rates of rejection or support for the three instruments.

1.4.3 Research context

This research and its data collections are all conducted in the context of the Netherlands. The Netherlands has a long history of proposals for road pricing. See Smaal (2012) for an extensive overview of that history up to 2010. Basically, the first concrete proposal for a road pricing scheme was launched at the end of the 1980's. This proposal concerned a time and place differentiated scheme for passenger cars ('rekeningrijden' in Dutch) and was fiercely debated and not considered feasible, neither from a social nor a political perspective. In the years that followed, different alternatives, including a toll charge to enter cities, a congestion supplement to the vehicle registration tax, and electronic road pricing with toll gates, were proposed and rejected by different political parties. In 1998, the coalition agreed to introduce a toll. But fierce opposition from various interest groups prevented the toll from being implemented. In particular, the interest group that represents car users (ANWB) played a prominent role in the opposition. In 2004, there was a renewed interest in road pricing in the political arena. The National Platform for Paying Differently for Mobility, led by its chairman, Nouwen, was set up to explore road pricing options. The platform consisted not only of governmental organizations, but also interest groups and societies, including the ANWB. In 2005, they came up with a widely-supported proposal for a nationwide road pricing scheme based on the principle of 'pay for road usage, replacing (part of) purchase and annual taxes'. In 2007, the new cabinet supported the proposal and preparations for implementing a scheme started. The support for the scheme seemed to stagger due to critical questions, also raised by some members of the platform. But ultimately, the implementation of road pricing came to an abrupt end in 2010, with the fall of the cabinet. Road pricing became a politically controversial topic and the coalitions that followed did not put the topic back on their agenda. In the meantime, urban regions have experimented with reward-based instruments in which car users receive a reward for avoiding peak hours (e.g. Knockaert, Bakens, Ettema, & Verhoef, 2011). As a short-term measure, rewarding is shown to be an effective solution for local situations, such as lane closures due to construction work (Bliemer, Dicke-Ogenia, & Ettema, 2009), and public acceptability of a reward-based instrument is likely to be higher than a charge-based instrument (van Delden & Cluitmans, 2009). But since rewarding projects involves a constant flow of money from the government to car users, they are only suitable for temporary applications with a limited number of participants, and they are not a long-term solution to congestion problems.

The public support issues concerning effective charge-based instruments on the one hand, and experience with the less-opposed but non-durable rewarding instruments on the other hand, contributed to the interest in the budget-neutral measure of tradable credits in the Netherlands. This interest is one of the things that has led to the formation of a multi-disciplinary consortium called 'U-SMILE' (Urban Smart Measures and Incentives for Quality of Life Enhancement). This thesis is part of this consortium that studies tradable credits for car use from different disciplines: spatial economics (Free University of Amsterdam), environmental psychology (University of Groningen), transport and planning (Delft University of Technology), and technology, policy and management (Delft University of Technology). Also, multiple 'real-world' experiments were being planned in corporation with the consortium. These experiments would take place in a few of the large Dutch cities and would each involve a couple of hundred car users. A local experiment with tradable parking permits was executed, but the experiments with road users were put on hold. In the months prior to the start of this consortium, a few news articles were published about car users who potentially committed fraud in the peak hour avoidance projects. These articles led to parliamentary questions. Not long after that, the experiments around tradable credits for congestion management were put on hold until the election in March, 2017. In their coalition agreement, the new government agreed that, under their leadership, no instruments would be implemented that charge car users for use of the road.

1.5 Contributions of this thesis

By addressing the research aim and answering the sub-questions, this thesis makes an addition to the existing amount of knowledge in the following ways:

To the best of my knowledge, this is the first scientific study that focuses on feasibility and public support for tradable credits for congestion management – and specifically the TPC instrument. The feasibility and acceptability of tradable credits that have the purpose of reducing carbon or overall kilometres driven have been studied before, but not as a congestion management tool. The thesis adds to empirical knowledge about support for TPC in several aspects. This thesis is the first that explores opinions about tradable credits for mobility management in a qualitative way, with the use of focus groups. This provides future researchers with an overview of factors that are relevant for opinions on TPC. Support is also measured quantitatively. Whereas most road pricing acceptability studies focus on support for one specific scheme design, this study acknowledges that support may heavily depend on the exact scheme design. Therefore, in this thesis, support for multiple TPC scheme designs is studied, and not just one. And in particular, the way in which the credits are distributed, which is often theorized as an important characteristic that can influence support. Furthermore, this thesis adds to the wider road pricing literature by focusing on the differences between people. Support is not a matter of reject of accept. Arguments, feelings, and opinions about road pricing differ greatly between people. Whereas many road pricing acceptability studies are centred around understanding the influence of variables on acceptability, support or voting behaviour, this thesis provides insights using several person-centred approaches. In total, three methods with a person-centred approach have been conducted: Q-methodology, Focus groups with content analysis, and Latent Class Cluster Analysis. It is not the primary aim of this thesis to develop or test methodologies, but an overall comparison and reflection upon the methods used adds to existing literature and may help future researchers when choosing the appropriate method for studying preferences regarding innovative (policy) instruments. Hence, this thesis does not only offer empirical insights, but it also contributes to existing literature in methodological terms.

1.6 Outline of this thesis

The remainder of this thesis consists of five substantive chapters that each answer one sub-question, and a final chapter that presents the overall conclusions and a discussion. The substantive chapters were written as research articles for publication in scientific journals. Hence the chapters show some overlap, especially in the introductions and literature reviews.

First, the wider feasibility of TPC and its main barriers to implementation are explored in Chapter 2. Chapters 3 to 6 focus on public support, as that is commonly the main barrier to road pricing implementation. Chapter 3 analyses the current road pricing debate by identifying people’s complete viewpoints using Q-methodology. Chapters 4, 5 and 6 focus on public support for TPC. Chapter 4 starts by exploring people’s attitudes, feelings and opinions in a qualitative way with the use of focus groups. Then, in order to also quantify public support, two chapters with quantitative analysis follow. Chapter 5 estimates a choice model based on a survey to find the public support levels for TPC and to analyse the influence of personal characteristics, attitudes, and scheme design characteristics. Chapter 6 analyses support for TPC and compares it to support for conventional instruments. Also, Chapter 6 conducts a Latent

Class Cluster Analysis (LCCA) to study the heterogeneity of the support levels for these instruments. Chapter 7 ends this thesis by providing general conclusions and a discussion. Figure 3 provides an overview of the substantive chapters.

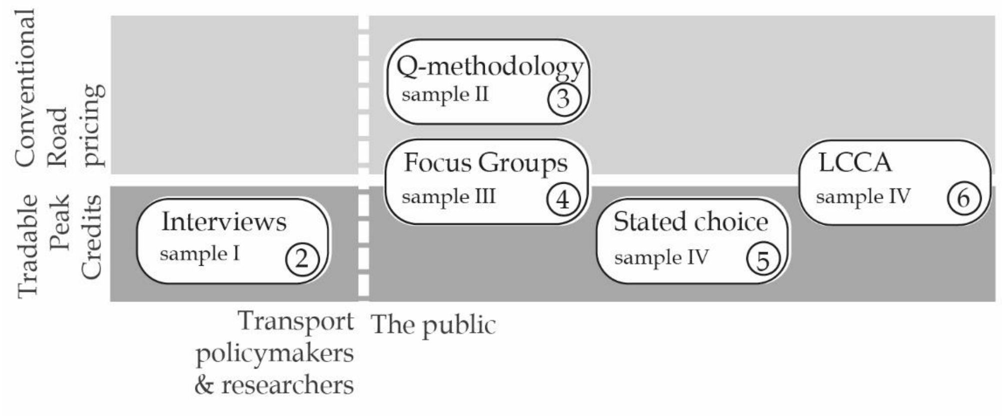

Figure 3 The five chapters with their main method and the sample, studied scheme(s), and studied population that was used. The numbers refer to the chapter numbering.

2 Exploring the feasibility of tradable credits for congestion management

This chapter is co-authored by Eric Molin, Jan Anne Annema and Bert van Wee and submitted to a journal.

Abstract - Tradable credits for congestion management is a novel policy concept that receives increased interest in transportation research. The interest is mainly driven by the belief that the concept can count on stronger social support and hence has a better prospect for implementation than charging based instruments. This study is the first that provides an analysis of the (social, political, economic and technical) feasibility of this concept. To that end, policymakers and researchers from the field of transport are interviewed. The results reveal so many barriers and challenges in the social and political context that some seem insurmountable, which exposes a difference with expectations formulated in the literature. We reflect on possible options to overcome or avoid barriers, but conclude that the concept of tradable peak credits lies very far from the current way of thinking about road use and seems unable to compete with the more established charging schemes.

2.1 Introduction

Although congestion pricing is generally seen as the most efficient way to manage the increasing congestion in urban areas, only a few schemes have been implemented worldwide. Many attempts failed due to a wide variety of factors, with the (lack of) public and political support as the most frequently mentioned factor (Vonk Noordegraaf, Annema, & van Wee, 2014). Congestion pricing is unpopular for different reasons, including the expected ineffectiveness and perceived unfairness of the scheme, car users' self-interest and the scepticism of the government's use of the revenues (e.g. Schade & Schlag, 2003a).

Recently, interest in tradable credits applied on congestion management has increased within academia, as this concept can address the above-mentioned concerns (see for reviews Dogterom et al., 2017; Fan & Jiang, 2013; Grant-Muller & Xu, 2014). Because the concept can be worked out using many different designs (Fan & Jiang, 2013), it needs to be specified with more precision for research purposes. In this chapter we use the following description: An authority establishes a clear limit (cap) for car use on a certain stretch of road, during a certain period of a day. This cap is translated into a number of credits that are distributed (free of charge) among the participants every week, month or other unit of time. Participants pay a credit when they use the defined road during the defined time of day and they can sell and buy credits on a market where supply and demand set the price. Participants can be households, but also taxpayers or car owners for example.

A tradable credit scheme is potentially effective in reducing car use since the cap guarantees the predefined reduction in car use. Whereas with a congestion charge, the price is controlled instead of the car use. Furthermore, the budget-neutral tradable scheme can address equity issues in a flexible way through the allocation of free credits and it provides the opportunity for users to get financial gains from the system. Lastly, the scheme does not generate revenues for the government as the money circulates between users.

These characteristics of the concept may lead to higher acceptability, and hence feasibility, but they are no guarantee for policy implementation. The cap-and-trade principle has been used in policies to, for example, limit greenhouse gas emissions and encourage sustainable fisheries (Sovacool, 2011) but a personal tradable credits scheme has not been implemented anywhere yet and consequently there is no relevant experience or evidence base. Feitelson and Salomon (2004) state that before a new policy can be adopted in practice, it does not only need to be technically and economically feasible, but it also needs sufficient public and political support. Vonk Noordegraaf et al. (2012) furthermore state that the likelihood of a road pricing policy being adopted not only depends on whether it is seen as feasible, but also on whether a policy opportunity occurs, and great political decisiveness is required. So far, most studies on tradable credits for mobility management focus on the scheme design, the effects on traffic flows or the behavioural responses of car users (see Section 2.2). Studies on the feasibility of related concepts show varying results, but to the best of the authors' knowledge, an in depth analysis of whether and under which circumstances the theoretical concept of tradable credits for congestion management is considered feasible, and hence can become a real policy option for congestion management, is still missing.

In this chapter, we therefore explore the social, political, economic and technical feasibility of tradable peak credits (TPC). We will present possible barriers, and reflect on how they can be overcome or avoided–if possible. The outcomes can be used to steer further research in the search for an effective yet acceptable congestion management instrument. Since TPC are still a concept rather than a fully developed scheme and we seek to explore, explain and understand this new phenomenon, a qualitative research approach seems suitable. To that effect, semi-structured interviews with policymakers and researchers from the field of transport in the Netherlands were held. These interviewees were expected to be able to quickly understand the rather complex concept and provide key insights into potential barriers to policy adoption. The use of semi-structured, in-depth interviews allows us to both have guidance and flexibility. The fixed set of questions helps to gather information on all subtopics, while it also leaves room for spontaneous reactions and hence relevant information may be gathered that has not been previously anticipated.

The chapter now proceeds with an overview of recent literature on the feasibility and policy challenges of policies involving (personal) tradable credits. Thereafter, an outline of the methodology follows in Section 2.3. Next, the outcomes of the interviews are presented before discussing them and comparing them with recent empirical studies and theories from literature on policy processes. Section2.5 2.5 presents the conclusions and recommendations.

2.2 Literature on the feasibility of tradable credits

To the best of our knowledge, no extensive studies have been conducted on the feasibility or barriers to the adoption of policies involving TPC. However, studies on related instruments may provide some relevant insights. Relevant literature regarding the feasibility of TPC can be divided into three categories: cap-and-trade systems (applied to industries), personal carbon trading and personal credits in the transport domain.

Ever since Coase (1960) presented the idea of tradable property rights as a more efficient way to manage negative externalities such as emissions, all kinds of cap-and-trade systems, transferable rights and tradable credits have been studied and promoted by economists (e.g. Crocker, 1966; Dales, 1968). Actual policy implementation did not occur at first because the concept was generally seen as impractical and many considered it ethically ambiguous. Later, the required technologies improved and confidence in the efficiency and equity of direct government intervention diminished (Ellerman, 2003) while other approaches were tried and failed (Tietenberg, 2003). Since the mid-1990s, several tradable credit schemes have been implemented in markets such as agriculture (Sovacool, 2011). Still, these schemes remain controversial and not every attempt to implement a scheme succeeds. Several proposals have been analysed regarding the policy obstacles (OECD, 2000; Sovacool, 2011). The level of the cap, the allocation of the (free) credits and the nature of the problem are all topics that can lead to lengthy debate among stakeholders including the users. Furthermore, governments may be concerned about high administrative costs, loss of revenues, the risk that big companies exploit market power in the credit market, free-riders and loss of dynamic efficiency. Thus, tradable permit schemes are implemented in various markets despite the controversies, and with increasing familiarity this number may further increase.

The idea of applying tradable permits at citizen level evolved as a policy idea aimed to reduce carbon emissions in the mid-1990s. Ten years later, personal carbon trading (PCT) was being studied, mainly in the UK. The government had ambitious carbon reduction goals and the PCT concept was explored, inspired by the belief that it is a policy that reduces emissions in an efficient and fair way (Fawcett, 2010). Studies on social feasibility find support levels of around

25% to 40% (Owen, Edgar, Prince, & Doble, 2008; Wallace et al., 2010), up to 80% (Bristow et al., 2010). These levels are relatively high given the radical novelty of the concept. Moreover, these studies found that PCT is preferred over an equivalent carbon tax. Parag and Eyre (2010) explored the wider feasibility of PCT by identifying barriers in the policy arena using theories from literature on policy processes and Woerdman and Bolderdijk (2017) defined barriers using insights from economics and behavioural science. Parag and Eyre conclude that the evidence base is currently inadequate to predict whether PCT would be adopted as a policy instrument. Woerdman and Bolderdijk conclude that the scheme can be feasible from a micro-economic and behavioural perspective, but argue that the implementation is unlikely from an institutional-economic point of view, especially because of its integration with the existing EU-ETS scheme. The small number of governmental studies are more negative. Defra declared that PCT seems to be an idea currently ahead of its time, with lack of social acceptability as its main weakness (Defra, 2008). The IPPR (2009) came to a similar conclusion after interviews with stakeholders. Many interviewees find it a nice idea in theory, but think it will not be workable. They have concerns about practicalities and costs, but mostly about fairness.

Attention to personal credits in the transport domain arose in academia when Verhoef et al. (1997b) and Viegas (2001) explored the concept. Further studies followed: on the effects of tradable credits on the transportation network, the market design and transaction costs, and user responses (e.g. Dogterom, Ettema et al., 2018; Wang, Yang, Zhu, & Li, 2012; Yang & Wang, 2011). Grant-Muller and Xu (2014) conclude in their review that credits could be feasibly introduced and have some advantages over other instruments to reduce congestion, specifically concerning efficiency and equity. Although economic viability is often an important requirement for a policy to become feasible, it is not sufficient, as argued in the introduction. However, studies on the wider feasibility and policy challenges are scarce. Social acceptability has been studied a few times. Dogterom, Bao et al. (2018) studied car users' acceptance of a tradable kilometres credits scheme in the Netherlands and Beijing and found support levels of 25% and 67%, respectively. Kockelman and Kalmanje (2005) found that about 25% of their respondents supported the concept of (non-tradable) credit-based congestion pricing (CBCP). Gulipalli, Kalmanje, and Kockelman (2008) conducted a survey among experts who were asked to predict the effects and share their concerns and ideas for implementation of CBCP in Texas. Most respondents expect CBCP to be more effective than normal congestion pricing, although many are concerned about the level of administrative costs. They are positive about the technological viability and most transport economists support CBCP.

2.3 Methodology

The feasibility of TPC and barriers to policy implementation are primarily explored using semi-structured interviews. The interviews were conducted within the context of the situation in the Netherlands.

2.3.1 Case background: road pricing in the Netherlands

Many types of road pricing have been discussed and considered in Netherlands. In 2010, a road pricing policy was at an advanced stage, involving many policymakers and scientists, when the new coalition decided to cancel the implementation. Since 2010, the ruling coalitions have declared all road charging instruments controversial. Instead, experiments rewarding peak hour avoidance were allowed and organised. Given that rewarding for peak hour avoidance is not a durable solution and charging for road use not an accepted solution, the idea of TPC was further developed. The first ideas regarding personal credits for mobility management were published over twenty years ago (Verhoef et al., 1997b) and from 2016 and beyond, the first steps towards a real-world pilot were taken in a consortium consisting of academics and municipalities.

2.3.2 Interviews

Selection of interviewees

The concept of tradable credits for mobility management is quite unknown even for most people working in the field of transportation. Therefore, we selected the interviewees on the basis of their knowledge and experience with road pricing in general. A list with researchers was compiled, based on publications on road pricing. This group covered different fields of research which are relevant for road pricing, including psychology, public administration, human geography, economy and transport engineering. As for the policymakers, we aimed to select policymakers at different governmental levels. Policymakers who were concerned with road pricing on a national level, as well as people who were the road pricing experts in large municipalities. A few leading Dutch researchers were excluded because they are involved in the authors' research consortium. During the interviews, snowballing was used to extend the list of names. In total we interviewed 16 people in 14 interviews, since 4 people preferred to do the interview as a couple. After the 11th interview, no new insights were given by the interviewees. After three more interviews without finding any new insights, we considered the data collection to be saturated.

The interview structure and data analysis

Since we seek to take a broad perspective on the feasibility and implementation of a novel policy idea, we adopted an existing framework to structure the interview questions and minimize the risk of overlooking relevant aspects of feasibility. To that end, we found the political-economics framework of Feitelson and Salomon (2004) the most suited because their framework is developed to analyse the adoption of technical innovations in a complex public-private context involving many actor categories. This framework has been used before in transportation literature to study the performance of the hyperloop (van Goeverden, Milakis, Janic, & Konings, 2018), and the implementation process of road pricing (Vonk Noordegraaf et al., 2012), for example.

The four types of feasibility as described by Feitelson and Salomon were used to guide the interviews. Their framework is illustrated in Figure 4. According to them, a first fundamental condition for a transport innovation to be considered as a new policy is that is has to be seen as technically feasible. When people do not believe that it can be used, it is very likely to fail. Furthermore, the benefits need to outweigh the (among others technical) costs in order to be feasible from an economic point of view. In case of road pricing, multiple studies showed that these schemes are still not widely implemented despite economic and technical feasibility. As they explain, that is because social and political feasibility are also requisites for adoption. An innovation can be considered socially feasible when a majority of the voters are likely to support it. According to them, social feasibility heavily depends on the public perceptions of problems, expected effectiveness and whether people are positive about the distribution of benefits and costs. These perceptions can be influenced by experience with similar policies and can also be affected by active agents that support or criticize the innovations. In that way, they influence the 'sanctioned discourse'. That discourse encompasses the policy ideas that are seen by the media and elites as publicly acceptable. Political feasibility is partly determined by social feasibility since politicians take their voters' preferences into account. Indeed, it is assumed that politicians want to be re-elected. For the same reason, politicians can also be influenced by interest groups since they need their support for their re-election and/or want to avoid negative publicity.

In order to leave space for spontaneous reactions unrelated to the framework, the interviews started with general questions such as 'what is your opinion on tradable peak credits?' and 'What are the main barriers for the implementation of a system involving tradable peak credits in the Netherlands?'.

The interview questions and a text about TPC were sent to the interviewees a week in advance in order to facilitate preparation (see Appendix A for the translated text and the questions). The interviews took one hour on average and took place in February and March 2018. The interviews were transcribed and summarised.

The summaries were first analysed in an impressionistic way to get an understanding of the interviewees' positions regarding each type of feasibility. Then, we analysed the barriers to implementation in a structured way using the principles for content analysis (Elo & Kyngäs, 2008). We coded the barriers using an inductive method within each type of feasibility.

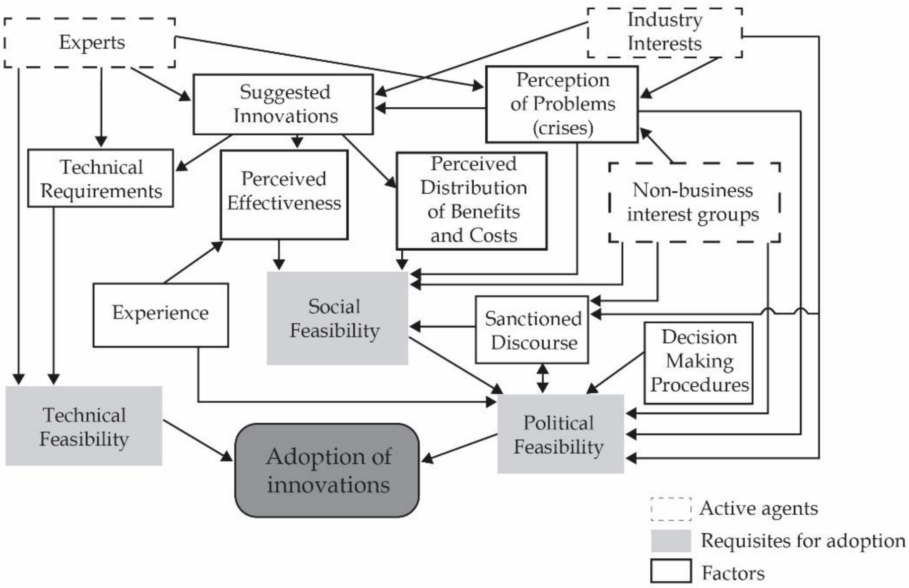

Figure 4 The political-economy framework by Feitelson and Salomon (2004)

2.4 Findings and discussion

Section 2.4.1 presents the findings, grouped in the order that the questions were asked, although these categories are interconnected rather than fully distinct. The numbers between brackets refer to the interviewees. The 'G' stands for governmental employee and the 'R' for researcher. Section 2.4.2 presents a broader discussion based on the findings and relates them to empirical studies and theories on policy processes.

2.4.1 Results

Technical feasibility

Although the technical feasibility heavily depends on the exact scheme design, most respondents expect that TPC is technically feasible considering the current development in the ICT field. These respondents mention that the principle of trading is already in use as emission rights, for example, which seems to work. Nevertheless, two respondents mention that it is *'the most challenging concept in terms of technique of all road pricing solutions'* [R4, R7]. Others are less positive and doubt whether the government is capable of implementing such an instrument: '*An independent app developer might come a long way, but considering that such an instrument would probably fall under the government's responsibility (because it is a public resource), through politics many requirements will be introduced which would make the instrument complex, technically speaking' [G3]; and 'You can expect problems similar to other government projects involving automation when introducing such a large and complex instrument [G6]'*.

As the TPC concept is a relatively complex policy, interviewees foresee barriers regarding privacy issues [R2; R5; R8; G2; G8] or problems with enforcement [R2; R5; R7; R8; G1; G2; G6; G7; G8]. Furthermore, the technical system requires a very high level of security in combination with the administration and detection system, which decreases the technical feasibility [R1]. Lastly, mobility behaviour is hard to predict which makes the exact design of the instrument difficult to determine. While in the end, as already stated, the exact end design determines the technical feasibility of the instrument.

Economic feasibility

Many interviewees believe TPC have the potential to effectively reduce and control congestion and create benefits for society. Indeed, the cap can guarantee the traffic flow – with exemptions for congestion caused by collisions or extreme weather conditions. However, some have doubts whether people will understand the system and the price signals properly, whereas this is a requirement for the scheme to be effective [R3; R8; G1; G4; G5; G6; G7]. The effectiveness of the instrument depends on the level and dynamics of the prices. The question hereby arises whether the behavioural effects will flatten out after a while [R6; G5]. Some interviewees are clearly negative about the effectiveness [G7]: '*I think market forces are imperfect. Not everyone will trade: some will forget to buy, or leave their credits on their account. So it is a lot of hassle. Or others simply do not care about the prices. When you constantly have to calculate the costs, you start to ignore the prices at a certain moment. Constant price incentives do not steer behaviour. A credit price should be high enough in order to be effective'*. Another risk is that tradable credits crowd out the intrinsic motivation of people: '*Tradable credits really focus on demand and supply(...). That bothers me, especially because I'm afraid that people forget the aim of the policy due to the focus on trading. Thus, trading or earning money becomes the goal instead of the higher goals (reducing emissions, congestion, improving liveability) [R5].*

Multiple interviewees mention the trade-off between differentiation of the prices and the user transaction costs as a dilemma that is relevant for the feasibility: '*Theoretically, higher differentiation in prices makes a better instrument. Thus: different tariffs depending on place and time. However, trading takes time. When individuals spend more time on trading, then they save travel time. (...) The trading should run almost automatically. Thus, effectiveness increases with precise differentiated prices* but that will drive participants crazy in practice [R3]' and 'The effectiveness is highest when a participant deals with the instrument on a daily basis. Although, he might fall back into his old habits [G4]'. Other risks mentioned concern the under-utilization of the roads [R3; R7; G4; G5; G7]. Empty roads might also negatively influence public support [R3]. Therefore, the definition of the optimal cap is important. 'When the cap is too high, there is a risk that people pay credits but are still experiencing congestion. When the cap is too low, traffic flow is excellent but with a high drop in demand [G5]'. Another risk regarding the cap is that too many credits are distributed, as happened in the EU-ETS program. 'Political parties may say: we will distribute an X amount of extra credits' [G6]. Furthermore, some think the effectiveness may be decreased due to speculation [G7] and latent growth [G2].

The respondents are less outspoken on the question of whether the instrument is cost efficient, thus whether societal benefits exceed societal cost. Some mention that the system costs will be relatively high [R2; R2; R4; R6; R7; G1]. Besides, the cost efficiency also depends on the definition of costs within the societal cost benefit framework: 'when you also include costs for future generations/environment/nuisance, and so on, it becomes more complex [R5]' and 'You should also consider the negative effects for the labour market. I think the likelihood that a societal cost benefit analysis is negative is quite high [G3]. However, another interviewee remarks that the costs of such a pricing instrument will always be lower compared to infrastructure expansion [G2].

Social feasibility
All interviewees evaluated the overall social feasibility as very low. A few interviewees expect that the instrument will be received by the public in a similar way as congestion pricing [R5; G1]. Only two interviewees expect the social feasibility to be higher than a charging instrument, but still quite low. The remaining interviewees expect that the social acceptability will even be lower compared to a charging instrument. The following barriers are mentioned.

The perceived unfairness is, unsurprisingly, mentioned by almost all interviewees as an important barrier to social feasibility. The unfairness between different incomes [R2; R5; R6; G2] is mentioned: '*certain groups can get the idea that the richest people will own the most credits'* [R2], but also the lack of an alternative [G1] is mentioned. While a kilometre or congestion charge implies that everyone loses, a TPC scheme does not. The interviewees recognise that this may benefit the perceived fairness, but others emphasize that there will always be people who have to pay more than in the status quo. Again, this can be perceived as being unfair [R3; R4; G1; R7; G2]. Related to fairness is the distribution of the credits. Indeed, the way in which the credits are distributed, and to whom, define the distributional outcome of the scheme. Many interviewees consider the distribution of credits to be a main barrier [R2; R4; R5; R7; R8; G2; G4; G6; G7]. They explain that the distribution '*will raise so many questions and discussion'* [R2] and any distribution will lead to a redistribution in wealth so there will always be people who find it unfair [R4].

The fear that that people may be excluded from the road during peak hours because they cannot afford the credit price is also mentioned as a barrier to social feasibility. Theoretically, the credit price can greatly increase and hence become unaffordable for people with lower incomes. People can be excluded because they cannot afford the credit [R1; R4; R6; G3; G4; G6; G7] or because they do not understand the system because they are visitors or not familiar with technology, for example [R3; G2; G3]. Also, the uncertainty due to the varying credit prices decreases the acceptability [R6; G6; G7]. Furthermore, many interviewees mention the infringement of people's freedom as an important barrier [R1; R2; R4; R6; R8; G2; G4; G5; G6; G7; G8]. One interviewee even draws a parallel with the '*feeling of gasoline vouchers'[G5]*. This may stir up a public debate whether it is desirable or acceptable to turn the public road into a market product [G2].

The expected ineffectiveness is also seen as a barrier, just like regular road pricing is perceived in literature on this subject. A TPC scheme has the unique characteristic that, theoretically, it can guarantee the reduction in trips because of the cap. As one interviewee mentioned: '*acceptability is higher when effects can be guaranteed' [R6].* On the other hand, opponents will *'always claim that it will not work anyway' [R3; R5; R6; R8; G1; G2; G5]* or cause privacy issues [G5; R7; R8; G2; G4]]. Although a TPC scheme does raise some new arguments for opponents. People can be sceptical of government-run ICT projects because in the past the government has conducted a few ICT projects that are considered to be failures [R6]. People from the public may also expect TPC to be ineffective because users can speculate or commit fraud with the credits or hack the system [R6; G2; G8].

But, the most reoccurring barrier is the 'hassle' or the transaction costs the trading requires [R3; R4; R6; R7; G2; G5; G6; G7]. A few interviewees think that some people might see this as a fun aspect: '*people like to be smarter than their neighbour'.* However, most mention trading as an aspect that decreases the social feasibility. The trading requires extra time and effort from the users and also makes the concept more complex and difficult to understand. Hence, multiple interviewees think the intelligibility - whether people understand the system correctly - can be quite low. The fact that the TPC concept is so novel and different from existing policies, decreases the social feasibility [R3; R4; R6; G1; G3; G4; G5; G6; G7; G8].

Political feasibility

Many of the interviewees argue that the political feasibility probably correlates strongly with the social feasibility since political parties are heavily influenced by their voters' preferences. Hence, low social support leads to low political support. Still, there are also other factors or actors besides social feasibility that influence political feasibility. The interviewees mentioned the following barriers.

The policy integration in the context of the EU is seen as a possible barrier [R1; G5; G7] '*Tradable peak credits are unknown and haven't been proven anywhere yet. Also, a EU-wide legal basis is missing. A kilometre charge, on the other hand, is in line with European policy guidelines that support 'pay according to use'. Thus, a system with tradable peak credits requires even more courage and perseverance from our politicians. I expect the political feasibility to be very low because of that. Why would a politician take such a risk? How can a politician 'score' with such an instrument?'* [R1].

The complexity is also seen as a political barrier. The TPC concept is relatively complex and contains many design options. According to some interviewees, this is an important barrier to political feasibility since the devil is in the detail: there are too many details that can become a topic of political debate [R1; R2; G2; G3; G4]. Multiple interviewees argue that it would be hard for a politician to explain the added value of TPC to the public [R1; G1; G2; G3; G7]; '*A minister cannot sell this instrument, it is not explainable to the public'* [G3]. This also relates to the fact that the current evidence base is lacking [R1; R2; R5; R8; R2].

The lack of revenues can also become a barrier. In contrast to a charging instrument, a TPC system will cost money and the revenues from parking and car possession will decrease, without generating any new revenue stream to the government. This might lower the political feasibility [R6; G1; G4; G5; G7; G8].

Lastly, some stakeholders are seen as potential barriers. Stakeholders, such as newspapers, can negatively influence the public debate and hence be a barrier to political acceptability [R2]. Political feasibility may also be lower because road pricing has already been discussed many times before and stakeholders may be fed up with it [R6].

2.4.2 Discussing the findings

The interviews revealed a wide range of potential barriers and indicate that the main barriers lie in the social and political context. This section presents a broader discussion. We first discuss barriers related to the scheme design and to the (international) context. Thereafter, we discuss potential barriers and ways to avoid or overcome them in the next steps in the process of policy development. The barriers are compared to what has been found in the small number of empirical studies on tradable mobility credits. Obviously, no real world empirical studies exist on the context and policy approach of TPC. Hence, we also have also used literature on road pricing and theories from the area of policy processes in our discussion of the findings.

Scheme design

First of all, the intelligibility - whether people understand the scheme, and behave as expected – was often mentioned as barrier. This corresponds with literature on road pricing, which found that understanding a scheme is a requisite for a scheme to be effective and acceptable (Giuliano, 1992). In general, people prefer simple, predictable tariffs (Bonsall et al., 2007). Dogterom, Ettema et al. (2018) report that, in their experiment on tradable kilometre credits, many people adapted their behaviour in a rather complex way, which suggests that they understood the scheme. However, this conclusion is based on their sample of 308 respondents, whereas 918 people started the experiment. It is plausible that people who do not understand the scheme are underrepresented in their final sample. Furthermore, the tradable credit scheme in Dogterom et al.'s experiment was somewhat simplified since they used fixed price levels. Brands, Verhoef, Knockaert, and Koster (2019) did use dynamic prices in their lab experiment on tradable parking permits and found that most choices were made in a rational way, which indicates that they understood the scheme. This sample is probably also not representative for the average car user or citizen since the participants were recruited from a former peak hour rewarding project, which consists of frequent car users who are interested in these kinds of projects. Thus, more research on the intelligibility of TPC is needed. The way in which the information is presented and explained should get extra attention since, according to Bonsall et al. (2007), this probably heavily influences people's ability to understand a scheme.

Also, the hassle, referring to the perceived time and (mental) effort that is required by the users, is another frequently mentioned factor which has barely been studied. Indeed, regular road pricing schemes do not require much action by the user. The effect of transaction costs on the way the market functions has been studied (Nie, 2012) but it is still rather unclear how potential users perceive the hassle and how this affects their acceptability level. Brands et al. (2019) report that a majority of their respondents (strongly) agreed with the statement: 'participating in the experiment took little time or effort', which suggests that the transaction costs are relatively low. In their experiment, participants were asked to make a choice every working day, for two weeks. Thus, the interviewees expect a lot of hassle, while the respondents in Brands' experiment did not experience much hassle. The perceived 'hassle' is relevant for further study since a higher number of transactions lead to a more effective instrument, while too many transactions may decreases public acceptability. If trading requires too much effort, a non-tradable alternative (such as CBCP) may be better.

The distribution of the credits was seen as an important barrier since it determines the distribution of costs and benefits to a great extent, hence: who will be the winners and losers of the scheme? Although the literature on tradable credits repeatedly mentioned the distribution of the credits as an important characteristic, the public acceptability of different allocations has barely been studied. Most studies confronted their respondents with one particular scheme design (often, one where all participants would receive an equal share of credits) when they asked for their opinion. Bristow et al. (2010, p. 1826) did vary the allocation mechanisms and found that most people prefer a PCT scheme in which permits 'are equally distributed, with extra permits for those with a greater need, like living in a rural area, poor housing or disability, for example'. Hence, the optimal distribution of credits, in terms of acceptability level, is still rather vague.

Nine interviewees mentioned the risk of social exclusion as a barrier to acceptability. The market mechanism can lead to prices which are unaffordable for certain people and consequentially may exclude them from using the road during peak hours. The regulators of TPC can diminish this problem by putting a maximum on the credit price and allocating extra credits to those in greater need. However, whether the wider public would accept an unequal distribution of credits is unknown. Moreover, TPC may also exclude people who do not understand the system. Hence, the ease of use of the system is very important and as stated before, the intelligibility of all the types of people who would be subject to the scheme should be studied.

Context and regulations

As mentioned by a policymaker, local governments do not have the autonomy and authorisation to introduce a road pricing system in the Netherlands. What is more, the EU regulatory context can also create barriers even if a TPC scheme is introduced on a national scale or local governments get permission to introduce road pricing. It is unlikely that foreign license plates will receive free initial credits and exempting them from the credit system will decrease public acceptability. Hence, surrounding countries will probably oppose the introduction of a system which disadvantages foreign license plates. This also happened when Germany tried to introduce a toll which disadvantages foreign license plates since the revenues of the toll would be used to compensate German car users. The European court therefore forbade the toll (BBC 2019). Thus, when designing the scheme, the international regulatory context should also be taken into account, which further complicates the process.

Furthermore, an interviewee pointed out that some lobby groups may prefer TPC and become advocates. However, other stakeholders may oppose TPC. Lobby groups and political parties with environmental goals will probably prefer regular road pricing over TPC since the 'polluter pays principle' applies less to TPC. Besides, TPC can lead to moral objections since one can consider it 'a right to pollute'. Hence, they may become active opponents of TPC. To our knowledge, the opinions of relevant lobby groups and other stakeholders, such as political parties, have not been studied yet.

Additional barriers in policy development

The interviewees indicated that their perception of the feasibility may change in the future if new studies or experiments reveal new insights. The following steps in the policy process may affect the feasibility.

First of all, many of the factors mentioned by the interviewees relate to the unclear policy design. This is a non-exhaustive list of unclear aspects: *How to determine the cap? Who receives the credits? How (often) are the credits distributed? How often do participants have to trade? How to deal with exemptions such as visitors and foreign license plates? Who, if anyone, would regulate the price? Where, and at what times are the credits needed? How will the scheme be regulated and by whom? Can participants also give credits to their visitors, for example?* Although some of these questions can be regarded a minor details that do not affect the mechanisms of TPC, they need to be answered since they might be crucial for the social and political acceptability. TPC should first stabilise into a dominant, fully developed design before it can pass through a 'window of opportunity' (Geels & Schot, 2007). Real-world experiments can help finding a dominant design. Although experiments cannot simulate all aspects and effects of a TPC scheme, varying experiments can nevertheless help with understanding the effects and mechanisms of TPC. Experiments based on voluntary participation, in areas where congestion is strongest, in order to capture the largest benefits and provide proof of concept about the effects and technical aspects, may change people's acceptability and reinforce the beliefs in the technical feasibility.

Regardless of the amount of evidence about the concept, the moral objection of changing a public road into a tradable, marketable product remains. Here, framing can play a role. Introducing the concept in a positive way, emphasizing the effects on congestion and avoiding it being seen as a rationing concept that infringes on people's perception of freedom. The budget neutral aspect should be emphasized: people receive a set of free credits and they can buy some extra credits if needed, or sell credits and earn some money. The trading aspect seems to add to the perceived complexity and therefore should not get a prominent role in the framing and communication. However, if the idea of marketing public property conflicts with people's deep core beliefs, it is unlikely that this will change through communication style or an adjusted scheme design. Therefore, future studies should try to better understand the underlying reasons for the public opposing (or proposing) TPC.

Even if a TPC scheme is considered feasible on all aspects, that does not necessarily mean it will be implemented. According to Kingdon's stream model, decisions regarding new policies can only be taken if there is a (coincidental) coupling of three streams: the solution stream, the problem stream, and a stream of political events (Kingdon (1984) in Koppenjan, 1993). When the streams meet, a so-called policy window occurs and during these time windows, decision makers can make a decision about the solution to a problem. Regarding TPC, it is likely that the streams will meet again in the future, since the congestion problem is further increasing. Currently, however, TPC are not within the 'basket of policy solutions'. If TPC further mature into a fully developed design, strong advocates will be needed who can place TPC in the solution stream. Then, TPC have to compete with the more established road charging solutions that are already in the solution stream. A future development that may decrease the likeliness of a TPC scheme being selected is the expected increase in electric vehicles. When the share of electric vehicles becomes substantial, the government may look for a different way of collecting taxes, instead of the excise duties on gasoline. This may be an additional reason for the government to prefer a policy that generates revenues, such as a kilometre charge, over a budget neutral option.

Lastly, if a TPC policy becomes part of the solution stream, and is selected as a solution during a policy window, it will probably lead to a long and complex policy process. As pointed out by Ardıç, Annema, and van Wee (2015), traditional road pricing is already too complex to be handled in one reign. Because of all the details and design options, a long negotiation process is needed. They explain that consensual political systems, such as the Dutch political system, are already known for the low capacity for innovation, and when a long negotiation process covers multiple coalitions (agreements) this gets even lower.

2.5 Conclusions

Tradable peak credits (TPC) are a new idea for congestion management and radically different to established alternatives. This study explored the feasibility of the concept and identified potential barriers to the implementation of such a policy, by interviewing policymakers and academic in the Netherlands. We found that all interviewees were generally sceptical or unreservedly negative about the concept, despite the theoretical advantages of TPC qua effectiveness and public acceptability, and they identified many potential barriers. The empirical studies and theories from the literature on policy processes identified some more challenges to the development of a TPC policy, including the (international) regulations and the long negotiation process in the policy arena. Although the number of interviewees is limited, the contrast between the expectations expressed in literature on tradable credits and our findings is striking.

Most interviewees think the concept would be technically possible but found it hard to estimate whether the costs of such a system would exceed the (societal) benefits in this conceptual phase. The results show that the main challenges lie in the context of the social and political feasibility. The distribution of the credits, the intelligibility and the balance between transaction costs and effectiveness are seen, in particular, as important challenges. Although most interviewees consider TPC unfeasible, they do not rule out the possibility that this will change in the future. Some of the barriers they foresee may be overcome by adjustments to the scheme design or in the policy process, as discussed. The concept might get more momentum if the design becomes more precise. Also, real-world experiments in congested areas can provide proof of concept about the effectiveness and technical feasibility of the concept and this may lead to an increase in acceptability. Other barriers however seem insurmountable such as the moral objection of 'trading access to public property' at this point in time. This requires a new way of thinking about car use and road access - a paradigm shift.

This study is limited since it is a small-scale exploratory study capturing only one moment in time. New insights, increasing congestion problems or decreasing trust in established policies can all lead to different conclusions regarding the feasibility of TPC. Besides, this study only considered the feasibility in the Netherlands. This country has a long history of road pricing alternatives, and many of the interviewees showed that they have trust in these alternatives. Policy acceptability is quite different in for example China (Liu et al., 2019) where Dogterom, Bao et al. (2018) found strong support for tradable kilometre credits among car users. Thus, TPC might be more viable in such areas. Moreover, this study reports on the expectations of policymakers and researchers regarding the feasibility aspects. As the discussion showed, studies on TPC are scarce and many of the interviewees' assumptions and predictions could not be verified. More research is needed on the actual public and political acceptability, the economic cost and benefits, and the technical requirements.

Based on the current knowledge base, we conclude that tradable peak credits as a policy solution has a low feasibility and faces even more barriers than the simpler congestion charging alternatives. TPC may be conceptually elegant, but the concept lies very far from the current way of thinking about use of public roads and a paradigm shift is needed before it can compete with more established and rigorously examined alternatives.

3 Public frames in the road pricing debate: A Q-methodology study

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Abstract - A deep understanding of people's support for road pricing may help policymakers to design more practical pricing schemes that are effective in abating congestion but lead to less public opposition. This study adds to the rich body of road pricing acceptability literature by taking a different approach that focuses on the underlying pattern of the arguments, beliefs and attitudes, which largely determine the viewpoint of individuals with respect to road pricing. We apply Q-methodology to find these viewpoints by asking respondents to rank order subjective arguments that are subtracted from the public debate on road pricing and to identify shared viewpoints that are called frames. Analysis revealed four frames: *The polluter should pay*, *Focus on fair alternatives*, *What's in it for me?* and *Don't interfere*. Only the *Polluter should pay* frame is positive about road pricing. The other three frames are negative about road pricing, which suggests that there is not just one single block of citizens opposed to road pricing, but that quite different arguments are used in the various frames. We discuss how these frames can be used by policy-makers that intend to implement road pricing, to fine-tune the design, communication and implementation process of road pricing schemes.

3.1 Introduction

For over 100 years, many road pricing schemes have been promoted by transport experts. It is regarded as ‘the best’ way (in increase of welfare terms) to manage congestion problems when infrastructure expansion is impossible or difficult (too expensive, spatial limitations). Despite the strong theoretical argument, only a few schemes worldwide have been implemented and most attempts to implement such schemes failed. The lack of the necessary public and political backing are regarded as the main reasons for most failures (Vonk Noordegraaf et al., 2014). Because of the longstanding issues around the implementation of road pricing and the increase of car related problems such as congestion, considerable research efforts have been conducted on the acceptability of road pricing instruments (see an overview in Schade & Schlag, 2003a).

Previous studies revealed a wide range of factors related to the acceptability of charging-based road pricing instruments. Socio-demographic variables, scheme-related variables, such as the perceived distribution of costs and benefits and self-interest, and other attitudinal variables, such as problem perception and trust in governments, among other things, correlate with the level of acceptability (Schade & Schlag, 2003a). These often purely quantitative studies are well-suited to investigate the statistical associations of multiple variables and the models typically explain between 30 and 60% of the variation to accept a certain road pricing instrument (e.g. Chen, Fan, & Farn, 2007; Kim et al., 2013; Sun et al., 2016). A limitation of this quantitative, variables-centred approach is that it does not give a complete view of the individuals’ viewpoints concerning the topic at hand, and it can even give a distorted view (Kroesen & Bröer, 2009). However, it is relevant to study people’s complete sets of beliefs, attitudes and opinions, since the general public is very heterogeneous in its worldviews when it comes to public policies such as road pricing. A few studies in current literature on road pricing took a different approach and studied, for example, the relation between acceptability and certain homogeneous clusters based on socioeconomic backgrounds (Gehlert, Kramer, Nielsen, & Schlag, 2011). However, as Anable (2005) argues, more meaningful insights may be obtained when an approach is adopted whereby groups are defined from empirical data and people are clustered according to their worldviews, attitudes, and motivations. Pronello and Rappazzo (2014) defined clusters of citizens in the road pricing debate ranging from ‘fierce opponents’ to ‘supporters’ and interpreted these clusters using the subjective statements given by the respondents in focus groups. However, what they do not make explicit is whether and how the participants’ statements, opinions and feelings were used in the process of identifying these clusters. This is also not possible with focus groups since not all respondents present their positions towards all the statements/arguments made. Consequently, it may be that two people end up in the ‘fierce opponents’ cluster, yet they may have different underlying reasons.

In this chapter, we assume that individuals create their own set of beliefs and attitudes about road pricing under the influence of the public debate, and from this personal viewpoint evaluate (novel) road pricing instruments. When multiple people share a similar viewpoint regarding road pricing, this is regarded as a ‘frame’ in this study. We expect that different frames concerning road pricing exist because it is a well-developed debate in many countries that has received a lot of media attention, with varying arguments since it would affect many individuals and it touches upon values such as equity and environmental beliefs. Individuals can perceive the road pricing debate differently and, as shown by Ardıç, Annema, Molin, and van Wee (2018), information from the debate can influence an individual’s support for road pricing.

The main aim of this study is to identify road pricing frames. These frames can give a better understanding of the great heterogeneity of public beliefs and attitudes concerning road pricing. It provides insights in which factors play a role in accepting/rejecting road pricing schemes among different groups of people. These fresh insights can be used in the design and implementation of (novel) instruments that are effective and can count on wider public support. We identify the frames with a methodology that is used to systematically study individuals' viewpoints, which is called Q-methodology, in Section 3.3. As further explained in Section Q-methodology3.2, in Q-methodology respondents rank order statements about road pricing in relation to each other. These rank orderings represent their individual viewpoint and when multiple of these viewpoints strongly correlate, they are interpreted as a frame. To the best of the authors' knowledge, this is the first systematic investigation into the rich variety of frames in the public debate and their relation to road pricing.

The study focuses on the public debate in the Netherlands where road pricing has been on the political agenda since 1960. Hence, the public debate about charging for road use is mature and contains many varying arguments to accept or reject road pricing. This makes it suitable for Q-methodology as we can use the statements from the public debate. Furthermore, this country is taking the lead in experiments concerning innovative road pricing instruments such as peak hour avoidance and tradable peak permit experiments (e.g. Ben-Elia & Ettema, 2011). This enables future research into the relations between frames and the acceptability of novel instruments.

The following Section elaborates on the methodology. Then, the results are presented in Section 3.3. Section 3.4 discusses these results completes the chapter with conclusions and recommendations.

3.2 Q-methodology

Q-methodology is a mixed qualitative-quantitative method that is used to reveal the main views on a certain topic. It combines the richness of qualitative studies with the rigour of quantitative studies. Respondents rank order statements about the topic at hand in relation to each other and are asked to explain their choices. By comparing the rank orderings, similar viewpoints can be defined. Q-methodology is well-established in social, political and health research and has been applied a few times before in transportation studies. The method has been employed to study the relative importance of different motives to use a car (Steg, Vlek, & Slotegraaf, 2001), to define people's viewpoints on the role of transport in their lives (Rajé, 2007) and to segment travellers regarding their medium-distance travel decisions (Cools, Moons, Janssens, & Wets, 2009; van Exel, Graaf, & Rietveld, 2003, 2011). Rajé explains that Q-methodology offers fresh insights, in comparison to approaches focused on (socio-demographic) variables, because it reveals that 'people across different social groups can share common perspectives and that within a particular social group there can be a number of perspectives' (Rajé, 2007, p. 476).

Q-methodology has several advantages. The most important one is that it allows respondents to express their own views (Corr, 2001), because the statements are derived from everyday communication and the respondent can use his or her own subjective criteria to evaluate the statements (Watts & Stenner, 2005). Furthermore, the statements are not structured to test any prior theories or hypothesis. Hence, the sample of statements in a Q-study (called Q-set) can be considered naturalistic and unstructured, and is therefore more realistic than a list of statements developed by researchers. An advantage of a Q-study over Likert scales, for example, is that respondents have to judge a statement in relation to all other statements. Respondents cannot equally agree with all statements, but they are forced to rank order the statements on a scorecard in the shape of a quasi-normal distribution. This study contains 42 statements (below we will explain why we choose 42) which, at least theoretically, forces the respondents to make 861 judgments [(1/2) (42) (42-1) = 861]. This provides the researcher with more information about the viewpoint (Corr, 2001) and also encourages respondents to construct their opinion about the topic.

The remainder of this chapter describes how we applied Q-methodology. Firstly, the concourse is defined. The concourse consists of the countless number of statements of opinion that can be found among members of a social group, all related to a single topic (Brown, 1980). Secondly, a balanced set of statements (Q-set) is selected that represents the concourse. Thirdly, the participants (P-set) that are expected to represent different viewpoints are selected. Fourthly, the data are collected by asking the P-set to place the Q-set on the scorecard. This procedure is called Q-sorting. This Q-sort represents the personal viewpoint, which is based on the assumption that the interpretation of a statement is relational: the meaning of each statement is inferred from the rank order in which it is placed and its position in relation to the other statements, as decided by the respondent (Wigger & Mrtek, 1994). Lastly, the completed scorecards, the Q-sorts, are factor analysed. When three or more Q-sorts correlate[2], the respondents are said to share a similar frame. Thus instead of clustering variables as regular factor analyses do, the correlation matrix is transposed and the respondents' profiles are clustered (Stephenson, 1935). For detailed information about Q-methodology, we refer to Brown (1980) and van Exel and Graaf (2005).

3.2.1 Defining the concourse

In our study the concourse incorporates all statements made by people living in the Netherlands related to the topic of road pricing. Statements were sampled from two sources: the first was an internet based survey about road pricing held in 2006 among a sample of 1224 car owners who are members of the Dutch roadside assistance company (Hermans & Koomen, 2006) and the second was Twitter. We chose this survey because it was done in a period when there was a lot of public and political debate about road pricing in the Netherlands. The survey included an open-ended question in which the respondents were asked to explain where they stood/what they thought about the proposed road pricing scheme[3]. The 1293 answers to that question were included in the concourse. The debate about road pricing started up again in the months leading up to the Dutch national parliament elections in March 2017. In order to capture the statements from that period, we found Twitter to be the most accessible and complete source. We searched using hashtags with the Dutch synonyms for road pricing[4] and manually collected all Tweets from the period September 2016 to September 2017. In total we obtained a set of 731 reactions after removing the Tweets from organisations such as newspapers.

2 The choice for a minimum of three correlated Q-sorts is explained in Section 3.2.5.
3 The survey proposed a national road pricing scheme in which car users would pay per kilometre driven and extra in the peak hours. Taxes on the possession and purchase of a vehicle would decrease.
4 Road pricing (in Dutch: Rekeningrijden) (n =533), kilometre charge (n = 192), congestion charge (n = 6).

3.2.2 Identification of the Q-set

A Q-set usually consists of 40–80 statements (Watts & Stenner, 2005). We choose to include 42 statements to minimise the cognitive effort required from respondents. In order to come to a representative Q-set from the concourse, Q-methodological researchers use a structured approach. This structure can either take form naturally through the data, or it may be imposed, based on existing theory (Brown, 1980). We found the latter approach more suitable for this study because of the large set of raw statements and the extensive theoretical knowledge on road pricing acceptability. We used Feitelson and Salomon's (2004) political-economic framework because it was developed to analyse and predict the adoption of complex technology innovations in which public and private parties play an important role. Since this framework covers a wide range of factors (in)directly related to acceptability, we expect to minimise the risk of overlooking important (sub)categories in the concourse. We selected the following categories from the framework: (1) problem perception, (2) suggested innovation, (3) technical requirements, (4) perceived effectiveness, (5) distribution of costs and benefits. We labelled all raw statements with one of these categories. Raw statements that contained multiple arguments were separated into statements with a single argument, while we tried to stay as close as possible to the original wording. Since not all statements referred to one particular category, we created a sixth category: (6) 'interplay between actors', for statements such as 'the government is not capable of implementing a road pricing instrument'. Next, within each category we clustered like statements into subcategories. Then, to ascertain a representative sample of statements, an equal number of statements from each category was selected to represent that category. If multiple statements covered a similar argument, we chose the clearest and most comprehensive one. We changed some of the negatively framed statements into positively formulated statements to finish up with a balanced set. The final Q-set of 42 statements can be found in the left-hand column of Table 2.

3.2.3 Selection of the P-set

The P-set does not require a large number of participants (Rajé, 2007) but is strategically chosen since the aim is to identify the different viewpoints that exist within a certain population, and not to test the distribution of the viewpoints within the larger population. In our case, respondents had to be 18 years or older, the minimum age required for obtaining a driver license in the Netherlands. We used car possession, employment rate and living area to balance the P-set. Hence, a matrix was designed, consisting of 12 (3 × 2 × 2) combinations: three car categories (no car, lease car, private car), two living area categories (rural, urban) and two employment rate categories (working and not working). We considered the combination of having a lease car and not working to be unrealistic and removed it from the matrix. A company called CG Research was hired to collect the data until each of the 10 cells in the matrix was represented by at least 5 respondents. This requirement was met when 130 respondents completed the survey. This number is quite large given that most Q-methodological studies have around 40 to 60 respondents, with outliers between 18 respondents (Rajé, 2007) up to 102 respondents (Davies & Hodge, 2007). The respondents were selected from the company's online panel and received a small fee for participating.

3.2.4 Administering the Q-sort

First, a small pilot study was organized among colleagues for a final check of the statements and questions, which led to a few minor modifications. In October 2017, we distributed the final survey to the respondents via an online tool[5]. The survey started with a short introduction about road pricing and explained the difference between a flat tax and a congestion tax. Thereafter, the 42 statements were presented in a random order and the respondents were asked to first place every statement on one of three piles (agree, neutral, disagree). In the next step, a scorecard with the shape of a quasi-normal distribution ranging from –5 (most disagree) to +5 (most agree) was presented. Thus, on this specifically shaped scorecard only four statements can be given the most extreme scores (–5 and +5), while gradually more statements can be given less extreme scores (six statements can be scored with the neutral score of 0), see Figure 5. The way the respondents had to sort the statements was to proceed from the outside and work inwards: the respondents were asked to first select the two statements from the 'disagree' pile which they most strongly disagreed with and place them under –5. Then they were asked to place the two statements they most strongly agreed with under +5. This procedure continued until the statements from the neutral pile were also placed on the scorecard. In the following step, the respondents were asked to explain their choice for the four statements under –5 and +5 in an open-ended answer box. The survey ended with questions about personal characteristics.

Most disagree | Most agree

-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5
	-4	-3	-2	-1	0	+1	+2	+3	+4	
		-3	-2	-1	0	+1	+2	+3		
				-1	0	+1				
					0					

Figure 5 Quasi-normal distribution

3.2.5 Data analysis

A disadvantage of paying a fee for participating in this study is that this may partly attract respondents who only participate for the fee, and who will provide responses that are too hasty or trivial. To avoid this we calculated that a respondent would need at least 400 s to read 42 statements and sort them in relation to each other. 19 of the respondents spent less time than this so did not meet our criteria. Therefore these 19 were removed from the database. Of the remaining 111 respondents, 40 own a car, 35 have no car and 35 have a lease car (1 unknown). 70 respondents live in urban areas (1500 addresses or more per km2) and 41 in rural areas. About half (53) have a paid job, 24 are retired, 5 are students and 28 do not have a paid job and are younger than 65 (the standard age of retirement) (1 missing value). Of the 28 respondents without a paid job, 4 are searching for a job. The combination of 'rural area – no car – unemployed' did not meet our criterion of a minimum of 5 respondents, because this type of respondent proved difficult to find.

To find viewpoints with a similar pattern, a correlation matrix of the 111 Q-sorts was constructed and factor-analysed using the centroid method. The PQMethod software was used for this purpose (Schmolck, 2014). We used the varimax rotation method to approximate a

[5] https://github.com/aproxima/htmlq https://github.com/aproxima/htmlq (last accessed March 2018), based on the work of Hackert and Braehler (2007).

simple structure. We followed Brown (1980) recommendations and started with seven initial factors. The standard requirement in Q-methodological studies is that factors should have at least two Q-sorts that load significantly upon the factor. Because of our relatively large sample, we decided to only consider factors with three or more significant Q-sorts. We computed that loadings greater than $\pm$ 0.40 are significant at the 0.01 level[6] (see Watts and Stenner (2005) for the procedure). Three factors did not meet this second criterion and were removed from the analysis. In total, 92 of the participants load solely on one factor. Hence, 70% of the raw data (N = 130) or 83% of the cleaned data (N = 111) were used in the interpretation of the factors. The latter number is in line with previous studies that collected Q-sorts through face-to-face interviews (Cools et al., 2009; Kroesen & Bröer, 2009).

Finally, the Q-sorts were merged into factor arrays. A factor array represents a single 'idealized' Q-sort. In other words, the factor arrays represent hypothetical people loading 100% on the factors. Only respondents that solely and significantly load on a factor were used in the computation of the factor arrays. In line with our theoretical arguments made in the introduction, the factors are called frames from here on. The following section interprets the four frames.

3.3 Results

We labelled the four frames as follows: A: *The polluter should pay,* B: *Focus on fair alternatives*, C: *What's in it for me?* and D: *Don't interfere.* The interpretation of these frames will be described in this section. The similarities and differences between the frames can be derived from the factor arrays in Table 2. The values indicate how the 'idealized' Q-sort of each frame ranked the statements. Table 1 shows the main personal characteristics of the respondents per frame.

[6] We used formula $2.58 * (\frac{1}{\sqrt{N}})$ (with N = the number of statements).

Table 1 Main socio-demographics and travel habits

	Frame A	Frame B	Frame C	Frame D
Number of respondents	44	29	12	7
Highly educated	50%	45%	17%	57%
Gross household income per year in euros				
Not known	7%	34%	17%	29%
Less than 15,000	11%	14%	17%	14%
15,000-30,000	39%	28%	25%	14%
30,000-60,000	34%	24%	25%	14%
60,000 or more	9%	0%	17%	29%
Occupation				
(self)employed	52%	48%	36%	43%
unemployed	27%	24%	64%	29%
retired	20%	28%	0%	29%
Main mode of transport				
car	30%	41%	67%	71%
public transport	18%	20%	8%	0%
bicycle	52%	24%	17%	29%
walking	0%	14%	8%	0%
other	0%	3%	0%	0%
Car possession	57%	69%	91%	86%

3.3.1 Frame A: polluter should pay

People in the first frame are quite positive about road pricing (13:+4[7]; 14:+3). This frame is characterized by the high perception of a problem. The respondents find the current level of car use a big problem for the environment *and* the economy, both in urban as rural areas (1:+5, 2:+3 and 6:–3). They strongly agree that congestion levels should be reduced, but do not consider building more roads to be a good solution (3:–4 and 4:–5). They believe road pricing is technically feasible (19:+4 and 17:–3) and also expect it to be effective in reducing congestion and emissions (28:–3 and 22:–1). The people in this frame do not attach high (or low) values to statements related to equity (e.g. 29:+1; 30:–1; 31:–2), in contrast to the other frames. On the other hand, this is the only frame that attaches a lot of value to the outcomes of road pricing research (40:+4). These findings are in line with the explanations given by the respondents, for example: *'the polluter should pay', 'the air quality/environment is bad', 'paying per kilometre is very simple'*.[8]

In total, 44 respondents fit this frame and the frame can account for 17% of the total variance of the analysis. Looking at their personal characteristics, 57% own a car and 30% use the car as their main mode of transport. Most respondents use the bicycle or public transport as their main mode of transport, or they go by foot. 50% of the respondents are highly educated[9], 11% have an income (gross national household income) of lower than 15,000 Euros (three

[7] Read: the factor array attaches a value of +4 to statement 13

[8] On request, the author will provide the full list of comments given by the respondents.

[9] Highly educated: BSc degree or higher

respondents did not divulge their income). 27% are unemployed without having reached retirement age (67 years).

Altogether, frame A, '*The Polluter has to pay'* has a clear structure: the people find current car use a big problem and consider road pricing to be an effective and feasible solution to it.

3.3.2 Frame B: Focus on fair alternatives

People in the second frame are negative about road pricing (13:–3 and 14:–4). This frame is characterized by attitudes towards (income) equality. Although people in this frame consider current car use to be an environmental threat (1:+2), they would rather see improvements in public transport or other alternatives, instead of introducing road pricing (10:+4). Actually, they are already quite positive about the current public transport and bicycle infrastructure as alternatives to the car (7:+3). They consider road pricing unfair for people with a lower income (33:+5) and think that it will be mainly lease car drivers who will benefit from the system (35:+5). They are also afraid that road pricing would invade people's privacy (20:+3). In their comments, the respondents reveal that they find safety and health important and therefore they prefer public transport or the bicycle.

In total, 29 respondents fit this frame and it accounts for 11% of the total variance. Looking at their personal characteristics, 69% own a car, of which 41% use the car as their main mode of transport. 45% of the respondents are highly educated. Information about household income is scarce, since 10 respondents did not want to share information on their income. 24% are unemployed without having reached retirement age.

Overall, people in the '*Focus on fair alternatives'* frame find congestion a problem but consider road pricing to be an unfair solution that will only benefit a few groups. Instead, they prefer alternatives, such as public transport and the bicycle, that are open to all (income) groups and are environmentally friendly.

3.3.3 Frame C: What's it for me?

The people in the third frame are also negative about road pricing (13:–3 and 14:–1). This is the only frame in which the respondents clearly state that their opinion about road pricing heavily depends on their personal financial consequences (36:+5). Also, they most strongly disagree with the statement 'the government appeases the strong lobby of car owners too often..' (39:–5). In a similar way to all other frames, the people in this frame strongly agree that 'something has to be done' about congestion (3: –5).

Unlike the other frames, people in frame C do not want more investment in public transport / the bicycle system (10:–4). The construction of more roads is also not their preferred option (4:–4). People in frame C seem rather sceptical and state, in a similar way to people in frames B and D, that the effects of road pricing should be clearer before decisions can be made on implementation (8:+4). Unlike frame B, they slightly agree that road pricing should be implemented if research shows the scheme functions well (40:+3). However, currently, they consider road pricing to be unfair for those with a lower income (33:+5), for those who have to work (31:+4) and for those who live in crowded areas (32:+3). The comments given by the respondents indicate a lot of distrust of the government and the effectiveness of road pricing. They are also critical of public transport: 'the government is already investing in (and earning from) public transport'.

In total, 12 respondents fit this frame and it can account for 7% of the total variance. Looking at their personal characteristics, 91% own a car and 67% use the car as their main mode of transport. 17% (2/12) are highly educated. 17% have a gross household income of lower than 15,000 Euros/year. 64% are unemployed without having reached retirement age.

In conclusion, the respondents in the frame '*What's in it for me?*' seem afraid that road pricing will negatively affect their personal situation and need more information about how road pricing will affect them before they can form a final opinion. This is consistent with the socio-economic characteristics of the respondents. Indeed, except for one respondent, all respondents in this frame own a car and have a lower income and/or are regular car users. Thus, a road pricing scheme will probably affect them.

3.3.4 Frame D: Don't interfere

People in the fourth frame are also rather negative about road pricing (13:–2 and 14:–1). This frame is characterized by the sceptical attitude towards road pricing, road pricing institutions and politicians (38:–4 and 39:–34 and 41:+4). They consider road pricing mainly as another means for the government to raise more taxes (37:+5) and they do not believe road pricing will lead to a decrease in car use (22:+5). They are afraid road pricing will harm car users' privacy (20:+4) and prefer the current system because the costs are transparent (12:+3).

This is the only frame in which the respondents are very negative about public transport and the bicycle as alternatives to car trips (7:–5). They are not outspoken on whether the government should invest more in public transport (10:+1) and in contradiction to the other frames, frame D is not negative about the construction of more roads (4:+1). Like the other frames, they do think, 'something needs to be done about congestion' (3:–3), but their problem perception is not as dominant as in the other frames (e.g. 6:0). The respondents provided explanations, such as 'everything the government does, revolves around paying more taxes', 'it has to stay as it is now', 'the government is corrupt', 'public transport is bad', 'people who work are punished by road pricing'.

In total, 7 respondents fit this frame and it can account for 5% of the total variance. Looking at the personal characteristics, 86% own a car and 71% use the car as their main mode of transport. 57% (4/7) are highly educated. 29% are unemployed without having reached retirement age.

Altogether, frame D '*Don't interfere*' has a relatively clear structure: they are regular car users who find congestion a huge problem, but find road pricing neither a fair nor an effective solution. They trust neither the government nor the effectiveness and technique of road pricing

3.4 Discussion, Conclusions and Recommendations

3.4.1 Discussion and Conclusion

This study aimed to identify the frames around road pricing in the public debate in order to better understand attitudes towards road pricing instruments. Q-methodology enabled us to study subjective arguments in relation to each other and by this, reveal the underlying sets of 'beliefs and attitudes that give meaning to reality'. The analysis revealed four frames among the broader public in the Netherlands, which we have labelled: A: *The polluter should pay*, B: *Focus on fair alternatives*, C: *What's in it for me?*, and D: *Don't interfere*.

We found that factors such as equity, institutional trust, environmental beliefs, self-interest and belief in effectiveness are important aspects that constitute the frames. This is not surprising and is in line with earlier studies (e.g. Schade & Schlag, 2003a). Because of the holistic, person-centred, qualitative yet statistically rigorous approach, this study offers a fresh perspective on road pricing acceptability.

An illustration of a fresh insight is that previous studies found strong links between environmental concerns and positive attitudes towards road pricing (Eliasson & Jonsson, 2011; Hamilton, Eliasson, Brundell-Freij, Raux, & Souche, 2014; Kim et al., 2013; Schuitema et al., 2011), but we could distinguish *two* types of people with environmental beliefs: people within frames A and B. People in frame A confirm the strong relation between environmental beliefs and acceptance of road pricing. However, people in frame B reject road pricing, mainly because they find it unfair for those with lower incomes. Börjesson et al. (2015) also report on a correlation between environmental and equity concerns. Their factor analysis revealed four factors in total: environment/intervention, equity, pricing and taxation. The person-centred approach of Q-methodology, however, gives us the insight into the fact that people who are positive about pricing, can also score highly on environmental beliefs. And people who are negative about taxation, can be in three different frames (B, C and D).

Another illustration is that earlier studies reported a relation between self-interest and acceptability (Börjesson, Eliasson, & Hamilton, 2016; Schade & Schlag, 2003b). We also found this relation, since most people in frames C and D oppose road pricing and are frequent car users. The attitudes of people in frame C can largely be explained by self-interest. However, people within frame D show a more complex set of beliefs and values. It illustrates the paradox of liberals / libertarians, who usually like market-based solutions, but are negative towards road pricing. Their personal financial benefits are a neutral factor in the Q-set, but they oppose the instrument due to low trust in government and technology. Self-interest may still be applicable in this frame though. Bolderdijk, Steg, and Postmes (2013) found that privacy concerns regarding registration devices (e.g. GPS devices needed for road pricing) increase with the expected personal financial costs. In other words, people in frame D might have adopted these ‘privacy’ and ‘low trust in government’ arguments in order to justify their rejection of road pricing.

A final remark is that we found a clear relationship between frames and personal characteristics. In short, relatively many frequent car users are in one of the negative frames, while cyclists and train users are overrepresented in the positive frame A. We do not claim that the relationships between frames and personal characteristics are unidirectional; travel habits may influence the frame someone fits into, and the other way around. Indeed, according to the cognitive dissonance theory (Festinger, 1957), people try to keep their behaviour and attitudes in harmony. And Kroesen, Handy, and Chorus (2017) have empirically shown that attitude and travel behaviour mutually influence each other, whereby dissonant travellers are more inclined to change their attitudes than their behaviour. Thus, in line with these studies, someone in the ‘Polluter should pay’ frame who needs to travel a lot by car, might be more inclined to change his/her frame than his/her behaviour. These insights emphasize that the public debate is much richer than just an accept/reject situation: the frames found showed that there are many ways to say ‘no’ or ‘yes’ to road pricing. Indeed, people within frames B, C and D all oppose road pricing but have varying reasons for being negative. Thus, there does not seem to be one bloc that is opposed to road pricing and which shares the same beliefs and attitudes towards road pricing. Two people can have the same level of acceptability while having totally different underlying arguments. This has been made more transparent because Q-methodology takes a person-centred approach and consequently the heterogeneity of the public becomes clearer.

3.4.2 Recommendations for policy and research

The search for a widely supported road pricing instrument is probably an illusion considering the great heterogeneity of beliefs, values, preferences and worldviews regarding road pricing amongst the public. Nevertheless, the four frames provide some input on how to design, and especially how to implement, a road pricing instrument that will be more accepted among the wider public.

People within frame A are already in favour of road pricing. They attach a lot of value to the environmental aspect, hence it is probably important for them that a road pricing instrument leads to environmental benefits in order to be and stay acceptable. Although this group is already in favour of road pricing, they will only become strong proponents when they have a strong incentive to win according to the theory of client politics (see King, Manville, & Shoup, 2007). When people in this frame feel more in charge of the revenue spending, they may become better mobilized and can influence the political feasibility of road pricing. Furthermore, people in frames B and C find road pricing very unfair since wealthier people can more easily afford the charges. Many existing road pricing schemes are indeed at least slightly regressive, which means that lower income groups pay a larger share of their income on the charges (Eliasson, 2016). However, as Eliasson discusses, the economic motivation of a congestion charge is to correct the price of car driving by including the external costs. In that perspective, one can argue that in the current situation (without road pricing) driving is actually subsidized. Emphasizing that road pricing is an instrument to pay in a different way for transportation, rather than to pay more for road use may lead to higher acceptability among people in frame B. Especially if the scheme is designed to make lower income groups benefit overall from the system which can be achieved by using the revenues to fund (public) transport improvements that target lower income people. People in frame B show a positive attitude towards public transport after all. Although this requires a rather large paradigm shift since many people consider road infrastructure a public good that is and should remain for free. The expected growth in paying for mobility services (such as shared bicycle or car) instead for mode possession may help this paradigm shift in time. People in frame C on the other hand seem to care mainly about their own financial consequences of the scheme. If the road pricing revenues are used to lower the fixed road and car taxes, a share of the people in this (car driver) frame will probably financially benefit from it and support the scheme. Thus these two frames illustrate one of many political dilemma’s on how to design a road pricing scheme. Furthermore, people in frames C and D, seem more suspicious about road pricing and economic instruments (e.g. taxes) and the government in general. It is uncertain whether the attitudes and acceptability levels of these people towards road pricing can be influenced, but it would be interesting to study whether a scheme design that lacks any revenues for the government - such as tradable permits handled by a private party, for example - could increase their acceptance. Furthermore, more information and research about the effects of road pricing schemes might increase acceptability, especially for people within frames B and C. In particular, more certainty and a better understanding of the revenue recycling might decrease the lack of trust (Dresner, Dunne, Clinch, & Beuermann, 2006), which seems to be a fundamental problem for frames B, C and D, and increase acceptability (Borger & Proost, 2012). Although people may already develop more positive attitudes towards road pricing when they get the impression that introduction of a pricing policy is almost inescapable (Schade & Baum, 2007).

Q-methodology does not provide information on how the frames are distributed over the population but we expect that the distribution will vary across regions. Therefore, we recommend studying the regional differences using frames in order to gain insight into which scheme design will be most feasible per region. If, for example, a region has a lot of frame A types, that region might be a good starting point for implementing a road pricing instrument with environmental effects. When this instrument proves to be effective, acceptability in other regions might increase and the scheme can be extended.

Regarding the methodology, we found Twitter a useful and easily accessible source for collecting the statements. A disadvantage is that Twitter is probably dominated by people who are familiar with technology and Tweets are usually posted and shared by people with an (strong) opinion. Hence, individuals on Twitter do not necessarily represent all viewpoints in a population. For future Q-studies we would recommend complementing Twitter statements with statements from more ‘silent’ individuals. This can be done by using reactions to a survey question as we did, or by interviewing various individuals. Moreover, the arguments in the debate we found using Twitter data show more heterogeneity than what most conventional road pricing studies looked at. Statements such as ‘11: *innovations such as automated vehicles will solve congestion problems’*, ’18: *I’m afraid people will misuse the system and commit fraud’ and ’20: I am afraid that the government would get too much privacy-sensitive information on who drives where if congestion tax is introduced’* were repeatedly found in our search for statements. Especially the latter statement helped to explain the difference between the frames since the factor array differs between –2 (frame A) to +4 (frame D). Thus, Twitter may be a relevant source to supplement Q-sets.

This study is a first step and follow-up studies need to be done before we can draw conclusions about the relation between frames and the acceptability of various road pricing instruments. Nevertheless, we can conclude that studying the frames offers a fresh perspective on road pricing acceptability, since a person-centred approach provides more insights into the coherence of the underlying beliefs, motives and (subjective) arguments.

Table 2 Factor arrays of the 4 rotated factors

Statement	A	B	C	D
1 Car use is a big problem for the environment.	+5	+2	+1	–1
2 Current congestion is very damaging to the economy.	+3	0	+1	+2
3 It is not necessary to do something about congestion.	–4	–5	–5	–3
4 There are not too many cars, there are too few roads.	–5	–3	–4	+1
5 People take their car too easily now.	+5	+1	+2	–2
6 Cars do not cause many problems outside the urban areas.	–3	–2	–1	0
7 Public transport or bicycles are good alternatives to the car in most cases.	+1	+3	0	–5
8 First it has to become clearer what the positive and negative effects of road pricing are before the decision to implement it can be made.	+2	+3	+4	+5
9 Measures to reduce congestion need to be paid from general tax money and the government should not let only car users pay for it.	–4	–1	+2	+3
10 The government should invest in improving public transport / bicycle infrastructure instead of introducing road pricing.	0	+4	–4	+1
11 Innovations, such as automated vehicles, will solve most of the problems in time.	0	–1	+1	+2
12 The current taxes for cars (fuel excise duty, vehicle circulation and purchase taxes) are better than road pricing because now you know what the costs of a car are.	–4	0	–1	3
13 It is a good idea to make car users pay per kilometre (flat tax).	+4	–3	–3	–2
14 It is a good idea to make car users pay for busy roads during peak hours (congestion tax).	+3	–4	–1	–1
15 Road pricing is a relatively cheap measure to improve mobility.	+1	–3	–1	–3
16 The revenues raised by road pricing should be invested solely in improving the car system and not public transport.	–5	–4	+2	0
17 The design of a road pricing instrument that would really work and would not be too complex is impossible.	–3	0	–2	0
18 I'm afraid that many car drivers will take advantage of road pricing if it is implemented and commit fraud.	–1	0	–3	+1
19 Making car users pay for congestion tax is feasible with today's technology.	+4	0	0	–2
20 I am afraid that the government would get too much privacy-sensitive information on who drives where if congestion tax is introduced.	–2	+3	0	+4
21 If the government knows where all cars drive because of congestion tax, this information can be useful to redirect traffic in a better way.	+2	–2	+3	0

22 Car users will not reduce their road use if they have to pay to use the road.	–1	+1	–2	+4
23 Employers will be more inclined to introduce flexible working hours if a congestion tax is implemented.	+2	–1	+4	+1
24 It is a bad idea to make car possession cheaper, since people can then buy a (second) car more easily.	0	0	–4	–5
25 A flat tax will lead to a positive effect on the environment.	+2	–3	0	0
26 A flat tax will do the economy more good than harm.	0	–2	–3	–3
27 A congestion tax will do the economy more good than harm.	0	–1	0	–2
28 Congestion will not reduce through introducing congestion tax.	–3	+1	–2	+1
29 Everyone benefits from road pricing: you have to pay less or you can travel faster.	+1	–4	–1	–4
30 A flat tax is unfair for the people who do not have many alternatives; because they live in rural areas, for example.	–1	+2	+2	+3
31 Congestion tax is a punishment for people who drive to work.	–2	+3	+4	+3
32 It is unfair that people who live or work in a crowded area, like in many big cities, need to pay more for the congestion charge.	–2	+1	+3	+2
33Road pricing is unfair since wealthier people can afford it more easily than people with a lower income	–1	+5	+5	–1
34 Road pricing will not infringe people's freedom.	+3	–2	0	–1
35 Lease drivers, especially, will benefit from road pricing: their car expenses are paid for by their boss.	0	+5	+1	–4
36 My opinion about road pricing heavily depends on personal financial consequences.	–2	+2	+5	–1
37 Road pricing is mainly another way for the government to raise more taxes.	–3	+4	+1	+5
38 The government is capable of implementing a fair road pricing scheme.	+1	–5	–3	–4
39 The government appeases the strong lobby of car owners too often, while people without a car sometimes get overlooked.	+3	+2	–5	–3
40 If research shows that a certain road pricing scheme functions well, it should be implemented.	+4	–1	+3	0
41 Politicians change their opinion about road pricing too often.	+1	+4	+3	+4
42 If ever a road pricing scheme is implemented, it will probably be a scheme that is ineffective because of all the exemptions that will be thought of.	–1	+1	–2	+2

4 Exploring public perceptions of tradable credits for congestion management in urban areas

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Abstract - Congestion is threatening the accessibility and liveability of urban regions. Cities are usually hesitant to consider the effective, yet controversial idea of congestion pricing as a measure to abate the growing economic and environmental problems. In the longstanding search for an effective and acceptable pricing scheme, there has been an increased interest in tradable credits. Compared to charging instruments, this novel concept has the theoretical advantage that it can better address equity issues while effectively reducing congestion. Although one may argue that tradable peak credits (TPC) lead to higher public acceptability, very few empirical studies have researched this. Therefore, this study explores attitudes towards TPC using five focus groups with Dutch citizens. The participants were confronted with a hypothetical city where two instruments were suggested: peak charge (PC) and TPC. Most participants preferred PC and only two participants supported TPC while opposing PC. The advantages as addressed in literature played minor roles in the discussions. Participants revealed a skeptical attitude towards TPC or were more convinced about PC. Contrary to expectations, the attitudes became more negative as the discussions developed. Based on these insights, we propose directions for future research to assist the search for an acceptable congestion pricing instrument.

4.1 Introduction

Accessibility is essential for strong and vital cities, but is under pressure in many urban areas. Increasing congestion levels have led to a longstanding search for efficient measures to manage car use and to decrease additional emissions. Congestion pricing is widely recognized by transport economists as the best measure, in welfare terms, to abate congestion and optimise traffic flow when the expansion of infrastructure is impossible or unwelcome (e.g. Eliasson & Mattsson, 2006; Kim & Hwang, 2004; Seik, 2000). The effect of congestion pricing on emissions has received less attention but this also has promise (Cavallaro, Giaretta, & Nocera, 2018; Kishimoto et al., 2017; Miguel, Blas, & Sipols, 2017). Despite the strong theoretical arguments, the implementation of congestion charging is currently limited to only a few cities worldwide, including Singapore, Durham, London, Stockholm, and Gothenburg. Congestion charging schemes have proven very difficult to implement, mainly due to their typically low public acceptability (Vonk Noordegraaf et al. (2014) provide an overview of studies). Hence, many researchers have tried to explain why people accept (or reject) road pricing (Gaunt et al., 2007; Grisolía, López, & Ortúzar, 2015; Jaensirisak et al., 2005; Kim et al., 2013; Schade & Schlag, 2003a; Schuitema & Steg, 2008; Ubbels & Verhoef, 2006). These studies have revealed various reasons why people oppose congestion pricing including people's disbelief in the effectiveness and efficiency of the scheme, scepticism towards the government and how they will employ the revenues, the perception that the scheme will treat people unfairly, and the expectation that they will be financially ill-served. With these arguments in mind, transport economists have increasingly shown an interest in the concept of tradable credits[10] as an instrument to manage congestion (e.g. Raux, 2002; Verhoef et al., 1997b; Viegas, 2001).

Tradable credits for congestion management can have different designs, but the basic idea is that the government sets a 'cap' on the number of cars passing a certain point, area or stretch of road within a particular time frame and translates this cap into credits. These credits are distributed (via auction/booking or free allocation) among the participants (e.g. all car users or citizens) every week, month of other unit of time. Every time the participant passes that certain point (within a certain time) a credit is redeemed from her/his budget. Once the credits have been distributed, participants can trade the credits within the group of participants and this market of supply and demand determines the price of a credit. We refer to Fan and Jiang (2013), Grant-Muller and Xu (2014), and Dogterom et al. (2017) for reviews on the concepts of tradable mobility credits. A tradable credit scheme is, theoretically, effective due to the cap since it can reach that predefined cap/goal with the lowest possible social costs because of the use of the market mechanism allocating capacity efficiently, and it can address equity issues by distributing free credits while remaining budget neutral, i.e. there is no revenue flow to the government. In other words, it is expected not to be perceived as 'yet another tax'.

Because of these characteristics, one can argue that this budget-neutral concept can lead to higher acceptability levels than alternative policies such as a congestion charge. This idea is also supported by empirical studies done by environmental scientists that typically find higher acceptability levels for tradable carbon permits compared to alternatives such as a carbon tax (e.g. Bristow et al., 2010; IPPR, 2009; Owen et al., 2008; Wallace et al., 2010). However, no studies have yet been done to see if this also applies to tradable credits applied to congestion

[10] Other studies also refer to credits as permits or rights (Fan & Jiang, 2013)

management (henceforth: 'tradable peak credits' or 'TPC') (see Section 4.2). Indeed, TPC is a different policy compared to tradable carbon credits, with different policy aims and a different scheme design, so public opinions may be different.

This study aims to provide a first, in-depth, exploration of public opinion about TPC and systematically compares it with peak charge (PC), a similarly minded but simpler charging based measure. To that effect, this study employs a qualitative approach, making use of focus groups. This method gives participants room for discussion by asking them to share their ideas, views, and experiences of the topic at hand. Participants quiz each other and have to explain their arguments and standpoint to each other. This interaction allows them to build upon one another's arguments, revealing ideas that otherwise may have stayed unheard, and it also allows them to identify and counter each other's extreme views or thinking errors. Hence, focus groups do not only give insights into the ideas and thoughts of the individuals but also into their motivations and behaviour and the extent of agreement and disagreement (Morgan, 1996). Since TPC is a novel and complex concept which the respondents do not have any experience of, and probably do not have fully developed opinions about, using focus groups may help to develop those opinions in a more comprehensive way than an in-depth interview or survey would. The reason is that in the real world people do not develop their opinion about policy ideas in isolation but they can be influenced by the arguments of others, which is what is simulated in focus group discussions (Kitzinger, 1994). Hence, using focus groups may result in a richer, more in-depth and potentially more valid measurement of participants' opinions, compared to in-depth interviews with single participants.

We investigated people's reactions to the introduction of TPC in a hypothetical city. A sample of 36 residents from the Delft region participated in five focus group meetings. The sample was selected to represent diverse perspectives that may exist among the public in general.

Section 4.2 gives an overview of existing literature on the acceptability of road pricing and personal tradable credits to put the novel concept of TPC in perspective. Section 4.3 describes the methodology. Section 4.4 presents the results, which are reflected upon in Section 1.1. The chapter ends with conclusions, a reflection on the method, and recommendations for further study in Section 4.6.

4.2 Literature: acceptability of road pricing and personal tradable credit schemes

First, a short overview of factors related to road pricing acceptability is given in Section 4.2.1 Section 4.2.2 provides an overview of studies on the acceptability of instruments related to TPC, including personal carbon trading and tradable kilometre credits.

4.2.1 Acceptability of road pricing

Public acceptability of different road pricing schemes has been studied extensively (Schade & Schlag, 2003a). In general, public acceptability of congestion or peak charges is low. A recent survey in the Netherlands found that 32% of the public finds a peak charge acceptable (I&O research, 2019).

Studies have revealed many factors that influence road pricing acceptability. Socio-demographic factors are loosely related to acceptability levels. In most of the studies, acceptability is found to decrease with age (Jaensirisak et al., 2005; Nikitas, Avineri, & Parkhurst, 2011), to increase with educational level (Börjesson et al., 2015; Ubbels & Verhoef, 2006) and income (Glavic, Mladenovic, Luttinen, Cicevic, & Trifunovic, 2017; Golob, 2001), and males are on average more positive about road pricing (Börjesson et al., 2015). Most analysts agree that personal perceptions and norms have a much stronger predictive power than socio-demographic factors (Jaensirisak et al., 2005; Schade & Schlag, 2003a). In particular, perceived fairness seems to be strongly related to acceptability. Perceived fairness is ranked higher for road pricing schemes that are believed to protect future generations and the environment (reflecting environmental justice), than for policy outcomes that reflect equality or egoistic concerns (Schuitema et al., 2011). Acceptability levels further correlate with expected effectiveness, perceived infringement of freedom, problem perception, environmental concern, expected personal outcome and social and personal norms (Bamberg & Rolle, 2003; Eliasson & Jonsson, 2011; Jakobsson, Fujii, & Gärling, 2000; Rienstra et al., 1999; Sun et al., 2016). Related to expected personal outcome, non-drivers are more supportive of road pricing than car drivers (Grisolía et al., 2015; Jaensirisak et al., 2005). More recently, trust in the government has also been pointed out as a factor which affects citizens' perceptions towards road pricing (Eliasson, 2016; Glavic et al., 2017; Grisolía et al., 2015; Nikitas, Avineri, & Parkhurst, 2018). Some people also oppose congestion charging because they fear for privacy issues. However, the causality of these relations is sometimes unclear. Bolderdijk et al. (2013) showed that some people construe privacy concerns when they anticipate that the policy will lead to negative personal outcomes.

Regarding the scheme design, revenue allocation is identified as a key factor (Ubbels & Verhoef, 2006). Several studies found that acceptability is higher when the revenues are allocated to the transport system rather than when revenues are added to general public funds (Schuitema & Steg, 2008). Indeed, a group of people finds congestion charging ‘just an excuse to squeeze extra money from the citizens’ (Pronello & Rappazzo, 2014, p. 204). Also, scheme complexity seems to play a role, but not all of the existing literature is in agreement. Bonsall et al. (2007) conclude that people strongly prefer simple tariff structures, and in a similar way, Jaensirisak et al. (2005) found that people prefer fixed charges over variable charges, mainly because it is more transparent. Ubbels and Verhoef (2006) did not find a significant relation between complexity and acceptability. Furthermore, Glavic et al. (2017) found that people find charges during weekdays more acceptable than at weekends. In the Netherlands, at least, charge differences during the day are not appreciated; a flat kilometre charge can count on much more support than a peak charge (59% versus 32%) (I&O research, 2019). Furthermore, acceptability is negatively influenced by the amount of the charges (Glavic et al., 2017; Ubbels & Verhoef, 2006).

Besides the influence of socio-demographic characteristics, attitudinal variables and scheme design, it is important to note that acceptability levels are not stable but may change over time. In many cases, acceptability increases once a scheme is implemented (Börjesson et al., 2015; Schuitema, Steg, & Forward, 2010). Nilsson, Schuitema, Jakobsson Bergstad, Martinsson, and Thorson (2016) explain that this increase in acceptability is related to changes in beliefs; more specifically, an increased perceived ease of use of the scheme. They further discuss that opposition is not so much explained by specific expected outcomes of the scheme (e.g. decrease in congestion levels), but rather by emotional and value-related motives. Börjesson et al. (2016)

provide several other explanations for this shift in attitude and conclude that the status quo bias, in particular, played a major role in the change of attitude.

4.2.2 Acceptability of personal tradable credit schemes

Although we are unaware of any studies on the acceptability of tradable credits for congestion management, quite a few studies have been conducted on personal tradable credit schemes in the context of carbon reduction. These studies found that most people prefer personal carbon trading over an equivalent carbon tax (Andersson, Löfgren, & Widerberg, 2011; Bristow et al., 2010; Wallace et al., 2010) although the concept is still generally acceptable to less than 50% of the population. Tradable credit schemes that primarily aim to manage car use have hardly been studied at all. Kockelman and Kalmanje (2005) introduced a non-tradable, credit-based congestion scheme (CBCP) to a group of respondents. They found that 25% of the respondents supported the measure (which is similar to the acceptability level of a flat toll). They expect this figure to grow when people get more familiar with it and, in turn, they conclude that the measure can be a promising policy. Harwatt et al. (2011) interviewed households about a personal carbon trading scheme for car use and a comparable fuel price increase. The trading scheme was perceived as much fairer, more effective and more efficient. Overall, the trading scheme scored much higher on both personal as well as social acceptability levels. Dogterom, Bao et al. (2018) conclude from their experiment that 22% of Dutch car users and 67% of Chinese car users support a tradable kilometres credit scheme (Dogterom, Bao et al., 2018; Dogterom, Ettema et al., 2018). Van Delden (2009) studied the acceptability of a mobility budget among car drivers using focus groups. The author concludes that most car drivers accept the instrument, but think that the effectiveness would be very low due to the complexity of the scheme. Thus, studies on personal tradable credits show varying acceptability levels but also indicate that many people prefer the tradable scheme over an equivalent tax. Nevertheless, these results have to be interpreted with caution since the policies that were studied have different designs, scopes and policy aims.

4.3 Methodology

This section presents the design of the focus groups (4.3.1), the methodology (4.3.2) and finally the data analysis approach (4.3.3).

4.3.1 Design of the focus groups

Scenario

The participants were presented with a hypothetical case study. We presented the tradable credits in a simplified city because we are interested in the perceptions and feelings of citizens towards the general principle of trading for congestion management and we think presenting the scheme in an existing city can lead the discussion, unintentionally, to specific local issues. Also, a peak charge was included to make the comparison between TPC and peak charging possible, as it is likely that a real-world tradable credit scheme would be introduced as an alternative to a peak charge. Indeed, the Dutch public in general know about the idea of peak charges, since several variants have been discussed in the media (Smaal, 2012).

We used animated clips with a voice-over to explain the congestion levels in the city and the two instruments. The animations enabled us to explain the concept in the same clear way to all groups. The city consists of two parts connected by a bridge, where there is a severe bottleneck every morning. The clips explain that most congestion can be solved if the number of peak trips decreases by 15%. Hence, the number of credits matches 85% of the current peak trips. The characteristics of the two concepts are described as neutrally as possible. The clips do not explicitly point out the (dis)advantages of TPC over PC, nor are the negative consequences of the congestion levels (such as travel time uncertainty, and economic or environmental damage). See Appendix B for the English translation of the movie scripts[11].

Pilot

A pilot was conducted using students to test the animated clips and the discussion guide (see Table 3). This pilot provided a few insights that led to a few small changes in the order of the topics and included information about the effects of both instruments at the level of a car driver to make the concept less abstract. Also, we included a few questions whereby the participants were asked to answer simultaneously by using coloured voting cards. This forced them to reveal their initial impression before being influenced by each other's arguments.

Number and composition of the focus groups

Most focus groups consist of 6–10 individuals. The ideal group size depends on the topic (Morgan, 1996), but basically, the groups have to be small enough for everyone to have an opportunity to share insights and large enough to provide a diversity of perceptions (Krueger, Casey, Donner, Kirsch, & Maack, 2001). The composition of the group is also of importance as discussions may flow more smoothly in groups that are homogeneous rather than mixed (Morgan, 1996). When all members have something in common (e.g. social class), this leads to greater dialogue. However, differences between individuals are also important for a vibrant and ‘rich’ discussion (Kitzinger, 1994). Regarding the number of focus groups, two to three focus groups are likely to capture at least 80% of all themes if the groups are relatively homogeneous (Guest, Namey, & McKenna, 2016).

We included a relatively large share of car users since this category of people is usually the most strongly opposed to traditional road pricing schemes and dominate the public debate. We chose educational level as the homogeneous social demographic factor because we expected that mixing people with different levels of debating skills and economic knowledge could lead to less effective discussions. This led to five groups in total: lower educated car users, higher educated car users, lower educated mix in mode users, higher educated mix in mode users, and the pilot. The total of 36 participants is in line with recent studies using focus groups (Ferrer & Ruiz, 2018; Kurniawan, Ong, & Cheah, 2018; Nikitas et al., 2018). We included the pilot in the data analysis since the setup of the guideline hardly changed.

Sampling and recruitment

Respondents from the region of Delft were recruited through placing an advertisement in a newspaper and using the Facebook page of a local newsroom. Since we are interested in people's first reactions to TPC, the advertisement was kept rather generic. The text invited people for a discussion on mobility and several traffic measures. The participants were paid 40 euros[12] for participating, which we consider to be fair compensation for their time and travel costs. The applicants that fit our classifications and led to the most diverse sample in terms of

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[11] The animated clips can be found here https://doi.org/10.4121/uuid:ce7e45cc-4711-4382-a2e9-1bbf59ede0ed

[12] A person with an average income receives about 25 euros after taxes

social demographics and household characteristics were invited to the focus groups. This study aims to find a broad range of attitudes, opinions, and arguments, hence representativeness is not of importance. Rather, we made sure to include participants that can be expected to have a different viewpoint on road pricing (e.g. a mother with young children, a well-paid employee with a lease car, a highly educated bicyclist, a lower educated car user with a fixed working schedule, and a retired person with a lower income).

The sample contains 12 women and 24 men who are rather highly educated: everyone obtained at least a secondary school diploma and 75% obtained a bachelor's degree or higher. The average age is 43, with a relatively high number of participants (N = 10) under 30 years old and only 2 participants older than 65. Regarding their main occupation, 16 respondents work fulltime, 4 work part-time, 4 respondents are unemployed, 4 are retired and 8 are studying. Regarding their gross yearly household income, 27% of the participants earn less than 20,000 Euros (mostly the students) 30% between 40,000 and 60,000 Euros, 14% 60,000 Euros or more, and 9 participants did not reveal their income. Regarding household composition, 17% live alone, 67% with a partner and 14% with flatmates. People living with children represent 42% of the sample. One participant did not reveal one's household composition. Although we did not ask for participants' ethnic background, we think the viewpoints of lower-educated people with an immigrant background are not represented in this sample. The same applies to (older) people with reduced mobility. The participants' (replaced) names, main socio-demographic characteristics and travel habits can be found in the first nine columns of Table 4.

4.3.2 Data collection

The focus groups were conducted in Dutch, lasted around 100 min and took place in the period between November 2018 and February 2019. The second author was the moderator of the focus groups and the first author took notes. The moderator is an experienced moderator and to avoid researcher bias he was not involved with the design of the research until the focus groups actually started. The moderator followed a semi-structured discussion guide which was developed according to the recommendations of Morgan (1996), see Table 3. The focus groups ended with a brief survey.

4.3.3 Data analysis

All verbal data were transcribed. The participants' votes were also included in the transcriptions. We did not transcribe non-verbatim statements such as nodding one's head since this would have required using a video camera, which could have made participants feel uncomfortable. The reactions were systematically analysed following the principles for content analysis (Elo & Kyngäs, 2008). Content analysis is a method for identifying, analysing and describing categories within data in order to attain a condensed and broad description of the topic at hand. We chose to employ an open-minded, inductive, coding approach in which we analysed the data without any a priori theoretical assumptions because attitudes towards TPC have not been studied before and arguments may come up that are new to the road pricing debate.

Table 3 Discussion guide

Min	Round	Topics	Questions
10	Intro	**Introduction**, explaining rules, programme consent form	*1. Please tell us your first name, main occupation and most used mode of transport?*
15	1	**Problem perception**	*2. Is congestion a big problem in the NL? [vote: big problem or not such a big problem]* *3. Should the government invest in measures to reduce congestion, even if this at the expense of other investments, such as healthcare education or traffic safety?* *4. If the government wanted to reduce congestion, what would be the best solution?*
15	2	**Peak Charge**	*5. Do you think this is a good or bad idea? [vote: bad idea, good idea]* *6. What is your opinion about this instrument?* *Can you name advantages / can you name disadvantages?* *7. Do you think this instrument will be effective in reducing congestion?*
15	3	**Tradable credits**	*8. Do you think this is a good or bad idea? [vote: bad idea, good idea]* *9. What is your opinion about this instrument? Can you name advantages / can you name disadvantages?* *10. Do you think this instrument will be effective in reducing congestion?*
15	4	**Comparison**	*11. Which instrument do you favour? [vote: tradable credits, peak charge]* *12. Which instrument do you prefer (and why)?*
15	5	**Tradable credits in more depth & credit distribution**	*13. Do you have any advice on how to adjust this instrument?* *14. Do you think it is a good or a bad idea to implement such an instrument in the Netherlands? [vote: good or bad idea]* *15. Who would be eligible for the credits (and who not)?* *16. How should the credits be distributed over this group?*
10	Ending	**Final remarks and questionnaire**	*17. Can you name the most important aspect that was raised in the discussion about peak charge and tradable credits?*

4.4 Results

The results are presented in accordance with the structure set out in the discussion guide: the perceived advantages (4.4.1), the perceived disadvantages (4.4.2), expected effectiveness (4.4.3) and acceptability (4.4.4). The first two topics are the explorative parts of the discussion, without the researchers prescribing any factors or topics. The latter two topics were more focussed, narrowing it down to acceptability and expected effectiveness. These two factors were also addressed in the survey. Hence, these topics are supplemented with data from the survey. The results are based on participants' arguments, even if these were factually incorrect. Section 1.1 will reflect on the misperceptions. Furthermore, it is important to note that the results in 4.4.1, 4.4.2, and 4.4.3 are based on the TPC scheme in which the credits are allocated based on historical road use (see appendix B). In the second part of Section 4.4.4, different credit distributions and their influence on acceptability will be addressed. The names of the respondents have been replaced by fictional names for privacy reasons. We refer the reader to Table 4 to see the group structure and the participants' main characteristics.

4.4.1 Perceived advantages

When asked about advantages, most arguments relate to the potential effects on congestion. Participants argued that TPC makes car users more aware of the problem and their own behaviour, and it makes them think twice before driving in peak hours (Karst; Quint; David;

Cato; Brent; Valco; Lucas). In line with this, someone thought that putting the responsibility to alleviate issues that accrue from congestion onto the road users was a positive thing (David). TPC puts road users in charge of the problem. This can give them the feeling that they are responsible for the problem, and also have the possibility to solve it: *'TPC makes the users, the market, responsible for the problem instead of the government. Now, citizens have to solve the problem with each other; it can give them the feeling of having more control'* – David.

Some argued fewer peak trips will decrease congestion. A few participants pointed out that congestion will even be solved, at least in theory (Aron; Anna; David): *'The peak trips will be reduced by 15%. Thus, the problem will always be - kind of - solved'* – Anna. It is also mentioned that a reduction of congestion is beneficial for the environment (Yara). The participants revealed rather generic perceptions regarding the advantages of a decrease in congestion, i.e. only one person (Aron) pointed out that car users' travel time losses will be reduced.

Others think it is beneficial that the concept is new and trendy (Lara; Aron). Some considered trading as fun (Lara, Nadine).

When compared to the peak charge, six participants considered TPC to be a more positive instrument, since car users are also rewarded instead of only punished (Lucas; Nico; Nadine; Lara; Simon; Cato). Indeed, under peak charge, all car users travelling in peak hours have to pay (Britt; Nadine). A few also considered it to be an advantage that car users could financially benefit from it (Lara, Nadine): '*Personally, I would like this instrument. Indeed, I'm a civil servant and have many vacation days (..) Hence, I can benefit from the instrument* – Lara'.

The characteristic that revenues stay within the system was only mentioned once as an advantage: '*the nice thing about TPC is that the money stays within the* system' – Thijs. One participant argued that TPC has less impact on a frequent car user compared to peak charge and therefore it is preferred: '*In the TPC system, it is feasible to adapt your behaviour. Indeed, avoiding the peak with the car once a week is still doable.* – Ulrich' .

4.4.2 Perceived disadvantages

When asked about the disadvantages, the arguments are greater in number, and more diverse.

Most arguments relate to perceived unfairness. Participants argued that TPC is unfair since most people cannot avoid the peak and hence are forced to pay (Gideon; Marc; Christiaan; Tirza; Xander; Hugo). '*You are tied to commitments. I would hope that the government would let us do our work* – Gideon'. Also, people with a lower income will be affected more than people who can easily afford it, which is perceived as unfair (Emiel; Marc; Zach). '*I'm afraid this picks on the little people, who can barely afford this* – Marc'. Some are afraid that the credits will become unaffordable for normal people when rich people or companies buy all the credits (Rene; David; Wende; Xander). *'I fear that companies, only rich companies, would buy up a lot of credits (...) People who have to travel to visit a physician or so, won't be able to buy a credit anymore'* – David. Also, the allocation of credits is seen as unfair. The allocation proposed in the clip distributes the credits according to the historical use of the bridge. Participants found this unfair for people like visitors and tourists (Olive; Valco; Xander; Christiaan), but also for people who do not get any credits in the initial allocation because they have previously been using a bicycle or public transport instead of a car (Peter). Multiple participants argued this allocation has a perverse effect because it favours those who drive a lot and will continue to do so (Olive; Edwin; Zach; Willem; Yara). '*By selling your credit, you reduce your chance on more credits for the next week* – Olive'. Or as a participant summarizes: *'Everyone receives the same number of credits at the start. But some need more credits than others. So do you look at equality of needs, or equality of people? You never get that right'* – Zach. Lastly, some found the trading mechanism unfair because it is disadvantageous to people who do not understand the system very well, while it is advantageous to smart traders. People who are not used to working with digital systems, such as the elderly (Frits; Emiel; Jaap; Quint; Zach), or who are not familiar with this system because they are only visiting the city (Christiaan) are at a disadvantage. This entails the risk of excluding these people from the transport system during peak hours.

The complexity of the trading system is also a frequently mentioned disadvantage. The complexity of the system complicates the feasibility, implementation, and enforcement of it, which were also often mentioned as disadvantages (Hugo; Nico; Olive; Thijs; Rene; Ulrich; Valco; Xander; Aron; Britt David; Anna; Lara; Marc). '*I just can't get the picture. I think too many problems will arise during the implementation* – Aron'. Several participants argued that users can misuse the system (e.g. speculation or fraud) (Isaak; Olive; Tirza; Xander; Marc; Rafaela; Zach) and that trading can even lead to dangerous traffic situations if users are trying to buy a credit while driving the car (Aron; Lara; Quint).

Another main argument is the 'hassle' of the trading system, referring to the time and (mental) effort users have to spend on trading (Aron; Christiaan; Jaap; Frits; Nico; Olive; Simon; Vera; Xander; Cato; David; Brent). '*People already forget to pay for their parking ticket..*'- Frits. Some of them argued that the benefits (reduction of congestion) do not outweigh the costs of the system (including the mental costs) (Valco; Xander; Brent; Christiaan; Aron): '*TPC solves one little problem but spoils it for everyone. Does 15 minutes of waiting in congestion justify TPC? Well, no!*' – Xander.

Lastly, some pointed out the invasion on people's privacy as a disadvantage (Marc; Maureen; Olive).

When comparing the two instruments, several participants argued that TPC has lower feasibility (Christiaan; David). The instrument is more complex and entails risk in implementation and enforcement. '*The peak charge system seems easier to implement, and also easier to explain...and it just seems more practical for everyone'* – Christiaan. Also, participants who were in favour of TPC acknowledged the difficulties regarding implementation: *'I agree that TPC will be difficult to enforce, but I also think that, if it is made feasible... it would be a rather fair system'* –Ulrich.

Furthermore, in a TPC system, the prices are uncertain, whereas with a peak charge system everyone knows the costs (Brent; Wende; Quint; Tirza); '*The price of a credit can already have increased in the time between leaving your house and crossing the bridge'* – Wende. Therefore, PC is also seen as fairer: '*in PC, the prices are the same for everyone. In TPC it might be that your neighbour pays just 70 cents while I have to pay 5 Euros'* – Cato.

Lastly, several respondents argued that a peak charge provides revenues, which are seen as something positive since it is an incentive for the government to improve the transport system (Yara; Rafaela; Simon; Wende): *'Although I acknowledge that a revenue flow to a government* *that can spend it freely has disadvantages… at least that money can be used to stimulate a pleasant environment'* – Wende.

The fact that TPC is much cheaper for a frequent car user compared to the peak charge does not seem to influence many people: '*the problem is, TPC still hits the lower income groups harder' – Zach. 'Why should this cost money, again?*' – Emiel.

4.4.3 Expected effectiveness

The animated clip explained that the total number of credits is based on the capacity of the bridge, which lies 15% lower than the current demand which is causing the congestion (see Appendix B). Nevertheless, only a few respondents argued that, due to this cap, TPC is potentially very effective (Anna; Aron; Peter; Cato). *'In principle, this solves all congestion because all overabundant cars are removed* – Cato'. Many participants had their doubt about the effectiveness, for diverse reasons:

- People will misuse the system (Britt; Aron; Zach; Xander; Tirza; Isaak; Olive; Rafaela; Marc; Simon) and, for example, commit fraud, hoard the credits or hack the system. This strategic trading behavior can lead to undesired side-effects, such as brokers pushing up the credit price. Participants draw the comparison with the extreme resale prices of concert tickets and the unpredictable volatility of bitcoins: *'Some will make a business case out of this; they buy credits they don't need, to sell them at a different moment. Like what happens with concert tickets'* – Xander.
- TPC will cause new congestion. Because the peak will shift in time (David; Britt) or because the physical toll gates of a TPC system will create new congestion (Marc)[13]. *'If no one wants the pay, everyone will use the road at a different time of day which will create a new peak period'* – David.
- It will work only temporarily (Cato; Wende; Rafaela; Hugo; Isaak; Jaap)[14]. '*At a certain point, when the demand decreases because more people start to take the bus, the price will also decrease. Consequently, it will become more attractive to take the car again. This way, you maintain the demand for car use'* – Cato.
- People will continue to drive in the peak hour and just accept the 5 Euros fine they receive (Aron; Simon; Willem; Wende)[15].'*It's not fool proof because of that fine of 5 Euros. Will that stop people from using the road? Not me.'*- Wende.

Furthermore, it is argued that TPC is not effective because it does not solve the real problem: '*The real problem is the congestion caused by accidents, which lead to very long and unreliable extra travel time'* –Tirza.

In the post-survey, the participants were asked to express their expectations of the effectiveness of both instruments on a 5-point Likert scale. 15 participants (strongly) agreed on the question

[13] Marc made a wrong assumption regarding the physical toll gates: the animations explained and visually showed that the credits would be redeemed automatically.

[14] It seems that several participants did not understand that TPC is able to attain the given goal for a reduction in peak trips, even if the demand increases, since the number of credits is an absolute constraint.

[15] They misinterpreted the information in the movies. The animations explained that if a car user crosses the bridge without a credit, (s)he will receive a fine and has to pay 5 Euros *+ the credit price*.

'*I think TPC reduces the congestion'*, whereas 10 answered neutral and 11 (strongly) disagreed. Regarding the question: '*I think TPC reduces the impact of the car on the environment'*, 12 (strongly) agreed and 17 (strongly) disagreed. The expected effectiveness is higher among the people who oppose TPC.

4.4.4 Acceptability

The first half of this section presents the results based on the arguments provided in round 3 and 4 about the TPC scheme with credit allocation based on historical use. Some participants changed their attitude towards TPC during the discussion which will be discussed in the second part of this section. That part also presents the influence of different credit allocations on support.

Five types of supporters and opponents

The reactions towards TPC in terms of support or acceptability were very heterogeneous. First, we distinguished three groups: opposing TPC, supporting TPC and a neither supporting nor opposing group. After clustering the arguments of the people in these groups, we could distinguish two types of opposers, and two types of supporters. We analysed all participants and their arguments again and could place 35 participants within one of the following homogeneous groups that we labelled as: fiercely opposed, clearly opposed, doubtful, approving, and opportunistic.

Nine participants strongly rejected both instruments (Maureen; Emiel; Jaap; Frits; Tirza; Isaak; Marc; Gideon; Hugo). They consider congestion to be a problem which should be solved by the government, without harming car users. TPC is considered as: *'A cheap non-idea. The government is saying; figure it out yourself'* – Gideon. Most of these participants reacted to both of the instruments suggested in an annoyed way and deviated from the discussion by repeatedly providing other ideas to combat congestion, including improving people's driving ability, park & ride facilities and extra lanes. Advantages, such as the lack of revenue for the government, were dismissed with the argument that the government never offers anything for free. Most of these people expressed a critical attitude towards the government. All of the people in this group use the car as their main mode of transport.

Fourteen participants clearly opposed TPC (Christiaan; Willem; Aron; Yara; Thijs; Zach; Anna; Rene; David; Brent; Simon; Wende; Xander; Peter). They showed a good knowledge of the Dutch transport system and other policy ideas. They were convinced that other policies or technologies can offer more effective and efficient solutions. Most of them supported the peak charge concept since they consider it an effective, simple instrument for managing congestion. Also, several people in this group emphasized that a financial instrument should be part of a larger transport policy including soft measures, such as flexible working hours. One of them, however, argued that he would support the implementation of TPC since '*any policy is better than the current system'* – Peter. Only three of them use the car as their main mode of transport. Most people in this group use a bicycle or train as their main mode.

Six participants (Cato; Quint; Olive; Ulrich; Vera; Britt) showed an open attitude towards the concept of TPC but did not take a strong position in either accepting or rejecting it. On the one hand, they see the advantages of the instrument and they reacted positively when the concept was presented. They like the positive approach that TPC has, compared to peak charge, and as Ulrich said, '*it is very hard for many car users to avoid the peak time five days a week, but with TPC you only have to reconsider your peak trip once a week'*. However, they also see many barriers and they became more negative about the implementation and feasibility of the concept during the discussion: '*At first, I found TPC a nice idea. But I believe disadvantages, in particular, will keep on emerging from the discussion'* – Quint. Half of them (3 out of 6) use the car as their main mode of transport.

Four participants supported TPC because they think it is necessary to implement a financial incentive to reduce congestion, regardless of whether the scheme is budget-neutral (TPC) or not (PC) (Lucas; Nico; Karst; Valco). They find congestion a big problem and feel that car users are (partly) responsible for solving it. Their main arguments are related to their belief in the effectiveness of the instruments. They find TPC more 'positive' but also mentioned disadvantages regarding practicability. All of them use the car as their main mode of transport.

Two participants (Nadine, Lara) were positive about TPC while rejecting the peak charge. They stated that TPC would be a fun instrument and both argued that they would probably benefit from such a system since they have flexible workings hours and can easily avoid peak times if they want to. Both use the car as their main mode of transport.

Figure 6 provides an overview of the respondents' acceptability levels, based on the answers in the post survey. 20% of the participants (strongly) agree with the statement 'I find tradable peak credits an acceptable system' and 58% state this about the peak charge instrument (using a five-point Likert scale). When we only consider the car users (N = 21), these numbers are 29% and 43%, respectively.

The acceptability of TPC is comparable what was found in the study done by Dogterom, Bao et al. (2018) where it was found that 22% of the car users accept tradable kilometre credits, and by Kockelman and Kalmanje who found support levels of 25% for credit based congestion pricing (Kockelman & Kalmanje, 2005). For tradable carbon permits, public acceptability typically lies between 36 and 44% (Andersson et al., 2011; Bristow et al., 2010; Wallace et al., 2010). The acceptability of the peak charge is relatively high in our sample, given that a recent opinion study found that about 32% of the Dutch population supports a congestion charge in the Netherlands (I&O research, 2019).

The answers given by a few participants in the survey seem to deviate from what their positions were during the discussion. Peter was very critical of TPC during the discussion, but in the post survey he agreed with the statement '*I find TPC an acceptable system'*. Also, Hugo, Isaak and Marc had a more critical attitude during the discussion than in the survey. Peter explained himself by stating that although he strongly prefers the peak charge, he would still support TPC since '*any policy is better than the current system'* – Peter. The other four participants did not explain their attitude, but a similar explanation may apply to them. Isaak, and Marc may consider TPC the least bad option, and Hugo may consider the peak charge the least bad option.

Shifts in support

Acceptability was also measured right after the explanation of TPC to force participants to reveal their initial response to TPC before they could be influenced by each other. This allows us to identify any shifts in acceptability. Thijs, Ulrich, Olive and Rafaela became more negative towards TPC during the discussion as can be seen in the tenth and eleventh column of Table 4. Peter was the only participant who became more positive about TPC as explained above. The data of the first group are incomplete because the voting cards were not yet introduced. The change in standpoint will be discussed in Section 4.5.2.

Since the distribution of the credits was expected to have a big impact on acceptability, the participants were also asked about their preferred credit allocation. Participants had rather differing ideas for credit distributions:

- Equal credits for *everyone* (Frits; Hugo;) or *for all inhabitants* (Peter; Yara; Zach), or for *people who use the road* (including cyclists etc.) (Thijs), or *for a combination of regular road users and inhabitants* (Ulrich).
- Equal allocation *for all cars / car owners* (Isaak, Jaap; Tirza; Quint; Simon) *with extra credits for families* (Maureen).
- An *allocation based on historical road use* (Lucas; Willem), *that takes into account (changing)* needs (Lara; Nadine).
- *People who make trips that are more important for the economy receive more credits* (Olive; Valco) or *credits should be distributed among companies* (Rafaela).
- Furthermore, Karst prefers a '*very simple allocation'*, and quite a few others refused to answer this question (Gideon, Rene, Wende, Xander).

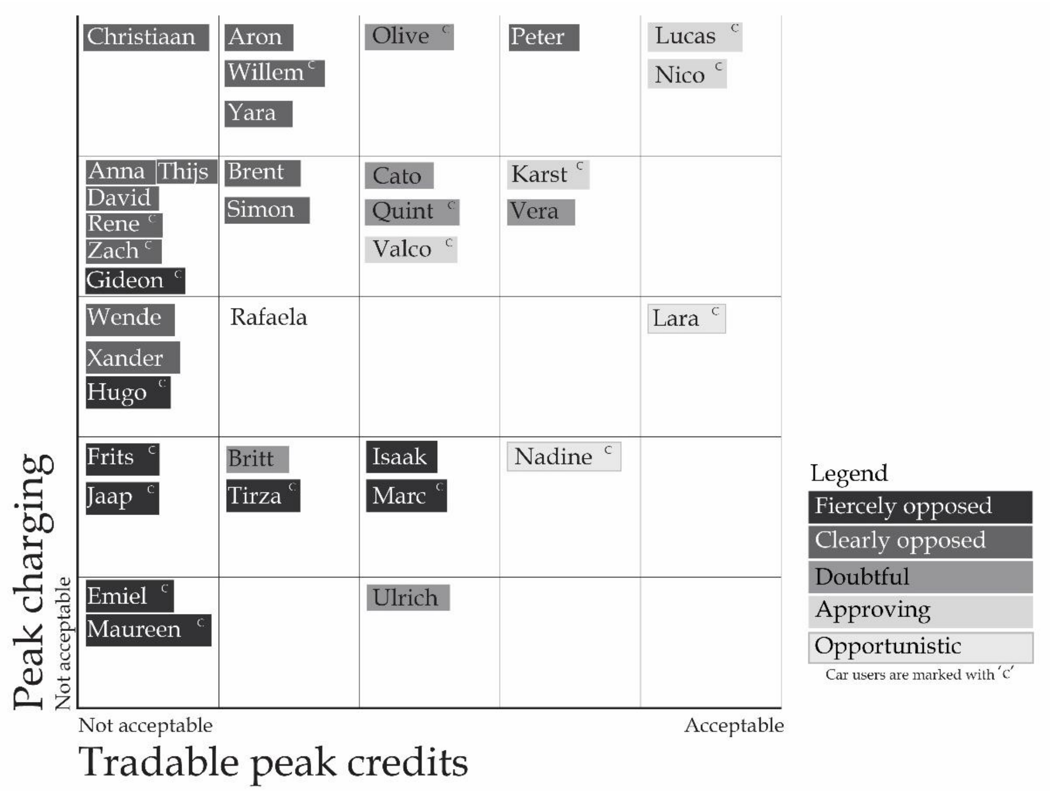


Figure 6 The participants' acceptability levels. The position of the names represents the respondents' answers to the statements in the post-survey: 'I find tradable peak credits an acceptable system' and 'I find peak charge an acceptable system', using a 5-point Likert scale ranging from 'strongly disagree' to 'strongly agree'. One person (Rafaela) did not provide enough arguments to be able to label her.

The last column of Table 4 shows the support for TPC given that the credits are allocated according to people's own preferred allocation. In total, ten participants changed their acceptability level towards a more positive attitude. Thus, about 20% of the participants consider TPC to be acceptable as presented in clip 3 (in which credits are allocated based on historical road use), and this rises to about 40% when the credits are distributed according to people's own preferred allocation.

Table 4 Main personal characteristics of the participants and their attitude towards TPC before and after the discussion.

	Name	Personal characteristics								TPC support			
										Start	Post survey		
		Sex	Age range	Education	Children	Occupation	main mode	car use	Peak trips	Bad/good	acceptable	vote	Own allocation
Group 1 (pilot)	Anna	F	20-29	B	N	Student	bicycle	monthly	< 1		1	×	×
	Aron	M	20-29	B	N	Student	train	monthly	< 1		2	×	×
	Britt	F	20-29	B	N	Student	bicycle	weekly	< 1		2	?	?
	Brent	M	20-29	B	N	Student	bicycle	(almost) never	< 1		2	?	✓
	Christiaan	M	20-29	B	N	Student	bicycle	few times a week	< 1		1	×	?
	Cato	F	20-29	M	N	Student	bicycle	monthly	< 1		3	×	✓
	David	M	20-29	B	N	Student	train	(no driver license)			1	×	×
Group 2	Emiel	M	70-79	HSD +1	N	Retired	car	few times a week	2	×	1	×	1
	Frits	M	30-39	HSD +2/3	Y	Fulltime	car	daily	5	×	1	×	3
	Gideon	M	-	B	N	Entrepreneur	car	few times a week	<1	×	1	×	1
	Hugo	M	30-39	HSD +2/3	N	Fulltime	car	daily	5	×	1	×	2
	Isaak	M	50-59	HSD	N	Fulltime	car	daily	5	×	3	?	4
	Jaap	M	60-69	HSD	N	Unemployed	car	few times a week	<1	×	1	×	1
	Karst	M	70-79	HSD	N	retired	car	few times a week	<1	✓	4	✓	3
Group 3	Lucas	M	50-59	M	N	fulltime	car	weekly	<1	✓	5	✓	4
	Lara	F	30-39	B	N	fulltime	car	few times a week	3	✓	5	✓	5
	Marc	M	50-59	M	N	retired	car	daily	3	×	3	×	3
	Maureen	F	50-59	B	Y	unemployed	car	few times a week	2	×	1	×	1
	Nico	M	30-39	M	N	fulltime	motorcycle	daily	5	✓	5	✓	5
	Nadine	F	40-49	B	Y	part-time	car	few times a week	2	✓	4	✓	4
	Olive	F	30-39	M	Y	unemployed	car	daily	3	✓	3	✓	3

Continuation of table 4

Group 4	Peter	M	20-29	M	N	part-time	bicycle	(almost) never		×	4	?	5
	Quint	M	40-49	HSD	Y	fulltime	car	few times a week	5	×&✓	3	?	3
	Rene	M	50-59	B	N	fulltime	truck	daily	5	×	1	×	1
	Rafaela	F	20-29	HSD	N	student	tram/metro	(no driver license)		✓	2	×	4
	Simon	M	50-59	B	N	fulltime	bicycle	weekly	<1	×	2	×	3
	Thijs	M	60-69	M	N	unemployed	bicycle	weekly	<1	✓	1	×	4
	Tirza	F	60-69	B	N	retired	car	few times a week	<1	×	2	×	2
	Ulrich	M	50-59	HSD+2/3	N	fulltime	car	daily	5	✓	3	▫	4
Group 5	Vera	F	60-69	B	N	part-time	bicycle	weekly	1	✓	4	?	4
	Valco	M	50-59	B	N	fulltime	car	daily	5	×&✓	3	✓	4
	Wende	F	50-59	M	N	part-time	bicycle	few times a week	1	×	1	×	1
	Willem	M	40-49	M	Y	fulltime	car	few times a week	4	×	2	×	4
	Xander	M	40-49	PhD	Y	fulltime	bicycle	weekly	<1	×	1	×	1
	Yara	F	30-39	M	Y	fulltime	train	(almost) never	<1	×	2	?	3
	Zach	M	20-29	M	N	fulltime	car	few times a week	2	×	1	?	4

Notes:
Education: highest achieved diploma where HSD stands for high school diploma; HSD + X stands for high school diploma + X years; B stands for Bachelor's degree; M stands for Master's degree; PhD.
Children: whether they have a child/children younger than 12 years old in their household (Yes / No).
Main mode: the mode they use to cover the largest distance on an average day (Monday to Friday).
Peak trips: average number of times they use the car in morning peak hours (07:00-09:15) in an average week (Monday to Friday).
TPC bad/good at start: this standpoint was measured right after the explanation of TPC and before the discussion started. It was measured using the coloured cards on the statement 'TPC is a good (✓) or bad (×) idea'.
TPC acceptable in post survey: this standpoint was measured with the statement 'I find TPC an acceptable instrument' on a five-point Likert scale (1:totally disagree to 5:totally agree).
TPC vote in post survey: this standpoint was measured with the question 'in a referendum setting where TPC is suggested, I would vote...' (× stands for against; ✓ stands for in favour; ? stands for I don't know; ▫stands for a blank vote).
TPC own allocation in post survey: this standpoint was measured in the post survey with the question 'I find TPC an acceptable instrument if the credits are distributed according to my own preference' on a five-point Likert scale (1:totally disagree to 5:totally agree), or in the case of the pilot: 'in a referendum setting where TPC with my own preferred credit allocation is suggested, I would vote…' (× stands for against; ✓ stands for in favour; ? stands for I don't know; ▫stands for a blank vote).

4.5 Reflection and discussion

A wide range of perceptions, opinions and arguments were presented in the previous section. This section reflects upon the results, and discusses a few insights.

4.5.1 Theoretical advantages of TPC

As stated in the introduction, current literature on tradable credits outlines certain benefits of the system. Obviously, the main advantage of TPC (or any road pricing instrument) is that it reduces congestion which can relieve economic and environmental traffic problems, including pollution and health problems, traffic noise, travel delays, travel time uncertainty, and insufficient room for active modes. Nevertheless, the majority of the participants maintained their rather generic standpoint about traffic problems and the potential advantages of TPC/PC, especially about the environmental advantages. When the discussions started with the question 'is congestion a big problem in the Netherlands?', almost everyone agreed that congestion is a big problem and participants gave different arguments related to economic damage or annoyance for road users. Only two participants explicitly mentioned environmental damage/emissions as a current problem and only one participant explicitly mentioned 'less pollution' as a potential advantage of TPC. These participants did not get response from other people in their group so their argument quickly died in the discussion. This lack of arguments related to environmental problems is remarkable since, as Schuitema et al. (2011) showed, for many supporters of road pricing, environmental justice is the main reason to support a road pricing instrument. The link between environmental arguments and supporters was also found by Pronello and Rappazzo (2014) in their focus groups about a road charge that would be in force between 7.00 a.m. and 7 p.m. in Lyon, while in our study, it seems that these environmental arguments did not play a major role for most supporters (or opponents) of TPC or PC. Although peak hour based schemes also lead to positive effects on emissions (Cavallaro et al., 2018), it may be that participants underestimate these effects. It may also be that this lack of environmental arguments was related to the framing in our study in which TPC and PC were both presented as possible solutions to manage car use and reduce congestion, and the participants were not provided with extra information on the potential impact on pollution, for example. In contrast, Pronello and Rappazzo (2014) presented transport policies as instruments to tackle congestion and pollution and most surveys about road pricing acceptability explicitly ask respondents about their environmental attitudes. This underlines that the way in which a policy is presented, can influence the outcomes.

Furthermore, TPC has some unique characteristics compared to traditional congestion charge schemes which may lead to higher acceptability. These include the higher effectiveness due to the cap, the free allocation of credits which can address equity issues and the absence of any increase in (coercive) collective payments. These characteristics, however, were not mentioned at all, or were barely mentioned, as advantages in the discussions. Most participants expect that TPC will decrease congestion, but not as much as a peak charge will. Only a few participants seemed to understand that a cap-and-trade system is theoretically more effective in reaching the predefined goal of peak trips. Interestingly, almost everyone indicated in the first round that congestion is a big problem and the government should do something about it, but as soon as TPC was introduced, some of them fine-tuned their argumentation and argued, for example, that travel time loss is not the problem, but the high unreliability in travel time caused by accidents is. TPC will not solve that problem. Others argued that the congestion levels are not severe enough to justify the implementation of TPC.

The lack of revenue for the government was not seen as an advantage by the majority of the participants. Some argued that revenue from a peak charge is an advantage since the government can use it to improve alternatives or infrastructure. But also, those who disliked the revenue stream from a peak charge, did not consider the lack of revenue in TPC to be an advantage. They do not believe TPC will be budget neutral and consider it a tax.

With respect to the distribution of costs and benefits, current literature argues that the TPC scheme can address equity issues related to traditional charging schemes by the distribution of free credits: this offers participants the opportunity to avoid any costs or even financially benefit from it, and it provides regulators a flexible tool with which they can control the distributional outcomes. However, only one participant argued that the (free) credit distribution could reduce equity issues, although many considered the allocation to be a difficult or even unsolvable task. The participants were first shown a TPC scheme in which credits are allocated based on historical car use. The fact that car users would be far better off financially through TPC considering this allocation compared to a peak charge scheme seems to be the deciding factor for the two ‘opportunistic’ participants, and their reason to support TPC. Unsurprisingly, many participants who use public transport or bicycle opposed this allocation and consider the scheme unfair. But also when the discussion started about other potential credit allocations, participants argued that regardless of the allocation it would still hurt certain groups disproportionally (such as people on lower incomes) and therefore it is unfair. Moreover, some found it unfair that TPC can provide the better/smarter traders with advantages.

4.5.2 Changing opinions

Participants developed their opinion during the discussion and some changed their position regarding the concept. In the post survey, 17 participants stated that they became more negative about the concept during the discussion, whereas 10 participants became more positive. 9 participants did not change their opinion about TPC, either positively or negatively. Self-report has limitations, but the evolving opinions were also noticed during the discussion. Some participants enunciated their strong opinion, without being visibly influenced by other people's arguments. However, most participants reacted to each other's arguments, bringing the discussion to a higher level. A few changed their standpoint about TPC towards a more negative position, namely Thijs, Ulrich, Olive, and Rafaela. At first, they were positive about TPC but became neutral or even negative by the end of the discussion. Arguments about the implementation issues, in particular, seemed to persuade them to move towards a more negative attitude. This observation of opinions becoming more negative may seem to be in contrast with Nikitas et al. (2018) who reported how participants in their focus groups changed their attitudes regarding conventional road pricing in Bristol. In their focus groups, seven participants (out of 30) changed their standpoint, with five becoming more positive. A possible explanation for this difference is that in a discussion on regular road pricing, proponents can convince others about the effectiveness of road pricing using a multitude of evidence and experts opinions. Whereas in a discussion about TPC, evidence and the opinions of experts that advocate the scheme are lacking.

4.5.3 Misperceptions

Even though the concept was explained by using a simplified case study, and the participants were relatively highly educated, the number of misperceptions about the scheme and its effects was quite high. In the post survey, two-thirds of the participants (fully) agreed with the statement: 'I find tradable peak credits perfectly understandable'. Nevertheless, at least 13 participants interpreted TPC (partly) incorrectly. It was hard for many participants to fully grasp the market mechanism, see Section 4.4.3. The cap-and-trade principle was hard to fully understand for many people, or, they did not believe the mechanism would work. Participants argued that TPC would not work since car users would simply accept the 5 Euro fine, neglecting the information from the video that explained that the fine would be 5 Euros + the cost of a credit. Others thought the expected increase in future car use would lead to more credits and hence congestion. Market mechanisms and trading are not common practice for most citizens, and they are totally different from current policies concerning citizens. This finding is in line with the results of Owen et al. (2008), who conducted focus group sessions on tradable carbon permits and report that quite a lot of participants had difficulties in grasping the concept of trading. On the other hand, participants did seem to understand the concept of a peak charge. It is unknown whether the misperceptions about TPC are caused by the lack of familiarity with the concept, and/or by the complexity of the scheme. This is relevant for further study since understanding a policy is considered to be a requisite for accepting it (Schlag & Teubel, 1997).

4.5.4 Opponents acted more fiercely than supporters

Lastly, when we compare the supporters of TPC with the opponents, we notice that many of the opponents had a much fiercer attitude. This is not surprising and has also already been described in congestion charging literature (Pronello & Rappazzo, 2014). It can be explained by prospect theory (Kahneman & Tversky, 1979): losses hurt more than similar gains feel good.

4.6 Conclusion, policy relevance & next steps

This study is the first exploration into public perceptions of the extremely novel policy concept of personal tradable credits for congestion management (TPC). To that end, 5 focus groups were employed in which 36 Dutch citizens participated. They discussed the (dis)advantages, expected effectiveness and acceptability of a peak charge (PC) and a TPC system.

The participants were heterogeneous in their perceptions and opinions, but we could distinguish five main types of reject/accept positions. The majority of the participants rejects TPC. One homogeneous group fiercely opposes any policy instrument that can disadvantage car users, regardless of the costs for the car user. The other homogeneous group of opponents simply do not see the point of making all the effort and taking all the risks associated with the implementation of TPC while simpler instruments, such as the peak charge, have already been proven to be effective and efficient. Of the minority that supports TPC, two people supported it mainly through self-interest. Four participants liked the positive framing of TPC, but also mentioned the difficulties regarding the feasibility. Lastly, six people initially liked TPC, but changed their mind during the discussion and moved towards a more neutral position.

On average, PC is considered more acceptable than TPC. This outcome contrasts with the studies on tradable carbon permits, which typically find higher support for tradable schemes compared to an equivalent tax as discussed in Section 4.2.2. A possible explanation is that TPC means that the user is required to do more transactions, while in a tradable carbon scheme, users can trade on a yearly basis. The method employed might also explain (part of) the differences in the results. We saw that participants developed their opinion about the topic having heard each other's arguments, and some of the people who were initially positive about TPC became more negative. Most of the earlier studies employed methods that did not have this influence, such as interviews or surveys. But the bottom line is that only seven participants (20%) found TPC to be an acceptable instrument. This number doubles when participants may decide their own credit allocation. Thus, even when people may decide the credit distribution and hence influence the welfare redistributions, many people still reject TPC.

There is plenty of overlap between current literature on road pricing and the arguments that emerged during the discussion. Arguments related to fairness/ equity, effectiveness, and trust in government were the main themes, which is similar to discussions on conventional road pricing (Grisolía et al., 2015; Liu et al., 2019; Nikitas et al., 2018; Pronello & Rappazzo, 2014). A few new themes emerged from the discussion that have barely been studied in the light of TPC's acceptability: the ‘hassle’ (time, effort), the perceived complexity and, related to this, the intelligibility and user friendliness. Respondents, including the supporters, also expressed their concerns about the chance of misuse and the (technical) feasibility of the instrument. Moreover, a new type of perceived unfairness arose in the discussion. Opponents do not only find TPC unfair since it disadvantages lower incomes and people with (fixed) schedules, but also since it disadvantages people who are not the smartest traders or who receive no credits because they did not use the bridge in the past. The only positive new aspects are that some find trading and the expectations of financial gains ‘fun’ and some argue that TPC will lead to increased awareness and it is a better motivational mechanism. In contrast to previous road pricing literature, this study found that environmental arguments were quite rare in the discussion.

Trading the right to access public property, such as road infrastructure, is a drastically new idea. Some of the objections opponents have, can be solved by the way of communication or by adjustments to the scheme design. This topic needs further study. Indeed, negative media coverage and unsuccessful communication are potential fail factors in road pricing implementation (Ardıç et al., 2018; Vonk Noordegraaf et al., 2014) and tailoring information with respect to people's values can be effective in getting more support for policy measures (Nilsson, Hansla, Heiling, Bergstad, & Martinsson, 2016). The amount of ‘hassle’ can be decreased by (partly) automating the system and/or distributing the credits over a longer period of time, and exemptions can be made for visitors/tourists. Successful real-world experiments can abate worries about the technical feasibility and undesired effects, such as hoarding, for example, and these experiments can also help users to better understand the system and market mechanism. Acceptability for the policy idea may increase when people see and understand the effects of the temporary system, which was the case in previous road pricing trials (Börjesson et al., 2015; Schuitema et al., 2010). Although the causality of the objections and the acceptability level is unclear. It may be that people rejected TPC regardless of the scheme design and adopted arguments that support their position.

Other objections are more challenging to tackle or even seem insurmountable. A big challenge lies in finding an acceptable distribution of credits. Participants had widely diverging ideas on *who* should get credits in the first place, the discussion did not even go into how credits should be distributed across groups of people. Just like a congestion charge, TPC redistributes income. However, whereas with a congestion charge this remains implicit, since it is based on travellers' willingness to pay, TPC makes this explicit, due to the allocation of credits. Thus, contrary to expectations, the (free) distribution of credits seems to make TPC less acceptable. Furthermore, many people (strongly) supported PC and considered TPC an unnecessarily complex alternative. It is questionable whether they would change their support level since the concept of the peak charge is already permeated in their minds. Hence, TPC may be a more viable alternative in areas or countries where congestion charging schemes are not well-known or cannot count on much support.

Turning to the method employed in this study, the focus groups proved to be useful to get in-depth insights into the richness of arguments, opinions and attitudes, since it helped many of the participants to develop their opinion regarding TPC. All participants were actively engaged in the discussion and everyone indicated in the survey that they felt (very much) at ease during the discussion. The approach also has some limitations. First, the respondents were recruited via an advertisement and received a fee for participating. This might facilitate the self-selection of persons who have a strong (negative or positive) opinion about car use or are solely interested in the allowance. We think the latter did not apply since all participants were actively engaged. Second, we limited the study to one simplified scheme in a hypothetical city. However, the exact scheme design (e.g. credit allocation), the way of explaining and framing the instruments and the underlying problems, and the implementation process within a larger package of transport improvements probably influence the acceptability levels to a large extent (see e.g. Bristow et al., 2010). Third, this is a qualitative study. It should be recognized that the findings are an indication of the views of only a small group of (relatively highly educated) individuals. It may be obvious that these views are not fully representative of the views of all citizens. Nor does this sample account for the possibility that certain subgroups such as older people (Nikitas et al., 2011) and car users, have potentially more influence on political decisions regarding road pricing. Lastly, we emphasize that this is a first study capturing one moment in time, while acceptability of road pricing instruments may change over time, through the influence of new knowledge and experience.

5 Public support for tradable peak credit schemes

This chapter has been resubmitted in a slightly modified version to *Transportation Research Part A,* with Chris van Langevelde–van Bergen and Eric Molin as co-authors.

Abstract - Congestion charging is generally regarded as an effective tool to manage the ongoing growth in road use and to abate congestion. However, public support is typically very low and therefore very few charging schemes have been implemented. The concept of tradable peak credits (TPC), which is based on the cap-and-trade principle, has characteristics that are believed to lead to more public support. First, a TPC system is budget-neutral since the money circulates within the user group. Also, the expected effectiveness, and thereby support, may be higher because, in a TPC system, the operator has more control over the inflow of cars due to the firm cap. Lastly, the allocation of free credits provides the opportunity to address equity issues. This study is the first that aims to quantify the levels of support for TPC among the public and to explore what the influence of scheme design, personal characteristics and attitudes is on these levels of support. To that end, a stated choice experiment has been conducted in which respondents were asked whether they would vote for the implementation of different TPC schemes. The discrete choice model shows that 32%, and up to a small majority of 52%, would support different TPC schemes. Most people, however, like or dislike TPC regardless of the scheme design. It is attitudes, and to a limited extent also socio-demographics, that explain more about someone's level of support, rather than the scheme characteristics. Support is especially higher among people who find TPC fair and effective, who live outside the borders of the municipality and are lower educated. Although the results indicate that a small majority would support a TPC scheme, directions for future research are given to supplement this first study.

5.1 Introduction

The ongoing growth in car use is increasingly threatening the liveability and economy of urban areas. Ever since Pigou's publication (1920), many academics from the field of transportation have been studying and promoting the efficiency of congestion pricing solutions to optimise the use of scarce road infrastructure (e.g. Small & Verhoef, 2007; Vickrey, 1963). A long-standing barrier to the actual implementation of congestion pricing solutions is, however, the typical, strong resistance of the public in general, and car users in particular (see Vonk Noordegraaf et al., 2014). Hence, the literature on the support for different congestion pricing solutions and the factors related to supporting (or opposing) these is extensive (Gaunt et al., 2007; Hamilton et al., 2014; Jaensirisak et al., 2005; Schade & Schlag, 2003b; Schuitema & Steg, 2008; Ubbels & Verhoef, 2006). In these studies, recurring factors that are found to affect public acceptability negatively involve the expected low effectiveness of the pricing solution, the perceived unfairness of the scheme's redistribution of welfare, a distrust in the government's use of the revenues, and the expected increase in travel costs.

Because of these problems, academic interest in the concept of tradable credits[16] as a tool to approach roadway capacity allocation and manage congestion has increased (Buitelaar et al., 2007; Grant-Muller & Xu, 2014; Raux, 2008; Raux & Marlot, 2005; Yang & Wang, 2011). The idea to apply the cap-and-trade principle in congestion management is not new (Goddard, 1997; Verhoef et al., 1997b; Viegas, 2001), but was not considered by many as a realistic policy option due to high transactions costs among other things. The rapid developments in technological solutions, such as internet trading and automatic vehicle detection, may have caused the increased amount of academic studies undertaken. Tradable credits for congestion management are still a concept rather than a developed policy that can lead to different scheme design (see Fan and Jiang (2013) for an overview). In this study the basic concept is understood as the following, and is referred to as TPC (tradable peak credits) from here on. The regulator (e.g. the government) determines a firm limit, a *cap*, on the total level of car use in a certain area or stretch of road during a certain time period and translates that cap into units (e.g. credits) which are distributed among recipients (e.g. citizens or road users) via a certain allocation method every trading period (e.g. week or month). In addition, the regulator creates a market where people can *trade* their peak credits, in which supply and demand set the price of a credit. When car users use the defined area during the defined time period, a credit will be taken from their budget. Although most studies on tradable credits for mobility management focus on the effects on traffic flows, the scheme design, or the behavioural responses, they usually state the following advantages that may lead to stronger support for these credits. First, the operator in this type of cap-and-trade system has more control over the number of cars than with a pricing-based solution. Indeed, with a pricing-based solution, the outcomes are uncertain since the price elasticity of the car users is unknown (Fan & Jiang, 2013). Its higher effectiveness is beneficial for road authorities and may enhance public acceptability as well. Second, TPC do not require a financial flow from road users to the government, which may positively affect public support since it may not be perceived as 'yet another (road use) tax'. Lastly, the allocation of free credits provides the opportunity to address equity issues in a flexible way when they are used to provide subsidies to specific groups of citizens.

[16] Other studies also refer to the concept as marketable/transferable rights or permits.

The notion that TPC can count on stronger public support is incited by empirical studies on the related concept of personal tradable carbon permits. This concept aims for on a general reduction of carbon and includes travel but also domestic energy use. Studies generally find stronger support for proposed tradable carbon permits than for an equivalent carbon tax (Bristow et al., 2010; Harwatt et al., 2011; Knobelsdorff, 2008; Wallace et al., 2010). Support levels between 42% - 44% are reported in these studies although it can reach up to 80% (Bristow et al., 2010) depending on the exact scheme design. In particular, the way in which the permits are allocated is found to influence support. However, whether these relatively high acceptability levels also hold for permits applied to mobility management is unsure, since people in a tradable carbon scheme are less restricted in their behaviour because they can reduce their carbon in different ways. For example, they can choose to reduce their car use, but if they don't want to do that, they can also choose to reduce their flights, or isolate their homes, etc. and still reach a reduction in carbon. Whereas in a TPC scheme, people can only reach the goal (less trips in peak hours) by changing their car use during peak hours. The few studies that looked into the acceptability of credits for mobility management show diverse results. Kockelman and Kalmanje (2005) surveyed citizens of Austin (Texas) asking about the hypothetical introduction of a (non-tradable) credit-based congestion pricing (CBCP) scheme and found that 24.9% of the respondents would support the introduction. They conclude that this is a substantial number given the unfamiliarity with the concept. Dogterom, Bao et al. (2018) found relatively high support for tradable kilometre credits (TDC) among car users in Beijing, but rather low support in the Netherlands. The acceptability levels were 67.0% and 21.6%, respectively. The schemes in these two studies fundamentally differ however from TPC in a few aspects. CBCP does not have a firm cap and the credits are non-tradable and CBCP, therefore, does not activate the market mechanism. Introducing a firm cap and the possibility to trade credits might increase people's support since it may enhance expected effectiveness, but may also negatively affect support since trading requires more effort and a firm cap might infringe on people's perception of freedom. The TDC scheme does not contain a time component since it focuses on the reduction of overall kilometres driven whereas TPC aims to reduce congestion during peak hours. This time component may affect public support. According to Jaensirisak (2005), acceptability is higher when a charge focuses on peak periods only, whereas other studies found lower acceptability levels for a peak charge than for a tax without a time component (Francke & Kaniok, 2013; Gehlert et al., 2011). To the best of our knowledge, public support of several credit schemes has been studied (see Figure 7) but public support for tradable credits for congestion management hasn't yet.

The main aim of this study is therefore to quantify public support for the implementation of TPC. Since TPC can be designed in different ways and many of the scheme characteristics may be important for support, this study additionally aims to explore the influence of some scheme characteristics (see Section 5.2.3). Furthermore, since previous road pricing acceptability studies showed that support levels can be explained not only by scheme characteristics, but also by certain socio-economic characteristics, and to a greater extent, by attitudes, such as fairness and expected effectiveness, the influence of these variables will be examined as well. To serve these aims, a stated choice experiment was conducted with 502 citizens from urban areas in the Netherlands participating.

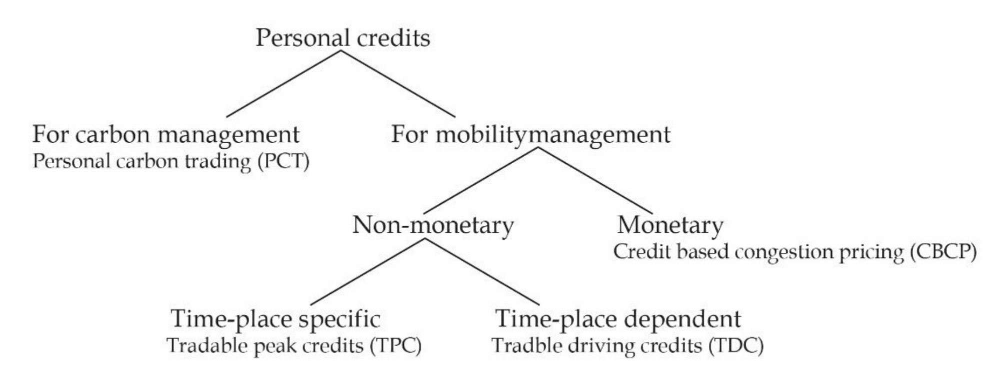


Figure 7 Overview of concepts that have been studied regarding public acceptability. Inspired by a diagram produced by Fan and Jiang (2013).

This chapter is structured as follows: Section 5.2 presents the conceptualization, by describing three categories of factors that may affect public support and by selecting attributes (scheme characteristics) for the stated choice experiment (see Section 5.3.1). Section 0 describes the methodology that includes the data collection, data preparation and method of analysis. Section 5.5 presents the results of the final estimated model and Section 5.5 presents the application of the model in order to gain insights into the support levels of different TPC schemes. Section 5.6 ends the chapter by drawing conclusions, providing policy recommendations and discussing directions for further research.

5.2 Conceptualisation

To identify factors that may be relevant in explaining public support for TPC, we mainly relied on two sources. First, we reviewed the current literature. Since literature on public perceptions regarding tradable credits for mobility management is rather scarce, we expanded the review to include the acceptability of road pricing, which is abundant and discusses many factors that may also be relevant for TPC support. To supplement this review, we rely on the results of a focus group study we conducted, in which a total of 36 citizens discussed expected (dis)advantages, effectiveness and acceptability of TPC. Car users, as well as public transport and bicycle users, were shown a fictional city facing a congestion problem, and the participants were asked to discuss two instruments: a peak charge and TPC. The transcriptions of the discussions were content analysed. See Krabbenborg, Mouter, Molin, Annema, and van Wee (2020) for more details. From these two sources (literature and focus group meetings), we identified three categories of factors: socio-economic variables, attitudinal variables, and scheme design characteristics.

5.2.1 Socio-economic variables and mobility behaviour

Several socio-economic variables have been pointed out that correlate with the acceptability of road pricing measures. A few studies found a positive relationship between income and acceptability (Golob, 2001; Verhoef, Nijkamp, & Rietveld, 1997a) whereas other studies did not find significant relations (Dogterom, Bao et al., 2018; Jaensirisak et al., 2005) and Harrington, Krupnick, and Alberini (2001) found a negative relation. Gehlert et al. (2011) report a similar inconsistent picture regarding age, gender and level of education. Age has a small and negative effect on acceptability (Jaensirisak et al., 2005), which also applies to being female (Börjesson et al., 2015). Regarding educational level, most studies report a positive relation to acceptability (Börjesson et al., 2015; Ubbels & Verhoef, 2006), while again Harrington et al. (2001) report a negative association. Furthermore, people who have a child in their household are more negative towards a congestion charge, which may be explained by higher car-dependency (Börjesson et al., 2015) and/or more time pressure. Residential location may also be a relevant factor: when Stockholm held a referendum about the introduction of congestion charging, people living in the areas around Stockholm were less supportive than people living within the city (Stockholms stad, 2007). This makes sense given that car trips passing the cordon payments stations are charged whereas car trips made within the affected area are not charged. Indeed, the intensity of car use has a negative relationship with acceptability (Börjesson et al., 2015; Eliasson & Jonsson, 2011; Gaunt et al., 2007) and people who do not use a car as their main mode of transportation are, in general, much more positive about road pricing than car users (Jaensirisak et al., 2005; Zheng, Liu, Liu, & Shiwakoti, 2014). Previous studies did not report a significant relationship between employment status and acceptability (Schuitema et al., 2010). It may be that people with a job are more negative about congestion pricing since they are less flexible in choosing departure time than people without a job. However, employed people do have a higher income, which has a positive relation with acceptability. Ubbels and Verhoef report that commuters who get financial compensation for their travel costs are more positive (2006). Hence, this study takes into account that both the socio-demographic mentioned, as well as mobility behaviour variables, are variables that could explain TPC support. We will refer to this group of factors as personal characteristics.

5.2.2 Attitudinal variables

People's attitudes generally seem to have more explanatory power than socio-economic variables in explaining support for pricing policy measures. These concern general beliefs and attitudes on the one hand, and attitudes towards the measure on the other hand. Acceptability is found to be higher when people have a higher problem awareness score (Eriksson, Garvill, & Nordlund, 2006; Harrington et al., 2001) or, more specifically, environmental concern (Eliasson & Jonsson, 2011). Perceived behavioural control is also positively associated with acceptability (Sun et al., 2016). Regarding attitudes towards the measure in particular the perception of fairness (e.g. Di Ciommo, Monzón, & Fernandez-Heredia, 2013; Eriksson et al., 2006; Jakobsson et al., 2000; Sun et al., 2016) is often reported as a factor that is strongly related to support. Acceptability is also higher when people do not perceive the scheme as an infringement on their freedom (Jakobsson et al., 2000; Kim et al., 2013; Sun et al., 2016). According to Bamberg and Rolle (2003) these concepts of perceived infringement on freedom and perceived unfairness are strongly related. However, Schade and Schlag (2003b) conclude that problem perception only contributes to acceptability to a negligible extent. Furthermore, acceptability is higher when people are positive about the expected personal outcome (Hamilton et al., 2014; Schade & Schlag, 2003b), when they have trust in public agencies who need to conduct the policy (Hamilton et al., 2014), and when they believe the scheme is effective in reducing congestion (Eliasson & Jonsson, 2011; Rienstra et al., 1999; Schade & Schlag, 2003b; Ubbels & Verhoef, 2006). The relationship between the expected effectiveness and acceptability is, however, under discussion since it can be hypothesised that respondents respond strategically by claiming that they perceive the instrument to be ineffective to justify their rejection (Rienstra et al., 1999). Schade and Schlag (2003b), however, could not find evidence for this hypothesis. Our focus group meetings complement this list by adding a few more attitudinal factors. The results suggest that the expected fun of trading and belief in technical feasibility are positively related to TPC support, whereas the expected 'hassle' (in terms of expected time and effort), expected misuse and the perceived complexity of the scheme seem to negatively influence people's standpoints towards TPC. Lastly, a few participants in the focus groups mentioned disliking TPC because it means that the travel costs are uncertain due to the fact that the credit price fluctuates. To explore the relationships between attitudes and support of TPC, all these attitudinal factors will be taken into account in this study.

5.2.3 Scheme design characteristics

With respect to scheme design, literature on road pricing acceptability shows that a range of characteristics influence public support. The charge level and the way in which revenues are used are found to be especially important (Jaensirisak et al., 2005; Schade & Schlag, 2003b; Schuitema & Steg, 2008; Ubbels & Verhoef, 2006). Also, the complexity of the scheme is found to play a role, as people strongly prefer simple tariffs (Bonsall et al., 2007). Regarding TPC, many more scheme characteristics can be determined that may influence support. These characteristics include the validity of the credits, the collection/verification service, the way in which credits are traded and trading rules (e.g. presence/absence of a maximum credit price), the scheme operator, the selection of recipients of credits, the ways that the credits are allocated, and so on. See Fan and Jiang (2013) for an overview of design characteristics of tradable credit schemes.

Since understanding the trading aspect of TPC already demands a significant amount of cognitive effort from the respondents, we decided to include only a limited number of varied design characteristics in the choice experiment to avoid overloading respondents with too much information. The literature review and insights from the focus group meetings were used to make a shortlist of design elements that are expected to influence people's support of TPC the most. Then, in consultation with five experts from the fields of economy, transport policy, behavioural sciences and psychology, four fundamental choices regarding the TPC design were selected that are expected to influence people's preferences most. These elements were translated into attributes and levels, which are described and discussed in the subsections below.

Eligible recipients of free credits

Several studies on tradable permits (Bristow et al., 2010; Grant-Muller & Xu, 2014), as well as the focus groups on TPC and the experts we consulted, conclude that the allocation of the credits is likely to be very important for the support levels. Indeed, the way in which credits are allocated and to whom, greatly determines the redistribution of welfare. Hence, credit allocation is included in the experiment in the first two attributes. The first attribute 'eligible recipients' concerns who will receive free credits. Eligible recipients can be the residents living in the municipality where TPC is introduced. Another option is to also allocate credits to people who work in that area. Furthermore, in the focus group meetings, some participants considered TPC an instrument to manage current car use and therefore suggested that credits should only be allocated to car users. Other participants argued that everyone has an equal right to use the road and the credits should therefore be allocated to all people, thus regardless of whether or not they drive or own a car. In total, four levels were selected to vary who receives credits (see Table 5).

Distribution principle

The second attribute concerns the way in which the credits are allocated. The credits can be distributed to all recipients in a uniform way, but it is also possible to distribute them in such a way that certain groups in society are spared. Three non-uniform distributions were chosen:

more credits for lower incomes, more credits for people who work more, and more credits for people who travel more.

Credit allocation interval

The focus group meetings suggest that expected ‘hassle’ (referring to time and effort) is an important factor in explaining people’s support. Support is expected to increase when the scheme requires limited effort by the user. There may, however, be an inverse relationship between simplifying the scheme (in terms of hassle) on the one hand, and the efficiency of the scheme on the other hand (Verhoef, Nijkamp, & Rietveld, 1996). The ‘credit allocation interval’ attribute is therefore interesting to study, as it concerns the frequency of the credit distributions among the recipients. Here it is assumed that credits remain valid for the entire time interval. Thus, if the interval is a week, the credits are valid only in that week. A shorter interval requires more hassle since people have to trade on a weekly basis, but can be more effective than a monthly interval since the regulator can adjust the cap more often. Two levels were selected for this attribute: a weekly and a monthly interval.

Credit price fluctuation

The final attribute is also about the balance between hassle and effectiveness. This attribute entails how often the credit price fluctuates. Although real-time dynamic pricing is better to balance supply and demand (Verhoef et al., 1996), it may negatively affect the acceptability since it brings uncertainty about the cost, according to the focus group results. Two levels have been chosen: every minute and every day. Table 5 provides an overview of all scheme characteristics that were varied in the stated choice experiment.

Table 5 Overview of attributes and attribute levels used in the choice experiment

Attribute	Levels
Eligible recipients of free credits	R1_All residents of the municipality
	R2_All residents of the municipality who own a car
	R3_All residents of the municipality + people who work there
	R4_All residents of the municipality + people who work there and own a car
Distribution principle	D1_Credits are equally distributed among all recipients
	D2_People who have travelled more km will receive more credits
	D3_People who work more hours per week receive more credits than people who work less hours per week
	D4_People with a lower income receive more credits than people with a higher income
Credit allocation interval	I1_Weekly
	I2_Monthly
Credit price fluctuation	F1_Every minute
	F2_Every day

5.3 Methodology

An online survey was designed consisting of four parts. In the first part, the respondents received an introduction which explained the concept of TPC[17]. Basically, the respondents were presented with a TPC scheme that can be applied on all highways and provincial roads in the city during peak hours on weekdays. The peak hours are 07:00 - 09:15 and 16:00 - 18:15. The government decides how many credits are issued and they are distributed free of charge. Compared to the current situation, the number of cars using peak hours should decrease by 10%. Participants have a personal online account to manage their credits and they can also trade their credits here. The price of a credit is determined by supply and demand, but the maximum credit price is set at EUR 6. People cannot buy more credits than they can use themselves in a particular specified period of time, which is the credit allocation interval (see Section 5.2.3). The credits are redeemed automatically when people use the specified roads during the specified time slots. If people drive there with an empty credit account, they receive a notification to buy a credit. If they do not do this, the system will automatically charge them for a credit plus a small fee of EUR 1 extra. Next, the attributes and their levels were described. The complete text of the introduction can be found in Appendix C.

In the second part, the respondents were presented with six choice tasks, where they were asked to choose between the different TPC schemes explained in Section 5.3.1 of this chapter. In the third part, the respondents were shown the attitudinal indicators on a 5-point Likert scale. The statements are based on the review of the literature that we did and the results of the focus group meetings, and these are explained in full in Section 5.3.4. The fourth and final part contained questions about the respondents' socio-demographic characteristics and travel behaviour. Table 6 shows these socio-economic variables and their categories.

[17] For the purpose of a different study, the fixed scheme design was presented to the respondents in four slightly different versions. The versions differed from each other in medium (two versions were shown in an animated video and two were presented in text) and in content (two version contained the basic information and two versions also included additional information about congestion problems). The versions were randomly assigned to the respondents. The influence of the different introductions was tested by including them in the model estimation and since the results were insignificant, these context variables will not be discussed in the remainder of this paper.

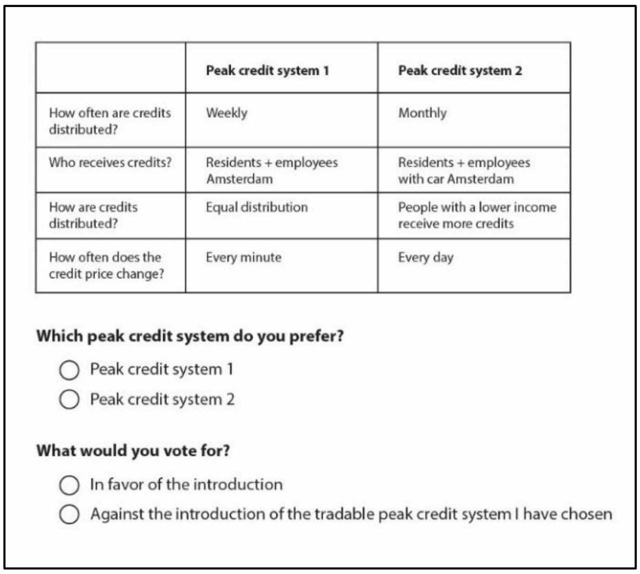
Table 6 socio-economic variables

Variable	Categories
Gender	Male
	Female
Educational level	No educational qualification, primary school
	Preparatory secondary vocational education (basic), intermediate vocational education level 1
	Preparatory secondary vocational education (theoretical), higher general secondary education & pre-university education (year 3)
	Intermediate vocational education level 2, 3 or 4
	Higher general secondary education & pre-university education (year 5/6)
	Bachelor's degree
	Master's degree, PhD
Age	In years (18 years and older)
Place of residence	Lives in the municipality of Amsterdam / Utrecht
	Lives outside the municipality of Amsterdam / Utrecht
Work situation	Student / in training
	Retired
	Paid job
	Other (unemployed, voluntary work, etc.)
Children in the household	Yes
	No
Driving license	Yes
	No
Car is main mode of transport	Yes
	No
Travel costs	Yes (I have commuting costs that are not reimbursed, or are only partially reimbursed)
	No (I have no commuting costs, or my commuting costs are fully reimbursed)
Weekly number of trips during peak hours	In numbers per week (0 to 10)
Weekly number of trips during peak hours in slow traffic/congestion	In numbers per week (0 to 10)

5.3.1 Experimental design

An orthogonal fractional factorial design was used to create the choice sets using Ngene software (ChoiceMetrics, 2018). In total, 12 choices sets were generated and each set had two unlabelled alternatives. Because the respondents of a pilot study found the alternatives rather complex, we blocked the design into two sets, with 6 choices each. Each respondent was randomly assigned to one block.

In each choice task, the respondents were first presented with two TPC schemes and were then asked to choose which one they preferred. To measure support for TPC as a policy instrument, they were next asked whether they would vote in favour or against the implementation of their preferred TPC scheme, should they be asked in a referendum. Figure 8 shows an example of one of the choice sets and two questions (English translation of the original Dutch version). In the data analysis, these two questions were merged into a single variable. When people voted in favour of the preferred peak credit system, the preferred alternative was coded as '1' or '2', and when they voted against implementation, this was coded as '3'.



	Peak credit system 1	Peak credit system 2
How often are credits distributed?	Weekly	Monthly
Who receives credits?	Residents + employees Amsterdam	Residents + employees with car Amsterdam
How are credits distributed?	Equal distribution	People with a lower income receive more credits
How often does the credit price change?	Every minute	Every day

Which peak credit system do you prefer?

- Peak credit system 1
- Peak credit system 2

What would you vote for?

- In favor of the introduction
- Against the introduction of the tradable peak credit system I have chosen

Figure 8 An example of a choice set for participants in the Amsterdam region (translated from Dutch).

5.3.2 Model specification and estimation

To explore people's preferences for TPC scheme designs, a discrete choice model, based on the utility maximization theory (McFadden, 1986), was estimated using the observed choices. This model assumes that the respondent tries to maximize their utility and thus chooses the alternative that offers the highest utility. The utility $U_{n,TPC}$ that a respondent n assigns to a TPC alternative is determined by observable factors (systematic utility) and the error term, $\varepsilon_{n,TPC}$. For the observable factors, parameters, β, are estimated. In this chapter, three categories of observed factors have been identified, as explained in Section 5.2: scheme characteristics (attributes), personal characteristics and attitudinal variables. In equation (1), β_x is the vector that stands for the attributes X, β_k for the personal characteristics K, and β_L for attitudinal variables L. In this model, we will also study how some personal characteristics relate to preferences by including the interaction-effects of attributes with socio-economic variables. Furthermore, a constant, C_{TPC}, is added which captures the utility that people attach to the TPC system when all attributes have a zero value. This captures the base preference of TPC relative to the base alternative of 'no implementation', which captures all factors associated with TPC that are not varied in the experiment.

When the random error term can be assumed to be independently and identically distributed, the simple Multinomial Logit (MNL) model can be used to estimate the values for the coefficients. However, the MNL model is not able to capture the unobserved correlations that are expected between the two TPC alternatives. These can be captured by adding an error component to the utility function, representing the utility of the unobserved factors in the TPC alternatives, $\vartheta_{n,TPC}$ as shown in equation (1). Furthermore, the MNL model assumes that tastes regarding the attributes do not vary across individuals beyond those captured by the socio-demographic and attitudinal variables that are included. Taste heterogeneity can be examined by allowing β's to vary randomly within the population. Lastly, as each respondent made 6 choices, we assume that a person's choices are correlated to some extent. To capture these effects, a panel Mixed Logit (ML) model with an error component structure is estimated. The utility function can be found in equation (1) and we refer the reader to Train (2003) for a more detailed description of the Mixed Logit model.

$$U_{n,TPC} = C_{TPC} + \beta_x X_n + \beta_k K_n + \beta_l L_n + \vartheta_{n,TPC} + \varepsilon_{n,TPC} \quad \text{Equation (1)}$$

Where:

$\vartheta_{n,TPC} \sim N\,(0, \sigma_{\vartheta TPC})$

$\beta_{n,X} \sim N\,(\beta_X, \sigma_{\beta_X})$

And the probability that citizen n supports TPC can be calculated using this formula:

$$P_{n,TPC} = \int_{\vartheta_n,\beta_n} \left(\prod_{t=1}^{6} (P_{n,TPC}^{t} \mid \vartheta_n, \beta_n) \times f(\vartheta_n, \beta_n) \right) \times d\vartheta_n \, d\beta_n \quad \text{Equation (2)}$$

5.3.3 Sample

We argue that a first implementation of TPC would be most likely to take place in a large city, since congestion problems are worst in urban areas. We find that it is relevant to study not only the public acceptability of city inhabitants, but also the public acceptability of the inhabitants of municipalities adjacent to a city. For these reasons, people living in and near two of the biggest municipalities in the Netherlands were sampled: Amsterdam and Utrecht. Both groups received a survey in which TPC was suggested in their region. A company called CG Research was hired to collect responses using their online panel. Only respondents 18 years and older were invited to participate in this survey. As a reward, respondents received points, worth EUR 1.50, which they could exchange for a gift voucher from an online store.

In total, 889 people opened the survey, and of these, 513 people actually completed the survey. We checked these 513 responses for inconsistencies and unreliable answers. We tested that clicking through the survey without reading anything takes a minimum of 210 seconds for the survey with a text as introduction, and 360 seconds for the survey with a video. Hence, we assumed that those respondents who completed the survey faster than the minimum time required, did not provide valid responses. Eight respondents were removed from the database on this basis. Another three respondents were removed because of missing values on key variables. This led to a remaining sample size of N=502 respondents. This means that 6 * 502 = 3,012 choices were observed in the choice experiment. The median value of time spent on the survey was 812 seconds (13.5 minutes).

Although the literature review showed that socio-economic variables are not strong predictors of acceptability, the sample was meant to be representative for the population in these areas, as far as possible. Table 7 shows the comparison between the main-socio economic variables of the sample and the population. Since distributions on socio-economic variables for the population of people living near Amsterdam and Utrecht are not readily available, we used distributions of those variables for the municipalities of Amsterdam and Utrecht as proxies (see Table 7). Females, retired people and people in the age category 65-79 years of age category seem to be somewhat overrepresented in the sample, and lower and higher educated people are slightly underrepresented. The survey was quite long so this may have resulted in less respondents with a higher value of time (people that have a job and or are higher educated). The underrepresentation of lower educated people may be caused by the somewhat complex topic. The representativeness of the sample regarding income could not be determined due to a large amount of missing values, though we can conclude that all income categories are fairly well represented. Regarding mobility habits, 44% of the sample use the car as their main mode of transport, 1% a motorcycle, 17% train/bus/metro, 29% (e)bicycle, 2% moped and 5% walk. Regarding residential location, 62% of the sample (N=310) live within the borders of Amsterdam and Utrecht, and 38% live outside the borders. See appendix D for descriptive statistics regarding the attitudinal variables. Although the sample is somehow skewed in some respects, all the main socio-economic groups are well represented, and since socio-economic variables are not strong predictors of acceptability, we believe the sample is suitable to gain a first insight into the acceptability of TPC and how it relates to background variables, which is the purpose of our study.

Table 7 The main socio-economic characteristics of the sample compared to the population

Socio-economic variable	Category	Share sample [%]	Share population [%]
Gender [a]	Male	42.2	49.4
	Female	57.8	50.6
Age [a] (yr)	18-24	6.2	13.7
	25-44	31.3	45.2
	45-64	30.6	29.3
	65-79	30.1	11.6
	80+	1.8	3.3
Level of Education [a]	Low	12.7	16.2
	Medium	33.2	27.1
	High (University)	54.0	56.6
Employment [a]	Student/in training	5.4	11.1
	Retired	24.7	13.4
	Paid work (up to 20 hours/week)	11.2	68.0
	Paid work (20 - 35 hours/week)	17.7	
	Paid work (35+ hours/week)	25.3	
	Other (e.g. incapacitated, volunteering)	15.7	7.5
Gross Household Income (Euros/yr) [b]	<10,000	4.6	4.9
	10,000 – 20,000	10.6	25.9
	20,000 – 30,000	15.5	32.4
	30,000 – 40,000	15.9	21.2
	40,000 – 50,000	11.4	8.9
	50,000 – 100,000	18.6	5.9
	100,000 +	2.8	0.7
	unknown	20.7	

[a] compared to the population of people living in Amsterdam and Utrecht municipality (CBS, 2019a, CBS, 2019b)
[b] compared to the Dutch population (CBS, 2017)
Education categories: Low: no academic certificate, primary school, preparatory secondary vocational education, intermediate vocational education level 1. Middle: higher general secondary education, pre-university education, intermediate vocational education level 2, 3 or 4. High: Bachelor's degree, Master's degree, PhD

5.3.4 Construction of attitudinal scales

In order to construct attitudinal scales, the 23 attitudinal indicators were exploratory factor analysed (see Appendix E for the complete list of 23 indicators). The extraction method of principal axis factoring was used in combination with the Direct Oblimin rotation technique. Indicators with a communality of <0.25 or with factor loadings of <0.50 were removed. A simple structure was formed with a 7-factor solution, as shown in Table 8. In total, 18 of the 23 indicators are part of the factor solution. In order to check for internal consistency of the factors, a Cronbach's Alpha test was conducted on the variables with high loadings on the same factor. The second and seventh factor have values of 0.654 and 0.682, which do not meet the widely accepted 0.7 criterion on the reliability scale. However, values between 0.6 and 0.7 are still considered acceptable in exploratory research (Taber, 2018). Hence, we decided to construct these attitude scales by taking the average of the scores of the high loading indicators. The attitudinal variables that were constructed were labelled as follows: expected effectiveness, importance of certainty, expected hassle, expected infringement, perceived fairness, trust, and problem perception.

Of the 5 statements which were excluded from the exploratory factor analysis, there are 2 statements that clearly represent attitudes that are different from the 7 scales that are of interest. Since both statements may be relevant to explain TPC acceptability, they were both included as potential predictors in the model estimation. These statements are labelled as personal problem perception and perceived behavioural control. Table 9 shows the correlations between the nine attitudes we distinguished. Unsurprisingly, expected effectiveness (scale 1), perceived fairness (scale 5) and trust (scale 6) correlate relatively highly.

Table 8 Rotated factor-loading matrix (factor loadings <0.30 are not shown) and the Cronbach alpha test results.

Label	Indicator	Factor							Cronbach alpha
		1	2	3	4	5	6	7	
1:Expected effectiveness	I think TPC reduce congestion	0.932							0.918
	How effectively do you think TPC reduce congestion?	0.817							
	I think TPC will reduce the impact of car use on the environment	0.813							
2:Importance of certainty	I find it important to have certainty about my travel costs		0.790						0.654
	I find it important to have certainty about my travel times		0.573						
3:Expected hassle	I think trading in peak credits requires a lot of effort			0.885					0.820
	I think trading in peak credits requires a lot of time			0.705					
	I find TPC very complex			0.663					
4: Infringement	I think TPC harm people's privacy				0.753				0.78
	I find TPC an infringement on people's (mobility) freedom				0.731				
5:Perceived fairness	How fair do you consider TPC for yourself?					0.740			0.823
	How fair do you consider TPC for others?					0.606			
	I think TPC will give me financial benefits					0.550			
	The trading in peak credits sounds like fun to me					0.524			
6:Trust	I think a system with TPC is technically feasible						0.844		0.783
	The government is capable of implementing and conducting a system with TPC						0.725		
7:Problem perception	Congestion is a big threat to the economy							0.680	0.682
	Congestion is a big threat to the environment							0.652	
8:Personal problem perception	I personally suffer from congestion	Communality is too low							
9:Perceived behavioural control	It is easy to find alternatives for most car trips in peak hours (such as bicycle, public transport or other travel times)	Communality is too low							

Table 9 Correlation with attitudes

	1	2	3	4	5	6	7	8	9
1	1	.096**	-.370**	-.461**	.788**	.643**	.371**	-.483**	.182**
2	.096**	1	.281**	.189**	0.039	.117**	.430**	.168**	.160**
3	-.370**	.281**	1	.508**	-.229**	-.343**	0.002	.520**	.103**
4	-.461**	.189**	.508**	1	-.441**	-.376**	-.127**	.632**	-.081**
5	.788**	0.039	-.229**	-.441**	1	.717**	.361**	-.449**	.351**
6	.643**	.117**	-.343**	-.376**	.717**	1	.279**	-.320**	.230**
7	.371**	.430**	0.002	-.127**	.361**	.279**	1	-.210**	.253**
8	-.483**	.168**	.520**	.632**	-.449**	-.320**	-.210**	1	-.121**
9	.182**	.160**	.103**	-.081**	.351**	.230**	.253**	-.121**	1

5.3.5 Model estimation procedure

Since all attributes that were varied in the choice experiment were discrete variables, they needed to be coded. For this purpose, we applied effect coding instead of dummy coding. In effect coding, an attribute with two levels has an indicator variable that can have the values -1 and 1. An attribute with four levels is coded with three indicator variables in which the values 1, 0, 0, -1 are used for the first indicator variable, 0, 1, 0, -1 for the second indicator variable and 0, 0, 1, -1 for the third indicator variable. To give an example, the third level (D3) of the attribute credit distribution is coded as [0, 0, 1] and is therefore equal to the third indicator variable in the model. The fourth level (D4) is coded as [-1,-1,-1] and is equal to the negative sum of all three indicator variables. Hence, the sum of the utility contribution of the levels of each attribute always adds up to zero and therefore the average contribution of the levels of each attribute is also equal to zero. The consequence of this, and this is the main advantage of effect coding, is that the estimated constant can be interpreted as the average utility derived from all the TPC alternatives that are presented, compared to implementing none of these policy measures (the base alternative). The utility contribution of an attribute level then expresses the difference compared to the average utility. The socio-economic variables were also effect coded, except for level of education and age. See Bech and Gyrd-Hansen (2005) for more information on effect coding in choice experiments. Biogeme (Bierlaire, 2018) was used to estimate the discrete choice models.

Because we are interested in how groups of variables contribute to the explanation, we estimated and compared a series of models. First a simple MNL model was estimated containing only the attributes (X), which is a significant improvement over the null-model (see Table 10 for fit measures). Then, personal characteristics (K) were added to the model, which led to a small yet significant improvement of the model fit. Thirdly, attitudinal variables (L) were added, which led to a strong improvement of the model fit. As explained in Section 5.3.4, the attitude variables were first determined by the use of an exploratory factor analysis and then incorporated in the utility function of the discrete choice model. In this sequential procedure it is assumed that the factor scores that represent the attitudes are free of measurement error. A simultaneous estimation, as done in hybrid choice models, can take these measurement errors into account. This more advanced procedure is usually preferred when one wants to study the influence of one (up to two or three) latent variables in depth, as more variables lead to complex models and may give estimation problems. Since many more attitudes were identified in this first study on TPC support, we explored the influence of all these attitudes instead of studying

Table 10 Main statistics of the different models and the coefficients. The last column is the final model.

	MNL			*Panel ML error component*	
Categories of variables and sigma included	*X*	*X* + *K*	*X* + *K* + *L*	*X* + *K* + *L*	*X* + *K* + *L* + sigma's
Final LL	-3110.028	-3070.562	-2664.768	-2235.322	-2188.167
LRS	437.534	78.932	811.604	858.892	94.31
Rho-square	0.063	0.078	0.193	0.324	0.339
	Coefficients (p-value)	Coefficients (p-value)	Coefficients (p-value)	Coefficients (p-value)	Coefficients (p-value)
Constant_TPC	-0.693 (0.00)	-0.487(0.00)	-4.09(0.00)	-2.92(0.00)	-3.4 (0.00)
F1_fluctuation_minute	-0.105(0.01)	-0.104(0.01)	-0.110(0.01)	-0.109(0.02)	-0.192 (0.00)
F2_fluctuation_daily	0.105	0.104	0.110	0.109	0.192
I1_interval_weekly	-0.0797(0.01)	-0.080(0.01)	-0.0867(0.01)	-0.106(0.00)	-0.147 (0.00)
I2_interval_montlhy	0.0797	0.080	0.08367	0.106	0.147
D1_equal distribution	0.276(0.00)	0.279(0.00)	0.314(0.00)	0.386(0.00)	0.599 (0.00)
D2_more km traveled, more credits	0.0120(0.89)	0.157(0.85)	-0.00698(0.94)	-0.05(0.617)	-0.101(0.414)
D3_more hrs working, more credits	-0.159(0.01)	-0.164(0.01)	-0.166(0.01)	-0.169(0.03)	-0.234 (0.02)
D4_lower income, more credits	-0.129	-0.272	-0.141	-0.167	- 0.264
R1_residents municipality	-0.245(0.00)	-0.247(0.00)	-0.281(0.00)	-0.186(0.00)	-0.287 (0.00)
R2_residents municipality who own car	-0.0209(0.81)	-0.0223(0.80)	-0.00234(0.80)	-0.0312(0.77)	0.0659 (0.624)
R3_residents municipality + people who work there	-0.0455(0.46)	-0.0439(0.47)	-0.0302(0.65)	0.0192(0.81)	0.0624 (0.494)
R4_residents municipality + people who work there that own a car	0.3114	0.3132	0.3135	0.198	0.1587
Level of education		-0.0567(0.03)	-0.169(0.00)	-0.323(0.01)	-0.346 (0.01)
work situation_other		0.0794(0.38)	0.162 (0.11)	0.328(0.47)	0.428 (0.35)
work situation_retired		0.336(0.00)	0.429(0.00)	0.589(0.07)	0.503 (0.14)
work situation_student		-0.416(0.00)	-0.591(0.00)	-1.17(0.02)	-1.13 (0.03)
Work situation_paid job		0.0006	0.000	0.253	0.199

Gender_male	-0.000103(0.00)			
Weekly number of car trips during peak hours in congestion	0.104(0.00)			
Weekly number of car trips during peak hours	-0.0416(0.06)			
Income	-0.000385(0.00)			
Having travel expenses	0.0902(0.03)			
Residence in municipality			-1.46(0.00)	-1.7 (0.00)
Interaction_residence in municipality_R1			-0.186(0.00)	-0.287 (0.00)
Attitude_perceived fairness		0.612(0.00)	1.12(0.00)	1.21 (0.00)
Attitude_expected effectiveness		0.517(0.00)	1.1(0.00)	1.17 (0.00)
Attitude_trust		0.168(0.00)	0.394(0.05)	0.496 (0.02)
Attitude_importance certainty		0.231(0.00)	0.391(0.07)	0.509 (0.03)
Attitude_infringement on freedom		-0.136(0.00)	-0.293(0.09)	-0.342 (0.09)
Sigma_C_TPC			-3.06(0)	3.33 (0)
Sigma_ D1_equal distribution				0.681 (0.00)
Sigma_ D2_more km traveled, more credits				0.662 (0.00)
Sigma_ D3_more hrs working, more credits				0.74 (0.00)
Sigma_ R1_residents municipality				0.648 (0.00)
Sigma_ R2_residents municipality who own a car				0.31 (0.04)

a few in-depth. Hence the sequential estimation procedure is more suited for the purpose of this study.

Then, the MNL model was extended to a panel ML model with an error component structure. That is, a nesting structure is added to the utility functions to capture the correlation between the two TPC alternatives, which is caused by attributes associated with TPC that are not varied in the experiment. This correlation is captured by an additional error component that is assumed to be normally distributed. The model is estimated, taking into account the panel effect, by acknowledging that the six choices made by the same respondent correlate, which results in correct t-values. This led to a significant and major improvement of the model fit. Lastly, the parameters of the attributes were estimated as random parameters with a normal distribution to study taste heterogeneity. Whereas the estimated parameters (Betas) represent the mean value of the population, the Sigma's represent the standard deviations. Thus, a Beta with a relatively large Sigma indicates a strong taste variation. The Sigma's related to the attributes regarding credit distributions turned out to be statistically significant. Including these Sigma's in the model led to a small yet significant improvement of the model fit.

Insignificant socio-economic and attitudinal variables were removed in the estimation procedure. These include variables related to gender, age, license possession, children in the household, car as main mode of transport, weekly number of car trips during peak hours, weekly number of car trips in congestion, whether people have travel costs for commuting trips, attitude to 'hassle', attitude to 'problem perception', attitude to 'personal problem perception', and attitude to 'perceived behavioural control'. Also several interaction-effects were tested and removed due to insignificant results. These include 'age and credit price fluctuation', 'income and distribution of credits', 'work situation and distribution of credits', 'having children and distribution of credits', 'educational level and allocation interval', 'frequency of car use and credit distribution', 'frequency of car use in congestion and credit distribution', 'car as main mode and recipients', 'car as main mode and credit distribution'.

The final model contains 26 parameters and was estimated using 2,000 draws to get stable estimates. These were drawn from a Monto-Carlo simulation with a normal distribution. The following section will describe the results of this final model.

5.4 Results

The results of the final choice model are presented in Table 11. Keeping in line with the estimation procedure, we first discuss the attributes, followed by the personal characteristics (socio-demographic variables and mobility behaviour) and then the attitudes.

The constant is negative (-3.4), but it is hard to interpret the constant since not all of the variables included were effect coded. Nevertheless, since the first model, which only had the attributes (*X*), also had a negative constant, it can be interpreted that on average people prefer to maintain the current situation rather than implementing TPC. However, the sigma of the constant (3.33) is relatively large, which shows that there is a high level of heterogeneity in unobserved preference for TPC alternatives compared to the status quo. In other words, preferences vary considerably. Regarding the attribute levels, support is stronger when the credit price fluctuates on a daily basis instead of every minute, when credits are distributed on a monthly basis instead of weekly, and when the credits are distributed 'equally' among ‘residents of the municipality plus the people who work there and own a car’. The values of the fluctuation and interval attributes imply that people generally prefer schemes that require less ‘trading hassle’. An additional explanation is that a daily price fluctuation gives less uncertainty about travel costs. Regarding credit distributions, people prefer an ‘equal distribution’ of credits, whereas the distribution in which lower incomes receive extra credits is least preferred. Nevertheless, the Sigma’s are significant and relatively large. This means that tastes regarding the distributional principles are very heterogeneous. Thus, apparently, people on average prefer a scheme in which all people who (can) actually use the road receive credits. Hence, there is less support for giving credits to people who do not own a car. However, the Sigma related to ‘eligible recipients’ is large and significant, indicating that preferences regarding this attribute vary considerably as well. Thus, the way in which the credits are distributed, and to whom, is quite important, but consensus on this is a far cry.

Regarding personal characteristics and the interaction-effects between personal characteristics and attributes, only a few variables turned out to be statistically significant. Educational level,work situation and place of residence are significant. Higher educated people, students and people living within the borders of Amsterdam and Utrecht have a stronger dislike for TPC. Most earlier studies on the relation between conventional road pricing acceptability and educational level found a positive relation, as explained in Section 5.2.1. Dogterom, Bao et al. (2018) however, also found a negative relationship between the acceptability of tradable driving credits and educational level, although it was not statistically significant. This is also interesting because an experiment on trading behaviour with parking permits (Brands et al., 2020) showed that higher educated people are better traders than lower educated people. Thus, this suggests that better trading skills do not necessarily lead to stronger support. Furthermore, people who live in the municipalities of Utrecht and Amsterdam have a larger dislike for TPC than people who live in the surrounding areas. This may seem surprising since in all TPC schemes, residents of Amsterdam and Utrecht receive credits whereas people living in the surrounding areas would only receive credits in two of the credit distributions (R3 and R4). A possible explanation is that people living in the municipality will always be confronted by TPC, whereas people living in the surrounding areas may have the option to avoid the area by traveling to other cities. Furthermore, it is remarkable that the inhabitants of Amsterdam/Utrecht are slightly more negative than average about the schemes in which only credits are given to them, instead of also giving credits to people from outside who work in the cities, for example, which seems to run counter to their self-interest.

Table 11 Results of the final panel ML model with error component structure

Name	Value	Rob. Std err	Rob. t-test	Rob. p-value
Constant_TPC	-3.4	0.714	-4.76	0.00**
F1_fluctuation_minute	-0.192	0.0602	-3.19	0.00**
F2_fluctuation_daily	0.192			
I1_interval_weekly	-0.147	0.0435	-3.38	0.00**
I2_interval_montlhy	0.147			
D1_equal distribution	0.599	0.108	5.56	0.00**
D2_more km traveled, more credits	-0.101	0.124	-0.816	0.414
D3_more hrs working, more credits	-0.234	0.102	-2.3	0.02**
D4_lower income, more credits	- 0.264			
R1_residents municipality	-0.287	0.0601	-4.78	0.00**
R2_residents municipality who own car	0.0659	0.134	0.491	0.624
R3_residents municipality + people who work there	0.0624	0.0913	0.684	0.494
R4_residents municipality + people who work there that own a car	0.1587			
Level of education	-0.346	0.131	-2.64	0.01**
work situation_other	0.428	0.454	0.943	0.35
work situation_retired	0.503	0.339	1.48	0.14
work situation_student	-1.13	0.527	-2.14	0.03**
Work situation_paid job	0.199			
Residence in municipality	-1.7	0.357	-4.76	0.00**
Interaction_residence in municipality_R1	-0.287	0.0601	-4.78	0.00**
Attitude_perceived fairness	1.21	0.264	4.58	0.00**
Attitude_expected effectiveness	1.17	0.227	5.15	0.00**
Attitude_trust	0.496	0.218	2.28	0.02**
Attitude_importance certainty	0.509	0.228	2.23	0.03**
Attitude_infringement on freedom	-0.342	0.204	-1.67	0.09*
Sigma_C_TPC	3.33	0.245	13.6	0**
Sigma_ D1_equal distribution	0.681	0.125	5.43	0.00**
Sigma_ D2_more km traveled, more credits	0.662	0.116	5.69	0.00**
Sigma_ D3_more hrs working, more credits	0.74	0.12	6.18	0.00**
Sigma_ R1_residents municipality	0.648	0.125	5.18	0.00**
Sigma_ R2_residents municipality who own a car	0.31	0.148	2.09	0.04**

** significant at 5% level
*significant at 10% level

Whereas the socio-economic variables and mobility behaviour explain relatively little about the support levels, the attitudinal variables explain more, according to the model fit improvement. Five attitudinal variables were found to significantly influence utility. Support is higher among people who perceive TPC as *fair* and *effective*, who have *trust* in the government and technical feasibility, who find *certainty* important, and do not consider TPC as an *infringement on their freedom* (only significant at a 10% level). The *perceived fairness* and *expected effectiveness* have the most influence on support and the signs of the coefficients are as expected. Less obvious is the positive value for the attitudinal variable *certainty*. This value indicates that people who consider it important to have certainty about travel costs and travel time show higher support for TPC. On the one hand, this makes sense because the introduction of TPC can make travel times less uncertain, but on the other hand, the travel costs become more uncertain. Thus, these people find certainty about travel times more important than certainty about travel costs, and/or they underestimate the increased uncertainty about travel costs within a TPC system. Within the set of attitudinal variables, we can conclude that ‘expected effectiveness' and 'perceived fairness' have a stronger relation with support than the other three attitudinal variables.

5.5 Predicted support levels

Based on the Mixed Logit model, we conducted simulations to predict the support levels of different TPC schemes using our sample. As a reference scenario, we calculated support for the TPC scheme with the highest average utility first. In that scheme, *all residents of the municipality + people who work there and own a car* receive credits, which are *equally distributed* on a *monthly basis* and the credit price fluctuates *daily*. We first calculated the probability that an individual would choose that TPC scheme. We used 100 draws for each random parameter. The mean support for that TPC scheme is 52.4%, indicating that a small majority of this sample supports this scheme.

At the other end of the scale, the least preferred TPC scheme has an average support level of 32.3% and consists of a scheme in which only *residents of the municipality* receive credits whereas *people with a lower income receive more credits than people with a higher income*. Furthermore, the credits are distributed *weekly* and the credit price fluctuates *every minute*.

Table 12 illustrates the impact of changing one attribute level when all other levels remain equal to the most supported scheme. Thus if instead of *equal distribution*, more credits are given to people who travelled more, this leads to a drop in support of 6.9%. The table shows that actually any change in scheme design will cause a drop in support level below 50% and thus to a minority for support. Nevertheless, operators may consider to make the credit interval smaller and the fluctuation of the credit price higher, if that makes the scheme more efficient. These two adaptations lead to a small drop in support, leading to a support level of 47%.

Table 12 The changes in support levels for TPC design caused by different attribute levels. The scheme with the highest support level is taken as the point of reference.

Change in design variable			Average absolute change in support level
Design variable	**Reference level**	**Other levels**	
Recipients of credits	All residents of the municipality + people who work there and own a car	All residents of the municipality	-7.96%
		All residents in the municipality who own a car	-3.01%
		All residents of the municipality + people who work there	-3.04%
Distribution principle	Credits are equally distributed among all recipients	People with a lower income receive more credits than people with a higher income	- 6.9%
		People who have travelled more km will receive more credits	-5.4%
		People who work more hours per week receive more credits than people who work less hours per week D3	-6.73%
Credit price fluctuation	Every day	Every minute	-2.98%
Credit allocation interval	Monthly	Weekly	-2.30%

5.6 Conclusion and discussion

This aim of this study was to explore public support for the novel concept of Tradable Peak Credits (TPC) as a policy instrument to reduce congestion. To that end, a discrete choice experiment was conducted, in which TPC schemes were varied in terms of who receive the credits, how these credits are distributed, how often they are distributed and how often the price fluctuates. In each choice set of the experiment, respondents first selected the TPC scheme they preferred and then indicated whether they would vote in favour or against this scheme in a referendum. A panel mixed logit model was estimated to examine the impact that the scheme characteristics, personal characteristics and attitudes had on support for the TPC scheme.

The results suggest that on average people prefer the status quo to implementing TPC. Overall, support increases if the credits are distributed monthly, the credit price fluctuates daily, and the credits are distributed equally, preferably among residents in the municipality + people who work there and own a car. This indicates that on average people prefer schemes that require less trading effort and in which credits are distributed equally, but preferably only to people who actually use the road. The tastes regarding the allocation of credits are however very heterogeneous. Depending on the scheme design, support levels range from 32.3% up to 52.4%. Thus, these results indicate that a small majority of people in this sample is in favour of the implementation of the most attractive TPC scheme. The support levels found in this study are higher than in a study on credit-based congestion pricing (CBCP) which found a support level of 24.9% (Kockelman & Kalmanje, 2005), and a tradable driving credit (TDC) scheme in the Netherlands that found a support level of 21.6% among car owners (Dogterom, Bao et al., 2018). The support levels found for TPC are also slightly stronger than support for a congestion charge. A recent opinion survey (I&O research, 2019) reports that 32% of Dutch citizens support a congestion charge. However, concluding that people like the TPC scheme design more than a congestion charge, CBCP or TDC design is probably too simplistic. When comparing these results, the sample and the way of questioning have to be kept in mind. For example, it is plausible that support for road pricing instruments is stronger in our sample of people from urban areas than the average of the Dutch population, since congestion problems are worse in and around cities. Furthermore, the TDC study, for example, found that 35% of the respondents had a neutral opinion, and in the congestion charge opinion study, this was 28%. Whereas in our study, respondents were presented with a referendum-based choice in which they either voted against or in favour of the scheme.

Furthermore, the difference of 20 percent between the least (32.3%) and most supported (52.4%) scheme design, is less than in the earlier study on tradable carbon permits which found that support levels increased from 20% to 80% (Bristow et al., 2010). But this difference is still quite substantial, especially given that it can make the difference between a policy being ‘rejected’ or ‘supported’ by a majority of the people. Nevertheless, the strong improvement in model fit indicated that people’s attitudes are very important in explaining their support. In other words, many people reject/accept TPC regardless of the scheme design. Remarkably, support is lower among people who live within the city boundaries, which contradicts the findings in Stockholm (Stockholms stad, 2007). The important role of attitudinal variables, including expected effectiveness, infringement on freedom and especially perceived fairness, is in line with earlier road pricing studies (Sun et al., 2016). However, the variables of problem awareness and perceived behavioural control were not significantly related to support, which contradicts with the theory of planned behaviour (Ajzen, 1991) and norm activation theory (Schwartz, 1977).

A few recommendations for policymakers can be made, based on the results. As explained above, the results indicate which scheme design is most preferred. The preferences for the different credit allocations were, however, very heterogeneous and should be further explored. The results also emphasize that people prefer a scheme that requires the users to have less trading ‘hassle’. This is in line with what has already written about in road pricing literature, which found that people have a strong preference for a simple tariff structure (Bonsall et al., 2007), even though people do respond in a rational way to complex tariffs (Bonsall et al., 2007) and tradable parking credits (Brands et al., 2020) which indicates that they understand it. Thus from the perspective of optimizing support, a simpler scheme is advisable. From a broader perspective, however, it is important to study the balance between the complexity (or ‘hassle’) and the efficiency of the instrument. Generally, road pricing schemes become more efficient when the tariffs are more differentiated, which leads to a more complex, ‘hassleful’ scheme, which is less acceptable. If simplifying a TPC scheme leads to undermining its efficient properties, the motivation to implement the scheme no longer hold.

The results have to be interpreted with some caution since this is a first quantitative study regarding public support of TPC, which has some limitations. TPC was presented to the respondents without mentioning system and administration costs. Due to the trading platform, it is likely that a TPC system will be more expensive for the operator (the government, in this case) than a congestion charge. It would be interesting to further study public support, using a representative sample, from a citizen’s perspective by confronting respondents with the societal costs (e.g. system costs) and benefits (e.g. reduction of congestion) of both instruments. Furthermore, only the influences of a limited set of variables are explored in this chapter, whereas some more variables may be of relevance in explaining support. According to the theory of planned behaviour (Ajzen, 1991), social norms and perceived social pressure are relevant in explaining behaviour. When one feels social pressure to reduce car use, the acceptability of TPC may be higher. Also, in line with the norm-activation theory (Schwartz, 1977), acceptability may be higher when people feel morally obliged to change their (car use) behaviour because they realize that their own car trips are part of the congestion problem. Sun et al. (2016) already found empirical evidence for these relationships in the acceptability of road pricing. Moreover, this chapter studied the support levels based on people’s first impression of this novel instrument, which they had never heard of before. TPC is new to people and some people might be reluctant to support an instrument they have never heard reliable experts speak about. In contrast, congestion pricing and kilometre charging schemes have increasingly received positive media attention in the Netherlands. It is unknown whether and how attitudes and acceptability change when people get more acquainted with the concept. Revealed preference studies that examine the support of people who have actually been using tradable credits in field studies would be very helpful in this respect. Finally, this first study, quantifying the support for tradable credits for congestion management, suggests that the best TPC design may be supported by a small majority, at least in this sample, but still many aspects of TPC design have to be further explored to gain insights into the feasibility of TPC as a tool to manage congestion. Indeed, public support is an important requisite for the implementation of an innovation, but it is not sufficient, since the instrument should also be technically feasible, politically accepted, and the societal benefits need to exceed the costs (Feitelson & Salomon, 2004). The first lab experiments showed that people respond to the scheme in a logical way (Brands et al., 2020; Dogterom, Ettema et al., 2018) but real world experiments are needed to better understand behavioural effects, to fine tune the design and to measure the acceptability better.

6 Public support for road pricing schemes: latent preference classes identified

This chapter has been submitted to a journal with Maarten Kroesen, Bert van Wee, and Eric Molin as co-authors.

Abstract - The concept of Tradable peak credits (TPC) is drastically different in the longstanding search for an effective and socially accepted road pricing policy. It is believed in the literature that tradable credits may be more supported by the general public, and specifically by car users, who typically oppose conventional road pricing schemes. In contrast, one can argue that typical supporters of conventional instruments, such as public transport users, may oppose TPC. Therefore, in a survey research, we have measured the support for three road pricing instruments: TPC, congestion charge, and kilometre charge. This survey was completed by 501 citizens from urban regions in the Netherlands. Contrary to expectations, the results indicate that TPC is not supported more than conventional road pricing schemes: its support (27%) is about equal to a congestion charge (29%), while a kilometre charge is the most supported (34%). To explore heterogeneity in the support of the three road pricing instruments, a Latent Class Cluster Analysis was conducted, which identified five homogeneous clusters of citizens. The largest cluster, representing 58% of the respondents, is undecided about all instruments, whereas a another cluster of 18% is negative and a cluster of 8% is positive about all instruments. Furthermore, 10% supports only TPC and 6% supports only a kilometre charge. As expected, the cluster that supports only TPC consists mainly of car users. Policy implications derived from the results are discussed in this chapter.

6.1 Introduction

Real-world implementation of road pricing is still a rare phenomenon despite scholars' longstanding theoretical arguments favouring the concept, the increase in congestion and pollution in urban areas, and the fact that a few cities have already demonstrated the effectiveness and feasibility of the policy (i.e. London, Stockholm, Milan). Low social support and the associated low political feasibility are the factors that are mentioned the most often, explaining the lack of implementation (Vonk Noordegraaf et al., 2014). Although the general public and public transport users often show mild support for road pricing, most car users are negative about road pricing (Börjesson et al., 2015; Gaunt et al., 2007; Jaensirisak et al., 2005). Since car users are typically better organized through interest groups, they have had more influence on the public and political debate regarding road pricing than non-users (Smaal, 2012). Hence, many of the road pricing acceptability studies (for an overview, see Schade & Schlag, 2003a) have focused on the support and preferences of car users regarding different road pricing alternatives (e.g. cordon based charges, congestion charges, kilometre taxes).

A drastically different alternative in the longstanding search for an effective yet accepted scheme is the concept of tradable credit schemes for congestion management. This concept is based on the idea of tradable property rights (Coase, 1960), which has been further developed into systems that regulate atmospheric pollution (Crocker, 1966) and water pollution (Dales, 1968), for example. The concept can be designed in various ways, but it is generally understood to be a market-based instrument that puts a strict limit (cap) on car use and distributes credits that represent a share of this car use among participants. They may trade their credits so that participants who value car use the highest can buy extra credits while those who value car use lower can sell them. The first papers on tradable credits in transportation research appeared two decennia ago (Verhoef et al., 1997b) and the number of papers dealing with the concept has risen considerably in the last few years. Most of these studies focus on behavioural implications, on scheme design, or they explore theoretical considerations (for reviews on these topics, see Dogterom et al., 2017; Fan & Jiang, 2013; Grant-Muller & Xu, 2014, respectively).

The main motivation for exploring tradable credit schemes lies in the notion that the concept has several characteristics that are hypothesized to be more acceptable to (at least part of) the public in comparison with conventional, pricing-based instruments. The first potentially favourable characteristic is that tradable credit schemes do not have a financial flow from road users to the government as regular road charging schemes have, since the money flows among participants of the schemes. Since scepticism regarding governments raising and spending revenue are major issues for the opponents of charging instruments, the budget-neutral characteristic of tradable credits are believed to enhance public support. The second potentially favourable characteristic is that initial credits can be allocated in many different ways, which offers the opportunity to address equity concerns in a more direct and flexible way than in traditional price-based schemes. This may increase acceptability, as the perception that road pricing schemes treat some groups unfairly is probably the reason that is most mentioned for opposing a scheme. Lastly, tradable credit schemes may be perceived as more effective than a regular pricing scheme since the operator has control over the inflow of cars, due to the firm cap.

Hence, it is hypothesized by researchers that the public support for tradable credits could be higher than for conventional road pricing schemes (e.g. Brands et al., 2020; Fan & Jiang, 2013;

Raux, 2002) because a share of people who oppose charging-based instruments would support tradable credits. Frequent road users, in particular, may be more positive about tradable credits since in a congestion charging system they would need to pay for every trip (during peak hours), whereas in a tradable credit system, they would receive a budget with free credits. At the same time, people who support charging-based instruments may reject tradable credits if, for example, they consider it important that revenues are generated that can be used for public transport investments. Evidence for this hypothesis is, however, largely lacking as support for tradable credit schemes has not received much research attention. A few studies measured support for related schemes. Kockelman and Kalmanje (2005) surveyed households in Texas about a (non-tradable) credit-based congestion pricing (CBCP) scheme and found that 24.9% would support it, which they consider to be a considerable number given that the concept is totally new to people, and this number is similar to support for flat tolls (24.2%). Bristow et al. (2010) studied public support for different personal carbon trading schemes and found that 22% - 80% would support a tradable scheme, whilst support for a carbon tax reached 70%. Harwatt et al. (2011) interviewed 60 people representing the UK's employed population about personal carbon trading and they also concluded that the tradable scheme is preferable to an equivalent tax measure (fuel price increase). Dogterom, Bao et al. (2018) solely focused on car users' acceptability of a tradable kilometre scheme and found strong support in Beijing (67%), but much lower support in the Netherlands (21%). Possibly car users in Beijing are more supportive of tradable credits because they currently have a relatively strict license plate policy, and because they face much more congestion in Beijing than the average car user in the Netherlands. They did not measure support for an (equivalent) kilometre charge in their sample.

Although these studies show that overall support for tradable credits can surpass support for equivalent taxes, they do not reveal whether the supporters of tradable credit schemes are the same people who support an equivalent tax. It may be that some people shift from 'reject' to 'accept' positions when they are confronted with different (novel) road pricing instruments, or vice versa. Therefore, it is relevant to not only measure the overall support levels of tradable credits for congestion management and to compare it to overall support for conventional schemes, but also to explore the heterogeneity among people. It is likely that there are several groups of people with different opinions about different schemes. Differences could exist based on personal interest, such as between (frequent) car drivers and others, but also based on perceived fairness, trust in governments, or other factors. These insights may be useful for policymakers because results could reveal how resistance to road pricing policies differs between groups of people and they should next consider alternative policy designs to increase support in general, and of specific groups in particular.

This explorative study therefore serves two aims. Firstly to quantify the support levels for tradable credits for congestion management in comparison to conventional road pricing instruments. Secondly, to identify distinct homogeneous clusters of people that show similar support behaviour to a set of (novel) road pricing schemes and relate these groups to mobility behaviour. To serve these aims, a survey has been conducted among citizens of urban areas in the Netherlands. The respondents were asked to indicate their support for a tradable peak credit scheme (TPC) and two conventional road pricing schemes (a kilometre charge and a congestion charge). To identify distinct clusters, latent class cluster analysis (LCCA) (Vermunt & Magidson, 2002) was applied, which is an explorative, probabilistic clustering technique. The method has been employed in transportation research before to identify segments among historic car owners (Araghi, Kroesen, & van Wee, 2017), to define customer segments regarding the adoption of mobility as a service (Alonso-González, Hoogendoorn-Lanser, van Oort, Cats, & Hoogendoorn, 2020), or to find classes of mode use (Molin, Mokhtarian, & Kroesen, 2016; Ton et al., 2019), for example. Besides mobility behaviour, also socio-demographic variables and attitudes are used to identify who belongs to which cluster.

The remainder of this chapter is structured as follows. Section 6.2 discusses the methodology and explains the choice for the LCCA method. Section 6.3 present the results, firstly by a short description of the overall support levels, and secondly by describing the identified clusters in detail. Section 6.4 ends this chapter by providing conclusions and discussing policy implications.

6.2 Research methodology

6.2.1 LCCA

In order to classify similar responses into groups (clusters), latent class cluster analysis (LCCA) is applied. The basic idea of LCCA is that individuals are assigned to classes in a probabilistic way according to a discrete latent variable that accounts for the observed associations between a set of indicators (i.e. support for the three instruments) in such a way that these associations become insignificant (Vermunt & Magidson, 2002). LCCA is preferred over conventional cluster analysis (e.g. K-means clustering) for the following reasons: (1) conventional cluster analysis assigns respondents in a deterministic way to a single class/cluster, which entails the risk that respondents are wrongly classified. Probabilistic assignment as LCCA does, reduces that bias. (2) LCCA provides more formal (statistical) criteria which can be used to decide on the optimal number of classes/clusters, (3) LCCA provides information on the statistical significance of the model parameters, and (4) LCCA is more flexible since it is easier to deal with variables of different scale types (Vermunt & Magidson, 2002).

The probability density function is as follows (following the notation of Vermunt and Magidson (2005):

$$P(y_{i1} = m_1, y_{i2} = m_2, y_{i3} = m_3) = \sum_{x=1}^{K} P(x) \prod_{t=1}^{3} P(y_t = m_t|x)$$

In this formulation, y_i stands for the individual's (i) response to to indicator variable t, with range m. Furthermore, x is the latent variable that explains the associations between the indicator variables. This is based on the assumption that the indicator variables are mutually independent of each other within a latent class, which is called the assumption of local independence (Magidson & Vermunt, 2004). The variable x has K categories. These categories are refered to as clusters or classes in LCCA studies. Thus, individuals are probabilistically assigned to a class that explains their response to a set of observed indicators. To be able to investigate the relationship between class membership and personal characteristics, the analysis can be extended by including external variables in the class membership function, which are typically called covariates in LCCA (note that these are not included in the formulation above, the reason for which will be described below). Figure 9 illustrates the conceptual model, Section 6.2.2 discusses the indicators for this study, and Section 6.2.3 discusses the covariates.

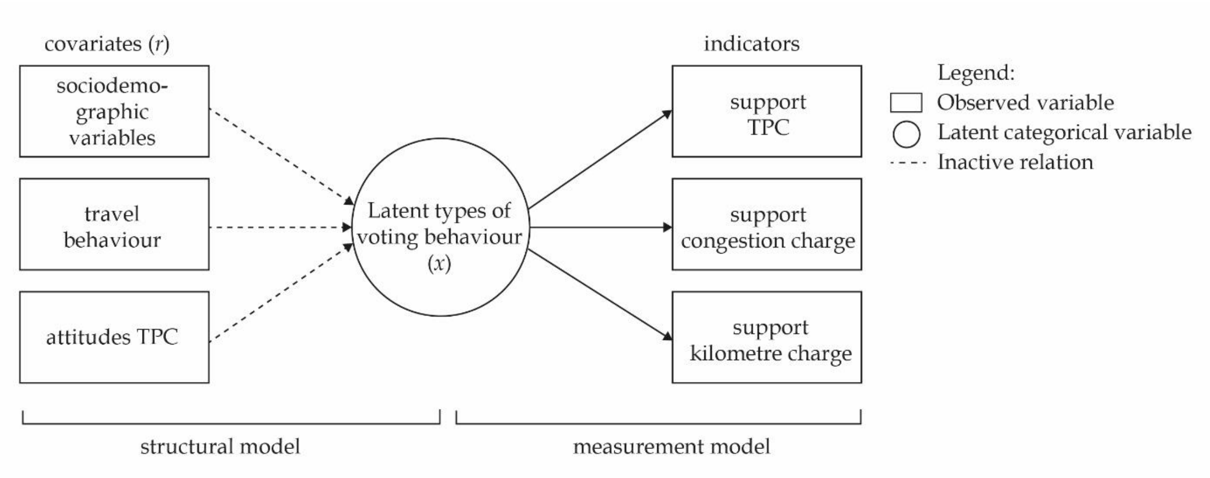


Figure 9 Conceptual model

6.2.2 Indicators

The support levels for the three road pricing alternatives considered - i.e. a kilometre charge, a congestion charge, and tradable peak credits (TPC) - are measured by asking respondents to what extent they would support the introduction of the schemes on a five-point Likert scale ranging from '1: completely against' to '5: completely in favour'. These indicator variables represent ordinal variables. Both a kilometre charge and a congestion charge have been widely discussed in political arenas and public debates, also in the Netherlands. In this survey, the congestion charge was explained as '*every car user pays a fixed tariff per trip during peak hours. The government uses the revenues for improvements in the transport system (for roads and public transport/bicycle)*'. The kilometre charge was explained as follows: '*every car user pays a fixed tariff to the government, per kilometre driven (in and outside peak hours). If a kilometre charge is implemented, the motor vehicle tax will be abolished'*. TPC on the other hand is new and was therefore explained in more detail to the respondents. Basically, the respondents were presented with a TPC scheme that can be applied on all highways and provincial roads in the city during peak hours on weekdays. The peak hours are between 07:00-09:15 and 16:00-18:15. The government decides how many credits are issued and they are distributed free of charge every month or week. Participants have a personal online account to manage their credits, and where they can also trade their credits. The credit price is determined by supply and demand, but the maximum credit price is set at 6 Euros. People cannot buy more credits than they can use themselves. The credits are redeemed automatically when people use the specified roads during the specified time slots. If people drive there with an empty credit account, they receive a notification to buy a credit. If they do not do this, the system will automatically buy a credit plus a small fee of 1 Euro extra. The complete text of the introduction can be found in Appendix C.

6.2.3 Covariates

A review of existing literature was conducted to identify personal characteristics that may be relevant in explaining support for (novel) road pricing instruments. Since the acceptability of tradable credits has not been studied in depth, focus group meetings were also used to complement the list of factors. The authors organised five meetings in total, in which 36 participants discussed TPC and a congestion charge (Krabbenborg et al., 2020). Based on these two sources, we distinguished three types of factors, which will be discussed accordingly: social demographics, mobility habits, and attitudes.

The studies on the relation between different socio-demographic variables and acceptability show a rather inconsistent picture. Regarding *income*, most studies found a positive relation with acceptability (Golob, 2001; Verhoef et al., 1997a), which is in line with the assumption that people with higher income value time have a higher value of time and hence are more willing to pay for uncongested roads. Some other studies, however, could not find a significant effect (Dogterom, Bao et al., 2018; Jaensirisak et al., 2005) and one study even reports a negative relation between income and acceptability (Harrington et al., 2001). Regarding *educational level*, most studies report a positive relation (Börjesson et al., 2015; Ubbels & Verhoef, 2006), whereas, again Harrington *et al.* (2001) report a negative relation. Furthermore, *age* is negatively associated with acceptability (Jaensirisak et al., 2005; Odeck & Bråthen, 1997), as is being *female* (Börjesson et al., 2015). People who have a *child in their household* are more negative towards road pricing according to Börjesson et al. (2015) but Gehlert et al. (2011) found that households with children are more positive about different road pricing schemes compared to couples/singles. One can argue that parents have higher value of time because they experience more time pressure and hence are more willing to accept road pricing, but parents may also be more negative about road pricing since they are more dependent on the car and/or are less flexible about changing their departure time. Furthermore, the relation between acceptability and *employment status* is often not systematically correlated to acceptability (Schuitema et al., 2010), although Ubbels and Verhoef (2006) did find more support among employed people who get financial compenstation for their travel costs. Lastly, the relation between *place of residence* and acceptability has not been studied much but the few studies that exist show fairly consistent results. In Edinburgh and Stockholm, people living in the areas outside the road charging cordons were less supportive than people living within the city (Cain & Jones, 2003; Stockholms stad, 2007). Also Gehlert et al. (2011) found lower acceptability levels among suburban families. Although this may also be explained by mobility habits, since people in cities are usually less dependent on their car.

Indeed, mobility habits are also related to acceptability levels. As stated in the introduction, frequent car users reject road pricing more often than people without a private car and less frequent car users, on average (Börjesson et al., 2015; Eliasson & Jonsson, 2011; Gaunt et al., 2007). People who do not use the car as their main mode of transport are, on average, much more supportive of road pricing (Jaensirisak et al., 2005). Especially people who are satisfied with their transit options are more likely to support road pricing (Eliasson & Jonsson, 2011). However, as Cain (2005) shows: the percentage of non-car users that support road pricing is not as high as the percentage of car users that reject road pricing. Gaunt et al. (2007) also conclude that car users strongly oppose the suggested scheme whereas non-car users only weakly supported it.

Attitudes towards the measures usually have much stronger relationships to acceptability than socio-economic variables. According to literature on road pricing, *perceived fairness,* in particular, is strongly positively related to acceptability (e.g. Di Ciommo et al., 2013; Eriksson et al., 2006; Jakobsson et al., 2000; Sun et al., 2016). Acceptability is also higher when people do not perceive the scheme as an *infringement on their freedom* (Jakobsson et al., 2000; Kim et al., 2013; Sun et al., 2016), when people have a *high problem awareness* (Eriksson et al., 2006; Harrington et al., 2001), when people are positive about the *expected personal outcome*

(Hamilton et al., 2014; Schade & Schlag, 2003b), if they *trust the public agencies* responsible for road pricing agencies (Hamilton et al., 2014) and when they think that the scheme is *effective* (Eliasson & Jonsson, 2011; Rienstra et al., 1999; Schade & Schlag, 2003b; Ubbels & Verhoef, 2006). In a focus group meeting study by the authors (Krabbenborg et al., 2020), a few more attitudes were revealed that may be relevant in the TPC debate. Support for TPC may be higher among people who consider trading *fun* and among those who believe in the *technical feasibility*. Support for TPC may be lower among those who expect *hassle* (in terms of expected time and effort), those who expect that people will *misuse* the system, and who consider the scheme very *complex*. A few participants in the focus group meetings also stated to dislike of TPC because it makes travel costs *uncertain*, since credit prices fluctuate.

Based on the literature review and the focus group sessions as presented by the authors, a total of 23 attitudinal statements were developed and measured in the survey. Before exploring the relationships between attitudes and support, these 23 statements were subjected to an exploratory factor analysis in order to identify the underlying dimensions and construct composite scales. Indicators with a low communality (<0.25) and low factor loadings (<0.50) were removed and this led to a simple structure of seven factors as indicated in appendix D. A Cronbach Alpha test was conducted on the variables with a high loading on a certain factor to check for their internal consistency and to see whether the scales are reliable. Two factors have values of 0.654 and 0.682, which is lower than the widely accepted 0.7 criterion. But since values between 0.6 and 0.7 are considered acceptable in exploratory studies (Taber, 2018), these factors were not excluded. The scales were constructed as sum scores. Of the five statements that were excluded from the factor analysis, two statements represent attitudes that were different from the seven factors and were therefore also included in the further analysis. In total, nine attitudinal factors are included and are labelled as: *expected effectiveness, importance of certainty, expected hassle, expected infringement, perceived fairness, trust, problem perception, personal problem perception,* and *perceived behavioural control*.

6.2.4 Data collection and sample

Since congestion problems are worst in urban areas and charging schemes are mainly considered in large cities (e.g. London, Stockholm), this study focuses on people living in or near two cities: Amsterdam and Utrecht (in the Netherlands). Responses were collected via an online panel of a company called CG Research (www.cgresearch.nl). Respondents had to be 18 years or older and received a gift voucher worth EUR 1.50.

In total, 889 people opened the survey, and of these, 513 people completed the survey. We checked the data for incompleteness and unreliability. Since clicking through the survey, without reading the text, takes 210 seconds (and 360 for the ones with a video), responses that were completed faster than that were removed. 12 respondents were removed from the dataset because they were too fast or their response was incomplete. This led to a remaining sample size of N=501. This dataset has also been used for the estimation of a choice model (Chapter 1).

Table 13 compares the main socio-demographic variables of the sample and the population. Since information on the distribution of socio-demographic variables for the population of people ‘living in and near Amsterdam/Utrecht’ are not readily available, the socio-demographic information of the municipalities of Amsterdam and Utrecht were used as proxies. Females between 65 and 79 years old and retired people are slightly overrepresented in the sample, while lower and higher educated people are slightly underrepresented. Nevertheless, all categories are represented with a sufficient number of people to allow the relationships between socio-demographics and their support for different instruments to be studied. Regarding transportation use, 44% of the sample uses the car as their main mode of transport, 1% a motorcycle, 17% train/bus/metro, 29% (e)bicycle, 2% moped and 5% walks.

Table 13 The main socio-economic characteristics of the sample compared to the population

Socio-economic variable	Category	Share sample [%]	Share population [%]
Gender [a]	Male	42.1	49.4
	Female	57.7	50.6
Age [a]	18-24	6.0	13.7
	25-44	31.3	45.2
	45-64	30.8	29.3
	65-79	30.1	11.6
	80+	1.8	3.3
Level of education [a]	Low	12.8	16.2
	Medium	32.9	27.1
	High	54.3	56.6
Employment [a]	Student/in training	5.2	11.1
	Retired	24.8	13.4
	Paid work (up to 20 hours/week)	11.2	68.0
	Paid work (20-35 hours/week)	18.0	
	Paid work (35+ hours/week)	25.1	
	Entrepreneur	1.6	
	Other (e.g. incapacitated, volunteering)	14.2	7.5
Gross household income (Euros/yr) [b]	<10,000	4.6	4.9
	10,000 – 20,000	10.6	25.9
	20,000 – 30,000	15.6	32.4
	30,000 – 40,000	15.8	21.2
	40,000 – 50,000	11.6	8.9
	50,000 – 100,000	18.6	5.9
	100,000 +	2.8	0.7
	Unknown	20.6	

[a] **compared to the population of people living in the Municipalities of Amsterdam and Utrecht (CBS, 2019a, CBS, 2019b)**
[b] **compared to the Dutch population (CBS, 2017)**
Education categories: Low: no diploma, primary school, preparatory secondary vocational education, intermediate vocational education level 1. Middle: higher general secondary education, pre-university education, intermediate vocational education level 2, 3 or 4. High: Bachelor's or Master's degree, PhD

6.2.5 Estimation procedure

To decide upon the appropriate number of latent classes, we estimated a series of models ranging from 1 up to 10 classes. Table 14 presents the fit of these models. To select the appropriate number of classes, it is common to evaluate both model fit and model parsimony. The Bayesian information criterion (BIC) is the most commonly used measure in LCCA to indicate that balance (Nylund, Asparouhov, & Muthén, 2007). The model with the lowest BIC value is the preferred one, given that the clusters have interpretable grounds. As Table 14 shows, the BIC reaches the lowest values with the 8-class model. A model with that many clusters is, however, difficult to interpret. We therefore also examined a local (instead of a global) measure of fit to decide upon the best model. This is done with the bivariate residuals (BVR). A BVR value substantially larger than 1 suggests that the model falls short in explaining the association between a pair of indicators (Porcu & Giambona, 2016). Based on this BVR criterion (see the last three columns of Table 14), the 5-class solution is the first that meets this requirement. Since these five classes were well interpretable, we selected this solution for the further analysis.

Table 14 Evaluation criteria for determining the number of classes

# class	LL	BIC(LL)	Npar	Smallest class (%)	BVR		
					TPC - Congestion charge	TPC - Kilometre charge	Kilometre charge - Congestion charge
1	-2299.55	4673.69	12	100.0	92.5	32.7	156.0
2	-2169.51	4438.48	16	25.33	18.0	0.05	13.0
3	-2128.96	4382.25	20	8.44	5.5	2.1	0.2
4	-2095.09	4339.39	24	5.02	0.05	0.00	1.4
5	-2080.82	4335.71	28	4.67	0.15	0.15	0.69
6	-2067.37	4333.67	32	3.57	0.15	0.40	0.38
7	-2053.17	4330.13	36	2.13	0.84	0.02	0.80
8	-2039.86	4328.38	40	2.17	0.04	0.01	0.14
9	-2034.77	4343.06	44	1.02	0.04	0.01	0.01
10	-2031.45	4361.30	48	1.14	0.03	0.01	0.00

LL = final log-likelihood of the model.
BIC(LL) = Bayesian information criterion (based on log-likelihood).
Npar = number of parameters.
BVR = bivariate residuals

Then, the classes were related to the personal characteristics, which can be done with a one-step or three-step approach (Bakk, Tekle, & Vermunt, 2013; Bakk & Vermunt, 2015). In the three-step approach, the researcher first builds a latent class model for the indicator variables and decides upon the optimal number of classes (weighing model fit and parsimony), then computes the posterior class membership probabilities, and then relates the latent classification scores to these external variables, called covariates. With this approach the covariates do not unduly affect the classification (which is solely based on the indicators), but at the same time, the relationships between the covariates and the class membership is 'corrected' for the measurement error in the latent class variable (because of the probabilistic assignment of respondents to the latent classes). This is also the reason why we did not include the covariates in the class membership function in the equation (1).

The software package of Latent Gold was used for the model estimations (Vermunt & Magidson, 2013).

6.3 Results

6.3.1 Support levels for TPC, congestion charge, and kilometre charge

Before presenting the clusters and their support levels in the next sub section, first the average support levels for the three instruments are described to get an indication of the overall support (see Table 15).

TPC has the lowest support (27.0% is somewhat/completely in favour), closely followed by a congestion charge (28.6%). A paired sample t-test, however, shows that the average scores do not differ significantly from each other. A flat kilometre tax can count on the most support (34.2%), which is significantly higher than support for TPC and a congestion charge, according to paired t-tests. The support for a congestion charge is similar to results found in a recent opinion survey done in the Netherlands that reports that 32% would support a peak charge (I&O research, 2019). Thus, in contrast to our expectations as stated in the introduction, the results suggest that the general concept of TPC does not receive higher support from the public than a congestion charge. Instead, support levels of these two instruments are more or less the same. Also, the share of people that is (completely/somewhat) against TPC (50.7%) is roughly the same as the share that is against a congestion charge (50.1%).

Although the overall support levels of TPC and a congestion charge are similar, that does not mean that people that support a congestion charge are the same people that support TPC. The correlations between the three support variables are significant and positive but rather low (the correlation between TPC and a congestion charge is 0.423, between TPC and a kilometre charge 0.255 and between a congestion charge and a kilometre charge 0.550). These low correlations indicate that relatively, many people who support TPC do not necessarily support a congestion charge and vice versa, which is in line with our expectations and this will be further explored in section 6.3.2.

Table 15 Support levels for TPC, a congestion charge and a kilometre charge on the 5-point Likert scale

Statistics	TPC	Congestion charge	Kilometre charge
Completely against [1]	34.5%	31.9%	34.1%
Somewhat against [2]	15.8%	17.8%	11.0%
Neither in favour/ nor against [3]	22.8%	21.8%	20.8%
Somewhat in favour [4]	19.8%	18.0%	19.6%
Completely in favour[5]	7.2%	10.6%	14.6%
Average	2.49	2.57	2.69
St. dev.	1.33	1.37	1.47

6.3.2 Five identified types of support/reject

For the interpretation of the five clusters of 'voting behaviour', the within-cluster distributions of Table 16 are used in the remainder of this chapter. We labelled each cluster using the answers to the indicator variables. The clusters are labelled as follows: *Undecided about all instruments*, *Negative about all instruments*, *Positive about all instruments*, *Supports TPC*, and *Supports a kilometre charge*.

Undecided about all instruments
The first and largest cluster consists of 57.9% of the sample and scores fairly neutral on all instruments. The support for TPC is a bit more towards the negative side with 39.9% being completely/somewhat against.

Regarding personal characteristics, this cluster does not deviate much from the sample average, which makes sense since this cluster contains almost 60% of the sample. In this cluster, 64.5% is female which is slightly higher than the sample average of 57.7%. The mean age of this cluster is 50 years, which is lower than the other clusters, although the difference with the sample average (52 years) is not that large. Most people in this cluster are highly educated (57.3%), which is a bit more than the sample average. Most people live alone (47%), which is slightly more than average. More than half has a paid job (54.5%) and this cluster has the lowest share of retired people (21.2%).

For 35.8%, the car is the main mode of transport, which is lower than the sample average (44.9%). Instead, people in this cluster use active modes (41%) or public transport (20.5%) as their main mode. Most people in this cluster use their car 2-4 days a week (38.5%), but also a large share uses the car less than once a month (23.5%) or is a daily car user (11.6%).

Also the scores on the attitudinal scales lie between the other four clusters. The people in this cluster are on average rather neutral about the expected effectiveness (3 on a 5-point Likert scale), expected hassle (3.2), infringement on freedom (3), perceived fairness (2.9), and trust in the government (3).

In short, people in this cluster do not have a strong reject or support position for the three road pricing instruments. In terms of personal characteristics, this cluster is rather similar to the overall sample.

Negative about all instruments
The second cluster consists of 18.3% of the sample and is negative about all the suggested road pricing instruments.

In terms of age and gender, again this cluster does not deviate much from the sample average (52.5% is female and there’s an average age of 54). The members of this cluster are lower educated than the sample average (43.9% has a high education). 32% lives with children in the household, which is more than the other clusters. 58.7% of the people in this cluster have a paid job, which is also more than all the other clusters. In terms of household income, this cluster does not deviate much from the sample average. But given that this cluster contains most households with children, their purchasing power may be the lowest of all the clusters.

Regarding mobility behaviour, most people use the car as their main mode of transport (66.7%) which is higher than the sample average (44.9%). Car use is quite high in this cluster. 76.8% of this cluster uses the car at least twice a week, which is more than most clusters, but not as much as cluster 4. Also their car use during peak hours is higher than the other clusters.

People in this cluster do not have much faith in the effectiveness of TPC (1.5 on a 5-point Likert scale), they expect a lot of hassle with TPC (3.6), and find it an infringement on their freedom (4.1). The perceived behavioural control (2.6) is lower than in most other clusters, which indicates that they do not see many alternatives to their car trips.

In a nut shell, people in this cluster are negative about all the suggested road pricing instruments. People in this cluster use their car a lot. Their car dependence is probably quite high given the relatively high number of children in their households.

Positive about all instruments

The third cluster consists of 7.9% of the sample and is predominantly positive about all three instruments. Nearly everyone in this cluster is somewhat/completely in favour of the two conventional instruments (congestion charge and kilometre charge). About two-thirds of this group is somewhat/completely in favour of TPC, whereas almost 25% is neither in favour, nor against TPC.

This group is predominantly male (88.2%) and is the only cluster that has a majority of men. The average age is 55 years old, which is a bit older than the sample average (52 years). Regarding household composition, only 5.1% have children, which is much lower than the sample average (24.4%) and this is the cluster with most people living alone (58.1%). Furthermore, this is the cluster with the most highly educated people (69.7% has a university degree) and the least lower educated people (10.1%). Relatively, many people in this cluster are retired (35.4%) and their income seems to be the highest of all the clusters (19.2% has a high income, versus 9.8% of the sample average).

This cluster is further distinctive through the very high share of people that live within the borders of Utrecht and Amsterdam (92.5%, versus 61.9% of the sample). In terms of main mode of transport this cluster does not deviate much from the average, with 43.1% using the car as their main mode. 17.4% never has access to a car, which is the highest of all clusters, but still, most people in this cluster always have access to a car (62.4%). Car use is the lowest of all clusters: 44.4% uses the car less than 4 days a month. Only 15.2% has travel costs for work, which is much lower than the sample average (41.5%). Also car use during peak hours is very low.

As can be expected, people in this cluster are rather positive about TPC. They have a high expectation of the effectiveness (scoring 3.8 on a 5-point Likert scale). They are, on average, neutral about the expected hassle of a TPC instrument (3 on a 5-point Likert scale). On average, they score 2.8 on the scale of ‘infringement of freedom’, which is the lowest of all clusters, and they have the highest score on perceived fairness of TPC (3.4). Furthermore, they are most positive when it comes to trust in the government and technology (3.6) and perceive the problem of congestion as the most severe (4.6). Lastly, they find it easy to find alternatives to the car (4.0), which makes sense since this cluster lives within the city borders.

In short, this cluster represents a group that is positive about all suggested road pricing instruments. They live within the borders of Amsterdam/Utrecht, find congestion a big problem, are positive about alternatives to the car and do not use the car that much, are relatively rich, highly educated and barely have to pay to travel to work themselves.

In favour of TPC

The fourth cluster contains 9.8% of the sample and is rather positive about TPC and negative about a congestion charge and a kilometre charge. The negative attitude towards a kilometre charge is clear (98% is completely against), whereas the negative attitude towards a congestion charge is slightly less strong (78% is completely against, and 21% is somewhat against). 52% is somewhat/completely in favour of TPC, but 29% is neutral and 19% is against.

Regarding personal characteristics, this cluster does not deviate much from the sample average in terms of gender (55% is female), average age (54 years), and educational level. This cluster is characterized by the relatively few single households (31%), since most either live as a couple (39%) and/or with children (30%). This cluster has more retired people (35%) than the sample average of 25% and the number of unemployed people is the lowest of all the clusters (4%). Furthermore, only a few people (2%) with a high income are in this cluster. 70% lives within the municipality, which is more than the sample average (62%).

More distinctive for this cluster is the car use. 70% uses the car as their main mode of transport, which is much more than the sample average (45%) and the use of public transport is the lowest of all clusters at 10%, as is the use of active modes (18%). Car availability is the highest in this group (82% always has access to a car), and 90% uses the car at least 2 days a week, which is higher than the other clusters. 52% of this cluster uses the car at least once a week during peak hours, which is similar to the second cluster.

The attitudes are in line with the support for TPC. The expected effectiveness of TPC is the highest of all the clusters (average of 3.6 on a 5-point Likert scale). They find certainty of travel costs and travel time very important (4.3), are relatively neutral when it comes to the expected hassle of TPC (2.8) and have trust in the government (4.1). Their perceived behavioural control is the lowest of all the clusters, which indicates that they are negative about alternatives (e.g. public transport or bicycle) for their car trips.

In short, this cluster contains people who reject the two charging instruments (peak charge and kilometre charge) and support TPC. The people in this clusters use their car quite often, do not see many options for alternatives to their car use, but do consider congestion to be a big problem.

In favour of a kilometre charge

The fifth and smallest cluster represents 6% of the sample. People in this cluster clearly reject TPC and a congestion charge, and support a kilometre charge (89% is somewhat/completely in favour of a kilometre charge).

This cluster has the largest share of women, with 71% being female. It is also the cluster with the highest average age, this being 58 years old. Quite a substantial share of this cluster is retired (35%) and there are no students in this cluster. Regarding household composition, this cluster does not differ much from the sample averages. This cluster is further characterized by relatively, many low income households (35%).

In contrast to the other clusters, this cluster contains mainly people who live outside the municipality (65%). The car is the main mode of transportation for only 28%, which is the lowest of all clusters and considerably lower than the sample average (45%). Many of the people in this cluster use an (e)bike or they walk as their main mode of transportation (53%). Most people in this cluster (always) have access to a car and 52.7% used the car but they hardly ever use it during peak hours (73% never used the car during peak hours), this being the fewest of all of the clusters.

Regarding attitudes, their expectations of the effectiveness of TPC are very low, they expect that TPC will require a lot of hassle, they find it an infringement on their freedom, they do not find it a fair instrument, and they have the lowest trust in the government when it comes to the implementation of TPC.

In short, people in this cluster prefer a kilometre charge and reject both peak hour instruments (peak charge and TPC), which is slightly remarkable given that people in this cluster barely use the car during peak hours and hence would barely be affected by a TPC scheme, whereas they are affected by a kilometre charge.

To sum up, a very large share of the respondents (58%) is rather neutral or indifferent about the three instruments. The second cluster consists of 18% of the sample and this cluster is negative about all three suggested instruments. People in this cluster may be more dependent on their car since they are frequent car users and have more children in their household than average. The third cluster consists of people that are positive about all the suggested instruments and represent 7.9% of the sample. People in this cluster are predominantly male, live alone, reside within the borders of Amsterdam and Utrecht, have a rather high income and high education and see many options for their car trips. The fourth cluster represents 9.8% of the clusters and consists mainly of car users who reject the conventional instruments while accepting TPC. People in this cluster do not see many options for changing their car trips to alternative modes but they consider congestion to be a big problem. The final and smallest cluster contains 6.1% of the sample and represents people that support a kilometre charge, and reject both peak hour instruments (congestion charge and TPC).

Table 16 The within-cluster distributions of indicators and covariates

Cluster	1	2	3	4	5	
Name	**Undecided about all instruments**	**Negative about all instruments**	**Positive about all instruments**	**Supports TPC**	**Supports kilometre charge**	
Class Size	57.9%	18.3%	7.9%	9.8%	6.1%	
Indicators						
						Wald
Tradable Peak Credits (TPC)						55.4377
Completely against [1]	19.5%	**88.1%**	3.4%	7.0%	**98.3%**	
Somewhat against [2]	20.4%	10.1%	7.7%	11.9%	1.7%	
Neither in favour/nor against [3]	**30.5%**	1.7%	24.7%	29.0%	0.0%	
Somewhat in favour [4]	23.1%	0.1%	**39.9%**	**35.6%**	0.0%	
Completely in favour[5]	6.6%	0.0%	24.3%	16.5%	0.0%	
Congestion charge						69.6633
Completely against [1]	2.8%	**98.9%**	0.0%	**77.7%**	**96.5%**	
Somewhat against [2]	26.4%	1.1%	0.0%	21.4%	3.5%	
Neither in favour/nor against [3]	**36.4%**	0.0%	0.8%	0.9%	0.0%	
Somewhat in favour [4]	28.1%	0.0%	15.1%	0.0%	0.0%	
Completely in favour[5]	6.3%	0.0%	**84.1%**	0.0%	0.0%	
Kilometre charge						48.9886
Completely against [1]	14.0%	**91.1%**	0.0%	**97.9%**	0.2%	
Somewhat against [2]	15.6%	7.6%	0.0%	2.0%	1.0%	
Neither in favour/nor against [3]	**33.7%**	1.2%	0.6%	0.1%	9.6%	
Somewhat in favour [4]	28.3%	0.1%	11.7%	0.0%	37.5%	
Completely in favour[5]	8.4%	0.0%	**87.8%**	0.0%	**51.7%**	
Covariates						
						Sample average
Gender						
Male	35.1%	47.6%	**88.2%**	44.6%	28.6%	42.1%
Female	**64.5%**	**52.5%**	11.8%	**55.4%**	**71.4%**	57.7%
Unspecified	0.3%					
Average age (years)	50	54	55	54	58	52
Educational level						
High	**57.3%**	**43.9%**	**69.7%**	**52.9%**	**39.6%**	54.4%
Middle	30.7%	41.9%	20.2%	37.0%	37.3%	32.9%
Low	12.1%	14.2%	10.1%	10.1%	23.1%	12.8%
Household type						
Couple	29.8%	**37.6%**	36.8%	**38.5%**	28.6%	32.5%
Single	**47.0%**	30.5%	**58.1%**	31.1%	**44.1%**	43.1%
Single/couple with children	23.2%	32.0%	5.1%	30.4%	27.3%	24.4%
Occupation						
Retired	21.2%	22.4%	35.4%	35.0%	**35.1%**	24.8%
Student	7.2%	1.1%	5.1%	4.1%	0%	5.2%
Paid job	**54.5%**	**58.8%**	**49.4%**	**56.9%**	**41.4%**	54.3%
Entrepreneur	1.5%	1.1%	0%	0%	8.8%	1.6%
Unemployed	15.6%	16.7%	10.1%	4.1%	14.7%	14.2%
Income household (yearly)						
High (70,000 Euro >)	11.1%	7.0%	19.2%	2.1%	5.7%	9.8%
Middle (30,000-70,000 Euro)	**36.9%**	**43.4%**	**50.4%**	**44.5%**	21.2%	38.9%
Low (<30,000 Euro)	31.6%	30.9%	22.7%	29.1%	35.4%	30.7%
Unknown	20.5%	18.7%	7.7%	24.3%	**37.7%**	20.6%

Living Area						
In Amsterdam/Utrecht	**58.9%**	**62.9%**	**92.5%**	**69.5%**	34.8%	61.9%
Around Amsterdam/Utrecht	41.1%	37.1%	7.5%	30.6%	**65.2%**	38.1%
Main mode of transport						
Car	**35.8%**	**66.7%**	**43.1%**	**70.3%**	27.5%	44.9%
Public transport	20.5%	12.0%	22.3%	9.9%	16.4%	17.8%
Moped/scooter/motorbike	2.8%	3.3%	5.1%	2.0%	3.3%	3.0%
Active modes	41.0%	18.0%	29.6%	17.8%	**52.8%**	34.3%
Driver license						
Yes	86.9%	89.1%	92.6%	98.0%	96.7%	89.4%
No	13.1%	10.9%	7.4%	2.0%	3.3%	10.6%
Car availability						
Yes, always	62.0%	**75.5%**	62.4%	**81.7%**	75.0%	67.3%
No, (almost) never	15.9%	6.6%	17.4%	2.0%	9.8%	12.6%
In consultation with others	22.1%	17.9%	20.2%	16.3%	15.2%	20.2%
Car use						
<1 a month	23.5%	14.5%	25.0%	4.1%	25.3%	20.2%
1-3 days a month	14.9%	8.7%	19.4%	6.1%	6.5%	12.8%
1-4 days a week	**38.5%**	24.6%	**30.3%**	37.8%	**46.2%**	35.7%
5-6 days a week	11.6%	11.1%	7.7%	12.6%	3.3%	10.8%
7 days a week	11.4%	**41.1%**	17.8%	**39.5%**	18.8%	**20.6%**
Travel costs						
No costs / costs are reimbursed	55.6%	56.7%	**84.8%**	53.7%	65.3%	58.5%
Costs	44.4%	43.4%	15.2%	46.3%	34.7%	41.5%
Car use in peak hours						
Never	**57.7%**	**48.2%**	**72.1%**	**48.2%**	**72.5%**	57.1%
1 to 4x a week	23.9%	19.0%	10.1%	32.3%	20.9%	22.6%
5x a week or more	18.4%	32.8%	17.8%	19.5%	6.5%	20.4%
Mean	1.840	3.190	1.503	2.303	0.929	
Car use in congested peak hours						
Never	67.2%	**52.9%**	**72.1%**	**48.2%**	**83.6%**	64.1%
1 or 2x a week	16.3%	22.0%	7.6%	21.3%	3.3%	16.4%
3x a week or more	16.5%	25.2%	20.4%	30.6%	13.1%	19.5%
Mean	1.268	1.831	1.503	1.990	0.687	
Expected effectiveness						
Mean	**3.0**	**1.5**	**3.8**	**3.6**	**1.6**	
Importance of certainty						
Mean	**3.8**	**3.6**	**4.0**	**4.3**	**3.9**	
Expected hassle						
Mean	**3.2**	**3.6**	**3.0**	**2.8**	**3.9**	
Infringement of freedom						
Mean	**3.0**	**4.1**	**2.8**	**3.1**	**4.2**	
Perceived fairness						
Mean	**2.9**	**1.7**	**3.4**	**2.9**	**1.7**	
Trust						
Mean	**3.1**	**2.2**	**3.6**	**3.4**	**2.0**	
Problem perception						
Mean	**4.1**	**3.1**	**4.6**	**4.1**	**3.9**	
Personal problem perception						
Mean	**2.4**	**2.0**	**2.8**	**2.5**	**2.4**	
Perceived behavioural control						
Mean	**3.4**	**2.6**	**4.0**	**2.4**	**3.2**	

6.4 Conclusions and discussion

The aim of this study was twofold. Firstly, to quantify the support levels for tradable peak credits in comparison to two conventional road pricing instruments: a congestion charge and a kilometre charge. Secondly, to reveal homogeneous clusters regarding support for these (novel) instruments. Data were collected through an online survey and a Latent Class Cluster Analysis (LCCA) was applied that revealed five distinct clusters regarding people's support for the three instruments.

Contrary to expectations, as explained in the introduction, TPC is not supported more than a congestion charge. The average support levels are similar (27.0% and 28.6%, respectively, are somewhat/completely in favour). Furthermore, a kilometre charge can count on the most support with a 34.2% support level. The support for a congestion charge is fairly similar to the support shown in a recent opinion poll in the Netherlands, which revealed that 32% would support a peak charge (I&O research, 2019). This poll also revealed that 59% is positive about a flat tax, which is much higher than the support for a kilometre charge in our study.

In line with expectations, it is found that the group of people supporting conventional instruments differs from the group that support TPC. As hypothesized, a group consisting of mainly car users accepts TPC while it rejects the conventional instruments. It is a rather small group though, representing 9.8% of the sample. A larger cluster of 18% also contains many car users and they are negative about all three suggested instruments. More striking is the large share of people (58%) that is rather neutral or indifferent about the three instruments. It may be that people in this group did not take the effort to really think about the instruments and create an opinion about them. A second explanation is that people in this cluster do not have a strong opinion about road pricing instruments since it would not directly influence their life, as only one-third of this group used the car as their main mode of transport. But a lack of interest is not the only possible explanation since the people in this cluster do find the issues related to car use problematic. It may also be that people in this cluster scored 'not in favour, nor against' the instruments because their opinion may depend on the exact scheme design.

These results have the following policy implications. First of all, TPC and a congestion charge have similar support levels, but since a TPC is more complex due to the trading market, this study does not prove any grounds for policymakers to consider TPC as an alternative to a (large-scale) congestion charge on public roads at this moment. Furthermore, a smaller group of regular road users is positive about TPC. Therefore, tradable credits may be a viable instrument for small-scale applications to manage car use among the employees of companies who want to reduce their road use, for example. Thirdly, the group that is clearly against all road pricing schemes is relatively small: just 18% of the sample. This study underlines the size of the 'neutral majority' that represents 58% of the sample. These people are not a priori against the road pricing alternatives, which provides opportunities for policy makers to increase support with a right scheme design and implementation process. People who are pertinently in favour or against road pricing are less likely to be influenced, but people in this large neutral group may be susceptive.

This study contains a few limitations which provide challenges for further research. First of all, this study looked at the acceptability of three main concepts, while support may vary depending on the exact scheme design. For example, the way in which the credits are allocated may influence support to a large extent. Bristow et al. (2010) found that support levels for tradable carbon permit schemes ranged between 22% and 80% depending on the scheme design. Thus, a more in-depth study into people's preferences among a representative sample for different scheme designs may reveal different support levels. Second, respondents in the Netherlands are familiar with congestion charges and kilometre charges, but TPC is new to people. Support may be different, higher or lower, when people get more acquainted or experienced with the concept. Congestion charge trials in Stockholm, for example, led to an increase in support levels (Schuitema et al., 2010), which may also hold for TPC. Even though this study found that TPC cannot count on more support than a congestion charge, it is still a topic that deserves further research in the search for an accepted road pricing scheme. Lastly, public acceptability is an important requisite for a policy to be feasible, but it is not sufficient (Feitelson & Salomon, 2004). Also aspects including the technical feasibility, the social costs and benefits, and political feasibility need further study.

Conclusion and discussion

The negative effects of increasing congestion levels feed people's frustration and stir up the need for suitable policies. Congestion charging is a heavily studied topic in political and academic circles as it is generally considered to be an efficient tool. However, the recurring difficulties concerning public support for congestion charging have led to broadening the search for suitable policy ideas. Tradable credits for congestion management is a radical, different, and rather unconventional policy idea in this search. The main reason for the (upsurge in) academic studies on tradable credits for congestion management lies in the notion that the policy concept has the potential to become a more socially supported, and hence feasible, instrument compared to conventional congestion charging. However, whether people are actually more positive about tradable credits for congestion management remains a topic that is still largely unstudied in current literature.

Therefore, the main aim of this thesis was ***to increase the understanding of the feasibility - in particular public support - of Tradable Peak Credits (TPC) as a policy instrument for congestion management.*** To serve that aim, five sub-questions were defined that were answered in the individual chapters (Chapters 2-6). In this final chapter, overarching conclusions in the light of the main aim of the thesis are discussed in Section 7.1. For more elaborate answers to the specific sub-questions, the reader is referred back to the conclusions of Chapters 2 to 6. This chapter ends with a reflection upon the results and methodologies, and with a discussion about the policy implications in Section 7.2.

7.1 Findings and contributions

The question of whether TPC is supported more by the public than a congestion charge, cannot simply be answered with a 'yes' or a 'no'. In the focus group study (Chapter 4), 7 out of the 36 participants (20%) found TPC to be acceptable by the end of the discussions, which was less than for a suggested charge on peak hours. However, these numbers have to be interpreted with caution because the sample in the focus group study is not meant to be representative of a particular population. The sample used in Chapter 6, on the other hand, was selected to be representative of citizens in urban areas. In that sample it was found that 27% is somewhat/completely in favour of TPC, which is about equal to that of a congestion charge (28.6%). This 27% seems to be in line with expectations based on previous literature on related schemes. Most of these studies looked at environmental trading schemes and conclude that most people find personal carbon trading more acceptable than an equivalent carbon tax (Bristow et al., 2010; Wallace et al., 2010). This makes sense, since people in a tradable carbon scheme have more ways to change their behaviour than just changing car use, in order to stay within the budget of the carbon permits they receive. Studies on tradable credits that focus on limiting the number of kilometres driven by car show more diverse results. Dogterom, Bao et al. (2018) found that 21.6% of Dutch car users support a tradable driving credits scheme. Harwatt et al. (2011) found that most households find a tradable carbon scheme fairer and more acceptable than an equivalent fuel price increase. Kockelman and Kalmanje (2005) focused on the acceptability of a (non-tradable) scheme aimed at congestion management and found in their survey that 24.9% of Texas citizens support credit based congestion pricing (CBCP).

However, the choice model (Chapter 5) showed that support for TPC depends on the exact scheme design. Whereas Chapter 6 queried respondents about their support for a general concept, as most road pricing acceptability studies do, this thesis also varied the TPC schemes using four scheme design characteristics. According to the answers given in the choice experiment, between 32% and 52% of the sample would support TPC implementation, depending on the scheme design. This is a substantial difference given that this suggests a difference between a scheme being supported by a majority (>50%) or not (<50%). In particular, the way in which the credits are allocated, and to whom, have an influence on the support levels. On average, people prefer an 'equal allocation' of credits, distributed among 'people who live in the city + people who work there and own a car'. However, the results also show that the preferences for these different credit allocations are very heterogeneous. This was also found in the focus group study (Chapter 4) where participants had diverging ideas about the desired credit allocation, and in the interviews (Chapter 2) where interviewees saw the distribution as a major challenge for public support. Furthermore, support for TPC is also higher when the price volatility is lower. This is in line with the focus group study as well, since people found price uncertainty to be a negative aspect of TPC. Lastly, people in the choice experiment preferred a monthly distribution of credits over weekly distribution. A possible explanation is that people prefer lower transaction costs and schemes with less 'hassle'. Weekly distribution requires users to trade on a weekly basis.

To the best of my knowledge, this is the first study that has tried to explain *why* citizens support or reject tradable credits in congestion management. The focus group study (Chapter 4) was organized to explore which arguments and attitudes towards the scheme play a role in explaining TPC. Many of the arguments and attitudes found in the focus groups overlap with factors mentioned in conventional road pricing literature. These include arguments related to fairness/equity, effectiveness of the policy, and trust in the government. Chapter 4 also revealed a few new themes that emerged from the focus group discussions that have not been studied much in the light of TPC's acceptability: the 'hassle' (time and effort) concerned with trading credits, perceived fun of trading, financial gains, the fear for misuse and the privacy issues of the scheme, the technical feasibility of the instruments, the perceived complexity of the scheme, and also related to complexity, the intelligibility and user friendliness. These arguments were translated into attitudinal statements and were measured in the survey. The estimated choice model, based on the observed choices (Chapter 5), found a few of these attitudes to have a significant relation to TPC support. According to the model, support for TPC is higher among people who find TPC fair, effective, who have trust in the government and TPC's technical feasibility, who find certainty important, and do not consider TPC to be an infringement of their freedom. The attitude related to 'hassle' and perceived complexity of TPC was not significant in this dataset, which is remarkable since the arguments related to hassle and complexity were often raised in the focus group meetings. Furthermore, a new type of perceived unfairness arose from the discussion in the focus group study. Participants argued that they found TPC unfair since it would disadvantage people who are not the smartest traders. An experiment on trading behaviour indeed showed that some people are better traders than others, and educational level, especially, was associated with smarter trading behaviour (Brands et al., 2020). Remarkably, the choice model demonstrated that educational level is negatively associated with support for TPC. Thus, even though higher educated people are 'better traders', they seem to reject TPC more often. A possible explanation can be found in the focus group study, which identified a cluster of higher educated people who reject TPC because they are already in favour of the simpler, established charging scheme.

Previous studies showed that public support for road pricing is not stable but may change under the influence of experience with a scheme and public debate about the instrument. In Stockholm, public support increased substantially after the introduction of a congestion charge (Eliasson, 2014; Schuitema et al., 2010), whereas in the year prior to the trial, public support was at an all-time low due to the heated debate (Eliasson, 2014). Different reasons are provided in existing literature that may explain these changes in support (Börjesson et al., 2016; Börjesson, Eliasson, Hugosson, & Brundell-Freij, 2012). Support may become higher over time because people experience more positive effects of the scheme than anticipated, and/or see that their negative effects are not as large as expected. The public debate and media around these experiments or policies may also have influenced people's attitudes, or it may be due to a status quo bias. As TPC or experiments with TPC do not exist in the real world (yet), this thesis did not study the influence of experience through a trial or public debate on the level of support. The focus group study (Chapter 4), however, did reveal some changes in support under the influence of the focus group discussion. Most participants stuck to their initial opinion about TPC, but some participants became more negative as the discussion continued. Especially arguments related to the (technical) feasibility of TPC seemed to make these participants more sceptical and critical. Thus, the support levels found in the survey on TPC (Chapters 5 and 6) are a snapshot in time, but can change when TPC becomes a more discussed topic due to more research and/or experiments. When these experiments and studies show positive results, support may increase. But support may also decrease if the public debate is full of negative arguments (as happened in a few of the focus groups), or if these experiments reveal negative results or any of the concept's shortcomings.

Road pricing support is often expressed in aggregated support levels, as above. But when it comes to road pricing, the public is very heterogeneous in its opinions, attitudes and arguments. This thesis therefore also tried to identify and analyse the differences between people's opinion regarding (novel) road pricing schemes. Chapter 3 identified four frames in Dutch road pricing using a quantitative-qualitative method (Q-methodology), and demonstrated that there are different reasons to be in favour of or against a policy. For example, previous road pricing studies already showed the significant relationship between public support and 'environmental concern', but since the Q-method takes a person-centred approach, it revealed that there are actually two segments of people that are concerned about the environment. The first favours road pricing, but the second is more convinced about public transport and cycling as sustainable transport alternatives. Chapter 4 (focus groups) used a qualitative content analysis to define five segments when it comes to people's attitudes towards TPC and a peak charge. This approach also showed that people have several reasons to be in favour or against TPC. Two segments were found that favour TPC: the 'opportunistic' people who think TPC can give them financial benefits, and the people who would support any price-related instrument because they believe in its effectiveness and they find it important to abate congestion. Also, two segments were found that reject TPC: those who are fiercely opposed because they distrust the government and pricing instruments, and those who reject TPC because they are already convinced about the advantages and effectiveness of a regular congestion charge. Unlike the Q-method study, the focus group study also identified a group of people that are 'in doubt' about the policies. And Chapter 6 (Latent Class Cluster Analysis) defined five clusters based on the extent to which people support TPC, a congestion charge, and a kilometre charge. The results of the focus groups and the LCCA are quite similar. Like the focus groups, the LCCA also identified a group of 'opportunistic' car users who support TPC but reject regular road pricing. This group of people is interesting because car users have typically been strong and fierce opponents and heavily influenced the road pricing debate. As expected, a share of these car users who oppose road pricing do support TPC. But the group is relatively small (10%) and still most car users are against both instruments. The LCCA also identified a group of people that reject all instruments and a group of people that accepts all instruments. Unlike the focus groups, the LCCA did not identify a group that rejects TPC while it accepts a conventional congestion charge. But the LCCA did identify a group that rejects TPC while it supports conventional kilometre charge. Lastly, both studies identified a 'neutral' group. In the focus groups this was quite a small group (6 out of 36), while in the LCCA this was a large group (58%). Section 7.2.2 discusses the methodologies in more detail, but these studies all underline the substantial heterogeneity of the public when it comes to road pricing acceptability.

The empirical findings about public support for TPC (Chapters 4, 5, 6) contrast with the expected public support in the interviews (Chapter 2). The policymakers and academics in the interview study evaluated public support for TPC as very low. 12 out of the 16 interviewees thought that public acceptability for TPC would be lower than for a charging instrument, and two interviewees thought that acceptability of both instruments would be about equal. However, the empirical studies demonstrated that public support for TPC is about equal to support for a congestion charge and can reach over 50%, depending on the scheme design. This difference between the interviewees' expectations and the empirical findings about public support is striking, even though the number of interviewees (N=16) in Chapter 2 is small and not necessarily representative of all transport-related policymakers and researchers. A possible explanation for this difference between expectations and empirical findings is that conventional road pricing is the norm in the world of transportation academics and policymakers. Indeed, most interviewees favour the introduction of regular road pricing in the Netherlands. In that sense, the interviewees are comparable to the group in the focus groups (Chapter 4) in which participants are against TPC as they are in favour of the simpler and more established congestion charge alternative.

The focus of this thesis was mainly on public support since that has often been the main barrier in the implementation of road pricing schemes and hence it is the main reason to explore and study tradable credits for congestion management. But, as already stated in the introduction, public support is a requisite for adoption, but it is not sufficient. The interview study (Chapter 2) explored the wider feasibility of TPC and identified a potential barrier to the adoption of such a policy. The results of that chapter show that the main barriers lie in the area of public and political support. The distribution of the credits was pointed out as a major challenge, which was later confirmed in the focus groups (Chapter 4) and stated choice study (Chapter 5) as well. Also, the intelligibility – whether users really understand the scheme correctly – was seen as a challenge. The focus groups confirmed that quite a lot of the participants had difficulties in understanding the concept. Lastly, the balance between transaction costs and effectiveness was seen as an important challenge. This worry was also confirmed in the empirical studies since people in the focus group identified ‘hassle’ as being a major disadvantage, and people in the choice experiment generally preferred the simpler schemes. Despite all these barriers and challenges, most of the interviewees in Chapter 2 did not rule out the possibility that the feasibility of TPC schemes can change in the future.

7.2 Reflection and further research

7.2.1 Discussing the results

Most literature on tradable (carbon) credit systems confront the respondents with a fixed scheme and credit allocation. By confronting the respondents with different TPC scheme designs, this thesis demonstrated the importance and influence of scheme design on support. Especially the credit distribution is of importance. Results show that there is no consensus about the preferred credit distribution. However, this thesis was limited to a number of different credit distributions and it is recommended that more options should be explored, as it is such an important aspect for public support. Distribution via auction, instead of via (free) grandfathering, was not studied in this thesis because in existing tradable credit literature it is generally assumed that this will lead to low support levels. However, when the revenues raised by the auction are used to invest in the (public) transportation system, or to lower the fixed costs of car possession, this may be a preferred credit allocation for many people. Indeed, in conventional charging schemes, the revenue allocation influences support levels (Ubbels & Verhoef, 2006; Zmud, 2008). Related to that, the percentage of the sample that support the implementation of a TPC scheme design in the choice experiment was higher (32% and up) than the percentage that is (somewhat/completely) in favour of TPC (27%). One explanation for this difference is the subtle difference in question wording. Another explanation is that people are more positive about a clearer scheme design rather than the ‘concept in general’. Also Zmud (2008) found that support for road pricing is higher when a specific project is targeted, rather than general questioning about road pricing.

Since acceptability studies on tradable credits for mobility management is in an incipient stage, this thesis took a more open approach to studying TPC, rather than a theory-testing approach. In that way, the study minimizes the risk of overlooking relevant new variables. The stated choice study found that several of the attitudinal variables were strongly related with support levels. Therefore, it would be interesting to study these attitudinal variables further. This can be done using behavioural theories which can help to better understand the effects of beliefs and attitudes on each other and on support. For example, Sun et al. (2016) used the theories of planned behaviour (Ajzen, 1991) and norm activation (Schwartz, 1977) to study public support of road pricing in more depth. A similar approach may be an interesting next step for TPC research as well.

This research focused on urban areas in the Netherlands, and data collections took place before the covid-19 crisis started. The results of this thesis have to be interpreted with caution when one wants to translate them to other times or contexts. Indeed, Liu et al. (2019) demonstrated that context variables are more important than they are often considered to be in road pricing acceptability studies. And as Dogterom, Bao et al. (2018) demonstrated, car user support for tradable driving credits is considerably higher in Beijing than in the Netherlands (67% and 21.6%, respectively). A general explanation for this difference is that support for TPC, or any road pricing instrument, depends on the satisfaction or dissatisfaction with the status quo. When dissatisfaction with congestion levels and emissions grows, support for TPC may increase. And people in Beijing were also more positive about TPC because many prefer it over the current license-based driving restrictions. It would be interesting to further explore these differences in context variables. This can be done by conducting experiments in different (international) contexts like Dogterom, Bao et al. (2018) did, but context variables, such as congestion levels can also easily be varied in stated choice experiments (for example, see Bos, van der Heijden, Molin, & Timmermans, 2004; Molin & Timmermans, 2010).

7.2.2 Discussing the methods

Although this thesis did not aim to contribute to the development of research methods, the multiplicity of the applied research methods allows for comparison and reflection. This reflection may help researchers in the future in choosing the most appropriate method when studying the acceptability of innovative technologies. Also, shortcomings of the applied methodologies are discussed in this section.

The results showed that the population is very heterogeneous when it comes to road pricing support, which underlines the relevance of these person-centred approaches. In total, three different methods with a person-centred approach were used to study the heterogeneity of public support and reveal segments or clusters within a sample: Q-methodology (Chapter 3), content analysis of the focus group transcriptions (Chapter 4), and Latent Class Cluster Analysis (LCCA) (Chapter 6). Unlike the Q-method study, the LCCA study revealed a large group of people who are ‘indifferent’ or neutral about the policies at hand (58% of the respondents). The focus group study also revealed a group of people ‘in doubt’, but that group was rather small (6 out of 36). The fact that in the Q-methodology no ‘neutral’ group was identified can have several explanations. First of all, the Q-methodology study was only about conventional, well-known instruments, so it is more likely that people have already an opinion about it. A second explanation is that on a Q-scorecard, respondents are forced to agree and disagree with some of the statements since they simply cannot place all statements on the neutral pile. The advantage is that respondents relate each statement to all other statements and in this way make up their mind and reveal their complete viewpoint about the topic at hand, at least in theory. The disadvantage is that the viewpoint of people who are truly indifferent (not agreeing, nor disagreeing) about the statements is neglected with this method. On the other hand, the LCCA study used a five-point Likert scale and respondents could check the middle box when they were asked about their support for TPC, a kilometre charge, and a congestion charge. This approach contains the risk that some respondents easily opt for the middle box without thinking their opinion through. The fact that most participants in the focus group study had a clear opinion about the instruments (TPC and congestion charge) may be the result of the self-selection bias. Indeed, it is plausible that an invitation for an 'evening to discuss car use measures' attracts people who have a (strong) interest in traffic measures and like to build on and discuss their opinion about it. Thus, the LCCA study may have overestimated the share of 'neutral' people, while the focus group study may have underestimated this group.

Self-selection may also have influenced the measured support levels in different ways. Regarding the focus group, it may mean that the group of people who dislike TPC because they are strongly convinced about the advantages and effectiveness of congestion charging is overrepresented, as is the group of people who have a pronounced negative opinion about all pricing instruments suggested by a government, while the more 'neutral' people are underrepresented. Self-selection may have also played a role, but in a different way, in the sample that was used in Chapter 5 and 6. The sample was taken from a panel and respondents received compensation (albeit small) for participation. People who value time highly are may be underrepresented in such panels, regardless of their income category. Support for road pricing is typically higher among people with a higher Value of Time (VoT) (Ubbels & Verhoef, 2006) since they are more willing to pay for a trip with less congestion. Thus, the people in the sample may be relatively negative about a kilometre charge and a congestion charge compared to the general population. However, whether or not the sample also led to an underestimation of support for TPC is less plausible. Indeed, in a TPC system not only people with a high VoT can benefit from the system (because of the reduction in congestion), but also people with a low VoT can benefit because they can sell their credits and in that way financially gain from the system. Thus, the focus group study may have underestimated TPC support due to self-selection, but whether that also holds for the studies in Chapters 5 and 6 is less clear.

A major challenge in this thesis concerned the explanation of the concept of TPC to the respondents. Indeed, the topic is new to the respondents, so it needed to be explained to them. At the same time, every piece of information provided by the researchers can influence and steer the opinion of the respondents (Ben-Akiva, McFadden, & Train, 2019). The exact wording, framing, and presentation of the concept may influence the way people think about the concept. Also, background information and the description of the context can be of influence. For example, pointing out the negative effects of congestion may affect the public support levels (Zmud, 2008). In this thesis, it was chosen to focus on the main features of TPC, compared to a congestion charge, also trying to keep the rest of the context and scheme design rather simple and neutral. These main features are the revenue-neutral aspect of the scheme, the trading market, the potential effectiveness due to the firm cap, and the possibility to address equity issues by distributing the credits in different ways. Moreover, respondents could also have interpreted the information they received wrongly. The focus group study reported that quite some participants had misperceptions about TPC (Section 4.2.3) and it is likely that a share of the respondents in the panel had misperceptions as well.

The methods in this thesis are suitable to give a snapshot in time about public support for TPC, in which people have limited information that they can misinterpret. When a drastically new policy is actually suggested in the public debate, it is likely that citizens also base their initial opinion on limited and perhaps wrongly interpreted information. Nevertheless, it would also be interesting to further study the potential impact of more and different information on TPC support to better tailor the policy process. This can be done by inviting an expert into the focus group sessions, who can act as a source of information and counter arguments based on misperceptions. Such an approach can be inspired by a stakeholder dialogue methodology, such as constructive conflict methodology, for example (see Cuppen, 2012). This approach allows learning through interaction when assessing options for addressing complex problems. In a stated preference study, more and different information can be included, but it is harder to counter any wrong assumptions that respondents may have about the instrument. One idea is to include a FAQ list (frequently asked questions) and/or to include different expert judgements which respondents can read or watch before handing in their final opinion about TPC.

When people receive more detailed information about the policy and (fact-based) counter arguments or explanation when they express a misperception, the support levels may be different. More detailed information can be about the current (congestion and emission) problems, the exact scheme design and options to tackle objections due to scheme design (such as the possibility to automate (part of) the trading, or to include extra trading rules), the technology (e.g. vehicle detection systems), the parties involved, the costs (e.g. system costs), and the effects (e.g. on travel times and welfare redistribution), for example. Especially people who are *neutral* about TPC or are '*doubtful'* may change their mind when they receive more information. Also the *clearly opposed* people who reject TPC because they are convinced about the efficiency of charging schemes may alter their opinion if they receive information that shows that the implementation costs and efficiency of the scheme are quite favourable, and/or when they actually experience that trading is not that complex (as participants in the lab-in-the-field study concluded (Brands et al., 2020)). However, quite a number of the people in this group use the train or bicycle as their main mode of transport so perhaps the absence of revenues which can be used for the improvement of the public transport network can become a new argument that they adopt to reject TPC when their earlier objections are tackled. It is therefore important to not only include the (distributional) effects of TPC, but also to include the different revenue redistributions and the effects on regular road pricing in the comparison. This can be done by giving respondents a complete overview of the different (conventional and trading) schemes, their societal costs, and societal benefits. On the other hand, people who reject TPC due to moral objections or due to deeper values are unlikely to change their mind about TPC. People that are '*fiercely opposed*' have a very critical attitude towards all instruments suggested by the government that would limit people's freedom and a change in scheme design or more explanation would probably not influence them. The amount of information on the congestion problems provided in the introduction in the stated choice experiment (Chapter 5) did vary slightly, as it was expected that support levels would be higher when people received this information. Half of the respondents received background information about the problem, and the other half did not. However, the effect of this information was not significant. Thus, this thesis confirms that scheme design has a lot of influence on support, but does not confirm that the inclusion of information about congestion problems influences support.

More detailed and complete information can also be given to the respondent through ("real world") experience with a tradable credit system. Studying people's opinions towards a non-existing measure limits the researcher to use stated preference or stated opinion data. Although it is quite common to study road pricing acceptability in that way (Li & Hensher, 2012), it has the disadvantage that a hypothetical bias may be present: people may answer differently in a survey than they would in a real situation. In the case of road pricing, it is often seen that public support is higher after the implementation of the scheme. It would therefore be interesting to conduct experiments with road users, so that participants can get a realistic impression of the concept. Such experiments were planned for this thesis, but unfortunately they had to be cancelled (see section 1.4.3). With these types of experiments it is important to keep in mind that self-selection can play a role. It is plausible that particularly those people who are enthusiastic about such experiments will participate and be more supportive of TPC.

A final point to note regarding the methods used in this thesis is the drop-out ratio in the panel (Chapters 5 and 6). Even though the introduction of TPC was kept concise, a share of the people who started the survey did not finish it. Out of the 889 people who started the survey, 513 finished it. In the stated choice study, 502 responses were used for the analysis (which is 56% of 889). It may be that people dropped out because they found the introduction too difficult or too lengthy. Dogterom, Ettema et al. (2018) report that only 33% (308 out of 918) of the respondents who started their experiment were used in the data analysis about public acceptability. It would be interesting to study non-response in these kinds of policy acceptability studies to better understand the implications.

7.2.3 Policy implications

As explained in Section 7.1, this thesis does not confirm the notion that TPC is more supported by the public and hence is a feasible policy alternative compared to conventional instruments. The policymakers and academics who were interviewed had rather low expectations of public support. The public support levels found in Chapters 4 to 6 were higher than these expectations, but not higher than for a congestion charge. Nevertheless, the public support levels for TPC found in this thesis are rather high given the respondents' total unfamiliarity with the system. As explained before, support levels may increase over time when more evidence about positive effects is found and experienced by people. This confirms the importance of conducting TPC experiments in 'real world' settings. People may also gain experience and hence increase their support due to development in related fields. For example, most people are not used to fluctuating travel costs. But, if fluctuating travel costs become more common in people's daily trips, due to an increase in Mobility-as-a-Service options, for example, support for TPC may change as well. When suggesting or experimenting with TPC, it is very important to carefully study preferences for different scheme designs. Indeed, Chapter 5 demonstrated that support levels depend on the scheme design, and Chapter 6 showed that a large share of the respondents is rather neutral about the instruments, which implies that at least some of these people may cross over to the 'support team' if the scheme design and implementation process is designed according to their preferences. Moreover, the results of Chapter 6 show that a group of frequent car users who oppose conventional road pricing, does support TPC. This was expected since these people would need to pay for every trip during peak hours in a congestion charging system, whereas in a TPC system, a share of their trip would be for free. This result is interesting, since car users, and more specifically the interest group (ANWB) that represents Dutch car users, have had a relatively strong voice in the public debate about road pricing (see

Smaal, 2012). Even though this cluster was rather small (9.8% of the sample), and a larger cluster of 18% of mainly car users opposed all suggested instruments, it can be an interesting start for further exploration for a tradable credits scheme that perhaps cannot count on the strong support of the wider public, but can at least stir up less opposition. The concept of tradable credits does not necessarily have to (immediately) involve all car users from a certain area, but can start with a smaller group of car users. TPC, or tradable parking permits, for example, can be applied at company or business district level. If these smaller 'real world' applications of tradable credit schemes are successful, support among other car users and people may increase. As long as there is no clear public preference for TPC compared to conventional congestion charge schemes, it is questionable whether TPC is the best policy alternative to abate congestion on a large scale. Indeed, the feasibility of an instrument does not only require public – and thereby political – support, but it also depends on the technical feasibility and economic appraisal. TPC is a relatively complex instrument, for both the users and the operator and the costs associated with transactions, the system set-up, operation and monitoring are very likely to be higher than for an equivalent congestion charge system. Tradable credit systems can be simplified by taking longer credit allocation intervals, for example, or by removing the time-place dependent aspect and changing it into a tradable kilometre credit system. Simplifying the scheme may enhance public support levels as well, since people generally prefer a simpler scheme. However, a rule of thumb in road pricing literature is that simpler schemes are usually less efficient. This balance between efficiency and support is important to policymakers. If, in order to be publicly supported, a tradable credit policy has to be simplified to an extent that the efficiency gains are lost, the reason to implement such a scheme no longer holds.

Another theme for policymakers to consider relates to people's scepticism regarding the government. The Q-methodology study, as well as the focus group study and the stated choice study, showed that distrust of the government is strongly related with people rejecting road pricing.. If people distrust the government, it is less likely that they will support road pricing policies. This also holds for TPC, even though the instrument does not provide the government with any revenues. Thus, for TPC, it is recommended that transparent information (campaigns) and marketing about the scheme and its effects are organised, as these are also success factors in road pricing cases (Vonk Noordegraaf et al., 2014).

Having said that, the concept of tradable credits can also be interesting for other applications. As already mentioned, TPC can be applied at company or business district level. Such a scheme can stimulate that employees should avoid peak hours and travel to work with alternative means of transport. Thereby, it is also important to make a tradable credit scheme part of a wider package of measures. These can include policies that improve public transport and bicycle options, but also policies about flexible working hours or working from home (Anas & Lindsey, 2011). Furthermore, this thesis focused on car use, but tradable credits may also be interesting for public transport. In the Netherlands, the train infrastructure already has a type of congestion pricing (tickets are cheaper outside peak hours), but a tradable credit system has the advantage that it can give the operator more control over the number of travellers. The current covid-19 crisis strengthens the need for an instrument with a 'firm cap'. Such a crisis can open a '*window of opportunity'* in which decision makers consider, or reconsider, solutions to the problem that became more urgent (see Chapter 2).

Conceptually, 'Trading access to the road' lies very far from the current reality of traffic demand measures. Nevertheless, the unique characteristics of TPC – being the finite 'cap' on road users, the absence of a revenue stream to the government, and the flexibility of (free) initial credit allocations – make the concept an interesting alternative compared to the extensively studied conventional road pricing schemes. Tradable credits are enriching but do not end the longstanding search for an efficient and well supported instrument to reduce congestion.

Appendix A

The text as shown to the interviewees (translated from Dutch).

Tradable Peak Credits interview

The interview is semi-structured, which means that there is enough room for supplementary questions and remarks. The questions below form the foundation of the interview. First, a short explanation of tradable peak credits follows.

Background information

The concept of tradable peak credits is based on the idea that, by creating a market for peak credits, the number of peak trips can be restricted and reduced in order to decrease congestion and accessibility problems. Participants pay a credit when they use a certain section of road during a certain period of the day.

The allocation of the peak credits is regulated by an authority who defines the maxium number of credits (the cap) and who distributed the credits to individuals every week, month or other unit of time. The allocation of the credits can be based on: 'all participants get an equal share', or 'certain participants get more/less credits based on historical data of car use', for example. Participants can be defined as citizens, households, car owners etc., for example. Besides the initial distribution, participants are also allowed to sell and buy credits via a market, where supply and demand set the price. Thus, when participants want more credits than they have received, they should buy more credits. If they use less credits than they have received, they can sell them.

A system with tradable peak credits can be designed in many ways. In this interview, we focus on the concept of tradable peak credits applied on a national scale for an indefinite duration.

Interview questions

1. What is your opinion on tradable peak credits?
2. What are the main barriers for implementing a system of tradable peak credits in the Netherlands?
3. Do you think that the money flow from tradable credits which remains between users, makes the system more fair, less fair or equally fair, compared to a system which is based on charging a money flow from user to the government?
4. If we compare all of the benefits to all of the costs, as in a social cost benefit analysis, to what extent does the system have the potential to be cost effective?
5. How do you see the technical feasibility of tradable peak credits?
6. A: What are the most important arguments of citizens who are *against* tradable peak credits?

   B: What are the most important arguments of citizens who are *in favour of* tradable peak credits?
7. To what extent do you expect the system of tradable peak credits to be politically acceptable?
8. Altogether, how feasible is the concept of tradable peak credits as a practical instrument to reduce congestion?
9. Finally, taking all advantages and disadvantages into consideration, do you find any type of road pricing in the Netherlands desirable? If so, which type would you advise and why this one?

Appendix B

In total, 4 animated clips were shown to the participants. The first author will share these animations on request. The English transcriptions of these clips are as follows:

Clip 1: introducing the casus

In the up-coming two discussions, we will talk about two traffic measures. First, I will explain the situation thatthe measures are proposed for. To this end, we will use a fictional city. We made this so-called 'City X' simpler than in the real world, whereby we can focus on the traffic measures and we won't spend too much time on the details of the surroundings.

City X is divided by a river. The shortest route from one side of the city to the other side is via the only bridge. There are no other bridges or tunnels in the city. Expansion of the infrastructure is impossible. There is, however, a bus and a cycle path crossing the bridge. The number of motorists that uses the bridge has increased over the last few years, which has resulted in severe congestion every week-day morning during peaks hours. Hence, motorists are stuck in traffic for 15 minutes on average, ranging up to 30 minutes.

Nowadays about 10,000 cars cross the bridge during this morning peak time, while the bridge can handle about 8,500 cars with a good traffic flow. In other words, if you reduce the current number of cars by 15%, you will solve the congestion. Researchers have calculated that in this case most of the congestion will vanish. If there was still some congestion once a week, a car user would have about a 5 minute delay.

Clip 2: peak charge

The following plan has been thought of to battle the congestion: peak charge. Several variations already exist in foreign countries. With a peak charge, motorists need to pay an amount to cross the bridge during morning peak hour. The morning peak hour is between 07:00 and 09:15.

The aim of the peak charge is to decrease the congestion by reducing the current number of peak trips by 15%. This is done by increasing the charge until 8,500 cars have crossed the bridge. If fewer cars cross the bridge, the price decreases. If more cars cross the bridge, the price increases. The charge will be adjusted on a weekly basis. The revenues of the peak charge go to the municipality who can spend the money. The revenues can be spent on public transport or parking spots, for example, but can also go to the general budget.

In order to avoid waiting lines due to toll gates, people can register their car to make the payment automatically. People who haven't registered their car, can buy an electronic ticket via telephone or computer. Motorists who haven't registered their car and haven't bought an electronic ticket, pay a fine. The fine is the price of a ticket plus 5 Euros. The bridge remains free of charge outside peak hours.

So, let's take a car user who used to drive 5 times a week in the morning peak hour. Due to the peak charge he now avoids the peak once a week on average. He pays the peak charge on the other 4 days. The revenues go to the municipality.

Clip 3: tradable peak credits

Also, another plan has been thought of to battle the congestion: tradable peak credits. This is a new concept and does not exist anywhere in the field of car use. Therefore, we are curious about your thoughts. Each trip in the morning peak time costs a 'credit'. The morning peak is between 07:00 and 09:15. The total amount of credits is equal to the number of trips the bridge can handle, thus 8,500. That's 15% less than the current number of peak trips. So, if this is the number of peak trips, then this is the number of credits [visualisation].

These credits are distributed free of charge on a weekly basis to all car users who used the bridge weekly in the past month. Everyone receives an equal share. Thus, it might be that some car users receive more credits then they need, while others receive less credits then they need. Hence people can trade their credits. People who want to sell their credits to a 'trade platform' receive some money. People who want more credits, can buy these. This platform does not make a profit.

The price of the credit is determined by demand and supply. If a lot of people want to buy a credit, the price increases. If a lot of people want to sell them, the price decreases. Trading and managing the credits works via an app or a website. People can register their car and then credits are automatically written off their budget. People who cross the bridge without a credit, pay the current price of a credit at that moment plus a fine of 5 Euros. The bridge remains free of charge outside peak hours.

So, let's take a car user who drives 5 times a week in the morning peak hour. If he avoids the peak once a week he does not make a profit and does not incur costs. If he continues to use the bridge 5 times a week, he must buy a credit. If he drives 3 times or less, he can sell his credit(s) and make a profit.

As explained, tradable credits are a new concept for car use. The concept of tradable credits, or rights, does exist in other fields. Tradable emission rights in the EU. Or tradable milk credits for farmers, for example.

Clip 4: distribution of the credits

Let's go back to the tradable peak credits. We will focus on one aspect: the distribution of the credits. In order to reduce the congestion, the amount of credits has to be lower than the current number of peak trips.

So far, we have assumed that the credits are evenly distributed among all car users who used the bridge on a weekly basis in the last month. But, the credits can of course be distributed in many other ways.

Firstly, it can be determined who are eligible for the credits. This could be the car users, but also all citizens with a driver license, for example, or all households of the city, all adults, you name it.

Secondly, the credits do not necessarily have to be distributed equally. The credits can also be distributed among motorists, but those with a less polluting car get more credits than those with a polluting car, for example. Another example is to distribute the credits among the citizens. And citizens with a job receive more credits than those without a job. Or, the credits are distributed among residents with a driver license and the credits are distributed according to how many people used the bridge in the past. Countless ways to distribute the credits can be thought of (visualizes many ways of distributing).

Appendix C

In total, we used four introductions that were randomly assigned to the respondents. Half of the respondents received standard information about TPC, and the other half of the respondents received this standard information + information on the consequences of congestion and the effects of the instrument. Thereby, we also varied the form of the introduction. Half of the respondents received the information in text, the other half in a (animated) video. The author will share these videos on request. Table 17 details the four types of introductions.

Table 17 The types of introductions

Video standard	Text standard
Video standard + info on problem and implications	Text standard + info on problem and implications

The sentences about 'info on problem and implications' are in *italics* and were only presented to half of the respondents. Respondents who live in or near Utrecht, received the same text/video, but with 'Amsterdam' replaced by 'Utrecht'.

Introduction text

There is often congestion in the Netherlands on weekdays. *The congestion levels are expected to further increase in the coming years if no measures are taken. Congestion costs car users a lot of time and gives them uncertainty about their travel times. Furthermore, congestion is bad for the economy, since it costs money when trucks or employees are waiting on motorways or when they have to take a detour. If congestion increases, the financial damage will also further increase.*

A new plan has been thought of to deal with congestion: tradable peak credits (please note: this is something different to a peak charge or road pricing). The basic idea is that 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 the municipality of Amsterdam. If you drive on multiple roads during 1 peak period, this costs 1 credit. Credits are not needed outside of the municipality of Amsterdam and outside peak hours.

The number of available credits depends on the capacity of the area. Thus, an area that can handle a maximum of 9,000 cars per peak period has 9,000 credits. Compared to the current situation, the number of cars using peak hours should decrease by 10% to solve most congestion. The credits are distributed free of charge and people can use these credits to drive in peak hours. The government administers the system.

If people have more credits than they need, they can sell them to people who want more credits using an online trading platform. Buying and selling goes via an app or via computer. You don't need to search for a buyer/seller yourself: you buy and sell the credit to the platform for the credit price at that moment. The trading platform does not make profits. The government also does not earn money, since car users trade the credits with one another.

The price of the credits on the platform is determined by supply and demand. The price increases if the demand is high. The price decreases if the supply is high. The price of a credit is expected to lie between EUR 2 and EUR 4. The maximum price of a credit is EUR 6. You cannot buy more credits from the platform than you can use yourself (so in a week you can have a maximum of 10 credits in your possession, since you can drive in peak hours twice a day). This prevents people from hoarding credits with the aim of reselling credits and making a profit in that way.

When people register their car, the credits will be automatically redeemed from their 'credit budget' when they use the road(s) during peak hours. When someone enters the road and they don't have any credits, the system will send them a notification in the evening that they should buy a credit retrospectively. If they do not do this, the system will automatically buy a credit for them and charge them for it at the credit price at that moment, plus a transaction cost of EUR 1. 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).

An example: a car user who previously drove in peak hours 8 times a week, receives 7 credits. If he keeps on driving in peak hours 8 times a week, he has to buy 1 credit. If he drives 7 times a week in peak hours, he does not have to sell nor buy credits. If he drives less than 7 times a week in peak hours, he can sell credits.

Researchers expect that tradable peak credits will strongly reduce congestion, since allocation of the credits gives control over the number of cars in peak hours. The introduction of tradable peak credits is expected to reduce the travel time losses due to congestion by 25% or more. *Thus, this means that car users spend less time in congestion and hence they have less travel time loss and more certainty about their arrival time.*

Appendix D

Table 18 Rotated factor-loading matrix (factor loadings <0.30 are not shown) and the Cronbach alpha test results

Label	Indicator	Factor							Cronbachs alpha
		1	2	3	4	5	6	7	
1:Expected effectiveness	I think TPC reduce congestion	0.932							0.918
	How effectively do you think TPC reduce congestion?	0.817							
	I think TPC will reduce the impact of car use on the environment	0.813							
2:Importance of certainty	I find it important to have certainty about my travel costs		0.790						0.654 (0.654)
	I find it important to have certainty about my travel times		0.573						
3:Expected hassle	I think trading in peak credits requires a lot of effort			0.885					0.820
	I think trading in peak credits requires a lot of time			0.705					
	I find TPC very complex			0.663					
4:Infringement	I think TPC harms people's privacy				0.753				0.78
	I find TPC an infringement on people's (mobility) freedom				0.731				
5:Perceived fairness	How fair do you consider TPC for yourself?					0.740			0.823
	How fair do you consider TPC for others?					0.606			
	I think TPC will give me financial benefits					0.550			
	The trading in peak credits sounds like fun to me					0.524			
6:Trust	I think a system using TPC is technically feasible						0.844		0.783
	The government is capable of implementing and conducting a system with TPC						0.725		
7:Problem perception	Congestion is a big threat to the economy							0.680	0.682
	Congestion is a big threat to the environment							0.652	
8:Personal problem perception	I personally suffer from congestion	Communality is too low							
9:Perceived behavioural control	It is easy to find alternatives for most car trips in peak hours (such as bicycle, public transport or other travel times)	Communality is too low							

Appendix E

Table 19 The set of 23 statements plus descriptive statistics

Statement	How often an answer is given in percentages					Mean	Std. Dev.
	1	2	3	4	5		
I think TPC reduce congestion	23	18	26	23	10	2.79	1.29
How effectively do you think TPC reduce congestion? [b]	22	17	36	22	3	2.66	1.13
I think TPC will reduce the impact of car use on the environment	25	15	29	23	8	2.73	1.28
I find it important to have certainty about my travel costs	4	6	28	30	32	3.80	1.07
I find it important to have certainty about my travel times	4	4	24	38	30	3.86	1.03
I think trading in peak credits requires a lot of effort	7	16	28	29	20	3.40	1.17
I think trading in peak credits requires a lot of time	5	18	30	27	20	3.38	1.14
I find TPC very complex	13	20	31	22	15	3.05	1.22
I think TPC harm people's privacy	13	21	27	20	19	3.11	1.30
I find TPC an infringement on people's (mobility) freedom	10	15	25	24	27	3.43	1.30
How fair do you consider TPC for yourself? [c]	13	15	49	19	4	2.87	1.00
How fair do you consider TPC for others? [c]	12	22	42	20	4	2.81	1.01
I think TPC will give me financial benefits	31	18	30	14	6	2.46	1.23
The trading in peak credits sounds like fun to me	37	15	24	15	8	2.41	1.33
I think a system with TPC is technically feasible	13	15	32	27	13	3.13	1.20
The government is capable of implementing and conducting a system with TPC	25	15	33	19	8	2.70	1.25
Congestion is a big threat to the economy	3	7	26	35	29	3.81	1.03
Congestion is a big threat to the environment	3	3	17	34	42	4.09	1.00
I personally suffer from congestion	29	28	24	11	7	2.38	1.21
It is easy to find alternatives for most car trips in peak hours (such as bicycle, public transport or other travel times)	13	17	27	21	22	3.22	1.32
I think people will misuse a TPC system	3	8	24	31	34	3.84	1.08
I find TPC understandable	13	14	26	31	16	3.23	1.25
I think I will be worse off when TPC are implemented	19	16	29	16	19	3.00	1.36

The statements were answered on a Likert scale ranging from 1: totally disagree to 5: totally agree. Except for:
b: 1: not effective at all 5: very effective
c: 1: very unfair 5: very fair

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Akamatsu, T. (2007). *Tradable Network Permits: A new scheme for the most efficient use of network capacity*. Working paper. Retrieved from http://www.plan.civil.tohoku.ac.jp/~akamatsu/Publications/

Al-Guthmy, F. M. O., & Yan, W. (2020). Mind the gap: Personal carbon trading for road transport in Kenya. *Climate Policy*, *1*(3), 1–20. https://doi.org/10.1080/14693062.2020.1785380

Alonso-González, M. J., Hoogendoorn-Lanser, S., van Oort, N., Cats, O., & Hoogendoorn, S. (2020). Drivers and barriers in adopting Mobility as a Service (MaaS) – A latent class cluster analysis of attitudes. *Transportation Research Part A: Policy and Practice*, *132*, 378–401. https://doi.org/10.1016/j.tra.2019.11.022

Anable, J. (2005). 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. *Transport Policy*, *12*(1), 65–78. https://doi.org/10.1016/j.tranpol.2004.11.004

Anas, A., & Lindsey, R. (2011). Reducing Urban Road Transportation Externalities: Road Pricing in Theory and in Practice. *Review of Environmental Economics and Policy*, *5*(1), 66–88. https://doi.org/10.1093/reep/req019

Andersson, D., Löfgren, Å., & Widerberg, A. (2011). *Attitudes to Personal Carbon Allowances* (Working papers in economics No 505). Retrieved from http://publications.lib.chalmers.se/records/fulltext/199967/local_199967.pdf

Araghi, Y., Kroesen, M., & van Wee, B. (2017). Identifying reasons for historic car ownership and use and policy implications: An explorative latent class analysis. *Transport Policy*, *56*, 12–18. https://doi.org/10.1016/j.tranpol.2017.02.008

Ardıç, Ö., Annema, J. A., Molin, E., & van Wee, B. (2018). The association between news and attitudes towards a Dutch road pricing proposal. *Transportation*, *45*(3), 827–848. https://doi.org/10.1007/s11116-016-9752-0

Ardıç, Ö., Annema, J. A., & van Wee, B. (2013). Has the Dutch news media acted as a policy actor in the road pricing policy debate? *Transportation Research Part A: Policy and Practice*, *57*, 47–63. https://doi.org/10.1016/j.tra.2013.09.005

Ardıç, Ö., Annema, J. A., & van Wee, B. (2015). Non-implementation of road pricing policy in the Netherlands: An application of the 'Advocacy Coalition Framework'. *European Journal of Transport and Infrastructure Research, 15*, 116–146. https://doi.org/10.18757/ejtir.2015.15.2.3065

Aziz, H. A., Ukkusuri, S. V., & Romero, J. (2015). Understanding short-term travel behavior under personal mobility credit allowance scheme using experimental economics. *Transportation Research Part D: Transport and Environment*, *36*, 121–137. https://doi.org/10.1016/j.trd.2015.02.015

Bagloee, S. A., & Sarvi, M. (2017). A modern congestion pricing policy for urban traffic: Subsidy plus toll. *Journal of Modern Transportation*, *25*(3), 133–149. https://doi.org/10.1007/s40534-017-0128-8

Bakk, Z., Tekle, F. B., & Vermunt, J. K. (2013). Estimating the Association between Latent Class Membership and External Variables Using Bias-adjusted Three-step Approaches. *Sociological Methodology*, *43*(1), 272–311. https://doi.org/10.1177/0081175012470644

Bakk, Z., & Vermunt, J. K. (2015). Step-3 Tutorial #1: Step-3 models with covariates, distal outcomes, and multiple latent variables. Retrieved from https://www.statisticalinnovations.com/wp-content/uploads/LGtutorial.Step3_.1.pdf

Bamberg, S., & Rolle, D. (2003). Determinants of people's acceptability of pricing measures: Replication and extension of a causal model. In J. Schade & B. Schlag (Eds.), *Acceptability of transport pricing strategies* (pp. 235–248). Oxford: Elsevier.

Bech, M., & Gyrd-Hansen, D. (2005). Effects coding in discrete choice experiments. *Health Economics*, *14*(10), 1079–1083. https://doi.org/10.1002/hec.984

Ben-Akiva, M., McFadden, D., & Train, K. (2019). Foundations of Stated Preference Elicitation: Consumer Behavior and Choice-based Conjoint Analysis. *Foundations and Trends® in Econometrics*, *10*(1-2), 1–144. https://doi.org/10.1561/0800000036

Ben-Elia, E., & Ettema, D. (2011). Rewarding rush-hour avoidance: A study of commuters' travel behavior. *Transportation Research Part A: Policy and Practice*, *45*(7), 567–582. https://doi.org/10.1016/j.tra.2011.03.003

Bierlaire, M. (2018). *PandasBiogeme: a short introduction*. Technical report TRANSP-OR 181219. Retrieved from Transport and Mobility Laboratory, ENAC, EPFL website: https://biogeme.epfl.ch/install.html

Bliemer, M., Dicke-Ogenia, M., & Ettema, D. (2009). Rewarding for Avoiding the Peak Period: A Synthesis of Four Studies in the Netherlands. In Proceedings of the 12th International Conference on Travel Behaviour Research (Chair),

Bolderdijk, J. W., Steg, L., & Postmes, T. (2013). Fostering support for work floor energy conservation policies: Accounting for privacy concerns. *Journal of Organizational Behavior*, *34*(2), 195–210. https://doi.org/10.1002/job.1831

Bonsall, P., Shires, J., Maule, J., Matthews, B., & Beale, J. (2007). Responses to complex pricing signals: Theory, evidence and implications for road pricing. *Transportation Research Part A: Policy and Practice*, *41*(7), 672–683. https://doi.org/10.1016/j.tra.2006.06.001

Borger, B. de, & Proost, S. (2012). A political economy model of road pricing. *Journal of Urban Economics*, *71*(1), 79–92. https://doi.org/10.1016/j.jue.2011.08.002

Börjesson, M., Eliasson, J., & Hamilton, C. (2016). Why experience changes attitudes to congestion pricing: The case of Gothenburg. *Transportation Research Part A: Policy and Practice*, *85*, 1–16. https://doi.org/10.1016/j.tra.2015.12.002

Börjesson, M., Eliasson, J., Hugosson, M. B., & Brundell-Freij, K. (2012). The Stockholm congestion charges—5 years on. Effects, acceptability and lessons learnt. *Transport Policy*, *20*, 1–12. https://doi.org/10.1016/j.tranpol.2011.11.001

Börjesson, M., Hamilton, C. J., Näsman, P., & Papaix, C. (2015). Factors driving public support for road congestion reduction policies: Congestion charging, free public transport and more roads in Stockholm, Helsinki and Lyon. *Transportation Research Part A: Policy and Practice*, *78*, 452–462. https://doi.org/10.1016/j.tra.2015.06.008

Bos, I., van der Heijden, R., Molin, E., & Timmermans, H. (2004). The Choice of Park and Ride Facilities: An Analysis Using a Context-Dependent Hierarchical Choice Experiment. *Environment and Planning A: Economy and Space*, *36*(9), 1673–1686. https://doi.org/10.1068/a36138

Brands, D., Verhoef, E., Knockaert, J., & Koster, P. (2019). Tradable permits to manage urban mobility: Market design and experimental implementation. *Tinbergen Institute Discussion Paper, 007/VIII*.

Brands, D., Verhoef, E., Knockaert, J., & Koster, P. (2020). Tradable permits to manage urban mobility: Market design and experimental implementation. *Transportation Research Part A: Policy and Practice*, *137*, 34–46. https://doi.org/10.1016/j.tra.2020.04.008

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

Brown, S. R. (1980). *Political Subjectivity: Applications of Q Methodology in Political Science*. New Haven and London: Yale University Press.

Buitelaar, E., van der Heijden, R., & Argiolu, R. (2007). Managing Traffic by Privatization of Road Capacity: A Property Rights Approach. *Transport Reviews*, *27*(6), 699–713. https://doi.org/10.1080/01441640701262949

Cain, A. (2005). Achieving Majority Public Support for Urban Road Pricing. *Transportation Research Record: Journal of the Transportation Research Board*. (1932), 119–128. https://doi.org/10.1177/0361198105193200114

Cain, A., & Jones, P. M. (2003). Using Public Consultation in Developing Edinburgh's Congestion-Charging-Based Transport Strategy. *Transportation Research Record*, 89–97. https://doi.org/10.3141/1839-09

Capstick, S. B., & Lewis, A. (2010). Effects of personal carbon allowances on decision-making: Evidence from an experimental simulation. *Climate Policy*, *10*(4), 369–384. https://doi.org/10.3763/cpol.2009.0034

Cavallaro, F., Giaretta, F., & Nocera, S. (2018). The potential of road pricing schemes to reduce carbon emissions. *Transport Policy*, *67*, 85–92. https://doi.org/10.1016/j.tranpol.2017.03.006

CBS (2017). Income of households. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83932NED/table?ts=1572453389344

CBS (2019a). Employment. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83523NED/table?ts=1572951457644

CBS (2019b). Population on January first; gender; age; region. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/03759ned/table?fromstatweb

Chen, C.-D., Fan, Y.-W., & Farn, C.-K. (2007). Predicting electronic toll collection service adoption: An integration of the technology acceptance model and the theory of planned behavior. *Transportation Research Part C: Emerging Technologies*, *15*(5), 300–311. https://doi.org/10.1016/j.trc.2007.04.004

Chen, Y.-J., Li, Z.-C., Lam, W. H. K., & Choi, K. (2016). Tradable location tax credit scheme for balancing traffic congestion and environmental externalities. *International Journal of Sunstainable Transportation*, *10*(10), 917–934. https://doi.org/10.1080/15568318.2016.1187230

ChoiceMetrics (2018). Ngene 1.2 User manual & reference guide. Retrieved from http://www.choice-metrics.com/NgeneManual120.pdf

Coase, R. A. (1960). The problem of societal cost. *Journal of Law and Economics*, *3*, 1–44.

Cools, M., Moons, E., Janssens, B., & Wets, G. (2009). Shifting towards environment-friendly modes: Profiling travelers using Q-methodology. *Transportation*, *36*(4), 437–453. https://doi.org/10.1007/s11116-009-9206-z

Corr, S. (2001). An Introduction to Q Methodology, a Research Technique. *British Journal of Occupational Therapy*, *64*(6), 293–297. https://doi.org/10.1177/030802260106400605

Crocker, T. D. (1966). The structuring of atmospheric pollution control systems. In H. Wolozin (Ed.), *The economics of air pollution: a symposium*. New York: Norton & Norton.

Cropper, M., & Oates, W. E. (1992). Environmental Economics: A Survey. *Journal of Economic Literature*, *30*(2), 675–740.

Cuppen, E. (2012). Diversity and constructive conflict in stakeholder dialogue: Considerations for design and methods. *Policy Sciences*, *45*(1), 23–46. https://doi.org/10.1007/s11077-011-9141-7

Dales, J. H. (1968). *Pollution, property & prices*. Toronto: University of Toronto Press.

Davies, B. B., & Hodge, I. D. (2007). Exploring environmental perspectives in lowland agriculture: A Q methodology study in East Anglia, UK. *Ecological Economics*, *61*(2-3), 323–333. https://doi.org/10.1016/j.ecolecon.2006.03.002

Defra (2008). *Synthesis report of the findings from Defra's pre-feasibility study into personal carbon trading*. London.

Di Ciommo, F., Monzón, A., & Fernandez-Heredia, A. (2013). Improving the analysis of road pricing acceptability surveys by using hybrid models. *Transportation Research Part A: Policy and Practice*, *49*, 302–316. https://doi.org/10.1016/j.tra.2013.01.007

Di Wu, Yin, Y., Lawphongpanich, S., & Yang, H. (2012). Design of more equitable congestion pricing and tradable credit schemes for multimodal transportation networks. *Transportation Research Part B: Methodological*, *46*(9), 1273–1287. https://doi.org/10.1016/j.trb.2012.05.004

Dogterom, N. (2017). *Tradable Driving Credits: car users' responses towards an innovative pricing measure in the Netherlands and China*. Enschede: Gildeprint.

Dogterom, N., Bao, Y., Xu, M., & Ettema, D. (2018). 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. (2018). 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

Dresner, S., Dunne, L., Clinch, P., & Beuermann, C. (2006). Social and political responses to ecological tax reform in Europe: An introduction to the special issue. *Energy Policy*, *34*(8), 895–904. https://doi.org/10.1016/j.enpol.2004.08.043

Eliasson, J. (2014). The role of attitude structures, direct experience and reframing for the success of congestion pricing. *Transportation Research Part A: Policy and Practice*, *67*, 81–95. https://doi.org/10.1016/j.tra.2014.06.007

Eliasson, J. (2016). Is congestion pricing fair? Consumer and citizen perspectives on equity effects. *Transport Policy, 52,* 1–15. https://doi.org/10.1016/j.tranpol.2016.06.009

Eliasson, J., & Jonsson, L. (2011). The unexpected "yes": Explanatory factors behind the positive attitudes to congestion charges in Stockholm. *Transport Policy*, *18*(4), 636–647. https://doi.org/10.1016/j.tranpol.2011.03.006

Eliasson, J., & Mattsson, L.-G. (2006). Equity effects of congestion pricing. *Transportation Research Part A: Policy and Practice*, *40*(7), 602–620. https://doi.org/10.1016/j.tra.2005.11.002

Ellerman, A. D. (2003). Tradable Permits: A market-based allocation system for the environment. *CESifo Forum*, *4*(1), 3–32.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

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

European Commission (2015). *EU ETS Handbook*. Retrieved from European Union website: https://ec.europa.eu/clima/policies/ets_en

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

Fawcett, T. (2010). Personal carbon trading: A policy ahead of its time? *Energy Policy*, *38*(11), 6868–6876. https://doi.org/10.1016/j.enpol.2010.07.001

Fawcett, T., & Parag, Y. (2010). An introduction to personal carbon trading. *Climate Policy*, *10*(4), 329–338. https://doi.org/10.3763/cpol.2010.0649

Feitelson, E., & Salomon, I. (2004). The Political Economy of Transport Innovations. In M. Beuthe, V. Himanen, A. Reggiani, & L. Zamparini (Eds.), *Transport Development and Innovations in an Evolving World* (pp. 11–26). Berlin, Heidelberg: Springer.

Ferrer, S., & Ruiz, T. (2018). The impact of the built environment on the decision to walk for short trips: Evidence from two Spanish cities. *Transport Policy*, *67*, 111–120. https://doi.org/10.1016/j.tranpol.2017.04.009

Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford: Stanford University Press.

Fleming, D. (1997). Tradable quotas: using information technology to cap national carbon emissions. *European Environment*, *7*, 139–148.

Francke, A., & Kaniok, D. (2013). Responses to differentiated road pricing schemes. *Transportation Research Part A: Policy and Practice*, *48*, 25–30. https://doi.org/10.1016/j.tra.2012.10.002

Gao, G., & Hu, J. (2015). Optimal Tradable Credits Scheme and Congestion Pricing with the Efficiency Analysis to Congestion. *Discrete Dynamics in Nature and Society*, *2015*, 1–6. https://doi.org/10.1155/2015/801979

Gao, G., Sun, H., Wu, J., Liu, X., & Chen, W. (2018). Park-and-ride service design under a price-based tradable credits scheme in a linear monocentric city. *Transport Policy*, *68*, 1–12. https://doi.org/10.1016/j.tranpol.2018.04.001

Gärling, T., Jakobsson, C., Loukopoulos, P., & Fujii, S. (2008). Acceptability of road pricing. In E. Verhoef, M. Bliemer, L. Steg, & B. van Wee (Eds.), *Pricing in Road Transport: A multi-disciplinary perspective* (pp. 193–208). Cheltenham, UK: Edward Elgar Publishing.

Gaunt, M., Rye, T., & Allen, S. (2007). Public Acceptability of Road User Charging: The Case of Edinburgh and the 2005 Referendum. *Transport Reviews*, *27*(1), 85–102. https://doi.org/10.1080/01441640600831299

Geels, F. W., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, *36*(3), 399–417. https://doi.org/10.1016/j.respol.2007.01.003

Gehlert, T., Kramer, C., Nielsen, O. A., & Schlag, B. (2011). Socioeconomic differences in public acceptability and car use adaptation towards urban road pricing. *Transport Policy*, *18*(5), 685–694. https://doi.org/10.1016/j.tranpol.2011.01.003

Giuliano, G. (1992). An assessment of the political acceptability of congestion pricing. *Transportation*, *19*(4), 335–358. https://doi.org/10.1007/BF01098638

Glavic, D., Mladenovic, M., Luttinen, T., Cicevic, S., & Trifunovic, A. (2017). Road to price: User perspectives on road pricing in transition country. *Transportation Research Part A: Policy and Practice*, *105*, 79–94. https://doi.org/10.1016/j.tra.2017.08.016

Goddard, H. C. (1997). Using Tradeable Permits to Achieve Sustainability in the World's Large Cities: Policy Design Issues and Efficiency Conditions for Controlling Vehicle Emissions, Congestion and Urban Decentralization with an Application to Mexico City. *Environmental and Resource Economics*, *10*, 63–99.

Golob, T. F. (2001). Joint models of attitudes and behavior in evaluation of the San Diego I-15 congestion pricing project. *Transportation Research Part A*, *35*, 495–514.

Grant-Muller, S., & Xu, M. (2014). The Role of Tradable Credit Schemes in Road Traffic Congestion Management. *Transport Reviews*, *34*(2), 128–149. https://doi.org/10.1080/01441647.2014.880754

Grisolía, J. M., López, F., & Ortúzar, J. d. D. (2015). Increasing the acceptability of a congestion charging scheme. *Transport Policy*, *39*, 37–47. https://doi.org/10.1016/j.tranpol.2015.01.003

Guest, G., Namey, E., & McKenna, K. (2016). How Many Focus Groups Are Enough? Building an Evidence Base for Nonprobability Sample Sizes. *Field Methods*, *29*(1), 3–22. https://doi.org/10.1177/1525822X16639015

Gulipalli, P. K., Kalmanje, S., & Kockelman, K. M. (2008). Credit-Based Congestion Pricing: Expert Expectations and Guidelines for Application. *Journal of the Transportation Research Forum*, *47*(2), 5–19.

Hackert, C., & Braehler, G. (2007). Flash-Q. Retrieved from http://www.hackert.biz/flashq/home/

Hamilton, C. J., Eliasson, J., Brundell-Freij, K., Raux, C., & Souche, S. (2014). *Determinants of Congestion Pricing Acceptability: CTS Working Paper 2014:11*. Stockholm.

Han, F., & Cheng, L. (2016). Stochastic user equilibrium model with a tradable credit scheme and application in maximizing network reserve capacity. *Engineering Optimization*, *49*(4), 549–564. https://doi.org/10.1080/0305215X.2016.1193357

Harrington, W., Krupnick, A. J., & Alberini, A. (2001). Overcoming public aversion to congestion pricing. *Transportation Research Part A*, *35*, 87–105.

Harwatt, H., Tight, M., Bristow, A. L., & Gühnemann, A. (2011). Personal Carbon Trading and fuel price increases in the transport sector: an exploratory study of public response in the UK. *European Transport*, *47*, 47–70.

Hermans, J., & Koomen, M. (2006). *Kilometerprijs [Kilometre charge]: Wat weten en vinden ANWB leden ervan? [What is the knowledge and opinion of members of the Dutch roadside assistance?]*. Amsterdam.

I&O research (2019). *Kilometerbeprijzing? Ja, maar onder voorwaarden [Road pricing? Yes, but under conditions]*. Amsterdam. Retrieved from https://ioresearch.nl/Portals/0/BVKREK_rapport_def_1.pdf

IPPR (2009). *Plan B? The prospects for personal carbon trading*. Summary. Retrieved from The Institute for Public Policy Research website: https://www.ippr.org/publications/plan-b-the-prospects-for-personal-carbon-trading

Jaensirisak, S., Wardman, M., & May, A. D. (2005). Explaining Variations in Public Acceptability of Road Pricing Schemes. *Journal of Transport Economics and Policy*, *39*(2), 127–153.

Jakobsson, C., Fujii, S., & Gärling, T. (2000). Determinants of private car users' acceptance of road pricing. *Transport Policy*, *7*(2), 153–158. https://doi.org/10.1016/S0967-070X(00)00005-6

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk. In *Handbook of the fundamentals of financial decision making: Part I* (pp. 99–127).

Kim, J., Schmöcker, J.-D., Fujii, S., & Noland, R. B. (2013). Attitudes towards road pricing and environmental taxation among US and UK students. *Transportation Research Part A: Policy and Practice*, *48*, 50–62. https://doi.org/10.1016/j.tra.2012.10.005

Kim, K. S., & Hwang, K. (2004). An application of road pricing schemes to urban expressways in Seoul. *Cities*, *22*(1), 43–53. https://doi.org/10.1016/j.cities.2004.10.005

King, D., Manville, M., & Shoup, D. (2007). The political calculus of congestion pricing. *Transport Policy*, *14*(2), 111–123. https://doi.org/10.1016/j.tranpol.2006.11.002

Kishimoto, P. N., Karplus, V. J., Zhong, M., Saikawa, E., Zhang, X., & Zhang, X. (2017). The impact of coordinated policies on air pollution emissions from road transportation in China. *Transportation Research Part D: Transport and Environment*, *54*, 30–49. https://doi.org/10.1016/j.trd.2017.02.012

Kitzinger, J. (1994). Chapter 10: Focus groups: method or madness? In M. Boulton (Ed.), *Challenge and Innovation: Methodological Advances in Social Research on HIV/AIDS*. London: Taylor & Francis.

Knight, F. H. (1924). Some Fallacies in the Interpretation of Social Cost. *The Quarterly Journal of Economics*, *38*(4).

Knobelsdorff, M. v. (2008). *Public acceptability of personal carbon trading: Master thesis.*

Knockaert, J., Bakens, J., Ettema, D., & Verhoef, E. (2011). Rewarding Peak Avoidance: The Dutch 'Spitsmijden' Projects. In J. A.E.E. van Nunen, P. Huijbregts, & P. Rietveld (Eds.), *Transitions Towards Sustainable Mobility* (pp. 101–118). Berlin, Heidelberg: Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-21192-8_6

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*(7-9), 671–690. https://doi.org/10.1016/j.tra.2005.02.014

Koppenjan, J. F. M. (1993). *Management van de beleidsvorming [Management of policy making]*. Den Haag: VUGA.

Krabbenborg, L., Mouter, N., Molin, E., Annema, J. A., & van Wee, B. (2020). Exploring public perceptions of tradable credits for congestion management in urban areas. *Cities*, *107*. https://doi.org/10.1016/j.cities.2020.102877

Kroesen, M., & Bröer, C. (2009). Policy discourse, people's internal frames, and declared aircraft noise annoyance: An application of Q-methodology. *Journal of the Acoustical Society of America*, 195–207.

Kroesen, M., Handy, S., & Chorus, C. (2017). Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modeling. *Transportation Research Part A: Policy and Practice*, *101*, 190–202. https://doi.org/10.1016/j.tra.2017.05.013

Krueger, R., Casey, M. A., Donner, J., Kirsch, S., & Maack, J. (2001). *Social Analysis: Selected Tools and Techniques* (Social Development series). Washington D.C. Retrieved from World Bank website: http://siteresources.worldbank.org/INTCDD/Resources/SAtools.pdf

Kurniawan, J. H., Ong, C., & Cheah, L. (2018). Examining values and influences affecting public expectations of future urban mobility: A Singapore case study. *Transport Policy*, *66*, 66–75. https://doi.org/10.1016/j.tranpol.2017.12.014

Li, Z., & Hensher, D. A. (2012). Congestion charging and car use: A review of stated preference and opinion studies and market monitoring evidence. *Transport Policy*, *20*, 47–61. https://doi.org/10.1016/j.tranpol.2011.12.004

Liu, Q., Lucas, K., & Marsden, G. (2019). Public acceptability of congestion charging in Beijing, China: How transferrable are Western ideas of public acceptability? *International Journal of Sustainable Transportation*, *78*(2), 1–14. https://doi.org/10.1080/15568318.2019.1695158

Liu, W., Yang, H., Yin, Y., & Zhang, F. (2014). A novel permit scheme for managing parking competition and bottleneck congestion. *Transportation Research Part C: Emerging Technologies*, *44*, 265–281. https://doi.org/10.1016/j.trc.2014.04.005

Magidson, J., & Vermunt, J. K. (2004). Latent class models. In D. Kaplan (Ed.), *The Sage handbook of quantitative methodology for the social sciences* (pp. 175–198). Thousand Oakes: Sage.

McFadden, D. (1986). The choice theory approach to market research. *Marketing Science*, *5*(4), 275–297.

Miguel, J.P.M., Blas, C. S. de, & Sipols, A.E.G. (2017). A forecast air pollution model applied to a hypothetical urban road pricing scheme: An empirical study in Madrid. *Transportation Research Part D: Transport and Environment*, *55*, 21–38. https://doi.org/10.1016/j.trd.2017.06.007

Molin, E., Mokhtarian, P., & Kroesen, M. (2016). Multimodal travel groups and attitudes: A latent class cluster analysis of Dutch travelers. *Transportation Research Part A: Policy and Practice*, *83*, 14–29. https://doi.org/10.1016/j.tra.2015.11.001

Molin, E. J.E., & Timmermans, H. J.P. (2010). Context Dependent Stated Choice Experiments: The Case of Train Egress Mode Choice. *Journal of Choice Modelling*, *3*(3), 39–56. https://doi.org/10.1016/S1755-5345(13)70013-7

Montgomery, W. (1972). Markets in licences and efficient pollution control programs. *Journal of Economic Theory*, *5*, 395–418.

Morgan, D. L. (1996). Focus Groups. *Annual Review of Sociology*, *22*, 129–152.

Nie, Y. (2012). Transaction costs and tradable mobility credits. *Transportation Research Part B: Methodological*, *46*(1), 189–203. https://doi.org/10.1016/j.trb.2011.10.002

Niemeier, D., Gould, G., Karner, A., Hixson, M., Bachmann, B., Okma, C., . . . Heres Del Valle, D. (2008). Rethinking downstream regulation: California's opportunity to engage households in reducing greenhouse gases. *Energy Policy*, *36*(9), 3436–3447. https://doi.org/10.1016/j.enpol.2008.04.024

Nikitas, A., Avineri, E., & Parkhurst, G. (2011). Older people's attitudes to road charging: Are they distinctive and what are the implications for policy? *Transportation Planning and Technology*, *34*(1), 87–108. https://doi.org/10.1080/03081060.2011.530831

Nikitas, A., Avineri, E., & Parkhurst, G. (2018). Understanding the public acceptability of road pricing and the roles of older age, social norms, pro-social values and trust for urban policy-making: The case of Bristol. *Cities*, *79*, 78–91. https://doi.org/10.1016/j.cities.2018.02.024

Nilsson, A., Hansla, A., Heiling, J. M., Bergstad, C. J., & Martinsson, J. (2016). Public acceptability towards environmental policy measures: Value-matching appeals. *Environmental Science & Policy*, *61*, 176–184. https://doi.org/10.1016/j.envsci.2016.04.013

Nilsson, A., Schuitema, G., Jakobsson Bergstad, C., Martinsson, J., & Thorson, M. (2016). The road to acceptance: Attitude change before and after the implementation of a congestion tax. *Journal of Environmental Psychology*, *46*, 1–9. https://doi.org/10.1016/j.jenvp.2016.01.011

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the Number of Classes in Latent Class Analysis and Growth Mixture Modeling: A Monte Carlo Simulation Study. *Structural equation modeling*, *14*(4), 535–569.

Odeck, J., & Bråthen, S. (1997). On public attitudes toward implementation of toll roads—the case of Oslo toll ring. *Transport Policy*, *4*(2), 73–83. https://doi.org/10.1016/S0967-070X(97)00008-5

OECD (Ed.) (2000). *Implementing Domestic Tradable Permits for Environmental Protection*. Paris: OECD Publishing. Retrieved from https://doi.org/10.1787/9789264181182-en

Owen, L., Edgar, L., Prince, S., & Doble, C. (2008). *Personal Carbon Trading: Public Acceptability: A report to the Department for Environment, Food and Rural Affairs*. London.

Parag, Y., & Eyre, N. (2010). Barriers to personal carbon trading in the policy arena. *Climate Policy*, *10*(4), 353–368. https://doi.org/10.3763/cpol.2009.0009

Pigou, A. C. (1920). *The Economics of Welfare*. London: Macmillan and Co.

Porcu, M., & Giambona, F. (2016). Introduction to Latent Class Analysis With Applications. *The Journal of Early Adolescence*, *37*(1), 129–158. https://doi.org/10.1177/0272431616648452

Pronello, C., & Rappazzo, V. (2014). Road pricing: How people perceive a hypothetical introduction. The case of Lyon. *Transport Policy*, *36*, 192–205. https://doi.org/10.1016/j.tranpol.2014.08.005

Rajé, F. (2007). Using Q methodology to develop more perceptive insights on transport and social inclusion. *Transport Policy*, *14*(6), 467–477. https://doi.org/10.1016/j.tranpol.2007.04.006

Raux, C. (2002). The use of Transferable Permits in the Transport Sector. In OECD (Ed.), *Implementing Domestic Tradeable Permits.: Recent development and future challenges* (pp. 141–185). OECD.

Raux, C. (2008). Tradable driving rights in urban areas: their potential for tackling congestion and traffic-related pollution. In S. Ison & T. Rye (Eds.), *The implementation and effectiveness of transport demand management measures: An international perspective* (pp. 95–120). Routledge.

Raux, C., & Marlot, G. (2005). A system of tradable CO2 permits applied to fuel consumption by motorists. *Transport Policy*, *12*(3), 255–265. https://doi.org/10.1016/j.tranpol.2005.02.006

Rienstra, S. A., Rietveld, P., & Verhoef, E. (1999). The social support for policy measures in passenger transport. A statistical analysis for the Netherlands. *Transportation Research Part D*, *4*, 181–200.

Santos, G., Behrendt, H., Maconi, L., Shirvani, T., & Teytelboym, A. (2010). Part I: Externalities and economic policies in road transport. *Research in Transportation Economics*, *28*(1), 2–45. https://doi.org/10.1016/j.retrec.2009.11.002

Schade, J., & Baum, M. (2007). Reactance or acceptance? Reactions towards the introduction of road pricing. *Transportation Research Part A: Policy and Practice*, *41*(1), 41–48. https://doi.org/10.1016/j.tra.2006.05.008

Schade, J., & Schlag, B. (Eds.) (2003a). *Acceptability of transport pricing strategies*. Oxford: Elsevier.

Schade, J., & Schlag, B. (2003b). Acceptability of urban transport pricing strategies. *Transportation Research Part F: Traffic Psychology and Behaviour*, *6*(1), 45–61. https://doi.org/10.1016/S1369-8478(02)00046-3

Schlag, B., & Teubel, U. (1997). Public acceptability of transport pricing. *IATSS Research*, *21*, 134–142. Retrieved from https://pdfs.semanticscholar.org/7d4e/135606ed94253317ca0fb786f501d625cf92.pdf

Schmolck, P. (2014). PQMethod 2.35. Retrieved from http://schmolck.org/qmethod/downpqwin.htm

Schuitema, G., & Steg, L. (2008). The role of revenue use in the acceptability of transport pricing policies. *Transportation Research Part F: Traffic Psychology and Behaviour*, *11*(3), 221–231. https://doi.org/10.1016/j.trf.2007.11.003

Schuitema, G., Steg, L., & Forward, S. (2010). Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. *Transportation Research Part A: Policy and Practice*, *44*(2), 99–109. https://doi.org/10.1016/j.tra.2009.11.005

Schuitema, G., Steg, L., & van Kruining, M. (2011). When Are Transport Pricing Policies Fair and Acceptable? *Social Justice Research*, *24*(1), 66–84. https://doi.org/10.1007/s11211-011-0124-9

Schwartz, S. H. (1977). Normative influence on altruism. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (pp. 221–279). New York: Academic Press.

Seik, F. T. (2000). An advanced demand management instrument in urban transport. *Cities*, *17*(1), 33–45. https://doi.org/10.1016/S0264-2751(99)00050-5

Seyfang, G., Lorenzoni, I., & Nye, M. (2009). *Personal Carbon Trading:a critical examination of proposals for the UK*. Working Paper 136. Norwich.

Smaal, M. (2012). *Politieke strijd om de prijs van automobiliteit: De geschiedenis van een langdurend discours: 1895-2010 [The political battle for the price of car mobility: The history of a long-term discourse: 1895-2010]*. Delft: Eburon.

Small, K., & Verhoef, E. T. (2007). *The Economics of Urban Transportation*. London: Routledge.

Sovacool, B. K. (2011). The policy challenges of tradable credits: A critical review of eight markets. *Energy Policy*, *39*(2), 575–585. https://doi.org/10.1016/j.enpol.2010.10.029

Steg, L., Vlek, C., & Slotegraaf, G. (2001). Instrumental-reasoned and symbolic-affective motives for using a motor car. *Transportation Research Part F: Traffic Psychology and Behaviour*, *4*(3), 151–169. https://doi.org/10.1016/S1369-8478(01)00020-1

Stephenson, W. (1935). Technique of Factor Analysis. *Nature*, *136*, 297. https://doi.org/10.1038/136297b0

Stockholms stad (2007). TRÄNGSELSKATT – RESULTAT AV FOLKOMRÖSTNINGAR. Retrieved from https://web.archive.org/web/20080608193744/http://val.cscs.se/

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

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tietenberg, T. (2003). The tradable-permits approach to protecting the commons: Lessons for climate change. *Oxford Review of Economic Policy*, *19*(3), 400–419. https://doi.org/10.1137/1.9780898719154.ch1

Ton, D., Zomer, L.-B., Schneider, F., Hoogendoorn-Lanser, S., Duives, D., Cats, O., & Hoogendoorn, S. (2019). Latent classes of daily mobility patterns: The relationship with attitudes towards modes. *Transportation*, *50*, 179. https://doi.org/10.1007/s11116-019-09975-9

Train, K. (2003). *Discrete Choice Methods with Simulation*. Cambridge: Cambridge University Press.

Ubbels, B., & Verhoef, E. (2006). Acceptability of road pricing and revenue use in the Netherlands. *European Transport \Transporti Europei*. (32), 69–94.

Van Delden, J. (2009). *Beprijzen, belonen of een budget: Onderzoek naar de verwachte effectiviteit en aanvaardbaarheid van de prijsmaatregelconcepten beprijzen, belonen en een budget onder spitsrijders [Charging, rewarding or a budget: A study on the expected effectiveness and acceptability of the road pricing concepts charging, rewarding and a budget among peak car users]*. Master thesis. Enschede.

Van Delden, J., & Cluitmans, C. (2009). Beprijzen, belonen of een budget. In *Colloquium Vervoersplanologisch Speurwerk*, Antwerpen.

Van Exel, J., & Graaf, G. de (2005). Q methodology: A sneak preview. Retrieved from www.jobvanexel.nl

Van Exel, N. J. A., Graaf, G. de, & Rietveld, P. (2003). Getting from A to B: Operant Approaches to Travel Decision Making. In *Operant Approaches to Travel Decision Making*, Ohio.

Van Exel, N. J. A., Graaf, G. de, & Rietveld, P. (2011). "I can do perfectly well without a car!": An exploration of stated preference for middle-distance travel. *Transportation*, *38*(3), 383–407. https://doi.org/10.1007/s11116-010-9315-8

Van Goeverden, K., Milakis, D., Janic, M., & Konings, R. (2018). Analysis and modelling of performances of the HL (Hyperloop) transport system. *European Transport Research Review*, *10*(2), 28. https://doi.org/10.1186/s12544-018-0312-x

Vanoutrive, T., & Zijlstra, T. (2018). Who has the right to travel during peak hours? On congestion pricing and 'desirable' travellers. *Transport Policy*, *63*, 98–107. https://doi.org/10.1016/j.tranpol.2017.12.020

Verhoef, E., Nijkamp, P., & Rietveld, P. (1996). The trade-off between efficiency, effectiveness, and social feasibility of regulating road transport externalities. *Transportation Planning and Technology*, *19*(3-4), 247–263. https://doi.org/10.1080/03081069608717572

Verhoef, E., Nijkamp, P., & Rietveld, P. (1997a). The Social Feasibility of Road Pricing: A Case Study for the Randstad Area. *Journal of Transport Economics and Policy*.

Verhoef, E., Nijkamp, P., & Rietveld, P. (1997b). Tradeable permits: their potential in the regulation of road transport externalities. *Environment and Planning B: Planning and Design*, *24*, 527–548.

Vermunt, J. K., & Magidson, J. (2002). Latent class cluster analysis. In J. Hagenaars & A. McCutcheon (Eds.), *Applied latent class cluster analysis* (pp. 88–106). Cambridge: Cambridge University Press.

Vermunt, J. K., & Magidson, J. (2005). *Technical Guide for Latent GOLD Choice 4.0: Basic and Advanced*. Belmont, MA.

Vermunt, J. K., & Magidson, J. (2013). *Latent Gold 5.0 Upgrade Manual*. Belmont, MA.

Vickrey, W. S. (1963). Pricing in urban and suburban transport. *The American Economic Review*, *53*(2), 452–465.

Viegas, J. M. (2001). Making urban road pricing acceptable and effective: searching for quality and equity in urban mobility. *Transport Policy*, *8*, 289–294.

Vonk Noordegraaf, D., Annema, J. A., & van de Riet, O. (2012). The policy implementation process for road pricing in the Netherlands. In H. Geerlings, Y. Shiftan, & D. Stead (Eds.), *Transition towards sustainable mobility: the role of instruments, individuals and institutions*. Farnham: Ashgate.

Vonk Noordegraaf, D., Annema, J. A., & van Wee, B. (2014). Policy implementation lessons from six road pricing cases. *Transportation Research Part A: Policy and Practice*, *59*, 172–191. https://doi.org/10.1016/j.tra.2013.11.003

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

Wadud, Z., Noland, R. B., & Graham, D. J. (2008). Equity analysis of personal tradable carbon permits for the road transport sector. *Environmental Science & Policy*, *11*(6), 533–544. https://doi.org/10.1016/j.envsci.2008.04.002

Wallace, A. A., Irvine, K. N., Wright, A. J., & Fleming, P. D. (2010). Public attitudes to personal carbon allowances: findings from a mixed-method study. *Climate Policy*, *10*(4), 385–409.

Wang, X., Yang, H., Zhu, D., & Li, C. (2012). Tradable travel credits for congestion management with heterogeneous users. *Transportation Research Part E: Logistics and Transportation Review*, *48*(2), 426–437. https://doi.org/10.1016/j.tre.2011.10.007

Watts, S., & Stenner, P. (2005). Doing Q methodology: Theory, method and interpretation. *Qualitative Research in Psychology*, *2*(1), 67–91. https://doi.org/10.1191/1478088705qp022oa

Wigger, U., & Mrtek, R. (1994). Use of Q-technique to Examine Attitudes of Entering Pharmacy Students Toward Their Profession. *American Journal of Pharmaceutrical Education*, *58*, 8–15.

Woerdman, E., & Bolderdijk, J. W. (2017). Emissions trading for households? A behavioral law and economics perspective. *European Journal of Law and Economics*, *44*(3), 553–578. https://doi.org/10.1007/s10657-015-9516-x

Xu, M., & Grant-Muller, S. (2016). Trip mode and travel pattern impacts of a Tradable Credits Scheme: A case study of Beijing. *Transport Policy*, *47*, 72–83. https://doi.org/10.1016/j.tranpol.2015.12.007

Yang, H., & Wang, X. (2011). Managing network mobility with tradable credits. *Transportation Research Part B: Methodological*, *45*(3), 580–594. https://doi.org/10.1016/j.trb.2010.10.002

Zheng, Z., Liu, Z., Liu, C., & Shiwakoti, N. (2014). Understanding public response to a congestion charge: A random-effects ordered logit approach. *Transportation Research Part A: Policy and Practice*, *70*, 117–134. https://doi.org/10.1016/j.tra.2014.10.016

Zmud, J. (2008). The public supports pricing if… A synthesis of public opinion studies on tolling and road pricing. *Tollways*. (Winter), 29–39.

Summary

Introduction

Dozens of variants for congestion charging have been studied and discussed in scientific and political circles in the search for an efficient policy to abate the negative effects of car use, these being congestion and emissions, in particular. Although congestion charging provides clear economic advantages and is technically possible, the actual implementation of these schemes is rare. Proposals for charging schemes typically stir up public opposition, which negatively influences political support and overall feasibility. Reoccurring arguments in the public debate include people's disbelief in the scheme's effectiveness, conviction that it is 'yet another revenue stream for the government', fear that it will treat them or others unfairly, and car users, especially, expect that it will (financially) disadvantage them.

The concept of tradable peak credits (TPC) is a drastically different alternative that can potentially address these concerns and hence become a more feasible policy instrument. This concept is based on the cap-and-trade principle and is, in theory, very effective since it puts a firm 'limit' on road access during peak hours. Access rights - the credits - are distributed among people who can use them to access the road or trade them via an online market where the credit price is set by supply and demand. Thus, money flow stays within the group of users and does not flow towards the government. Since the credit distribution does not affect the scheme's efficiency, the operator (government) can distribute the credits in any way to meet equity concerns.

The main reason for the recent upsurge in literature on tradable credits in transportation research lies in the notion that support from the public in general, and of car users in particular, might be higher than it is for a congestion charge. Studies on theoretical explorations, scheme design, effects on traffic flow and behavioural effects have expanded in the last decade, but empirical studies on public support has remained remarkably scarce. A few empirical studies on related concepts in mobility management have been conducted, but these typically study support for a fixed scheme design, whereas support may heavily depend on the scheme design, for example on the credit distribution. Furthermore, public support for road pricing is often studied in a quantitative way and analysed on an aggregated level. However, the public debate about road pricing is full of varying arguments, which indicates that the public is very heterogeneous in their opinion and preferences. To better understand how (novel) road pricing can be designed and implemented, this thesis therefore also focuses on the underlying arguments and the differences between (groups of) people. Lastly, a broader view on the feasibility of TPC with insights from fields other than transportation economics also seems to be missing. Hence, the main aim of this study is ***to increase the understanding of the feasibility - and in particular public support - of Tradable Peak Credits (TPC) as a policy instrument for congestion management***.

This research is conducted in the context of the Netherlands. This country has a longstanding history with (non-implementation of) road pricing. In the period 2006 to 2018, while congestion charging was not negotiable in politics, experiments were organized, rewarding car users to avoid peak hours. The public support issues concerning charging schemes on the one hand, and the rather positive experience with the less opposed but not durable rewarding instruments on the other hand, contributed to the increased interest in the budget-neutral tradable credits concept in the Netherlands. This interest has also led to the formation of a multi-disciplinary consortium, which this thesis is a part of: U-SMILE (Urban Smart Measures and Incentives for quality of Life Enhancement).

Theoretical set-up

As knowledge of support for TPC is scarce, this thesis takes a rather open, explorative approach, and not a theory-testing approach. This means that the research set-up of this thesis is inspired by, but not limited to the empirical findings from current literature on conventional road pricing, as well as frameworks for the adoption of innovations. This thesis starts with a conceptual framework that is based on a political-economic framework about the adoption of transportation innovations, supplemented with the road pricing literature, and adjusted to fit the situation of tradable credits for congestion management.

Outline of the thesis and methods

The main aim of this thesis is translated into five sub-questions that are addressed in the five substantive chapters of the thesis. Figure 10 provides an overview of the five substantive chapters with the main methods.

- In Chapter 2, the wider feasibility of TPC and its main barriers to implementation are explored through interviews with policymakers and researchers from different backgrounds in the field of transportation (N=16, *sample I*). The insights from the interviews are supplemented with insights from empirical studies and theories on the policy process.

The remainder of the thesis focuses on public support, as that is commonly the main barrier to road pricing implementation. Chapter 3 regards the current road pricing debate and Chapters 4, 5, and 6 focus on public support for TPC.

- Chapter 3 analyses the current road pricing debate by identifying people's holistic viewpoints with the help of qualitative-quantitative Q-methodology. In an online survey (N=111, *sample II*), respondents were asked to rank-order a set of statements that represent the Dutch road pricing debate. A particular rank-order represents an individual's complete viewpoint, and by systematically comparing the rank-orders, shared viewpoints among individuals were identified. These represent the main 'frames' of the road pricing debate.
- Chapter 4 starts with the exploration of people's attitudes, feelings and opinions towards TPC through using focus group meetings. Citizens of the Delft region (N=36, *sample*

III), a medium sized city in the Netherlands, discussed the concepts of TPC and compared it to an equivalent peak charge.

- Chapter 5 quantifies public support for TPC, using a survey that was conducted among citizens that live in or near two Dutch cities (Amsterdam and Utrecht) (N=513, *sample IV*). Respondents were asked to choose between different TPC scheme designs in a choice experiment. The scheme designs varied in the way credits were distributed, who the credits were distributed to, how often the credits were distributed, and how often the credit price fluctuated. Different utility-based choice models were used to estimate the observed choices, to find public support levels for TPC scheme designs, and to analyse the influence of personal characteristics, attitudes, and scheme design characteristics on the amount of support.
- Chapter 6 uses the same sample (*sample IV)* to analyse support for TPC and to compare it to support for a conventional congestion charge and a kilometre charge. A Latent Class Cluster Analysis (LCCA) was also conducted to reveal which distinct homogenous clusters of people exist that show similar rejection rates for support of these three instruments.

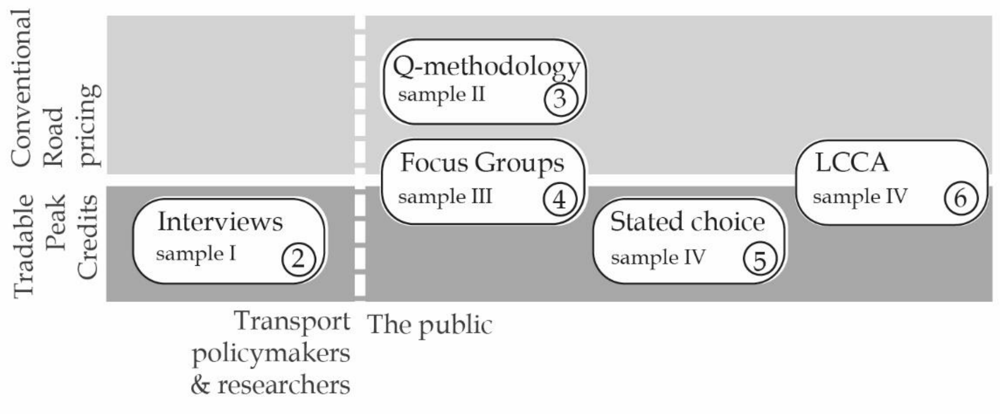


Figure 10 The five chapters with their main method, studied scheme(s), and studied population. The numbers refer to the chapter numbering.

Findings

Chapter 2: Feasibility of TPC according to transportation researchers and policymakers

All interviewees were generally sceptical or unreservedly negative about the concept and they identified many potential barriers. Most interviewees think the concept would be technically possible, but found it hard to estimate whether the economic benefits of the instrument would exceed the costs. A review of empirical studies and theories from literature on policy processes identified further challenges. In total, the results show that the main challenges lie in the context of public and political support. Important challenges, in particular, are considered to be the distributions of the credits, whether people understand the scheme correctly, and the balance between transaction cost and effectiveness.

Chapter 3: Public viewpoints in the road pricing debate

Four shared viewpoints - the so-called 'frames' in the road pricing debate - were found. The first group is labelled as '*the polluter should pay',* and people within this frame are quite positive about road pricing. They find the current level of car use a big problem for the economy and the environment and they show that they have a lot of trust in the technical feasibility and effectiveness of road pricing. People in the second frame, '*focus on fair alternatives',* find congestion also to be a big problem, but consider road pricing to be an unfair solution. Instead, they prefer to focus on alternatives to using a car, such as public transport and the bicycle, that are open to all (income) groups and are environmentally friendly. People in the third frame, '*What's in it for me?',* are mainly car users who seem to be afraid that road pricing will negatively affect their personal situation and they need more information before they can form a final opinion. People in the fourth frame, '*Don't interfere'*, are also regular car users. They find congestion a huge problem, but find road pricing neither a fair nor effective solution. This frame is characterized by distrust of the government and the feasibility of road pricing.

Chapter 4: Public perceptions of TPC

The advantages of TPC, as addressed in academic literature, played minor roles in the discussions. Participants found the flexibility of the credit allocation a big point for discussion, and many did not understand or neglected to see the potential effectiveness of TPC, due to the firm cap. Also, not everyone believed that TPC would be truly 'budget-neutral'. The disadvantages that were raised are greater in number, and more diverse, than the advantages. Most participants in the focus group preferred the simpler peak charge (PC) instrument and many participants had a rather sceptical attitude towards TPC. Participants were, however, very divided about the two instruments. Five groups of people were identified that had similar thoughts about TPC and PC. Nine participants were *fiercely opposed* to both instruments and had a critical attitude towards the government. Fourteen participants were *clearly opposed* to TPC but were rather positive about PC. They showed a good knowledge of the transport system and other policy ideas. Most people in this group use a bicycle or train as the main mode of transportation. Six participants were rather *doubtful*. They showed an open attitude towards TPC and liked the positive approach of it compared to PC. But they also foresaw many difficulties regarding the implementation and feasibility. Four participants were *approving* of both instruments. They argued that it is necessary to implement a financial incentive to reduce congestion, regardless of whether the scheme is budget neutral or not. Lastly, two participants were *opportunistic* and liked TPC while opposing PC. Both participants are regular car users who argued that TPC would give them financial benefits. Some of the participants changed their opinion about TPC during the discussion. They became more negative, mainly due to arguments related to technical feasibility.

Chapter 5: Public support for TPC scheme designs

The results of the choice models suggest that on average people prefer the status quo to implementing TPC. But support levels differ between the different scheme designs. Of the sample, 32% to 52% would support different TPC designs. Support is highest for the scheme design in which credits are distributed equally among people who live in the city plus people who work there and own a car, where credits are distributed every month, and prices fluctuate on a daily basis, although preferences towards these design characteristics vary considerably between respondents. Moreover, the different choice models showed that attitudinal variables, including expected effectiveness, infringement of freedom, and especially perceived fairness, play an important role in explaining support.

Chapter 6: Support for TPC, a kilometre charge, and a congestion charge

On an aggregated level, 27% of the sample is somewhat or completely in favour of the general concept of TPC, 29% in favour of a congestion charge, and 34% in favour of a kilometre charge. The group of people that supports TPC differs considerably from the group that supports the conventional instruments. The LCCA revealed five clusters of people with similar thoughts in terms of support for the three instruments. The largest cluster (58%) is rather undecided or neutral about all instruments. 18% is negative about all instruments, and a cluster of 8% is positive about all instruments. The smallest cluster represents 6% and only supports a kilometre charge. 10% of the sample supports TPC while rejecting the conventional instruments. As can be expected, the latter cluster consists mainly of car users.

Generic conclusions

The question of whether TPC is a more supported, and hence a more feasible, policy than a congestion charge cannot simply be answered with a 'yes' or a 'no'. The expectations of the policymakers and researchers that were interviewed regarding public support were more negative than the actual empirical findings among citizens. The findings show that 27% of the sample of citizens in two Dutch cities is in favour of TPC, which is about equal to support for the general concept of a congestion charge (29%). However, when the same respondents are confronted with more specific TPC scheme designs, support levels are higher. Support levels vary between 32% and 52%, which demonstrates the relevance of the scheme design for gaining public support. The way in which the credits are distributed especially influences support levels, although preferences for the different credit distributions vary greatly between respondents. Respondents also prefer schemes in which the credits are distributed less frequently and credit prices do not fluctuate that often. A previous stated choice experiment conducted on a similar concept (personal carbon trading) showed much bigger differences between support for scheme designs. In other words, many people like or dislike TPC because of their attitudes towards the instrument, and differences in scheme design barely alter their opinion.

Furthermore, this thesis also tries to explain *why* citizens support or reject TPC. The focus group study showed that many of the arguments used in the debate about TPC overlap the arguments used in the regular road pricing debate. These include arguments related to fairness/equity, belief in the effectiveness, and trust in the government. Also some new arguments were found that have not been studied much in the light of support for TPC: the 'hassle' (time and effort) created through having to trade, the expected 'fun' of trading, the fear of misuse, privacy issues, the technical feasibility of the scheme, the perceived complexity, and the intelligibility and user friendliness. Also, a new type of concern about 'fairness' was raised by some participants. They were afraid that TPC would disadvantage those who are not the best, or cleverest, traders. The choice model in Chapter 5 confirms that support for TPC is higher among people who perceive TPC as fair, effective, who have trust in the government and technical feasibility, who find certainty important, and do not consider TPC as an infringement of their freedom.

As the Q-methodology study revealed, the public is very heterogeneous when it comes to support for road pricing. There are different reasons for rejecting or supporting a policy. This study used several person-centred approaches to study this heterogeneity regarding TPC. The focus group study took a qualitative approach and the Latent Class Cluster Analysis (LCCA) study a quantitative one. Both studies revealed a group of people that (fiercely) reject all instruments. The focus group study showed that the theoretical advantages of TPC, such as the absence of a revenue stream for the government, are neglected, or these people do not believe them. Furthermore, both studies also revealed a group that supports all instruments. These people have trust in the technology and find it important to 'do something about congestion'. Both studies also revealed an 'indifferent' or 'doubtful' group. In the LCCA, this group represents 58% of the sample, while in the focus groups only 6 out of 36 (17%) are doubtful. This difference may be caused by the different methods: focus group meetings may attract relatively few people with a 'neutral' opinion on the topic, while in LCCA, the 'neutral' group may have been overrepresented since some respondents simply opt for the middle option on a Likert scale. Both studies also revealed a group of people that reject TPC, but support a conventional pricing instrument. In the focus groups, these people showed they had a lot of trust in the effectiveness of road pricing and considered TPC an unnecessarily complex variant to it. Lastly, both studies also identified an 'opportunistic' group of people: regular car users who reject road pricing, but support TPC. This is the most interesting group since car users have typically been the most fierce opponents in the road pricing debate. The expectation that TPC would be more strongly supported by car users than a congestion charge proved to be true for a certain share of car users. However, the group is quite small (10%) and most car users are still in the 'reject all instruments' group.

Recommendations and further research

The public is very heterogeneous when it comes to support for TPC. Thereby, previous studies showed that public support levels for road pricing instruments are usually not stable, but tend to change over time, under the influence of experience with a certain scheme and public debate about it. Support usually increases once a trial or policy is implemented. Therefore, if policymakers are interested in tradable credits, it would be interesting to conduct real-world experiments. These experiments provide the opportunity to study the influence of experience on support, as well as many more aspects, such as behavioural effects, and technical and policy implementation. Therewith, it is important to pay careful attention to the exact scheme design, as this thesis proved how important this is for support. It is especially challenging to find a credit distribution that is supported by many people. Although this thesis focused on large-scale implementation, the concept of TPC can also be applied on the scale of a company or company district. Indeed, the results showed that there is a group of regular car users who are rather positive about the concept.

This thesis is a 'snapshot in time' about support for, and the feasibility of, tradable credits for congestion management. As long as there is no clear public preference for TPC over conventional congestion charging, it is doubtful whether it is wise to implement TPC on a large scale. The concept is relatively complex which brings along more costs with it than the simpler and more established congestion charging alternatives. Nevertheless, the unique characteristics of TPC, these being the finite 'cap' on road users, the absence of a revenue stream to the government, and the flexibility of (free) initial credit allocations, make the concept an interesting alternative compared to the extensively-studied, conventional road pricing schemes. Tradable credits are enriching but not they have not (yet) ended the long-standing search for an efficient and supported instrument to reduce congestion.

Samenvatting

Introductie

Tientallen varianten op congestieheffing zijn bestudeerd en bediscussieerd in wetenschappelijke en politieke kringen in de zoektocht naar een efficiënt beleid om de negatieve effecten van autogebruik te verminderen, met name congestie en emissies. Hoewel congestieheffing heldere economische voordelen biedt en technisch mogelijk is, worden dergelijke systemen zelden daadwerkelijk ingevoerd. Voorstellen voor congestieheffing wekken doorgaans publieke oppositie op, wat de politieke steun en algemene haalbaarheid negatief beïnvloedt. Terugkerende argumenten in het publieke debat zijn onder meer het ongeloof van mensen in de effectiviteit van het instrument, de overtuiging dat het 'nog een bron van inkomsten is voor de overheid', de angst dat het hen of anderen oneerlijkheid behandelt, en met name autogebruikers verwachten dat het hen (financieel) benadeelt.

Het concept van verhandelbare spitscredits (VSC), ook wel verhandelbare spitsrechten genoemd, is een drastisch ander alternatief dat bovenstaande zorgen potentieel kan adresseren en dus een haalbaarder beleidsinstrument kan worden. Het concept is gebaseerd op het *cap-and-trade* principe en is, in theorie, zeer effectief aangezien het een ferme limiet zet op toegang tot de weg tijdens spitsuren. Toegangsrechten – de credits – worden verdeeld onder mensen die de credits kunnen inleveren bij gebruik van de weg. Ze kunnen de credits ook ruilen via een online markt waar de creditprijs bepaald wordt door vraag en aanbod. Dus de geldstroom blijft binnen de groep van gebruikers en stroomt niet naar de overheid. Omdat de creditverdeling de efficiëntie van het instrument niet aantast, kan de uitvoerder (de overheid) de credits op elk mogelijke manier verdelen om zo bezorgdheid omtrent eerlijkheid tegemoet te komen.

De voornaamste reden voor de recente stijging in literatuur over verhandelbare credits in mobiliteit ligt in de notie dat publieke steun in het algemeen, en van autogebruikers met name, hoger kan zijn dan voor een congestieheffing. Studies over theoretische verkenningen, ontwerp van het instrument, effecten op verkeersstromen en gedragseffecten zijn in het laatste decennium toegenomen, maar empirische studies over publieke steun zijn opmerkelijk schaars gebleven. Enkele empirische studies zijn uitgevoerd over gerelateerde concepten in mobiliteitsmanagement, maar deze bestuderen doorgaans steun voor één vaststaande uitwerking van het concept, terwijl steun zeer afhankelijk kan zijn van de precieze uitwerking, bijvoorbeeld van de manier waarop credits zijn verdeeld. Verder is publieke steun voor prijsbeleid voor weggebruik (in het vervolg prijsbeleid genoemd) vaak bestudeerd op een kwantitatieve manier en geanalyseerd op een geaggregeerd niveau. Dat terwijl het publieke debat over prijsbeleid vol is met verschillende argumenten, wat indiceert dat het publieke zeer heterogeen is qua opinies en preferenties. Om beter te begrijpen hoe (innovatief) prijsbeleid kan worden ontworpen en geïmplementeerd, zal dit proefschrift focussen op de onderliggende argumenten en de verschillen tussen (groepen) mensen. Tenslotte lijkt ook een bredere blik op de haalbaarheid van VSC te missen, met daarin inzichten uit meer vakgebieden dan transporteconomie. Vandaar is het voornaamste doel van dit proefschrift om ***meer inzicht te krijgen in de haalbaarheid – met name de publieke steun – van verhandelbare spitscredits (VSC) als beleidsinstrument voor congestiemanagement.***

Dit onderzoek is uitgevoerd binnen de context van Nederland. Dit land heeft een lange geschiedenis met (het niet implementeren) van prijsbeleid. In de periode tussen 2006 en 2018, terwijl congestieheffing onbespreekbaar was in de politiek, werden experimenten georganiseerd waarin autogebruikers beloond werden om de spitsuren te mijden. De problemen met publieke steun rondom congestieheffing aan de ene kant, en de overwegend positieve ervaringen met de minder afgewezen maar niet duurzame beloningsinstrumenten aan de andere kant, hebben bijgedragen aan de toegenomen interesse in het budgetneutrale concept van verhandelbare credits in Nederland. Deze interesse heeft ook geleid tot de formatie van een multidisciplinair consortium waar dit proefschrift onderdeel van is: U-SMILE (*Urban Smart Measures and Incentives for quality of Life Enhancement*).

Theoretische opzet

Aangezien kennis over steun voor VSC schaars is, neemt dit proefschrift een vrij open, explorative aanpak en niet een theorie-testende aanpak. Dit betekent dat de onderzoeksopzet van dit proefschrift geïnspireerd is door, maar niet beperkt is tot, empirische bevindingen uit de bestaande literatuur over prijsbeleid en theoretische raamwerken over adoptie van innovaties. Dit proefschrift start met een conceptueel raamwerk dat is gebaseerd op een politiek-economische raamwerk over de adoptie van transportinnovaties, aangevuld met de literatuur over conventioneel prijsbeleid en aangepast aan de situatie van verhandelbare credits voor congestiemanagement.

Structuur van het proefschrift en methoden

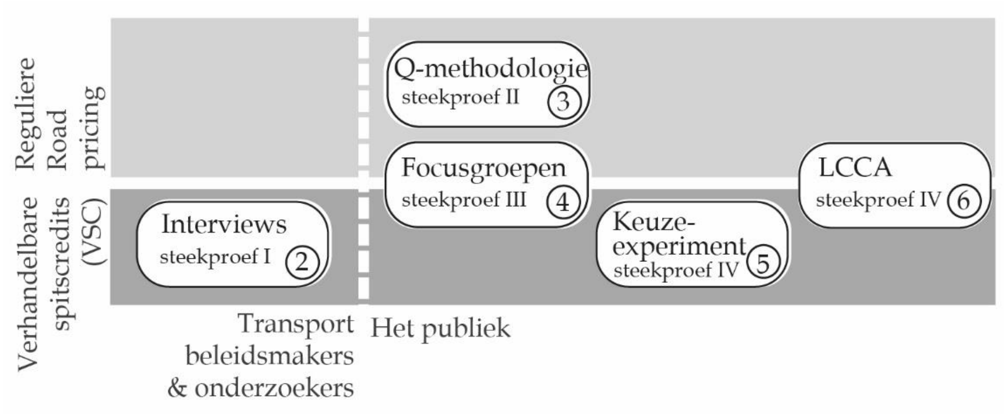
Het hoofddoel van dit proefschrift is vertaald naar vijf deelvragen die geadresseerd worden in de vijf inhoudelijke hoofdstukken. Figuur 11 geeft een overzicht van de vijf inhoudelijke hoofdstukken met de daarin toegepaste methoden.

- In Hoofdstuk 2 wordt de haalbaarheid van VSC in brede zin en de belangrijkste barrières tot implementatie onderzocht door middel van interviews met beleidsmakers en onderzoekers met verschillende achtergronden in het transportveld (N=16, *steekproef I*). De inzichten uit de interviews worden aangevuld met inzichten uit empirische studies en theorieën over beleidsprocessen.

Het vervolg van dit proefschrift focust op publieke steun, aangezien dat doorgaans de voornaamste barrière is voor implementatie van prijsbeleid. Hoofdstuk 3 gaat over het huidige debat over prijsbeleid en Hoofdstukken 4, 5 en 6 focussen op publieke steun voor VSC.

- Hoofdstuk 3 analyseert het huidige debat over prijsbeleid door het identificeren van de holistische standpunten van mensen met behulp van de kwalitatief-kwantitatieve Q-methodologie. In een online enquête (N=111, *steekproef II*), werden respondenten gevraagd om een set statements te rangschikken die het Nederlandse debat vertegenwoordigen. Een bepaalde rankschikking representeert het complete standpunt van een individu en door het systematisch vergelijken van die rankschikkingen, zijn gedeelde standpunten geïdentificeerd. Deze representeren de voornaamste 'frames' van het debat over conventioneel prijsbeleid.

- Hoofdstuk 4 start met het verkennen van de attitudes, gevoelens en meningen van mensen ten opzichte van VSC door het gebruik van focusgroepsbijeenkomsten. Inwoners van de regio Delft (N=36, *steekproef III*), een middelgrote stad in Nederland, bediscussiëren het concept van VSC en verhouden het tot een vergelijkbare spitsheffing.
- Hoofdstuk 5 kwantificeert publieke steun voor VSC, met gebruik van een enquête onder inwoners die in of nabij twee grote Nederlandse steden wonen (Amsterdam en Utrecht) (N=513, *steekproef IV*). Respondenten werden in een keuze-experiment gevraagd om te kiezen tussen verschillende uitwerkingen van VSC. De uitwerkingen verschillen in de manier waarop credits worden verdeeld, naar wie de credits gaan, hoe vaak de credits worden verdeeld en hoe vaak de creditprijs fluctueert. Verschillende nut-gebaseerde keuzemodellen zijn geschat op de geobserveerde keuzes om de publieke steun voor verschillende VSC uitwerkingen te vinden en om de invloed van persoonlijke kenmerken, attitudes en de ontwerpkenmerken op de steun te analyseren.
- Hoofstuk 6 gebruikt dezelfde steekproef (*steekproef IV*) om de steun voor VSC te analyseren en te vergelijken met steun voor de conventionele congestieheffing en kilometerheffing. Ook is een *Latent Class Cluster Analysis* (LCCA) uitgevoerd om te zien welke homogene clusters van mensen op basis van vergelijkbare afwijs- of steunniveaus voor de drie instrumenten te onderscheiden zijn.



Figuur 11 De vijf hoofdstukken met hun voornaamste methode, de bestudeerde alternatieven en de bestudeerde populatie. De nummers refereren naar de hoofdstuknummering.

Bevindingen

Hoofdstuk 2: Haalbaarheid van VSC volgens transportonderzoekers en beleidsmakers

Alle geïnterviewden waren doorgaans sceptisch of zonder voorbehoud negatief over het concept en ze identificeerden veel potentiele barrières. De meeste geïnterviewden denken dat het technisch haalbaar is, maar vinden het moeilijk in te schatten of de economische baten van het instrument de kosten overschrijden. Een overzicht van empirische studies en theorieën uit de literatuur over beleidsprocessen identificeren nog meer uitdagingen. In totaal laten de resultaten zien dat de grootste uitdagingen liggen in de context van publieke en politieke steun. Belangrijke uitdagingen zijn met name de verdelingen van de credits, de begrijpelijkheid van het instrument en de balans tussen transactiekosten en effectiviteit.

Hoofdstuk 3: Publieke standpunten in het debat over conventioneel prijsbeleid

Vier gedeelde standpunten – de zogenoemde 'frames' in het debat – zijn geïdentificeerd. The eerste groep is gelabeld als '*de gebruiker moet betalen'* en mensen in dit frame zijn vrij positief over prijsbeleid op de weg. Ze vinden het huidige autogebruik een groot probleem voor de economie en het milieu en ze laten zien dat veel vertrouwen hebben in de technische haalbaarheid en de effectiviteit van prijsbeleid. Mensen in het tweede frame, '*focus op eerlijke alternatieven'*, vinden congestie ook een groot probleem maar zien prijsbeleid niet als een eerlijke oplossing. In plaats daarvan focussen ze liever op alternatieven voor de auto, zoals openbaar vervoer en de fiets, die te gebruiken zijn voor alle (inkomen)groepen en milieuvriendelijk zijn. Mensen in het derde frame, '*wat zit er voor mij in?'*, zijn voornamelijk autogebruikers die bang lijken te zijn dat prijsbeleid hun persoonlijke situatie benadeelt en ze willen meer informatie voordat ze hun uiteindelijke mening vormen. Mensen in het vierde frame, *'laat me met rust'*, zijn ook regelmatige autogebruikers. Ze vinden congestie een groot probleem, maar vinden prijsbeleid niet een eerlijke noch effectieve oplossing. Dit frame is gekenmerkt door het wantrouwen jegens de overheid en in de technische haalbaarheid van prijsbeleid.

Hoofdstuk 4: Publieke percepties van VSC

De voordelen van VSC zoals genoemd in de academische literatuur, speelden een geringe rol in de discussies. Deelnemers vonden de flexibiliteit van de creditverdeling een groot discussiepunt en veel begrepen de potentiele effectiviteit van VSC wegens de ferme limiet niet of ze negeerden het. Ook geloofde niet iedereen dat de geldstromen in een VSC systeem per saldo neutraal zouden zijn. De nadelen die werden genoemd waren groter in aantal en meer divers dan de voordelen. De meeste deelnemers in de focusgroepen prefereerden de simpelere spitsheffing (*peak charge – PC)* en veel deelnemers hadden een overwegend sceptische houding tegenover VSC. Deelnemers waren echter zeer verdeeld over de twee instrumenten. Vijf groepen van mensen zijn geïdentificeerd die vergelijkbare gedachten hadden over VSC en spitsheffing. Negen deelnemers waren *fel tegen* beide instrumenten en hadden een kritische houding tegenover de overheid. Veertien deelnemers waren *duidelijk tegen* VSC maar waren redelijk positief over een spitsheffing. Ze lieten een goede kennis van het transportsysteem en andere beleidsmiddelen zien. De meeste mensen in deze groep gebruiken een fiets of trein als voornaamste manier van reizen. Zes deelnemers waren vrij *twijfelend*. Ze lieten een open houding zien ten opzichte van VSC en waardeerden de positieve aanpak vergeleken met spitsheffing. Ze voorzagen echter ook veel problemen omtrent de implementatie en haalbaarheid. Vier deelnemers waren *goedkeurend* tegenover beide instrumenten. Ze beargumenteerden dat het nodig is om een financiële prikkel in te voeren om congestie te reduceren, ongeacht of dit beleid budgetneutraal is. Tenslotte waren twee deelnemers *opportunistisch* en positief over VSC terwijl ze spitsheffing afwezen. Beide deelnemers zijn regelmatige autogebruikers die uitlegden dat VSC hen financiële voordelen zou bieden. Enkele van de deelnemers veranderden hun mening over VSC gedurende de discussie. Ze werden negatiever, met name door argumenten gerelateerd aan technische haalbaarheid.

Hoofdstuk 5: Publieke steun voor VSC ontwerpuitwerkingen

De resultaten van de keuzemodellen suggereren dat, gemiddeld genomen, mensen de status quo prefereren over de implementatie van VSC. De steun verschilt echter tussen de verschillende uitwerkingen. Van de steekproef steunt tussen de 32% en 52% verschillende VSC uitwerkingen.

Steun is het hoogste voor de uitwerking waarin credits gelijk verdeeld zijn onder mensen die in de stad wonen plus mensen die er werken en een auto bezitten, waarin credits maandelijks worden verdeeld en de creditprijs op een dagelijkse basis fluctueert. De voorkeuren voor deze karakteristieken verschillen echter sterk tussen respondenten. Daarnaast lieten de verschillende keuzemodellen zien dat attitudes, waaronder de verwachtte effectiviteit, inbreuk op de privacy en gepercipieerde eerlijkheid, een belangrijke rol spelen in het verklaren van de steun.

Hoofdstuk 6: Steun voor VSC, een kilometerheffing en een congestieheffing

Op een geaggregeerd niveau is 27% van de steekproef enigszins of compleet voor het generieke concept van VSC, 29% is voor een congestieheffing en 34% voor een kilometerheffing. De groep van mensen die VSC steunen verschilt sterk van de groep die conventionele instrumenten steunen. De LCCA onthulde vijf clusters van mensen met vergelijkbare gedachten in termen van steun voor de drie instrumenten. De grootste cluster (58%) is vrij besluiteloos of neutraal over alle instrumenten. 18% is negatief over alle instrumenten en een cluster van 8% is positief over alle instrumenten. De kleinste cluster representeert 6% en steunt alleen een kilometerheffing. 10% van de steekproef steunt VSC en wijst de conventionele instrumenten af. Zoals te verwachten was, bestaat deze laatstgenoemde cluster voornamelijk uit autogebruikers.

Algemene conclusies

De vraag of VSC een meer gesteund en daardoor haalbaarder beleid is dan een congestieheffing kan niet eenvoudig met een 'ja' of 'nee' worden beantwoord. De verwachtingen van de geïnterviewde beleidsmakers en onderzoekers wat betreft publieke steun waren negatiever dan de gevonden empirische resultaten onder inwoners. De resultaten laten zien dat 27% van de steekproef onder inwoners van twee Nederlandse steden VSC steunen, wat nagenoeg gelijk is aan de steun voor het generieke concept van een congestieheffing (29%). Echter, wanneer dezelfde respondenten geconfronteerd worden met meer specifieke uitwerkingen van VSC, was de steun hoger. Steun varieerde tussen 32% en 52%, wat het belang van de uitwerking op het verkrijgen van steun bevestigt. Met name de creditverdeling beïnvloedt de steun, hoewel voorkeuren voor de verschillende creditverdelingen aanzienlijk verschillen tussen de respondenten. Respondenten prefereren ook uitwerkingen waarin credits minder frequent worden uitgedeeld en creditprijzen niet vaak fluctueren. Een eerder uitgevoerd keuze-experiment over een vergelijkbaar concept (*personal carbon trading*) liet veel grotere verschillen in steun voor verschillende uitwerkingen zien. Ofwel, veel mensen zijn positief dan wel negatief over VSC vanwege hun attitudes tegenover het instrument en hun mening wordt beperkt beïnvloed door verschillen in de uitwerking.

Daarnaast probeert dit proefschrift ook te verklaren waarom inwoners VSC steunen of afwijzen. De focusgroepstudie liet zien dat veel van de argumenten gebruikt in het debat over VSC overlappen met de argumenten gebruikt in het debat over conventioneel prijsbeleid op de weg. Deze omvatten argumenten gerelateerd aan eerlijkheid/rechtvaardigheid, geloof in de effectiviteit en vertrouwen in de overheid. Ook zijn enkele nieuwe argumenten gevonden die nog weinig zijn bestudeerd in het licht van VSC: het 'gedoe' (tijd en moeite) wegens het handelen, het verwachte plezier met het handelen, de angst voor misbruik, privacy problemen, de technische haalbaarheid van het instrument, de gepercipieerde complexiteit, en de begrijpelijkheid en gebruiksvriendelijkheid. Ook een nieuw aspect van eerlijkheid werd genoemd door enkele deelnemers. Zij zijn bang dat VSC de mensen benadeelt die niet handig of slim zijn in handelen. Het keuzemodel in Hoofdstuk 5 bevestigt verder dat steun voor VSC hoger is onder mensen die VSC als eerlijk en effectief zien, vertrouwen hebben in de overheid en in de technische haalbaarheid, zekerheid belangrijk vinden en VSC niet als een beperking van hun vrijheid zien.

Zoals de Q-methodestudie liet zien, is het publiek erg heterogeen als het aankomt op steun voor prijsbeleid. Er zijn verschillende redenen om een beleid af te wijzen of te steunen. Dit proefschrift heeft verschillende persoonsgerichte methoden gebruikt om die heterogeniteit rondom VSC te bestuderen. De focusgroepstudie heeft daarbij een kwalitatieve aanpak en de Latent Class Cluster Analysis (LCCA) een kwantitatieve. Beide studies identificeerden een groep mensen die alle instrumenten (fel) afwijst. De focusgroepstudie liet zien dat de theoretische voordelen van VSC, zoals de afwezigheid van een geldstroom richting de overheid, worden genegeerd of niet geloofd door deze mensen. Beide studies identificeerden verder ook een groep mensen die alle instrumenten steunt. Deze mensen hebben vertrouwen in de technologie en vinden het belangrijk om ‘iets te doen aan de congestie’. Beide studies identificeerden ook een ‘onverschillige’ of ‘twijfelende’ groep. Deze groep representeert 58% van de sample in de LCCA studie, terwijl in de focusgroepen enkel 6 van de 36 (17%) twijfelend zijn. Dit verschil kan veroorzaakt zijn door de verschillende methoden: focusgroepen trekken wellicht relatief weinig mensen aan met een ‘neutrale’ mening over het onderwerp, terwijl in een LCCA de ‘neutrale’ groep wellicht oververtegenwoordigd is als sommige respondenten simpelweg de middelste optie van een Likertschaal kiezen. Beide studies identificeerden verder ook een groep mensen dat VSC afwijst, maar wel een conventioneel prijsinstrument steunt. In de focusgroepen lieten deze mensen zien dat ze veel vertrouwen hebben in de effectiviteit van conventioneel prijsbeleid en ze VSC als een onnodige complexe variant zien. Beide studies identificeerden ten slotte ook een ‘opportunistische’ groep mensen: regelmatige autogebruikers die regulier prijsbeleid afwijzen, maar VSC steunen. Dit is de meest interessante groep aangezien autogebruikers vaak de felste tegenstanders waren in het debat over conventioneel prijsbeleid. De verwachting dat VSC meer gesteund zou worden door autogebruikers dan een congestieheffing is dus waar gebleken voor een deel van de autogebruikers. Echter, de groep is redelijk klein (10%) en veel autogebruikers zitten alsnog in de ‘wijs alle instrumenten af’ groep.

Aanbevelingen en vervolgonderzoek

Het publiek is zeer heterogeen als het op steun voor VSC aankomt. Daar komt bij dat voorgaande studies lieten zien dat publieke steun voor conventioneel prijsbeleid doorgaans niet stabiel is, maar verandert over de tijd onder invloed van ervaringen met een bepaald instrument en publiek debat daarover. Steun stijgt vaak zodra een proef of beleid is geïmplementeerd. Als beleidsmakers geïnteresseerd zijn in verhandelbare credits, zou het daarom interessant zijn om realistische experimenten te houden in ‘de echte wereld’. Deze experimenten bieden de kans om de invloed van ervaring op steun te bestuderen, alsmede andere aspecten, zoals gedragseffecten en de technische- en beleidsimplementatie. Daarbij is het belangrijk om veel aandacht te geven aan het exacte beleidsontwerp aangezien dit proefschrift heeft laten zien hoe belangrijk de uitwerking is voor de steun. Het is vooral uitdagend om een creditverdeling te vinden die steun krijgt van veel mensen. Hoewel dit proefschrift focuste op grootschalige implementatie kan het concept van VSC ook op de schaal bij een bedrijf of zakelijk district worden ingevoerd. De resultaten lieten immers zien dat er een groep van regelmatige autogebruikers is dat vrij positief staat tegenover het concept.

Dit proefschrift is een momentopname van steun voor, en haalbaarheid van, verhandelbare credits voor congestiemanagement. Zolang er geen duidelijke publieke voorkeur voor VSC ten opzichte van conventionele congestieheffing bestaat, is het te betwijfelen of het wijs is om VSC op grote schaal te implementeren. Het concept is relatief complex, hetgeen meer kosten meebrengt dan de eenvoudigere en meer gevestigde instrumenten gebaseerd op congestieheffing. Dat gezegd hebbende, de unieke kenmerken van VSC waaronder de ferme limiet op weggebruik, de afwezigheid van een geldstroom richting de overheid, en de flexibiliteit door de (gratis) initiële creditverdelingen, maken het concept een interessant alternatief tegenover de reeds uitgebreid bestudeerde conventionele prijsbeleid instrumenten. Verhandelbare credits verrijken, maar beëindigen niet de lange zoektocht naar een efficiënt en gesteund instrument om congestie te reduceren.

About the author

Lizet Krabbenborg was born on the 30th of May, 1990 in Winterswijk, the Netherlands. In 2008, she started at the Delft University of Technology, taking a Bachelor's degree in Architecture and the Built Environment. While studying for this degree, she took a Minor in International Entrepreneurship which involved staying in Bangalore in India for a couple of months. After graduation, she undertook an internship at Hosper in Haarlem, a landscape design office. In 2012, Lizet started her Master's degree in Urbanism, but never finished it because elective courses in the field of transportation piqued her interest and she switched to the Master of Transport, Infrastructure and Logistics degree. During this period, she participated in the faculty student council, she was a board member of Polis, the study association for Urbanism and Landscape design, and she did a project at Royal IHC. In 2015, she graduated with a Master thesis project concerning the route choices of cyclists, which she completed at PBL (Netherlands Environmental Assessment Agency). She stayed at PBL as a project assistant for a short period of time and returned to the TU Delft in the summer of 2016 to start on the research for her PhD. While doing her PhD, she acted as a representative in the TRAIL PhD council. Since October 2020, Lizet has been working as a researcher for the KiM (Netherlands Institute for Transport Policy Analysis).

List of publications and conference contributions

Krabbenborg, L., Mouter, N., Molin, E., Annema, J. A., & van Wee, B. (2020). Exploring public perceptions of tradable credits for congestion management in urban areas. *Cities*, *107*. https://doi.org/10.1016/j.cities.2020.102877

Krabbenborg, L., Molin, E., Annema, J. A., & van Wee, B. (2020). Public frames in the road pricing debate: A Q-methodology study. *Transport Policy, 93*, 46-53. https://doi.org/10.1016/j.tranpol.2020.04.012

Krabbenborg, L., Van Langevelde – Van Bergen, C., Molin, E., (*resubmitted*). Public support for tradable peak credit schemes. *Transportation Research Part A*

Krabbenborg, L., Molin, E., Annema, J. A., & van Wee, B. (*under review*). Exploring the feasibility of tradable credits for congestion management.

Krabbenborg, L., Kroesen, M. & Molin, E. (*under review*). Public support for road pricing schemes: latent preference classes identified.

Krabbenborg, L., Mouter, N., Molin, E., Annema, J.A. & van Wee, B. (2020). Exploring public perceptions of tradable credits for congestion management: A focus group study. Contribution to the *Transportation Research Board*. Washington, USA.

Krabbenborg, L., Mouter, N., Annema, J.A. (2019). Publieke percepties van verhandelbare spitscredits: een focusgroepstudie. Bijdrage aan het *Colloquium vervoersplanologisch speurwerk*. Leuven, België.

Krabbenborg, L., Molin, E. & van Wee, B. (2018). Public viewpoints on road pricing: An application of Q-methodology. Contribution to the *IATBR*. Santa Barbara, USA.

Krabbenborg, L., Annema, J.A., Snellen, D. (2015). De invloed van bebouwde omgeving op fietsen in voortransport. Bijdrage aan het *Colloquium vervoersplanologisch speurwerk*. Antwerpen, België.

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